UG_CleanPowerVFD_OnlineMirror_En_V20260213





Table of Contents

UG_CleanPowerVFD_OnlineMirror_En_V20260213 1
Table of Contents 2
1. Home 8
2. Introduction 11
2.1. Warranty and legal provisions 13
2.2. Safety labels 14
2.3. Warranty and liability - summary 15
2.4. Copyright 16
3. How to select a VFD? 17
3.1. Comprehensive Guide to Selecting Clean Power VFD and Motor 18
3.2. Clean Power VFDs Overview 23
3.3. Clean Power VFDs Ratings 25
3.4. Motor nameplate 27
4. Installing the VFD 30
4.1. Installing the Clean Power VFD: Safety message 31
4.2. Installation: overall procedure 32
4.3. Installation regulations and rules 33
4.4. Unboxing 34
4.5. Mechanical installation 52
4.6. Electrical Installation 77
5. Starting procedures 146
5.1. Operating the Clean Power VFD : Safety messages 147
5.2. Powering the Clean Power VFD : Safety messages 149
5.3. Initial Clean Power VFD Setup 151
5.4. Get the mobile App 153
5.5. First connection to network 156
5.6. First Time Authentication 162
5.7. Check list: Before starting the Clean Power VFD 165
5.8. Test run 169
6. Mobile App 172
6.1. Configuration application 174
6.2. Intuitiveness 177
6.3. Authentication 178
6.4. Mobile App and Firmware Version Compatibility 181
6.5. Application menu 188
6.6. Organization of the configurations 190

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6.7. Configuration Notes 192
6.8. VFD control by Mobile App 193
7. Smart HMI 196
7.1. HMI description 197
7.2. Illuminated logo 199
7.3. Initial Clean Power VFD Setup 201
7.4. Quick setup wizard using the HMI 203
7.5. Functions of the HMI 208
7.6. VFD configuration from the HMI 209
7.7. Display and define the motor setpoint 213
7.8. Access and manage the alarms 214
7.9. Display settings 217
7.10. BLE status 218
7.11. Test the HMI 220
7.12. HMI screensaver 222
7.13. Lock & Unlock Display 223
7.14. Configuration export 225
8. Functions and parameters 229
8.1. Dual Configurations 230
8.2. Power Line parameters 234
8.3. Motor parameters 236
8.4. Auto-tuning 252
8.5. Motor Control Mode 267
8.6. Motor Thermal Protection 346
8.7. Inputs and outputs 358
8.8. Two Current Limits With Automatic Switchover 383
8.9. Torque Deactivation 388
8.10. Remote/ Local control source 390
8.11. Date and Time 398
9. Applications 402
9.1. PID Control 403
9.2. HVAC 436
10. Networks and communication 444
10.1. Network settings 445
10.2. Display network information 449
10.3. Renew the IP address 450
10.4. Network Topologies 451

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10.5. Modbus TCP 453
10.6. BACnet IP 458
10.7. EtherNet/IP-Overview and Capability 484
11. Metrics 512
11.1. Motor number of starts 513
11.2. Motor runtime 514
11.3. VFD runtime 515
11.4. Fans runtime 516
12. Alarms and Protections 517
12.1. If the Clean Power VFD is not configured 518
12.2. How alarms are triggered 519
12.3. Alarms Severity 520
12.4. Alarms actions 522
12.5. System reset 524
12.6. Clean Power VFD protection against short-circuits 529
12.7. Protection of the 24 VDC supply 530
13. List of alarms sorted by code with their severity level 532
14. List and Details of alarms and protections 538
14.1. DC undervoltage (Code: 4) 539
14.2. DC Overvoltage (Code: 5) 540
14.3. Line voltage sag (Code: 6) 541
14.4. Line voltage balance (Code: 7) 542
14.5. HMI communication loss (Code: 9) 543
14.6. Line Overcurrent (Code: 11) 544
14.7. Motor currents unbalanced (Code: 12) 545
14.8. Motor overheating protection (code: 14) 546
14.9. Application overload prevention (Code: 15) 550
14.10. VFD internal over temperature (Code: 16) 551
14.11. Unknown boot state (Code: 17) 552
14.12. Booted from backup software (Code: 18) 553
14.13. Booted from backup software copy and restored factory settings (Code: 19) 554
14.14. VFD high temperature (Code: 20) 555
14.15. Line voltage swell (Code: 21) 556
14.16. Software update failed (Code: 22) 557
14.17. Cooling fan (1-4) fault (Code: 24 to 27) 558
14.18. Cooling fan capacity fault (Code: 28) 559
14.19. Line unexpected voltage (code: 29) 560

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14.20. Internal error (Code: 30)..... 561
14.21. DC unbalanced (Code: 31)..... 562
14.22. Drive output overcurrent (Code: 32)..... 563
14.23. Simultaneous forward and reverse command (Code: 33)..... 564
14.24. System boot time exceeded (Code: 34)..... 565
14.25. System degraded (Code: 35)..... 566
14.26. Abnormal CPU usage (Code: 36)..... 567
14.27. Abnormal memory usage (Code: 37)..... 568
14.28. DC OverVoltage stall prevention (Code: 38)..... 569
14.29. Motor overcurrent stall prevention (Code: 39)..... 571
14.30. Line unexpected frequency (Code: 40)..... 572
14.31. DC unexpected voltage (Code: 41`)..... 573
14.32. AFE fault (Code: 42)..... 574
14.33. AFE low voltage ride-through (Code: 43)..... 575
14.34. Remote to local override (Code: 44)..... 576
14.35. Analog output sensor loss (Code: 45)..... 577
14.36. PID process value alarms (Code: 46 and 47)..... 578
14.37. Control board power loss (Code: 48)..... 580
14.38. Motor control instability (Code: 49)..... 581
14.39. Motor over speed and under speed (Code: 50 and 51)..... 582
14.40. Motor wrong direction (Code: 52)..... 584
14.41. Encoder speed error (Code: 53)..... 585
14.42. Encoder communication failure (Code: 54)..... 586
14.43. Analog input loss (Code: 55, 56, and 57)..... 587
14.44. Modbus comm loss (Code: 58)..... 588
14.45. VFD high ambient temperature (Code: 59)..... 589
14.46. Motor phase loss (Code: 61)..... 590
14.47. Motor stalled (Code: 62)..... 591
14.48. Motor disconnected (Code: 63)..... 594
14.49. Motor application underload (Code: 64)..... 595
14.50. Motor auto-restart failure (Code: 65)..... 597
14.51. AFE Low Voltage Ride Through Cannot Recover (Code: 66)..... 598
14.52. Drive Overload (Code: 67)..... 599
14.53. PIN invalid (Code: 68)..... 600
14.54. Damper feedback loss (Code: 69)..... 602
14.55. External start-stop feedback timeout (Code: 70, and 71)..... 604
14.56. Motor ground fault (Code: 72)..... 606

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14.57. Fire Emergency Inhibited (Code: 73)..... 607
14.58. External alarm (Code: 74 to 77)..... 608
14.59. Motor Thermal Overload (Code: 78)..... 610
14.60. Internal MCU comm loss (Code: 79)..... 615
14.61. BACnet IP communication loss (Code: 80)..... 616
15. Troubleshooting..... 618
15.1. I/O's status monitoring..... 619
15.2. Versioning..... 621
15.3. Audit logs..... 623
15.4. Troubleshooting Operation Issues..... 627
15.5. Troubleshooting the alarms..... 632
15.6. Alarms reset/acknowledgment..... 666
15.7. Bluetooth pairing issue..... 667
15.8. Export support package..... 669
15.9. Ping Support Configuration..... 671
16. Clean Power VFD operation..... 675
16.1. VFD IoT Health Monitor..... 676
16.2. Emergency Fire Mode..... 677
16.3. Maintenance Mode..... 680
17. Maintenance..... 683
17.1. Maintenance: Safety messages..... 684
17.2. Routine inspections..... 686
17.3. Annual inspection..... 688
17.4. RTC Battery replacement..... 690
17.5. Update the software from the HMI..... 691
17.6. Update the software from the mobile App..... 698
17.7. Torque Deactivation acceptance test..... 702
17.8. Reset to factory settings..... 705
18. Disposal..... 711
18.1. WEEE - Waste Electrical and Electronic Equipment..... 712
18.2. Disposal instructions..... 713
19. Technical Specifications..... 714
19.1. Ratings SDB-1-2110-A..... 716
19.2. Ratings SDB-1-2150-A..... 718
19.3. Ratings SDB-1-2185-A..... 720
19.4. Ratings SDB-1-2220-A..... 722
19.5. Ratings SDB-1-2220-AL..... 724

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19.6. Ratings SDB-1-2300-A 726
19.7. Ratings SDB-1-2375-A 728
19.8. Ratings SDB-1-2450-A 730
19.9. Ratings SDB-2-2150-A 732
19.10. Ratings SDB-2-2185-A 734
19.11. Ratings SDB-2-2220-A 736
19.12. Ratings SDB-2-2300-A 738
19.13. Ratings SDB-2-2375-A 740
19.14. Ratings SDB-2-2450-A 742
19.15. Ratings SDB-2-2550-A 744
19.16. AFE performance and immunity 746
19.17. Deratings SDB-x-xxxx-A 750
19.18. Deratings SDB-x-xxxx-AL 751
19.19. Control I/Os 752
19.20. Motor cable length 759
19.21. Operating environment 760
19.22. Enclosure type, rating, material and finishes 762
20. Compliances and certifications 765
20.1. SmartD VFD Certification Matrix 768
21. Warranty, Software License and Legal Provisions 779
22. Registered trademarks 782

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1. Home

Starting to discover the Clean Power VFD

- Introduction
- How to select a VFD

Here are the instructions to unbox, mount, and wire the Clean Power VFD.

- installing the VFD
- mechanical installation
- electrical installation

Ready to run the Clean Power VFD + motor.

Here are the instructions to execute the powering up, settings, and tests.

Read the safety messages carefully.

- Checklist before starting the VFD
- Get the Mobile App
- Test run

The Clean Power VFD provides users with two primary interfaces.

- Mobile App
- Smart HMI

How the Clean Power VFD operates

- Functions and parameters

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- Motors parameters
- Auto-tuning
- Motor control

Applications functions

- PID control
- Damper control

Connect the Clean Power VFD

- Networks settings
- Modbus TCP
- Bacnet IP

Alarms and protections

- How alarms work
- Alarm details
- Troubleshooting

How to perform regular inspections as well as how to safely execute prescribed maintenance?

- Maintenance

End-of-life instructions

- Disposal

Products technical specifications

- datasheet

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2. Introduction

For simplicity, SmartD Technologies Inc. is referred to as SmartD throughout the document, and the SmartD Clean Power Variable Frequency Drive is called Clean Power VFD.

SDB series Clean Power VFDs have been designed for the specific requirements of fan and pump applications. However, their flexible design, incorporating V/F control, allows them to be used in other applications requiring accurate speed control and fast torque response.

Their innovative clean power design saves space, cost, and time.

This user manual offers detailed instructions for the Clean Power VFD series, encompassing product features, parameter settings, operation, commissioning, as well as inspection and maintenance.

Be sure to carefully read and follow all the safety instructions before use, to ensure the safety of personnel and property.

Use the menu

We recommend reading this user guide in the sequence listed in the menu.

The menu will always appear on the left side for larger screens.

If you have a small screen, open the menu by clicking the top menu sign ☰.

Qualified personnel

This user manual is intended for qualified personnel.

You must be able to program and operate Variable Frequency Drives.

In addition, you must understand the parameter settings and functions.

Important notes:

For instructional purposes, this guide contains pictures showing the product with the casing or safety cover removed.

When using this product, ensure that the casing and safety cover are in place and operate the unit according to the instructions in this documentation.

SmartD is dedicated to the ongoing enhancement of our products. As product features evolve, the information in this manual may be subject to updates.

Please refer to our website for the most up-to-date product document.

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Warning:

The Clean Power VFD can be used only to control the variable speed of 3-phase induction motors.

They are NOT suitable for 1-phase motors or other purposes.

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Using the product safely

Read and follow all safety instructions in the User Guide precisely to avoid unsafe operating conditions, property damage, personal injury, or even death.

- Safety labels
- Warranty and liability - summary
- Copyright

Previous Next

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2.1. Warranty and legal provisions

The selection and application of SmartD Technology Inc.'s Clean Power VFD remain the responsibility of the equipment designer or end user.

SmartD Technology Inc. accepts no responsibility for the way its variable frequency drives are incorporated into the final system design.

Without exception, all controls should be designed to detect faults dynamically and fail safely under all circumstances.

All systems designed to incorporate a Clean Power VFD manufactured by SmartD Technology Inc. must be supplied to the end user with appropriate warnings and instructions as to the safe use and operation of that part.

Any warnings provided by SmartD Technology Inc. must be promptly provided to the end user.

SmartD Technology Inc. offers an express warranty only as to the quality of its products in conforming to standards and specifications published in the user guide (please read the full Limited Warranty at the end of this user guide).

SmartD Technology Inc. assumes no liability for any personal injury, property damage, losses, or claims arising from the misapplication of its products (please read the full Limited Warranty and Disclaimer at the end of this user guide).

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2.2. Safety labels

The following **safety symbols** are used in this user guide. Please take the time to learn their meaning.



Danger indicates an **imminent hazardous** situation that, if not avoided, **will result** in severe injury or even death.



A warning indicates a **potentially hazardous** situation that, if not avoided, **could result** in injury or even death.



Caution indicates a potentially hazardous situation that, if not avoided, could result in minor injury or property damage.



Notice indicates important information that is not directly related to personal injury, but should still be followed for proper operation of the Clean Power VFD..

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2.3. Warranty and liability - summary

This summary is provided as a courtesy to our users. It does not replace the terms and conditions regarding the Warranty Information, Limitation of Liability, and Intellectual property that can be found at the end of this document, and should be read in full before deploying the Clean Power VFD.

This SmartD quality product is warranted to operate as described in this User Guide and to be free from manufacturing defects in material and workmanship for a period of eighteen (18) months from the date of shipment to the person or organization to which the equipment was initially sold.

In no event and under no circumstances shall the manufacturer be liable for damages and failures due to misuse, abuse, improper installation, abnormal temperature conditions, dust, or corrosion, or failures due to operation outside the published ratings. The manufacturer is not liable for consequential and incidental damages.

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2.4. Copyright

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3. How to select a VFD?

The selection of motor and clean power VFDs should be performed by skilled and experienced personnel.

This guide is a supplement, not a replacement for such expertise.

⚠ CAUTION

Exceeding Drive Capacity

It is essential to ensure that the motor Full Load Amps (FLA) do not exceed the Variable Frequency Drive (VFD) capability.

If you are using a motor with a published Service Factor (S.F.), which could be the case in North America, ensure that the Motor Service Factor Amps (SFA = FLA* S.F.) do not exceed the VFD capability.

While our VFDs are equipped with advanced features that may allow the operation of motors with a higher FLA than the drive's specified maximum, this configuration is primarily intended for specific testing purposes in a controlled laboratory environment.

Installation of a motor that exceeds the drive capacity under normal operational conditions is strongly discouraged and may result in equipment failure, decreased efficiency, and potential safety hazards.

Limitation of Liability

SmartD Technologies is not liable for any issues, damages, or failures that arise from installing a motor with an FLA exceeding the VFD's rated capability.

It is the responsibility of the user to verify and comply with the drive specifications to ensure safe and optimal operation.

Previous Next

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3.1. Comprehensive Guide to Selecting Clean Power VFD and Motor

Choosing the right Clean Power Variable Frequency Drive (VFD) and motor for your application is essential for ensuring optimal performance, longevity, and system reliability.

Understanding the Application

Before selecting a Clean Power VFD and motor, it is crucial to understand the operating environment and the specific tasks to be performed. The selection process involves:

1. Motor Selection:

- Choose a motor based on the load's driving force and movement cycles.

- Basic movement cycle: start > acceleration > constant speed > deceleration > stop.

2. VFD Selection:

- Select a Clean Power VFD capable of driving the chosen motor effectively.

Key Considerations in VFD Selection

1. Motor Current Rating

The primary consideration when selecting a VFD is the motor's current rating.

The VFD must provide a current equal to or greater than the motor’s full load amperage (FLA). This ensures the motor can operate at its maximum capacity without the risk of underpowering.

Steps to Consider:

- Check the motor’s nameplate for its FLA.

- Ensure the VFD’s continuous current rating matches or exceeds this value.

2. Motor Operation Cycles

Understanding the motor’s operation cycles is crucial for choosing a VFD. This involves knowing how often the motor will start and stop, and the duration of these cycles.

Key Considerations:

- Frequent start/stop cycles can cause thermal stress.

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- The VFD should be capable of handling the motor's duty cycle.

3. Motor Potential Temporary Overload

Motors often encounter temporary overload conditions that the VFD must handle without tripping.

Temporary Overload Capacity:

- VFDs are typically rated for overload conditions, such as 110% of the VFD’s rated current for 60 seconds.

- Ensure the VFD’s overload rating aligns with the motor’s overload rating in the application.

4. Ambient Temperature

The ambient temperature where the VFD operates significantly affects its performance and lifespan. Higher temperatures can reduce the VFD’s capacity and efficiency.

Temperature Adjustments:

- Check the VFD’s de-rating, which shows how current capacity decreases with rising ambient temperatures.

- Select a VFD with sufficient capacity to handle expected temperature ranges.

5. Duty Cycle (IEC 60034 Definition)

The duty cycle, as defined by IEC standards, represents the ratio of operating time to rest time of the motor.

Duty Cycle Categories:

- Continuous operation (S1): Running at constant load for a long period.

- Short-time duty (S2): Running at a constant load for a limited time.

- Intermittent periodic duty (S3-S9): Cycles of running and stopping.

VFD Selection:

- Match the VFD to your motor application's specific duty cycle category.

- Ensure the VFD can handle the motor’s operating pattern.

6. Service Factor (NEMA Definition)

The service factor, as defined by NEMA, indicates the motor's ability to operate over its rated load under specific conditions.

Service Factor Implications:

- A motor with a service factor of 1.15 can operate at 115% of its rated load without damage.

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- Select a VFD that can handle the motor’s rated load and service factor. This might mean choosing a VFD with a higher current capacity.

Additional Considerations for Specific Operations

1. Start

- The motor torque must be larger than the load starting torque.

2. Acceleration

- The motor torque must be larger than the load torque required for acceleration:

- Motor torque > Load torque + Acceleration torque.

- Acceleration torque = (total inertia of the system * (target speed - starting speed)) / (9.55 * acceleration time).

3. Deceleration

- During deceleration, the motor acts as a generator, and energy flows back into the Clean Power VFD.

- The deceleration capability is determined by the Clean Power VFD's ability to consume or regenerate this energy.

- Ensure the deceleration time is correctly set to avoid triggering alarms or entering a "self-protective" lock state.

4. Constant Speed

- Check that the motor temperature rise specification is compatible with both the movement cycles and the operating environment.

- During acceleration or constant speed operation, the Clean Power VFD's capacity is limited by the peak current it can deliver to the motor.

- Ensure that the rated current output and overload capacity are the correct size for the application.

5. Clean Power VFD Current Ratings

Clean Power VFD current ratings are provided for Normal-duty operation = continuous operation (S1) / Running at constant load for a long period. It's an RMS value.

- It's the current rating suitable for variable torque applications where torque drops with speed. Overload capacity: 110% of the VFD nominal output current for 60 seconds every 10 minutes at 40°C.

6. Acceleration and Deceleration Time

When acceleration or deceleration time is restricted, the selection of the VFD cannot be based solely on matching the VFD current capacity with the motor's rated current.

Aggressive acceleration/deceleration rates will lead to higher currents, potentially causing overload or overcurrent faults. The system's capacity (VFD + motor) must be selected to satisfy the predetermined acceleration/deceleration time.

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Ensure that the Clean Power VFD capacity is fully considered in advance for operations requiring frequent acceleration/deceleration, such as vertical lift operations.

Putting It All Together

1. Calculate the Required VFD Current Rating:

- Start with the motor's FLA.
- Adjust for duty cycle and service factor.
- Consider potential overloads and ambient temperature.

2. Match the VFD Specifications:

- Verify that the chosen VFD meets or exceeds all calculated requirements.
- Ensure the VFD can handle the expected operational conditions.

Example Calculation:

- Motor FLA: 27 A
- Service Factor: 1.15
- Duty Cycle: S1 (Continuous)
- Potential Overload: 110% for 60 seconds
- Ambient Temperature: 40°C

Step-by-Step:

1. Adjust for Service Factor:

- Motor operational current = 27A x 1.15 = 31 A

2. Consider Overload Capacity:

- Overload current = 31 A x 1.1 = 34.1 A (for temporary conditions)

3. Temperature Adjustment:

- Check VFD de-rating: The Clean Power VFD has no derating up to 50°C

4. Choose a VFD:

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- Select a VFD with a continuous current rating of at least 34 A, and ensure it supports the overload and duty cycle requirements.

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3.2. Clean Power VFDs Overview

Values are given for the rated operating range of the Clean Power VFD (-15 to 50°C without derating, 50 to 60°C with derating of 2% per °C). If not specified otherwise (e.g., SDB-1-2220-AL)

Sizes S3 - IP20 / UL type 1



SDB-1-2110-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 22 A

SDB-1-2150-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 28 A

SDB-1-2185-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 34 A

SDB-1-2220-AL

Input voltage: 3~ 400 Y - 480 Y VA

Output current (ND): 41 A @ 40 °C (104 °F)

SDB-2-2150-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 22 A

SDB-2-2185-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 22 A

SDB-2-2220-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 34 A

Sizes S4 - IP20 / UL type 1



SDB-1-2220-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 41A

SDB-1-2300-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 55A

SDB-2-2300-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 44A

SDB-2-2375-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 54A

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SDB-1-2375-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 68A

SDB-1-2450-A

Input voltage: 3~ 400 Y - 480 Y VAC

Output current (ND): 82A

SDB-2-2450-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 66A

SDB-2-2550-A

Input voltage: 3~ 600Y/347Δ (*)

Output current (ND): 79A

(*): *600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

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3.3. Clean Power VFDs Ratings

The ratings are given for **Normal Duty operation**: Continuously available without overload.

The values are given for **ambient temperature of 50 °C / 122 °F** (except: SDB-1-2185 and SDB-1-2220-AL: 40 °C / 104 °F), at **altitudes up to 2000m (6600 ft)**

Apply the recommendation of the previous section to select the VFD that fits your application.

Rated Voltage Input (VAC) 3~ 400 Y .. 480 Y –15%/+10% - Rated Frequency Input 50 and 60 Hz +/-5%

	INPUT		OUTPUT
Part Number	Input Current (A)	Apparent Power @ 480 VAC (kVA)	Nominal Output Current (A)
SDB-1-2110-A	23	20	22
SDB-1-2150-A	30	25	28
SDB-1-2185	29	24	34
SDB-1-2185-A	36	30	34
SDB-1-2220-AL	43	35.75	41 @ 40 °C (104 °F)
SDB-1-2220-A	43	35.75	41
SDB-1-2300-A	58	48.22	55
SDB-1-2375-A	71	50.03	68
SDB-1-2450-A	86	71.50	82

Rated Voltage Input (VAC) 3~ 600Y –15%/+10% - Rated Frequency Input 50 and 60 Hz +/-5%

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Part Number	INPUT		OUTPUT
	Input Current (A)	Apparent Power @ 600 VAC (kVA)	Nominal Output Current (A)
SDB-2-2150-A	23	24	22
SDB-2-2185-A	30	32	28
SDB-2-2220-A	36	37.42	34
SDB-2-2300-A	47	48.84	44
SDB-2-2375-A	57	59.23	54
SDB-2-2450-A	69	71.7	66
SDB-2-2550-A	83	86.25	79

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3.4. Motor nameplate

A motor nameplate is the ID card of a motor. It displays several pieces of information.

This information is useful for the motor selection itself, useful for the Clean Power VFD selection, and they are used to set the Clean Power VFD parameters.

Horsepower output (kW / hp).

Usually given as hp or kW, this is a measure of the motor's mechanical power.

Time rating (DUTY).

This designation specifies the length of time that the motor can carry its nameplate rating safely.

Usually, this is “continuous” (Cont), which NEMA defines as indefinite.

The duty for motors used intermittently (e.g., on cranes, hoists, and valve actuators) is usually expressed in minutes.

Maximum ambient temperature.

This is the maximum allowable temperature of the surrounding air to ensure that the motor's operating temperature won't exceed the insulation system limit.

Insulation system designation (CLASS, INS. CLS., INSUL CLASS).

This indicates the motor winding's thermal endurance using industry standard letter designations such as A, B, F or H.

Number of poles

The pole count of a motor is the number of magnetic poles, north, and south, on the rotor. There is always the same number of north and south poles on the rotor. For example, in a 12-pole motor, there are 6 north poles and 6 south poles. This motor would also be considered a 6-pole-pair motor.

The synchronous speed of the motor depends on the number of poles (2p) of the motor and on the line frequency (f) in Hertz (Hz).

AC Motor Speed Formula: Synchronous Speed (RPM) =120 x Frequency / Number of Poles

For example, the speed of a 4-Pole Motor operating at 60 Hz would be:

120 x 60 / 4 = 7200 / 4 = 1800 RPM

The speed at rated load (RPM).

This is the speed at which rated horsepower output is delivered to the load (full-load speed).

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This will be less than synchronous rpm, the speed of the stator's revolving magnetic field. The difference between the two is the “slip speed” or “slip rpm.”

Frequency (HZ).

Rated frequency of the AC power to be applied to the motor. The standard frequency is 60 Hz in North America and usually 50 Hz elsewhere.

The number of phases (PH).

Single or three phases of the AC power lines supplying the motor.

Rated load current (AMPS).

Rated load current in amps, at nameplate horsepower (hp) with nameplate voltage and frequency.

Voltage (VOLTS).

Rated voltage of the AC power to be applied to the motor.

Code letter for locked rotor kVA (CODE).

NEMA MG 1 defines locked rotor kVA per hp with a series of code letters (A to V). Generally, the farther the code letter is from A, the higher the inrush current per hp.

Design letter (DES, NEMA DESIGN, DESIGN)

NEMA MG 1 defines four motor designs (A, B, C, and D) in terms of torque and current characteristics.

Nominal efficiency

Efficiency is defined as output power divided by input power, expressed as a percentage:

(Output/Input) x 100

Service factor (SF)

At nameplate voltage and frequency, the allowable overload for a motor with a nameplate service factor equals the rated load multiplied by that service factor.

The service factor is only required on a nameplate if it is higher than 1.0.

Some motor manufacturers show their Sinusoidal and VFD Service Factor ratings. Clean Power VFD should be programmed for the Sinusoidal value.

Power factor (PF or P.F. or cosΦ)

The power factor is the ratio of active power (watts) to apparent power (volt-amperes) for the motor at full load.

Previous Next

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4. Installing the VFD

This section explains how to unbox, mount, and wire the Clean Power VFD.

Before proceeding, please carefully read the safety messages.

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4.1. Installing the Clean Power VFD: Safety message

⚠ WARNING

This drive should only be installed by qualified personnel as defined in the user's jurisdiction.

Failure to do so may result in property damage, electric shock, serious injury, or death.

Previous Next

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4.2. Installation: overall procedure

The following steps list the sequence to be followed during installation.

Install the product following this sequence and check the operational status.

For more information on each step, refer to the sections below.

1. Product identification.
    - Check that the product part number is understood and the features match the application.
2. Unbox your Clean Power VFD.
    - Stock, carry, and unpack the Clean Power VFD with caution.
3. Select the installation location.
    - Check that the environmental conditions are within specifications.
4. Follow the instructions to mount your Clean Power VFD onto its support.
5. Follow the instructions to wire properly and safely the power cables on both the input and output sides.
6. Follow the recommendations for an efficient grounding
7. Follow the instructions to wire properly and safely the control signals
8. Before powering up, follow the verification checklist.
9. Switch on power to the Clean Power VFD.
10. Follow the instructions to set up the Clean Power VFD.
11. Before the operation, perform a test sequence.

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4.3. Installation regulations and rules

As a user, you must take into account local regulations.

- European countries: Following European EN standards.
- United States of America (USA):
  - National Electrical Code (NEC).
  - National Electrical Manufacturers Association (NEMA), as well as local engineering regulations.
  - Regulations of the National Fire Protection Association (NFPA).
- Canada: Canadian Standards Association (CSA).
- Other countries:
  - International Organization for Standardization (ISO).
  - International Electro-technical Commission (IEC).

Previous Next

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4.4. Unboxing

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4.4.1. Unboxing: Safety message

DANGER

- Do not install the product if the package shows signs of excessive damage, water ingress, or a missing or broken component.
- Do not install the product if the label on the product does not match the one on the packaging.
- If the Clean Power VFD appears to be damaged upon receipt, do not install it and contact the carrier immediately.

WARNING

- Exercise care when carrying or transporting the device to minimize the risk of damage.
- If the Clean Power VFD has been stored or transported at a temperature outside the specifications, call SmartD technical support before attempting to use it.
- Wear necessary PPE (including gloves) before handling the VFD

Previous Next

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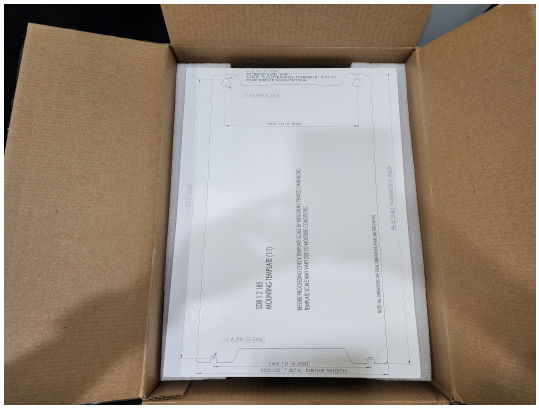
4.4.2. How to handle and unbox your Clean Power VFD

The shipping box is marked for which way is up.

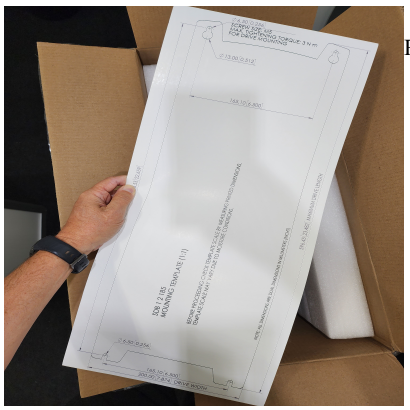
STEP 1

Place the box on a suitable flat surface and cut the tape on either end. Then cut along the tape to release the two lid halves. DO NOT use a knife.

Open the box to reveal the included mounting template.



STEP 2



Remove and keep the mounting template for later use.

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STEP 3

You have now access to the Quick Start guide. Remove it and **READ it**.



STEP 4

To remove the side protections, just gently pull them.



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STEP 5

The Clean Power VFD can now be pulled out its packaging.

The Clean Power VFD is a heavy device. SmartD recommends 2 people to proceed to the next action:

Place your hands under the VFD and lift it.

Then place the VFD on a suitable surface (not the floor) while you prepare for mounting and wiring.



During unpacking, this is an opportunity to check for damage due to shipping.

If there is damage stop unpacking, take photos, and contact SmartD.

Previous Next

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4.4.3. Clean Power VFD description

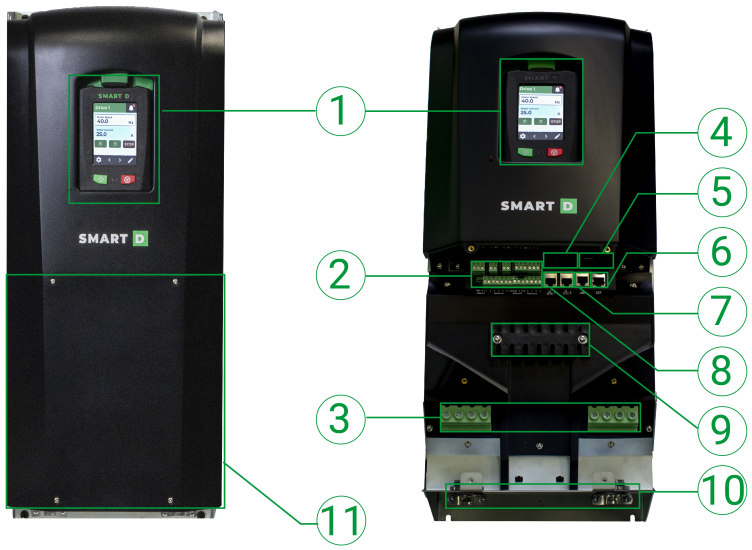
Description VFDs size S3

Description VFDs size S4

Previous Next

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4.4.3.1. Description VFDs size S3



1 Detachable HMI

User Interface. It can be detached and mounted remotely.

2 Control terminal blocks

Control wires have to be wired into this terminal block.

Refer to the wiring section of this document for details.

3 Power terminals

Power wires, input and output, and grounding must be wired into this terminal block.

Refer to the wiring section of this document for details.

4 Replaceable battery

The battery, used to save the real-time clock, can be changed easily.

Refer to the maintenance section of this document for details.

5 USB port

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The USB port can be used to upload a drive configuration or update the SmartDrive firmware.

6 unused RJ45

Do not plug anything in. This is for future features.

7 HMI port

The cable from the HMI must be plugged in here.

8 Ethernet ports

The Clean Power VFD provides users with 2 Ethernet ports.

9 cables tie holder

Tie the cables on this holder.

10 Glands for cable In and Out

Insert the power and control cables through the glands to keep them in a safe position.

11 Safety Protection cover

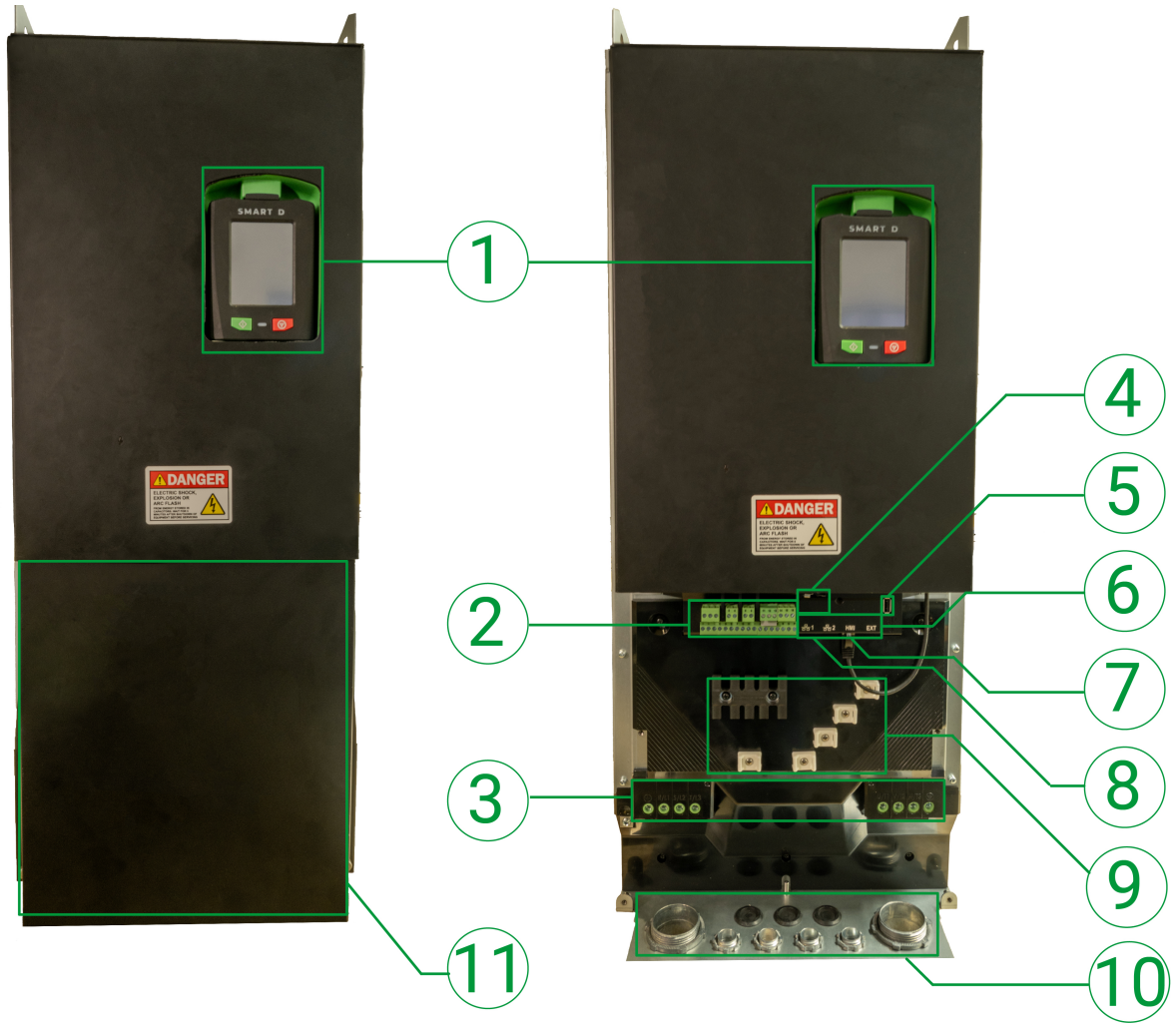
The Safety protection cover is screwed onto the Clean Power VFD housing.

Do not remove it when power is on as the live parts may be accessible.

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4.4.3.2. Description VFDs size S4



1 Detachable HMI

User Interface. It can be detached and mounted remotely.

2 Control terminal blocks

Control wires have to be wired into this terminal block.

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Refer to the wiring section of this document for details.

3 Power terminals

Power wires, input and output, and grounding must be wired into this terminal block.

Refer to the wiring section of this document for details.

4 Replaceable battery

The battery, used to save the real-time clock, can be changed easily.

Refer to the maintenance section of this document for details.

5 USB port

The USB port can be used to upload a drive configuration or update the SmartDrive firmware.

6 unused RJ45

Do not plug anything in. This is for future features.

7 HMI port

The cable from the HMI must be plugged in here.

8 Ethernet ports

The Clean Power VFD provides users with 2 Ethernet ports.

9 cables tie holder

Tie the cables on this holder.

10 Glands for cable In and Out

Insert the power and control cables through the glands to keep them in a safe position.

11 Safety Protection cover

The Safety protection cover is screwed onto the Clean Power VFD housing.

Please do not remove it when power is on as the live parts may be accessible.

Previous Next

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4.4.4. Understand the Clean Power VFD part number

The Clean Power VFD part number can be found on the identification label on the right side of the Clean Power VFD.

Please check that the model is suitable for the installation.

SD	B	-1	-2185	-A
Product Family **S**mart **D**rive				
Enclosure type: B = UL type 1 F = Flange Mounting & UL type 1				
Input Voltage in VAC: 1 = 3 ~ 400 to 480 2 = 3 ~ 600Y / 347Δ (*)				
Motor Rating (1): 2110 = 22 A - 15HP / 11 kW 2150 = 28 A - 20HP / 15 kW 2185 = 34 A - 25HP / 18.5 kW 2220 = 45 A - 30HP / 22 kW 2300 = 55 A - 40HP / 30 kW				

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2375 = 70 A - 50HP / 37 kW

2450 = 85 A - 60HP / 45 kW

2550 = 100 A - 75HP / 55 kW

2750 = 130 A - 100HP / 75 kW

2900 = 165 A - 125HP / 90 kW

3110 = 165 A - 150HP / 110kW

VFD Type:

- = 6 pulses

-A = embedded AFE

-AL = embedded AFE + restricted operating temperature

(*): *600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

(1): *Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer.The Clean Power VFD must not be selected from the motor power rating.The Clean Power VFD must be selected by skilled and experienced personnel.*

Previous Next

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4.4.5. Packaging

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4.4.5.1. Packaging content

If any of the following items are missing, please contact your distributor or SmartD Technologies:

- Clean Power VFD (According to model part number)
- Quick Start Guide (including safety instructions)
- Mounting template for the Clean Power VFD
- Mounting template to mount the HMI remotely on a cabinet's door

Previous Next

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4.4.5.2. Catalog part number and Nameplate Check

The product name and specifications are detailed on the nameplate. Ensure that the model received is the correct one by checking the information on the nameplate.

If the model received is not the correct one, contact the supplier.

Check the product specification before installing the product and make sure that it is suitable for the intended use.

Always select the motor that fits your application first and then select the appropriate Clean Power VFD.

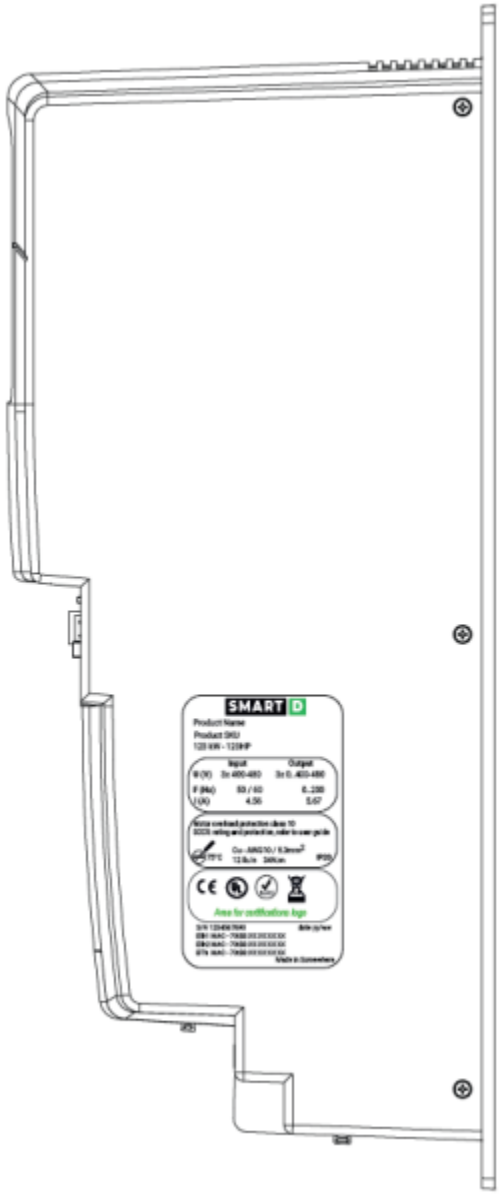
Verify that the motor you are using fits your application: check what kind of load is to be driven, calculate its moment of inertia, and check that the motor capacity matches these criteria. If you have any doubts or need some support, do not hesitate to call your motor manufacturer or its local representative

To select a Clean Power VFD: check the operation requirements (acceleration time, deceleration time, and frequency in operation) of the load to be driven by the motor selected above. The Clean Power VFD capacity must be defined in regards to current and overload capacity, not power.

If you have some doubts about your selected Clean Power VFD vs your application, please check the guideline for selecting VFD on SmartD Technologies website.

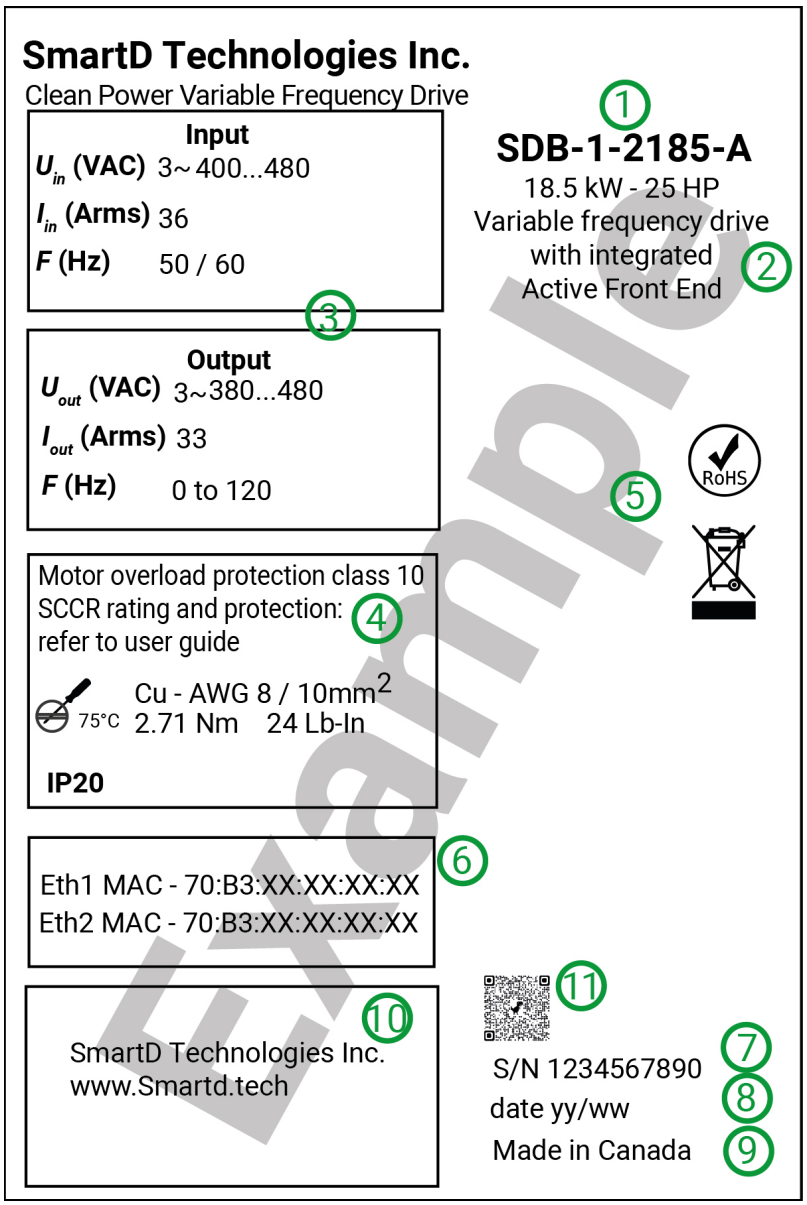
The Clean Power VFD nameplate is located on the right side of the device:

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Previous Next

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1. Product part number
2. Suitable Motor power
    - The motor power values are indicative. They vary with the motor type, technology, and manufacturer.
    - The Clean Power VFD must not be selected from the motor power rating.

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- The Clean Power VFD must be selected by skilled and experienced personnel.
- The Clean Power VFD must be selected according to motor Full Load Amps (FLA), the load's driving force, the movement cycle, and the operating environment.

3. Power input and power output rated values.
4. Technical features.
5. Certifications and compliances.
6. Mac Addresses
7. Product serial number.
8. Manufacturing date code.
9. Location of the main manufacturing process.
10. Local representative contact.
11. QR code - SmartD internal usage.

Previous Next

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4.5. Mechanical installation

- Mechanical installation: Safety messages.
- Mounting instructions
- Mounting the HMI remotely
- Application environment
- Installation position and distances
    - Mounting clearance distances and heat dissipation-VFDs size S3
    - Mounting clearance distances and heat dissipation-VFDs size S4
- Enclosure types
- Dimensions
    - Dimensions VFDs size S3
    - Dimensions VFDs size S4

Previous Next

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4.5.1. Mechanical installation: Safety messages.

DANGER

- Do not install the Clean Power VFD in an environment containing explosive gases.

  Risk of explosion.

WARNING

- The installation base shall be made of metal or other non-flammable materials.

  Risk of fire.

- Do not unscrew the fixing bolts.

  The Clean Power VFD may fall, risk damaging it and other surrounding products, as well as risk losing the cable connections, with subsequent risk of short-circuits

- Do not leave cable strips or screws in the Clean Power VFD.

  Risk of Clean Power VFD damage.

- Ensure that foreign materials, such as metal shavings or wire fragments, cannot fall into the VFD during installation.

  Place temporarily a cover over the VFD during installation, but remove it before use to ensure proper ventilation and avoid overheating the VFD.

  Risk of damage to the VFD.

CAUTION

- Ensure the ambient temperature will never exceed the allowable range while operating the drive.

  Risk of damage to VFD.

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- Install the product in a location with minimal vibration and out of direct sunlight.

  Risk of damage to VFD.

- If two or more Clean Power VFDs are installed in the same enclosure, ensure that there is sufficient ventilation to ensure proper cooling of all the devices.

  Risk of damage to the VFD.

- Failure to respect the minimum mounting clearances may cause the Clean Power VFD to overheat, potentially reducing the operational lifespan of the VFD and/or voiding the warranty.
- Do not install the Clean Power VFD on the floor or mount it sideways against a wall.
- The VFD must be installed vertically on a wall or inside a panel, with its rear flat on the mounting surface.

Previous Next

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4.5.2. Mounting instructions

Mount the Clean Power VFD inside a panel, on a pre-slotted plate, following the procedures provided hereafter.

Before installation, ensure that there is sufficient space to meet the clearance specifications and that there are no obstacles impeding the cooling airflow.

Select a wall or panel suitable to support the installation.

Refer to the dimensions section in this document and check the Clean Power VFD's mounting bracket dimensions.

1- Prepare to mount with corresponding threaded holes

Use a level to draw a horizontal line on the mounting surface, and then carefully mark the fixing points.

Apply the mounting template (delivered with the Clean Power VFD) on the mounting surface to ensure the right position of the fixing points.

Distances are given in the mounting dimensions section of this document

2- Drill and prepare fixtures

Drill the mounting bolt holes and then install the mounting bolts.

Fit screws and washers.

Do not fully tighten the bolts at this time.

3- Mount the Clean Power VFD

Mount the Clean Power VFD on the prepared mounting area via the keyhole suspensions.

Fully tighten the upper mounting bolts, then install two lower mounting bolts and tighten them fully to mount the VFD.

Ensure that the VFD is placed flat on the mounting surface and that the installation surface can securely support the weight of the VFD.

4- Clamping force of mounting screws

NOTICE

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- Always follow the **tightening torque recommended by the screw (fastener) manufacturer and by the support/anchor manufacturer.**
- This manual specifies a **minimum clamping force**, not a fixed tightening torque.
- Ensure you use a flat washer to protect the VFD housing and a spring/lock washer (or thread-locking compound) to prevent loosening due to vibration.
- SmartD Technologies Inc. is responsible for:
    - Specifying the **mounting pattern**, **permitted orientations**, **weight**, and **minimum recommended clamping force per screw**.
    - Providing general installation guidelines for safe operation of the product.

  The **panel builder / installer** is responsible for:
    - Selecting a **suitable support system** (material, thickness, reinforcement, anchors) that can safely carry the weight of the VFD and the specified clamping forces, including vibration and other mechanical loads.
    - Selecting **screws, anchors, and other fasteners** compatible with the support material and following the **fastener/anchor manufacturer's torque and installation instructions**.
    - Ensuring that the final installation complies with **applicable codes, standards, and local regulations**.

  If the support deforms, cracks, or shows signs of damage during tightening, the installation is not acceptable.
  The installer must **reinforce or redesign the support** and adjust fastener selection and torque accordingly.
  SmartD Technologies Inc. cannot be held responsible for damage or failure resulting from inadequate supports, incorrect fasteners, or improper installation.

The tightening torque of the VFD mounting screws is **not fixed**.

It depends on several factors:

- The screw size (e.g. M6, M8)
- The screw material and property class (e.g. steel 8.8, stainless A2-70)
- The material and thickness of the support (sheet metal panel, concrete wall with anchors, etc.)

The mounting quality of the VFD does **not** depend directly on a specific tightening torque.

What really matters is the **clamping force** applied by the screws between the VFD and its support.

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In real-world installations, the installer often does **not** know the exact characteristics of the support (material, thickness, type of anchors). For this reason, this manual does **not** specify a “one-size-fits-all” tightening torque. Instead, we specify a **minimum recommended clamping force** per mounting point.

You must choose:

- A suitable screw size and grade according the information given in the " dimensions" section of this document.
- A suitable **support and/or anchoring system**

and then apply a tightening torque (according to the fastener/anchor manufacturer) that achieves **at least this clamping force**, without damaging the support or the threads.

Recommended clamping force

For correct mechanical fixation and to withstand vibration during operation, each mounting screw of the VFD should provide at least:

VFD	Recommended clamping force per screw F_{clamp}
S3 frames VFD	4893 N / 1100 lbf
S4 frames VFD	9934 N / 2233 lbf

Support material and thickness

The clamping force specified in this manual assumes that the VFD is mounted on a **rigid, suitable support**.

The **choice of material, thickness, and anchoring system** for this support is part of the **panel / installation design** and is the responsibility of the installer or panel builder.

To ensure safe mounting:

- The support must be **mechanically strong enough** to carry the **weight of the VFD** plus a suitable safety margin and any dynamic loads (vibration, starting/stopping, shocks).
- The support must be **rigid enough** so that tightening the mounting screws to the required clamping force does **not cause permanent deformation** (bending, local buckling, tearing of thin sheet metal).
- The support must be **compatible with the chosen fasteners or anchors** (steel panel, mounting frame, concrete wall with anchors, etc.).

Typical examples of suitable supports include:

- Steel mounting plates or enclosure backplates designed for electrical equipment
- Rigid metal frames or mounting rails
- Concrete or masonry walls with correctly sized anchors (as per the anchor manufacturer’s instructions)

How this ties back to clamping force and torque

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1. The manual gives a **minimum clamping force per screw** (F_{clamp}).
2. The installer selects:
    - suitable support (material, thickness, type)
    - suitable fasteners / anchors for that support
3. The installer then:
    - uses the fastener/anchor manufacturer's torque–tension data (or the approximate formula) to find the torque that produces at least F_{clamp}
    - checks that the support does not deform, and
    - adjusts the support design (reinforcement, different anchors, etc.) if necessary.

From clamping force to tightening torque

This manual specifies a **minimum clamping force per mounting screw** instead of a fixed tightening torque.

To convert this clamping force into a tightening torque, proceed as follows:

1. Identify the screw size and grade
    - Example: M6 or M8, property class 8.8 steel.
2. Check the fastener or anchor manufacturer's documentation
    - Look for a **torque–tension chart** (sometimes called "torque–preload" or "torque–clamp load" table). Example: Fastenal+1
    - Find the row for your screw size and grade.
3. Select the torque that gives at least the specified clamping force
    - If the exact clamping force is not listed, choose the nearest higher value, without exceeding the manufacturer's maximum recommended torque.
4. Set your torque wrench to that value and tighten all mounting screws evenly.

If the fastener manufacturer does not provide a table but only gives material properties, a qualified person may estimate the torque using the standard torque–tension relationship:

$$\mathbf{T = K \times F_{clamp} \times d}$$

where:

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- **T** = tightening torque (in N·m)
- $\mathbf{F_{clamp}}$ = required clamping force (in kN)
- **d** = nominal screw diameter (in mm)
- **K** = "nut factor" (dimensionless), typically around **0.20** for clean, lightly lubricated steel metric screws, but this value can vary significantly with lubrication and surface condition.

Previous Next

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4.5.3. Mounting the HMI remotely

The embedded HMI of the Clean Power VFD can be detached from the front of the drive and mounted remotely for ease of access or visibility.

SmartD recommends using the 5-meter long cable, part number **SD-HC-5M** to ensure reliable operation. This cable is sold separately and can be ordered directly from SmartD.

Important Warning:

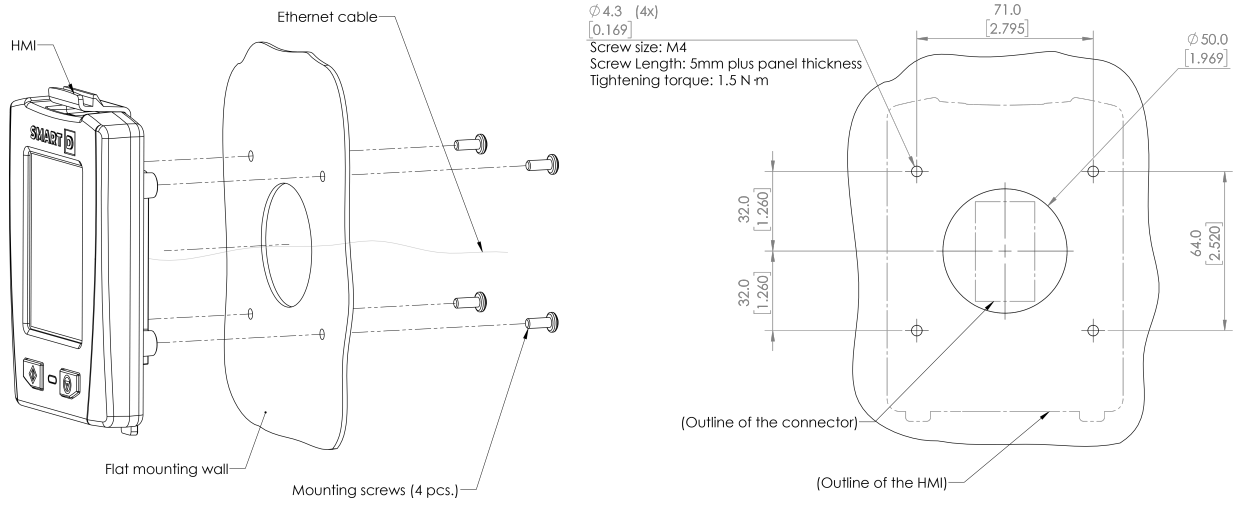
Do not use a standard Ethernet cable to connect the HMI remotely. Doing so can result in the following issues:

- Flickering of the display
- Unintended resets
- Malfunctioning of the HMI

Using a non-approved cable may void your Clean Power VFD warranty.

Remote Mounting Instructions:

A mounting template for the remote installation of the HMI is provided in the packaging. Follow the template carefully to ensure proper alignment and secure mounting of the HMI in the desired location.



Previous Next

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4.5.4. Application environment

Environment and deratings

The Clean Power VFDs are manufactured with precision electronic components.

Therefore, the installation environment can impact the lifespan and reliability of the product.

The information below describes the recommended operation and installation conditions for the Clean Power VFD.

The user must comply with the environmental conditions listed below to ensure the Clean Power VFD operates safely and correctly.

Failure to adhere to these environmental conditions may shorten the device's lifespan, lead to malfunctioning and failure, and void the warranty.

Installation area	The Clean Power VFD must be mounted in a well-ventilated electrical cabinet, respecting the clearance distances described in this document.
Operating temperature	The normal operating range of the Clean Power VFD is **-15 to 50°C** without derating**, 50 to 60°C with derating of 2% per °C**. If not specified otherwise (e.g., SDB-1-2220-AL) The reliability of the Clean Power VFD increases in environments where temperature fluctuations are limited. When using an enclosure, install a cooling fan or air conditioner in the area to ensure the air temperature inside the housing does not exceed the specified levels. Do not allow ice to form on the frequency converter.
Relative humidity	Below 95% non-condensing.
Surrounding environment pollution degree	2, conforming to IEC61800-5-1
Storage temperature	-40...70 °C / -40...158 °F
Surrounding area	Mount in an area free of • oil mist and dust-metal shavings, oil, water, or other foreign materials • radioactive materials • combustible materials • toxic or corrosive gases and liquids • excessive vibration • chlorides

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	• direct sunlight • EMI source and other electronic devices that are sensitive to EMI
Altitude	**Lower than 2000 m/6600 ft.** Contact SmartD Technologies Inc. if you intend to use the Clean Power VFD at a higher altitude.
Vibrations	Mount in a location where vibrations are less than an amplitude of 1.5 mm peak to peak (f= 2...13 Hz) and acceleration lower than 1 gn (f= 13...200 Hz).

Best practices:

To prevent high surrounding air temperature, users should design their electrical panel following the listed best practices:

- No heat stagnation in the panel.
- Sufficient heat dissipation of the panel (Size not too small, proper ventilation).
- Ventilation slits of the Clean Power VFD are not blocked by any object such as cable or cable trays.
- Avoid the proximity of any exothermic device.
- Ensure the mounting orientation of the Clean Power VFD allows an optimized airflow.
- Respect the clearance distances.

Previous Next

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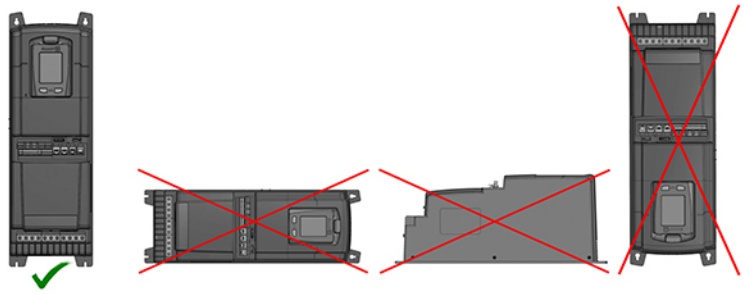
4.5.5. Installation position and distance

When selecting the installation location of the drive, check the following points:

- The Clean Power VFD must be installed on a surface that can support the weight of the device and is free from vibration exceeding the specified tolerances.
- The surface must be fire-resistant or flame-retardant and compliant with local electrical regulations.
- There must be sufficient clearance around the Clean Power VFD to allow air to circulate freely.

If the Clean Power VFD is installed inside an electrical panel, ensure that the cooling fan of the Clean Power VFD is properly located within the enclosure to ensure the proper evacuation of heat from both the Clean Power VFD and the enclosure.

Mounting orientation



For correct heat dissipation, the Clean Power VFD must be mounted vertically. But do not install it upside down.

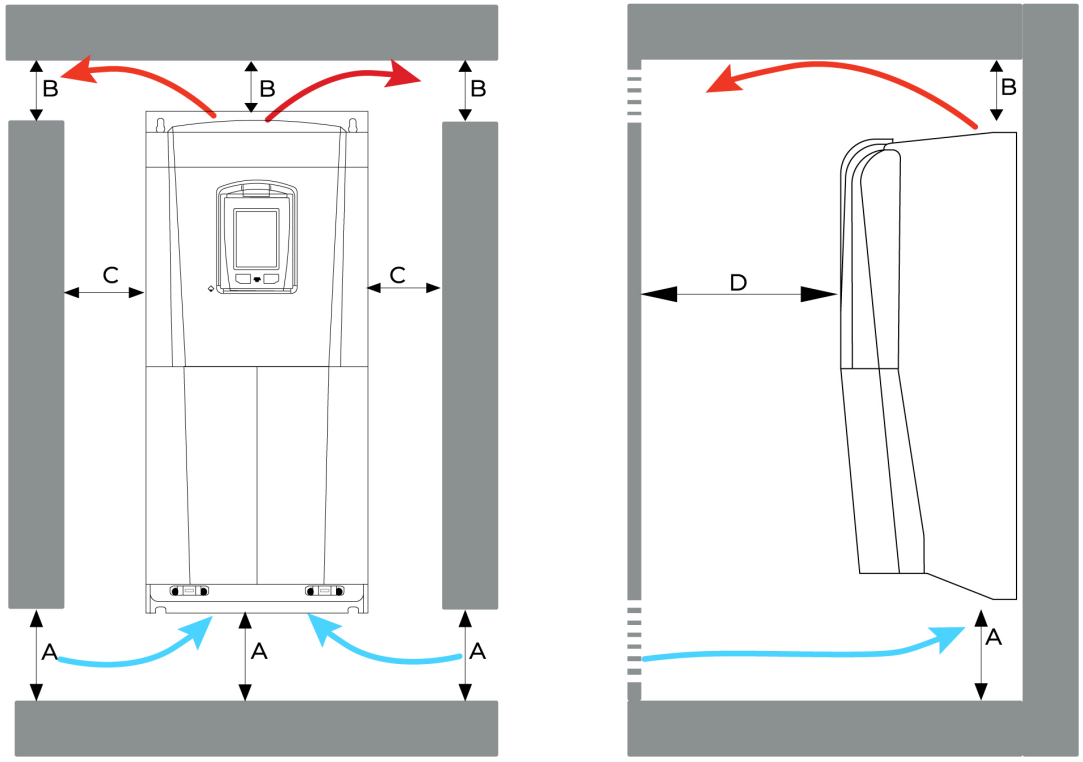
Do not mount it on its side or on its back.

Previous Next

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4.5.5.1. Mounting clearance distances and heat dissipation-VFDs size S3

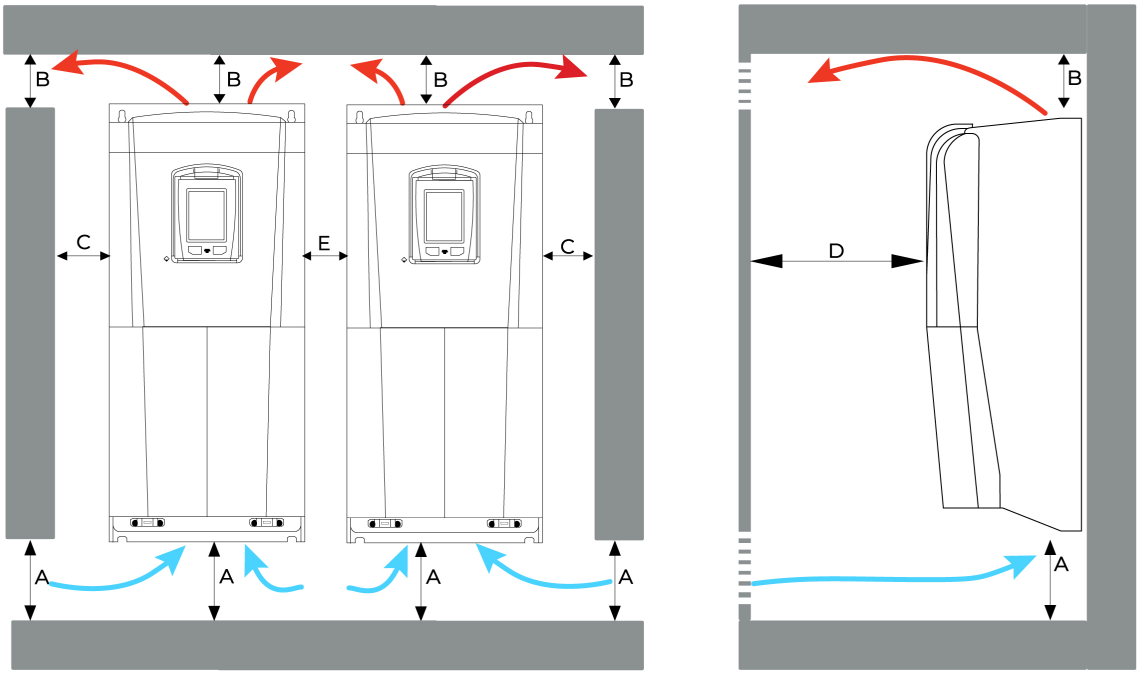
Minimum mounting clearance distances - single drive installation:



Clean Power VFD models	A mm / inch	B mm / inch	C mm / inch	D mm / inch
• SDB-1-2110-A • SDB-1-2150-A • SDB-1-2185-A • SDB-1-2220-AL • SDB-2-2-220-A	300 / 11.81	200 / 7.87	50 / 1.97	10 / 0.39

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Minimum mounting clearance distances - side-by-side drive installation:



VFD models	A mm / inch	B mm / inch	C mm / inch	D mm / inch	E mm / inch
• SDB-1-2110-A • SDB-1-2150-A • SDB-1-2185-A • SDB-1-2220-AL • SDB-2-2220-A	300/11.81	200/7.87	50/1.97	10/0.39	50/1.97

If a VFD is mounted above another it is important to ensure that the air temperature around the upper unit is not heated beyond the specified maximum operating temperature by the exhaust from the lower unit.

An air guide between the VFDs is recommended to prevent the rising hot exhaust air from being drawn into the upper unit.

Heat dissipation:

VFD models	W	BTU / h
SDB-1-2110-A	598	2040

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VFD models	W	BTU / h
SDB-1-2150-A	741	2530
SDB-1-2185-A	866	2955
SDB-1-2220-AL	990	3380

The heat dissipation values given in this section are based on the VFD driving a motor at its rated voltage, current, and frequency (rated load). At lower motor load, the actual heat dissipation is typically lower. Under overload or demanding operating conditions, it can be higher. Use these values as a reference for enclosure and cooling design.

Airflow of fans:

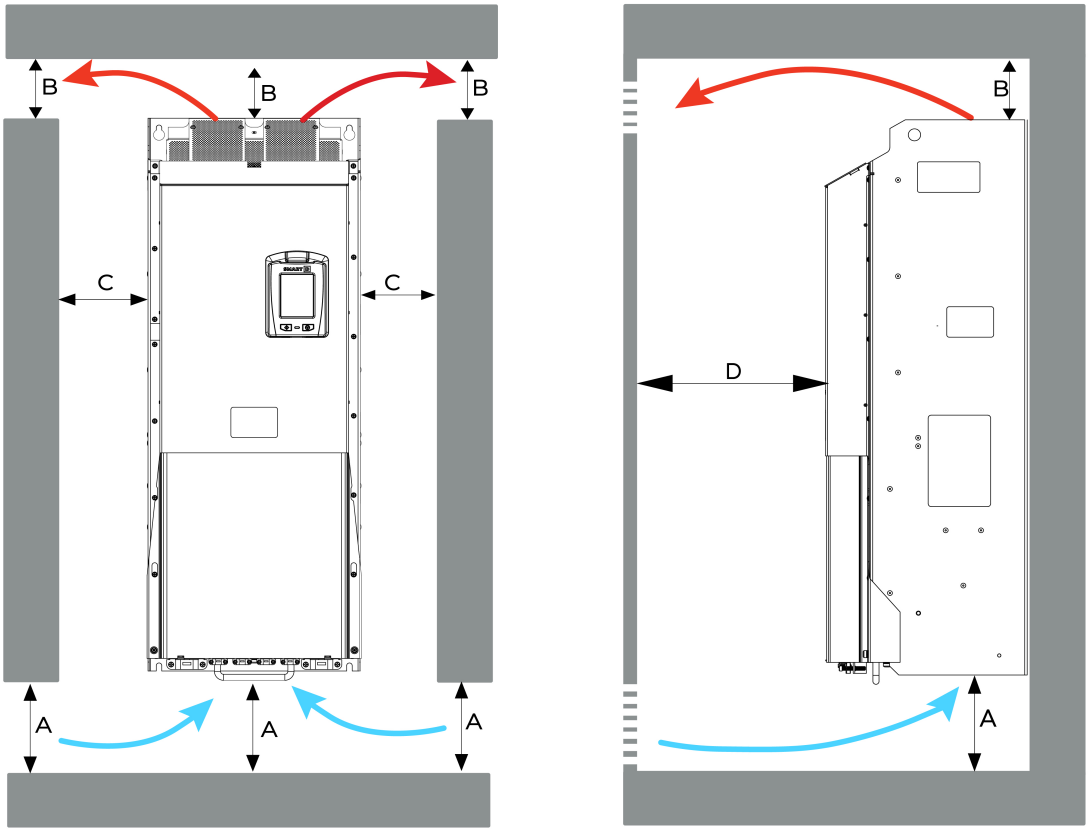
VFD models	Fans	airflow	
all VFD of S3 frame	2 fans are located at the bottom of the VFD behind a metal screen	212.6 CFM	6.02 m3/min

Previous Next

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4.5.5.2. Mounting clearance distances and heat dissipation-VFDs size S4

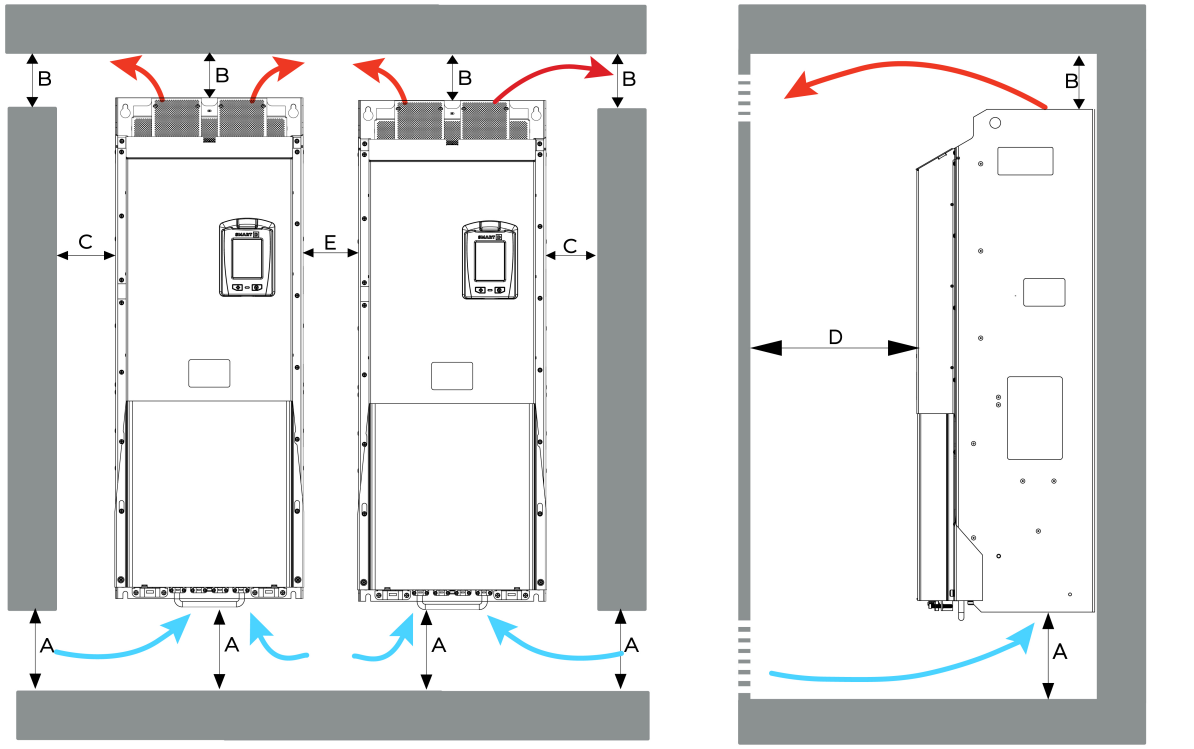
Minimum mounting clearance distances - single drive installation:



Clean Power VFD models	A mm / inch	B mm / inch	C mm / inch	D mm / inch
SDB-1-2220-A and SDB-2-2300-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98
SDB-1-2300-A and SDB-2-2375-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98
SDB-1-2375-A and SDB-2-2450-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98
SDB-1-2450-A and SDB-2-2550-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98

Minimum mounting clearance distances - side-by-side drive installation:

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VFD models	A mm / inch	B mm / inch	C mm / inch	D mm / inch	E mm / inch
SDB-1-2220-A and SDB-2-2300-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98	150 / 5.91
SDB-1-2300-A and SDB-2-2375-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98	150 / 5.91
SDB-1-2375-A and SDB-2-2450-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98	150 / 5.91
SDB-1-2450-A and SDB-2-2550-A	250 / 9.84	250 / 9.84	75 / 2.95	25 /0.98	150 / 5.91

If a VFD is mounted above another it is important to ensure that the air temperature around the upper unit is not heated beyond the specified maximum operating temperature by the exhaust from the lower unit.

An air guide between the VFDs is recommended to prevent the rising hot exhaust air from being drawn into the upper unit.

Heat dissipation

VFD models	W	BTU / h
SDB-1-2220-A	1188	4050
SDB-1-2300-A	1611	5500
SDB-1-2375-A	2060	7030

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VFD models	W	BTU / h
SDB-1-2450-A	2693	9190

The heat dissipation values given in this section are based on the VFD driving a motor at its rated voltage, current, and frequency (rated load). At lower motor load, the actual heat dissipation is typically lower. Under overload or demanding operating conditions, it can be higher. Use these values as a reference for enclosure and cooling design.

Airflow of fans

VFD models	Fans	airflow	
SDB-1-2220-A and SDB-2-2300-A SDB-1-2300-A and SDB-2-2375-A SDB-1-2375-A and SDB-2-2450-A SDB-1-2450-A and SDB-2-2550-A	2 fans are located at the bottom of the VFD behind a metal screen	560 CFM	15.9 m3/min

Previous Next

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4.5.6. Enclosure types

The Clean Power VFD must always be mounted into an enclosure to meet the requirements of the surrounding environment.

Users must refer to local regulations in order to select the proper enclosure that meets the surrounding environmental conditions.

Previous Next

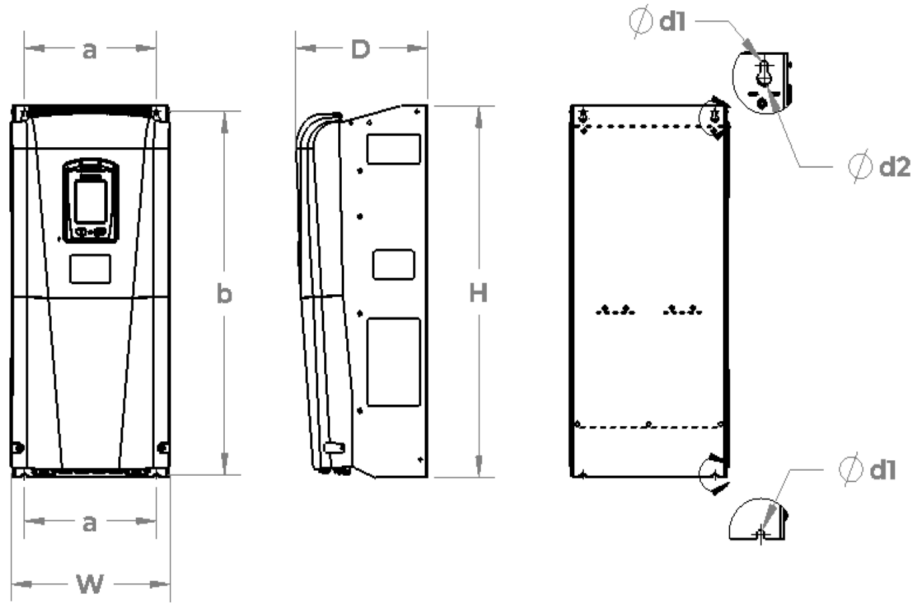
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4.5.7. Dimensions

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4.5.7.1. Dimensions VFDs size S3

Dimensions of VFDs size S3



W	301 mm	11.85 in.
H	650 mm	25.59 in.
D	251 mm	9.88 in.
Weight	30 kg	66 lb

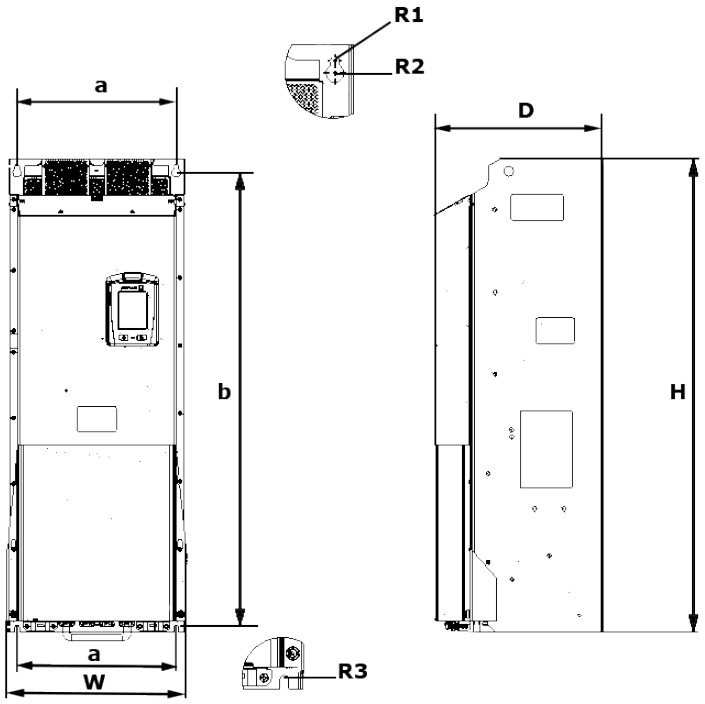
a	250.0 mm	9.84 in.
b	635.0 mm	25.59 in.
d1	7.0 mm	0.276 in.
d2	13.0 mm	0.512 in.
Screw size	M6	1/4 in.

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4.5.7.2. Dimensions VFDs size S4

Dimensions of VFDs size S4



W	350mm	13.78 in.
H	940.5 mm	37.03 in.
D	329.5 mm	12.97 in.
Weight	60.4 kg	133.16 lb

a	311 mm	12.24 in.
b	900 mm	35.43 in.
R1	4.5 mm	0.177 in.
R2	9 mm	0.354 in.

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R3	4.5 mm	0.177 in.
Screw size	M8	5/16

Previous Next

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4.6. Electrical Installation

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4.6.1. Electrical installation: Safety messages

DANGER

- Apply rated torques to the terminal screws.

  Under-torqued screws may allow connections to come loose while over-torqued screws may damage the terminals.

  Risk of short circuit. Risk of drive malfunction.

- Wiring must be performed by authorized, qualified personnel.

  Risk of personal injury or death. Risk of damage to equipment.

- A circuit breaker must be installed between the Clean Power VFD and the mains.

  Risk of personal injury or death. Risk of fire. Risk of damage to equipment

- Make sure the input power supply has been completely disconnected before wiring.

  Risk of personal injury or death. Risk of damage to equipment

- Never connect the input line power cables to the output terminals (U/T1, V/T2, W/T3) of the AC drive.

  The power supply must be connected to the R/L1, S/L2, and T/L3 terminals.

  Connecting them to the U/T1, V/T2, and W/T3 terminals will damage the Clean Power VFD.

  Pay attention to the marks of the wiring terminals and ensure correct wiring.

  Risk of damage to equipment.

- Since the overall leakage current of this equipment may be up to 45 mA, ensure that the Clean Power VFD and its associated motor have a proper ground connection compliant with local regulations.

  Risk of personal injury or death.

- Improper grounding of equipment may lead to dangerous electrical potentials on the equipment chassis.

  Risk of serious injury or death.

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- Drive not provided with integral motor overtemperature protection

⚠ WARNING

- Always mount the VFD before carrying out wiring connections. Moving or mounting the VFD when wires are already connected may damage the wires and/or terminals, loosen the terminal connections or cause complete cable disconnection.
- For power terminal wiring, use only 600V 75℃ rated copper wire with the cable dimension specified in this document.

  Risk of overheating or fire.

- Ensure that the input phase wiring sequence (R/L1, S/L2, T/L3) is identical to the output phase sequence (U/T1, V/T2, W/T3).

  Failure to do so may cause the motor to rotate in the opposite direction.

  Risk of damage to equipment.

- Ensure that grounding wires meet the technical standards for electrical equipment. Impedance must conform to national and local regulations, safety regulations, and/or electrical codes
- Furthermore, ensure that the length of grounding wires is minimized.
- Connections should be periodically checked.
- The Clean Power VFD must be grounded by a connection capable of carrying the prospective fault current until the protective device (fuse, etc.) disconnects the AC supply.
- The ground connections must be inspected and tested at appropriate intervals.
- Do not connect power to the Clean Power VFD until the installation has been fully completed and the Clean Power VFD is ready to be operated.

  Failure to do so may cause an electrical shock and result in personal injury or even death.

- Integral solid-state short circuit protection does not provide branch circuit protection.

  Branch circuit protection must be provided following the National Electrical Code (in North America) and any additional local codes.

  Failure to install properly rated fuses may result in fire.

- The AC supply to the Clean Power VFD must be installed with fuses to protect against overloads and short-circuits.

  Nominal fuse ratings are shown in this user guide.

  Failure to install properly rated fuses may result in fire.

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CAUTION

- Lock out and tag out all potential energy sources before working on the Clean Power VFD.
- Do not share the ground wire with other devices, such as welding machines or electrical equipment using a high current.

  Improper equipment grounding may cause the VFD to malfunction due to electrical interference.

  Risk of equipment malfunction.

- When using multiple Clean Power VFDs, ground each drive according to instructions.

  Do not share a common ground between devices.

  Improper grounding of equipment could result in abnormal operation of the drive.

  Risk of equipment malfunction.

- Ensure that input and output power cables are kept remote from the control cables in order to avoid interference with the latter.

  If this is not possible, ensure that all crossovers occur at a right angle to minimize signal noise interference.

  Risk of equipment malfunction.

- Do not start or stop the Clean Power VFD with a magnetic contactor.

  Risk of damage to equipment.

- High levels of current drawn during power-on can affect the system.

  Ensure that correctly rated circuit breakers are installed to operate safely during power-on.

  Risk of nuisance breaker trip.

- High impulse voltages, like lightning, may cause damage to the VFD.

  While SmartD VFDs have built-in surge protection, they do not have sufficient protection to mitigate a lightning strike or similar high-energy event.

  SmartD recommends the use of specialized surge protectors in areas prone to frequent lightning strikes.

- When wiring the power, do not connect more than one wire to a terminal position.
- Shielded cables must be used for control terminal wiring.

  Failure to do so may cause a malfunction due to interference.

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- When grounding is needed, use shielded twisted pair cables.

Previous Next

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4.6.2. Power cables and fuses specifications for USA and Canada

- Fuse and cable selection
- Using Circuit Breakers (“MCB/MCCB”) for Branch-Circuit Protection
- What does “equivalent to fuse” mean here
- Tested breaker part numbers (reference)
- How to pick a breaker instead of a fuse (step-by-step)
- Notes on terminology (to avoid confusion)
- Keep the existing fuse/cable guidance
- UL-Certified Options by Model Group

Fuse and cable selection

The data listed in the table below are only used to select fuse and cable dimensions for the USA / Canada.

For power terminal wiring, use only 600 V 75°C rated copper wire with the cable dimension specified in this document.

Verify if the chosen cable size can withstand the fault current (Iscc). Some cable manufacturers provide short-circuit current ratings for their cables.

Following UL61800-5-1 :

The fuses are required for branch circuit protection per the National Electrical Code (NEC) (One fuse per phase)

Fuses are not included in the purchased drive and must be provided by others.

Fuses with higher current ratings than the specified ones must not be used.

When installing a drive, always follow installation instructions and NEC requirements.

Refer to local codes and regulations.

Clean Power VFD model	Recommended fuse	Cable for Power Connections	Cable for grounding connections
SDB-1-1750-A and SDB-2-2110-A	Class J, 25A -600V	AWG 10	AWG 10
SDB-1-2110-A and SDB-2-2150-A	Class J, 30A -600V	AWG 10	AWG 10

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Clean Power VFD model	Recommended fuse	Cable for Power Connections	Cable for grounding connections
SDB-1-2150-A and SDB-2-2185-A	Class J, 40A -600V	AWG 8	AWG 8
SDB-1-2-185	Class J, 50A -600V	AWG 8	AWG 8
SDB-1-2185-A	Class J, 50A -600V	AWG 8	AWG 8
SDB-1-2220-A and SDB-1-2220-AL	Class J, 60A -600V	AWG 6	AWG 6
SDB-1-2300-A	Class J, 80A -600V	AWG 4	AWG 4
SDB-1-2375-A	Class J, 90A -600V	AWG 2	AWG 2
SDB-1-2450-A	Class J, 110A -600V	AWG 2	AWG 2
SDB-2-2220-A	Class J, 50 A -600V	AWG 6	AWG 6
SDB-2-2300-A	Class J, 60A -600V	AWG 6	AWG 6
SDB-2-2375-A	Class J, 80A -600V	AWG 4	AWG 4
SDB-2-2450-A	Class J, 90A -600V	AWG 2	AWG 2
SDB-2-2550-A	Class J, 110A -600V	AWG 2	AWG 2

Using Circuit Breakers (“MCB/MCCB”) for Branch-Circuit Protection

In the USA/Canada, branch-circuit protection must comply with **UL 489**/**CSA C22.2 No. 5** and **NEC** rules. In UL language, this device is a circuit breaker (often a molded-case circuit breaker, MCCB).

IEC “MCB” products (B/C/D curves) are not automatically equivalent unless they are UL 489 branch-circuit listed and meet the UL short-circuit conditions below.

What does “equivalent to fuse” mean here

For each Clean Power VFD model family, UL testing establishes:

- a Short-Circuit Current Rating (SCCR) at a given system voltage, and
- The types and limits of protective devices (fuse class, breaker type, and their maximum ampere ratings) that may be used to achieve that SCCR.

If you use a circuit breaker instead of the listed Class J fuse, it must:

1. be **UL 489 branch-circuit listed**,
2. have an **interrupting rating ≥ the stated kA** at the stated voltage, and

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3. **not exceed** the **maximum ampere rating** UL specifies for that VFD group.

If any of the three are not met, the installation **does not** achieve the stated SCCR.

Tested breaker part numbers (reference)

Where SmartD lists tested breaker(s), use them to simplify selection (they meet the above UL conditions for the referenced models):

- HLL36070

You may use an **equivalent UL 489 breaker** from another brand **only if** it matches:

- the **kA interrupting rating at the same system voltage**,
- the **instantaneous-trip characteristic if specified**, and
- the **maximum ampere cap** stated above for that model group.

How to pick a breaker instead of a fuse (step-by-step)

1. **Identify your VFD model** and find its **UL SCCR group** above (100 kA or 50 kA, plus the allowed device type and maximum amperage).
2. **Confirm system voltage** (e.g., 480Y/277Δ V or 600Y/347Δ V) and match it to the breaker's tested rating.
3. **Check the breaker's interrupting rating (kAIC)** at that same voltage: it must be ≥ the UL SCCR stated for the VFD group.
4. **Check the breaker frame/ampere rating**: do not exceed the UL max A listed for that model group (e.g., ≤ 200 A in the 100 kA group; ≤ 70 A in the 50 kA group).
5. If the UL text calls for an instantaneous-trip type (e.g., HRL36150), the equivalent must have the same instantaneous behavior.
6. Apply all **NEC/CEC** rules for conductor sizing, terminals, ambient, and feeder/transformer SCC.

Notes on terminology (to avoid confusion)

- **"MCB" (IEC)** vs **"MCCB/CB" (UL)**: In North America, UL/NEC branch-circuit protection uses UL 489 circuit breakers (often MCCB). An IEC MCB is not valid here unless it is UL 489 listed with adequate kAIC at the correct voltage and within the UL max amperage for the VFD group.
- **SCCR vs breaker kAIC**: The VFD SCCR is the level that the entire assembly can withstand when used with the specified protective device. Your breaker's kAIC must meet or exceed that level at the same voltage.
- **"Max rating" in UL text**: This is a hard upper limit on the protective device's ampere rating for that VFD group—do not exceed it, even if conductors would otherwise allow it.

Keep the existing fuse/cable guidance

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All cable rules you already state still apply (e.g., **600 V, 75 °C copper**, verify cable short-circuit withstand vs **Iscc**). Fuses remain fully valid: **Class J** with the specified **maximum ampere** and **voltage** per your model tables. Always follow **installation instructions**, **NEC/CEC**, and **local codes**.

SmartD recommends the device(s) that have been tested with the given Clean Power VFD model:

Clean Power VFD model	Suitable circuit breaker
SDB-1-2185-A and SDB-2-2220-A	HLL36070

UL-Certified Options by Model Group

A) High-fault rating – SCCR = 100 kA

480 V class (up to 480Y/277 V or 480 V Δ)

Models: SDB-1-2450-A, SDB-1-2375-A, SDB-1-2300-A, SDB-1-2220-A

Use: UL **Class J fuse**, **480 Vac**, **max 200 A**, **interrupting rating ≥ 100 kA**

600 V class (up to 600Y/347 V or 600 V Δ)

Models: SDB-2-2550, SDB-2-2450-A, SDB-2-2375-A, SDB-2-2300-A

Use: UL **Class J fuse**, **600 Vac**, **max 200 A**, **interrupting rating ≥ 100 kA**

B) High-fault rating — SCCR = 50 kA

For these models, you may select Class J fuses (≤ 100 A) or a breaker rated 50 kA at the correct voltage, provided it does not exceed 70 A.

480 V class (up to 480 Vac)

Models: SDB-1-2185-A, SDB-1-1750-A, SDB-1-2110-A, SDB-1-2150-A, SDB-1-2220-AL

Use: UL **Class J fuse**, **480 Vac**, **max 100 A**, **interrupting rating ≥ 50 kA**

600 V class (up to 600 Vac)

Models: SDB-2-2220-A, SDB-2-2110-A, SDB-2-2150-A, SDB-2-2185-A

Use: UL **Class J fuse**, **600 Vac**, **max 100 A**, **interrupting rating ≥ 50 kA**

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Short-Circuit Current Ratings (SCCR) are valid only for the described configurations of VFDs with listed protections, using the specified UL Class J fuses.

SCCR is based on symmetrical RMS fault current at the stated system voltage; use of other protective devices or ratings may reduce the SCCR.

Previous Next

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4.6.3. Selecting Power Cables in regions following IEC practices

- Table of cable sizes by VFD output current
- Power Cables selection rule with Clean Power VFD
- Cable voltage rating & insulation (IEC practice)
- Cable construction
- Determine the design current
- Protective earthing (PE) sizing (IEC 60364-5-54)
- Shield Grounding and Termination
- Ferrite Installation
- Power Connection Mode B1 (Standard Grounded Installation)
- Power Connection Mode B2 (Concentric or Integrated Protective Conductor)
- Power Connection Mode E (Shielded EMC Installation)

Table of cable sizes by VFD output current

Cable selection based on Cu conductors, 0.6/1 kV, XLPE 90 °C, multicore 3C+PE, ambient air temperature 30 °C.

VFD Model	Rated Iout (A)	Main Line Phase (mm²)	Motor Phase (mm²)	PE (mm²)
SDB-1-2110-A, SDB-2-2150-A	22	6	6	**10**
SDB-1-2150A, SDB-2-2185-A	28	6	6	**10**
SDB-1-2185-A, SDB-2-2220-A	34	10	10	**10**
SDB-1-2220-A, SDB-1-2220-AL	41	10	10	**10**
SDB-1-2300-A	55	16	16	**16**
SDB-1-2375-A	68	25	25	**16**
SDB-1-2450-A	82	35	35	**16**
SDB-2-2300-A	44	16	16	**16**
SDB-2-2375-A	54	16	16	**16**
SDB-2-2450-A	66	25	25	**16**

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VFD Model	Rated Iout (A)	Main Line Phase (mm²)	Motor Phase (mm²)	PE (mm²)
SDB-2-2550-A	79	35	35	16

If ambient air temperature >30 °C, grouping, conduit, or sunlit trays apply, **apply IEC derating** (60364-5-52) and consider stepping up one size.

Please select the appropriate cable type to match your installation requirements and avoid problems such as equipment malfunction, safety risks, or failure to meet regulatory standards.

1. Safety and Reliability
    - Proper cable selection ensures safe operation and reduces the risk of electrical faults, fire hazards, or equipment damage.
    - Clear guidance prevents incorrect installations that could lead to equipment malfunction or downtime.
2. Electromagnetic Compatibility (EMC)
    - EMC ensures the VFD operates correctly without interfering with nearby sensitive equipment.
    - Choosing the correct cable mode (B1 or B2, or E) can significantly improve EMC performance by reducing electromagnetic interference (EMI).
3. Regulatory and Compliance Requirements (CE and IEC)
    - Clearly defining cable types and connection modes helps meet CE marking and IEC regulatory standards.
    - Compliance avoids legal or certification issues that can delay projects or incur extra costs.

    Standards referenced (informative):
    - IEC 60364 (Low-voltage installations, notably -5-52 and -5-54),
    - IEC 60502-1 (0.6/1 kV cables),
    - IEC 60228 (conductors),
    - IEC 61800-3 (EMC for drives),
    - IEC 61800-5-1 (safety).

The following paragraphs guide you to the selection of input (main line) and output (motor) power cables for the Clean Power VFD in regions that follow IEC practices.

Power Cables selection rule with Clean Power VFD

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- **Sine-wave output:** The motor sees a clean sinusoidal voltage, so you do not need "VFD-rated" motor cable for dV/dt stress, and you do not size or choose cable based on typical PWM edge effects (partial discharge, high capacitance heating, reflected-wave peaks, etc.).
- **No output filters required:** Do not add dV/dt or sine filters..

You still size and select cables according to IEC standards for ampacity, voltage drop, short-circuit withstand, and protective earthing—the fundamentals remain unchanged.

Cable voltage rating & insulation (IEC practice)

- **VFDs rated 400 480 V:** Use 0.6/1 kV cables per IEC 60502-1.
- **VFDs rated 600 V:** 0.6/1 kV remain standard under IEC.
- **Insulation:** XLPE 90 °C or PVC 75 °C(or above) are both acceptable. Prefer XLPE for thermal headroom and current capacity, not because of dV/dt.

Cable construction

- **Input (main line) → VFD:**
  - 3-core + PE (or 4-core with separate PE), copper conductors.
  - If you select a cable with mechanical protection (crush/impact, rodent protection, and improved pulling/tension strength), the armour can also serve as a **protective earth (PE)**—but only if its cross-section and continuity meet the PE sizing rules.
  - Otherwise, bond the armour and provide a separate PE.
- **Output (motor) ← VFD (sine-wave):**
  - Standard industrial motor cable is acceptable (0.6/1 kV, Cu, XLPE or PVC).
  - Screening is optional, used for site EMC. Symmetrical 3PE designs are not required for dV/dt.
- **Screened motor cable or not?**
  - Use screened motor cable when any of these apply:
    - The motor cable shares trays with sensitive I/O/analog/communication networks.
    - Local EMC rules or your site specification require it.
    - Very long parallel runs in instrumentation-heavy areas.
  - Otherwise, an unscreened motor cable is acceptable.

Determine the design current

- Use the VFD continuous output current (from the drive nameplate) or the motor FLA (nameplate)—whichever is higher—as the base current I_b.

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- Overload capability of the VFD (e.g., 110 % for 60 s) is **not** used for continuous ampacity; it is checked in short-time/short-circuit steps.
- Select the cross-section from IEC 60364-5-52 / manufacturer ampacity tables for 0.6/1 kV cables and your installation method.
- Apply derating for ambient temperature, grouping, and installation. Ensure corrected ampacity > I_b.

Protective earthing (PE) sizing (IEC 60364-5-54)

Use copper for the protective earth. Here is the way to define the minimum size per the code:

Phase S	Minimum PE
S ≤ 16 mm²	PE = S
16 < S ≤ 35 mm²	PE = 16 mm²
S > 35 mm²	PE = S/2

SmartD recommendation: for a safe installation, PE shall be no smaller than 10 mm² Cu, and in all cases sized per IEC (whichever is larger).

Shield Grounding and Termination

- Terminate the cable shield at both the VFD and motor ends to achieve effective EMC protection.
- At the motor side, terminate the shield using an EMC-compatible cable gland, establishing a direct and broad-area connection to the motor frame.
- At the VFD side, terminate the cable shield as close as possible to the VFD output terminals.
- When mounting the VFD in a metal enclosure or cabinet, secure the cable shield directly to the cabinet backplate using an EMC gland or grounding clamp situated as near to the VFD as practical.
- Connect the VFD earth terminal directly to the enclosure grounding point using a cable with low impedance at high frequencies.
- Adhering to these cable specifications and shielding guidelines ensures compliance with IEC standards, maximizes operational efficiency, and significantly enhances electromagnetic compatibility.
- In short:
    - **Separation:** Route motor cables away from control/comm cables; cross at 90° if needed.
    - **Bonding:** Solid PE bonding of VFD and motor frames to the same earthing system.
    - **If screened is used:** Terminate 360° at least at the drive end; both-end terminations may be used where permitted by site EMC policy.

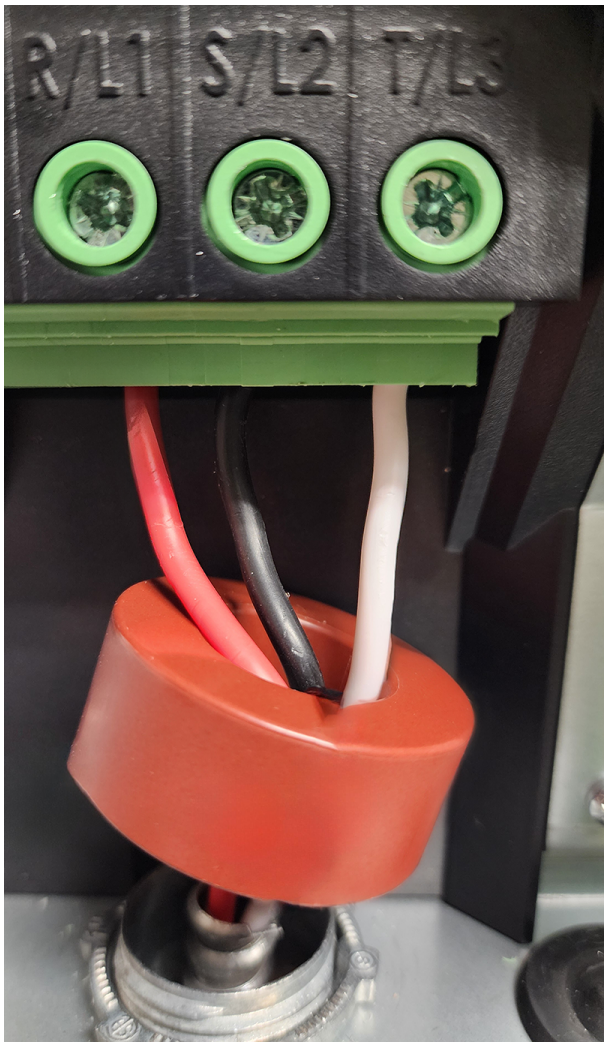
Ferrite Installation

For S3 frame VFDs

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Install a ferrite ring around the three-phase grid conductors before connecting them to the VFD terminal block. This significantly reduces high-frequency noise transmission and improves electromagnetic compatibility (EMC).

SmartD recommends the part number T60006 L2045-V118 from VAC MAGNETICS LLC or equivalent.



For S4 frame VFDs

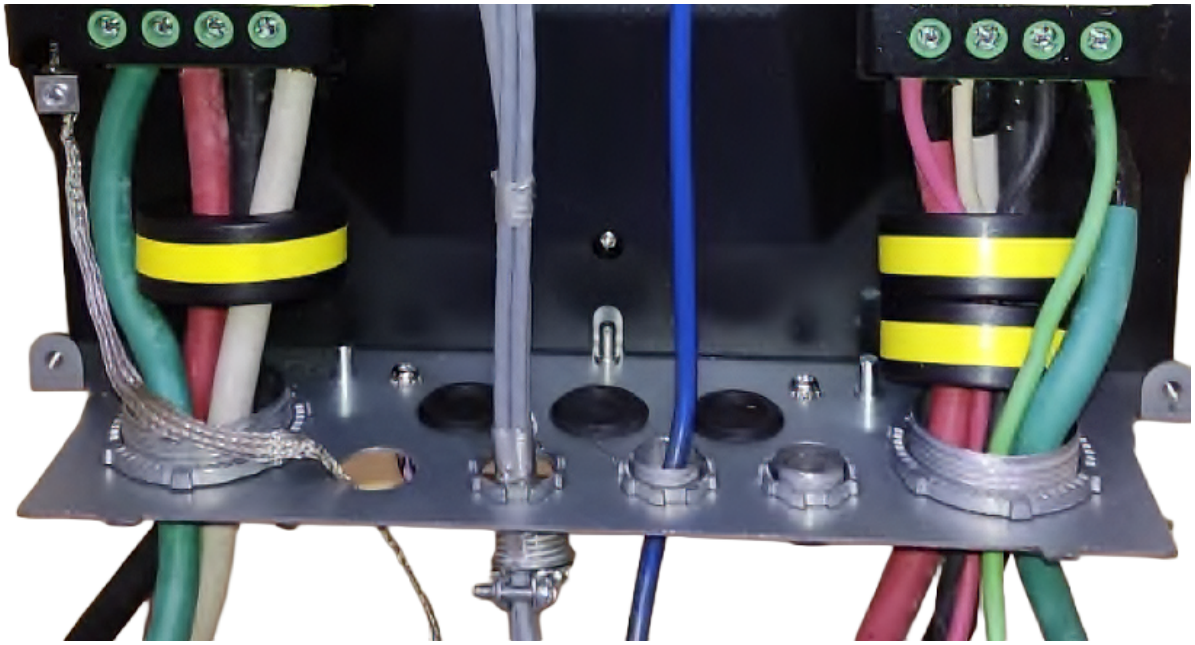
Install a ferrite ring around the three-phase grid conductors before connecting them to the VFD terminal block, and 2 (two) ferrite around the power output cables.

Recommended ferrites:

For Radiated Emission and Conducted Emission requirements: A Kemet model ESD-R-613325H-NC23 ferrite is required around L1, L2, and L3 of the power Input cables near the connection terminals (straight through).

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For Radiated Emission requirements: Two Kemet model ESD-R-613325H-NC23 ferrites are additionally required around U, V, and W of the Power Output cables near the connection terminals (straight through).



Power Connection Mode B1 (Standard Grounded Installation)

- Mode B1 refers to a standard three-phase power cable installation with a separate protective earth conductor. In this mode, a dedicated grounding conductor runs alongside the three power conductors (L1, L2, L3), connected directly to the protective earth terminal.
- Typical Usage: Most common in standard industrial environments, where reliable grounding is mandatory for safe operation and EMC compliance.
- Ensure a proper grounding conductor size and connection following IEC grounding standards (IEC 61800-5-1).

Power Connection Mode B2 (Concentric or Integrated Protective Conductor)

- Mode B2 involves a three-phase cable where the protective conductor (earth) is concentric (surrounding or integrated into the cable structure). This provides improved EMC shielding compared to a separate conductor, due to the grounding conductor completely or partially encircling the phase conductors.
- Typical Usage: Preferred for environments demanding higher electromagnetic compatibility (EMC), especially in sensitive applications, or where the cable length between drive and motor is considerable.

Power Connection Mode E (Shielded EMC Installation)

- Mode E specifies a fully shielded or screened cable, where the cable shield (braided or foil type) provides electromagnetic compatibility by containing electromagnetic interference (EMI). The shield is connected directly at both ends (drive and motor/equipment) using EMC-specific glands or clamps, ensuring minimal high-frequency interference.

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- Typical Usage: Ideal for environments that require strict EMC compliance, such as installations near sensitive electronic equipment, instrumentation, IT equipment, medical equipment, data centers, or industrial automation systems.

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4.6.4. Protection in regions following IEC

- Tables of fuses
- Fuse Selection
- Choosing an upstream circuit breaker (IEC 60947-2)

Tables of fuses

VFD Model	Rated input current (A)	VFD's Iscc (kA)	Fuse type gG	Circuit Breaker (1)
SDB-1-2110-A, SDB-2-2150-A	23	50	30A - 600V	GV3P25
SDB-1-2150A, SDB-2-2185-A	30	50	40A - 600V	GV3P32
SDB-1-2185-A, SDB-2-2220-A	36	50	50A - 600V	GV3P40
SDB-1-2220-A, SDB-1-2220-AL	43	50	63A - 600V	GV3P50
SDB-1-2300-A	58	100	80A - 600V	GV3P65
SDB-1-2375-A	71	100	100A - 600V	GV3P80
SDB-1-2450-A	86	100	125A - 600V	GV4L115
SDB-2-2300-A	47	100	63A - 600V	GV3P50
SDB-2-2375-A	57	100	80A - 600V	GV3P65
SDB-2-2450-A	69	100	100A - 600V	GV3P80
SDB-2-2550-A	83	100	125A - 600V	GV4P115N

(1) *Breaker options are specified by the required protection level. They have not been type-tested by SmartD and must be verified for coordination by the installer/system integrator.*

Fuse Selection

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This section details how to select and size fuses upstream of a SmartD Clean Power VFD. Proper sizing protects the supply, feeder cables, and the drive's AFE/DC bus (against inrush and faults) while avoiding nuisance trips.

Key IEC references

- IEC 61800-5-1 Adjustable speed power drive systems — Safety requirements
- IEC 60269 Low-voltage fuses (gG/gL, aM, aR)
- IEC 60947-2 Low-voltage switchgear — Circuit-breakers
- IEC 60364 Low-voltage electrical installations (cables, ADS/disconnection, PE sizing)

Inputs you need (from VFDs data):

Collect these before sizing:

1. **Rated input current** of the selected Clean Power VFD at your line voltage.
2. **Prospective short-circuit current** at the drive line terminals.

Tip: SmartD's multilevel SiC topology greatly reduces input harmonic current and inrush spikes compared to conventional drives, but you must still size upstream protection per IEC and our published ratings.

Fuse types explained:

gG: Provides full-range overload and short-circuit protection. It is commonly used as a feeder/branch device.

aR (Semiconductor Fuse): Offers the fastest limitation of I^2t for short-circuit protection.

Warning: aR fuses are for short-circuit protection ONLY. They will not protect against overloads. If you select an aR fuse, you must coordinate it with a separate overload device (like an MCCB or electronic overload).

gG fuse:

Calculate the Gg fuse ratings based on standard IEC and industry guidelines for selecting fuse protection for VFDs. Here's how to determine the ratings:

Step-by-Step Calculation:

- Identify the rated input current of the VFD: Example: 36 A
- Apply the recommended IEC fuse sizing factor:

  IEC and general industry practice typically recommend sizing a fuse between 125% to 150% of the VFD input current.

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This factor ensures protection against short circuits and avoids nuisance trips during normal VFD operation and inrush currents.

- Check that the selected fuse has a breaking capacity ≥ Isc at the installation point (often 50…120 kA as marked on the fuse).
- Calculate preliminary fuse rating:

For example, at 36 A rated current: Minimum fuse size = 36 A × 1.25 = 45 A, and Maximum fuse size = 36 A × 1.50 = 54 A

- Select a commercially available fuse size (IEC Gg type) from standardized values:

IEC standard fuse sizes typically follow these increments:

16, 20, 25, 32, 40, 50, 63, 80, 100, 125, 160 A, etc.

From the calculated range (45–54 A), select the nearest standardized fuse size, typically rounding upwards:

In this example: 50 A.

aR fuse:

Select a fuse with In(aR) ≈ 1.25 × I_{rated} of the Clean Power VFD (never below I_{rated})

If your plant has frequent brownouts/restarts or large bus capacitance banks, you may need up to ~1.6 × I_{rated} to ride through pre-charge without nuisance fuse operation

Ensure fuse breaking capacity ≥ Isc (many aR are 80–120 kA at 400–500 V)

Important: aR fuses alone are NOT acceptable as the sole protective device (no overload protection). For fuse-only installations, use gG type. Add a close-coupled aR fuse in series with the gG only if:

- Enhanced semiconductor protection is required, AND
- You can demonstrate proper selective coordination between both fuses

Choosing an upstream circuit breaker (IEC 60947-2)

Thermal (overload) setting: set I_{th} ≈ 1.05…1.2 × I_{rated}.

Instantaneous (magnetic) pickup: VFDs need headroom for DC bus inrush. Adjustable-magnetic MCCBs: set **8…12 × I_{rated}** as a typical starting point (tune to site behavior).

Breaking capacity: must be **≥ Isc** at the point of installation.

Instead of a thermal-magnetic breaker, you can use a **magnetic-only circuit breaker** (instantaneous trip only) upstream of a **Clean Power VFD** as the **short-circuit protective device (SCPD)**, but you must cover **overload** somewhere else (another upstream thermal device)

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4.6.5. Standard connection diagram

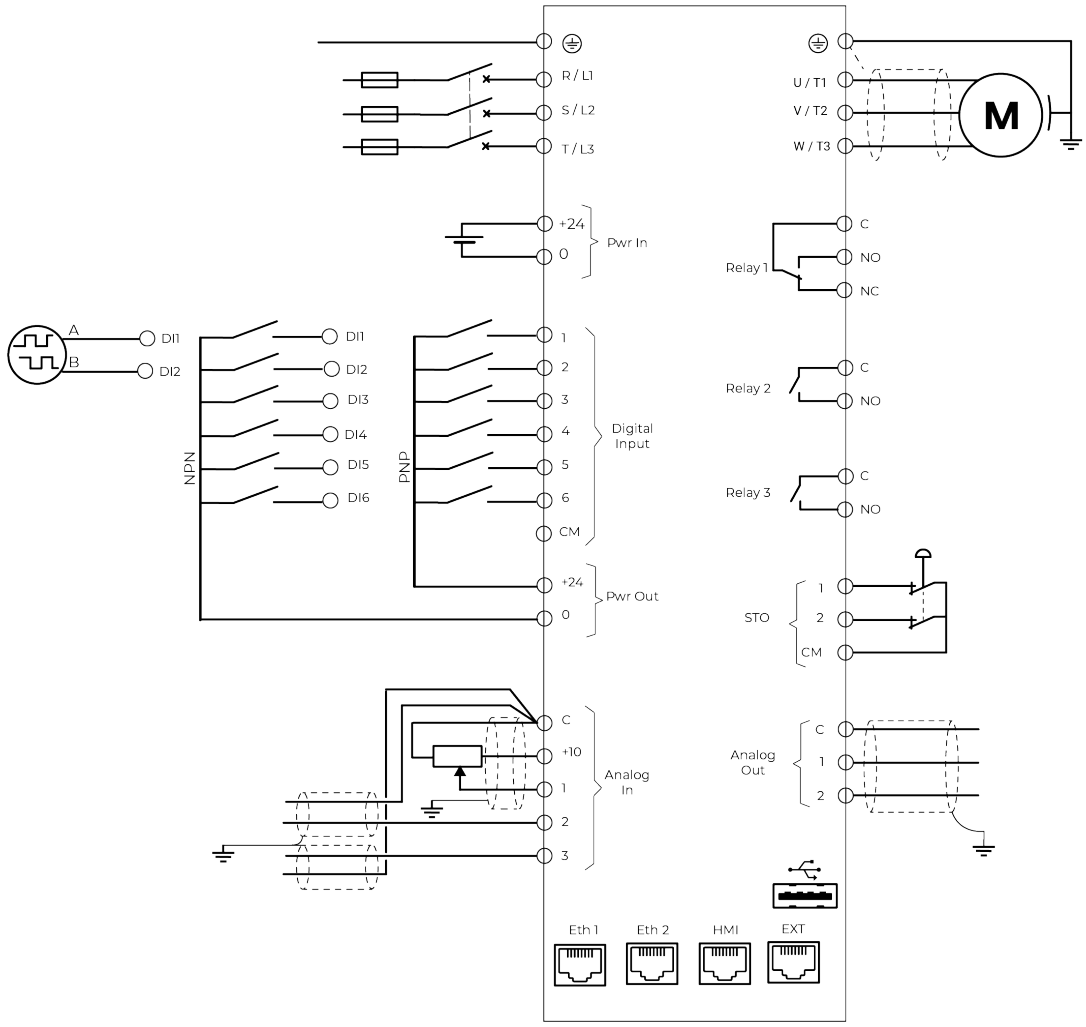
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4.6.5.1. Standard Connection Diagram SDB-x-yzzz-A

Wiring diagram

This diagram illustrates the typical connections of the Clean Power VFD, part numbers that embed an active front end (AFE)

Mandatory upstream protection is describe in sections Selecting Power Cables in regions following IEC practices and Power cables and fuses specifications for USA and Canada



Previous Next

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4.6.6. Basic configuration

The diagram below shows the basic system configuration. Refer to this diagram when connecting the Clean Power VFD within the overall system.

Also, ensure that each component in the system has the appropriate rating for the application and that the complete installation complies with local electrical codes.

Previous Next

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4.6.6.1. Basic configuration SDB-x-yzzz-A (AFE)



Line-Side Contactor (Between protection and VFD)

A line-side contactor may be installed between the upstream circuit protection (MCB/fuses) and the VFD to provide **isolation**, **power removal on external interlocks**, or **section control** of a lineup.

It must **not** be used as a run/stop device for the motor.

When a line-side contactor is appropriate?

- **Isolation / Lockout-Tagout (LOTO)**: Positive disconnection for maintenance; often with a door interlock or key system.
- **Emergency Power-Off (EPO) – Category 0**: External system requires hard power removal to a zone.
- **Fire alarm or building interlock**: Central system commands de-energization of equipment in an area.

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- **Section feeder control**: Multiple VFDs share a supply; the contactor isolates one section.
- **Automatic supply transfer**: Schemes with generators or ATS that require opening feeders during transfer.
- **Arc-flash risk reduction**: Remote or interlocked device to de-energize before opening enclosures.
- **Idle leakage management**: Sites that de-energize drives when idle to reduce cumulative leakage on sensitive protection devices (verify coordination).

Do not use a line-side contactor to:

- **Start or stop the motor.** Use the VFD's control inputs/commands for run/stop.
- **Cycle power repeatedly.** Rapid off/on sequencing shortens capacitor life and may cause trips.

Required practices

1) Timing and re-energization

- **Minimum OFF time**: After opening the contactor, wait until the VFD's DC bus has discharged before re-closing. Implement a **re-close inhibit timer** (typ. 60–300 s).
- **Power-up ready check**: After closing, allow the VFD to complete pre-charge. Enable the run command only when the VFD indicates **Ready to run**.

2) Stop-before-drop

- When commanded by an external interlock (EPO/fire/PLC), first issue a **stop command** (freewheel or controlled, per application), then open the contactor.
- Avoid opening while the drive is actively decelerating a high-inertia or overhauling load to prevent DC-bus overvoltage.

3) Coordination with protection

- **Short-circuit protection**: The contactor is not a protective device. Verify the upstream Short Circuit Protection Device (SCPD) interrupting rating meets the available fault current (Icc).

4) EMC and control wiring

- **Coil suppression**: Install RC snubbers (for AC coils) or diodes (for DC coils) at the contactor coil to reduce switching noise.
- **Auxiliary contacts**: Use aux contacts to signal "Line Contactor Open/Closed" to the PLC or interlock logic and to enforce permissives.
- **Cable layout**: Route coil/control wiring away from motor cables. Maintain shielding and grounding best practices.

Recommended interlocks (functional schematic)

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- **Permissive chain**:
  Run_Command enabled only if **(Line_Contactor = Closed) AND (VFD_Ready = True) AND (No_Trip = True)**.

- **Anti-reclose**:
  After the contactor opens, block re-energization for a minimum time off delay.

- **Stop-then-open sequence**:
  On the external interlock, issue **a Stop**, verify the speed is 0 (or timeout), then open the contactor

Labeling and operator guidance

- Identify the device function on the panel: **“Line Isolator / EPO – Not for Normal Start/Stop.”**

- Provide a note near HMI: **“After power is removed, wait for DC bus discharge before servicing.”**

Quick selection checklist

☐ AC-1 contactor, Ue ≥ supply, Ie ≥ VFD input current, high making capacity (capacitor duty).

☐ Coil suppression fitted; coil control from a clean source.

☐ Auxiliary contacts wired for permissives and status.

☐ Upstream SCPD interrupting rating ≥ available fault current.

☐ Logic implements **Stop-before-Drop**, **T_off_min**, **Ready-before-Run**.

☐ Clear labeling: isolation/EPO function; not a run/stop device.



Do not use the line-side contactor for routine motor control. Frequent power cycling can damage the drive and may cause unexpected trips.

Previous Next

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4.6.7. Wiring Best Practices

To ensure the safe and optimal performance of the SmartD Clean Power VFD, follow these wiring best practices:

Grounding:

Establish a solid ground connection as instructed in the Grounding section of this guide.

Proper grounding helps mitigate electrical noise, ensure safety, and maintain the reliable operation of the VFD and the entire system.

Cabling Standards:

When connecting power and control cables to the terminal blocks, always use cables that meet the required specifications for safe and reliable operation.

Refer to the relevant cable standards for North America and Europe/IEC regions to ensure compliance with regional electrical codes and industry best practices.

Pre-Wiring Review:

Before connecting to the Clean Power VFD, carefully review all wiring instructions and diagrams.

This ensures that the installation complies with safety standards, avoiding costly errors that could damage equipment or create safety risks.

Separation of Voltage Levels:

Maintain a minimum distance of 150mm between high-voltage and low-voltage wires.

This separation prevents electrical interference that can degrade signal quality and affect the VFD's performance.

Use separate trays or conduits to run power and control cables inside the panel.

Shielded Cables for Control Wiring:

For all control wiring, especially for sensitive analog signals, use shielded cables to reduce the risk of electromagnetic interference (EMI).

Ground the shield at one end only to avoid ground loops, which could introduce noise into the system.

Cable Routing:

Ensure that control and power cables are routed separately to minimize EMI.

Control cables should not run parallel to high-power cables unless properly shielded and spaced.

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If crossing is unavoidable, ensure they intersect at a 90-degree angle to minimize interference.

Cable Length Considerations:

Keep cable lengths as short as possible, especially for control and feedback signals.

Excessive cable lengths can introduce unwanted noise, increase voltage drops, and impair signal quality..

Torque Settings for Terminals:

When connecting wires to the terminal blocks, always follow the specified torque settings.

Loose connections can cause arcing, which can lead to equipment failure, while overtightened connections may damage the terminal.

Labeling and Color Coding:

Use proper labeling and color coding for all cables to maintain clarity during installation and future maintenance.

This practice ensures faster troubleshooting, reduces the risk of wiring errors, and enhances overall system reliability.

Compliance with Local Codes:

Ensure that all wiring adheres to local electrical codes and standards, such as NEC (National Electrical Code) in North America or IEC (International Electrotechnical Commission) standards in Europe.

Non-compliance can result in safety hazards, fines, or operational inefficiencies.

Check for Loose Connections:

Loose or incomplete connections can lead to overheating, voltage drops, and erratic VFD performance.

Wiring Strain Relief:

Use proper strain relief on all wiring to prevent mechanical stress at the terminal connections.

Strain relief protects against vibration and physical movement that could loosen connections over time.

By following these best practices, you can ensure the optimal performance, safety, and longevity of your SmartD Clean Power VFD system while minimizing the risk of installation errors and potential operational issues.

Previous Next

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4.6.8. Main electrical lines and motor connections

This section describes the functions, specifications, and procedures required to safely connect the Clean Power VFD to the electrical mains and to the motor.

When you install power and signal cables in the terminal blocks, only use cables that meet the required specification for the safe and reliable operation of the product.

Refer to the following information to assist you with cable selection.

Previous Next

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4.6.8.1. Configuration power terminals block

Marking	Name	Function
R / L1	Mainline input terminals	Connect the main supply to the Clean Power VFD power input.
S / L2		
T / L3		
	Grounding	Connect to earth (Impedance of the connection must conform with local regulations).
U / T1	Power output terminals	Connect the motor to the Clean Power VFD power output.
V / T2		
W / T3		

Previous Next

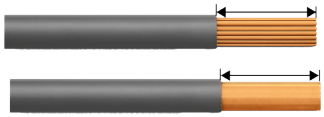
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4.6.8.2. SDB....A: Power terminals specifications S3 and S4

Power terminals specifications

Clean Power VFD models	Terminal	Screw	Tightening torque	Conductor stripping length	solid conductor cross-section
Models size S3 and size S4	Ground	- Thread: M5, - Slotted screwdriver size (Blade thickness x Width)(mm): 1.0x5.5 - Philips screwdriver size: PH2	-Rated: 3.8 N.m / 33.6 in-lbs -Recommended min: 3.73 N.m / 33.01 in-lbs -Recommended max: 4.5 N.m / 39.8 in-lbs	18 to 19 mm 0.71 to 0.75 in.	max 35 mm^2 max AWG 2
	R/L1, S/L2, T/L3	Thread: M5, - Slotted screwdriver size (Blade thickness x Width)(mm): 1.0x5.5 - Philips screwdriver size: PH2	-Rated: 3.8 N.m / 33.6 in-lbs -Recommended min: 3.73 N.m / 33.01 in-lbs -Recommended max: 4.5 N.m / 39.8 in-lbs	18 to 19 mm 0.71 to 0.75 in.	max 35 mm^2 max AWG 2
	U/T1, V/T2, W/T3	Thread: M5,	-Rated: 3.8 N.m / 33.6 in-lbs	18 to 19 mm 0.71 to 0.75 in.	max 35 mm^2 max AWG 2

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Clean Power VFD models	Terminal	Screw	Tightening torque	 Conductor stripping length	 solid conductor cross-section
		- Slotted screwdriver size (Blade thickness x Width)(mm): 1.0x5.5 - Philips screwdriver size: PH2	-Recommended min: 3.73 N.m / 33.01 in-lbs -Recommended max: 4.5 N.m / 39.8 in-lbs		

Previous Next

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4.6.8.3. Motor cable, type, length, voltage drop, capacitance

- Cable type
- Cable Length
- Voltage Drop Consideration
- Cable Capacitance Effects
- Summary: Cable Length vs Cable Type
- Reminder

WARNING

Always verify that the selected wire gauge is compatible with the VFD's terminal block specifications.

Cable type

The Clean Power VFD produces a true sinusoidal output—much like a direct-on-line (DOL) supply—which significantly reduces electromagnetic stress, eliminates high-frequency switching noise, and allows very long motor cable runs without the need for output filters or special VFD-rated cables.

Standard industrial-grade power cables are suitable for most installations with the Clean Power VFD.

Unlike traditional PWM drives, our clean sine wave output typically allows you to avoid the cost and complexity of VFD-rated cables.

However, special cable types may still be considered for the following scenarios:

Condition	Cable Type Recommendation	Rationale
>300 m, shielded runs	Use low-capacitance, shielded cable only if EMI/RFI mitigation is required	Shielding increases capacitance but provides physical/EMI protection in

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Condition	Cable Type Recommendation	Rationale
		sensitive environments
Parallel cable runs	Use standard cable, properly sized and routed	To increase ampacity and reduce voltage drop without risk of reflection or imbalance
Legacy motors	Standard cable accepted; no special insulation needed	Clean sine wave avoids dV/dt stress; only voltage drop matters

Cable Length

The maximum length for the cable between the motor and the Clean Power VFD is **4,500 m (14,800 ft)**, thanks to its clean sine wave, which eliminates the need for output filters, even on extended runs, ensuring reliable motor operation in distributed installations.

However, the following considerations must be observed:

Voltage Drop Consideration

Ensure that the voltage drop along the motor cable is properly accounted for during the installation process. If the calculated drop exceeds **3%** of the rated motor voltage, use a **larger conductor size** to minimize efficiency loss and torque degradation.

Voltage drop may be calculated using the following formula:

Line loss voltage (V) = √3 x wire resistance (Ω /m) x wire length (m) x current (A)

Cable Capacitance Effects

While capacitance in cables is usually a concern for PWM drives, it still introduces **charging current** and reactive power flow even at 50/60 Hz.

- Longer or shielded cables have higher capacitance
- The charging current drawn by the cable adds to the total current at the source
- It can slightly distort the power factor and affect the voltage regulation on lightly loaded motors

The impact is low but noticeable for very long cables or light loads.

Summary: Cable Length vs Cable Type

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Cable Length	Cable Type Recommendation
0-150 m	Standard industrial cable. No filtering or shielding needed
150-300 m	Standard industrial cable fits. In EMI-sensitive environments, use a VFD-rated cable if shielded
>300 m	Standard industrial cable fits. For legacy motors or long shielded runs, consider a low-capacitance cable if shielded or parallel
>1000 m	Requires impact analysis and validation. Check voltage drop, reactive current, and torque limits

Reminder

Clean sine wave output enables unmatched cable length freedom and motor compatibility. Still, proper cable sizing for voltage drop and current capacity remains essential for safe, efficient operation, especially for long runs or high-load motors.

Previous Next

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4.6.8.4. Grounding

The Clean Power VFD **must** be connected to the earth ground of the AC supply.

Ensure that grounding wires meet the technical standards for electrical equipment.

Impedance must conform to national and local regulations, safety regulations, and electrical codes

Furthermore, ensure that the length of grounding wires is minimized.

The Clean Power VFD has 2 earth (ground) terminals that must be securely connected to the earth ground before use.



ELECTRIC SHOCK CAUSED BY LEAKAGE CURRENT

Failure to follow the following instructions may result in death or serious injury.

The Clean Power VFD enclosure has been designed with materials that ensure electrical isolation. Despite this, there is the possibility that small leakage currents may still be present.

1- Verify compliance with all local and national electrical code requirements as well as all other applicable regulations for grounding the entire Clean Power VFD.

2- The Clean Power VFD must be connected to low-impedance earth ground to mitigate the risks posed by these leakage currents. Proper grounding eliminates the risk of electric shock due to the leakage current when touching the Clean Power VFD case.

3- Ground the Clean Power VFD before applying voltage.

4- The size of the protective grounding conductor must meet the relevant standards.

5- Avoid using conduits as protective ground conductors; instead, install a protective ground wire inside the conduit.

6- Cable shields should not be regarded as protective ground conductors.

7- Secure the grounding screws following the guidelines outlined in the Power terminals specification section of this user guide.

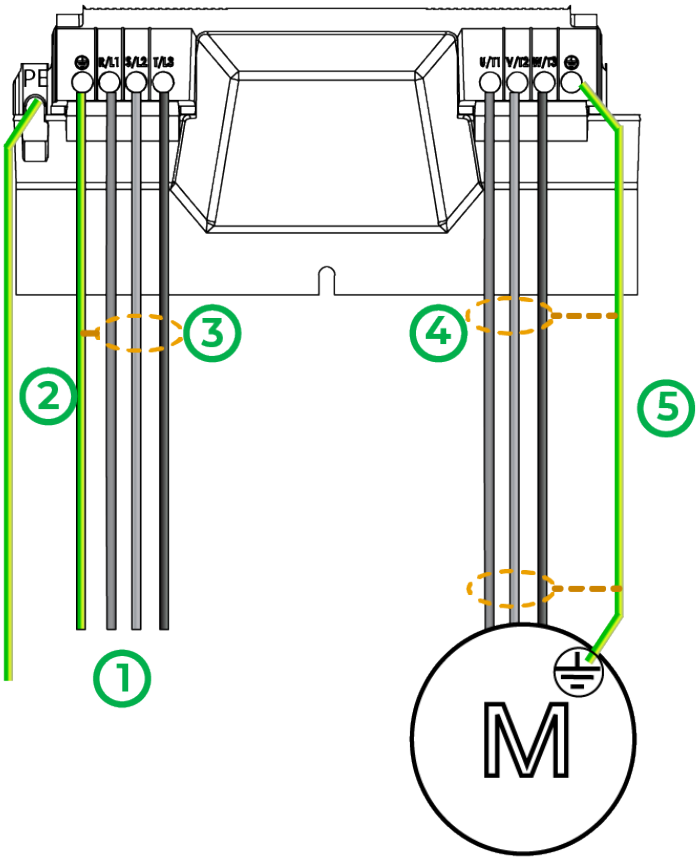
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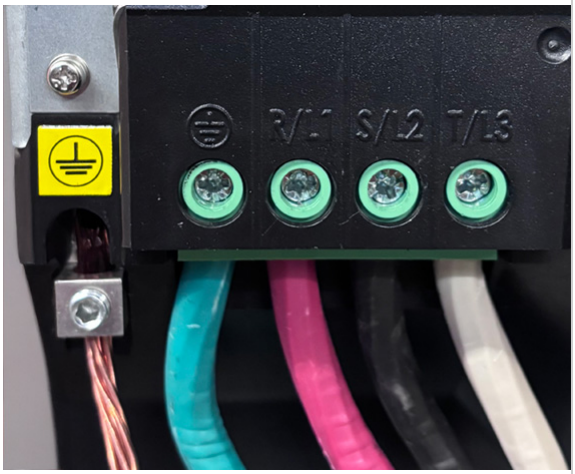
In addition to mitigating leakage current, a good low-impedance ground is important for the correct functioning of EMI-sensitive equipment, it reduces the impact of electrical noise in the installed environment.

To ensure proper operation and avoid potential issues such as ground loops, noise interference, and malfunctions, please follow the following recommendations :

1. Ensure proper grounding of the VFD: Proper grounding is essential for the safe and reliable operation of the VFD. Follow the guidelines and recommendations for grounding practices. This includes connecting the VFD's ground terminal to a suitable grounding point.
2. Do not connect the 24VDC common terminal to the ground: It is important to note that the common terminal of the 24VDC input power supply should not be connected to the ground. This helps prevent ground loops and potential issues arising from a difference in ground potential between different points of the circuit. The 24VDC common terminal should be connected only to the appropriate DC power supply and not to the ground.
3. Separate the grounding of the VFD from other power equipment: To minimize the risk of interference and ensure proper operation, it is recommended to separate the grounding of the VFD from other power equipment. This means avoiding sharing grounding wires between the VFD and other equipment, such as welding machines or other electrical devices. Separate grounding helps maintain a clean ground reference and reduces the risk of noise interference.
4. Ensure proper cable routing and shielding, if necessary: Proper cable routing is crucial for minimizing interference and maintaining signal integrity. Make sure to route the cables in a neat and organized manner, keeping them away from potential sources of electromagnetic interference. Additionally, if necessary, consider using shielded cables to further reduce the risk of noise interference.

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1 : Power Supply: The connection to the power source must fulfill power cable and fuses specifications as recommended in this user guide.

2 : If the conductivity of the shield does not meet the standards for a PE conductor, use either a dedicated grounding PE cable or a cable that includes a separate PE conductor.

3: It is recommended to use 360-degree grounding when shielded cable is utilized. Connect the opposite end of the input cable shield or PE conductor to the ground at the distribution panel.
360-degree grounding refers to a method of grounding in electrical systems where a conductive connection is established around the entire circumference of the cable. This creates a continuous, low-impedance path to the ground, providing more effective shielding and reducing electromagnetic interference (EMI).
The goal is to ensure that the grounding connection surrounds the cable, improving the overall effectiveness of the grounding and reducing the potential for electrical noise.

4: It is recommended to use 360-degree grounding.

5: IEC 61439-1 emphasizes that all conductors, including shields, must meet specific standards for conductivity and safety.

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	If the shield does not comply with the requirements of IEC 61439-1 and the cable lacks a symmetrically designed grounding conductor, it is necessary to use a separate grounding cable. This ensures proper grounding and safety, as a compliant shield or grounding conductor is critical for reducing electrical noise and providing adequate fault protection.

Previous Next

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NOTICE

IMPORTANT:

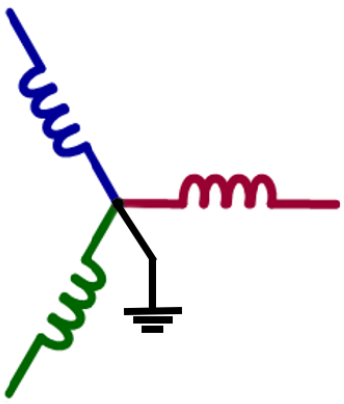
- The diagrams in this chapter illustrate the electrical distribution systems and their grounding arrangements. They are **not** wiring diagrams of the Clean Power VFD.
- The Clean Power VFD shall be connected only to a **solidly grounded Wye system**. The diagrams are provided solely to identify the supported distribution systems and shall not be interpreted as approval for connection to other grounding configurations.
- The installer is responsible for ensuring that the installation complies with this guide and all applicable national and local electrical codes.
- The presence of a Delta (Δ) symbol in certain figures or product markings refers to the upstream transformer configuration and **does not** indicate that the VFD is approved for direct connection to a Delta distribution system.

The Clean Power VFD can be powered up by Wye Solidly Grounded, TT, and TN electrical distribution systems.

Wye (also known as Star), Solidly Grounded, TT, and TN are three different electrical distribution systems used to supply power to homes, businesses, and industrial facilities.

These systems differ in how they are grounded and the level of protection they offer against electrical faults and shocks.

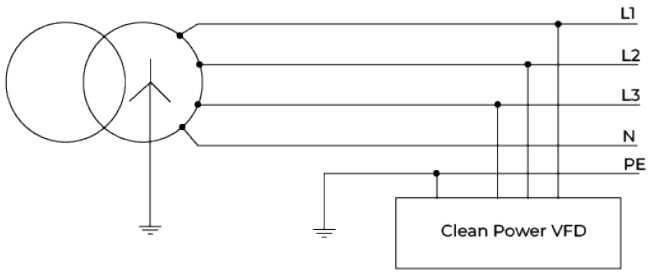
1. Wye (Star) Solidly Grounded System:

	In a Wye Solidly Grounded system, the neutral point (the midpoint of a three-phase system) is connected directly to the earth (ground) with a low-resistance conductor. This system is commonly used in industrial and commercial settings. It provides a high degree of protection against electrical faults because the neutral point is effectively grounded. In the event of a ground fault (a short circuit to ground), a large fault current flows, causing protective devices, such as circuit breakers or fuses, to trip and disconnect

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	the faulty circuit. This helps prevent electrical fires and shock hazards.

2. TT System (Terre-Terre):

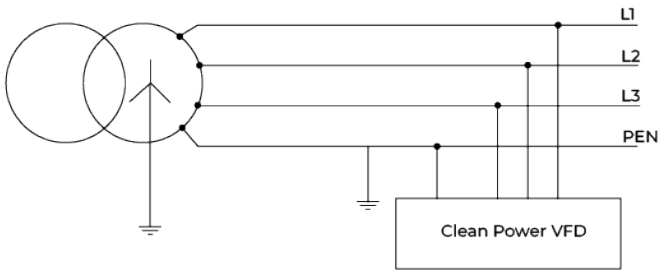
	In a TT system, both the power source (transformer or substation) and the electrical installation have their separate ground electrodes. This system is typically used in rural or remote areas where the quality of the ground (soil resistivity) may vary, making it challenging to ensure a low-resistance earth connection at all points. The TT system provides good fault protection by grounding both the power source and the electrical installation. However, it requires additional grounding electrodes and is more complex to implement than TN systems.

3. TN System (Terre-Neutre):

In a TN system, the neutral point of the power source (usually a transformer) is connected to the earth, and this earth connection is extended throughout the electrical installation.

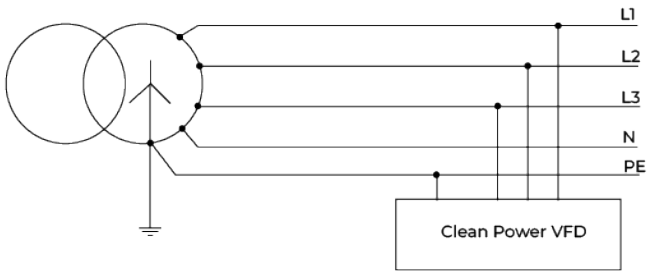
There are two common variations of the TN system: TN-C and TN-S.

TN-C (Combined Neutral and Ground):

	In TN-C, the neutral and ground conductors are combined for a portion of the system. This is common in older installations but is being phased out due to safety concerns.

TN-S (Separated Neutral and Ground):

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In TN-S, the neutral and ground conductors are kept separate throughout the installation, ensuring better safety and fault protection.

TN systems are widely used in residential, commercial, and industrial settings. They offer good protection against electrical faults, provided the grounding is properly maintained.

Previous Next

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4.6.9. Output circuit and motor protection

Two levels of protection are integrated into the Clean Power VFD.

Clean Power VFD protection against short circuits.

In case of a short-circuit on the outputs, the Clean Power VFD will immediately shut down its outputs and generate an alarm.

This protection is not configurable by the user.

No additional short-circuit protection devices are required.

Motor protection against overload.

The Clean Power VFD provides overload protection for the motor and its cable.

If the current drawn by the motor exceeds a threshold for a defined time, the Clean Power VFD will shut down its outputs and generate an alarm.

For more details, refer to the section Alarms and Protections

When multiple motors are operated in parallel, the motors cannot be protected by the built-in electronic thermal relay function. It is recommended that each motor be connected to the Clean Power VFD through a protection relay since the Clean Power VFD cannot protect each motor individually.

Previous Next

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4.6.10. Wiring power connections

1. Wire your Clean Power VFD as per the connection diagram.
2. **Select the appropriate cable** following the recommendation given in the section "Power cables and fuses specifications"

   For installation in the USA and Canada

   For installation in IEC regulation geographical area

   and connect the cable to one of the ground terminals of the Clean Power VFD.

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2. Carefully tighten the screw at the recommended torque. Torque values are listed here.

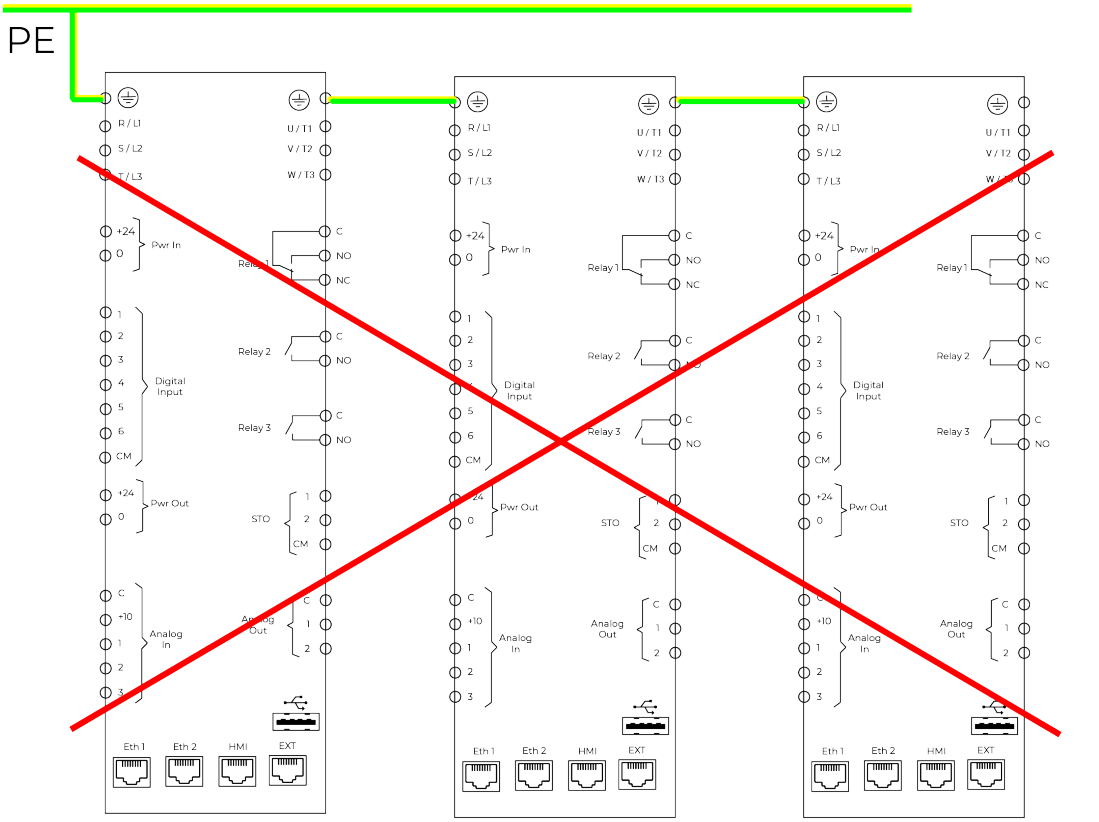
3. **Connect the other end of the ground cables** to the supply earth ground terminal.

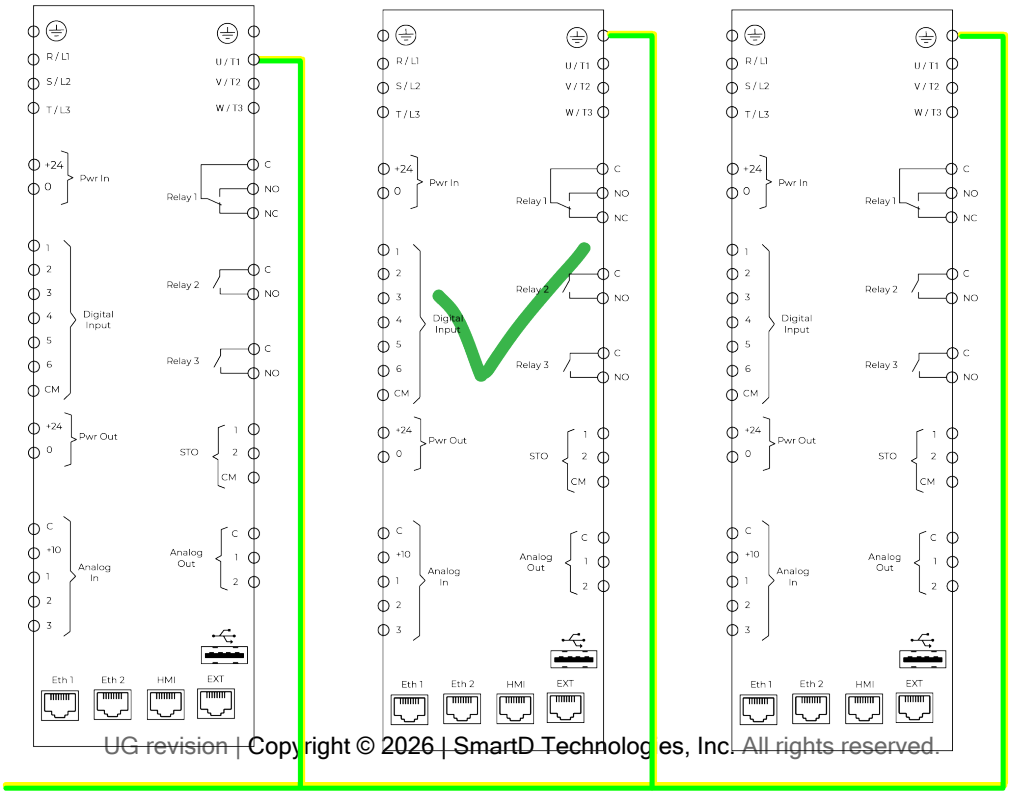
Use a dedicated ground wire for input power, motor power, and control wiring.

Each Clean Power VFD must have its own low-impedance ground connection, ensuring that ground wires are as short as possible.

Do not daisy-chain ground connections between multiple Clean Power VFDs as shown in the diagram.

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4. **Locate the Clean Power VFD input and output terminals on the power terminal block**.

   Refer to the detailed descriptions to understand the function and location of each terminal before making wiring connections.

5. **Connect the motor to the U/T1, V/T2, and W/T3 terminals.**

   Run motor cable separately from other signals.

   Follow the wiring requirements specified by the motor manufacturer.

6. **Connect the AC input power cables to R/L1, S/L2, and T/L3 terminals.**

Previous Next

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4.6.11. Control Circuit description

CAUTION

Digital Input Signal Integrity:

Incorrect digital input states can lead to unintended drive behavior.

Improper wiring or excessive input voltage may cause the VFD to misinterpret input signals (0/1 logic state). This can result in:

- Unexpected motor start when a stop command is intended
- Failure to start when a run command is issued
- Incorrect rotation direction selection

Instructions:

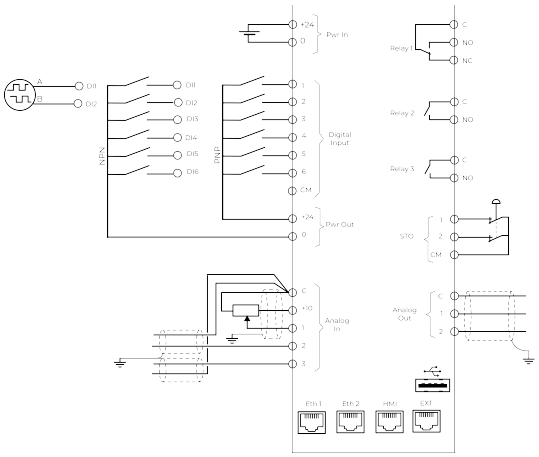
- Verify wiring against the control diagram before commissioning
- Confirm logic configuration (NO/NC) matches the application intent
- Measure input voltage levels to ensure they remain within specification
- Validate input status via HMI or mobile app before enabling motor operation

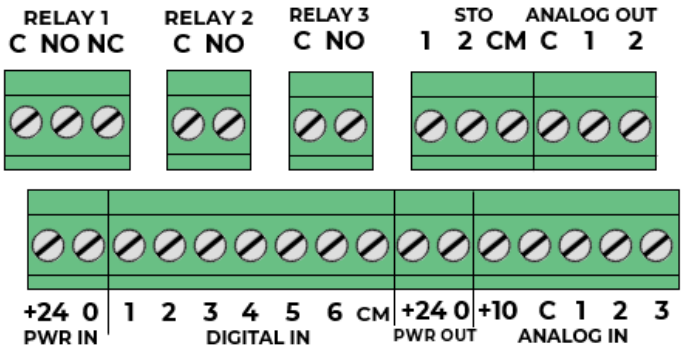
Failure to follow these instructions may result in unintended motor operation.

Control Circuit Connection Diagram and functions

The illustration below shows the detailed layout of control wiring terminals.

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Control terminal blocks Features:

- Screw type: M3
- Tightening torque: 0,5 Nm / 4.5 in-lbs.
- Conductor type: copper only
- Conductor stripping length: 7 mm / 0.28 in
- Solid conductor cross-section: 0.05mm² ... 2,5 mm² / AWG 30 ...12
- Flexible conductor cross-section with Ferrule: 0,05 mm² ... 2,5 mm² / AWG 30 ... 12

24VDC power in

The 24VDC auxiliary supply will power the Clean Power VFD control board without line power, allowing the control board, communications, and the HMI to continue to operate.

It is recommended that you connect a 24VDC to this auxiliary power input, as this allows you to export logs for support and troubleshooting purposes if needed.

If a 24VDC is used while commissioning the Clean Power VFD and line power is absent, the Clean Power VFD will be in the under-voltage alarm state.

Ensure to use a DC power supply that meets the following specifications:

- Nominal operating voltage: 24 VDC
- Minimum continuous operating voltage: 19.2 VDC
- Maximum continuous operating voltage: 28.8 VDC
- Maximum power supply requirement at 24V: 50 W
- Recommended protection fuse: 4A - 50 VDC

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! To ensure proper operation and avoid potential issues like ground loops, noise interference, and malfunctions, do not connect the 24VDC common terminal to the ground.

Read carefully and apply the recommendations from the user guide chapter Grounding

24VDC power out

This power is used to energize the digital inputs or to energize some sensors.

Ensure that the maximum current level, as defined in the following specifications, is respected.

- Nominal operating voltage: 24 VDC
- Minimum continuous operating voltage: 19.2 VDC
- Maximum continuous operating voltage: 28.8 VDC
- Maximum output current at 24V: 100mA
- Recommended protection fuse: 4A - 50 VDC

Digital input terminals

Marking	Name	Default Operation
1	Digital input 1	User-settable. It can be used for an encoder, phase A. Default setting: unused
2	Digital input 2	User-settable. It can be used for an encoder, phase B. Default setting: unused
3	Digital input 3	Run forward
4	Digital input 4	Run Reverse
5	Digital input 5	Stop
6	Digital input 6	Select reference speed between preset 1 and analog input 1
+24	Common terminal for digital inputs	

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The user can assign the digital inputs to various functions such as:

- Rotation direction,
- Stop,
- Selection of the speed setpoint source
- Selection of the local/remote control mode

Check the complete list in the chapter "Digital Input Settings"

Their logic operation is also user-settable; the choices are between:

- rising or falling edge
- level high or low

Last, a debounce delay is also user-settable to avoid false input triggering. This timer's range is 0 to 5000 ms; its default value is 200 ms.

Analog Input Terminals

Marking	Name	Default Operation
1	Analog input 1	Speed reference (Hz) - preset to be used as potentiometer input
2	Analog input 2	un-assigned
3	Analog input 3	un-assigned
+10V	Reference power supply	10VDC - 10 mA max
C	Common terminal for Analog inputs	

The user can assign analog inputs from AI1 to AI3 to various functions and electrical signals.

Available choices for the functions are

- Speed (frequency - Hz) setpoint
- Velocity (RPM) setpoint

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- PTC motor thermal sensor
- Unused.

Check the complete list in the chapter " Analog input settings"

The signal that can be wired to the Analog input can be either

- 0..10VDC,
- 4..20mA,
- PTC.

Relay output terminals

Relay 1: SPDT

Marking	Name	Default Operation
C	Common of the contacts	Relay 1 (SPDT) is assigned by default to be the alarm relay. The relay is energized when there is no alarm present (C and NO connected). The relay is de-energized when there is an alarm or a loss of power supply (C and NC connected)
NO	Normally opened contact	
NC	Normally closed contact	

Relays 2 and 3: NO

Marking	Name	Default Operation
C	Common of the contact	Relay 2 (NO) is the factory default setting to be closed when the drive is in the state “ready to run”. Relay 3 (NO) is the factory default setting to be closed when the drive is in the state of “running”.
NO	Normally opened contact	

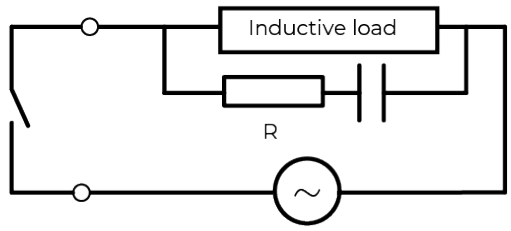
The operation of the 3 independent relay outputs of the Clean Power VFD can be set by the user.

The settings are described in the chapter " Relays setting"

Relays protection

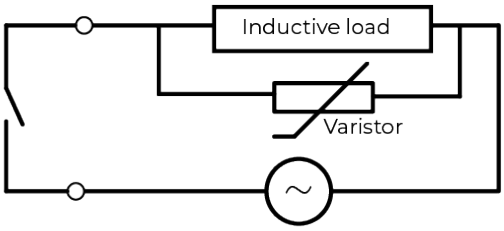
Always protect relay outputs from inductive load damage, using an appropriate external protective circuit or device.

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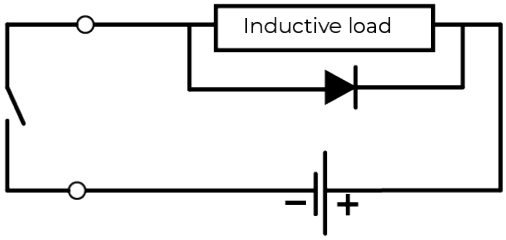


C: a capacitor from 0.1 to 1 µF.

R: resistor of approximately the same resistance value as the load.



In applications where the inductive load is switched on and off frequently and/or rapidly, ensure that the continuous energy rating (J) of the varistor exceeds the peak load energy by 20 % or more.



Use a diode with the following ratings:

Reverse withstand voltage: power voltage of the load circuit x 10.

Forward current: more than the load current.

Analog Output Terminals

Marking	Name	Default Operation
1	Analog output 1	Analog Output 1 is factory-preset to be assigned to the motor frequency. The preset signal is 0..10VDC

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Marking	Name	Default Operation
2	Analog output 2	Analog Out 2 is factory-preset to be assigned to the motor current I_{rms} total. The preset signal is 0..10VDC
C	Common terminal for Analog outputs	

The user can assign analog outputs 1 and 2 to various functions and electrical signals.

Available choices for the functions are

- Motor Current
- Motor Frequency
- Motor Torque
- Motor Power
- Unused.

Check the complete list in the chapter "Analog outputs setting"

The signal that is delivered by the analog output can be either

- 0..10VDC
- 0..20mA
- 4..20mA.

Selection and scaling are made using the mobile App.

Torque Deactivation terminals

The Torque Deactivation enabling terminals are positive logic input only.

The user is responsible for ensuring the complete system is safe and designed correctly according to the relevant safety standards.

If the Torque Deactivation function is not required, the terminals STO1 and STO2 must remain connected to +24VDC.

Marking	Name	Default settings
STO1	Torque Deactivation - input 1	Open: Torque Deactivation is enabled, and the Clean Power VFD output is de-energized. Closed: Torque Deactivation is disabled, and the Clean Power VFD is in normal operation

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Marking	Name	Default settings
		Note: Remove the jumper between STO1 and +24V using the torque deactivation input. The length of the wire should not exceed 30 m (98.4 ft).
STO2	Torque Deactivation - input 2	Open: Torque Deactivation is enabled, and the Clean Power VFD output is de-energized. Closed: Torque Deactivation is disabled, and the Clean Power VFD is in normal operation Note: Remove the jumper between STO1 and +24V using the torque deactivation input. The length of the wire should not exceed 30 m (98.4 ft).
+24 / CM	Torque Deactivation supply connection	Delivers +24V for the Torque Deactivation inputs when the VFD is configured in Source logic mode. Refer to the digital input logic connection section to wire the Torque Deactivation terminals correctly

Previous Next

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4.6.11.1. Digital input Logic Connection

- Sourcing / Sinking
- Wiring in Source mode
- Wiring in Sink mode - use of the internal power supply
- Wiring in Sink mode - use of an external power supply
- Torque Deactivation wiring

Learn about sinking and sourcing

Sourcing / Sinking

Digital inputs DI1 to DI6 can be wired either in Source (PNP) or Sink (NPN) mode.

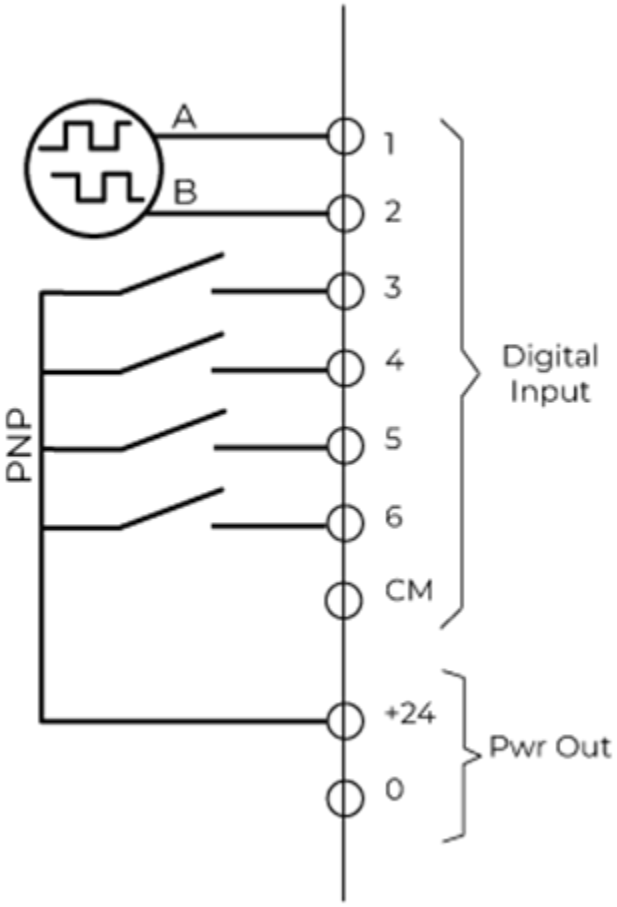
Selection is made by settings in the software.

By default, the digital inputs are set to be wired in Source (PNP) mode.

Note that you can not mix source and sink wiring modes, all inputs from DI1 to DI6 must be wired in the same mode.

Wiring in Source mode

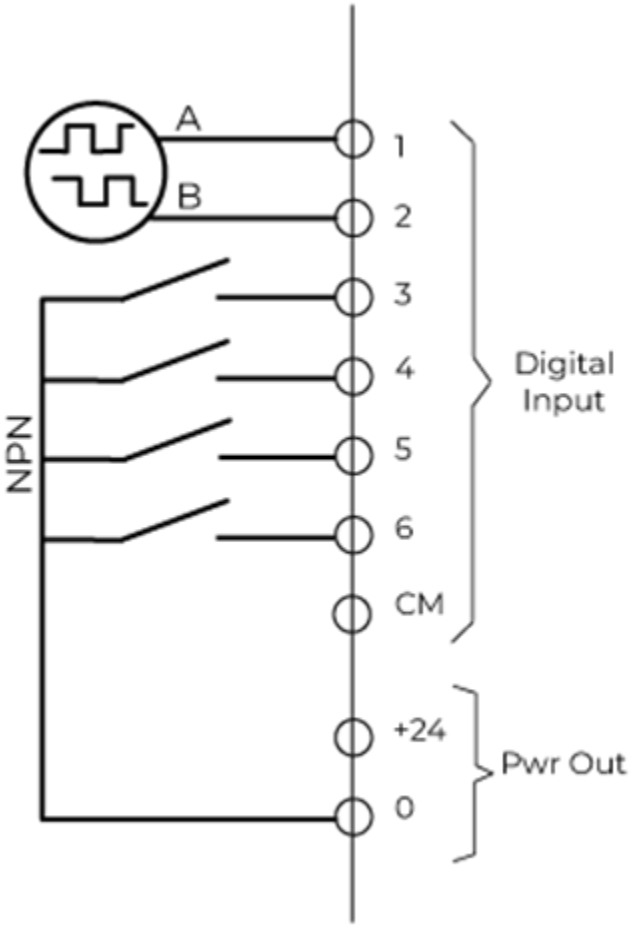
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The terminal CM, within the Digital Input group, is named +24 on the former generation of Clean Power VFD.

Wiring in Sink mode - use of the internal power supply

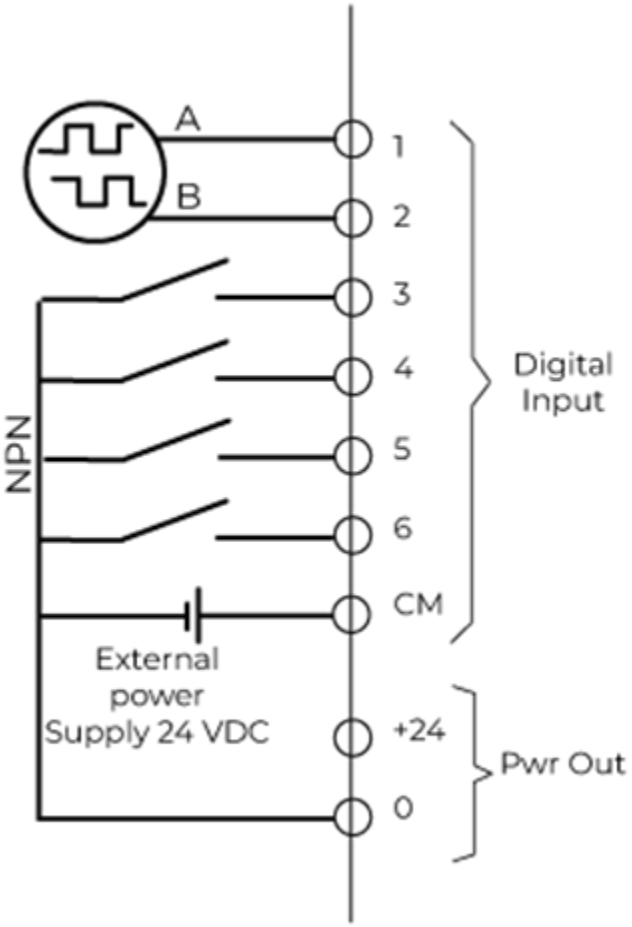
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The terminal CM, within the Digital Input group, is named +24 on the former generation of Clean Power VFD.

Wiring in Sink mode - use of an external power supply

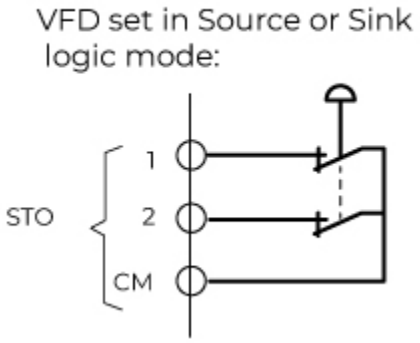
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The terminal CM, within the Digital Input group, is named +24 on the former generation of Clean Power VFD.

Torque Deactivation wiring

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Terminals STO1 and STO2 must always be energized by +24VDC.

If you don't use the Torque deactivation function, do not remove the short-circuit already wired on the delivered VFD

Previous Next

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4.6.11.2. Analog input connection

The Clean Power VFD's analog input terminals support three distinct modes for signal input:

- Resistive Mode,
- Current Mode,
- and Voltage Mode.

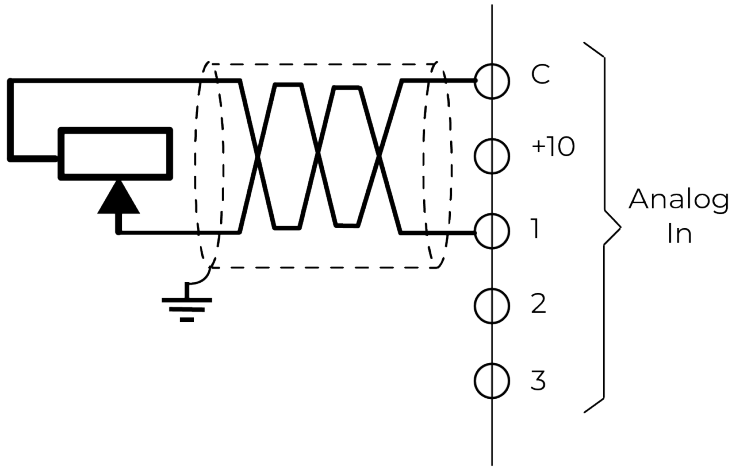
Each mode enables different control signals to be connected to the VFD to regulate speed, torque, or other process variables.

In **Resistive Mode**, a potentiometer or resistive sensor is used to provide a variable signal to the VFD.

Choose a potentiometer with a resistance between 1kΩ and 10kΩ,

Connect the low side of the potentiometer to terminal C.

Connect the wiper (middle terminal) of the potentiometer to the analog Input terminal 1, 2, or 3.



Analog input - Potentiometer wiring

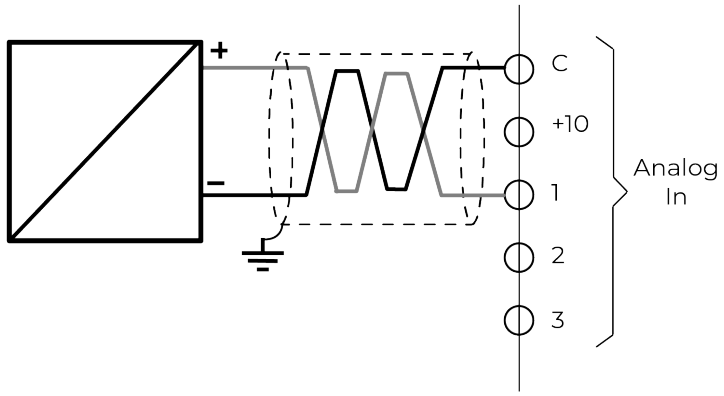
The VFD accepts an analog voltage signal in **Voltage Mode**, typically ranging from 0-10V.

Connect an analog voltage source (e.g., a 0-10V signal from a controller or sensor).

Connect the positive voltage output to the analog Input terminal 1, 2, or 3.

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Connect the negative voltage output (ground) to terminal C.



Analog input - sensor or transmitter 2-wire wiring - Voltage signal

In **Current Mode**, the VFD accepts a current signal (commonly 4-20mA) from sensors, controllers, or transmitters.

Connect a current signal generator or sensor capable of producing a 4-20mA signal.

Connect the positive side of the current loop to the analog Input terminal 1, 2, or 3.

Connect the negative side of the current loop to terminal C.

Several transmitter wiring options exist. These wiring options include:

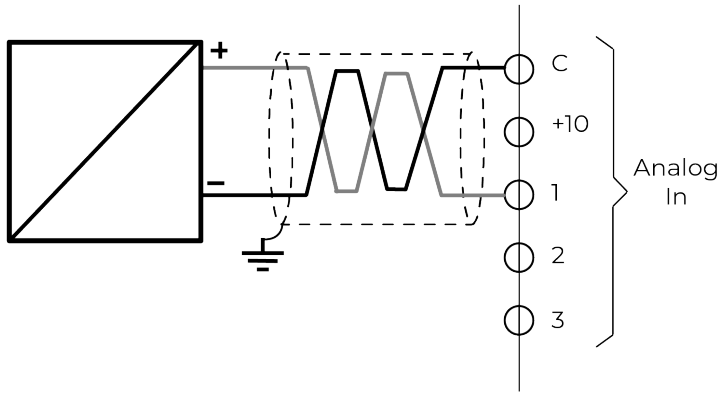
- Two-wire loop-powered transmitters,
- Current transmitter, non-isolated (3 wire),
- Fully isolated (4 wire)

Always check the documentation of your analog sensor or transmitter to select and implement the most reliable wiring type.

2-wire loop transmitter:

If the transmitter is active (has its own power supply)

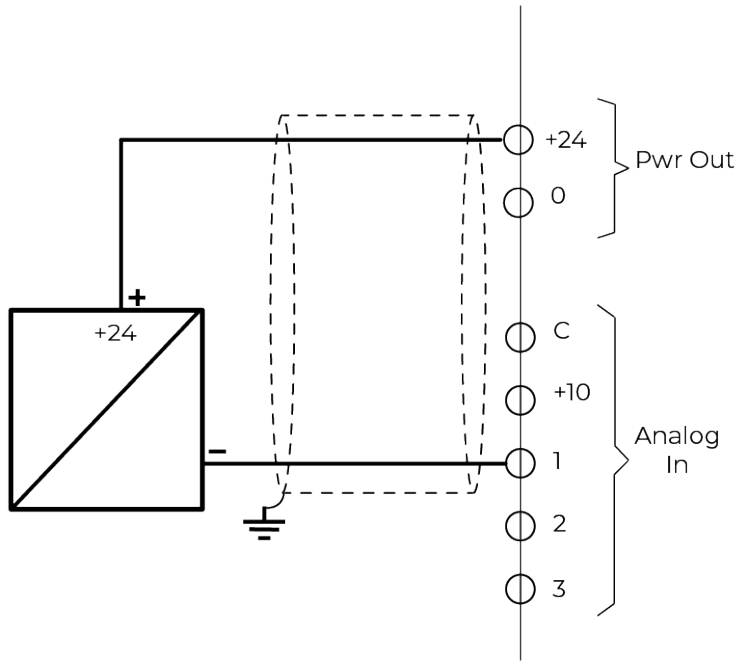
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Analog input - active sensor or transmitter 2-wire loop wiring - current signal

If the transmitter is passive (the power supply must be in serial connection in the loop)

In the Clean Power VFD, the common of the 24 V output and the common of the analog input are internally connected: You don't need to tie the 0 V of the supply to the VFD analog common at this point



Analog input - passive sensor or transmitter 2-wire loop wiring - current signal

3-wire loop transmitter:

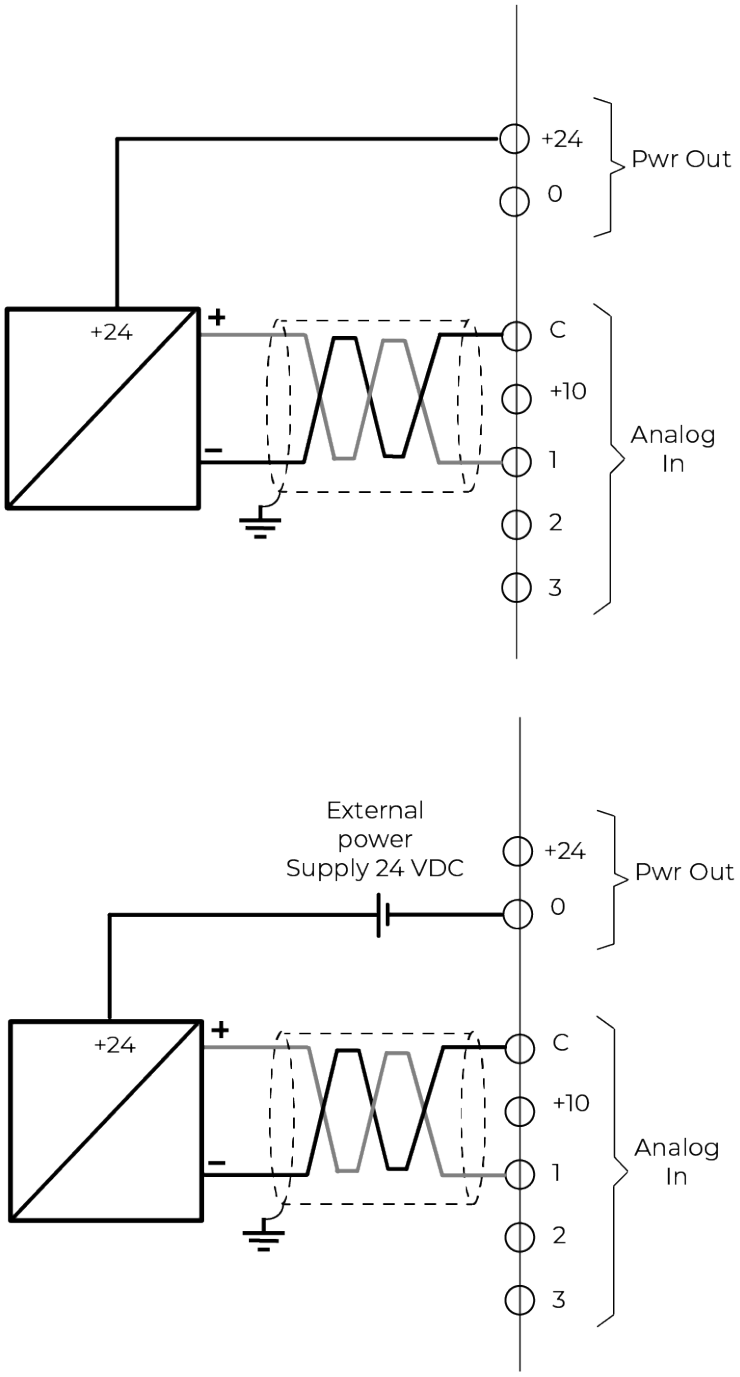
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Using the 24VDC power supply delivered by the VFD.

Always check that the sum of the currents of the powered devices does not exceed the current capacity of the VFD's power supply output.

In this case, SmartD recommends using a separate power supply to deliver 24VDC to the transmitter.

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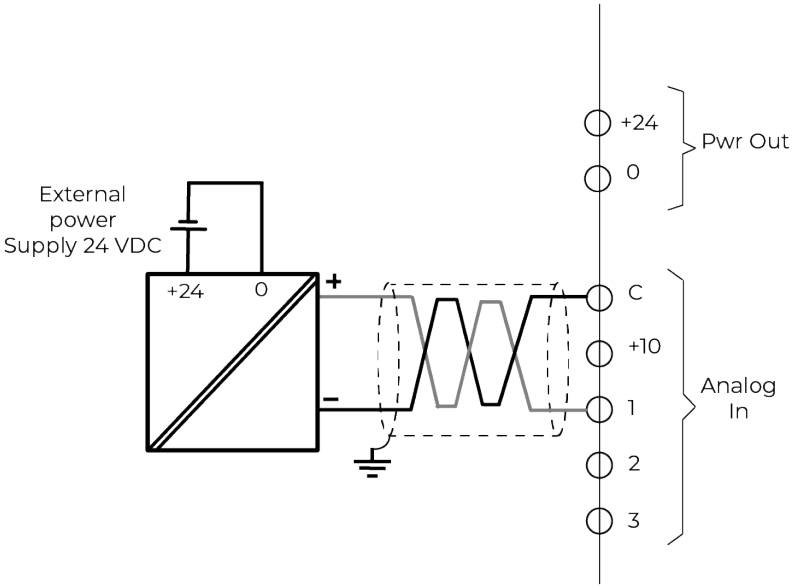
Analog input - sensor or transmitter 3 wires loop wiring of a current signal

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4 wires loop transmitter - fully isolated:

In this configuration, the transmitter and VFD each have their dedicated power supply.

Electrical interference on the power supply lines won't affect the 4-20mA signal line. This isolation helps reduce the chance of unwanted signals reaching the VFD.



Recommendations:

Cable Selection: Always use appropriate twisted pair, shielded cables to reduce interference.

Secure Connections: Tighten all connections to avoid signal loss or intermittent behavior.

Configuration: Before operation, ensure the VFD is configured in the correct input mode (Resistive, Current, or Voltage) via its settings.

Previous Next

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4.6.12. Best practices for EMC

It is recommended to apply EMC best practices to

1. Assure personnel's safety
2. Protect installations against power system faults and lightning (Earthing),
3. Allow a low impedance path to divert the power faults current and high-frequency currents without passing through other equipment and to ensure equipotential (Bonding),
4. Ensure the equipment's performance and reliable operation,
5. To comply with EMC regulations.

The Clean Power VFD is UL type 1, it must be installed in an enclosure with side openings less than 12.5 mm (0.5 in.) and top openings less than 1.0 mm (0.04 in.) for compliance with the Low Voltage Directive (LVD)

The motor cable should be kept as short as possible in order to avoid electromagnetic emissions as well as capacitive currents.

Note that conformity of a VFD with CE EMC requirements does not guarantee an entire machine/installation complies with CE EMC requirements.

The specific characteristics of a given installation govern installation compliance.

Grounding must be done as described in the section: grounding.

Output power, control (I/O), and network wiring must be braided.

Use a shielded cable with a coverage of at least 75%.

Ground a large surface area of the shield at both ends.

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5. Starting procedures

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5.1. Operating the Clean Power VFD : Safety messages

DANGER

- Do not open the Clean Power VFD when powered.

  Risk of electrical shock.

- Do not touch any of the terminals of the Clean Power VFD when powered.

  Risk of electrical shock

- The Clean Power VFD becomes hot during operation.

  Avoid touching the Clean Power VFD until it has cooled.

  Risk of injury - burn.

WARNING

- The STOP function does not remove dangerous voltages from the Clean Power VFD or the motor.

  Risk of electrical shock when touching live parts.

- The Torque Off function does not remove dangerous voltages from the Clean Power VFD or the motor.

  Risk of electrical shock when touching live parts.

- Ensure that the Clean Power VFD is free from foreign objects during installation and operation.

  Risk of device damage.

- Do not control the start/stop of the Clean Power VFD by switching a contactor ON and OFF.

  Risk of device damage.

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CAUTION

- If the motor rating does not match that of the Clean Power VFD, especially when the rated power of the Clean Power VFD is higher than that of the motor, adjust motor protection parameters in the Clean Power VFD or install a thermal relay to protect the motor.

  Risk of damage to the motor and/or Clean Power VFD.

- If the Clean Power VFD is required to operate above the motor nominal frequency (50.00Hz or 60Hz depending on your location), please take the endurance of mechanical devices into consideration.

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5.2. Powering the Clean Power VFD : Safety messages

⚠ WARNING

- When the Clean Power VFD is powered on, if there is an active command on the control inputs, the Clean Power VFD will run immediately.
- When using the 2-wire control method, ensure that the inputs are turned off before powering up the Clean Power VFD.

Risk of serious injury.

- Do not use a line-side contactor for routine motor control

When the Clean Power VFD is energized, the DC bus charges through an inrush-limiting circuit that is bypassed by an internal relay once charging is complete.

Using a magnetic contactor to switch input power on/off as a start/stop method is prohibited. Cyclic power switching (e.g., daily or repeated on/off) exposes the rectifier and inrush-limit components to repeated charging peaks, shortening their life and causing nuisance trips.

Required practice

- Use the contactor only for isolation, EPO (power removal), or section control—not for normal run/stop.
- Stop the drive first, then open the contactor. Do not open while the drive is decelerating a high-inertia or overhauling load.
- After opening, wait until the DC-bus discharges before re-closing. Implement a minimum OFF time and anti-reclose logic per product labeling.
- After closing, allow the drive to pre-charge and confirm “Ready/Healthy” before enabling any run command.

⚠ CAUTION

- Resolve all faults before powering on the Clean Power VFD.

If a fault is still present when the Clean Power VFD is powered on, it will not exit the lockout state.

To remove the lockout state, follow the instructions from the system reset chapter of this document.

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- Quick pre-start checks: Verify that
  - The input voltage is identical to the rated voltage of the product.
  - The correct wiring of input terminals R, S, and T.
  - The correct wiring of output terminals U, V, and W.

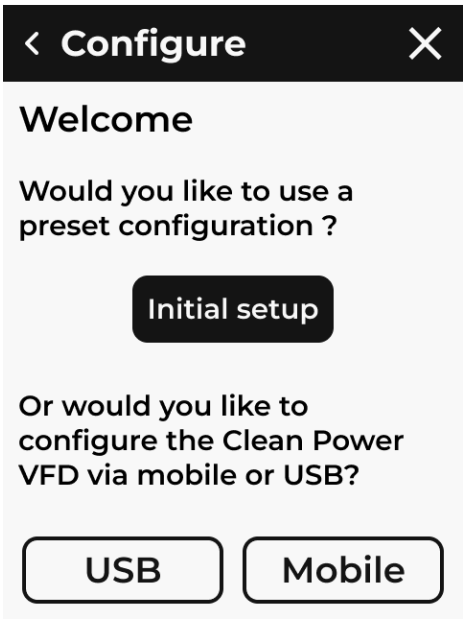
Risk of Clean Power VFD damage.

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5.3. Initial Clean Power VFD Setup

When the VFD is unconfigured or after a factory reset, the HMI follows a structured setup process to ensure proper configuration and user guidance.



The HMI displays choices for configuration methods:

- Initial setup
- Configure via USB
- Configure via Mobile

Initial Setup

The HMI prompts the user through the following steps

1. Select either the 2-wire or 3-wire preset configuration or Modbus TCP for immediate setup.
2. Set the input line frequency to match the local power supply's frequency.
3. Input the motor’s nominal current to ensure proper motor operation.
4. Set the date, time, and time zone to support accurate logging and scheduling.

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5. Finally displays the main screen when the previous steps are complete.

Configuration via USB:

The HMI prompts the user through the following steps

1. Follow the steps to import the configuration file from a USB key. If the file is invalid, the HMI displays an error message stating: “Invalid configuration file.”
2. Set the date, time, and time zone after importing the configuration to maintain accurate system settings.
3. Finally displays the main screen when the previous steps are complete.

Configuration via Mobile:

The HMI prompts the user through the following steps

1. Select how to connect the mobile app: BLE (Bluetooth) or Wi-Fi.
2. If Wi-Fi is selected, configure the Ethernet network settings to connect the VFD to a local network.
3. Set the date, time, and time zone to allow the mobile app to connect seamlessly.
4. Pair with the mobile device following the guide process, ensuring secure and reliable communication between the mobile app and the VFD.
5. Finally displays the main screen when the previous steps are complete.

Previous Next

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5.4. Get the mobile App

Get the smartphone App to configure your Clean Power VFD.

Phone requirements:

- Android phone with firmware version 9 or higher,
- iOS phone with firmware version 13.4 or higher.

The Clean Power VFD Application app can be downloaded with any of the methods below:

- **Scan the QR code displayed on the Clean Power VFD's HMI screen**, this will bring you to the Google Play Store or Apple Store for App downloading.
- **Click on the below badge for ios users**



- **Click on the below badge for Android users**



- or scan the following QR code with your cell phone:

Apple store:

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Google Play:

CAUTION

On first launch, the app will ask for two permissions so it can find and connect to your device over Bluetooth:

- **Bluetooth** access
- **Location** (on iOS and older Android) or **Nearby devices** (on newer Android)

We only use these to enable Bluetooth. We do **not** track or store your location.

iOS (first launch)

1. When asked to “Allow Clean Power VFD to use **Bluetooth**,” tap **OK**.
2. If you’re also asked for **Location**, tap **Allow While Using App**.
3. Keep Bluetooth turned **On** in Control Center/Settings.

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If you tapped “Don’t Allow” by mistake: go to **Settings › Clean Power VFD**, enable **Bluetooth** and **Location**.

Android 12 and newer (first launch)

1. When asked to allow **Nearby devices**, tap **Allow**.
2. Keep Bluetooth turned **On** (Quick Settings).

If you denied it: go to **Settings › Apps › Clean Power VFD › Permissions**, allow **Nearby devices**.

Android 11 and earlier (first launch)

1. When asked to allow **Location** for Bluetooth scanning, tap **Allow**.
2. Keep Bluetooth turned **On** (Quick Settings).

If you denied it: go to **Settings › Apps › Clean Power VFD › Permissions**, allow **Location**.

Quick check if pairing fails

- Bluetooth is **On** and the device is powered/advertising.
- The required permission is **Allowed** (see steps above).
- Toggle Bluetooth off/on and retry.

Privacy note: Location/Nearby Devices is requested only because the operating system requires it for Bluetooth discovery. The app does not collect or store your location.

Previous Next

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5.5. First connection to network

Pairing with the Ethernet connection

Pairing with Bluetooth

Note for the early version of the Clean Power VFD, which does not use Bluetooth, the user must connect to a local network, and ensure the mobile phone app is connected to the same network.

Previous Next

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5.5.1. Pairing with the Ethernet connection

---

1. Connect the Clean Power VFD to your local network

The Clean Power VFD provides users with 2 Ethernet ports.

Before powering up, connect one of the Ethernet ports to your local network

See the product description

2. Connect your SmartPhone with App to the same local network

Use your smartphone settings menu to select and connect to the correct WiFi network.

3. Power up

Power up the Clean Power VFD and wait until the end of the booting process.

4. Access to the setup menu

When booting is complete, the HMI displays the Clean Power VFD dashboard.

Tap the hamburger menu button to enter the setup menu.



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5. Select Setup Mobile App.



6. Scan to pair

With your phone, open the SmartDrive App

6.1. If your VFD settings have already been made offline

Select the Clean Power VFD you want to transfer into the drive, tap on "Connect" and follow the instructions to power the VFD (if not yet done), and scan the QR code displayed on the VFD's HMI.

6.2 If Your VFD settings have not been made

Select "Add a VFD" in the pop-up window, select "Set-up online" and follow the instructions to power the VFD (if not yet done), and scan the QR code displayed on the VFD HMI.

6.3 Wait a few seconds until you see the Clean Power VFD and your SmartPhone paired

Previous Next

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5.5.2. Pairing with Bluetooth

To connect and pair your Clean Power VFD Application using the Bluetooth connection, follow the steps:

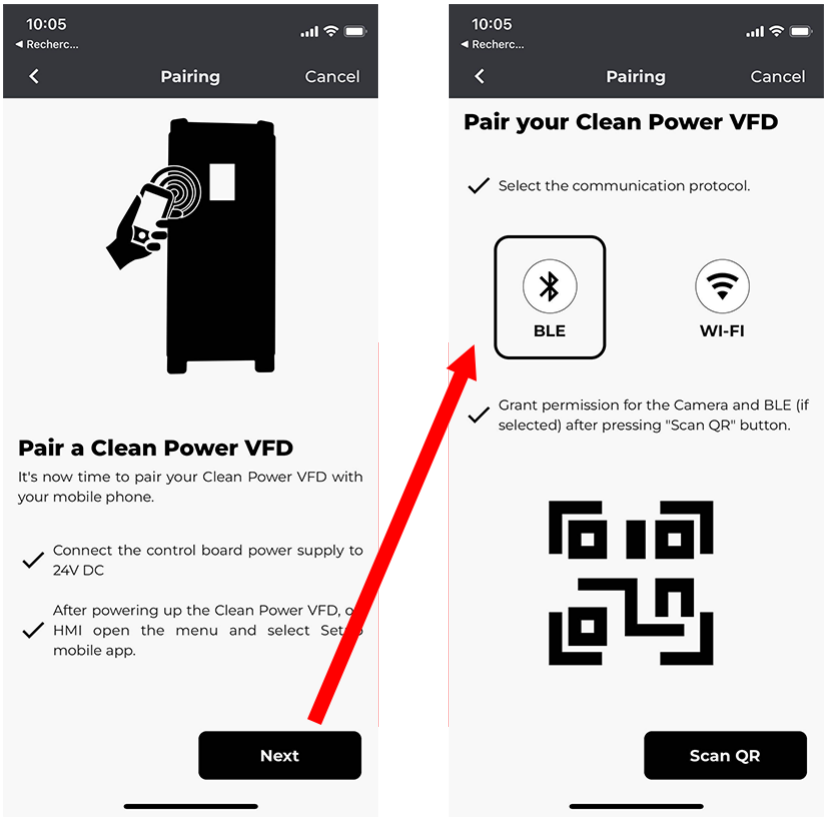
1- **ensure that the Bluetooth is activated** on your phone

2- **start the Clean Power VFD Application**

3- Tap "**Add a VFD**" and select "**Setup online**"

4- Follow the sequence displayed on your screen, moving step by step and taping the button "next" to go to the **pairing** task

5- Once the pairing page is displayed**, select "Bluetooth (BLE)"** and click on "**scan QR**"

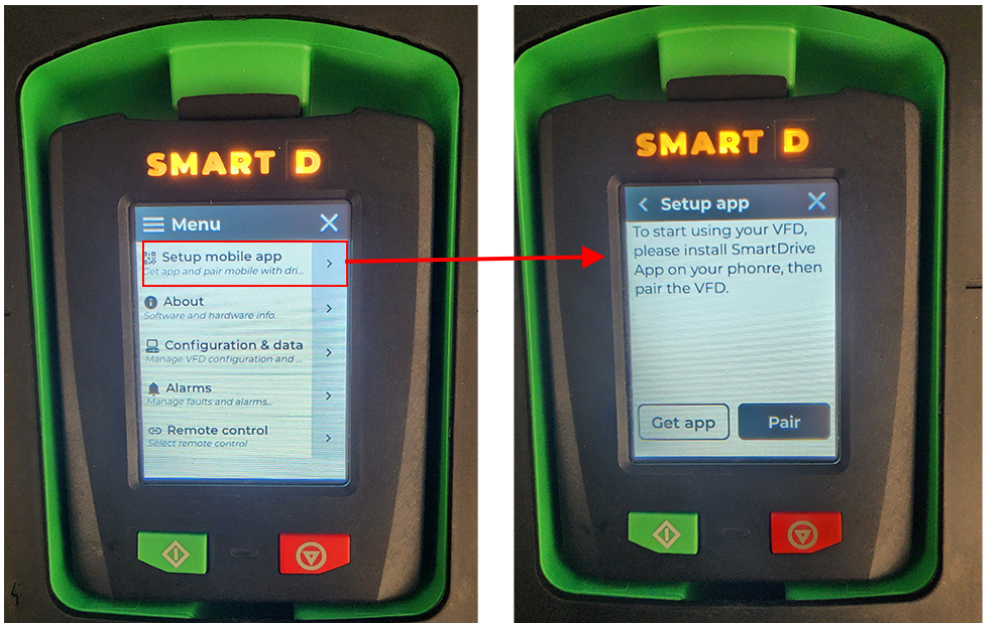


6- On the **Clean Power VFD HMI**, tap the hamburger button to display the menu.

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7- select "**Set up mobile App**" to pair the Clean Power VFD with your Clean Power VFD Application App.



Then tap on the button "Pair"

8- The screen is displaying the button **"Scan"**.

Tap on the button "scan" to display the pairing QR code.

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Then **scan the QR code with your Clean Power VFD Application** to execute the pairing.



When the Clean Power VFD advertises its Bluetooth connection, you have one (1) minute to scan the displayed QR code.

During this time, the HMI LEDs are blinking in blue.

Past this time, you must close the HMI menu and restart from step 6.

9- Note that the QR Code displays a PIN code to specify on your mobile on your first pairing with the VFD. This creates a bounding, and the USB sessions are encrypted and secure afterward.

Previous Next

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5.6. First Time Authentication

Once the app is installed, the user can log in with username "admin" and password as the serial number of the CleanPower VFD

The serial number of the Clean Power VFD must be written with a hyphen, in this format: xxxx-xxxxxxxx-xxxxxx

The serial number of the Clean Power VFD is written on the device side label, which is described in the section VFD nameplate description

- Change password
- Password complexity:
- Regular login
- Notes on privacy (how the app handles your password)
- Reset the password
- Log out from mobile application
- Mobile App Background Behavior

Change password

1. Go to **Menu > configuration > authentication**
2. Enter a **new password**.
3. Save. Your next login will use these new credentials.

Password complexity:

The new password must be different from the current password

The password you create must have

- Minimum length of 10 characters
- Maximum length of 255 characters
- Minimum 1 upper case
- Minimum 1 lower case

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- Minimum 1 digit
- Minimum 1 symbol
- Maximum 2 consecutive identical characters
- Maximum 3 consecutive sequential characters

and can not

- Contain the word "password"
- Contain your username

Regular login

To log in, provide:

- **Username**
- **Password**

If login fails, you'll see: **"Invalid username or password."**

Notes on privacy (how the app handles your password)

- Passwords are never stored in clear text.
- Passwords are salted and hashed, then encrypted at rest in the database.

Reset the password

For security reasons, the password cannot be reset through unsecured methods.

Access must be restored by performing a factory reset; however, this action will also erase the current system configuration.

To reset the password while preserving your configuration, please strictly follow this procedure:

From the HMI,

1. **Export** the current configuration to a USB drive.
2. Perform a **factory reset** on the device.
3. **Import** the previously exported configuration from the USB drive.

Log out from mobile application

For cybersecurity reason, when you chooses **Logout**, the remote endpoint immediately ends the current session.

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This action closes the active connection and invalidates the session credentials, so the VFD will no longer accept requests made with the same authorization token or refresh token.

After logout, any attempt to reuse these tokens is rejected, and you must authenticate again to interact with the VFD.

Mobile App Background Behavior

The mobile application maintains active communication with the VFD when running in the background for a limited duration.

When the application is sent to the background, it continues to exchange heartbeat messages with the drive for approximately 10 minutes. This mechanism is intended to preserve the active session during short interruptions (e.g., switching apps).

After this period, communication is automatically lost and must be re-established when returning to the application.

The VFD does not implement an automatic disconnect mechanism; the session termination is driven by the mobile application behavior.

Previous Next

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5.7. Check list: Before starting the Clean Power VFD

The following list intends to help the user go through a stepwise check before powering up the Clean Power VFD.

Check	Item
☐	**Model number**. Check the model number of the Clean Power VFD to make sure you have received the correct model.
☐	**Environment.** Check that the area and environment around the Clean Power VFD comply with the specifications.
☐	**Power supply voltage.** Check that the power supply voltage is within the range of the input voltage specifications of the Clean Power VFD.
☐	**Motor voltage** Check that the nominal motor voltage corresponds to the output specifications of the Clean Power VFD.
☐	**Short-circuit protection** Check that a short-circuit protection is properly installed, complying with international and local regulations.
☐	**Power supply connections** Check that the main line power supply is correctly wired to the terminals R / L1, S / L2, and T / L3 of the Clean Power VFD.
☐	**Connection to the motor**

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Check	Item
	Check that the Clean Power VFD is connected properly to the motor. The motor cables must correspond to the output terminals U / T1, V / T2, and W / T3 of the Clean Power VFD to respect the order of the phases. If the phase sequence is incorrect, the motor will rotate in the reverse direction.
☐	**Cross-section of the wires** Check that the cross-section of the wires complies with the recommendation of this document.
☐	**Voltage drop on the cable** Check that the voltage drop on the cable between the Clean Power VFD and the motor is less than 2% of the motor's nominal voltage.
☐	**Grounding** Check that the Clean Power VFD PE terminal is properly connected to the ground. Also: Check that the Motor ground wire is connected to the other Clean Power VFD PE terminal and NOT to the system ground
☐	**Power terminal screws tightening torque** Check that the power connectors' screws are tightened as specified in this document.
☐	**Power cable end connections** Check that the cables are not loosened from the terminals and not stripped too long, to avoid risks of short circuits.
☐	**Multiple motors protection** When using multiple motors on a single Clean Power VFD, ensure that each motor is installed with overload protection.

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Check	Item
☐	**Cables for control** Check that all control wiring to the Clean Power VFD control circuit uses twisted pair cables.
☐	**Shielding** Check that all the shielding on all shielded cables is connected to the protective earth terminal. SmartD recommends using a copper earthing bar to do so.
☐	**Wiring preset** Check that the wiring preset (3-wires or 2-wires) complies with the schematic in this document.
☐	**STO1 and STO2 terminals** Check that the STO1 and STO2 terminals are correctly wired to a safety device. If STO is not used in your application, check that the STO1 and STO2 terminals are connected to the +24 terminal.
☐	**Control terminal screws tightening torque** Check that the screws on the control terminal blocks are tightened as specified in this document.
☐	**Control cables end connections** Check that the cables are not loosened from the control terminal blocks and not stripped too long, to avoid risks of short circuits.
☐	**Clean connection** Check that no cable copper strands touch other terminals or connections on the terminal block.
☐	**Foreign objects**

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Check	Item
	Pick up any small pieces of cables or copper that may remain on or around the Clean Power VFD from your stripping and wiring operations.
☐	**Separation of power and control** Check that control circuit wires and main circuit wires (power supply and motor) are correctly separated.
☐	**Analog signals cables** Check that the cable for the analog signal is shorter than 30 m (98.4 ft).
☐	**STO cables** Check that the cable length for the STO signal, from operating contacts to the Clean Power VFD, is shorter than 30 m (98.4 ft)

Previous Next

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5.8. Test run

Prerequisite

After the wiring checklist has been completed, follow the instructions below to test the Clean Power VFD.

This test procedure uses the digital and analog inputs of the Clean Power VFD to control it.

Test run steps

1. **Unloaded motor**

   Check that the motor is separated from its mechanical load.

2. **Turn on the power supply**

   Turn on the power supply to the Clean Power VFD. Ensure that the HMI and LEDs are ON.

   Switch on the breaker upstream of the Clean Power VFD.

   If you power the control board via its 24VDC, switch it on to check its operation.

3. **Setting**

   Use the mobile app to set the motor and Clean Power VFD parameters.

4. **Motor parameter**

   Follow the wizard to set the motor parameter according to its nameplate.

5. **I/O's configuration**

   Select the I/O's preset configuration complying with your wiring.

6. **Frequency reference**

   Select the frequency reference as external from Analog input 1

7. **Acceleration and deceleration**

   Set acceleration and deceleration times taking into account that this test runs an unloaded motor.

8. **Upload**

   Follow the App instructions to upload the settings into the Clean Power VFD

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9. **Press the run button**: Start the motor and check the motor rotates in the correct direction.

   If the forward command is on, the 3 phases are wired in direct sequence, phases L1, L2, and L3 to the motor terminals U, V, and W in this order, the motor shall rotate in forward..

   If the motor rotates in the reverse direction, stop the motor immediately.

   You can change the default rotation direction via the setting parameter "Phase Inversion" without changing the wiring of the motor.

   But if you prefer to exchange two phases on the output:

   Then turn off the power supply to the Clean Power VFD.

   Wait 5 minutes for the capacitors to discharge fully.

   Finally, switch the cables at the U and V terminals.

   Restart this test run from step 1.

10. **Change the speed**

    Increase the analog input value slowly, then decrease it gradually.

    The motor accelerates and decelerates accordingly to reach the speed set via the analog input

    The set speed is displayed in the HMI

11. **Acceleration and deceleration**

    Ensure that the motor accelerates and decelerates according to the set times and that the speed reaches the frequency reference.

    Adjust acceleration and deceleration times.

    Adjust torque boost parameters as described in the "low-speed torque compensation" section.

    and download your new settings if any.

12. **If you use the STO function**, test its operation:

    Open STO1 / STO2 when the motor is running.

    The motor should stop because the Clean Power VFD deactivates its output.

    Try to start the motor while STO1 or STO2 is not activated. The motor should not start.

    If they are not operating as expected, call SmartD technical support for assistance.

Previous Next

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6. Mobile App

The Clean Power VFD Application

This mobile smartphone app provides step-by-step guidance for configuring and controlling your Variable Frequency Drive.

Key Features:

Configuration Flexibility

- **Offline Mode:** Create and save VFD configurations on your phone for later upload
- **Online Mode:** Connect directly to your Clean Power VFD for real-time configuration

Two Configuration Methods

- **Guided Setup:** Follow an intuitive step-by-step wizard
- **Manual Configuration:** Browse the complete parameter list for advanced customization (includes expert-level parameters)

Live Dashboard Control Once connected, you can:

- Monitor and control operational settings (start, stop, direction, speed, torque)
- Initiate auto-tuning procedures
- View and acknowledge system alarms
- Generate audit logs and support packages
- Update VFD firmware

Built-in Support

- Access the complete user guide online whenever you have internet connectivity

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- Get the App
- Authentication
- Mobile App and Firmware version compatibility
- Organize the configurations

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6.1. Configuration application

Get the smartphone App to configure your Clean Power VFD.

Phone requirements:

- Android phone with firmware version 9 or higher,
- iOS phone with firmware version 13.4 or higher.

The Clean Power VFD Application app can be downloaded with any of the methods below:

- **Scan the QR code displayed on the Clean Power VFD's HMI screen**, this will bring you to the Google Play Store or Apple Store for App downloading.
- **Click on the below badge for ios users**



- **Click on the below badge for Android users**



- or scan the following QR code with your cell phone:

Apple store:

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Google Play:

CAUTION

On first launch, the app will ask for two permissions so it can find and connect to your device over Bluetooth:

- **Bluetooth** access
- **Location** (on iOS and older Android) or **Nearby devices** (on newer Android)

We only use these to enable Bluetooth. We do **not** track or store your location.

iOS (first launch)

1. When asked to “Allow Clean Power VFD to use **Bluetooth**,” tap **OK**.
2. If you’re also asked for **Location**, tap **Allow While Using App**.
3. Keep Bluetooth turned **On** in Control Center/Settings.

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If you tapped “Don’t Allow” by mistake: go to **Settings › Clean Power VFD**, enable **Bluetooth** and **Location**.

Android 12 and newer (first launch)

1. When asked to allow **Nearby devices**, tap **Allow**.
2. Keep Bluetooth turned **On** (Quick Settings).

If you denied it: go to **Settings › Apps › Clean Power VFD › Permissions**, allow **Nearby devices**.

Android 11 and earlier (first launch)

1. When asked to allow **Location** for Bluetooth scanning, tap **Allow**.
2. Keep Bluetooth turned **On** (Quick Settings).

If you denied it: go to **Settings › Apps › Clean Power VFD › Permissions**, allow **Location**.

Quick check if pairing fails

- Bluetooth is **On** and the device is powered/advertising.
- The required permission is **Allowed** (see steps above).
- Toggle Bluetooth off/on and retry.

Privacy note: Location/Nearby Devices is requested only because the operating system requires it for Bluetooth discovery. The app does not collect or store your location.

Previous Next

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6.2. Intuitiveness

The smartphone application has been designed to ease the user's life.

It is speaking the user's natural language, meaning that each parameter and information is delivered in full text.

The settings of the Clean Power VFD are organized by logical steps and groups, the users can follow the step-by-step approach to write and store their application parameters.

No programming guide is needed to complete this task.

When moving from one step to the next, the summary of the last setting is displayed, allowing the user to check and modify it if needed.

If a modified parameter must be rewritten to its default value, an icon allows the user to activate the default value in one single click.

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6.3. Authentication

Once the app is installed, the user can log in with username "admin" and password as the serial number of the CleanPower VFD

The serial number of the Clean Power VFD must be written with a hyphen, in this format: xxxx-xxxxxxxx-xxxxxx

The serial number of the Clean Power VFD is written on the device side label, which is described in the section VFD nameplate description

- Change password
- Password complexity:
- Regular login
- Notes on privacy (how the app handles your password)
- Reset the password
- Log out from mobile application
- Mobile App Background Behavior

Change password

1. Go to **Menu > configuration > authentication**
2. Enter a **new password**.
3. Save. Your next login will use these new credentials.

Password complexity:

The new password must be different from the current password

The password you create must have

- Minimum length of 10 characters
- Maximum length of 255 characters
- Minimum 1 upper case
- Minimum 1 lower case

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- Minimum 1 digit
- Minimum 1 symbol
- Maximum 2 consecutive identical characters
- Maximum 3 consecutive sequential characters

and can not

- Contain the word "password"
- Contain your username

Regular login

To log in, provide:

- **Username**
- **Password**

If login fails, you'll see: **"Invalid username or password."**

Notes on privacy (how the app handles your password)

- Passwords are never stored in clear text.
- Passwords are salted and hashed, then encrypted at rest in the database.

Reset the password

For security reasons, the password cannot be reset through unsecured methods.

Access must be restored by performing a factory reset; however, this action will also erase the current system configuration.

To reset the password while preserving your configuration, please strictly follow this procedure:

From the HMI,

1. **Export** the current configuration to a USB drive.
2. Perform a **factory reset** on the device.
3. **Import** the previously exported configuration from the USB drive.

Log out from mobile application

For cybersecurity reason, when you chooses **Logout**, the remote endpoint immediately ends the current session.

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This action closes the active connection and invalidates the session credentials, so the VFD will no longer accept requests made with the same authorization token or refresh token.

After logout, any attempt to reuse these tokens is rejected, and you must authenticate again to interact with the VFD.

Mobile App Background Behavior

The mobile application maintains active communication with the VFD when running in the background for a limited duration.

When the application is sent to the background, it continues to exchange heartbeat messages with the drive for approximately 10 minutes. This mechanism is intended to preserve the active session during short interruptions (e.g., switching apps).

After this period, communication is automatically lost and must be re-established when returning to the application.

The VFD does not implement an automatic disconnect mechanism; the session termination is driven by the mobile application behavior.

Previous Next

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6.4. Mobile App and Firmware Version Compatibility

- Overview
- Key Concepts and Terminology
- Scope
- Offline Configuration Management - General Capabilities
- Offline Configuration Management - Version Tagging
- Version Compatibility Scenario 1: Newer Mobile App vs. Older Offline Configuration
- Version Compatibility Scenario 2: VFD with Same Firmware Version (Online)
- Version Compatibility Scenario 3: VFD on Older Firmware (Online)
- Version Compatibility Scenario 4: VFD Upgraded (VFD Newer than Local Config, App Compatible)
- Version Compatibility Scenario 5: VFD Reverted to Older Version
- Version Compatibility Scenario 6: VFD Newer Than Mobile App ⚠
- Feature Visibility
- Summary Matrix
- Best Practices

Overview

This guide explains how the Clean Power VFD Mobile App and VFD firmware interact across different versions, how configurations are managed, and what operations are permitted when version mismatches occur.

Key Concepts and Terminology

Before diving into version compatibility scenarios, it's important to understand the following terms and concepts that will be used throughout this guide:

- **Firmware**

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The embedded software permanently installed on the VFD hardware. Firmware determines what features and parameters the VFD supports. Firmware can be upgraded to add new capabilities or reverted to previous versions if needed.

- **Mobile App (Clean Power VFD Mobile App)**

  The smartphone application used to configure, monitor, and manage VFD settings. The app runs on your mobile device and communicates with VFDs when connected.

- **Configuration**

  A complete set of parameters and settings that define how a VFD operates. This includes motor specifications, control modes, protection settings, and other operational parameters that you define for your specific application.

- **Offline Mode**
  - Operating the mobile app without being connected to a physical VFD. In offline mode, you can:
  - Create new configurations
  - Edit existing saved configurations
  - View and manage locally stored configuration files
  - All work is done locally on your mobile device, and no data is exchanged with a physical VFD.
- **Online Mode**
  - Operating the mobile app while paired/connected to a physical VFD. In online mode, you can:
  - View the current configuration stored in the VFD
  - Compare your local configuration with the VFD's configuration
  - Transfer (write) your local configuration to the VFD
  - Import (read) the VFD's configuration to your mobile device
  - This mode requires an active connection between your mobile device and the VFD.

Scope

This compatibility information applies to:

- **Local configurations** saved in the Clean Power VFD Mobile App (offline drives)
- **Online configurations** when the app is paired with a physical Clean Power VFD
- **Version scenarios** where VFD firmware is older than, equal to, newer than, or reverted from the app version

Offline Configuration Management - General Capabilities

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The Clean Power VFD Mobile App supports full offline operation. You can:

- Create new configurations offline
- Edit any locally saved configuration offline
- Save configurations locally without VFD connection

Offline Configuration Management - Version Tagging

Each offline configuration is associated with a specific firmware profile:

- **Version Association**: Configurations are stored with the target firmware version against which they were created
- **Persistence**: Configurations remain fully viewable, editable, and saveable even after app updates
- **Version Stability**: The app does not automatically change the target firmware version of existing offline configurations

Note: Effective behavior when connecting to a VFD depends on the version relationship described in the scenarios below.

Version Compatibility Scenario 1: Newer Mobile App vs. Older Offline Configuration

Situation: A configuration was created with an older app/firmware profile. The mobile app has been updated (supporting new features), but the configuration remains offline.

Capabilities:

- Open and view the existing offline configuration
- Edit parameters belonging to the original firmware version profile
- Save the configuration locally

Behavior of the new parameters :

- Parameters introduced in newer firmware/app versions are **not** automatically injected into older configurations
- The app will **not** show the new fields until the related VFD is upgraded and the mobile is connected.

  This way, we provides a clean experience to older version and it is not "spamming" with unavailable features for the related older version

- Configuration migration occurs only when linked to a physical VFD (see subsequent scenarios)

Version Compatibility Scenario 2: VFD with Same Firmware Version (Online)

Situation: The app version is compatible, and the connected VFD runs the same firmware version as the local configuration.

Capabilities:

Viewing:

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- View VFD configuration
- Compare local saved configuration vs. VFD configuration
- Mismatches are clearly indicated

Configuration Management:

- Keep local configuration as-is
- Import VFD configuration and overwrite local version
- Edit local configuration
- Transfer local configuration to connected VFD

Feedback: Users are informed whether configuration transfers succeed or fail.

> **Note**: This behavior also applies when the local configuration was created on the same version as the VFD, even if both are older than the current app version.

Version Compatibility Scenario 3: VFD on Older Firmware (Online)

Situation: The local configuration or app supports newer parameters, but the connected VFD runs older firmware.

Capabilities:

Viewing:

- View VFD's configuration (older version)
- See mismatches between local and VFD configurations

Parameter Handling:

- Parameters not supported by older VFD firmware are **excluded** from transfer
- Configuration is automatically constrained to VFD-supported parameters

Configuration Management:

- Edit configuration within constraints of VFD's supported parameters
- Save adjusted configuration
- Transfer compatible configuration to VFD

Protection: The app prevents unsupported parameters from being written to the VFD, protecting system integrity.

Feedback: Users are informed whether transfers succeed or fail.

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Version Compatibility Scenario 4: VFD Upgraded (VFD Newer than Local Config, App Compatible)

Situation: The local configuration was created for older firmware, but the connected VFD has been upgraded. The mobile app version is compatible with the newer VFD firmware.

Automatic Migration:

- The app automatically migrates the local configuration
- Existing parameters are mapped to their equivalents in the new version where applicable

Capabilities:

Viewing:

- View configuration mismatches between migrated local configuration and upgraded VFD
- New parameters introduced in upgraded firmware appear as mismatches or unconfigured items

Configuration Management:

- Edit migrated local configuration (including new parameters)
- Save updated configuration
- Transfer configuration to upgraded VFD

Feedback: Users are informed whether transfers succeed or fail.

Benefit: Older offline configurations remain usable. The app assists with migration rather than requiring recreation from scratch

Version Compatibility Scenario 5: VFD Reverted to Older Version

Situation: A VFD previously running newer firmware has been reverted to an older version.

Parameter Handling:

- Parameters exclusive to newer firmware are automatically ignored
- Only parameters valid for the reverted firmware version are considered

Capabilities:

Viewing:

- View VFD configuration on reverted version
- See mismatches between VFD configuration and the compatible subset of local configuration

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Configuration Management:

- Edit configuration constrained to reverted VFD's supported parameters
- Save version-compatible configuration
- Transfer compatible configuration to VFD

Protection: The app enforces the reverted firmware's capability set, preventing unsupported settings from being written.

Feedback: Users are informed whether transfers succeed or fail.

Version Compatibility Scenario 6: VFD Newer Than Mobile App ⚠

Situation: The mobile app version is older than the connected VFD firmware.

Warning:

- Users are informed that VFD firmware is more recent than the mobile app
- Users are notified that the latest mobile app version is required for safe configuration
- User acknowledgment is required

Restrictions:

- Transfer of older local configurations to the newer VFD is **blocked**
- No full configuration write is permitted until app is updated

Protection: This prevents incompatible settings from being pushed to a drive with capabilities the app does not understand.

Feature Visibility

To prevent confusion when searching for new functionality:

A feature is visible and configurable only when **all** of the following conditions are met:

1. The mobile app version supports the feature
2. The VFD firmware version supports the feature
3. The scenario complies with compatibility rules (no "VFD newer than app" block)

Unavailable Features:

When conditions are not met, features are either:

- **Hidden** from the user interface, or

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- **Presented as unsupported/unavailable** according to compatibility logic

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Summary Matrix

Scenario	View Config	Edit Config	Transfer to VFD	Notes
Offline (any version)	✓	✓	–	Full offline support
Same firmware version	✓	✓	✓	Full compatibility
VFD older than config	✓	✓ (constrained)	✓ (subset)	Unsupported parameters excluded
VFD upgraded	✓	✓	✓	Automatic migration assisted
VFD reverted	✓	✓ (constrained)	✓ (subset)	Newer parameters ignored
VFD newer than app	✓	✗	✗	**Blocked until app updated**

Best Practices

1. **Keep App Updated**: Always use the latest mobile app version to access new features and ensure compatibility
2. **Version Awareness**: Check firmware and app versions before configuration transfers
3. **Configuration Backup**: Maintain local copies of configurations before major firmware upgrades
4. **Review After Upgrade**: When VFD firmware is upgraded, review new parameters and update configurations accordingly
5. **Test Transfers**: Verify configuration transfer success through the app's feedback system

Previous Next

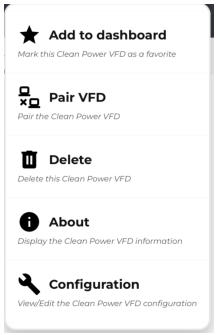
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6.5. Application menu

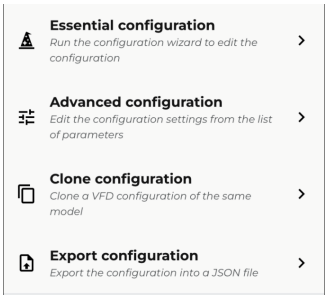
To access the app menu, tap the three-dot icon in the smartphone app's upper right corner.



The menu includes the following options:

- 

- **Add to Dashboard:** Quickly add the VFD to your dashboard for easy access to your preferred configurations.
- **Pair VFD:** Pair the VFD with your smartphone for seamless connectivity.
- **Delete:** Remove the VFD from your list of devices.
- **About:** View important information about the VFD, including its name, IP address, software version, serial number, and revision.
- **Configuration:**



- Run the configuration wizard to edit the VFD's settings.
- Access advanced configuration to display and edit all parameters, including those not shown in the wizard.

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- Clone a VFD configuration for replication.
- Export a configuration as a JSON file.

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6.6. Organization of the configurations

Each of the created configurations is defined by a unique name given by the user.

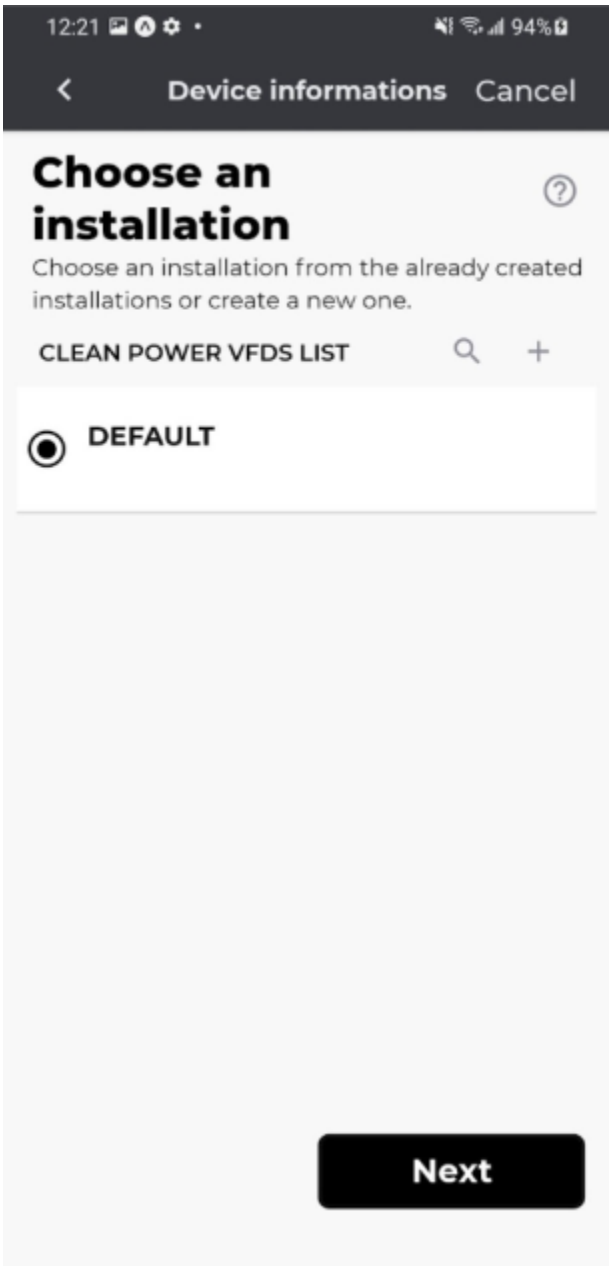
The configurations are organized in groups named "Installation".

Each Installation can be user-named for fast and easy management of the various Clean Power VFD configurations.

The installations are created when the user adds a Clean Power VFD configuration.

At this stage, the user can select a previously created installation or create a new one.

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6.7. Configuration Notes

The configuration App provides the user with the possibility to write some notes to a VFD configuration file for several reasons.

It's good practice to make notes clear, concise, and directly relevant to the configuration settings they describe.

The notes area can be used to:

Documentation:

Just like any piece of software or hardware, good documentation is critical to its efficient use. Notes can provide insight into why certain parameters are set the way they are, which can be useful for troubleshooting or future modifications.

Clarification:

Particularly for complex systems, notes can help to clarify the purpose or function of specific parameters. This can help to reduce confusion and potential errors when the system is being adjusted or modified.

Collaboration:

If multiple people are working with the same VFD system, notes can aid in collaboration. They can inform others about changes that have been made, or need to be made, and can be used to communicate insights or suggestions.

Problem-solving and Debugging:

If there have been issues with the VFD in the past, notes can be used to record these and to detail how they were resolved. This can be a valuable resource if similar issues arise in the future.

Version Tracking:

If the configuration file undergoes regular changes, notes can be used to document these changes over time, effectively creating a log or history of alterations made.

Previous Next

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6.8. VFD control by Mobile App

Overview

The Clean Power VFD can be controlled through the mobile app.

Mobile control is Disabled by default. The user can enable it

You can choose to allow or deny motor and PID control from the mobile app at any time. This setting is managed from the mobile App and from the HMI.

Enabling or Disabling Mobile Control

Mobile control can be enabled or disabled using the HMI or the mobile App:

1. Open the HMI /mobile App menu:
    - On HMI: menu > configuration > remote control > mobile control
    - On mobile: menu > configuration > advanced configuration > system > mobile configuration > mobile control
2. Set:
    - **Disabled** – mobile app cannot control the motor or PID (default).
    - **Enabled** – mobile app is allowed to control the motor and PID according to user rights and safety logic.

Effect on Motor and PID Control

- When mobile control is disabled, the VFD will reject any control requests coming from the mobile app related to:
    - Motor start/stop
    - Direction changes
    - Control mode or control source changes
    - PID setpoint and limit changes
    - Maintenance mode and interlock commands
    - Resetting lockouts

Local/HMI and other configured control sources continue to operate normally according to your application setup.

Mobile App Behavior When Mobile Control is Disabled

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If the mobile control is disabled on the VFD:

- The mobile app displays a notification indicating that:
    - Mobile control is currently disabled.
    - Mobile application can still re-enable the control through the configuration if required.

Available Mobile Actions When Mobile Control Is Disabled

When mobile control is disabled, the mobile app behaves as a **monitoring and configuration tool only**. The following actions remain available or are blocked:

Allowed actions

You can still perform these actions from the mobile app:

- **Change configuration parameters** (within your access level and security rules).
- **Restore factory defaults** (if your user rights allow it).
- **Acknowledge alarms.**
- **Change software version** (for example, performing a firmware update).

Denied actions

All direct motor or PID control actions are blocked. The app cannot send the following commands to the VFD:

- Start Motor
- Stop Motor
- Interlock
- Change Motor Setpoint
- Change Direction
- Change Control Mode
- Change Control Source
- Change PID Setpoints
- Change Motor Setpoint Limits
- Change Maintenance Mode
- Reset Lockout

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These commands are only available again from the app once mobile control is re-enabled on the HMI or from the mobile advanced configuration menu.

Previous Next

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7. Smart HMI

NOTICE

Use fingers only

Operate the HMI touchscreen with your fingers only. Do not press the screen with a pen, screwdriver, tool, or any other hard or sharp object.

Using anything other than fingers may scratch the screen or break the LCD glass. If the LCD glass shatters, the HMI may fail immediately. This risk is greatly increased when force is applied with a pen or other tool.

This section provides an overview of the HMI layout, functions, and operation method.

It is important to have a good understanding of the basic operation of the Clean Power VFD before exploring advanced features, adjusting speed, or changing rotation direction.

The Smart HMI features a graphic touch-screen interface.

It can be attached to the front face of the Clean Power VFD or installed remotely.

If you choose to install the HMI remotely, refer to the instructions provided in the section "Mounting the HMI remotely."

The Clean Power VFD can be managed through its digital and analog I/Os or the Ethernet Ports, allowing for the Smart HMI to be detached and disconnected from the Clean Power VFD if needed.

! However, **do not disconnect or reconnect the Smart HMI while the Clean Power VFD is powered on**.

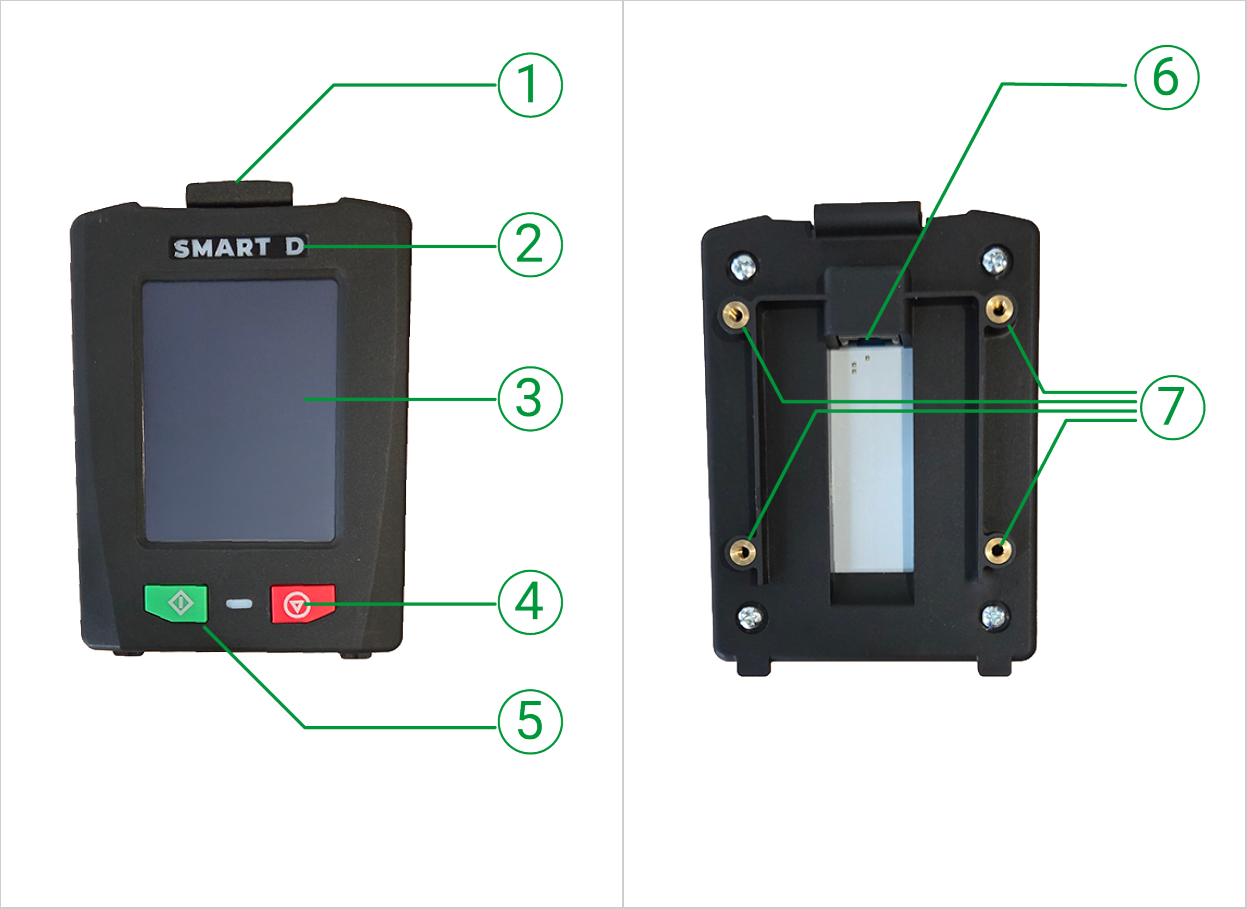
Always power off the Clean Power VFD before making any changes to the Smart HMI connection.

Previous Next

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7.1. HMI description

HMI part number SD-HM-01 description:



HMI front side

1- Holding clip

Secures the HMI in position when mounted to the VFD.

2-Illuminated logo

Status indicator integrated into the HMI front panel. The logo changes color and lighting pattern according to the VFD operating status. For details, read the section illuminated logo.

3- Touch screen

Primary user interface for monitoring, navigation, and command access.

4- Stop button

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Dedicated local command button used to stop the motor.

5- Start button

Dedicated local command button used to start the motor.

HMI rear side

6- RJ45 receptacle.

Communication and connection port used to connect the HMI to the VFD.

Use only cables approved by SmartD, as described in the section " Mounting the HMI 2 remotely"

7- Mounting nuts

Threaded fastening points used to secure the HMI to the mounting surface

Previous Next

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7.2. Illuminated logo

The SmartD logo is illuminated in different colors and patterns , depending the Clean Power VFD status.

BLUE

Blinking blue during the pairing process window (maximum duration 5 minutes).

RED

Blinking red, the system has at least one unresolved CRITICAL alarm that is not acknowledged by the user.

Solid red, the system has at least one unresolved CRITICAL alarm but this alarm has been acknowledged by the user.

Single blinking red (after booting the VFD or connecting the HMI), the HMI firmware has failed to start.

ORANGE

Blinking Orange, the system has no CRITICAL alarm but, at least one unresolved MAJOR alarm that is not acknowledged by the user.

Solid orange, the system has no CRITICAL alarm but, at least one unresolved MAJOR alarm that has been acknowledged by the user.

YELLOW

Blinking yellow, the system has no CRITICAL nor MAJOR alarms but, at least one unresolved MEDIUM alarm that is not acknowledged by the user.

Solid yellow, the system has no CRITICAL nor MAJOR alarms but, at least one unresolved MEDIUM alarm that has been acknowledged by the user.

GREEN

Blinking green, the system has no CRITICAL nor MAJOR nor MEDIUM alarms but, at least one unresolved MINOR alarm (minor alarm does need to be acknowledged)

Solid green, The system has no Alarm and is either in ready to run or running state.

WHITE

Blinking white, the HMI firmware is updating.

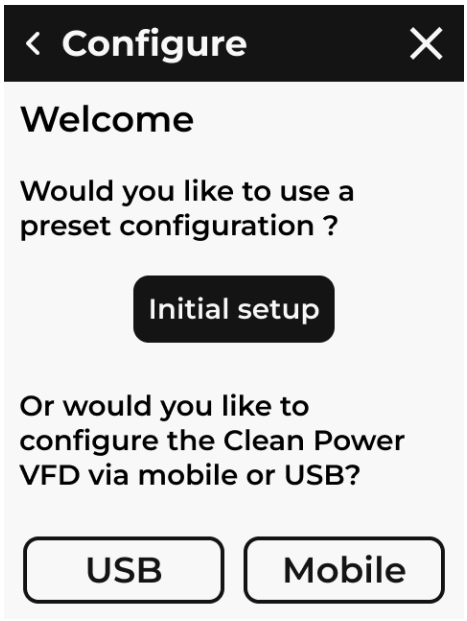
Solid white, the system is booting. Turns on as soon as the HMI is powered ON.

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7.3. Initial Clean Power VFD Setup

When the VFD is unconfigured or after a factory reset, the HMI follows a structured setup process to ensure proper configuration and user guidance.



The HMI displays choices for configuration methods:

- Initial setup
- Configure via USB
- Configure via Mobile

Initial Setup

The HMI prompts the user through the following steps

1. Select either the 2-wire or 3-wire preset configuration or Modbus TCP for immediate setup.
2. Set the input line frequency to match the local power supply's frequency.
3. Input the motor’s nominal current to ensure proper motor operation.
4. Set the date, time, and time zone to support accurate logging and scheduling.

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5. Finally displays the main screen when the previous steps are complete.

Configuration via USB:

The HMI prompts the user through the following steps

1. Follow the steps to import the configuration file from a USB key. If the file is invalid, the HMI displays an error message stating: “Invalid configuration file.”
2. Set the date, time, and time zone after importing the configuration to maintain accurate system settings.
3. Finally displays the main screen when the previous steps are complete.

Configuration via Mobile:

The HMI prompts the user through the following steps

1. Select how to connect the mobile app: BLE (Bluetooth) or Wi-Fi.
2. If Wi-Fi is selected, configure the Ethernet network settings to connect the VFD to a local network.
3. Set the date, time, and time zone to allow the mobile app to connect seamlessly.
4. Pair with the mobile device following the guide process, ensuring secure and reliable communication between the mobile app and the VFD.
5. Finally displays the main screen when the previous steps are complete.

Previous Next

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7.4. Quick setup wizard using the HMI

The Quick Setup Wizard allows users to configure the VFD with the minimum required parameters to operate the motor.

This setup streamlines the process by focusing on essential settings, making it ideal for rapid deployment.

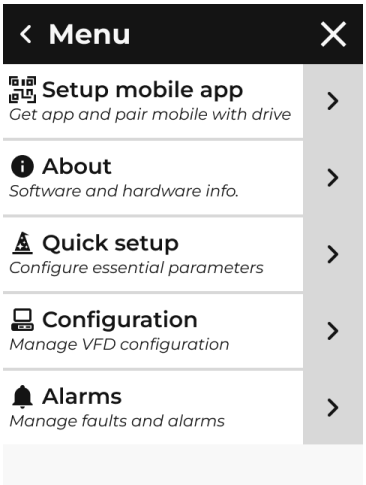
With the Quick Setup Wizard, you can get your motor running efficiently with minimal effort while maintaining flexibility for advanced configurations later.

Below are the steps and details of the configuration process using the HMI.

- The quick setup process may end with an invalid configuration when the user also uses the mobile to configure the VFD.
- If the drive is not starting after running the quick setup, we recommend performing a factory reset to help restore proper operation.

Accessing the Quick Setup Wizard

Open the HMI menu screen and click on Quick Setup. Please follow the on-screen prompts to begin the configuration process.

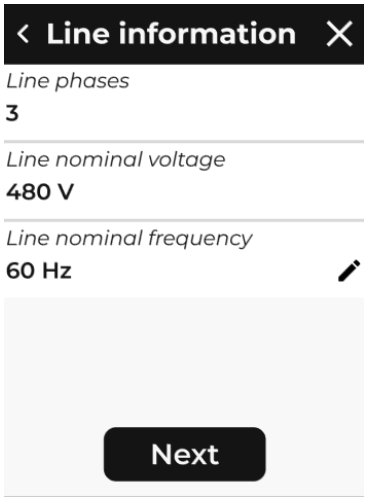


Parameters Displayed in Quick Setup Wizard

Line Parameters:

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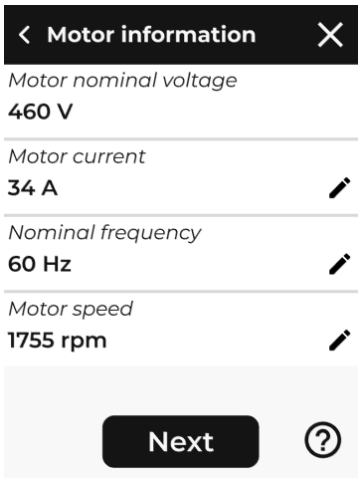
The HMI displays the following parameters for the electrical line:



- **Line Phases**: This parameter displays the number of phases connected to the VFD. It is read-only and cannot be edited.
- **Nominal Voltage**: Displays the nominal line voltage. This parameter is read-only and cannot be edited.
- **Nominal Frequency**: This option allows the user to input the nominal line frequency (50 Hz or 60 Hz).

Motor Parameters (Nameplate):

These parameters are derived from the motor’s nameplate. Please ensure the motor nameplate data is available before proceeding:



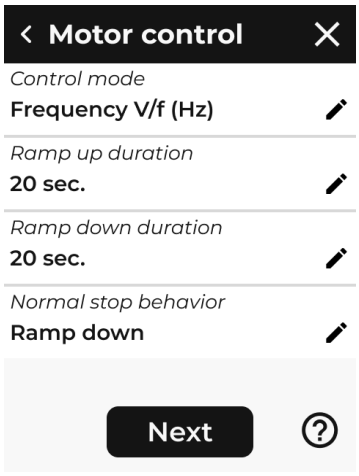
- **Nominal Voltage**: Displays the motor's nominal voltage. This parameter is read-only.
- **Nominal Current**: Allows the user to input the motor's nominal current.

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- **Nominal Frequency**: Allows the user to input the motor's nominal frequency.
- **Nominal Speed**: Allows the user to input the motor's nominal speed.

Motor Control Parameters:

These parameters define how the motor will be controlled:

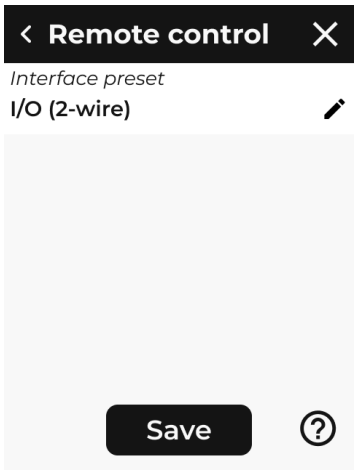


- **Control Mode**: Select the desired control mode (e.g., V/Hz, vector control).
- **Ramp-Up for Single Linear Ramp**: Set the acceleration time for the motor to reach its rated speed.
- **Ramp-Down for Single Linear Ramp**: Set the deceleration time for the motor to stop from its rated speed.
- **Normal Stop Behavior**: Choose the motor's default stopping behavior (e.g., freewheel, ramp-to-stop).

Remote Control Parameters:

These parameters define how the VFD will be remotely controlled:

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- **Remote source 1**: Set the remote source 1: 2-wire I/O preset, 3-wire I/O preset, Modbus TCP or BACnet IP
- **Remote source 2**: Set the remote source 2: Unconfigured (no 2nd source), 2-wire I/O preset, 3-wire I/O preset, Modbus TCP or BACnet IP
- **Source selector**: Select which will be used to control the VFD (local, source 1, source 2)

Error Handling

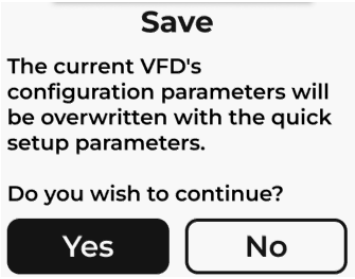
If there are errors in the configuration, the HMI will display an error message indicating a configuration issue.

Note:

The HMI does not validate parameter dependencies during the Quick Setup process. Users must ensure all parameters are consistent with the VFD's operational requirements.

Finalizing the Configuration

Confirm the configuration parameters after setting the remote control parameters by selecting "Save".

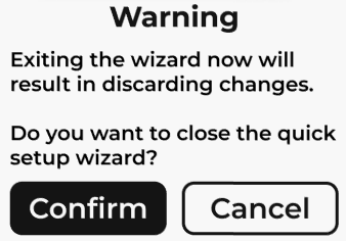


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Please click on Yes to save and apply the new configuration.

Please note that the new VFD's configuration parameters will overwrite the existing ones; however, system settings—such as date and time, network configuration, and language—will remain unchanged.

To cancel and exit the Quick Setup wizard, click on the X in the top-right corner, and click on Confirm to discard all changes.



Refer to the detailed configuration guide for advanced settings and troubleshooting.

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7.5. Functions of the HMI

The HMI is the local interface for user operations.

It gives access to several functions that are:

- Display the status of the Power Drive System (VFD + motor)
- Control the connected motor: start, stop, speed, and direction.
- Display the alarms, their status, and their statistics.
- Acknowledge and reset the alarm status.
- Access to the troubleshooting guide for the alarms.
- Display the electrical values, powers, voltages, currents, and DC bus.
- Display VFD cooling status.
- Export the audit file to a USB drive.
- Access to the online user guide.
- Access to the installation of the mobile App for your smartphone.
- Reset to factory settings.
- Set the date and time of the VFD manually.

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7.6. VFD configuration from the HMI

The user can view the VFD settings from the VFD HMI.

Main power line configuration

Select Menu >> Configuration >> Motor Control >> Line information

It displays all line settings (power supply input) in the same order displayed in the summary screen in the Mobile application.

- Number of phases
- Line nominal voltage
- Line nominal frequency

Motor configuration

Select Menu >> Configuration >> Motor Control >>Motor information

It displays all motor settings (nameplate) in the same order displayed in the summary screen in the Mobile application.

For Asynchronous motors:

- Motor brand and part number
- Motor nominal Voltage
- Motor full load current (FLA)
- Power engineering unit
- Motor rated power
- Nominal frequency
- Number of poles
- Motor Nominal speed
- Min. frequency
- Max. frequency

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- Zero speed behavior
- Phase reversal
- Power factor

Motor control mode

Select Menu >> Configuration >> Motor Control >> Motor control

It displays

- if the motor is controlled in V/f frequency or velocity, or controlled in iFOC velocity
- Ramp-up and ramp-down times
- Low speed torque compensation
- Low speed torque compensation cut-off frequency
- Preset velocities
- Reverse rotation enablement

Motor Auto-tuning

Select Menu >> Configuration >> Motor Control >> Motor tuning

It displays all motor tuning settings as of the mobile app interface for auto-tuning.

PID configuration

Select Menu >> Configuration >> PID Control

It displays the PID settings:

- Enabled/disabled
- Engineering units
- Setpoint limits
- Gain Kp
- Integral gain Ti

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- Derivative Gain Td
- Mode direct or reverse
- Min. and Max. PID output
- Forced output settings
- compensation factor
- sleep/wake-up settings

Remote / Local control settings

- Source 1 and 2 of the remote controls
- State and source selector

Digital inputs configuration

Select Menu>> Remote Control>> I/Os >> Digital Inputs

It displays all digital input settings in the same order displayed in the summary screen in the Mobile application.

- Digital input logic connection: source or sink
- List 6 digital inputs with their configuration
- Access to each digital input settings
    - Assigned function
    - Trigger type
    - Debounce delay

Relays configuration

Select Menu >> Remote Control >> I/Os >> Relays

It displays all relay settings in the same order as the summary screen in the mobile application.

For each relay view the variable assigned to the contact

Analog inputs configuration

Select Menu>> Remote Control>> I/Os >> Analog inputs

It displays all analog input settings as in the Mobile application.

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- assigned function
- type of electrical signal
- conversion linear curve

Analog outputs configuration

Select Menu>> Remote Control>> I/Os >> Analog outputs

It displays all analog output settings as in the Mobile application.

- assigned function
- type of electrical signal
- conversion linear curve

Modbus TCP

Select Menu>> Remote Control>> Modbus TCP

It displays if the Modbus TCP server is enabled or not and the number of the used port,

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7.7. Display and define the motor setpoint

The application's speed can be set and displayed in Hertz or RPM, depending on the user's settings.

If the motor control mode parameter is **Frequency (Hz)**, the engineering unit is Hertz (Hz).

If the motor control mode parameter is **Velocity V/f (RPM)**, or **iFOC Velocity (RPM)** then the engineering unit is revolution per minute (RPM).

If the motor control mode parameter is **iFOC Torque (%)**, the engineering unit %, as a percentage of the motor's rated torque. The VFD automatically calculates the motor's rated torque from its parameters.

Slip compensation

The slip compensation is automatically calculated and enabled when the motor control mode parameter is Velocity V/f (RPM).

No slip compensation in control mode Frequency (Hz).

Min and max velocities

If the user defines the application speed setpoint in RPM, the setpoint value must remain between the min and the max velocities configured on the Clean Power VFD.

The settings ask the user to define the min and max frequencies of the motor in Hz. To convert those values in RPM:

min_velocity = min_frequency * (nominal_velocity / nominal_frequency)

max_velocity = max_frequency * (nominal_velocity / nominal_frequency)

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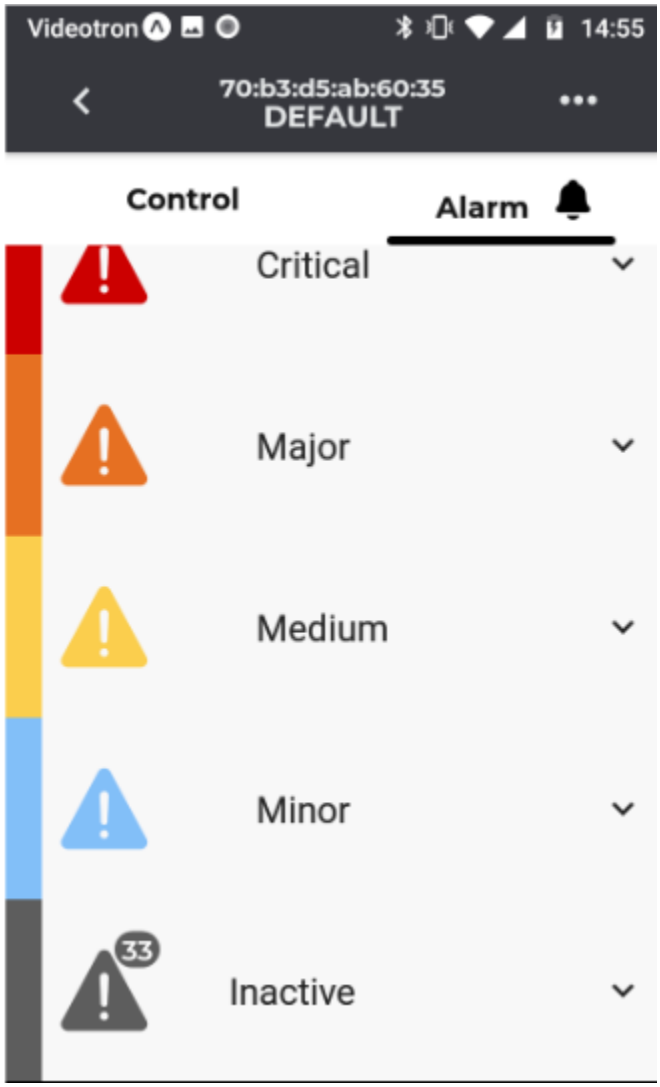
7.8. Access and manage the alarms

Alarms can be accessed and managed either from your paired SmartPhone or from the Clean Power VFD HMI.

Alarms using the paired Smartphone

From the dashboard, click on ALARM in the upper right corner of the screen.

This opens the page that displays a general overview of the alarms, grouped by criticality.



The number and status of the alarm are summarized by the background color and by the acknowledgment radio button:

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- besides the warning sign, the number of active alarms is displayed with a background related to the criticality, and the total number of alarms (active and past) with a dark grey background

- if the alarm is active, the background is colored accordingly to its criticality.

- the radio button is filled if the alarm has been acknowledged, empty if not.



Acknowledge

Clicking on the radio button changes the alarm status to "acknowledge".

The radio button becomes filled

Last event

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Clicking on the i (information) radio button displays the last events of the alarm and the number of occurrences.

The last event gives the user the date and time of

- the alarm is detected,

- the alarm is acknowledged,

- the alarm is resolved.

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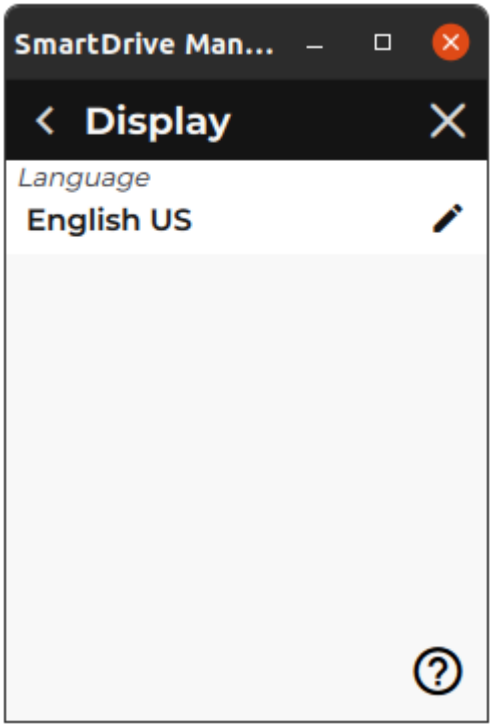
7.9. Display settings

From the HMI menu, the user can access and edit the display settings and choose his preferred language.

Select: Configuration >> System >>Display

Select the language of your interface by clicking on the pen.

Do not forget to save the changed parameters before leaving the page.



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7.10. BLE status

To access the Bluetooth settings of the Clean Power VFD, navigate to:
Select Configuration >> System >> BLE from the HMI menu.

Enabling or Disabling Bluetooth

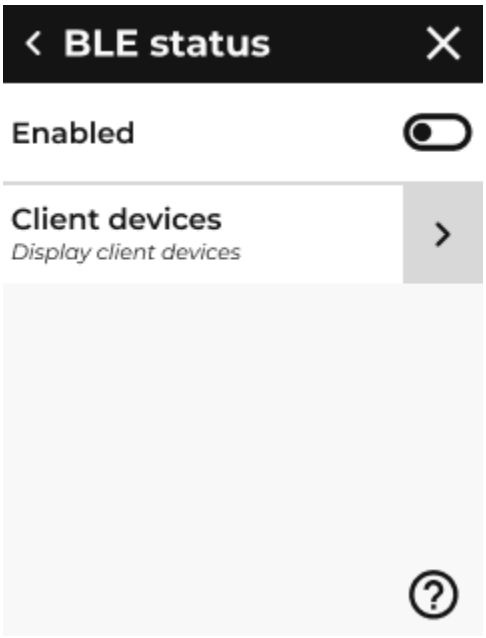
By default, Bluetooth is **enabled**.
To disable it, slide the toggle switch to **"Disable."**

- The current Bluetooth status (**Enabled/Disabled**) is displayed on the HMI.
- A confirmation message will appear after changing the Bluetooth status.
- Changes to the Bluetooth status are logged in the **event history**, including:
    - **Timestamp**
    - **Action performed** (Enabled/Disabled)
    - **User ID** (if applicable)

Managing Connected Devices

- Click **"Client Devices"** to view the list of paired devices.
- To disconnect a device, click **"Disconnect."**
- To remove a device from the paired list, click **"Forget."**

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If you have some difficulties with the Bluetooth connection: Bluetooth pairing issue

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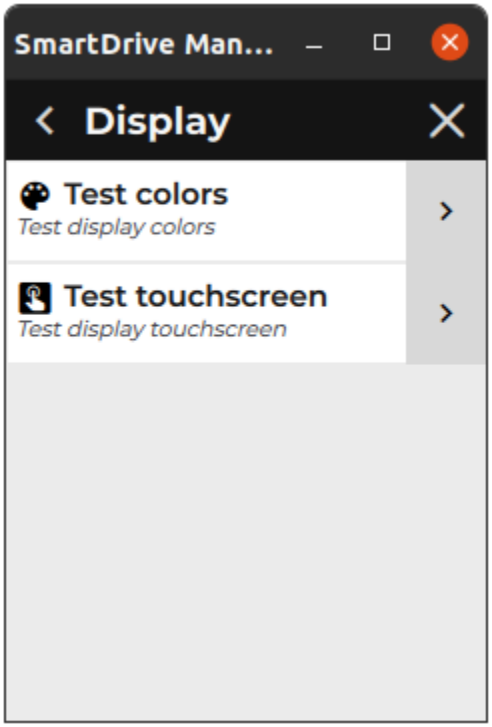
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7.11. Test the HMI

You can easily test the health of the HMI, both touchscreen reaction and display.

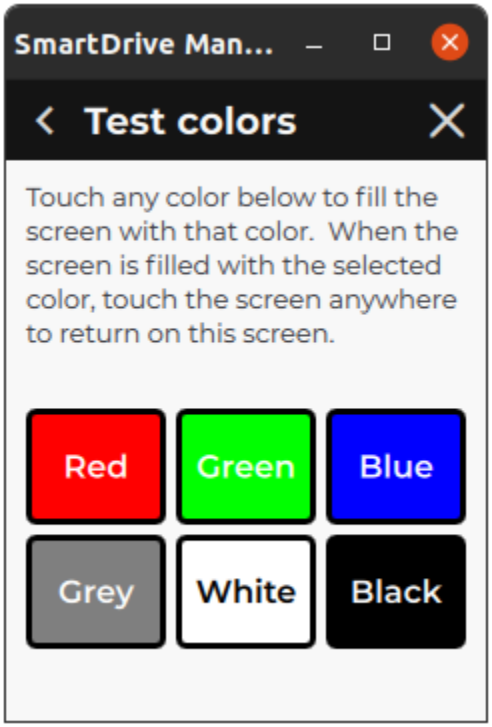
From the HMI menu: >> About >> Diagnostic >> Display, select Display Diagnostics.

Then select Test colors or Test touchscreen depending on what you need to test.



Test the colors:

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7.12. HMI screensaver

To extend the life expectancy of the HMI, a screensaver can kick in after an inactivity timer has elapsed.

Go to Menu >> Configuration >> System >> Display

Click on the pencil to activate the backlight switch off.

NOTE: *The Blur option is no longer available (since firmware 2025.16.00), it will now fall back to Backlight off*

You can also configure the HMI inactivity timer. Range: 11 to 1800 seconds, default: 300 seconds.

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7.13. Lock & Unlock Display

Setting and Managing the HMI Lock PIN

Setting and Changing the PIN:

To enhance security, you can set and manage a 6-digit Personal Identification Number (PIN) for access protection.

The following guidelines apply:

- Set PIN: You can set a unique 6-digit PIN for the admin account. This PIN is required to enable the HMI lock feature.

- Change PIN: You can change the existing PIN if necessary.

- PIN Storage: The PIN is not stored in clear text for security reasons. It is encrypted and not saved in the VFD's standard configuration file.

Enabling/Disabling the HMI Lock:

If a PIN has been defined, you can enable or disable the Lock HMI feature. Without a PIN, this feature is inaccessible.

- Audit Logging: Every time the HMI lock is enabled or disabled, the event is logged in the system audit log for traceability.

Lock HMI Functionality:

When the inactivity timer expires and the Lock HMI feature is enabled, the VFD enters screensaver mode (either blackout or blur, as defined by the user) and locks the HMI.

HMI's Buttons Behavior:

When the HMI is locked, the following button behaviors apply:

- STOP Button: Pressing the HMI's STOP button will stop the motor according to the user-defined STOP behavior. You will be prompted to enter the PIN.

- START Button: Pressing the HMI's START button will not start the motor, and a PIN prompt will appear. After successful unlock, you must press start again to run the motor.

Unlocking the HMI:

To unlock the HMI, the following steps apply:

- Touchscreen: Pressing the touchscreen will prompt you to enter the PIN to unlock the HMI.

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- Successful Unlock: If the correct PIN is entered, the HMI will unlock and return to the last screen displayed before the screensaver was activated. This event is logged in the audit log.

- Failed Unlock Attempts:

    - If an incorrect PIN is entered, the HMI will display the message “Invalid PIN. Please try again.”

    - You must acknowledge this message and re-enter the correct PIN.

    - Each invalid attempt will trigger a minor alarm labeled "Unlock HMI failed."

Resetting the PIN:

A factory reset will clear all defined PINs and will disable the Lock HMI feature.

PINs During Software Upgrades and Reverts:

- Upgrade: The configured PIN will be retained after a software upgrade.

- Even after a software revert or update, the latest PIN remains active.

Rebooting the VFD:

If the Lock HMI feature is enabled and a PIN has been set, the HMI will prompt the user to enter the PIN after a reboot.

Previous Next

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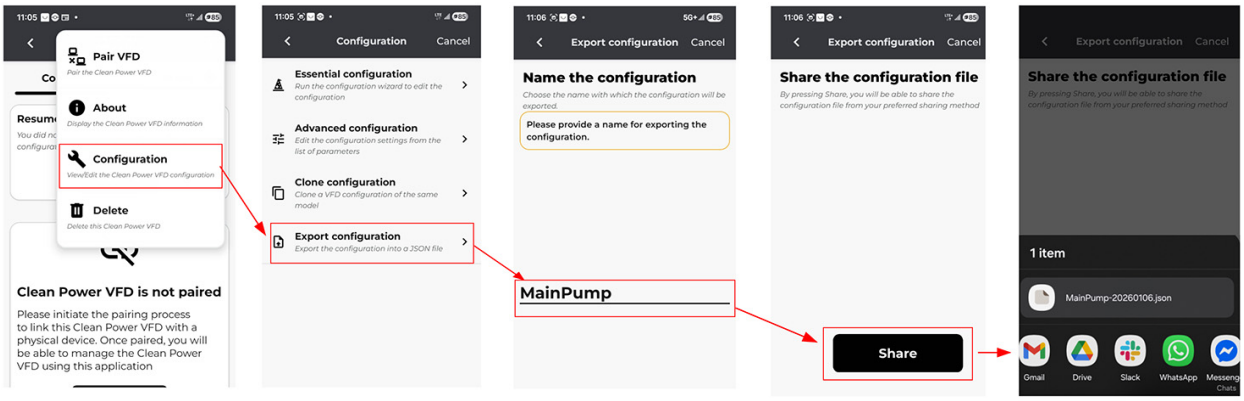
7.14. Configuration export

- Export and share from your mobile App into a JSON file
- Export from the HMI into a JSON file to a USB drive
- Import from a USB drive

Export and share from your mobile App into a JSON file

VFD configurations can be exported and shared as JSON files using the mobile app.

1. Navigate to ***Menu >> Configuration >> Export Configuration***.
2. Enter a name for the configuration file and tap **Next**.
3. Tap **Share**.
4. Select your preferred sharing method from your phone's native menu. You may:
    - Save the file to a cloud drive.
    - Save locally to your device (iOS only).
    - Send via email or an installed messaging app.



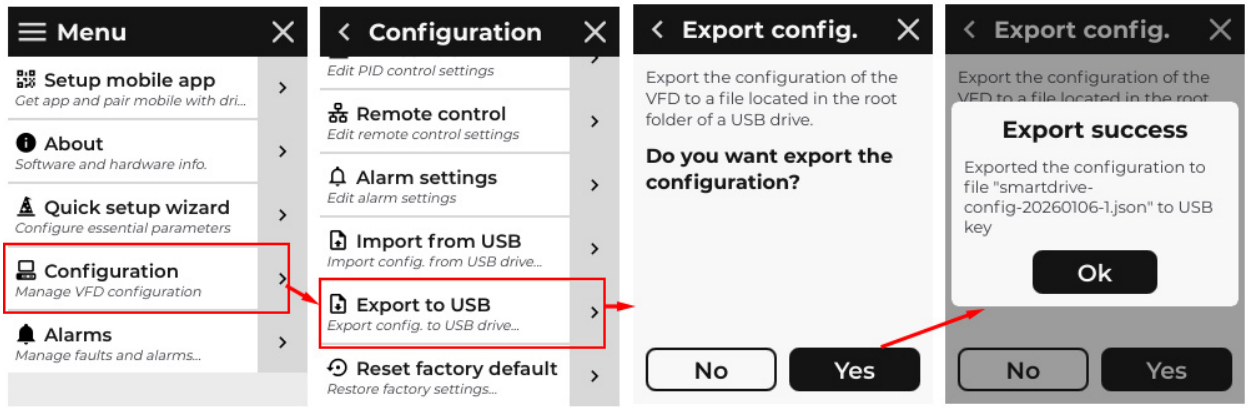
Export from the HMI into a JSON file to a USB drive

VFD configuration can be exported as JSON file into a USB drive plugged onto the VFD.

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Navigate to ***Menu >> Configuration>>Export to USB***

Ensure that a USB drive is plugged onto the USB socket of the VFD, then click Yes



Import from a USB drive

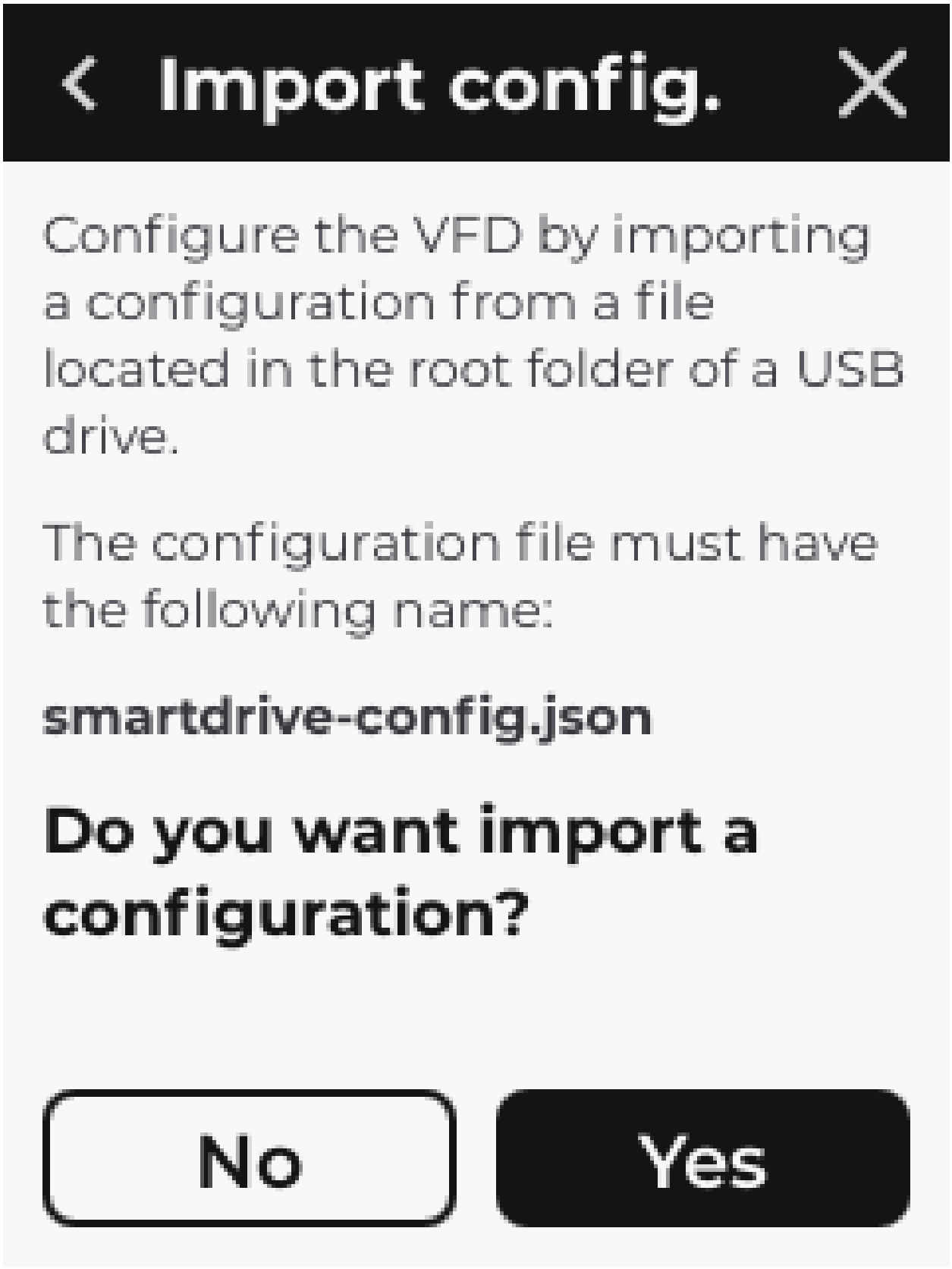
You can import a previously exported VFD configuration file (.JSON) using the VFD's USB interface.

Note: This action is restricted to hardware compatibility. The configuration file can only be imported onto a VFD with the exact same part number as the source device.

Navigate to ***Menu >> Configuration>>Import from USB***

Click Yes once the USB drive containing the file is plugged onto the USB socket of the VFD.

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8. Functions and parameters

This section provides a complete list and description of the functions and parameters of the Clean Power VFD.

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8.1. Dual Configurations

Purpose

This feature allows the VFD to store up to **two full configurations**.

A configuration is a complete set of user settings used to operate the drive in a given application or setup. This can be useful when one VFD must support two different machine setups, two operating modes, or two motors that require different parameter sets.

At all times, only **one configuration is active** in the VFD.

What the function does

The VFD supports:

- **1 active configuration**
- **1 inactive configuration**

The active configuration is the one currently used by the VFD.

The inactive configuration is stored in memory and can be edited, saved, activated, or deleted, depending on the operating state of the drive.

The VFD cannot store more than **two full configurations**.

Default behavior

By default, the VFD contains:

- **Configuration number 1 – Active**

Only one valid active configuration is present after factory default or after reset to factory settings.

What is included in a configuration

A configuration stores a full set of application parameters, including for example:

- Command and reference settings
- Frequency or speed reference
- Torque or PID setpoint reference
- Acceleration and deceleration ramps
- Current limits

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- Protection-related settings
- Motor control settings
- Application-specific parameters

The exact content depends on the features enabled in the VFD.

Access from HMI and Mobile App

You can manage configurations from:

- **HMI**
- **Mobile app**

You can:

- Edit the active configuration
- Save changes to the active configuration
- Save a second configuration
- Edit the inactive configuration
- Save and activate the inactive configuration.
- Delete the inactive configuration
- Activate the inactive configuration when the VFD is in the proper state

Save and activate

Save and activate stores the edited inactive configuration and immediately makes it the active configuration, if activation conditions are met.

When this happens:

- the previously active configuration becomes inactive
- the previously inactive configuration becomes active

Activating a configuration

The inactive configuration can only be activated when the VFD is in **Ready to run** state.

The inactive configuration can be activated by:

- **HMI**
- **Mobile app**

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- **Digital input**
- **Supported communication protocols**

Activation behavior

If the selected configuration is inactive:

- the current active configuration becomes inactive
- the selected inactive configuration becomes active

If the selected configuration is already active:

- the VFD ignores the request

Deleting a configuration

Only the **inactive configuration** can be deleted.

The active configuration cannot be deleted.

After deletion, the VFD returns to a single valid active configuration.

Audit log

The VFD records the following actions in the audit log:

- save configuration
- activation of the inactive configuration

This helps track configuration changes over time.

Reset to factory

After a factory reset, the VFD returns to:

- **one active configuration only**

Any second stored configuration is removed.

Firmware upgrade and revert behavior

Upgrade from firmware with one-configuration support

When upgrading from an older firmware version that supports only one configuration, that existing configuration is kept and becomes:

- the default configuration
- the active configuration

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Accept or commit of new firmware

When the new firmware is accepted or committed, the VFD supports for **two configurations**

Revert to firmware with one-configuration support

When reverting to an older firmware version that supports only one configuration, only one configuration is restored

Revert again to firmware with two-configuration support

When returning to a firmware version that supports two configurations, the two configurations are restored

Operating data and logs

Switching between configurations is intended to support different operating setups without losing stored application information.

Application-specific logs and operating data remain associated with their respective configuration or use case, according to system implementation.

Including:

- running hours
- start and stop history
- fault occurrences
- other operating records relevant to the application

Switching the active configuration does not erase the stored data associated with the inactive configuration.

When to use this function

Use this function when one VFD must support two distinct setups, such as:

- two different motors with different parameter requirements
- one machine with two operating modes
- one installation with a normal mode and an alternate mode
- commissioning and validated production configurations stored separately

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8.2. Power Line parameters

Set only these two items during commissioning. All other supply checks are automatic (including phase sequence).

- Supply Voltage

  Select the plant voltage class (e.g.,400 / 480 / 600 V).

  Use the site data or a qualified measurement.

- Line Frequency

  Select 50 Hz or 60 Hz to match the site standard.

No other settings are required. The drive automatically handles phase sequence, imbalance checks, and precharge.

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8.2.1. Line Phase Sequence

The VFD is not sensitive to the incoming line phase sequence. In other words, the drive will operate normally regardless of the order of the three supply phases (L1/L2/L3).

Important: Do not swap any two input phases while the VFD is powered and running. If two supply phases are changed during operation, the drive will detect the disturbance and may trigger an alarm to protect itself.

In practice, there is no normal operating reason to re-order the input phases on a running VFD. If phase wiring must be corrected, stop the drive and isolate power first.

Previous Next

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8.3. Motor parameters

Motor nominal voltage

Motor nominal current

Motor power

Motor nominal frequency

Motor frequency limits

Motor number of poles

Motor nominal speed

Motor min and max frequency

Motor phase reversal

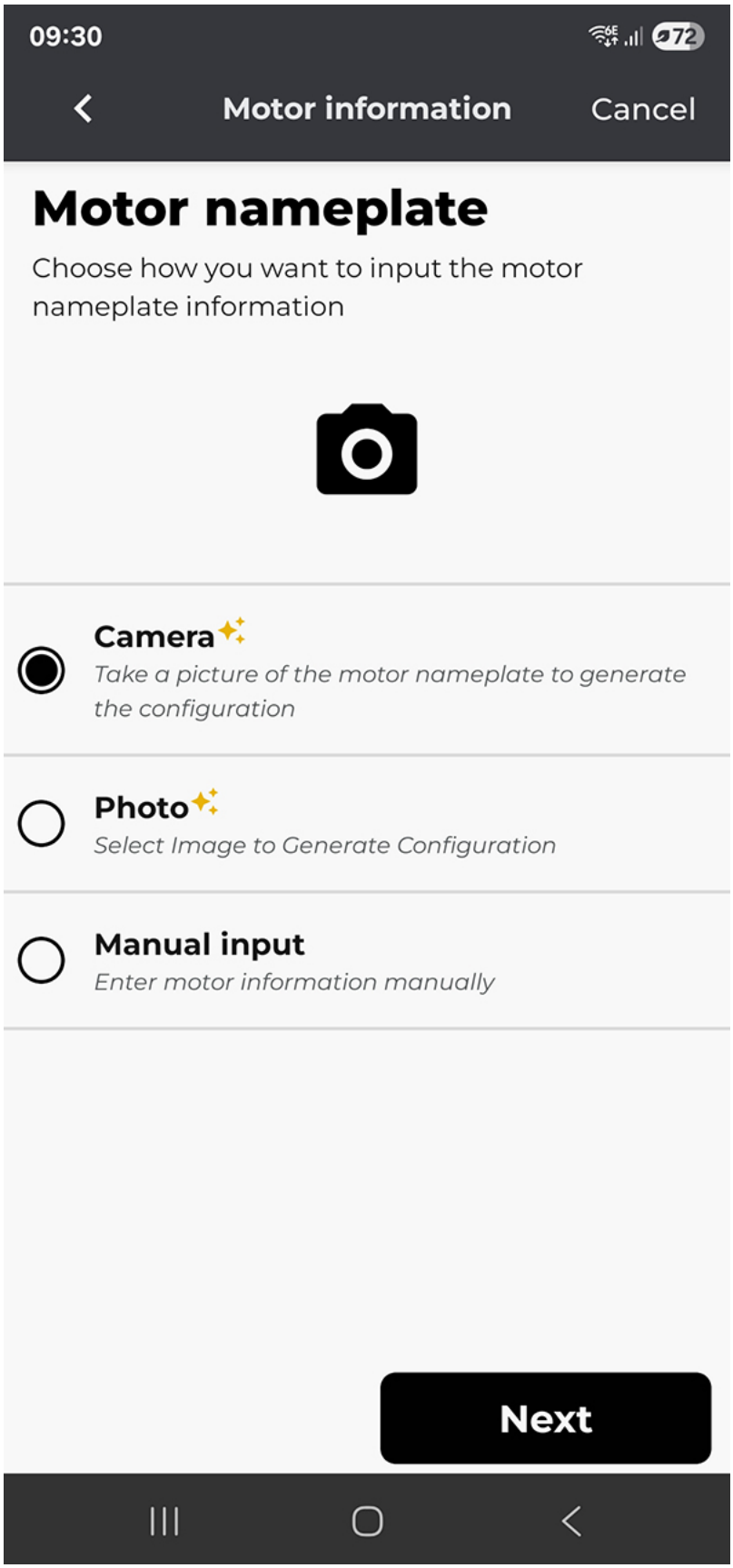
Motor power factor

Entering Motor Nameplate Information

You can capture motor nameplate data in three ways: **using a camera (AI)**, **selecting a Photo (AI)**, or **manually entering the data**.

This section explains when to use each method, how to proceed, and what happens behind the scenes.

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Before you begin:

- **Internet required for AI:** Camera (AI) and Photo (AI) need an active internet connection. If the phone is offline, these options are unavailable, and you'll be prompted to use Manual input.
- **Data storage:**
    - Any photo you capture or select is automatically saved in the app's local database, allowing you to review it later.
    - AI-extracted parameters are saved separately from your corrected values. This preserves a clean audit trail.

Option 1 – Camera (AI)

Use this when you're in front of the motor and can take a clear, straight-on shot of the nameplate.

1. Tap Camera (AI).
2. Frame the entire nameplate. Use on-screen tools:
    - Torch: tap the torch icon to toggle the phone's light on/off.
3. Tap the Capture button.
4. Review the image:
    - If it's blurry, glarey, or cropped: tap Retry to return to the input method selection screen.
    - If it's good: tap next to use the photo.
5. The app uploads the image for AI processing.
6. If the nameplate lists multiple voltage/frequency setups, you'll be prompted to select the setup you intend to use (e.g., 460 V @ 60 Hz, 400 V @ 50 Hz).
7. The app shows a Summary of detected parameters. You can review and edit any field.
8. Tap Continue to proceed to the next step of the commissioning wizard.

If AI can't extract critical parameters (e.g., rated voltage, frequency, rated power, rated current, poles/base speed), you'll see a failure notice, and the app will propose you to try again.

Option 2 – Photo (AI)

Use this when you already have a good picture of the nameplate (e.g., from your gallery or a prior site walk).

1. Tap Photo (AI).
2. Select an existing image that clearly shows the full nameplate.
3. The selected image is saved to the app's database and uploaded for AI extraction.

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4. If multiple setups are detected, choose the desired voltage/frequency setup.
5. Review and edit values on the Summary screen.
6. Tap Continue.

Option 3 – Manual input

Use this when AI is unavailable (no internet) or the photo is unreadable.

1. Tap Manual input.
2. Enter the nameplate fields. Typical required fields include:
    - Rated voltage (V)
    - Rated current (A)
    - Rated power (kW or HP)
    - Frequency (Hz)
    - Number of poles
    - Rated spinning speed (rpm)
    - Min frequency
    - Max frequency
    - Power factor
    - Optional: Brand, motor part number, phase reversal
3. Review and confirm on the Summary screen, then tap Continue.

Summary screen

After any method, you'll land on a Summary page listing all nameplate parameters. Here you can:

- Adjust fields as needed; dependent fields recalculate automatically where applicable.
- Confirm to move on in the wizard.

Privacy & storage

- Photos and parameter data are stored in the app's local database on the phone.
- You can review or remove stored photos later from the app's data management screens (when available).

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8.3.1. Motor nominal voltage

The nominal voltage of the motor is the voltage for which the motor is designed to operate under stable conditions and reliability.

The value must be the one from the motor's nameplate.

The unit is Volt (V)

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8.3.2. Motor nominal current

Always refer to the motor's nameplate information for the most accurate FLA values.

FLA or FLC?

While both terms are related to the current drawn by a motor, they have slightly different meanings and uses:

Motor FLA (Full Load Amperes):

This is the actual current drawn by the motor when it is operating at its rated horsepower and rated voltage.

You can find this value on the motor's nameplate.

It is used for various purposes, including:

- Selecting circuit breakers and overload protection devices for the motor circuit.
- Calculating the power consumption of the motor.
- Comparing the performance of different motors.

Motor FLC (Full Load Current):

This is a standard reference value for the current drawn by a motor of a particular size and type.

You can find these values in tables provided by electrical standards like the National Electrical Code (NEC) in the US.

It is typically used for initial circuit design and planning when the specific motor hasn't been selected yet.

It is not always identical to the actual FLA of a specific motor, as there can be slight variations between different manufacturers and models.

Key Differences:

- Source: FLA is based on the specific motor, while FLC is a general reference value.
- Accuracy: FLA is more accurate for the specific motor, while FLC is an estimate.
- Use: FLA is used for detailed calculations and selection, while FLC is used for initial planning.

In summary:

Use FLA when you have a specific motor and need accurate information about its current draw.

Use FLC for initial planning and design when the specific motor hasn't been selected yet.

Formula

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The formula to calculate the FLA for a three-phase AC motor is:

$$FLA = \frac{Motor\ Power\ in\ kW \times 1000}{V\ \times Power\ factor\ (PF)\ \times Efficiency\ \times \sqrt{3}}$$

In this formula:

- V represents the phase-to-phase voltage for a 3-phase supply.
- Power Factor (PF) is the motor's rated power factor.
- Efficiency (η) is the motor's efficiency.

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8.3.3. Motor power

Nominal motor power in kilowatts (kW) or in horsepower (hp) as indicated on the motor's nameplate

The power of a 3-phase motor is the mechanical power output that the motor can deliver at its shaft when it is operating under its rated conditions.

This power is usually expressed in kilowatts (kW) or horsepower (hp).

The formula to calculate the power of a 3-phase motor is:

$P = \sqrt{3} \times V \times I \times PF$

Where:

- P is the power in watts (W).

- V is the phase-to-phase voltage in volts (V).

- I is the current in amperes (A).

- PF is the power factor.

Always refer to the motor's nameplate for the most accurate power rating.

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8.3.4. Motor nominal frequency

The nominal frequency of a 3-phase motor is the frequency at which the motor is designed to operate and deliver its rated power.

It is usually specified by the manufacturer and can be found on the motor's nameplate.

In most parts of the world, the nominal frequency of the power supply is either 50 Hz or 60 Hz, and motors are designed to operate at these frequencies.

The nominal frequency is important because it affects the motor's speed, torque, and efficiency.

Always refer to the motor's nameplate or the manufacturer's specifications for the correct nominal frequency.

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8.3.5. Motor number of poles

The number of poles in a 3-phase motor is a key factor that determines the motor's speed.

The poles are essentially the magnetic field's points of origin within the motor, which are created by winding sets located around the motor's stator.

In a 3-phase motor, the number of poles can be 2, 4, 6, 8, and so on. The number of poles is always an even number because poles are generated in pairs (north and south).

The more poles a motor has, the slower it will rotate.

The relationship between the number of poles (p), the frequency of the power supply (f), and the synchronous speed of the motor (N) is given by the formula:

N = 120 x f / p

- N is the synchronous speed of the motor in revolutions per minute (RPM).

- f is the frequency of the power supply in hertz (Hz).

- p is the number of poles in the motor.

For example, a 2-pole motor running on a 60 Hz power supply will have a synchronous speed of 3600 RPM, while a 4-pole motor on the same power supply will have a synchronous speed of 1800 RPM.

Always refer to the motor's nameplate or the manufacturer's specifications for the correct number of poles.

Operating a motor with the wrong number of poles can lead to performance issues and potential damage to the motor.

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8.3.6. Motor nominal speed

The nominal speed of a 3-phase motor, also known as the rated speed, is the speed at which the motor operates when it is under full load and supplied with its rated voltage and frequency.

Always refer to the motor's nameplate or the manufacturer's specifications for the correct nominal speed.

Operating a motor at a speed higher than its nominal speed can lead to excessive wear and potential damage to the motor.

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8.3.7. Motor min and max frequency

The minimum and maximum frequencies for a 3-phase motor are the lowest and highest frequencies, respectively, at which the motor can operate without causing damage or significantly reducing its lifespan.

The **minimum frequency** is often determined by the motor's cooling system.

At lower frequencies, the motor's speed decreases, which can reduce the effectiveness of fan cooling.

This can cause the motor to overheat, especially under full load conditions.

The **maximum frequency** is typically limited by the motor's insulation system and mechanical construction.

At higher frequencies, the motor's speed increases, which can lead to increased vibration and mechanical stress.

Additionally, higher frequencies can cause increased losses in the motor's iron core and windings, leading to higher operating temperatures.

Most 3-phase motors are designed to operate at a standard frequency of 50 Hz or 60 Hz. When using a VFD, it's important to ensure that the motor's minimum and maximum frequency limits are not exceeded to avoid damaging the motor.

Always refer to the motor's nameplate or the manufacturer's specifications for the correct minimum and maximum frequency values.

Operating a motor outside of these limits can lead to performance issues and potential damage to the motor.

→ Set Motor frequency limits

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8.3.7.1. Motor frequency limits

Minimum frequency

This is the lower limit of the frequency setpoint

The value of this limit can be set through the SmartDrive app.

The range is between 0Hz and 120Hz. The default value is 1 Hz.

Maximum frequency

This is the upper limit of the frequency setpoint, the value can be set through the SmartDrive app.

The range is between 0.1Hz and 120Hz. The default value is 60Hz.

The maximum frequency must always be greater than the minimum frequency.

The SmartDrive app generates a warning and prevents the configuration from being uploaded if this is not respected.

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8.3.8. Motor phase reversal

The Clean Power VFD allows the user to change the direction of rotation without modifying the wiring of the motor.

If the motor does not turn in the expected direction, clockwise instead of counter-clockwise or vice-versa, a standard solution is to exchange two wires on the power output connectors, the sequence UVW becomes UWV for example.

However, the Clean Power VFD makes this operation easier:

Just change the parameter Phase Reversal, this will invert the forward and reverse spin directions without modifying the drive wiring.

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8.3.9. Motor power factor

The power factor of a 3-phase motor is a measure of how effectively the motor uses the electrical power supplied to it.

It is a dimensionless number between 0 and 1, and it represents the ratio of the real power (in watts) to the apparent power (in volt-amperes) in the circuit.

Mathematically, the power factor (PF) is defined as:

PF =P/S

Where:

- P is the real power in watts (W). This is the power that is actually used by the motor to produce useful work.

- S is the apparent power in volt-amperes (VA). This is the product of the voltage and current supplied to the motor.

A power factor of 1 indicates that all the power supplied to the motor is being used effectively, and the current and voltage are in phase.

This is the ideal scenario, but in reality, the power factor of a motor is usually less than 1 due to the inductive nature of the motor.

This means that some of the power supplied to the motor is used to establish the magnetic field in the motor, and this power (known as reactive power) does not contribute to the useful work output of the motor.

Always refer to the motor's nameplate or the manufacturer's specifications for the correct power factor.

Previous Next

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8.4. Auto-tuning

Auto-tuning is an intelligent function of the Clean Power VFD that allows the refinement of the motor parameters and maximizes the performance of the whole power drive system.

Pre-requisite

Auto-tuning can be run when:

1. The variable frequency drive is in the “ready to run “ state.
2. The motor is at a standstill.
3. The motor is at ambient temperature.
4. The motor's parameters are set correctly at the motor nameplate values and downloaded in the VFD

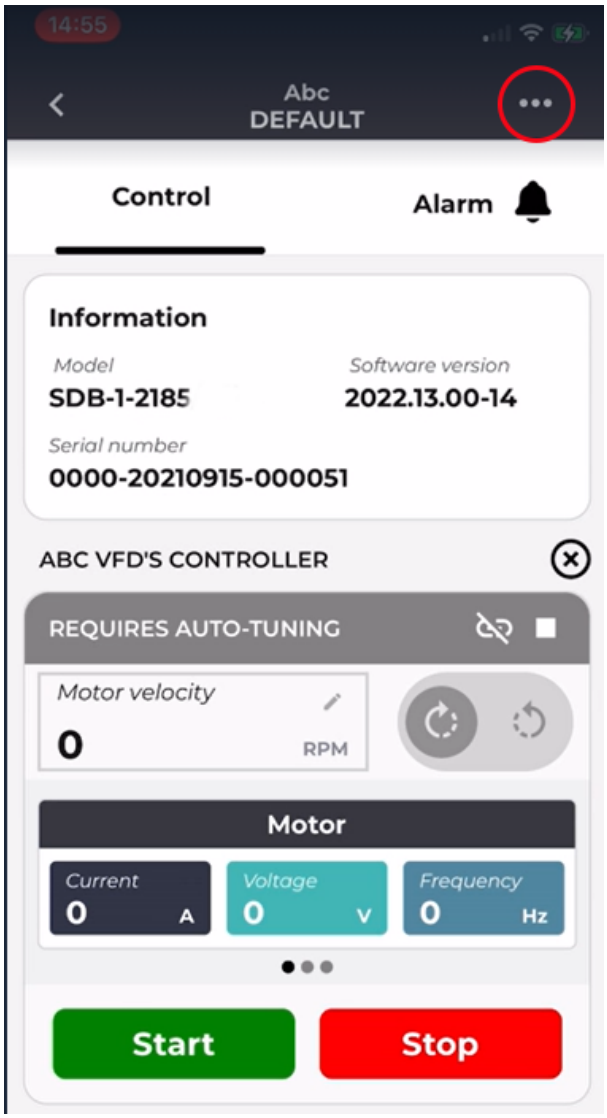
If the VFD is not in the “ ready to run state” or if the back EMF from the motor shows that the motor is spinning, the user can not start the auto-tuning function.

Procedure

The user can initiate the motor auto-tuning process via the mobile App or the HMI:

From the dashboard, tap on the hamburger in the upper right corner of the screen to open the menu.

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Then select "Configuration", and "Motor Auto-Tuning"

When the auto-tuning wizard screen is displayed, tap on the "start".

The auto-tuning starts, and the procedure step is shown by its radio button.

After 5 seconds, the auto-tuning is complete, and the following step, "review the parameters" is accessible.

In case of an error, the application shows an error modal when pressing the icon **!**

When the user leaves the error modal, the application goes to the done state, and the user can start a new auto-tuning sequence by tapping the "retry" button.

When done with success, the user can save and apply the motor values by tapping on the button "Apply"

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8.4.1. Static auto-tuning

When all the prerequisite conditions have been fulfilled, you can execute the static auto-tuning as described in the introduction of this section.

When the auto-tuning function is complete, the variable frequency drive can get two different states depending on the auto-tuning result:

1- Auto-tuning successful (or motor parameters identified):

The auto-tuning function has run correctly, and all parameters are stored.

The page displays:

Auto-tuning complete and motor's advanced parameters stored.

The list of calculated parameters and their values:

- Stator resistance
    - Precision: 5 decimals
    - Unit: ohm
- Rotor resistance
    - Precision: 5 decimals
    - Unit: ohm
- Magnetizing Inductance
    - Precision: 2 decimals
    - Unit: mili-henry (mH)
- Leakage Inductance
    - Precision: 2 decimals
    - Unit: milli-henry (mH)

An icon beside each parameter allows the user to manually overwrite the auto-tuned value.

2- Auto-tuning reports an error if it does not run correctly:

The auto-tuning function did not run correctly, and some parameters are missing or not consistent (motor power and variable frequency drive power do not match, wrong setting of motor nameplate parameters, no connection of converter and motor, osr motor phase loss, can not read currents, sequence intentionally interrupted via a stop command, …).

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The HMI/mobile App then displays:

- Pre-requisite states not fulfilled:
  The variable frequency drive is in the “ready to run “ state, the motor is at a standstill, the motor is at ambient temperature, and the speed setpoint is equal to or close to the motor's nominal speed (nameplate value). The motor parameters are set correctly at motor nameplate values and downloaded in the VFD.

- Motor Not Detected:
  If the VFD can't detect the motor, it could be due to a wiring issue or motor malfunction.

- Incorrect Motor Parameters: Auto-tuning might fail if the entered motor parameters are incorrect.

- Motor temperature is too High: If the motor temperature is too high, it could interfere with auto-tuning.

- Incompatible Motor: If the motor is incompatible with the VFD, the auto-tuning process may fail.

- Mainline Power Supply Issue: If there's an issue with the power supply, this could also interfere with the auto-tuning process.

The choice is given to the user:

- Fix the error(s) and run the auto-tuning again.
  If selected, the wizard returns to the motor parameter’s summary page.

- Manually write the motor’s advanced parameters
  If selected, the list of advanced parameters is displayed, with the icons to write each of them, and the “save” + “Next” buttons

- Skip Auto-tuning
  If selected, the Auto-tuning is canceled (but the operation and its failure are recorded in the login file), and the wizard displays the next step of the configuration operations

Previous Next

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8.4.2. Safety: Dynamic auto-tuning

Please read the following important warnings and precautions before you proceed with the **dynamic auto-tuning** procedure for your motor.

As a user, you must play the role of a vigilant guardian. Your task is to ensure the drive remains safe, even when faced with unforeseen challenges.

DANGER

DANGER — Uncontrolled motor speed during dynamic auto-tuning

Dynamic auto-tuning rotates the motor. If the driven load is overhauling, or if the auto-tuning speed settings are incorrect, the motor can exceed the safe mechanical speed of the machine.

This can cause a mechanical crash, shaft or coupling failure, and serious injury or death to personnel near the rotating parts.

Before starting dynamic auto-tuning, set the Overspeed alarm limit to the same value as, or lower than, the maximum speed allowed for dynamic auto-tuning.

Do not set the Overspeed alarm limit higher than the safe mechanical speed of the motor, load, shaft, coupling, gearbox, or driven equipment.

Keep all personnel away from rotating parts during auto-tuning. Do not perform dynamic auto-tuning on an overhauling load unless the load is mechanically secured and the speed can remain within the safe operating limit.

WARNING

The Unstable Situation:

During dynamic auto-tuning (as during operation), sudden chaos can erupt.

A power surge, an electrical glitch, or an external force can affect the system.

In such moments, the VFD's behavior becomes unpredictable. (e.g: a conveyor belt unexpectedly accelerating or a robotic arm jerking erratically)

Safeguards:

- Emergency Stop (E-Stop) Buttons: The user must ensure that strategically placed emergency push

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- Torque Deactivation (STO) and/or Emergency Stop (E-Stop) buttons: The user must ensure that the Torque Deactivation inputs are connected and working to cut the power to the motor. If Torque Deactivation inputs are not used then the user must ensure that emergency stop buttons are strategically placed to instantly cut the power to the motor.
- Limit Switches: In translating motion applications, the limit switch must trigger a safe shutdown of the power drive system.
- Overcurrent Protection: Circuit breakers or fuses that prevent excessive current must be selected and correctly wired before running a dynamic auto-tuning.

User Responsibility: The Final Checkpoint:

As the user, your responsibility is twofold:

- Verification: verify that all safeguards are in place. Inspect the Torque Deactivation inputs, E-Stop buttons, limit switches, and protective devices.
- Education: Understand how each safeguard functions. Know where the E-stop buttons are located, and familiarize yourself with the system's behavior during unstable situations.

1. Safety First

- Ensure all personnel involved are trained and knowledgeable about the dynamic auto-tuning process.
- Ensure the area around the motor is clear of any obstructions or potential hazards.
- Disconnect the power supply to the motor and follow proper lockout/tagout procedures before initiating tuning.

2. Proper Equipment:

- Use appropriate test equipment and tools, and ensure they are calibrated and in good working condition.
- Double-check the compatibility of your motor control system with the selected tuning method.

3. Environmental Considerations:

- Ensure that the operating environment (temperature, humidity, etc.) is within the specified limits for the motor and control system.

4. Monitor Progress:

- Continuously monitor the auto-tuning process to ensure it proceeds as expected, and be prepared to interrupt it in case of any irregularities.

5. Emergency Procedures:

Familiarize yourself and your team with emergency shutdown procedures if the motor behaves unexpectedly during tuning.

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6. Expert Consultation:

If you encounter any doubts or difficulties during the dynamic auto-tuning process, do not hesitate to consult our technical support team or a qualified expert for assistance.

7. Record Keeping:

- Maintain a detailed record of the tuning process, including parameters used, any issues encountered, and the final results.

Please be aware that improper execution of the dynamic auto-tuning process can lead to motor damage, safety risks, and operational disruptions.

We strongly advise you to exercise caution, adhere to safety protocols, and seek professional guidance if needed.

Your safety and the optimal performance of your motor are of utmost importance to us.

Thank you for choosing our products and services. If you have any questions or concerns, please do not hesitate to contact our customer support team.

Previous Next

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8.4.3. Set and Run the dynamic auto-tuning

This operation is executed with the load connected to the motor so that motor + load inertia is measured.

If an encoder is installed, related encoder parameters must be set (Pulses per revolution of the encoder).

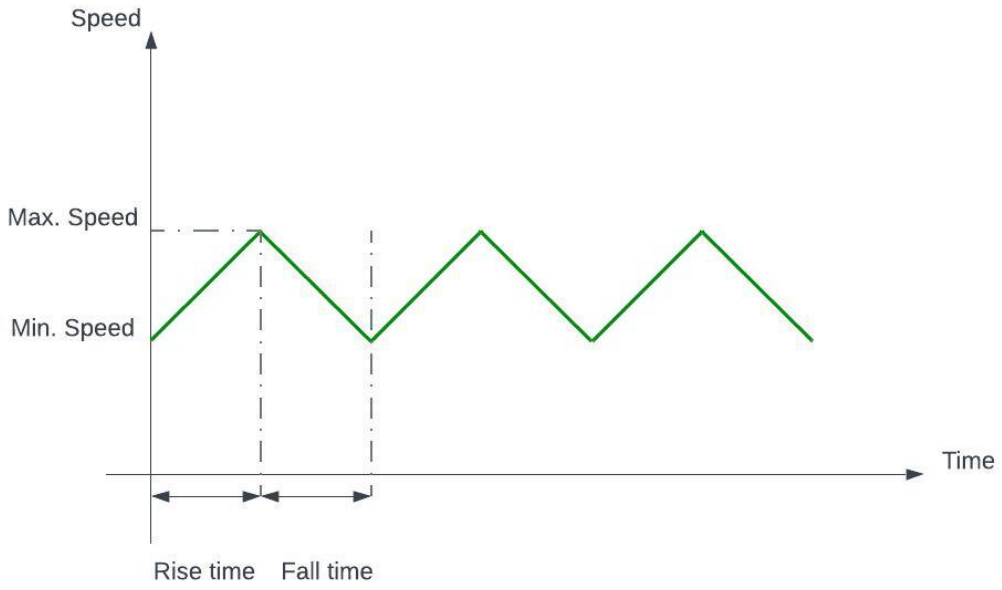
When executing the dynamic auto-tuning, the Clean Power VFD runs the motor at 2 different speeds, with a pre-defined rise and fall time between those 2 speeds, and with a controlled torque. This defines a triangle pattern.

During the execution of this pattern, the VFD observes the motor's response and calculates the system's inertia (motor + load). Unit: kg * m^2

To execute this pattern safely and correctly, the user must define the parameters of this pattern.

Before running the dynamic auto-tuning, the user interface(s) (HMI/mobile app) displays the default values of the dynamic auto-tuning parameters with the option to either validate them as they are or to change their value.

There are typical ranges for those parameters, however, the load inertia and motor capabilities are different from one application to another. Then the setting ranges shall cover the complete capability of the motors and not simply the typical use-cases. Use cases are given as information not as rules.



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Dynamic auto-tuning parameters:

Max speed (%):

Settable as a percentage of the motor nominal speed from 0 to 100%.

Default value = 70 %.

It should be bigger than “Min speed (%)”.

Typically it should be set between 50% to 90% of the motor’s nominal speed.

Min speed (%):

Settable as a percentage of the motor nominal speed from 0 to 100%.

Default value = 30 %.

It should be smaller than “Max speed (%)”.

Typically it should be set between 10% to 50% of the motor’s nominal speed.

Torque max (% of n.m):

The amount of torque that will be used when executing the dynamic auto-tuning.

Settable as a percentage of the motor-rated torque from 0.1 to 100.0%.

Default value = 70%.

Typically it should be set between 50% to 90% of the rated torque.

Rise and fall time (s):

The rise and fall time determines how quickly the VFD changes the speed output during the auto-tuning pattern. Time in seconds, for the VFD to change the speed output from auto-tuning min speed to auto-tuning max speed.

Range: 0.00 s to 10.00 s. Default value = 0.50 s.

The user shall set this value based on the motor’s characteristics. Smaller values (e.g., 0.1 to 0.3 seconds) provide faster tuning but may sacrifice accuracy. Larger values (e.g., 1 to 2 seconds) enhance accuracy but extend the tuning process.

Execute the dynamic auto-tuning parameters:

When the parameters are validated according to the application, the dynamic auto-tuning can be started.

Previous Next

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8.4.4. Dynamic auto-tuning recommended settings

Dynamic auto-tuning is highly recommended for typical applications below:

(This is not a complete list of applications, other applications could also benefit from the dynamic auto-tuning feature):

1. High-Inertia Conveyor System:

- Motor Characteristics: This system involves a large conveyor with heavy loads.

- Application Requirements: Accurate control over speed during both acceleration and deceleration is critical.

- Optimized Rise and Fall Time: Extended times (e.g., 1.5 seconds) provide more data points, enhancing stability and ensuring smoother transitions under load.

2. Pump System for Water Treatment Plant:

- Motor Characteristics: A pump motor designed for varying water demand levels.

- Application Requirements: The system must quickly adapt to changes in water flow.

- Optimized Rise and Fall Time: Shorter durations (e.g., 0.3 seconds) allow for rapid adjustments, matching the dynamic requirements of the application.

3. Textile Industry Weaving Machine:

- Motor Characteristics: A medium-sized motor that drives a weaving machine.

- Application Requirements: Maintaining consistent fabric tension is necessary throughout the weaving process.

- Optimized Rise and Fall Time: Tailored settings (e.g., 0.6 seconds) prevent sudden changes in tension, ensuring smooth fabric handling.

4. HVAC Fan Motor:

- Motor Characteristics: A fan motor used in HVAC systems for efficient and quiet operation.

- Application Requirements: The system should operate efficiently while minimizing noise.

- Optimized Rise and Fall Time: Longer settings (e.g., 1 second) minimize electrical stress and noise, enhancing user comfort and system efficiency.

Recommendations for dynamic auto-tuning settings

1. Motor Stress and Overheating:

Short rise and fall times lead to quick changes in motor speed. This rapid acceleration and deceleration can place significant stress on the motor's windings, bearings, and other mechanical components.

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This stress can cause the motor to overheat, which may reduce its operational lifespan and lead to damage.

Ensuring adequate rise/fall times to prevent these issues is crucial.

2. Inaccurate Inertia Calculation:

The duration of rise and fall times directly influences the precision of inertia calculations. Short durations may not provide enough data points at varied speeds, leading to errors in inertia estimation.

Errors in inertia calculation can negatively affect the motor's control and operational stability.

3. Electromagnetic Interference (EMI):

Quick transitions in speed can cause rapid changes in voltage and current, generating electromagnetic interference. This interference can disrupt the operation of nearby electronic devices.

Adjusting the rise and fall times can help control and reduce the amount of EMI produced.

4. Control Instability:

If the rise and fall times are too brief, they can destabilize the control systems of the motor. Inaccurate parameter adjustments by the VFD can result in oscillations or unpredictable motor behavior.

Control stability is crucial for consistent motor operation.

5. Risk of Tripping or Faults:

Very short rise and fall times are likely to activate fault alarms or cause the motor protection systems to trip, potentially leading to sudden shutdowns to avoid damage.

It is important to optimize these times to prevent such disruptions.

6. Recommended Approach:

- Begin with a standard rise and fall time (suggested starting point: 0.5 seconds) and adjust based on the motor’s performance during auto-tuning.

- Carefully observe how the motor responds to different settings and find a balance between precision (favoring longer times) and responsiveness (favoring shorter times).

Previous Next

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8.4.5. Auto-Tuning errors

The auto-tuning function did not run correctly, and some parameters are missing or not consistent

- Motor power and variable frequency drive **power do not match**.
- **Wrong setting of motor nameplate parameters**
    - number of poles,
    - nominal input frequency (Hz),
    - nominal velocity (rpm),
    - nominal power,
    - nominal current,
    - nominal voltage.
- **Motor Not Detected:** No connection to the motor or motor phase loss, or motor malfunction.
- **can not read currents**,
- **Sequence intentionally interrupted** via a stop command,
- **Pre-requisite states not fulfilled:**
    - The variable frequency drive is in the “ready to run “ state or in the "needs autotune" state,
    - The motor is at a standstill,
    - The motor is at ambient temperature,
    - Motor parameters are set correctly at motor nameplate values and downloaded into the VFD.
- **Motor Temperature Too High:**
  If the motor temperature is too high, it could interfere with auto-tuning.
- **Incompatible Motor:**
  If the motor is incompatible with the VFD, the auto-tuning process may fail.
- **Mainline Power Supply Issue:**
  if a problem occurs with the grid during the autotuning, an alarm will be raised, and the autotuning process will be stopped without returning any result. In this case, the user needs to verify the system state and the alarms

You can:

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- Fix the error(s) and rerun the auto-tuning.
- Manually write the motor's advanced parameters
- Skip Auto-tuning (note that without auto-tuning, the motor control mode is limited to frequency)

Previous Next

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8.5. Motor Control Mode

The user can select how the algorithm controls the motor.

Choice can be made between **Frequency**, **Velocity V/f, velocity iFOC, and Torque iFOC**

The user selects this parameter during the configuration stage of the VFD and can not change it when the VFD is in operation.

The default value is "Frequency".

Frequency (Hz)

In frequency mode, also known as scalar V/f, the motor speed is set in Hertz (Hz), and the applied voltage is adjusted automatically.

The ratio V/f directly affects the magnetic flux in the motor. This helps prevent motor overheating and saturation, ensuring optimal motor performance.

This mode is suitable for asynchronous three-phase induction motors.

Velocity V/f (RPM)

In Velocity V/f mode, the motor speed is set in revolutions per minute (RPM).

The control is similar to frequency mode, and the slip is automatically compensated to get the motor speed as close as possible to the synchronous speed.

This mode is suitable for asynchronous three-phase induction motors.

Velocity iFOC (RPM)

iFOC, or Indirect Field Oriented Control, is a way to control induction motors. It's an open-loop field-oriented control.

iFOC decouples the rotor flux and torque-producing current components of the stator current.

It means it separates two important aspects of how the motor works - the magnetic field created by the rotor and the force that the motor produces.

By controlling these two things separately, we can make the motor work more efficiently and precisely.

Torque iFOC (%)

In Torque iFOC mode, the VFD controls the motor torque directly rather than the motor speed.

The user sets a desired torque value in percentage (%), and the VFD adjusts the motor's current to produce the required torque output.

Torque iFOC mode decouples the control of motor torque and flux, allowing for precise management of the torque generated by the motor.

This mode is particularly useful in applications where constant torque is required, such as in conveyors, cranes, and hoists.

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8.5.1. General

The following points apply to every motor control mode

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8.5.1.1. Acceleration and deceleration

Acceleration time

Acceleration time, also known as **ramp-up time**, defines the duration required for the motor to transition from a standstill to its rated speed.

- **In torque control**, it refers to the time needed for the motor torque to increase from zero to 100% of its rated value.
- The default setting **is 20 seconds**, but this may not suit all applications.
- The acceleration time is adjustable up to **3600 seconds.**
- **Caution:**

  Setting the acceleration time too short can result in overcurrent conditions.

Deceleration time

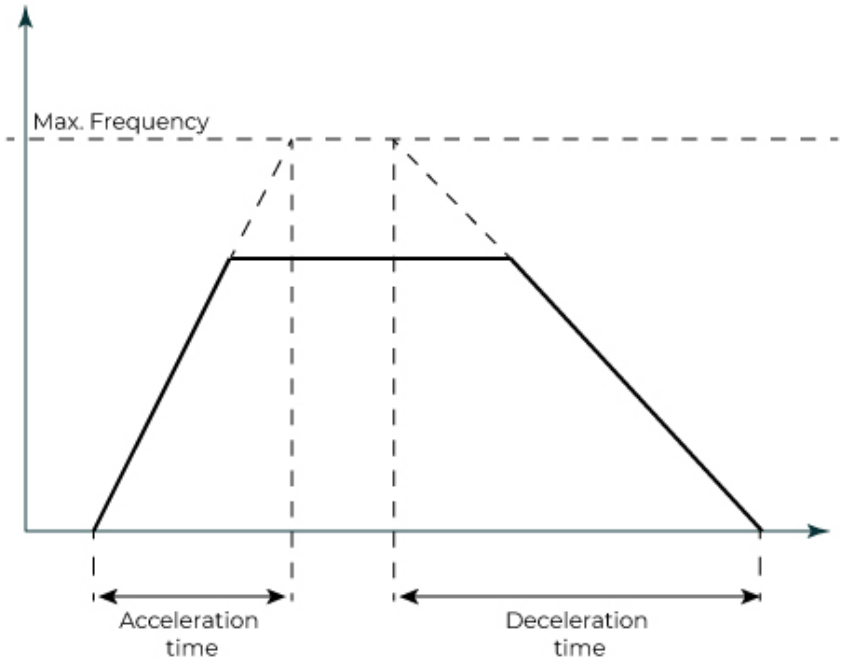
Deceleration time, also called **ramp-down time**, controls the time needed for the motor to slow down, typically to a complete stop.

- **In torque control**, it defines the time required for the motor torque to decrease from its rated value to zero.
- The default setting is **20 seconds**, but this can also be adjusted up to **3600 seconds** to fit specific application needs.
- During deceleration, the motor speed exceeds the synchronous speed (corresponding to the Clean Power VFD output frequency), causing the motor to act as a generator. This process, known as

  regeneration, results in the motor returning energy to the VFD, causing the DC voltage to increase.

if the deceleration time is too short it will produce an overvoltage condition

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8.5.1.1.1. Acceleration and deceleration ramp selection

The Clean Power VFD allows the user to define **up to 4 acceleration and 4 deceleration ramps**.

With digital inputs, Modbus TCP, BACnet IP, and user-friendly interfaces on both the HMI and mobile app, operators can easily manage and switch between predefined ramps to suit specific motor performance requirements.

The selection of ramps can be achieved through:

- Digital Inputs (DI)
- Modbus TCP
- BACnet IP

Digital Input (DI) Ramp Selection

Using a single digital input (DI), the user can switch between two defined acceleration and deceleration ramps.

DI Assignment:

- The mobile app allows the user to assign a digital input for switching both acceleration and deceleration ramps.
- This same digital input is used for switching during both ramp-up and ramp-down phases.

Ramp Switching:

- When the digital input changes from 0 to 1, the VFD will switch from ramp 1 to ramp 2 during both ramp-up and ramp-down.
- When the digital input changes from 1 to 0, the VFD will switch from ramp 2 to ramp 1 during both ramp-up and ramp-down.

Acceleration Ramp Only Selection

In this mode, a dedicated digital input can be used to control only the acceleration ramp selection.

DI Assignment:

- The mobile app allows the user to assign a digital input exclusively for switching the acceleration ramp.

Ramp Switching:

- When the digital input changes from 0 to 1, the VFD will switch from acceleration ramp 1 to acceleration ramp 2 during ramp-up.

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- When the digital input changes from 1 to 0, the VFD will switch back to acceleration ramp 1 during ramp-up.

Deceleration Ramp Only Selection

This mode allows for using a dedicated digital input for selecting only the deceleration ramp.

DI Assignment:

- The mobile app allows the user to assign a digital input exclusively for switching the deceleration ramp.

Ramp Switching:

- When the digital input changes from 0 to 1, the VFD will switch from deceleration ramp 1 to deceleration ramp 2 during ramp-down.
- When the digital input changes from 1 to 0, the VFD will switch back to deceleration ramp 1 during ramp-down.

Modbus TCP Ramp Selection

Acceleration Ramp Selection

- The Modbus TCP interface provides a specific register for selecting the acceleration ramp.

Ramp Switching:

- On a Modbus write operation to the acceleration ramp register, the VFD will switch from the current ramp to the specified acceleration ramp (1-4) during ramp-up.

Deceleration Ramp Selection

- A separate register is provided via Modbus TCP for deceleration ramp selection.

Ramp Switching:

- A write operation on the deceleration ramp register will switch the VFD to the selected deceleration ramp (1-4) during ramp-down.

BACnet IP Ramp Selection

Acceleration Ramp Selection

- The BACnet IP protocol supports a BACnet MV (Multi-State Value) object for selecting the acceleration ramp.

Ramp Switching:

- When a command/write operation is performed on the acceleration ramp MV object, the VFD will switch from the current ramp to the selected acceleration ramp (1-4) during ramp-up.

Deceleration Ramp Selection

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- A separate BACnet MV object is provided for selecting the deceleration ramp.

Ramp Switching:

- A command/write operation on the deceleration ramp MV object will switch the VFD to the selected deceleration ramp (1-4) during ramp-down.

HMI and Mobile App Ramp Selection

When more than one ramp is defined for acceleration or deceleration, both the HMI and mobile app display the currently selected ramp during both ramp-up and ramp-down phases.

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8.5.1.1.2. Multi-segment ramps

The multi-segment ramps feature allows users to precisely control the motor's acceleration and deceleration profiles within the VFD.

This functionality is used in applications where the transition between different speed phases must be controlled, helping to optimize performance, reduce mechanical stress, and improve energy efficiency.

Purpose

The multi-segment ramp functionality is designed to provide enhanced flexibility when controlling motor speed.

It enables users to define multiple ramp segments, each with distinct acceleration and deceleration rates, suited to various phases of an application.

This feature is particularly useful for:

- Conveyor Systems: Adjust speeds at different points to accommodate various materials.
- Cranes and Hoists: Smooth transitions between speeds reduce mechanical stress and extend equipment lifespan.
- Centrifuges and Pumps: Avoid sudden speed changes that could cause mechanical shock or fluid turbulence.
- Textile Machines: Gradual speed changes maintain the integrity of delicate materials during processing.

How It Works

Users can configure multiple acceleration and deceleration segments within a speed profile.

Each segment allows for a different rate of acceleration, ensuring that the motor behaves predictably, without unnecessary stress or energy waste.

Acceleration:

When the VFD receives the command to run, it accelerates the motor according to the ramp-up time 1 (1 on the graph).

Then it switches to the ramp-up time 2 (2 on the graph) when the ramp-up switch frequency (5 on the graph) is reached.

And so on up to 4 ramps-up if more than 2 ramps-up are configured.

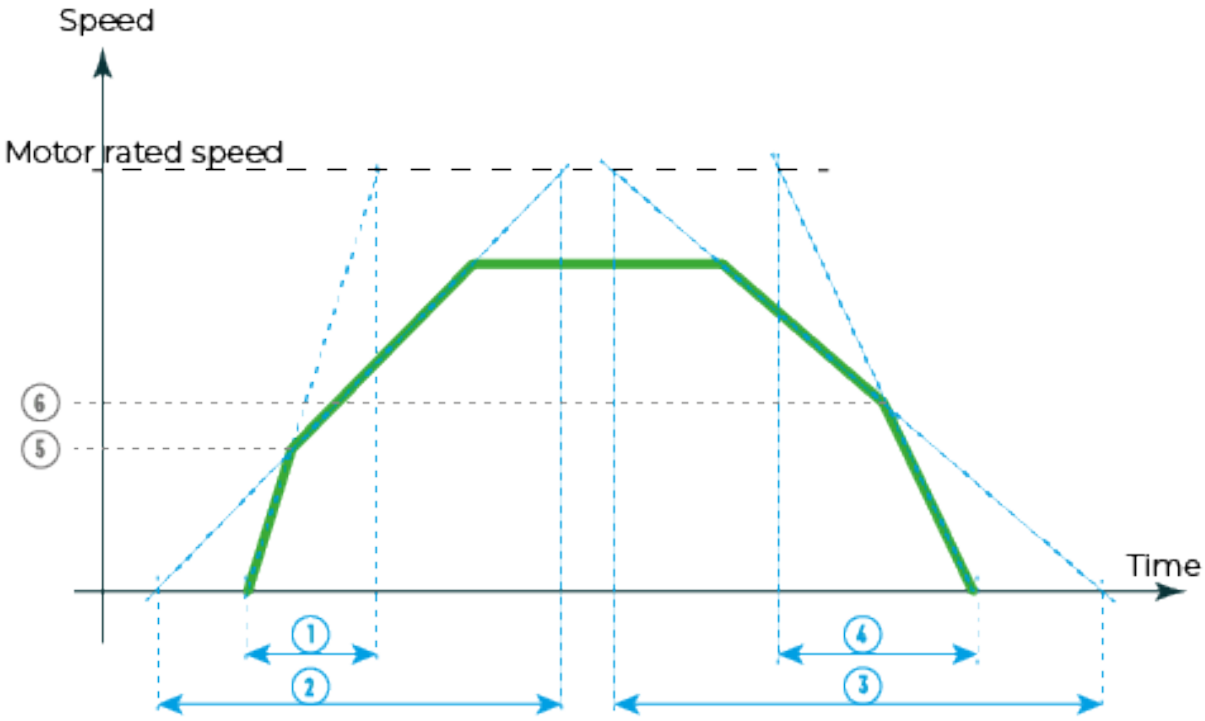
Deceleration:

When the VFD receives the command to stop, it decelerates the motor according to the ramp-down time 2 (3 on the graph).

Then it switches to the ramp-down time 1 (4 on the graph) when the ramp-down switch frequency (6 on the graph) is reached

And so on up to 4 ramps-down if more than 2 ramps-down are configured.

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Ramp Definitions:

Acceleration time, or **ramp-up time**, controls the time between when the motor starts from 0 and when it reaches its rated speed (in Hz or RPM, defined on the motor nameplate).

Deceleration time, or **ramp-down time**, controls the time that is taken to slow the motor down from its rated speed (in Hz or RPM, defined on the motor nameplate) to zero.

Configuration Guidelines

To configure multi-segment ramps, follow these steps:

Access the ramp configuration section in the VFD's configuration menu.

1. Define each ramp-up time: [ramp-up time 1] up to [ramp-up time 4] from 0 to 3600s. Take care that the total sum of all the ramps-up is not greater than 3600s.
2. Define each ramp-down time: [ramp-down time 1] up to [ramp-down time 4] from 0 to 3600s. Take care that the total sum of all the ramps-down is not greater than 3600s.
3. Define the frequency threshold to switch from one ramp-up to the next:
    a. Ramp-up switch frequency 1 between ramp-up 1 and ramp-up 2,

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b. Ramp-up switch frequency 2 between ramp-up 2 and ramp-up 3,

c. and Ramp-up switch frequency 3 between ramp-up 3 and ramp-up 4.

4. Ensure that the ramp-up switch frequencies are increasing: Switch frequency 1 < switch frequency 2 < switch frequency 3

5. Define the frequency threshold to switch from one ramp-down to the next:

   a. Ramp-down switch frequency 1 between ramp-down 1 and ramp-down 2,

   b. Ramp-down switch frequency 2 between ramp-down 2 and ramp-down 3,

   c. and Ramp-down switch frequency 3 between ramp-down 3 and ramp-down 4.

6. Ensure that the ramp-down switch frequencies are decreasing: Switch frequency 1 > switch frequency 2 > switch frequency 3

When the ramp value is configured = 0 then this ramp is disabled and the related frequency switch is disabled.

When a setpoint changes, the specific ramp to be used will depend on whether the conditions for **[Ramp-up/down, Switching]** are met. The VFD will select the appropriate segment (Ramp 1 or Ramp 2, etc.) based on the set parameters and the state of the switching condition.

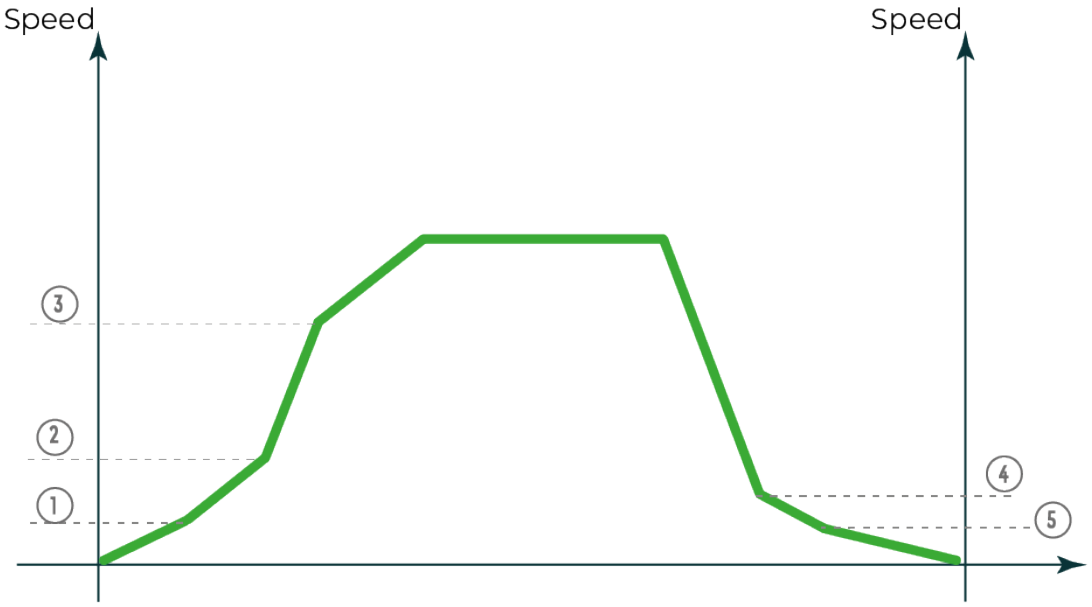
Example:

Profile of acceleration and deceleration with:

4 ramps-up with different times and 3 ramp-up switching frequencies, allowing smooth the acceleration of the driven load,

and 3 ramps-down with different times, sequenced by 2 ramp-down switching frequencies for a fast deceleration followed by a smooth and controlled landing of the driven load.

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8.5.1.2. Stopping the motor

When the motor is in running status, it can be stopped by receiving a **normal stop** command.

The **normal stop** command is not a stop driven by the torque deactivation function, nor a stop commanded by an alarm action.

The normal stop command can come from:

- a digital I/O that has been configured to do so, or by the absence of a run command in the 2-wires configuration of the I/O
- an action on the stop button of the HMI
- an action on the stop button of the mobile app
- A stop command received from the communication media

While configuring the VFD, the user can define how the VFD stops the motor when the normal stop command is received. This is a configuration made with the mobile App that can not be changed when the VFD is in operation.

Choices are:

- Ramp down
- Freewheel

Ramp Down

Purpose: Ramp down involves gradually reducing the motor speed over a set time. This is done by decreasing the frequency and voltage supplied to the motor in a controlled manner.

Typical Applications:

- Conveyor Systems: To prevent material spillage or damage by allowing conveyors to come to a smooth and controlled stop.
- Centrifugal Pumps and Fans: To avoid water hammer in pumps and to reduce stress on fans and blowers.
- General Industrial Machinery: To ensure a smooth and controlled deceleration of equipment, minimizing mechanical stress.

Freewheel (Coasting)

Purpose: Freewheel or coasting stop simply removes power from the motor, allowing it to slow down and stop on its own due to friction and load inertia.

Applications:

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- Emergency Stop Situations: When an immediate power cut is required without considering the deceleration profile.
- Low-Inertia Loads: Applications where the load naturally comes to a stop quickly without additional braking effort.
- Safety Systems: When safety systems dictate that power should be removed immediately.

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8.5.1.2.1. Priority of stop command

Both in local mode and distant mode, the stop command is **always the highest priority,** even when some conflicting commands are sent to the VFD from a different source.

In control mode 3-wires:

In the case of a stop command that overrides a run command, this being a true logical state (1) and not a rising edge, a warning is displayed on the HMI and a new start must only be authorized when the active run command(s) have returned to a false logic state (0) and the VFD has returned to “ready to run”.



In control mode 2-wires:

Unexpected start: In 2-wire control, if STOP overrides RUN, the motor will **automatically restart** when STOP is released **if RUN FWD or RUN REV remains active**.

Previous Next

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8.5.1.3. Spinning direction

Reverse Rotation Prevention

Spinning Direction Priority

Change spinning direction

Previous Next

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8.5.1.3.1. Reverse Rotation Prevention

If the motor must be run in only one direction, the reverse rotation can be disabled.

The parameter allows the user to enable/disable the rotation in the reverse direction.

Previous Next

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8.5.1.3.2. Spinning Direction Priority

Overview

In forward and reverse motor operations applications, the **RUN FORWARD** and **RUN REVERSE** commands can be activated simultaneously.

The Spinning Direction Priority feature allows you to define how the Variable Frequency Drive responds in such scenarios.

This section explains the Spinning Direction Priority options and guides you through configuring the VFD to suit your application's needs.

Purpose

- **Prevent unintended motor behavior** when conflicting directional commands are received.
- **Provide flexibility** by allowing you to assign priority to either the forward or reverse command.
- **Enhance safety and control** by defining clear motor responses in simultaneous command situations.

Spinning Direction Priority Options

The VFD offers four configurable options when both **RUN FORWARD** and **RUN REVERSE** commands are received at the same time:

1. Stop the Motor and Raise a Medium Alarm (Default)

- **Behavior:**

  The motor will **stop** according to the configured stop mode (e.g., ramp stop, coast stop).

- **Alarm:**

  A medium-level alarm is raised to indicate the simultaneous activation of conflicting commands.

- **Use Case:**

  This is best for applications requiring the motor to cease operation immediately upon detecting conflicting commands for safety or process reasons.

2. Maintain Current State

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- **Behavior:**
    - If the motor is **stopped** or **freewheeling**, it will **not start**.
    - If the motor **runs**, it will **continue operating in its current direction** without change.
    - An event is recorded in the audit log of the occurrence of simultaneous commands.
- **Use Case:**

  Ideal for applications where unintended starts or changes in direction must be avoided unless explicitly commanded.

3. Priority to RUN FORWARD

- **Behavior:**
    - The motor will **start or continue running forward**, overriding any reverse command.
    - If the motor is running in reverse, it will **change direction to forward.**
- **Direction Change:**

It applies a seamless direction change if it has been enabled and configured.

- **Use Case:**

  It is suitable when the forward operation is critical and should take precedence over reverse commands.

4. Priority to RUN REVERSE

- **Behavior:**
    - The motor will **start or continue running in reverse**, overriding any forward command.
    - If the motor is running forward, it will **change direction to reverse.**
- **Direction Change:**

It applies a seamless direction change if it has been enabled and configured.

- **Use Case:**

  Ideal when the reverse operation is more critical and should override forward commands.

Configuring Spinning Direction Priority

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In the advanced motor control settings, find the parameter labeled **"Spinning direction priority"**

Select the desired option based on your application requirements:

- **Stop the Motor and Raise a Medium Alarm (Default)**
- **Maintain Current State**
- **Priority to RUN FORWARD**
- **Priority to RUN REVERSE**

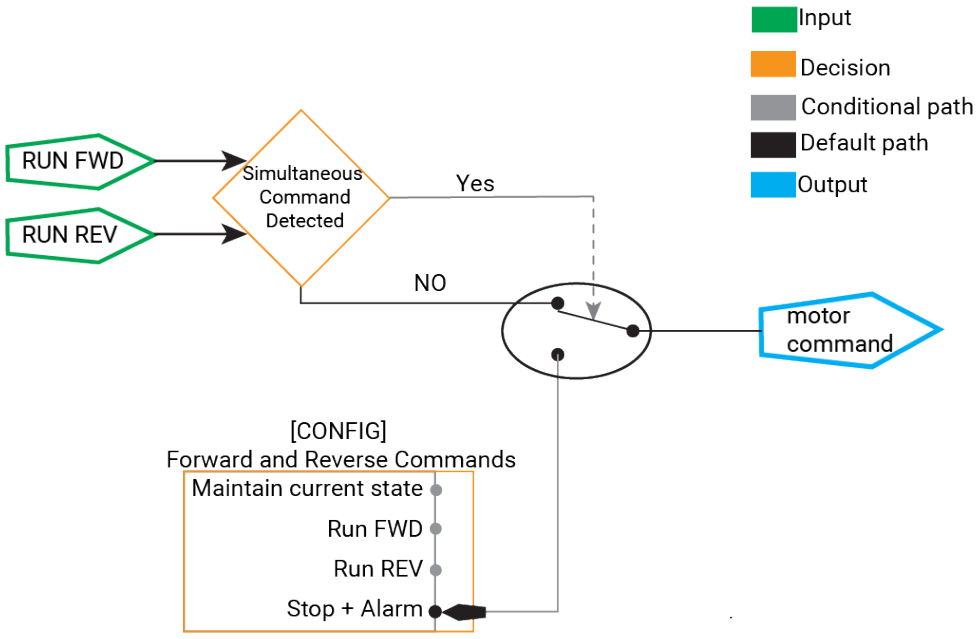
To ensure smooth direction changes without stopping the motor when the spinning priority is set to Forward or Reverse, follow these steps:

1. Go to **Advanced Motor Control Settings**.
2. Enable **Seamless Direction Change**.



- **Review Application Requirements:** Before changing the spinning direction priority settings, assess the operational needs and safety implications.
- **Test Configurations:** After configuring, perform controlled tests to ensure the motor behaves as expected.
- **Consult Documentation:** For detailed information on alarms, stop modes, and the seamless direction change feature, refer to other sections of the user guide.

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8.5.1.3.3. Change spinning direction

The **Seamless Direction Change** feature allows for a seamless transition between forward and reverse motor directions without bringing the motor to a complete stop.

When enabled, the VFD continues to use the active deceleration and acceleration ramps, providing smoother direction changes.

When the VFD receives the command to spin the motor in the opposite direction from its current rotation, the VFD takes control of a seamless transfer between the two directions, executing a ramp down, followed by a ramp up. Without the need for a standstill stop between the two spinning directions.

This feature enhances operational efficiency, minimizes mechanical stress, and fulfills specific application needs.

Benefits of Seamless Direction Change

1. Operational Efficiency
    - Reduced Downtime: Avoiding a complete stop reduces interruptions, enhancing productivity in applications with frequent direction changes.
    - Continuous Operation: Critical in processes requiring uninterrupted workflow.
2. Mechanical Stress Reduction
    - Smooth Transitions: Prevents the sudden jerks and stops that can lead to wear on mechanical components.
3. Application-Specific Needs
    - Process Continuity: Prevents disruption in sensitive processes, ensuring seamless operation.
    - Precise Control: Allows precise motor direction and speed control without interruption.

Typical Applications

1. Conveyor Systems
    - Material handling and sorting systems benefit from smooth transitions to avoid jostling or damage.
2. Cranes and Hoists
    - Precise positioning with minimized load swinging.

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3. Mixing and Agitation
    - In chemical and food processing, smooth changes in direction maintain product consistency.
4. Textile Machinery
    - High-speed operations without stopping to ensure fabric quality and prevent defects.

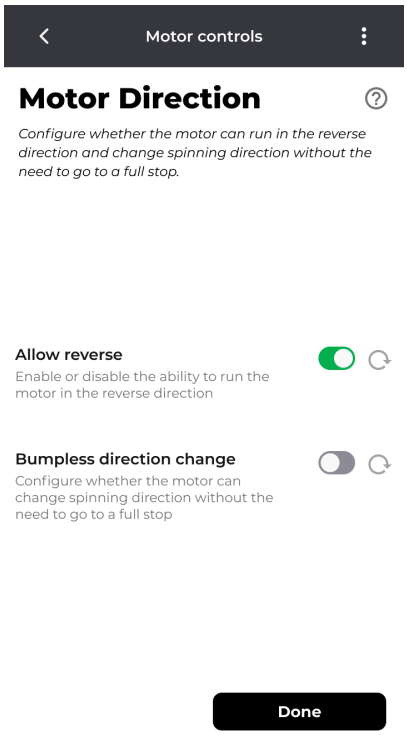
Configuration

The Seamless Direction Change feature is configurable in the VFD settings:

Seamless Direction Change: **If the reverse rotation is enabled** (the parameter "allow reverse" is enabled in the Motor Controls chapter of the configuration wizard), Seamless Direction Change can be enabled.

This parameter can be set to:

- **Disabled** (default): A stop command is required before the VFD will accept a command to spin the motor in the opposite direction from its current rotation.
- **Enabled**: The VFD will accept and execute a command to spin the motor in the opposite direction without requiring a stop command in between.



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Example:

see the below picture

1 - Run forward and run reverse are simultaneously active. Then the VFD does not start.

2 - Only run forward is active, then the motor ramps up to reach the speed setpoint.

3- Run reverse is activated, Run forward is not activated, and the motor spins in the run forward direction. The run reverse command initiates a bumpless direction change, ramping down the motor as per the active ramp down.

4- at the end of the ramp down, and when the motor reaches zero speed, the VFD accelerates the motor in the reverse direction as per the active user-defined ramp-up to reach the speed setpoint.

5- The stop command is activated. The motor starts to ramp down (or decelerates in freewheeling) as per the user-defined ramp-down time.

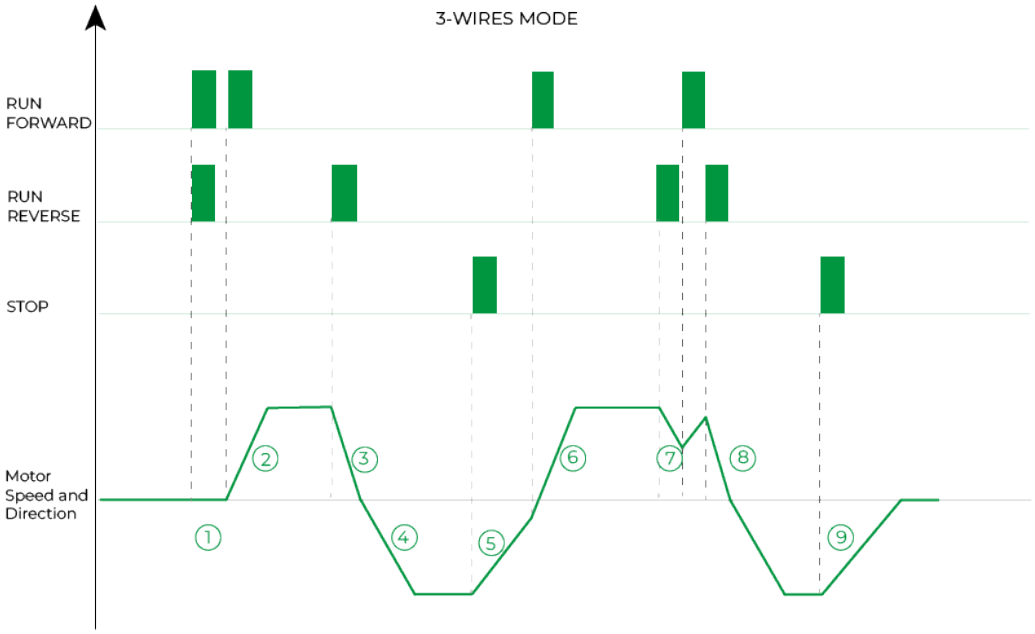
6- The run forward command is activated before the ongoing ramp down is complete. As soon the motor reaches zero speed, the VFD accelerates the motor in the forward direction as per the active user-defined ramp-up to reach the speed setpoint.

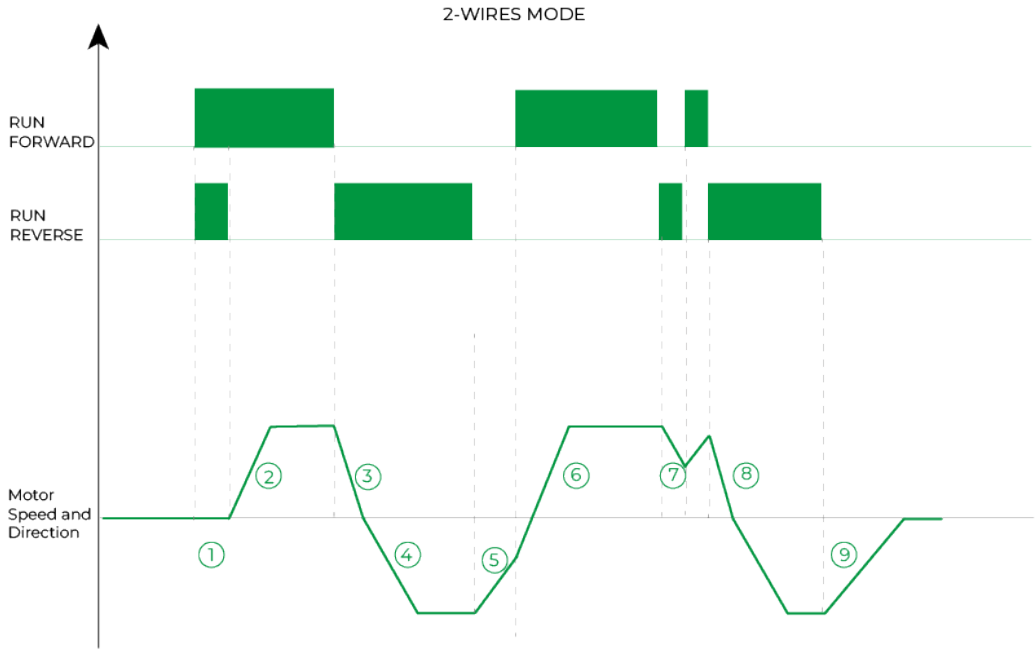
7. Run reverse is activated and not run forward, then the VFD initiates a bumpless direction change. Before the end of the movement, another command of direction change happens, and then the VFD re-accelerates the motor to keep spinning in the initial direction, as per the active ramp-up time.

8- Run reverse is activated before reaching the setpoint, the VFD acts as in step 3.

9- Stop is activated, and the motor ramp-down till its standstill position

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8.5.1.4. Over modulation

When the required output voltage of the Clean Power VFD exceeds a factory-defined limit (typically when running over-synchronously), the output voltage is increased by over-modulation.

Some applications may face vibrations if the harmonics generated by the over-modulation are close to the resonance frequency of the driven system.

Users can minimize the vibrations by disabling the over-modulation function.

To Disable the Over modulation:

There is one parameter named Over modulation.

Its value can be ON or OFF.

Its default value is: ON (over modulation is active).

This parameter is accessible in the " Advanced parameters" chapter of the mobile App.

Previous Next

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8.5.1.5. Automatic restart

Introduction

The Automatic Restart feature allows the Variable Frequency Drive (VFD) to restart the motor from a fault clearance automatically, provided certain conditions are met.

This section outlines the procedure for enabling and configuring this feature and the safety precautions and operational details involved.

Enabling Automatic Restart

To enable the Automatic Restart feature, follow these steps:

1. Navigate to the Automatic Restart Setting: Access the settings menu on the VFD interface.
2. Enable the Feature: Select the option to enable Automatic Restart.

User Warning and Acknowledgement

The VFD will display a warning message when enabling the Automatic Restart feature.

This message informs the user that an automatic restart may present a danger and that proper safety measures must be taken before proceeding.

The user must acknowledge this warning by confirming that the necessary safety precautions have been implemented. This confirmation will be recorded in the VFD's audit logs.

Automatic Restart Function

Once the Automatic Restart feature is enabled, the following conditions and procedures apply:

1. Lockout Mode: The VFD will not initiate a motor restart in lockout mode. The user must resolve the issue that caused the lockout and reset the VFD. After resetting, the user must start the motor manually.
2. Ramp-Up Procedure: When the VFD initiates an automatic restart, it will apply a ramp-up to bring the motor to the preset speed setpoint after the configured restart delay.
3. Tracking Restart Attempts: The VFD will increment the number of restart attempts with each attempt. It will maintain a record of the number of automatic restart attempts and the number of successful automatic restarts as part of its operational data.

Successful Restart

If the automatic restart is successful and the motor reaches the running state, the VFD will reset the number of restart attempts to zero.

Failed Restart

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In the event of a failed restart, the following conditions apply:

1. Restart Attempts: If the number of restart attempts is less than or equal to the configured maximum number of attempts, the VFD will wait for the configured delay before initiating another restart attempt.
2. Maximum Attempts Reached: If the number of restart attempts reaches the maximum configured limit, the VFD will generate a critical alarm indicating that the automatic restart has failed. The user must then reset the VFD and manually restart the motor.

User Control Override

Suppose a Start or Stop command is received from either local or remote control during the automatic restart process. In that case, the VFD will cancel the automatic restart operation and reset the attempts counter.

Parameters:

1. Automatic restart delay: Value is settable from 10 to 4000 seconds, default = 10 seconds.
2. Maximum number of restart attempts: user-settable from 1 to 10, default = 10.

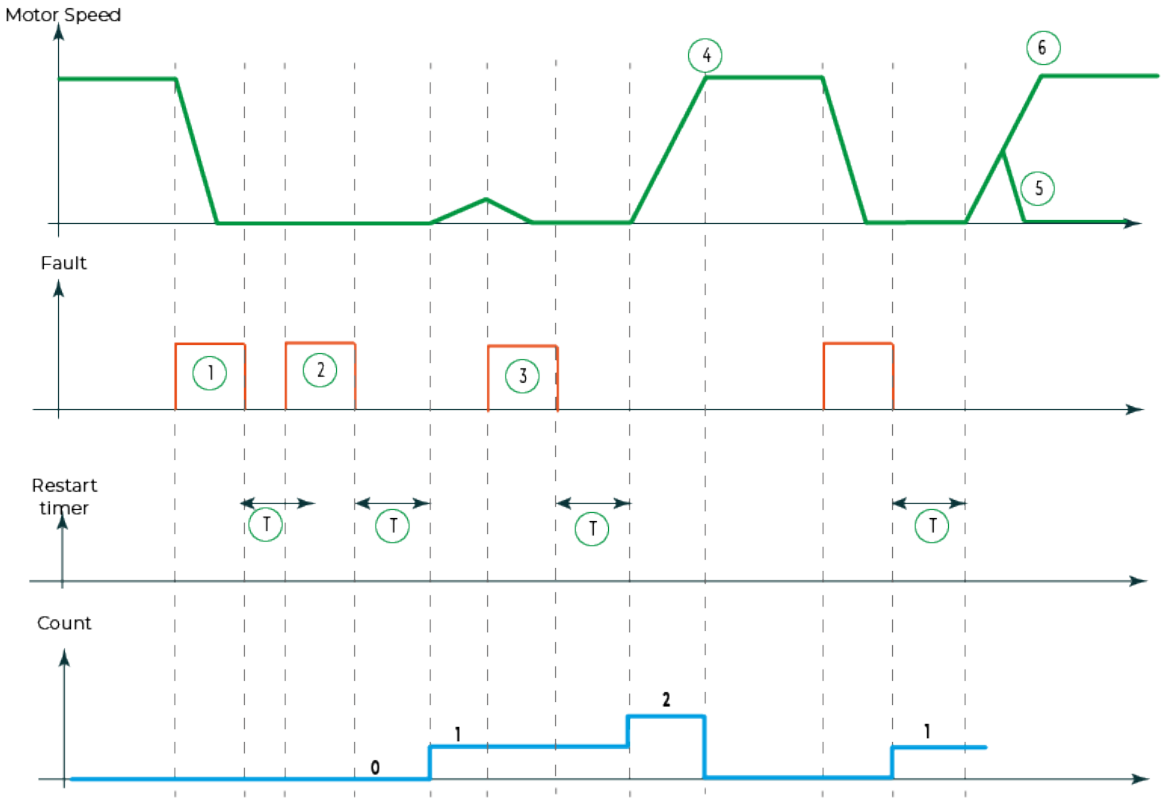
Criteria for Automatic Restart

1. Successful Restart Criteria: The criteria for a successful automatic restart is that the motor reaches the running state.
2. Alarm and Attempt Count: If the motor fails to restart, the VFD firmware will raise the alarm and increment the automatic restart attempts count. If the VFD fails to restart the motor after the configured number of automatic restart attempts, it will raise a critical alarm and put the VFD in lockout mode.
3. Resetting Attempts Count: The automatic restart attempts count is only reset on a successful automatic restart, i.e., when the motor state is running.
4. Automatic Restart Delay: The automatic restart delay is used between attempts to ensure that the motor is at a full stop before the next automatic restart attempt.

Functional timeline

1. A fault of medium severity appears, and then the motor decelerates to a stop. When the fault is cleared, the reset timer T starts.
2. Before the end of the reset delay, a new fault of severity medium appears, and then the restart process is canceled. When this new fault is cleared, the reset timer starts. When the time has elapsed, the motor restarts and the attempt counter is incremented.
3. During the restart ramp-up, another fault of medium severity appears, and then the restart process is canceled, and the accelerating motor is coasting to a stop. When this new fault is cleared, the reset timer starts. When the time has elapsed, the motor restarts, and the attempt counter is incremented.
4. The motor is in the correct running state, and the attempts counter is reset.
5. During a restart ramp-up, a stop command will override the automatic restart
6. During a restart ramp-up, a run command will override the automatic restart

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8.5.1.6. Low Voltage Ride Through - LVRT

Introduction

Low-voltage ride-through (LVRT) is the Clean Power VFD's ability to maintain operation during temporary input voltage dips.

This feature ensures process continuity and minimizes downtime in critical applications.

In industrial and commercial settings, where an uninterrupted operation is essential, LVRT prevents disruptions caused by short-term voltage sags, maintaining control over motors and machinery.

Additionally, LVRT compliance may be mandatory in some regions to support grid stability.

How LVRT Works

LVRT operates by detecting voltage dips and dynamically adjusting operations to maintain motor control.

The Clean Power VFD’s LVRT uses the energy generated by the load inertia of the motor to power the electronic circuits.

Duration depends on the load and operating conditions.

Prerequisite

To perform LVRT functionality, the Clean Power VFD requires proper configuration and calibration.

The following motor parameters must be set during static autotuning :

- Stator Resistance
- Rotor Resistance
- Magnetizing Inductance
- Leakage Inductance

Failure to configure these parameters will trigger the "AFE Low Voltage Ride Through Cannot Recover" alarm, and the VFD will be unable to handle LVRT conditions.

Motor Control Modes

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At the moment, LVRT is only supported in VELOCITY_FOC and TORQUE_FOC modes.

Alarms and Diagnostics

The Clean Power VFD provides alarms to ensure proper monitoring and response to voltage dips, refer to the section Undervoltage

Best Practices

To maximize the effectiveness of LVRT:

- Ensure that all required autotuning parameters are configured.
- Regularly monitor and test the system to verify LVRT functionality.
- Maintain proper grounding and electrical connections to minimize the impact of voltage dips.

Previous Next

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8.5.1.7. Pre-magnetization

The Variable Frequency Drive includes a pre-magnetization feature that allows for DC magnetization of the motor before starting.

This feature is designed to ensure the highest possible breakaway torque.

Pre-magnetization configuration

Automatic mode (default configuration)

After the start command, the drive automatically pre-magnetizes the motor for the set time.

The duration of the pre-magnetization is automatically calculated by the Clean Power VFD algorithm based on the motor's rating.

Manual mode

If needed, the pre-magnetization duration can be modified. First select the pre-magnetization mode to ***Manual*** and enter a ***new duration between 1 to 10000ms*.**

The manual adjustment of pre-magnetization duration is useful when the automatic calculation doesn't match the specific needs of the motor and application, particularly in cases where breakaway torque is critical or starting characteristics need to be fine-tuned:

- **High Inertia Loads**:

  When starting a motor connected to a high inertia load, such as large fans, pumps, or conveyors, the motor may require a longer pre-magnetization time to ensure it builds enough magnetic flux to produce the necessary breakaway torque.

  The user can increase the pre-magnetization time if the default duration does not provide sufficient torque.

- **Precise Starting Control:**

  For applications requiring very smooth or controlled starts, such as delicate material handling or processes sensitive to sudden movements, a longer pre-magnetization duration could help reduce mechanical stress during startup by ensuring the motor is fully magnetized before rotating.

- **Motor Variability:**

  If a motor has specific characteristics such as larger size, older construction, or non-standard ratings, the default pre-magnetization time calculated by the VFD might not be sufficient.

  Manual adjustment ensures the motor is properly magnetized before startup, preventing potential issues like delayed or uneven starts.

- **Startup Performance Tuning:**

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Sometimes, a user might fine-tune the VFD's performance to meet precise operational requirements.

Shortening the pre-magnetization duration might reduce startup delays for applications that prioritize speed over high torque while extending it can ensure higher torque availability for more demanding starts.

- **Troubleshooting:**

  If a motor experiences issues with starting (such as failing to achieve sufficient torque or starting too abruptly), modifying the pre-magnetization duration can be a troubleshooting step to improve performance.

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8.5.1.8. V/f start modes

Overview

The V/f Start Mode parameter defines how the Clean Power VFD initiates motor control when operating in Volts-per-Hertz (V/f) control mode. Depending on the selected mode, the VFD will either start from a stop or attempt to detect and manage a spinning motor condition before proceeding.

Correct selection of this parameter ensures reliable motor start behavior that aligns with your application needs and system configuration.

Purpose

- Define how the VFD should behave when a start command is issued while operating in V/f mode.
- Handle scenarios where the motor may already be spinning before the VFD is enabled.
- Ensure proper magnetization and direction of rotation.

Configuration Parameter

Parameter	Editable	Description	Valid Values	Default Value	Units
Start Mode	Yes	Defines the V/f starting behavior of the VFD	See table below	Start from zero	N/A

Start Mode Options

Mode Name	Code	Description
Start from zero	1	The VFD assumes the motor is at a standstill or close enough to stop it using **pre-magnetization**. This is the standard and safest startup method. The motor should not be spinning freely or under inertia when the start command is issued. This mode is suitable for applications where the motor is guaranteed to be at a standstill before startup, such as conveyor belts or systems with mechanical interlocks.
Scan Restart	2	The VFD will **scan** for the motor's current speed and direction before attempting a start. If it detects a rotating motor, it will apply a **controlled deceleration** (using the active ramp-down profile), bring the motor to a stop, then **pre-magnetize** and reaccelerate it to the desired setpoint. Useful for applications with frequent or uncontrolled stops, or where coasting motors may be re-engaged.

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Mode Name	Code	Description
		This mode is ideal for systems where the motor may still be spinning due to inertia or external forces, such as fans, pumps, or hoists.
Catch on the fly	3	The VFD detects a motor that is already rotating and attempts to take control of it without first forcing a full stop. This mode is intended for applications where the motor may still be spinning at the time of the start command. This mode is ideal for systems where the motor may still be spinning and can not be stopped when the start command is activated

Dependencies

- This parameter is only applicable when the **motor control mode** is set to **V/f**.
- **Catch on the fly can only be enabled when the pre-magnetization duration is set to Automatic.**

  If a fixed pre-magnetization duration is configured, the VFD must not accept **Catch on the fly** as the selected start mode.
- Static Auto-tuning MUST be completed for Catch on the Fly to function correctly



When using **Scan Restart**, ensure that the load is within controllable limits and **not free-spinning dangerously**. Load conditions matter when using Scan Restart.

When the Scan Restart mode is selected, the VFD attempts to detect the motor's existing speed and direction before taking control. This is useful when the motor is still spinning due to inertia—such as after a power loss or a brief stop command.

However, **if the motor is mechanically coupled to another system that can independently drive it**, the resulting speed may be **unpredictable**, making reliable speed detection difficult or impossible. This can result in:

- A longer scanning process, delaying the motor restart.
- A failed synchronization, causing mechanical shock or torque surges.
- Unsafe conditions, especially if the motor restarts while spinning in the opposite direction.
- An overcurrent alarm

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Example:

Consider a **conveyor system** where multiple conveyors are mechanically linked through the same belt or gearbox. If one conveyor stops while others continue running, the stopped motor may be **driven by the remaining active conveyors**, causing it to spin at a speed not accurately detectable by the VFD. Initiating a Scan Restart in this case can result in the VFD attempting to take over while the motor is spinning at an unexpected speed or direction, leading to serious mechanical damage or system instability.

Recommendation:

Use Scan Restart only when:

- The load comes to a predictable stop or slows down due to friction/inertia.
- No external mechanical force is acting on the motor shaft.

Avoid Scan Restart in scenarios like:

- Motors connected to **gravity-fed vertical hoists**, where the load may descend and drive the motor.
- **Fans** in large HVAC systems that coast down slowly or are backfed by airflow.
- **Multiple motors on a common shaft or mechanically linked system**, where one motor may spin due to the motion of others.

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8.5.1.9. Catch on the Fly

The Clean Power VFD provides specialized start-up methods for applications where the motors may already be spinning (coasting) when the start command is issued. The available behavior depends on the selected Control Mode (iFOC vs. V/f).

- **Catch on the Fly :** (also named "fly restart") the drive detects the current motor speed and direction, synchronizes its output, and smoothly resumes control without stopping it.
- **Scan Restart (V/f only):** the drive actively brings the motor to a stop (0 Hz), magnetizes it, and then accelerates it from a standstill. see details in the section V/f start modes

Catch on the Fly

This allows for a smooth "pickup" of a spinning load (e.g., a fan driven by draft or a pump back-spinning) without mechanical shock or high-current trips.

Behavior:

1. Upon a start command, the drive estimates the rotor flux and speed.
2. If an encoder is present, the drive uses the encoder feedback. If no encoder is present (Sensorless), the drive estimates speed.
3. The drive synchronizes the output frequency to the motor speed and ramps to the target frequency.

Prerequisites:

- **Static Auto-tuning (Mandatory):** Static Auto-tuning MUST be completed for Catch on the Fly to function correctly. The algorithm relies on accurate motor parameters (Stator Resistance, etc.).
- **Note:** Setting pre-magnetization to Automatic enables the rotor flux estimation, speed synchronization logic and seamless pickup of a spinning motor.

Use cases of Catch on the Fly:

Below are some common use cases for this functionality in pump and fan applications:

1. Power Restoration After Momentary Outages

In the event of a brief power outage, a motor may continue spinning due to inertia.

When power is restored, the VFD uses the Fly Restart feature to "catch" the motor at its current speed and gradually regain control.

This prevents downtime and avoids the mechanical stress associated with restarting a stopped motor.

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2. Restarting Pumps in Fluid Circulation Systems

In systems such as water or HVAC setups, fluid flow can keep the pump motor spinning even during power interruptions or intentional shutdowns.

The Fly Restart function enables the VFD to match the motor's speed and resume control smoothly, preventing issues like water hammer or pressure surges that can damage equipment.

3. Dynamic Load Situations

In processes with rapidly changing loads, such as ventilation systems responding to variable environmental conditions, the motor may slow down but not fully stop.

The Fly Restart function allows the VFD to quickly detect the motor's speed and regain control, ensuring uninterrupted operation and efficient response to load changes

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8.5.1.10. Interlock (Motor Disable)

DANGER

Incorrect interlock input logic can leave the outputs powered

For an interlock function, configure the input as **negative logic**.

If the input logic is configured incorrectly, the system can appear to be disabled while the outputs remain powered. This can create a false sense of safety and can lead to unexpected motor operation, electric shock, mechanical movement, serious injury, or death.

Before operating the equipment, verify that the interlock input state correctly disables the system and that the outputs are not powered when the interlock is active.

Do not rely on a incorrectly configured interlock input to make the equipment safe. Use the required safety function, isolation device, or lockout/tagout procedure before working on the machine.

WARNING

If the interlock is released while the RUN command is active in 2-wire mode, the VFD will start the motor immediately.

The Interlock (Motor Disable) function prevents the motor from starting and forces a stop as per the normal stop setting if asserted while the motor is running.

It is intended for external permissives (e.g., safety gates, process interlocks, lock-out/tag-out procedures) that must inhibit motion regardless of the current control source.

Configuration

- You can assign a Digital Input (DI) to the Interlock (Motor Disable) function.
- Default state: Interlock disabled (motor control enabled).

Operation

When the assigned DI becomes active (Interlock asserted), the VFD behaves as follows:

1. If the motor is running, it performs the user-set normal stop immediately.

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2. It blocks any start/run command (the other actions: direction change, speed/torque reference will be accepted and taken into account the next time the VFD will start (once the interlock is lifted)) as long as the Interlock remains active.

3. This applies in all control modes (Local HMI, Mobile App, I/O control, Network control).

Interaction & Priority

- **Emergency Fire Mode**
  If Emergency Fire Mode is triggered, the VFD ignores the Interlock state and executes the configured Emergency Fire action.

- **Maintenance Mode**
  If Maintenance Mode is enabled, Interlock has higher priority. The VFD does NOT start the motor when the Interlock is active.

- **Auto-Restart (after trip or power loss)**
  Auto-Restart does NOT start the motor solely because the Interlock is released. The motor remains stopped until a new valid start is issued.

- **Alarm/Warning Actions that would start the motor**
  Any alarm or medium-level action configured to start/enable the motor does NOT result in a start while Interlock is active. The motor remains disabled.

Audit Log & Diagnostics

- **Event Logging**
  Changes of the Interlock state are recorded in the Audit Log:
  - Interlock Enabled (DI active) — timestamped
  - Interlock Disabled (DI inactive) — timestamped

- **Status/Indication**
  - The HMI shows Motor Disabled by Interlock in the banner status area.
  - The state of the motor (disabled) can be seen in Modbus or BACnet

Previous Next

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8.5.1.11. Internal Filter Compensation

⚠ WARNING

- **Default Rule:** Keep this setting **Enabled** unless you have a specific reason to change it (e.g., firmware recovery or specific instructions from SmartD Support).
- **One Change at a Time:** When troubleshooting, never change multiple settings (like Torque Boost and Internal Filter Compensation) simultaneously. Change one, test, and then proceed..

Purpose

Internal Filter Compensation adjusts the drive's control calculations to account for internal hardware filtering. Think of it as a calibration tool that ensures the VFD "sees" the motor voltage correctly.

- **Goal:** To provide the most stable control and consistent motor behavior.
- **Default Setting:** Enabled (Recommended for all normal operations).

Setting guide

Setting	Status	When to use
Enabled	Normal	• New Installations: Always start here. • Standard Operation: Use this for best stability, smooth ramping, and predictable speed regulation under load.
Disabled	Recovery	• Post-Upgrade Instability: If the motor becomes unstable immediately after a firmware upgrade for which the starting version is smaller than v2024.16.00. • Diagnostic Step: If requested by SmartD Support to rule out internal hardware anomalies. • Temporary Bypass: To regain control while identifying a root cause for erratic behavior.

Default: Enabled

Symptoms & Expectations

What to expect when **ENABLED** (Normal)

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- Stable current, speed, and torque response.
- Smooth behavior during acceleration and load changes.

What to expect when **DISABLED**

Disabling this stops the internal correction. While this may restore operation during a fault, you might notice:

- A different "feel" in low-speed torque.
- Slight variations in speed regulation under heavy load.
- Different reaction times during rapid speed changes.

Note: If disabling this setting restores function, it is likely a temporary fix. Contact SmartD Support to confirm the best long-term configuration.

Troubleshooting Procedure

If you suspect an issue related to internal compensation (e.g., instability after an upgrade), follow these steps strictly in order.

1. Capture the Baseline

Before changing anything, write down:

- Current Firmware Version.
- Motor Nameplate Data.
- The specific symptom (e.g., "Motor vibrates at 10Hz under 50% load").

2. Isolate Variables

- If you changed Torque Boost or other settings during an upgrade, restore them to their previous values first.
- Test the system. If the issue persists, proceed to Step 3.

3. The Toggle Test

1. Change Internal Filter Compensation from Enabled $\rightarrow$ Disabled.
2. Test operation.
    - If behavior improves: Keep the system in this safe state and note the improvement.
    - If no change: Switch back to Enabled to maintain standard configuration.

4. Report to Support

Send your findings to SmartD Support, specifically identifying if disabling the compensation restored operation.

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8.5.2. Motor frequency (Hz) - Velocity (RPM)

The following points apply to

- frequency V/f (Hz),
- velocity V/f (RPM)
- and velocity FOC (RPM) motor control modes

Previous Next

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8.5.2.1. Motor frequency setpoint

SmartDrive provides several ways to set up and modify the frequency setpoint.

- The embedded HMI,
- the SmartDrive App,
- the analog inputs,
- the preset speeds,
- and the remote control from the network connection.

Set the frequency setpoint from the Clean Power VFD analog input.

Analog inputs from AI1 to AI3 can be assigned to be the frequency setpoint input. By default, the analog input AI1 is assigned to the frequency setpoint.

The software can set analog signals to be either a potentiometer input, a 4 to 20 mA input, or a 0 to 10 VDC input. By default, the analog input AI1 is set as a potentiometer input.

A +10V voltage output on the control terminal is the reference value.

From the SmartDrive app, the user can define the conversion scale from the analog signal to the frequency by defining the minimum and maximum frequencies.

Any value change on this input will be read instantaneously by the Clean Power VFD and become the reference setpoint.

The Frequency output will vary immediately from the actual speed to the new speed defined by the setpoint.

A change of the setpoint value from the analog input is displayed on the Clean Power VFD's HMI.

If the motor speed does not reach the set value

Check the most common following causes:

- The magnitude of the analog input differs from the Clean Power VFD input scale. Check the voltage across the analog input terminals.

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- The scale of the analog input is not set according to the user's application. Check the minimum and maximum frequencies assigned to the minimum and maximum analog input values.

Previous Next

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8.5.2.2. Motor velocity setpoint

SmartDrive provides several ways to set up and modify the velocity (RPM) setpoint.

- The embedded HMI,
- the SmartDrive App,
- the analog inputs,
- the preset speeds,
- and the remote control from the Ethernet connection.

Set the velocity setpoint from the Clean Power VFD analog input.

Analog inputs from AI1 to AI3 can be assigned to be the velocity setpoint input. By default, the analog input AI1 is the velocity setpoint.

Analog signals can be set by software to be either a potentiometer input, a 4 to 20 mA input, or a 0 to 10 VDC input. By default, the analog input AI1 is set as a potentiometer input.

A +10V voltage output on the control terminal is the reference value.

From the SmartDrive app, the user can define the conversion scale from the analog signal to the velocity by defining the minimum and maximum velocities.

Any value change on this input will be read instantaneously by the Clean Power VFD and become the reference setpoint.

The frequency output will vary immediately from the actual velocity to the new velocity; defined by the setpoint.

A change of the setpoint value from the analog input is displayed on the Clean Power VFD's HMI.

If the motor velocity does not reach the set value:

Check the most common following causes:

- The magnitude of the analog input differs from the Clean Power VFD input scale. Check the voltage across the analog input terminals.

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- The scale of the analog input is not set according to the user's application. Check the minimum and maximum velocities assigned to the minimum and maximum analog input values.

Previous Next

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8.5.2.3. Preset frequencies / preset velocities

Motor speed can be defined by the frequency in Hertz (Hz) of the sine wave applied to the stator, or by the shaft velocity in revolution per minute (RPM)

The users can define up to **8 preset** frequencies/velocities.

The values of the preset frequencies/velocities are fixed set points saved in the Clean Power VFD.

Velocities are set in Revolution Per Minute (RPM), and frequencies are set in Hertz (Hz). These engineering units are not mixed in the 8 presets

Previous Next

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8.5.2.4. Zero Speed Behavior

Overview

This feature applies in Frequency (V/Hz) mode and Velocity mode (RPM), not in Torque control mode

The Clean Power VFD allows users to configure the drive's behavior when the speed setpoint falls below the user-defined minimum speed, named the zero speed condition.

From the mobile application, follow the path: Configuration Plan > Motor Information > Min Frequency.

This provides flexibility to suit different application needs.

Users can choose from the following options to control how the VFD handles these conditions:

1. [DEFAULT] VFD Pauses

- **Description:**

When the zero speed condition is met, the VFD pauses the motor by applying the user-defined normal stop mode.

After the motor stops, the VFD enters a low-power standby mode.

When the speed setpoint increases again, the VFD accelerates the motor towards the new setpoint, following the user-defined ramp-up settings.

This is the default behavior for most VFD applications.

- **Example:**

In a conveyor belt system, when there is no product to transport, the speed setpoint is set to 0 Hz.

Using the configured stop method, the VFD stops the conveyor motor smoothly and enters standby mode.

When the system detects a product, the speed setpoint adjusts automatically, and the VFD accelerates the motor according to the user-defined ramp-up settings.

2. Minimum Speed Operation

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- **Description:**

In this mode, the VFD continues to run the motor at the user-defined minimum speed.

This is useful for applications requiring continuous motion, such as pumps or fans, where a minimum flow or circulation must be maintained.

When the VFD's setpoint changes, the motor will accelerate towards the new speed setpoint, following the user-defined ramp-up settings.

- **Example:**

Continuous air circulation is necessary in an HVAC system to maintain air quality.

Even when no active cooling or heating is required, the VFD runs the fan motor at a minimum speed (e.g., 10% of the rated speed).

When more airflow is needed, the speed setpoint increases, and the VFD ramps up the motor accordingly.

3. Stop and Wait for Run Command

- **Description:**

In this mode, the VFD stops the motor by applying the user-defined normal stop mode and enters a "ready to run" state.

The VFD remains in this state, waiting for an explicit "run" command to resume motor operation.

When the command is received, the VFD accelerates the motor toward the new speed setpoint, following the predefined ramp-up profile.

- **Example:**

In a manufacturing process, the equipment may need to stop between production cycles.

The VFD stops the motor and enters a ready-to-run state. When the next production cycle begins, the control system sends a "run" command, and the VFD accelerates the motor to the new speed setpoint following the user-defined ramp-up setting.

Previous Next

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8.5.3. V/f

The following points apply to frequency V/f (Hz) and velocity V/f (RPM) motor control modes

Previous Next

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8.5.3.1. Low Speed Torque Compensation : Safety messages

DANGER

Be careful not to increase the torque compensation rate too much because it could cause an overcurrent trip at startup.

Moreover, before the over-current protection trips, the motor may overheat.

To avoid such a situation, adjust the torque boost to an appropriate level.

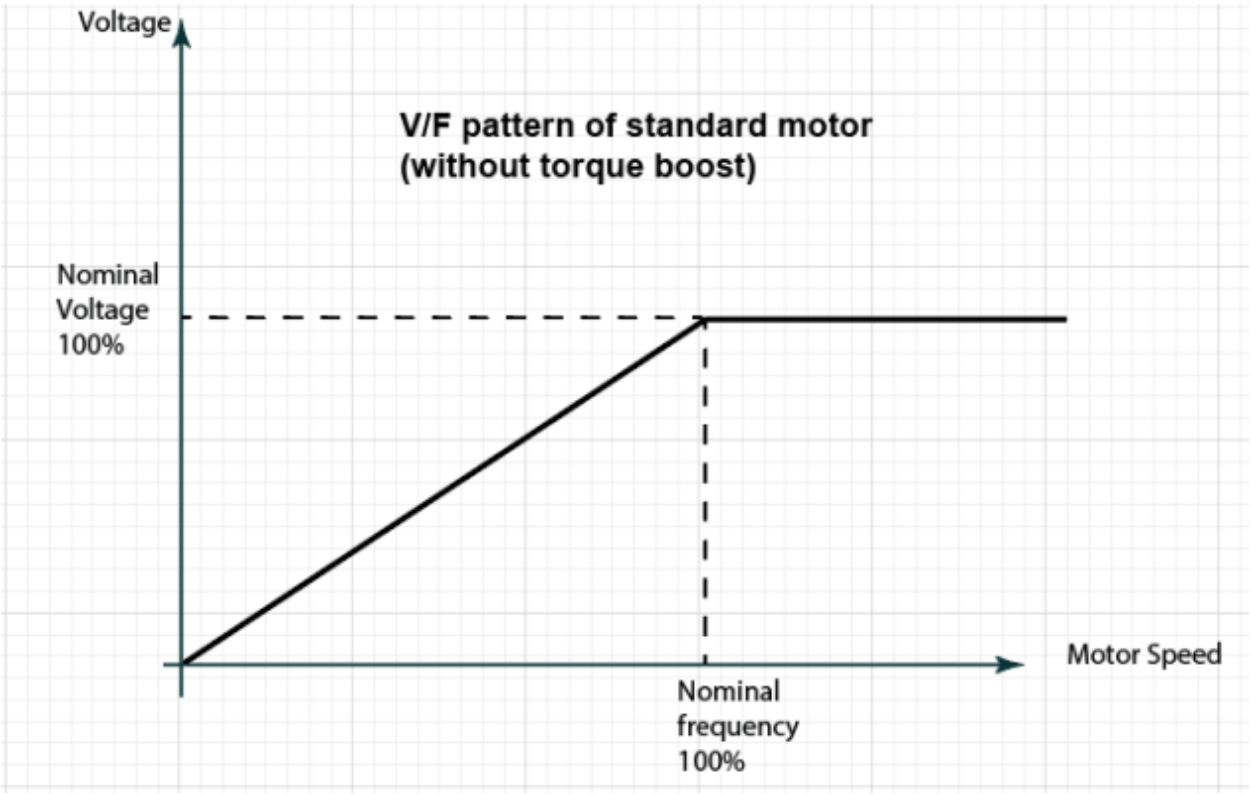
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8.5.3.2. Low Speed Torque Compensation

With conventional V/F operating mode, when F (frequency) is changed, V (output voltage) is changed in the constant ratio (V/F) as shown in the figure below.

For this reason, this system is called V/F control.



The valid voltage value decreases due to a voltage drop in the wiring or the primary coil of a motor, and a sufficient amount of torque cannot be output.

The load inertia may also require greater torque to start moving.

The slower the speed is, the more prevalent this phenomenon is.

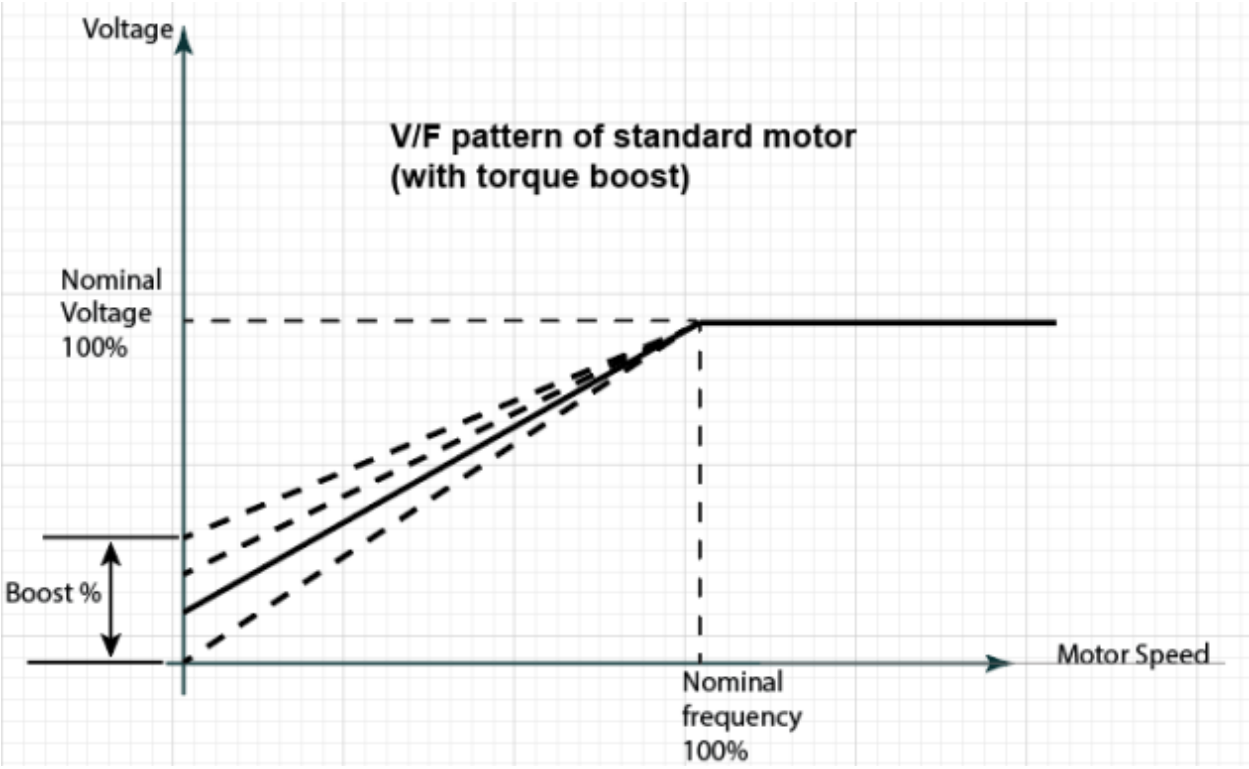
Boosting the voltage inversely proportional to the speed during ramp-up ensures good low-speed torque, and helps the motor start difficult loads more reliably.

Users can set higher voltage (torque boost) as indicated with the solid line in the figure below to cover the shortage of torque at low speeds.

Setting the torque boost value must be done cautiously and tested in small increments.

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If torque boost is increased too much or applied for too long a time, some excessive current may be drawn triggering overcurrent protection.



Setting the starting torque boost

To adapt the starting torque boost to the application, the user can define its amount and its duration.

Amount of starting boost

Parameter amount of starting boost

Settable from 0% to 30% of nominal operating voltage.

Increments: 0.1%

Default value: 0%

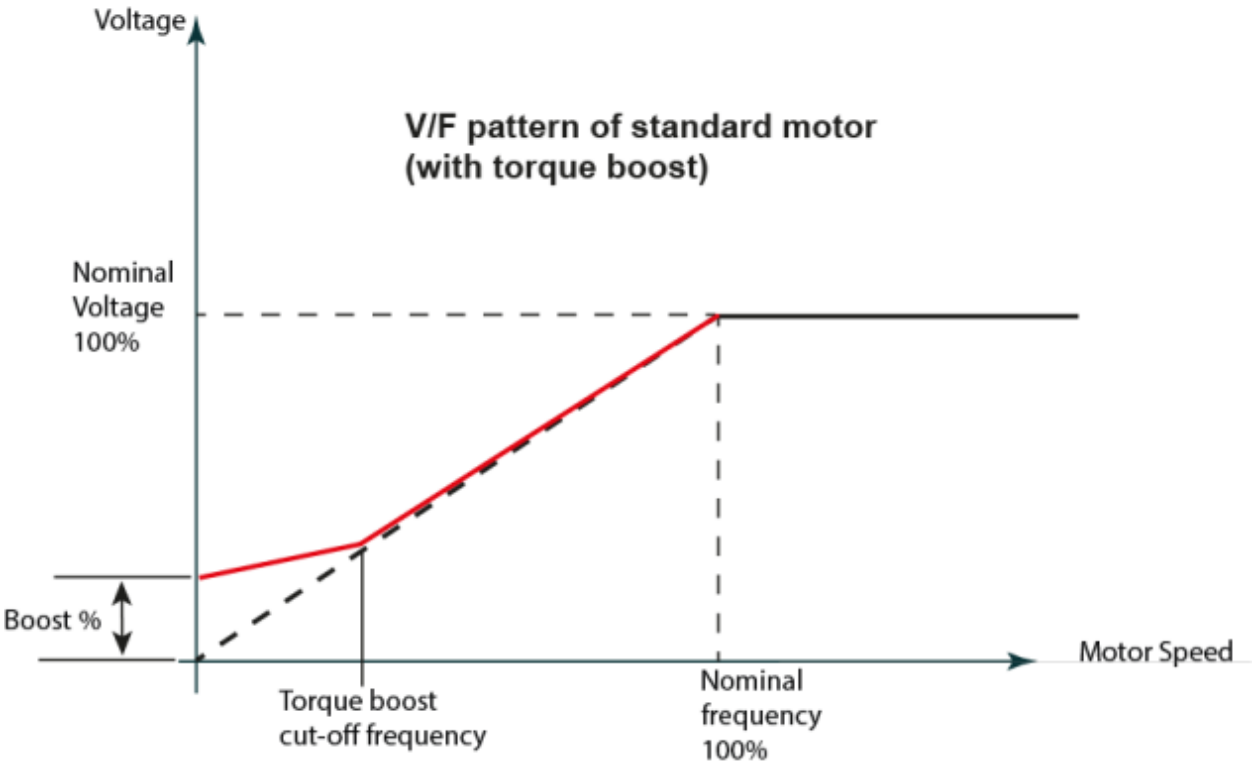
Starting torque boost cut-off frequency

Parameter starting torque boost cut-off frequency

Settable from 20 to 80% of nominal speed.

Default value: 25% (boost stops when the speed reaches this value)

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8.5.4. Field Oriented Control (FOC)

The following sections explain the control modes that are based on Field-Oriented Control (FOC) algorithms.

The torque mode and the velocity mode.

Field-oriented control, also known as vector control, is a modern method used to control AC electric motors, giving smoother and more precise control over the motor's speed and torque.

Why Is FOC the Best for VFDs?

1. **Precise Control of Speed and Torque:**
    - FOC allows for adjustment of the motor's speed and the force it produces with great accuracy. This is essential when you need the motor to perform exact movements, such as in robotic arms or CNC machines.
2. **Quick and Responsive Performance:**
    - The motor can accelerate or decelerate rapidly, responding swiftly to commands. This quick responsiveness is necessary in applications where timing is everything.
3. **Energy Efficiency:**
    - By optimizing how the motor uses electricity, FOC reduces energy waste. This means lower electricity bills and a smaller environmental footprint.
4. **Smooth Operation:**
    - Motors controlled with FOC run smoothly without jerks or vibrations. This reduces wear and tear, leading to longer-lasting equipment and less maintenance.
5. **Excellent Performance at All Speeds:**
    - Whether the motor is running slowly or at full speed, FOC ensures it operates efficiently without losing torque. This makes it versatile for various applications that require different speeds.
6. **Works with Different Types of Motors:**
    - FOC is compatible with various AC motors, including induction motors and permanent magnet motors.

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8.5.4.1. Motor limits

When using a Clean Power VFD with Indirect Field Oriented Control (iFOC) mode, understanding the limits in torque, power, and current is crucial for optimal operation.

iFOC enhances motor performance by regulating the torque and speed based on the magnetic flux's orientation. However, several factors inherent to this control mode can impose limits.

- Firstly, torque limitation arises due to the VFD’s ability to control the current vector components separately — torque-producing (direct) and flux-producing (quadrature) currents.
- The maximum torque is constrained by the maximum allowable current that the VFD can safely manage without overheating or causing electromagnetic stress to the motor.
- Power limitation is a direct consequence of torque and speed limits. Since power is the product of torque and speed, any limit on these parameters restricts the drive’s power output.
- In iFOC mode, maintaining the balance between torque and flux to optimize efficiency often means that the drive cannot operate at its absolute power capacity continuously.
- Lastly, the current limitation is pivotal because excessive current can lead to thermal overload and potential damage to both the VFD and the motor. The iFOC mode is designed to optimize the current flow to the motor, ensuring efficient operation within safe operational limits. This mode adjusts the current dynamically to respond to load demands while preventing overcurrent conditions that could compromise system integrity.

Motor torque limits

Motor power limits

Motor current limits

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High torque

If the motor torque exceeds this value, the “high torque” status is generated.

This high torque limit is settable from -500.0% to + 500.0 %, its default value is 300.0% (to prevent the motor from overloading during standard operation). Accuracy: one decimal position, 0.1%

Low torque

If the motor torque is lower than this value, the status “low torque “ is generated.

This low torque limit is settable from -500.0% to + 500.0 %, its default value is -300.0%. Accuracy: one decimal position, 0.1%

VFD behavior when a High Torque limit is reached:

If the actual torque value reaches/exceeds the limit of “high torque”, the following sequence happens:

1. The VFD displays the status of high torque to the connected screen(s) (HMI / Mobile App).
2. The VFD automatically reduces the output voltage or frequency to keep the torque within the acceptable range (between the low and high torque limits).

VFD behavior when a Low Torque limit is reached:

If the actual torque value is smaller than the limit “low torque”, the following sequence happens:

1. The VFD displays the status of low torque to the connected screen(s) (HMI / Mobile App).
2. The VFD automatically attempts to increase the torque by adjusting its output (increasing the voltage or changing the frequency) to keep the torque within the acceptable range (between the low and high torque limits).

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Maximum start limitation

This is a temporary motor current limit specifically for starting.

It can be user-defined in the configuration phase of the system and can not be changed when the VFD is in operation.

When this parameter is different from zero, then the limitation is enabled.

The user can set this parameter from **0A up to the drive's capability** of the "normal duty" rated current. The default value is 0 A, which means to use the current limit from the drive's internal capability.

The drive observes the start current limit defined by this parameter "Maximum start current". The limit is in force for 2 seconds after initial magnetization (of an asynchronous induction motor) or autophasing (of a
permanent magnet motor), but not more often than once in every 7 seconds. Otherwise, the limit defined by the parameter Maximum current is in force.

Note: The availability of a start current higher than the general limit depends on the drive hardware.

Maximum current

The user can define a value for the parameter "maximum current". It is the maximum allowed motor current.

This parameter is defined in the configuration phase of the system and can not be changed when the VFD is in operation.

When this parameter is different from zero, then it is enabled.

The setting range is from **0A up to the drive's capability** of the "normal duty" rated current. The default value is 0 A, which means to use the current limit from the drive's internal capability.

If the actual current value reaches/exceeds the limit of "Maximum current", the following sequence happens:

1. The VFD displays the status of max current to the connected screen(s) (HMI / Mobile App).
2. The VFD automatically reduces the output voltage or frequency to keep the current lower than or equal to the maximum current.



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This parameter must be safely set within the VFD capability and motor characteristics.

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8.5.4.1.3. Motor power limits

Defining power limits when controlling a motor with an AFE-embedded VFD in torque control mode is important for several reasons:

1. **Protection of Motor and Drive**: Power limits help protect both the motor and the drive from potential damage caused by excessive current or torque, which can occur during overloads or fault conditions. By setting a power limit, the drive can prevent the motor from drawing more power than it can safely handle.

2. **Improved Efficiency**: Power limits ensure that the motor operates within its most efficient range. Operating a motor beyond its efficient power range can lead to unnecessary energy consumption and reduced performance.

3. **Prevention of Overheating**: Exceeding the motor's rated power can cause overheating, which can degrade insulation, damage motor windings, and lead to premature motor failure. Power limits help in maintaining the motor temperature within safe operational limits.

4. **Enhanced Control Accuracy**: In torque control mode, the primary focus is on controlling the torque output of the motor. However, without power limits, there could be scenarios where the torque demand leads to excessive power consumption. Setting power limits ensures that torque control remains accurate and within the safe operating range of the motor and drive.

5. **Grid Stability and Quality**: An AFE-enabled VFD can feed energy back into the power grid. Defining power limits is crucial to ensure that this regeneration process does not negatively impact grid stability or power quality. Excessive power feedback can cause grid disturbances or violate grid compliance regulations.

6. **Preventing Equipment Stress**: Motors and mechanical systems connected to them can be subjected to stress if operated beyond their designed power capacity. Power limits help preserve the mechanical integrity of the system by avoiding excessive force or speed.

7. **Compliance with Standards and Regulations**: Many industrial applications have standards and regulations regarding energy consumption and motor operation. Setting power limits can help ensure compliance with these requirements, avoiding potential legal and safety issues.

8. **Predictability in Performance**: Defining power limits makes the system's performance more predictable, which is crucial for applications requiring precise motion control or where safety is a critical concern.

Motoring or generating

- The system VFD+motor+load can be motoring: the VFD controls the torque and speed of the system;
- or in a generating state: where the motor+load generates energy which is fed back to the grid by the VFD.

Power motoring limit:

Defines the maximum allowed power fed by the inverter to the motor in percent of nominal motor power.

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- Range: settable from 0.0 to 600.0 %
- Accuracy: one decimal position, 0.1%
- Default Setting = 300.0%

Power generating limit:

Defines the maximum allowed power the motor feeds to the inverter in percent of nominal motor power.

- Range: settable from -600.0 to 0.0 %
- Accuracy: one decimal position, 0.1%
- Default Setting = -300.0%

Power Motoring Limit - VFD behavior

If the actual power motoring value is greater than the limit, the following sequence happens:

1. The VFD displays that the power motoring has exceeded the preset power motoring limit to the connected screen(s) (HMI/mobile app). This serves as a notification that the system is operating beyond its configured limits.
2. The VFD automatically reduces the speed to decrease the power consumption.
3. Since power is a function of torque and speed, the VFD automatically limits the motor torque and/or speed to keep the power consumption within the acceptable range.

Power generating Limit - VFD behavior

If the actual power-generating value is greater (absolute value) than the limit, the following sequence happens:

1. AFE technology allows the VFD to handle regenerative energy efficiently
   Suppose the power generation exceedance is due to regenerative braking (like in decelerating high-inertia loads). In that case, the VFD can feed this excess energy back into the power grid or store it in an energy storage system.
2. Similar to the power motoring limit, the VFD will display and log status to indicate that the power generation limit is being exceeded.

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8.5.4.2. Min torque and max torque setpoints

The torque setpoint is limited by the **minimum torque setpoint** and the **maximum torque setpoint**.

- The **minimum torque setpoint** can be user-defined between -500.0 % and 0.0% of the motor nominal torque. Its default value is -300.0%.
- The **maximum torque setpoint** can be user-defined between 0% and 500.0 % of the motor nominal torque. Its default value is 300.0%.

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8.5.4.3. Eco Mode

⚠ CAUTION

Eco mode not recommended for shock-load applications.

Do not enable MTPA where load torque can change abruptly. Rapid torque transients can cause unstable control response, current spikes, torque overshoot, and nuisance trips.

Use a more conservative control strategy with robust current/torque limiting for these applications.

The Eco Mode in the Clean Power VFD control system leverages **Maximum Torque per Ampere (MTPA)** technology to optimize energy consumption.

This advanced energy optimization function enhances the VFD's performance and efficiency, making it an essential feature for users looking to reduce energy costs.

Energy Optimization:

The Eco Mode utilizes MTPA technology to maximize the torque output for a given amount of current, thereby minimizing the motor's power losses.

Continuous Adjustment:

The system continuously adjusts the motor’s operating parameters to maintain optimal efficiency, ensuring the best performance.

Substantial Energy Savings:

Eco Mode reduces the amount of current required to produce the same torque, leading to significant energy savings.

User interface:

The Eco Mode can be enabled or disabled via a toggle switch within the iFOC modes on the Human-Machine Interface (HMI) or mobile application.

- Enable: Activates the Eco Mode, optimizing energy consumption and enhancing motor efficiency.
- Disable: Deactivates the Eco Mode, returning the system to its standard operating parameters.
- Default Value: Disable

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Dynamic Response:

- **Transient Performance:**

  While MTPA control focuses on efficiency, it can impact the transient response of the VFD.

  The drive might prioritize efficiency over rapid torque response, potentially affecting applications requiring fast dynamic changes.

- **Control Tuning:**

  The VFD control system may need fine-tuning to balance the trade-off between efficiency (MTPA) and dynamic performance.

  Proper tuning ensures that the drive can handle dynamic loads without compromising efficiency significantly.

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8.5.4.4. FOC speed response

While configuring the VFD into iFOC control mode, the user must define the speed controller response, choosing between one of the following 3 values.

Default value: Normal

Slow

- Meaning: A "Slow" setting means the speed controller will respond more gradually to changes in speed commands or load conditions.
- Impact:
    - Smooth Operation: This setting is beneficial for applications requiring very smooth and gradual changes in speed, reducing the risk of mechanical shocks or stress.
    - Reduced Overshoot: It minimizes overshoot in speed control.
    - Stability in Variable Load Conditions: Offers stability in applications where load conditions change slowly or where a gentle response is needed.
    - Energy Efficiency: Can be more energy-efficient in certain scenarios where rapid speed changes aren't necessary.

Normal

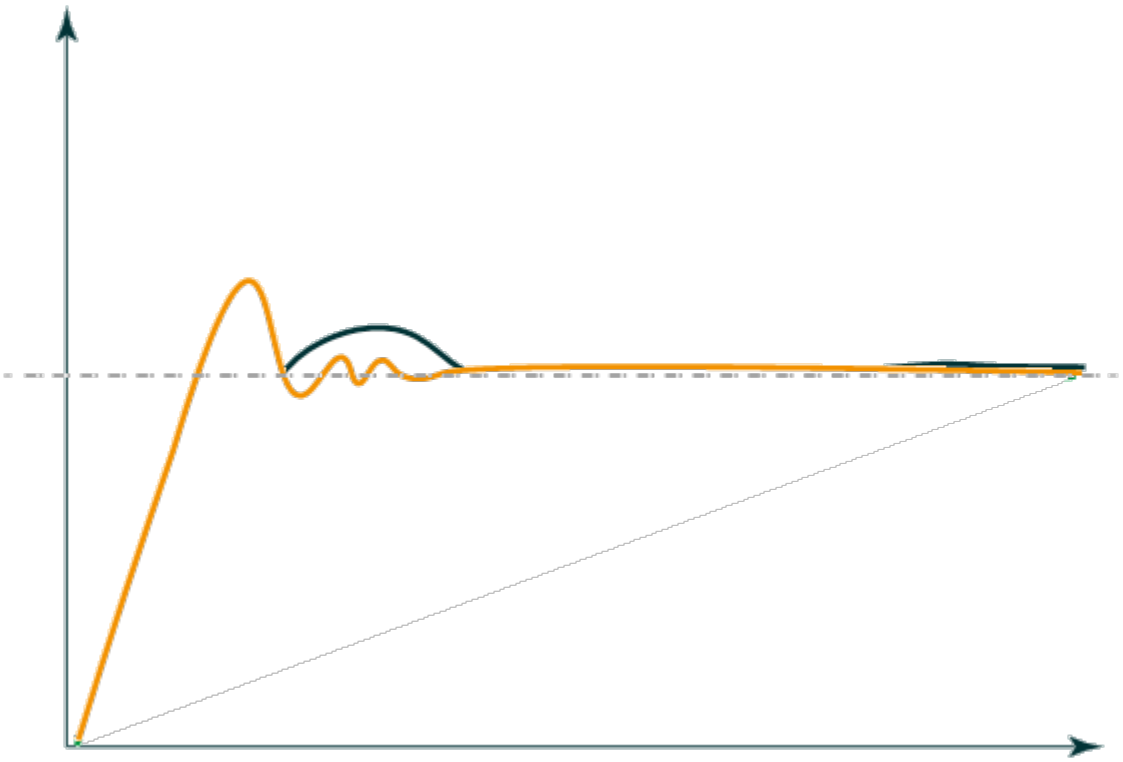
- Meaning: The "Normal" setting provides a balanced response that is neither too slow nor too fast.
- Impact:
    - Balanced Performance: Suitable for a wide range of general-purpose applications where neither very quick nor very slow responses are needed.
    - Good Compromise: Offers a good compromise between responsiveness and smooth operation.
    - Moderate Overshoot and Stability: Balances between minimizing overshoot and maintaining a stable response to load changes.

Fast

- Meaning: A "Fast" setting means the speed controller will respond quickly to speed commands or load variations.
- Impact:
    - Rapid Response: Ideal for applications requiring quick acceleration and deceleration, such as in high-speed machinery or processes.
    - Higher Potential for Overshoot: This can lead to more overshoot in speed, which might be acceptable or even necessary in some applications.

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- Increased Wear and Tear: The faster response can lead to increased mechanical wear and tear due to more frequent and rapid changes in speed and torque
- Increased Wear and Tear: The faster response can lead to increased mechanical wear and tear due to more frequent and rapid changes in speed and torque



Choosing the Right Setting

The appropriate setting depends on the specific application and the desired performance characteristics. Factors to consider include the nature of the load (steady vs. variable), the required precision in speed control, mechanical system characteristics (like inertia), and how the system responds to speed changes.

For example, in a conveyor system carrying fragile items, a "Slow" setting might be preferred to avoid jolts. Conversely, in a CNC machine requiring quick and precise changes in speed, a "Fast" setting might be more appropriate.

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8.5.4.5. FOC Speed Source

Two speed sources can be chosen during the configuration

- Estimated: the motor speed is calculated by the internal algorithm based on the output current and the static auto-tuning parameters.
- Measured from Encoder: the motor speed is measured from the encoder signal

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8.5.5. Motor torque (%)

The following points apply to torque FOC (%) motor control mode

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8.5.5.1. Safety Messages Torque Control

DANGER

- **Incorrectly setting the torque limits**

  Wrong settings can result in unsafe operating conditions, potentially causing severe damage to the motor and connected equipment.

  Always double-check parameter values before saving.

- **Parameter Range Enforcement:**

  The low torque limit must be set between -500% and 0% of the motor's nominal torque. The high torque limit must be set between 0% and 500% of the motor's nominal torque.

  However, setting values above 100% can lead to unexpected and hazardous motor behavior.

- **Critical Parameter Changes:**

  Changes to critical parameters, such as torque limits and protection settings, should only be made by qualified personnel.

  Unauthorized changes can compromise the safety and performance of the system.

- **Consistent Parameter Settings:**

  Ensure that the low torque limit is always less than or equal to the high torque limit. Inconsistent settings can cause the drive to operate unpredictably.



- **Protection Mechanisms Configuration:**

  Failure to properly configure protection mechanisms (e.g., over-torque, over-speed) by the set parameters can result in inadequate protection, leading to equipment damage or personal injury.

- **Monitoring and Alerts:**

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Continuously monitor the VFD parameters and heed any alerts or warnings generated by the system.

Ignoring alerts can lead to severe operational issues.

- **Access Level Restrictions:**

Limit access to critical parameter settings to authorized personnel only.

Implement access controls to prevent unauthorized changes that could jeopardize system safety.



- **Confirmation of Parameter Changes:**

Caution: When changing critical parameters, always confirm the new settings before applying them. Incorrect settings can lead to immediate operational hazards.

- **Use of Default Values:**

If unsure about the correct settings, use the default safe values provided by the VFD.

Default settings are designed to ensure safe and reliable operation under typical conditions.

Regular Audit and Logging:

Regularly review the audit logs for changes to critical parameters. This practice helps in identifying and rectifying unauthorized or erroneous parameter changes promptly.

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8.5.5.2. Why torque control ?

Why torque control

Torque control in a Variable Frequency Drive (VFD) is important for several reasons, primarily due to its direct impact on motor performance and efficiency in various applications:

- Precise Motor Control:

  Torque control allows for the precise management of the motor's torque output.

  This is particularly important in applications where the load changes dynamically, such as in lifting equipment.

  By accurately controlling torque, a VFD ensures that the motor can respond quickly to changing load conditions, maintaining stability and efficiency.

- Protection Against Overload:

  Implementing torque control can protect the motor from overload conditions.

  By limiting the maximum torque, a VFD prevents the motor from drawing excessive current, which could lead to overheating or mechanical stress.

  This feature is especially vital in applications with high starting loads or where sudden load changes are common.

- Improved Process Control:

  In many industrial applications, such as mixing, pumping, or conveyor systems, maintaining a specific torque level is essential for process consistency and quality.

  Torque control in VFDs ensures that the motor operates within the desired torque range, leading to uniform product quality and process efficiency.

- Energy Efficiency:

  Torque control can contribute to energy savings. By ensuring that the motor only generates the amount of torque needed for the application, unnecessary energy expenditure is avoided.

  This is especially significant in applications with varying loads where the required torque can fluctuate.

- Extended Equipment Life:

  Proper torque management reduces mechanical stress on the motor and connected machinery.

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This prolongs the lifespan of the equipment, reduces maintenance costs, and minimizes downtime due to mechanical failures.

- Enhanced Performance in Regenerative Applications:

In applications like elevators or cranes, where energy can be regenerated and fed back into the power system, torque control is crucial for managing this process effectively.

It ensures that the energy is captured and utilized efficiently, contributing to overall energy savings.

- In summary:

Precise Torque Control: The VFD ensures the motor provides the exact torque needed for the load, regardless of the motor's speed.

Efficient Use of Power: By controlling the torque directly, energy is used more efficiently, as the motor operates only with the necessary power to achieve the desired torque.

Smooth Operation: This mode provides smooth and stable operation, especially in load-sensitive applications, preventing sudden changes in motor speed and torque that could cause mechanical wear or system instability.

This mode is ideal for applications requiring constant torque or precise torque regulation, such as hoisting systems, material handling, and certain industrial processes that demand high torque accuracy.

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8.5.5.3. Speed limits in torque control mode

In torque control mode, the user must define the speed limits for which the motor should not exceed while attempting to reach the desired torque:

- Min Speed Limit in Torque Control Mode
- Max Speed Limit in Torque Control Mode

These limits are different from the motor min and max frequency in the motor parameters. However, the speed limits in torque control cannot exceed the max frequency as described in the parameter settings below.

In torque control mode, the VFD is designed to maintain a constant torque, regardless of the speed of the motor. However, the speed limits set for the motor must also be respected for safety and longevity.

When the motor speed reaches either the high-speed or low-speed limit (measured by an encoder or estimated by the algorithm), the VFD adjusts its output to prevent the speed from exceeding that limit:

- If the speed reaches the high limit, the VFD stops increasing the supplied frequency while continuing to regulate torque as per the setpoint.
- If the speed reaches the low limit, the VFD stops decreasing the supplied frequency while still maintaining the torque setpoint.

This ensures the motor operates within safe speed boundaries without compromising torque control.

Parameters setting:

Parameter	Setting range	Default value	Dependencies
Min Speed Limit in Torque Control Mode	**-rpm_limit** to +**rpm_limit** RPM where rpm_limit = max_frequency_hz * nominal_velocity_rpm / nominal_frequency_hz	**-nominal_velocity_rpm** RPM (signed as per counter-clockwise rotation direction)	This value can not be higher than the Max Speed limit defined by motor nameplate
Max Speed Limit in Torque Control Mode	**-rpm_limit** to +**rpm_limit** RPM where rpm_limit = max_frequency_hz * nominal_velocity_rpm / nominal_frequency_hz	**+nominal_velocity_rpm** RPM (signed as per clockwise rotation direction)	This value can not be lower than the minimum speed limit defined by motor nameplate

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8.5.5.4. Torque setpoint

The torque setpoint is specified as a percentage of the motor’s rated torque, with a user-adjustable range from −500% to +500%.

SmartDrive provides several ways to set up and modify the torque setpoint.

- The embedded HMI,
- the SmartDrive App,
- the analog inputs,
- and the remote control from the network connection.

Set the torque setpoint from the Clean Power VFD analog input.

Analog inputs from AI1 to AI3 can be assigned to be the torque setpoint input. By default, the analog input AI2 is assigned to the torque setpoint.

The software can set analog signals to be either a potentiometer input, a 4 to 20 mA input, or a 0 to 10 VDC input. By default, the analog input AI2 is set as a potentiometer input.

A +10V voltage output on the control terminal is the reference value.

From the SmartDrive app, the user can define the conversion scale from the analog signal to the torque by defining the minimum and maximum torques.

Any value change on this input will be read instantaneously by the Clean Power VFD and become the reference setpoint.

The torque output will vary from the actual torque to the new torque defined by the setpoint through the user defined torque ramps.

A change of the setpoint value from the analog input is displayed on the Clean Power VFD's HMI.

If the motor torque does not reach the set value

Check the most common following causes:

- The magnitude of the analog input differs from the Clean Power VFD input scale. Check the voltage across the analog input terminals.

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- The scale of the analog input is not set according to the user's application. Check the minimum and maximum torques assigned to the minimum and maximum analog input values.
- There is insufficient load and the VFD is being limited by the speed limits in torque control mode.

Previous Next

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8.6. Motor Thermal Protection

⚠ WARNING

Multi-motor on one drive.

This function estimates the thermal energy of a **single motor**. If you run multiple motors from one VFD, per-motor thermal protection is not possible—you must use **external thermal relays (one per motor).**

⚠ CAUTION

A higher overload trip class allows the motor to remain overloaded for a longer time. Select the trip class according to the motor thermal capability and the application starting profile

---

This function prevents motor overheating by combining:

1. a temperature-based thermal model (with fixed time constant and cooling-type compensation),
2. an I^2t (current-squared–time) accumulator, and
3. the Motor Load Curve, which tells the drive how hard the motor is expected to work at different speeds so the model can predict heating realistically—especially at low speed.

When the model determines the motor is too hot, the drive raises **Motor thermal overload** and executes the configured stop action.

Power-Up Behavior (Temperature at Start)

Set how the drive interprets motor temperature when it powers up:

- **Cold Start (default):** The drive assumes the motor is at the ambient temperature at power-up, regardless of prior operation.
- **Retain Last Temperature:** The drive restores the previously estimated motor temperature exactly as it was before power-down (thermal memory).

Tip: Use **Retain Last Temperature** for short power outages or frequent on/off cycles application. Use **Cold Start** for applications where the motor fully cools between start or when conservative behavior is required.

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How It Works

1) Temperature-based model + I²t

- Copper heating ≈ **I²·R**. The drive integrates RMS current squared and feeds it to a first-order thermal model (τ = 256 s, fixed).
- The model outputs both Estimated Motor Temperature and Thermal Load, internally computed as TCU% (Thermal Capacity Used).

TCU value	Typical meaning
0%	Motor is considered cold, close to ambient temperature.
50%	Motor has used approximately half of its thermal capacity.
88%	Default warning threshold, if the warning function is available.
100%	Default trip threshold.
> 100%	Motor is above the default thermal capacity limit. Operation depends on the configured thresholds and action.

The VFD continuously updates the TCU value while the motor is running.

When the motor is stopped, the VFD estimates cooling and decreases the TCU value over time.

2) Motor Load Curve

- The Motor Load Curve tells the VFD how much current the motor normally needs across speed, so the thermal model can weight heating realistically and avoid false confidence at low speed.
- You don't draw the curve or set breakpoints. Instead, the drive derives the curve from two inputs: **Cooling Type** and **Motor Load Nominal (I/IN)**.
- **Cooling Type** defines the assumed zero-speed load point (no separate parameter to edit):
    - **Self-cooled (default): Zero-speed load = 70%** of *Motor Load Nominal*
    - **Forced-cooled: Zero-speed load = 100%** of *Motor Load Nominal*
- **Motor Load Nominal (I/IN)** tells the model the typical continuous operating load vs the motor nameplate current. It adjusts the whole curve vertically.

Why this matters:

Self-cooled motors have little airflow at low speed, they heat faster.

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The 70% zero-speed reference prevents the model from assuming “zero current” at zero speed and reflects real workload/torque needs for many applications.

Forced-cooled motors keep airflow, a 100% zero-speed reference is safe.

3) Overload trip class

The **Overload Trip Class** defines the inverse-time overload behavior of the motor thermal model.

A lower class trips faster.

A higher class allows a longer overload time.

Trip class	Behavior	Typical use
Class 5	Very fast overload protection	Very light loads or motors that require fast thermal protection
Class 10	Fast overload protection	Standard pump, fan, and general-purpose applications
Class 20	Medium overload delay	Applications with longer acceleration time
Class 30	Long overload delay	Higher inertia loads or difficult starts
Class 40	Very long overload delay	Special applications only; verify motor thermal capability

Changing the trip class updates the inverse-time curve immediately.

Parameters

Parameter	options	Default	Notes
Motor Thermal Time Constant (τ)	100 to 10 000 s	256 s	Sets heating/cooling dynamics (~63% step response). Larger = slower temp change; influences TCU rise/decay
Motor Temperature at Power Up	Cold Start / Retain Last Temperature	Cold start	Controls thermal memory at boot.
Overload Trip Class	5 / 10 / 20 / 30 / 40 / Undefined	10	Updates the inverse-time curve immediately. If Overload Trip Class is Undefined, the Motor Thermal Time Constant will be used for triggering the alarm.
Cooling Type	Self-cooled / Forced-cooled	Self-cooled	Also defines the zero-speed load assumption (no separate parameter): Self-cooled → 70% of Motor Load Nominal; Forced-cooled → 100%.

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Parameter	options	Default	Notes
Motor Load Nominal (I/IN)	Settable 50…150%	100%	Ratio of typical operating current to nameplate FLA. Influences the entire load curve (and thus heating predictions).
Alarm: Motor thermal overload	Enable / disable	Enable	Disable for multi motor applications
	Trigger delay	0	Settable from 0 to 120 s
	Action: ramp down / freewheeling	Ramp down	
	Trigger Condition: Thermal load ≥ Trigger threshold	100 %	Settable from 80% to 150% of the motor's thermal load capacity
	Reset Condition: Thermal load < Reset threshold	88 %	Settable from 30% to 100% of the motor's thermal load capacity
	Reset delay	0	Settable from 0 to 120 s
	Alarm Persistence option: • Cleared at boot • Persistent to reboots	Cleared at VFD boot	Even if alarm is selected non-persistent; logs remain.
Audit Log	Enabled by default		

What Happens on Alarm

1. **Trigger:** When Thermal Load ≥ Trigger threshold (default 100%), the drive raises Motor thermal overload (medium) and executes selected action
2. **While active:** The alarm stays active while Thermal Load ≥ Reset threshold.
    a. **Reset:** The alarm auto-clears when Thermal Load < Reset threshold (default 88%). The alarm also clears on power-up (non-persistent).
3. **Restart eligibility:** General restart/interlock policy applies. If your system allows restart on alarm clear and all interlocks are healthy, the motor can start once below the reset threshold.

Commissioning Checklist (with Load Curve)

1. **Select power-up mode:** *Cold Start* (default) or *Retain Last Temperature*.
2. **Select Cooling Type:**
    - *Self-cooled* (default) → zero-speed load = 70% × Motor Load Nominal

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- *Forced-cooled* → zero-speed load = 100% × Motor Load Nominal

3. **Set Motor Load Nominal (I/IN):**
   - Default 100%; set 50…150% based on expected continuous duty.
   - 100% can be used (e.g., nameplate service factor) only if motor and installation permit—verify manufacturer limits.
4. **Choose Action on Trigger:** Stop – ramp down (default) or Stop – freewheel.
5. **Verify on a warm test:** Run typical load at low and nominal speeds; watch current value that triggers the alarm. Adjust **I/IN** if the model persistently over/underestimates heating.

Previous Next

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8.6.1. Validate Motor Thermal Protection Parameterization

⚠ WARNING

Incorrect motor thermal protection settings can lead either to nuisance tripping or to insufficient motor protection.
The user is responsible for verifying that the configured motor data and overload assumptions match the actual motor and the real application duty before placing the equipment into continuous service.

Validating the Motor Thermal Protection Settings

The motor thermal protection function of the drive acts as an electronic overload relay.
Its purpose is to estimate the thermal stress of the motor and trigger a protective action before the motor is exposed to unacceptable overheating.

For this protection to be relevant, the related parameters must match the real motor and the real application.

This is why SmartD recommends validating the motor thermal protection settings during commissioning, and again after any significant change affecting the motor or its operating conditions.

Typical cases where this validation should be done include:

- replacement of the motor
- change of motor nameplate data entered in the drive
- change of motor rated current
- change of the **I/In** setting
- change of starting parameters
- change of operating speed range or load profile
- change of motor cooling or ventilation conditions

Why this validation matters

The electronic motor thermal protection does not directly measure the winding temperature.
It works from a thermal model based on configured motor data and operating conditions.

If the entered data does not match reality, the protection may become inaccurate.

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Typical consequences are:

- **trip too early**, causing nuisance faults during normal operation
- **trip too late**, allowing the motor to overheat
- **underestimate the effect of repeated starts**
- **overestimate the cooling capacity of the motor at low speed**

This point is especially important for self-ventilated motors running for long periods at low speed.

Parameters that must be checked

Before validating the function in operation, confirm the following parameters carefully.

Motor nameplate information

Verify that the motor data entered in the drive matches the installed motor nameplate, including at least:

- rated voltage
- rated frequency
- rated current
- rated power
- rated speed, where applicable

Wrong motor data leads to a wrong thermal estimation.

Motor rated current

The rated motor current is one of the main references used by the protection model.
If this value is set too low, nuisance trips may occur.
If it is set too high, motor protection may become insufficient.

I/In setting

The **I/In** setting must be consistent with the real overload capability of the motor and the intended operating duty.

A value that is too permissive may allow excessive heating.
A value that is too restrictive may create unwanted trips during normal load variations or starting.

Starting parameters

Starting behavior has a direct impact on motor heating.
Acceleration ramp, current limit, torque boost, and control mode can all affect the thermal stress seen by the motor during startup.

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A motor that starts correctly from a mechanical point of view may still accumulate too much thermal stress if the settings are not appropriate.

Motor ventilation type

Motor cooling has a major effect on real thermal capacity.

This must be considered carefully for:

- self-ventilated motors
- separately ventilated motors

A self-ventilated motor does not cool the same way at 20 Hz and at 60 Hz.
If this is not considered, the thermal protection may not reflect the real motor condition.

Recommended validation procedure

1. Record the reference data

Before testing, record the following:

- motor nameplate data
- configured motor thermal protection parameters
- motor ventilation type
- expected operating speed range
- expected load profile
- expected starting duty
- ambient conditions, if relevant

This information should be kept in the commissioning record.

2. Check operation at no load or light load

Start the motor at no load or light load and confirm that:

- the motor starts normally
- acceleration is stable
- output current is reasonable
- no unexpected motor thermal warning or trip appears

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This first step helps detect obvious parameter errors before testing under normal load.

3. Check operation under normal load

Operate the machine in its normal process conditions and let it run long enough for the operating condition to stabilize.

Confirm that:

- motor current is consistent with the expected load
- the motor does not show abnormal heating
- no nuisance thermal warning or trip occurs
- the drive behaves normally across the intended speed range

Where practical, compare the drive thermal indication with the real motor condition observed in the field.

For example, check:

- drive output current
- operating speed
- load condition
- motor frame temperature trend measured externally

The purpose is not to obtain an exact winding temperature, but to confirm that the drive model is coherent with what is observed on the real machine.

4. Check repeated starting duty

If the application includes repeated starts, test a starting sequence representative of the real duty.

Verify that:

- normal starts do not create unjustified trips
- repeated starts increase thermal stress as expected
- the protection reacts consistently with the real severity of the duty

If the drive trips during a start sequence that is normal for the application, review:

- motor rated current
- I/In setting

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- acceleration time
- current limit
- torque boost
- ventilation assumptions

5. Check low-speed operation

This step is strongly recommended when the motor is self-ventilated.

Run the motor at the minimum continuous operating speed expected in service, with representative load, for a sufficient duration.

Check for the following:

- stable operation
- current consistent with the load
- no abnormal rise in motor temperature
- coherent increase of thermal utilization in the drive, if displayed
- no evidence that the motor is overheating while the thermal model remains unrealistically low

Low-speed operation is one of the most common cases where thermal assumptions become too optimistic.

6. Check behavior in sustained high-load condition

Where the machine can be operated safely in such a condition, observe the drive response in a sustained high-load situation representative of a real overload tendency.

The objective is to confirm that the protection reacts in a credible way.

The test must remain within safe machine and process limits.
Do not force a destructive stall or locked-rotor condition unless such a test has been specifically approved by engineering and can be carried out safely.

During this check, confirm that:

- thermal stress increases as expected
- the warning or trip behavior is realistic
- the protection is neither clearly too sensitive nor clearly too permissive

7. Review and adjust if needed

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After the validation test, review whether the settings remain consistent with the real application.

Adjustment may be needed if you observe:

- nuisance trip during normal operation
- nuisance trip during normal starting duty
- abnormal motor heating without protective reaction
- clearly underestimated low-speed heating
- settings that do not match the motor nameplate or the real cooling condition

After adjustment, repeat the relevant part of the validation.

What should be considered acceptable

The motor thermal protection settings can be considered validated when all of the following are true:

- the motor data entered in the drive matches the installed motor
- the rated current setting is correct
- the I/In setting is consistent with the motor and the duty
- the motor starts normally without unjustified trip
- the motor operates under normal load without abnormal heating
- low-speed operation, when applicable, has been checked
- repeated starts, when applicable, have been checked
- the protection response is consistent with the real thermal severity of the application

Good practice

- Recheck these settings after replacing a motor, even if the replacement has the same power rating.
- Be conservative when the cooling condition is uncertain.
- Pay special attention to self-ventilated motors used at low speed.
- Do not use the motor thermal model as a substitute for correct motor sizing.
- When the application is severe, additional motor temperature monitoring may still be appropriate.

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8.7. Inputs and outputs

The Input/Output (I/O) interfaces of the VFD are the gateway to control and monitoring.

Whether you're setting up command signals, integrating external sensors, or automating feedback loops, understanding the I/Os is key to unlocking the full potential of your drive.

These chapters provide a comprehensive overview of all available I/Os, their configurations, and practical applications, ensuring you can easily adapt them to your specific needs.

From digital and analog inputs to relay outputs, each section is designed to guide you through functionality, wiring best practices, and configuration tips for optimal performance.

Digital inputs setting

Relay outputs setting

Analog inputs setting

Analog outputs setting

Incremental encoder

I/O's preset configuration

Previous Next

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8.7.1. Digital inputs setting

The user can assign digital inputs. The options available are as follows:

Assignment:

- **Damper feedback**: to monitor the damper limit switch, providing its state, open or closed.
- **Activate Fire Emergency Mode**: When active, this function keeps critical systems operational during a fire event
- **Incremental Encoder**: only for Di1 and Di2. Assign phase A or phase B to the input
- **Run Forward (2-Wire Control Mode)**: This command prompts the motor to rotate clockwise. The command remains active as long as the logic state is 1; otherwise, the motor stops.
- **Run Reverse (2-Wire Control Mode)**: This command prompts the motor to rotate counterclockwise. The command remains active as long as the logic state is 1; otherwise, the motor stops.
- **Run Forward (3-Wire Control Mode)**: This command prompts the motor to rotate clockwise. The command is triggered by a pulse lasting a minimum of 20 milliseconds.
- **Run Reverse (3-Wire Control Mode)**: This command prompts the motor to rotate counterclockwise. The command is triggered by a pulse lasting a minimum of 20 milliseconds.
- **Stop (3-Wire Control Mode)**: This command instructs the motor to cease rotation. The command is triggered by a pulse lasting a minimum of 20 milliseconds.
- **Select PID Forced Output State**: If inactive, the PID Forced Output is disabled. If active, the PID forced output mode is enabled.
- **Reset lockout state**: When the VFD is in lockout state, it can be reset when all the faults are cleared by using the defined digital input
- **Select Control Mode**: When active, the remote control mode is selected. If inactive, the local control mode is selected.
- **Select Ramp-Down**: switch between two user-defined ramps-down
- **Select Ramp-up and ramp-down**: Enable the related ramp when energized
- **Select Ramp-Up**: switch between two user-defined ramps-up
- **Select Remote Control Source**: If inactive, this will select remote source 1. If active, this will select remote source 2.
- **Select Speed Frequency Reference**: When active, the frequency reference is determined by the configured analog input. If inactive, the frequency is set by the preset value.
- **Select Speed Velocity Reference**: When active, the velocity reference is determined by the configured analog input. If inactive, the velocity is set by the preset value.
- **Activate Maintenance Mode**: Set the VFD into maintenance mode

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- **External Critical Alarm**: trigger an internal VFD alarm based on events occurring outside the drive
- **External Major Alarm**: trigger an internal VFD alarm based on events occurring outside the drive
- **External Medium Alarm**: trigger an internal VFD alarm based on events occurring outside the drive
- **External Minor Alarm**: trigger an internal VFD alarmsbased on events occurring outside the drive
- **Interlock**: Motor-Disable function preventing the motor from starting and forces a stop
- **Select active configuration**: Switches which stored configuration controls the drive
- **Not assigned**: Not currently assigned to any specific task or function

Di1 and Di2 can also be assigned to an incremental encoder input. Read more in the dedicated chapter.

Trigger type:

The input can be set as "active" depending on the user-defined trigger.

The choices for the trigger are:

- **Not assigned**: The input remains inactive whatever electrical signal happens on its terminal
- **Rising edge**: The input becomes active when a transition from a low voltage (inactive state) to a high voltage (active state) is detected on its terminal. This is typically used in digital systems for edge-triggered events.
- **Falling edge**: The input becomes active when a transition from a high voltage (active state) to a low voltage (inactive state) is detected on its terminal. Like the rising edge, this is used for edge-triggered events.
- **High**: The input is considered active when a high voltage is detected on its terminal. This is typically used in systems that operate on level-triggered events.
- **Low**: The input is considered active when a low voltage is detected on its terminal. This is also used in systems that operate on level-triggered events.

Please note that the specific levels for “high” and “low” states refer to the voltage levels for states ON and OFF, for Sink and Source connection logic, as defined in the digital input specifications chapter.

Debounce delay:

A debounce delay can be set to prevent rapid fluctuations in input signals from causing erratic behavior in the motor control.

It ensures that the VFD only responds to sustained changes in input, rather than temporary fluctuations

Previous Next

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8.7.2. Relays setting

Configuration:

You can configure a function to trigger a change in the relay's state (either energized or de-energized). The supported activation trigger functions are described below:

- **Not assigned**: No activation trigger, the relay is not used.
- **Ready-to-run**: When the power drive system (VFD + Motor) is ready to run, it waits for a Start command.
- **Motor running**: When the power drive system (VFD + Motor) is running.
- **Any alarm above minor**: When there is an active alarm (critical, major, or medium) on the VFD.
- **Motor lockout**: When the power drive system (VFD + Motor) is in the lockout state.
- **Motor torque:** When the VFD magnetizes the motor, it provides torque before ramping up.
- **Damper control:** When a command is sent to control the damper.
- **Active switchover limit**: Indicates which current limit is currently active via relay state.
- **Unacknowledged alarm:** when there is at least one unacknowledged critical, major or medium alarm

The user can also define the default coil state for each relay: Energized or De-energized.

Relay's behavior when the activation trigger is ON:

- For relay R1 (SPDT relay / Form C relay):
    - **Relay De-energized**: The NC contact of the relay is closed, and the NO contact of the relay is opened when the activation trigger is activated.
    - **Relay Energized**: The NO contact of the relay is closed and the NC contact of the relay is opened when the activation trigger is activated.
- For relays R2 and R3 (NO relay / Form A relay):
    - **Relay De-energized**: The contact of the relay is opened when the activation trigger is activated.
    - **Relay Energized:** The contact of the relay is closed when the activation trigger is activated.

Previous Next

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8.7.3. Analog inputs setting

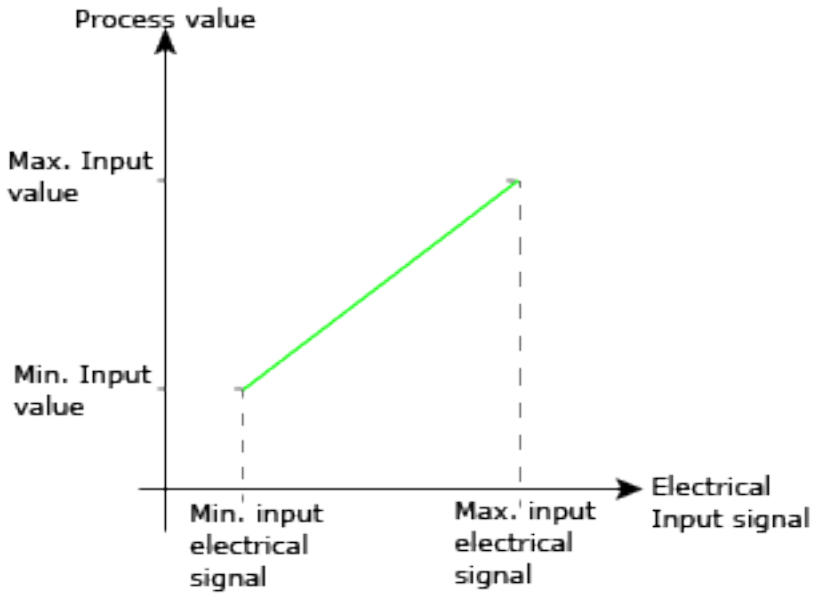
The user can assign analog inputs. The options available are as follows:

- **PTC sensor:** Reading from the PTC sensor connected to the analog input used for motor over-temperature alarm.
- **Set motor frequency**: Send a variable value to the VFD control to define the motor frequency setpoint.
- **Set motor velocity**: Send a variable value to the VFD control to define the motor velocity setpoint.
- For motor torque control:
    - **Set motor torque:** Send a variable value to the VFD control to define the motor torque setpoint.
    - **Set motor maximum torque:** Send a variable value to the VFD control to define the maximum limit of the torque setpoint.
    - **Set motor minimum torque:** Send a variable value to the VFD control to define the minimum limit of the torque setpoint.
- If the PID is enabled in the configuration:
    - **PID1 process feedback**: Send the process value (PV) to the PID control.
    - **PID1 setpoint**: send the setpoint value (SV) to the PID control.
    - **PID1 forced output value**: Send a speed setpoint to the motor control when the PID forced output is activated and the source of the forced value is defined as an analog input.
- **Unspecified**

The user can also define the electrical signal connected to each analog input and scale it. The options available are as follows:

- **4 - 20 mA**: The input signal is a current between 4 and 20 mA.
- **0 - 10 V**: The input signal is a voltage between 0 and 10 V.
- **Resistor**: The input signal is a resistance from 500 to 10K Ohms.

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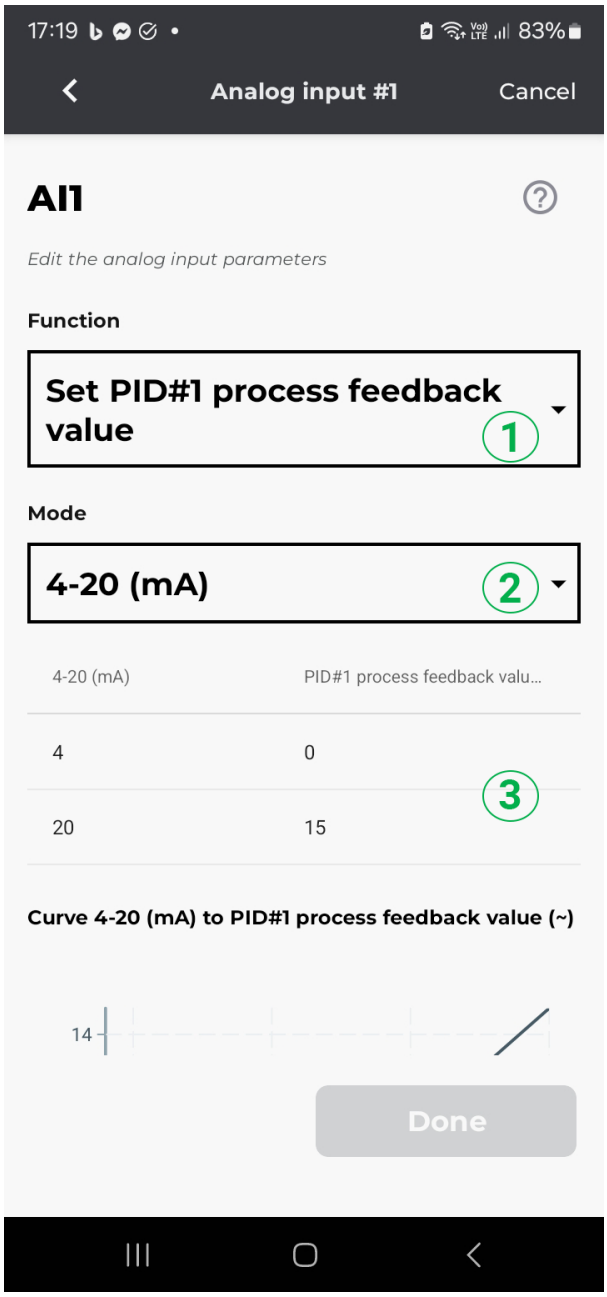
Example:

A pressure sensor is connected to one of the analog inputs. It is used as the process feedback of a PID loop

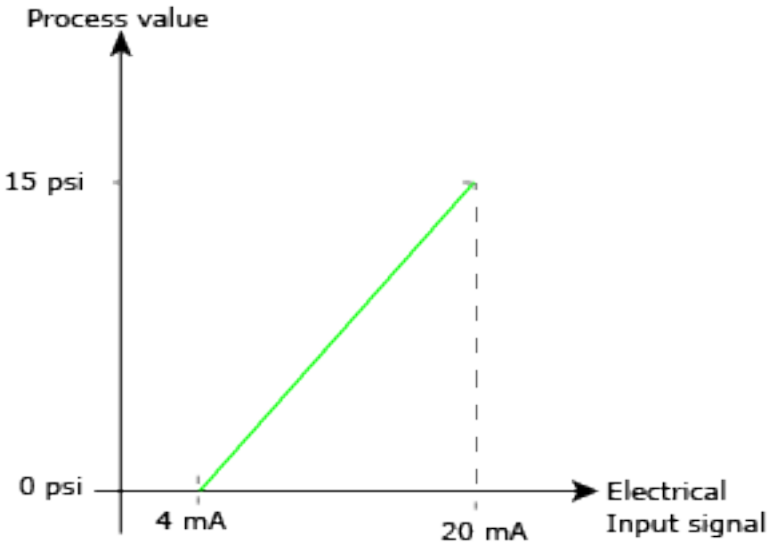
This sensor delivers a 4 to 20 mA signal proportional to the detected pressure.

- Click on the I/O's configuration screen, click on the pen icon of the analog inputs to edit the configuration
- Then on the analog input, the sensor is wired to, i.e Ai1
- For the function, select Set PID#1 process feedback value (1)
- Mode: Select 4-20 mA (2)
- Then, on the scaling (3,) click on the values you need to edit and enter the number that fits the application.

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Previous Next

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8.7.4. Analog outputs setting

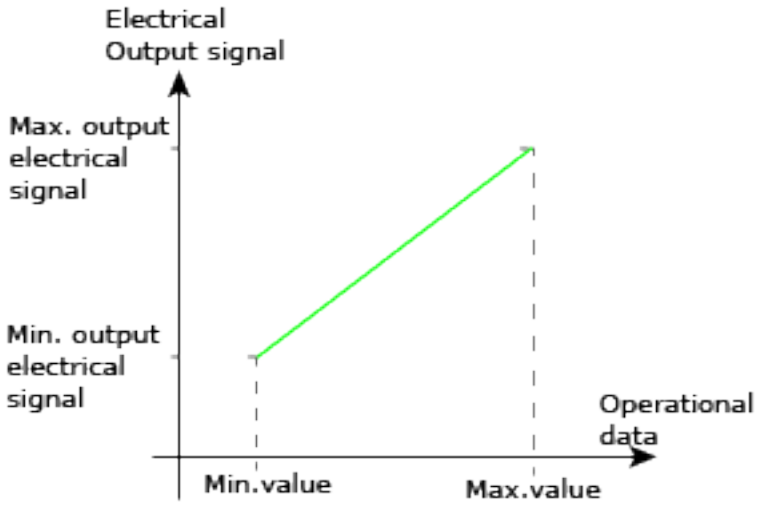
The user can assign analog outputs. The options available are as follows:

- **Unspecified**: Not currently assigned to any specific task or function.
- **Motor frequency (Hz)**: The VFD outputs an electrical signal proportional to the motor frequency.
- **Motor current RMS (A)**: The VFD outputs an electrical signal proportional to the motor current RMS.
- **Motor velocity (RPM)**: The VFD outputs an electrical signal proportional to the motor velocity.
- **Active power (kW)**: The VFD outputs an electrical signal proportional to the motor's actual power consumption.
- **Motor torque (%)**: The VFD outputs an electrical signal proportional to the motor torque in percentage

The user can also define the electrical signal connected to each analog output and scale it. The options available are as follows:

- **Unspecified**: There isn't any signal generated on the output

  Do not keep the signal as "unspecified" when an analog output is assigned to one of the possible variables.
- **4 - 20 mA**: The output signal is a current between 4 and 20 mA.
- **0 - 10 V**: The output signal is a voltage between 0 and 10 V.



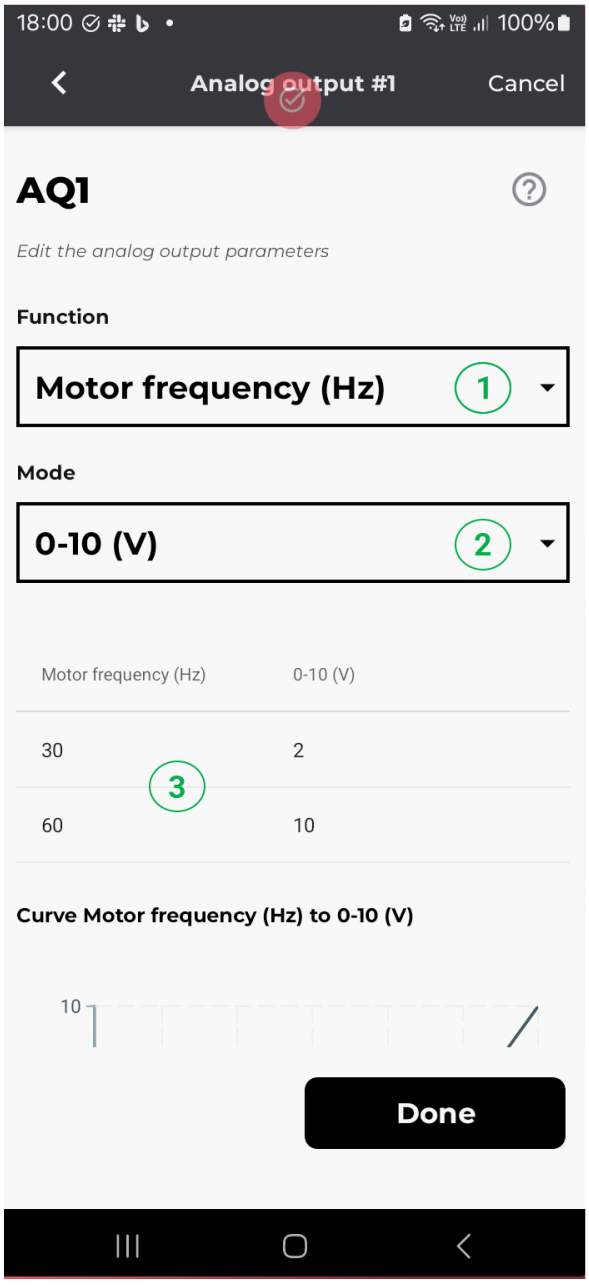
Example:

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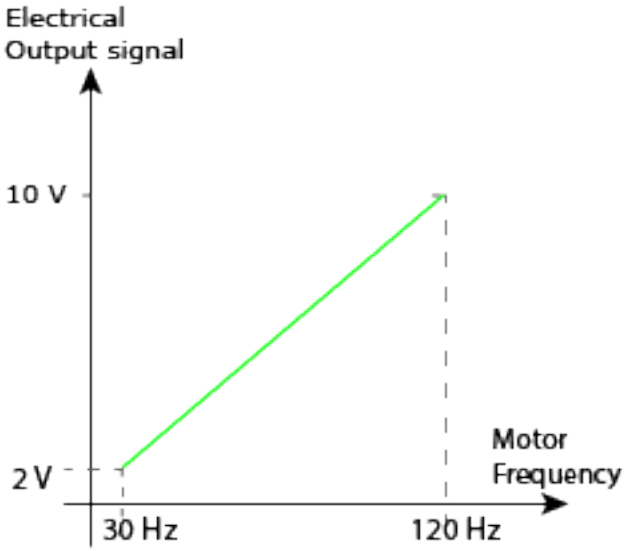
In this example, it is required to display the motor speed in Hz from a minimum operating speed of 30 Hz to a maximum of 120 Hz, thus onto a digital display meter with a 2 to 10 V input.

- Click on the I/O's configuration screen, click on the pen icon of the analog outputs to edit the configuration
- Then on the analog output, the digital display meter is wired to, i.e AQ1
- For the function, select Motor Frequency (Hz) (1)
- Mode: Select 0-10 (V) (2)
- Then on the scaling (3) click on the values you need to edit and enter the numbers that fits the application.

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Previous Next

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8.7.5. Incremental encoder

- Introduction
- Type of encoder and wiring
- Selecting the Encoder's frequency and PPR
- Check that the Encoder Output max. Frequency fits the VFD's input frequency
- Define the encoder max number of pulses per revolution
- Settings
- Commissioning the incremental encoder

Introduction

To measure the rotation speed and direction of the motor, and in some applications, the position, an incremental encoder is mounted on the motor shaft and delivers pulses to the VFD.

The motor's actual speed is then fed back to the control circuit. With this, fluctuation of the motor speed can be compensated and a close loop control can be achieved.

Being able to monitor the motor shaft rotation gives also the ability to detect faults and then generate appropriate alarms.

Type of encoder and wiring

An incremental encoder (from the motor shaft) can be connected to the VFD dedicated inputs: **digital input 1 and digital input 2** (1)

The embedded VFD software calculates the actual speed and rotation direction of the motor shaft from the signals delivered by the encoder.

If the driven motor is an asynchronous motor, the VFD also calculates the actual slip and compensates for it.

The encoder's outputs that must be used are A and B. The Clean Power VFD is compatible only with a 24VDC encoder.

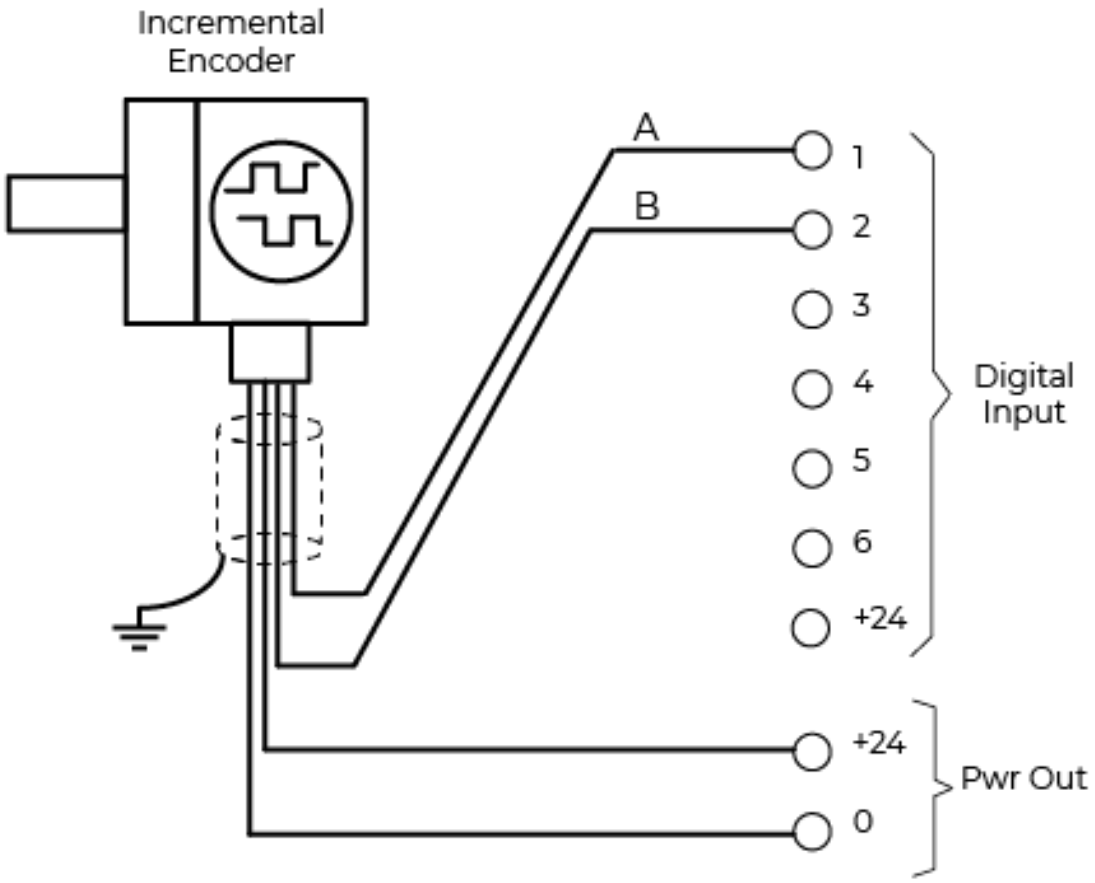
TTL encoders must not be used with SmartD VFD (their not compatible voltage level will lead to wrong readings and then the risk of misoperation of the VFD).

The encoder must be wired to

- Power out +24VDC

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- Power out 0
- Digital input 1 for channel A
- Digital input 2 for channel B



(1) Clean Power VFD versions and compatibility with encoder:

The digital inputs 1 and 2 (Di1 and Di2) on the Clean Power VFD are compatible with pulse train signals up to a maximum frequency of 50 kHz.

This compatibility applies to hardware produced on or after June 14, 2024.

You can verify this by checking the VFD's serial number. Ensure that the middle segment of the serial number is "20240614" or later (e.g., 0001-20240614-000001).

If your Clean Power VFD was manufactured before this date, it does not support the pulse train signal for the incremental encoder function.

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Selecting the Encoder's frequency and PPR

Check that the Encoder Output max. Frequency fits the VFD's input frequency

Encoder Frequency (Hz)=[Pulses Per Revolution (PPR)×Speed (RPM)] / 60

Pulses Per Revolution (PPR): This represents the number of pulses or counts generated by the encoder in one full revolution of its shaft.

Speed (RPM): This is the rotational speed of the encoder shaft in Revolutions Per Minute.

60: This is the conversion factor used to convert minutes to seconds, as the frequency is expressed in Hertz (cycles per second).

The result you get from this equation will be the frequency of the output signal from the encoder in Hertz (Hz), which corresponds to the speed at which it's rotating.

This information is for the VFD to accurately control the speed of the motor based on the feedback from the encoder.

Define the encoder max number of pulses per revolution

Max PPR=[Max Input Frequency of VFD (Hz)×60] / Max Speed of Motor Shaft (RPM)

Max Input Frequency of VFD (Hz): The highest frequency that the VFD can accept as an input (50kHz)

Max Speed of Motor Shaft (RPM): The highest speed at which the motor shaft can rotate

60: Conversion factor from minutes to seconds.

This calculation will give the maximum number of pulses per revolution the encoder can have without exceeding the VFD's maximum input frequency limit at the motor's maximum operating speed.

This ensures the encoder's output remains within the VFD's acceptable range.

Settings

1) To use an incremental encoder with the Clean Power VFD, Di1 and Di2 must be configured as incremental encoder inputs for signal phase A and phase B, respectively.

2) Then the incremental encoder's PPR must be defined. This parameter can be set between 50 and 10,000. Its default value is defined according to the motor's rated frequency and number of poles.

For example, for a 2-pole motor,

- In the case of a 60Hz motor, the default value must be 800.
- In the case of a 50 Hz motor, the default value must be 1000.

3) In case of miswiring phase A and phase B, a toggle switch allows swapping A and B without the need to modify the wiring

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Commissioning the incremental encoder

When commissioning closed-loop control, verify that your I/Os are working correctly before using them in a feedback loop.

Specifically, for the encoder, this would imply:

1. Configuring it with the correct PPR setting while keeping the FOC speed source to "estimated“
2. Make sure no encoder alarms are raised ("motor wrong direction“ ," encoder communication failure“ and "encoder speed error“)
3. Tune the thresholds/delays of the alarms to make them more or less strict depending on needs

When this is OK, switch the iFOC speed source to "measured from encoder“



SmartD recommends checking the correct operations of the I/O's, as well as the correct setting of the encoder PPR.

Defective input or wrong setting of the encoder could make the control unstable and end up having a major alarm that protects the hardware (e.g., "motor control instability“ or "drive output overcurrent“).

Previous Next

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8.7.5.1. Encoder faults

When an encoder is connected to the VFD and this encoder is active, it checks it and manages its failures and alarms.

Encoder failures are of the medium category.

If one of the encoder failures is detected, then the VFD stops the motor in a freewheeling mode (it de-energizes its output).

The event is logged.

To re-start the motor,

- the fault must be cleared,
- and the VFD must receive the command "Run"

Missing encoder / Encoder communication failure:

When the signal on phase A or B is missing while the motor is running.

Or when the pulse frequencies between channels A and B are different.

Speed error (Estimated vs measured from the encoder):

The discrepancy between the speed feedback by the encoder and the speed estimated by the VFD is high.

The threshold is a percentage of the motor's rated speed. The threshold is configurable from 1.0 % to 100.0 %, its default value is 5.0 %.

For example, if the motor's rated speed is 1000 RPM, the fault might be triggered if the discrepancy exceeds 50 RPM for a threshold configured at 5.0%.

Note that the configuration shall be rejected if the calculated threshold of discrepancy is lower than 5RPM.

Previous Next

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8.7.6. I/O's preset configuration

The following sections explain the two primary methods for wiring your VFD's control inputs and outputs —commonly referred to as "2-wire" and "3-wire" configurations.

These 2 options offer considerable flexibility in how the VFD is controlled, whether you prefer a simple maintained contact (such as a PLC output) or separate momentary push buttons (like a dedicated start/stop station).

The following sections provide a detailed explanation of each wiring mode and their operational scenarios.

- 2-wires, 3-wires preset I/Os assignment
- 3-wires preset - operation
- 2-wires preset - operation

Previous Next

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8.7.6.1. 2-wires, 3-wires, preset I/Os assignment

There are 2 wiring presets with their configuration selectable by the user, via the mobile application: 2-wires mode and 3-wires mode.

“2-wire” and “3-wire” refer to two different ways you can wire the start/stop control (and sometimes forward/reverse) inputs for the drive.

Offering both “2-wire” and “3-wire” modes gives you flexibility in how the drive is controlled—whether by simple maintained contacts (e.g., a PLC output) or by separate momentary push buttons (e.g., start/stop station)

The preset configuration is editable by the user during the configuration phase of the VFD.

The default preset is the 3-wire configuration.

The following drawings show the I/O's that are used in the default presets with their function assignment. Those drawings are not wiring diagrams.

- Check the standard connection diagram section for the wiring.
- Check the control circuit description section for the attributes and values of the control terminals,
- and check the digital input logic connection section for the details of Source and Sink logic connection modes.

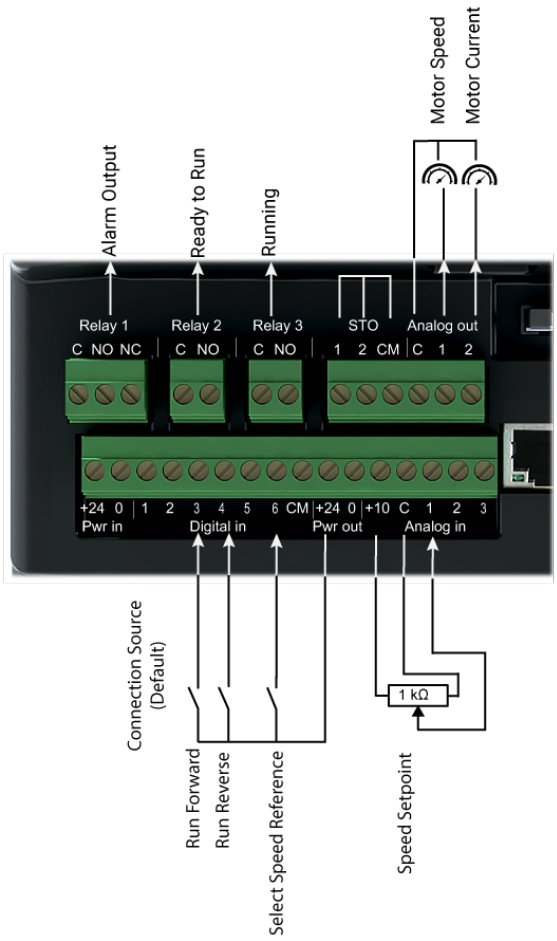
Wiring presets are available for speed control mode and torque control mode, with some slight differences in I/O assignment.

I/O	2- wires preset		3-wires preset	
	Speed control	Torque control	Speed control	Torque control
Di 3	run forward	torque applied in the forward direction	run forward	torque applied in the forward direction
Di 4	run reverse	torque applied in the reverse direction	run reverse	torque applied in the reverse direction
Di5			stop	stop
Di 6	select speed reference (if a preset speed is defined)		select speed reference (if a preset speed is defined)	
Ai 1	speed setpoint		speed setpoint	
Ai 2		torque setpoint		torque setpoint
Relay 1	alarm output	alarm output	alarm output	alarm output
Relay 2	ready to run	ready to run	ready to run	ready to run

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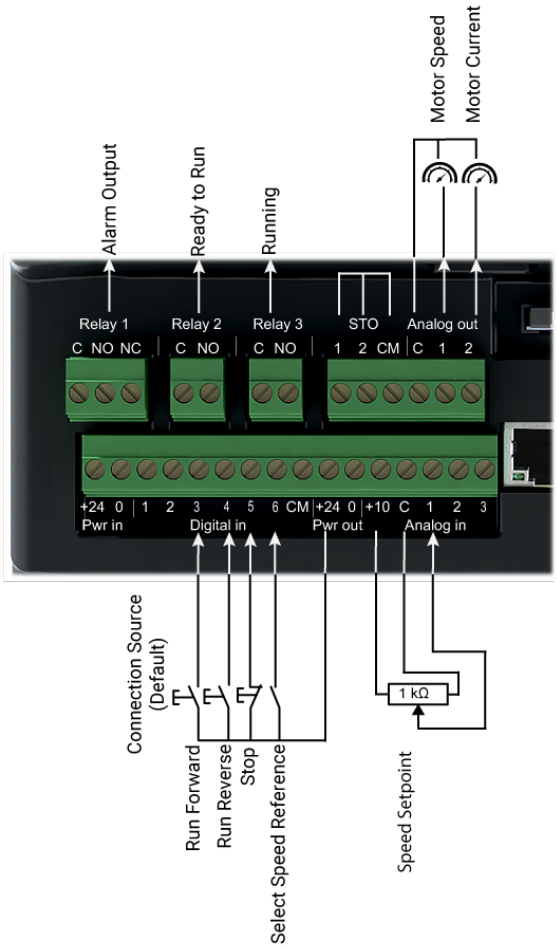
I/O	2- wires preset		3-wires preset	
Relay 3	running	running	running	running
Aq 1	motor speed	motor torque	motor speed	motor torque
Aq 2	motor current	motor current		

2-wires connection for speed control:



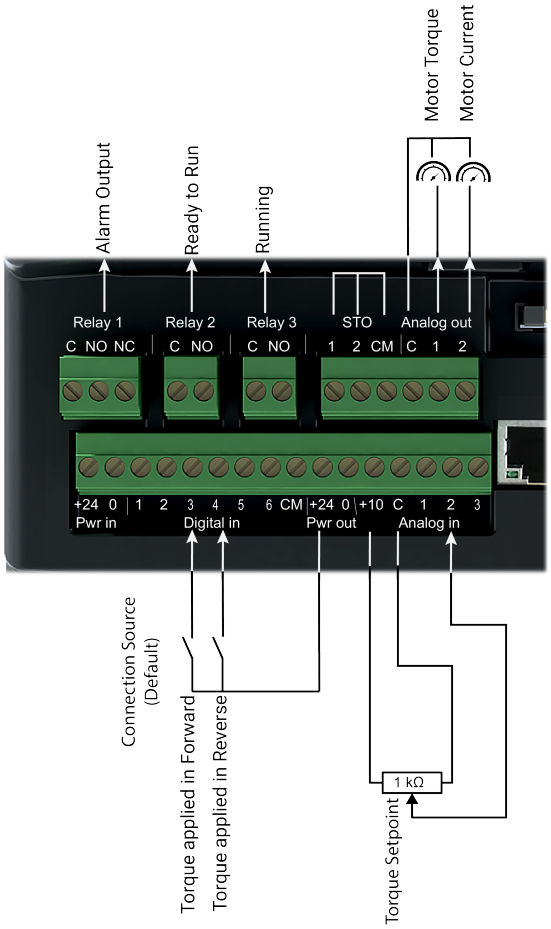
3-wires connection for speed control :

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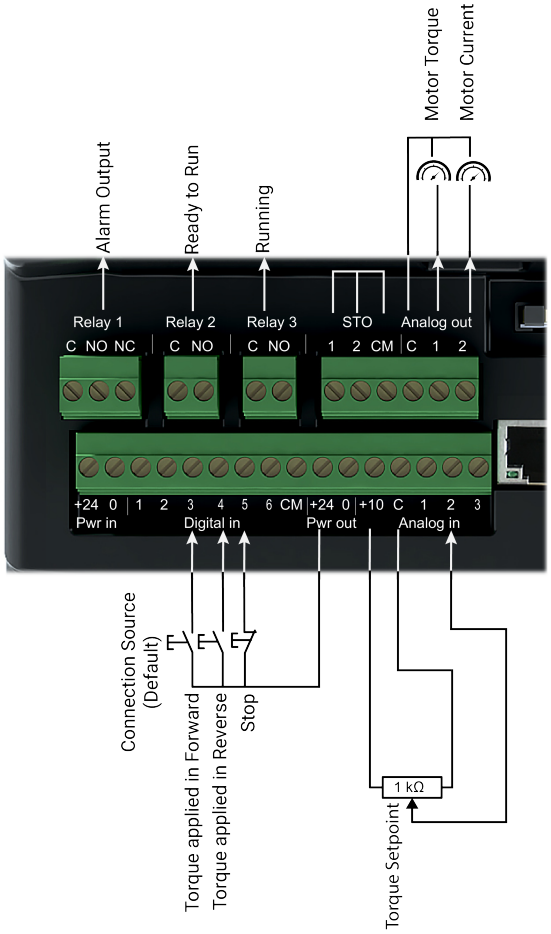
2-wires connection for torque control:

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3-wires connection for torque control :

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Previous Next

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8.7.6.2. 3-wires preset- Operation

In 3-wires mode, the basic controls are:

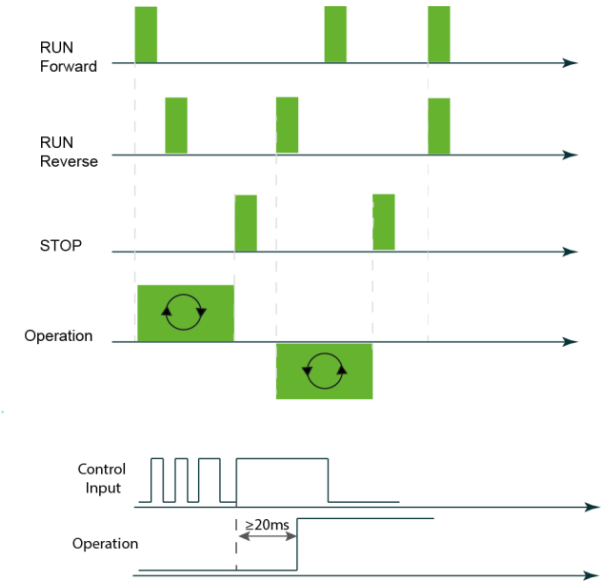
- Run forward (default: Di3 input)
- Run reverse (default: Di4 input)
- Stop (default: Di5 input)

Pressing the run forward or the run reverse button momentarily “latches” the drive into a running state internally.

Pressing the Stop button breaks that latch, causing the drive to stop the motor

The control inputs are managed as pulses of a minimum duration of 20ms.

Simultaneous activation of run forward and run reverse is managed depending user setting for the priority of spinning direction.



The 3-wire mode can be configured to operate only in the forward direction.

When the single direction is enabled, the preset I/O "Run Reverse" (digital input number 4) is available to be associated with another function such as selecting a preset speed

Previous Next

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8.7.6.3. 2-wires preset- Operation

In 2 wires mode, the basic controls are run forward and run reverse.

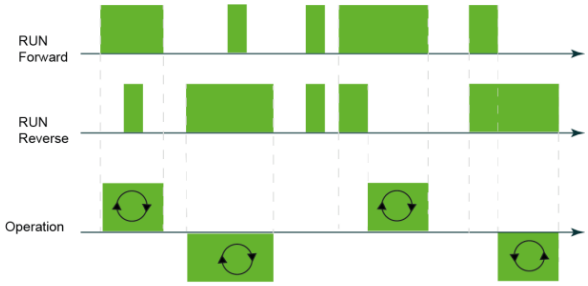
- Run forward (default: Di3 input)
- Run reverse (default: Di4 input)

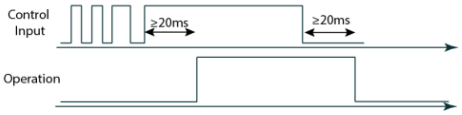
If none of those inputs is active, the Clean Power VFD stops the motor.

Simultaneous activation of run forward and run reverse is managed depending user setting for the priority of spinning direction.

A digital input is managed as active upon its steady state.

A filter (acting as a delay) of fixed 20ms is enabled on the digital inputs to prevent false triggering of the control.





Previous Next

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8.8. Two Current Limits With Automatic Switchover

⚠ WARNING

Unexpected motor behavior due to incorrect current limit settings:

Incorrect current limitation settings can reduce the available motor torque or allow more current than expected in part of the operating range. This can cause unstable operation, process malfunction, or mechanical stress. Before enabling this function, verify that both current limits are suitable for the motor, the driven equipment, and the operating conditions.

⚠ CAUTION

Current limitation is not a safety function.

Do not use this function as a safety-related torque, speed, or motion limiting function. If the machine requires a certified safety function, use an appropriate safety system.

NOTICE

The current limit switchover configuration cannot be changed while the motor is running. Stop the motor before changing the configuration.

The **Two Current Limits With Automatic Switchover** function lets the drive automatically select between two current limitation values according to the output motor frequency.

Use this function when the application requires one current limit in one speed range and another current limit in another speed range.

For example, the drive can use **Current limitation 1** at lower output frequencies and automatically switch to **Current limitation 2** when the motor frequency increases above a configured switchover threshold.

Operating Principle

When the function is enabled, the drive monitors the output motor frequency and automatically selects the active current limit.

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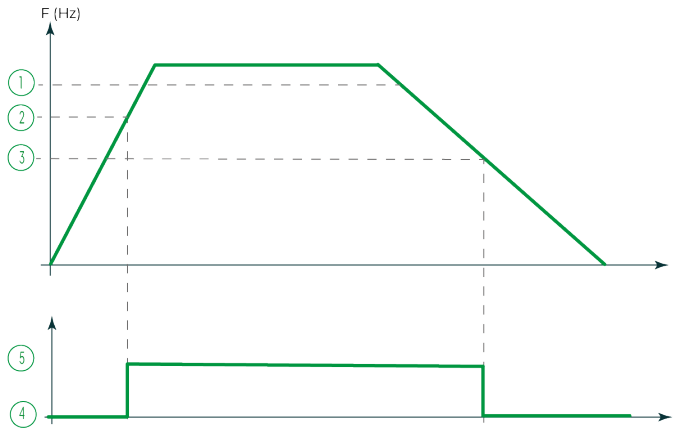
4 onto the diagram: The drive uses **Current limitation 1** by default.

1 onto the diagram: The switchover does not occur exactly at the Frequency Threshold level (`FTD_Level`).
The drive uses hysteresis values to define when the active current limit changes:

`2 onto the diagram: Frequency Threshold in Hysteresis (FTD_In_Hyst)` allows the drive to switch to **Current limitation 2** (5 onto the diagram) slightly before the output frequency reaches `FTD_Level`. This helps avoid reaching an operating point where the drive could deliver an unexpected or undesired current level before the second current limit becomes active.

`3- onto the diagram: Frequency Threshold out Hysteresis (FTD_Out_Hyst)` defines when the drive switches back to **Current limitation 1** during deceleration or when the output frequency decreases. This prevents repeated switching when the output frequency is close to the switchover area.

Condition	Active current limit
Output frequency rises above `FTD_Level - FTD_In_Hyst`	Current limitation 2
Output frequency falls below `FTD_Level - FTD_Out_Hyst`	Current limitation 1
Output frequency remains between both thresholds	The drive keeps the current limit that was already active



NOTE

`FTD_In_Hyst` is used to anticipate the switchover to Current limitation 2. It helps the drive apply the second current limit before the motor reaches the configured frequency threshold.

Before You Begin

Before enabling this function:

1. Verify the motor nameplate data and drive ratings.

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2. Confirm the required current limit values for the application.
3. Confirm the frequency at which the drive must switch from one current limit to the other.
4. Make sure the motor is stopped.
5. Make sure the motor thermal protection and overload settings remain correctly configured.

Parameters

Parameter	Description	Range / Valid values	Default value	Unit	Availability
Enable	Enables or disables the automatic current limit switchover function.	Enabled / Disabled	Disabled	–	Always visible
FTD_Level	Motor frequency switchover threshold.	0…120	50 if nominal motor frequency is 50 Hz; 60 if nominal motor frequency is 60 Hz	Hz	Available when the function is enabled
FTD_In_Hyst	Hysteresis used when switching to Current limitation 2.	Maximum of 0.1 Hz or 2% of `FTD_Level`	0.1	Hz	Applied when the function is enabled
FTD_Out_Hyst	Hysteresis used when switching back to Current limitation 1.	Maximum of 0.3 Hz or 6% of `FTD_Level`	0.3	Hz	Applied when the function is enabled
Current limitation 1	Current limit used by default and used below the lower switchover threshold.	1 A to 1.2 × nominal drive current in Normal Duty	1.2 × nominal drive current in Normal Duty	A	Available when the function is enabled
Current limitation 2	Current limit used above the upper switchover threshold.	1 A to 1.2 × nominal drive current in Normal Duty	1.2 × nominal drive current in Normal Duty	A	Available when the function is enabled

NOTE

Current limitation 2 is not necessarily higher than Current limitation 1. Configure both values according to the application requirement.

Configure the Function

1. Stop the motor.
2. Open the current limit switchover settings on the HMI or in the mobile app.
3. Set **Enable** to **Enabled**.
4. Set **Current limitation 1**. This is the current limit used by default.

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5. Set **Current limitation 2**. This is the current limit used when the output frequency is above the switchover threshold with hysteresis.
6. Set **FTD_Level**. This is the output motor frequency threshold used by the automatic switchover logic.
7. Verify the applied hysteresis values. The drive uses hysteresis to avoid repeated switching around the threshold.
8. Save the configuration.
9. Start the motor and verify the behavior during acceleration and deceleration.

Active Current Limit Feedback

The active current limit can be assigned to a relay output.

Relay state	Meaning
Relay de-energized	Current limitation 1 is active
Relay energized	Current limitation 2 is active

CAUTION

Do not use the relay state alone to confirm that the drive is running

A de-energized relay indicates that Current limitation 1 is active, but it can also occur when the relay has no power or when the drive is not in operation. Use the drive status and application control signals to confirm the actual operating condition.

Commissioning Validation

After configuration, perform the following validation:

Validation step	Expected result
1. Function disabled	The drive uses the standard current limitation behavior.
2. Function enabled	Current limitation 1 is active.
3. Output frequency below the lower threshold	Relay state follows the active current limit 1.
4. Output frequency rises above `FTD_Level - FTD_In_Hyst`	The drive switches to Current limitation 2.

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Validation step	Expected result
	Relay state follows the active current limit 2.
5. Output frequency decreases but remains inside the hysteresis band	The active current limit does not change.
6. Output frequency drops below `FTD_Level - FTD_Out_Hyst`	The drive switches back to Current limitation 1. Relay state follows the active current limit 1.
7. Motor running	Configuration parameters cannot be changed.

Troubleshooting

Symptom	Possible cause	Recommended action
The current limit does not switch	Function is disabled.	Enable the function.
The current limit does not switch at the expected frequency	`FTD_Level` or hysteresis values do not match the expected switchover point.	Verify the threshold and hysteresis logic.
The drive switches to Current limitation 2 earlier than expected	The switch to Current limitation 2 occurs at `FTD_Level - FTD_In_Hyst`.	Recalculate the effective switching frequency.
The drive does not immediately switch back to Current limitation 1 during deceleration	The drive keeps Current limitation 2 until the output frequency is below `FTD_Level - FTD_Out_Hyst`.	Verify that the output frequency is below the lower threshold.
The relay does not indicate the expected current limit	Relay output is not assigned to active current limit feedback.	Check the relay assignment.
The parameters cannot be edited	The motor is running.	Stop the motor before changing the configuration.

Previous Next

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8.9. Torque Deactivation

The "Torque Deactivation" function is used to prevent the Clean Power VFD from generating torque to the motor and preventing the motor from restarting as long as the Torque Deactivation function is activated.

This prevents the Clean Power VFD/motor system from operating while Torque Deactivation is engaged.

This Torque Deactivation function corresponds to **stop category 0** according to IEC 60204-1: the stopping is executed by immediate removal of power to the machine actuators.

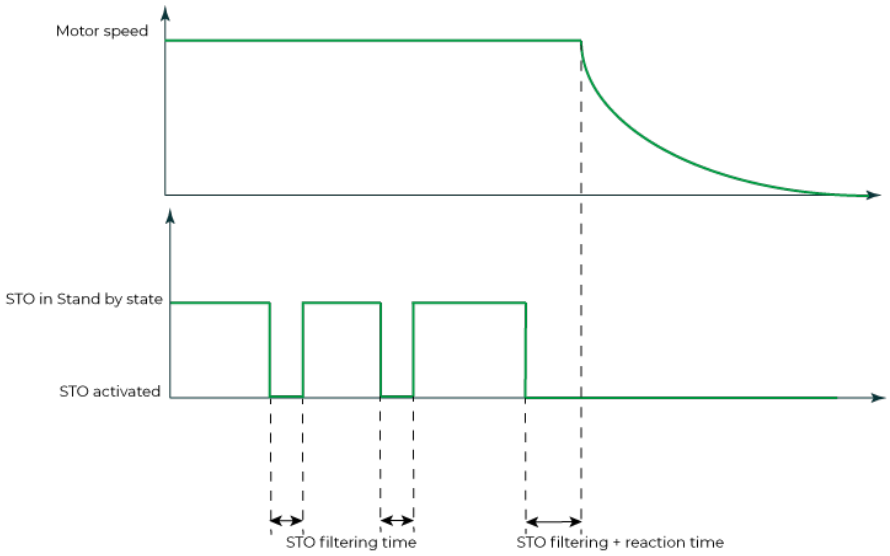
Note for users, other stop categories are

- Stop Category 1: A controlled stop with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved.
- Stop Category 2: A controlled stop with power left available to the machine actuators

When the Clean Power VFD is operating normally it is in a "normal" state and the Torque Deactivation function is in a "standby" state.

If one or both STO1 or STO2 channels are de-energized the Torque Deactivation function is activated and the Clean Power VFD transitions to the "torque deactivation output" state.

In this state, the Clean Power VFD shuts off power to the semiconductors and disables the startup.



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Filtering time refers to the width of the low-level pulse onto Torque Deactivation input. When the input pulse width is less than or equal to the Torque Deactivation filtering time, there is no influence on the operation.

Reaction time is the time interval from the power-off time of any Torque Deactivation input to the stop time of power output components.

Before using the Torque Deactivation function, a complete risk analysis of the system must be done. Depending on this analysis, additional measures may be necessary to prevent any hazard (e.g. mechanical brake with vertical load).

Acceptance test

The correct operation of the STO function must be checked at least once a year and during the validation (initial start-up).

The goal of this procedure is to verify that all subsystems of the function are operational.

After any maintenance work related to the function, or after any modification related to the function (wiring, settings, etc) the acceptance test must also be executed.

The checking must be executed by an operator aware of potential risks due to a wrong operation of the system. This operator must master safety in general and functional safety specifically. He must report and sign the acceptance test in a dedicated document.

The initial acceptance test report and subsequent test reports must be stored in a logbook.

→ Link to Acceptance test guide

Previous Next

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8.10. Remote/ Local control source

⚠ WARNING

- If the VFD is running and the active control source is switched from Local (HMI) to Remote (digital I/Os) in 3-wire mode, the drive does not re-evaluate the current state of the digital inputs at the moment of the changeover.
    - Consequence:

      any Run/Stop/Direction state that is “present” on the inputs may be ignored until a new 3-wire transition (start pulse / stop action) occurs.

      This can lead to unexpected behavior after the switch (for example: the drive keeps running even though a remote Stop input is already active, or it does not react as expected until the next valid input edge is detected).
- If the VFD is running and the active control source is switched from Remote (digital I/Os) to Local (HMI), the VFD keeps its current operating status (run/stop/direction) until the HMI issues a new command.
    - Consequence:

      control authority moves to the HMI, but the drive may continue running with the last commanded state until the operator sends a Stop/Run command from the HMI. If the operator assumes the HMI immediately takes control and forces a safe state, this may create a risk of unintended continued operation.
- Recommendation:

  Avoid switching the active control source while the drive is running. If a source change is required, bring the drive to a controlled stop first, then switch sources, then issue a fresh start command from the newly selected source.

NOTICE

In remote mode, you can not modify the configuration. To do so, you must switch to the local mode.

The Clean Power VFD speed setpoint and the stop/start/direction controls can come from various sources.

Remote / Local

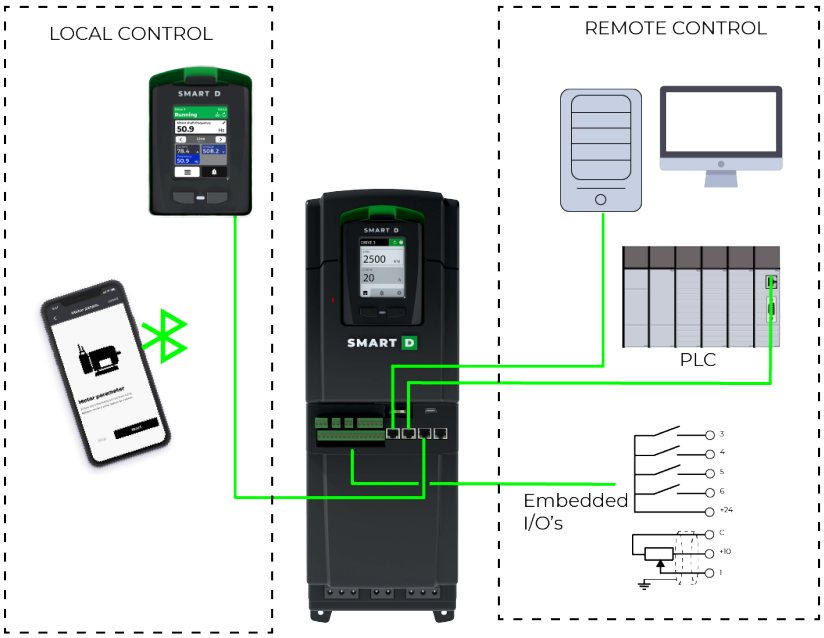
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This is the remote control mode when the VFD needs to be controlled remotely (away) (for example, from a control room using digital and/or analog inputs or from a remote system/device (PLC, DCS, network…, etc.).

In other words, the commands are coming from a system or a human not close to the VFD.

When the VFD needs to be controlled from its front face HMI or locally with a connected SmartD App (commissioning, maintenance, test, …), the user does not want any remote action to interfere and start a dangerous operation while working locally on the VFD. This is the local control mode.

In other words, a human is close to the VFD and controls it.



The switch between local and remote control modes can be performed from the HMI screen or the SmartD mobile App, or by using a digital input.

On the HMI

One of the icons below is displayed In the lower-right corner of the HMI to indicate the current control mode.

In **remote control mode**:

or in **local control mode**:

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If the remote control source is configured, you can switch between local and remote control by clicking on the icon.

On the mobile app

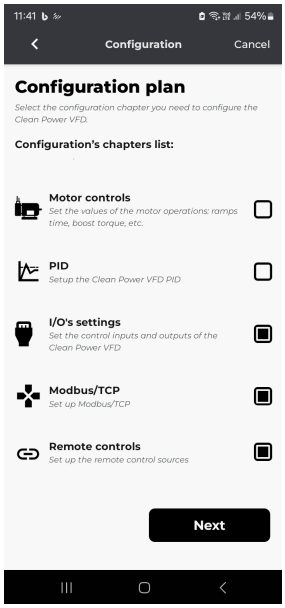
One of the icons below is displayed next to the VFD state:

In **remote control mode**:

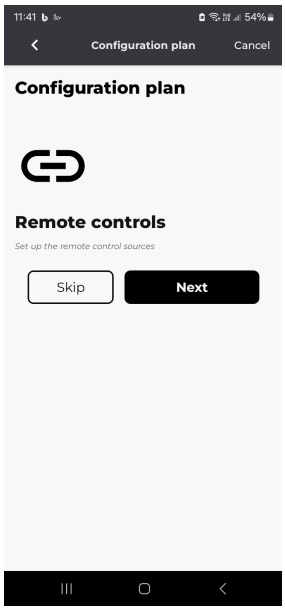
or in **local control mode**:

If the mobile app is connected to the VFD, you could configure the VFD to be in local or remote control mode:

Remote source selection



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The " Remote controls" section of the configuration wizard allows you to define

- the remote control sources
- the selector that will allow to switch from local to remote and vice versa

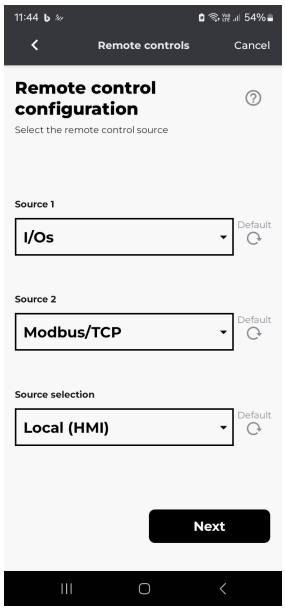
---

If the source selection is HMI, whatever the active control mode:

HMI can engage and disengage the remote control mode or remote control source (source 1 / 2) without restriction.

No remote control source can change the remote control mode status or active remote control source.

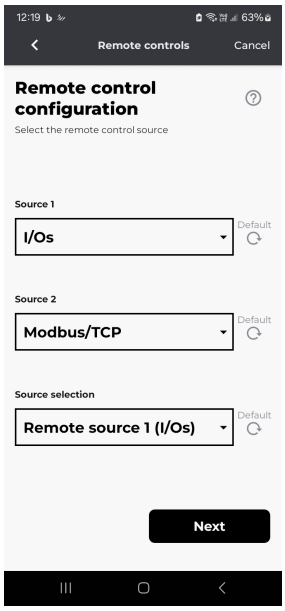
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If the source selection is remote source 1 or 2 (I/Os or Modbus/TCP):,

- If the VFD is in local control mode
    - HMI can do anything (change control mode and source)
- If the VFD is in remote control mode
    - HMI can engage remote control mode, but if it disengages it, the VFD will go to lockout because of “remote control override“
    - HMI cannot change the active remote control source
    - The source configured as the “source selection” can engage and disengage the remote control mode or remote control source (source 1 / 2) without restriction

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Remote Control Scenarios

This section presents three common remote control configurations using discrete I/Os and explains how to set up the drive accordingly.

Scenario 1: Remote Control Using Discrete I/O (Default Configuration)

In this setup, we keep the **default Remote Control configuration**, where the **HMI is used to switch between Local and Remote modes**.

Wiring and Configuration

- **Digital Input 3**: 3-wire Start
- **Digital Input 4**: 3-wire Stop
- **Digital Input 5**: Frequency Select (optional)
- **Analog Input 1**: Speed reference
- **HMI**: Used to switch between Local and Remote modes

Operation

1. Set the drive to **Remote mode** using the HMI.
2. Start and stop the motor using external push buttons connected to DI3 and DI4.
3. If **DI5 is OFF**, the drive uses **Analog Input 1** for the speed reference.
4. If **DI5 is ON**, the drive uses a **preset speed** defined in the parameter settings.
5. If you want the speed to be controlled **only** via analog input, do **not assign DI5**.

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Note: The **3-wire Stop** input on **DI4** will stop the drive in **both Local and Remote modes**.

Scenario 2: Remote Mode Controlled by a Digital Input

In this scenario, a digital input is used to toggle between Local and Remote modes. The **HMI is no longer used** for this function.

Wiring and Configuration

- **Digital Input 3**: 3-wire Start
- **Digital Input 4**: 3-wire Stop
- **Digital Input 5**: Frequency Select (optional)
- **Digital Input 6**: Control Mode (Remote/Local switch)
- **Analog Input 1**: Speed reference

Operation

1. When **DI6 is ON**, the drive enters **Remote Control mode**.
2. When **DI6 is OFF**, the drive returns to **Local mode**.
3. HMI will display the **Remote mode status** when active.
4. Start/Stop behavior and speed selection (via DI5) remain as described in Scenario 1.

Important: When this method is used, the HMI **can no longer be used** to switch between Local and Remote.

Scenario 3: Remote Mode Controlled by Digital Input, with Selection Between I/Os and Network Control

In this scenario, we use one input to switch between **Local and Remote**, and another input to choose between **discrete I/O control** and **Modbus Network control**.

Wiring and Configuration

- **Digital Input 3**: 3-wire Start
- **Digital Input 4**: 3-wire Stop
- **Digital Input 5**: Control Source (I/O vs. Network)
- **Digital Input 6**: Control Mode (Remote/Local switch)

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- **Analog Input 1**: Speed reference (used when in I/O mode)

Operation

1. When **DI6 is ON**, the drive enters **Remote Control mode**. When OFF, it returns to **Local**.
2. When in Remote:
    - If **DI5 is OFF**, the drive is controlled via **discrete I/Os** (DI3/DI4 and Analog In 1).
    - If **DI5 is ON**, the drive switches to **Modbus Network control**.
3. The HMI will display that the drive is in **Remote mode** and indicate the active source (I/O or Network) depending on the state of DI5.

Previous Next

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8.11. Date and Time

- Automatic update of the date and time:
- Update the date and time using the VFD's HMI:
- NTP servers
- Use internal DNS to redirect time1.google.com to your local NTP server

Sometimes it can happen that pairing is not possible and causes problems. The main reason is that it is caused by an issue of synchronizing the time and date of the VFD from the phone.

The mobile and the VFD need to have synchronized time/date and time zone to establish a secure connection. But it is only possible when the phone and VFD time and date are in range.

By default, when the VFD is connected to Ethernet, the VFD will try to reach the known NTP server (Network Time Server) on the Internet to retrieve the current date/time. But, you still have to configure the timezone properly of the VFD.

Automatic update of the date and time:

During the pairing process of the mobile App and the VFD, the date and time are set on the VFD.

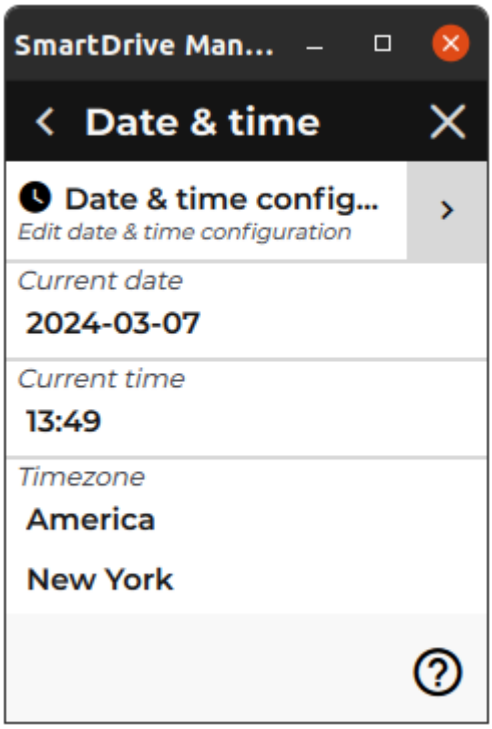
Every time the mobile App reconnects with the VFD, the date and time are updated on the VFD.

Update the date and time using the VFD's HMI:

The user can access the manual setting of the date and time following the path:

Menu >> Configuration >> system >> Date & time

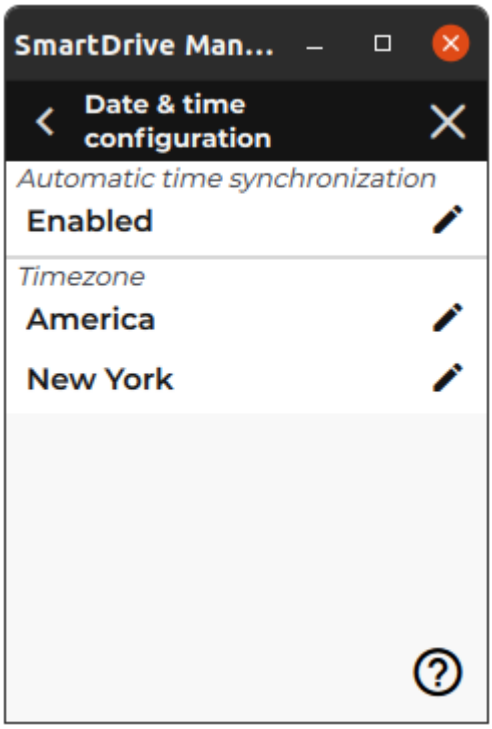
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Clicking on " Date & time configuration",

- The automatic synchronization can be enabled and disabled:
  This only disables the NTP synchronization (network synchronization when Ethernet is connected),
  Note that the connection to a mobile app with Bluetooth always synchronizes the time with the smartphone.
- The time zone can be selected
- The time and date can be manually defined if the synchronization is disabled.

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NTP servers

The Clean Power VFD NTP client is expecting to have access to the following time servers:

1. time1.google.com
2. time2.google.com
3. time3.google.com
4. time4.google.com

Use internal DNS to redirect `time1.google.com` to your local NTP server

If your network uses an internal DNS server, you can override the public record for time1.google.com, allowing devices to sync time from your own NTP host.

On your internal DNS (e.g., Windows DNS, BIND, DNS appliance):

1. **Create a record**
    - **Option A – A record:**
      Name/Host: `time1.google.com`
      Address: your internal NTP server IP (e.g., `192.168.1.10`)

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- **Option B – CNAME:**

  Name/Host: `time1.google.com`

  Target: your internal NTP hostname (e.g., `ntp.company.local`)

2. **Apply and test**

   - (Optional) Set a low TTL (e.g., 300 seconds) while testing.
   - Flush DNS caches on a client and verify resolution with `nslookup time1.google.com`.

Result: Any client that queries your **internal** DNS for `time1.google.com` will receive your NTP server's address and sync time locally.

Notes

- Ensure your NTP server is reachable (UDP/123) and running.
- This override affects only clients using your internal DNS; it does not change public DNS.

Previous Next

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9. Applications

PID: PID Control

HVAC: Damper control

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9.1. PID Control

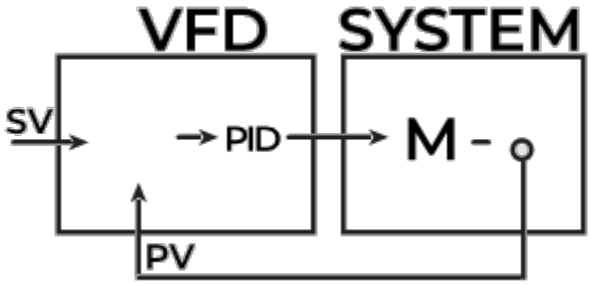
Process control introduction

In a controlled process, a desired value of the process is given to the VFD as a setpoint: this is commonly named Setpoint Value (SV)

A sensor measures the process value and sends back this value to the VFD as process feedback: this is commonly named Process Value (PV)

A Proportional, Integral, and Derivative (PID) algorithm adjusts the VFD output (speed/torque) to keep the process feedback value at the setpoint value.

Therefore some settings and parameters must be added to the VFD to achieve this operation.

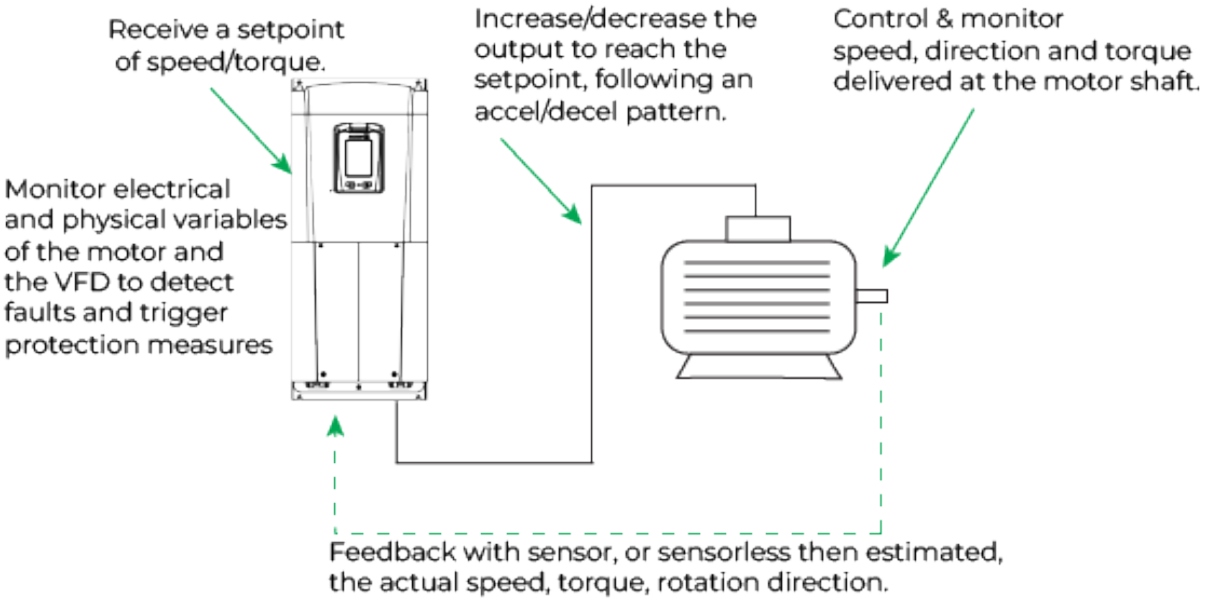


PID Control of the process is a layer over the VFD speed and torque control

The VFD not only governs the speed and torque exerted at the motor shaft but also ensures the safeguarding of both the motor and the VFD.

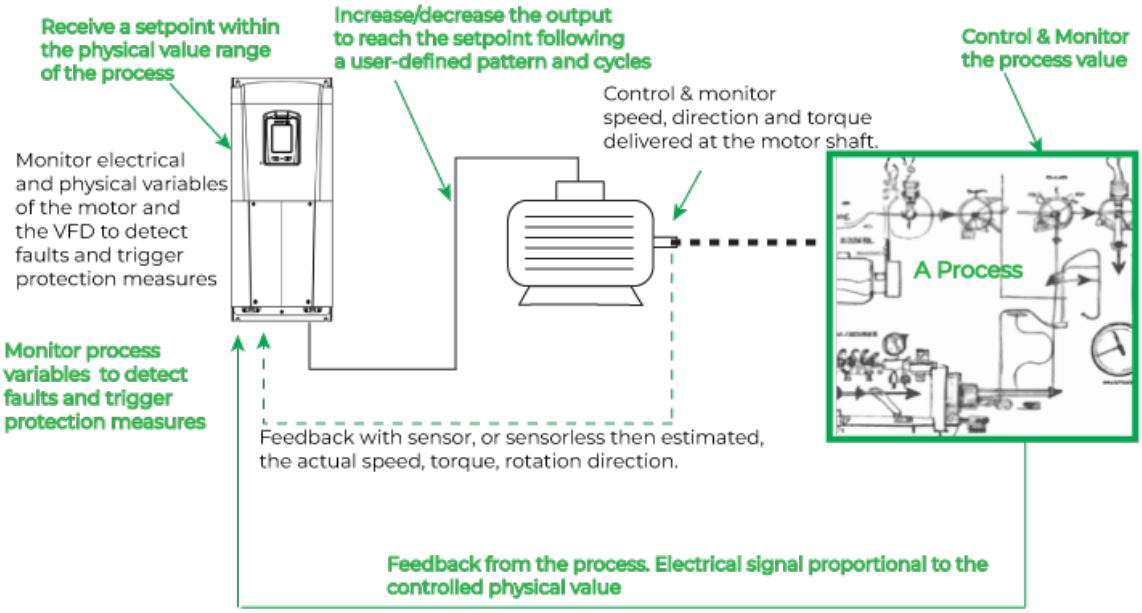
It achieves this by monitoring pertinent electrical and mechanical parameters of the motor and the VFD itself, ensuring comprehensive protection.

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When managing a process, the VFD effectively regulates and safeguards whatever component is connected to the shaft, while controlling the process.

Controlling the process means delivering the right amount of work accurately and consistently while making sure it stays within the guidelines set by the designer of the controlled process.



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Processing

The Clean Power VFD processes the PID as the ISA ideal PID equation (sometimes called the ideal or dependent PID form) :

$$PIDoutput = \left[K_p \times e(t)\right] + \left[\frac{K_p}{T_i} \times \sum e(t)\Delta t\right] + \left[K_p \times T_d \times \frac{e(t) - e(t-1)}{\Delta t}\right]$$

Where

- K_p = Proportional gain
- T_i = Integral time constant
- T_d = Derivative time constant
- e(t) = Error at the current time step
- e(t−1) = Error at the previous time step
- Delta t (Δt) = Time interval between successive samples

Characteristics of the ISA Ideal Form:

In this form of the PID equation,

1. Proportional Gain (Kp) Applies to All Terms

The proportional gain K_p is factored into all three components—Proportional, Integral, and Derivative.

This ensures that each term is scaled by the proportional gain.

2. Independent Modification by T_i and T_d

The integral time constant (Ti) and derivative time constant (Td) adjust only their respective terms:

- K_p/T_i determines the contribution of the integral term.
- K_p*T_d determines the contribution of the derivative term.

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Explanation of each term:

Proportional Term: the proportional response scales the current error e(t) by the proportional gain Kp.

Integral Term: the integral response accounts for accumulating past errors over time to eliminate steady-state errors. This is a sum of errors multiplied by the time interval (Delta t (Δt)).

Derivative Term: the derivative response predicts future errors by evaluating the rate of change of the error between the current and previous time steps.

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9.1.2. PID Control parameters

Enable PID

You need to enable PID in the mobile app and configure the PID parameters to benefit from the Clean Power VFD's PID control.

Control loop performance

The PID control loop period is 100ms.

If you already use a PID control loop and desire to use the same parameters for the Clean Power VFD, check that your former control loop period is compatible.

If your former control loop period is much shorter than 100ms, you can't use the Kp and Ti parameters as they are; you need to evaluate new values.

Kp-PID proportional gain

It’s the proportional coefficient of the PID.

Adjustable from 0.01 to 250.00

Default setting=10

Ti-PID integral time constant

It’s the time constant of the PID.

Adjustable from 0.0 to 2000.0 (values are in seconds)

When Ti is set to zero, the integral action of the PID is disabled

Default setting=1

The integral action helps to eliminate steady-state error by accumulating past errors and adjusting the control effort accordingly. The integration time for a process PID controller is the time required for the integral action of the controller to match the control provided by the proportional action of the controller. It is important to set this time to be the same order of magnitude as the reaction time of the process being controlled. If the controller's integral action is too fast (i.e., the integration time is too short), it can cause the control loop to oscillate and result in instability.

Td-PID derivative time constant

adjustable from 0.0 to 1000.0 (values are in seconds)

Default setting=0.0

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When the derivation time is set to 0, the VFD operates as a PI controller.

The derivative action of a PID controller acts as a brake or dampener on the control effort, helping to reduce overshoot and hunting by decelerating the descent of a process variable that is approaching the setpoint too rapidly.

If Kp, Ti, or Td is set to zero, then the related function (proportional, integral, respectively derivation) is disabled. E.g.: if Kp and Ti are set to a non-null value, and Td is set to zero, then the loop is controlled as a PI.

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9.1.3. PID engineering units

Engineering units

The user of the Clean Power VFD can use the PID control within the engineering units of his process.

The choice can be made in the following list:

Engineering Unit	Name	System	Typical application
Pa	Pascal	S I	Used in most industrial applications worldwide. Used to measure the difference in pressure between two points. Often used in HVAC systems and low-pressure applications. Application: Filter monitoring, flow measurement
bar	Bar	S I	Used in most industrial applications worldwide.
psi	Pounds per square inch	Imperial	Used in most industrial applications worldwide. Commonly used in the USA for pumps
m³/s m³/h	Cubic meter per second Cubic meter per hour	S I	Used for larger flow rates in industrial applications. Used for pumps and water systems. Application: Water treatment plants, industrial processes Examples: the airflow capacity of fans, blowers, and air conditioning systems. the air output of compressors or the ventilation rate in factories and workshops.

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Engineering Unit	Name	System	Typical application
			rate of air exchange in indoor environments, ensuring adequate ventilation and air quality. airflow in wind tunnels and other testing environments.
L/s	Liters per second	S I	Used for larger flow rates in industrial applications. Used for pumps and water systems. Application: Water treatment plants, industrial processes
GPM	Gallons per minute	Imperial	Used for larger flow rates in industrial applications. Used for pumps and water systems. Application: Water treatment plants, industrial processes
CFS CFM	Cubic feet per second Cubic feet per minute	Imperial	Used for larger flow rates in industrial applications. Used for pumps and water systems. Application: Water treatment plants, industrial processes. Examples: the airflow capacity of fans, blowers, and air conditioning systems. the air output of compressors or the ventilation rate in factories and workshops. rate of air exchange in indoor environments, ensuring adequate ventilation and air quality. airflow in wind tunnels and other testing environments.
K	Kelvin	S I	Used in HVAC (boilers, chillers ….) and industrial cooking, cooling, and freezing processes.

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Engineering Unit	Name	System	Typical application
°C	Celsius	S I	Used in HVAC (boilers, chillers ….) and industrial cooking, cooling, and freezing processes.
°F	Fahrenheit	Imperial	Used in HVAC (boilers, chillers ….) and industrial cooking, cooling, and freezing processes.

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9.1.4. PID Control Process Value (PV)

DANGER

Loss of PID feedback can drive the motor to maximum output

When PID control is active and the PID mode is set as **Direct**, a low feedback value can cause the VFD output to increase.

If the PID feedback uses a **0–10 V analog input**, a broken sensor, disconnected wire, or failed feedback signal can be interpreted as a valid 0 V value. In this condition, the PID controller can drive the motor to maximum speed or maximum output.

This can cause unexpected machine operation, overpressure, mechanical damage, process instability, serious injury, or death.

For PID feedback signals where loss of feedback could create a hazard, use a **4–20 mA feedback signal** with analog input fault detection enabled, or use an external control system to detect sensor loss and bring the machine to a safe state.

Set the Maximum PV alarm correctly to prevent the process variable from reaching a hazardous value. The Maximum PV alarm threshold must be set below the maximum safe process limit of the machine or installation.

Before operating the system, test the reaction to feedback sensor loss and verify that the machine remains within safe operating limits.

---

1. The user must define the PID loop feedback input.

The read value from the loop feedback is named the **Process Value** or **PV**

The choice can be made between an analog input or data from the communication media.

2. The user must define the engineering units of his process.

The VFD settings provide a list of usual engineering units, and It can be freely writable by the user (4 characters).

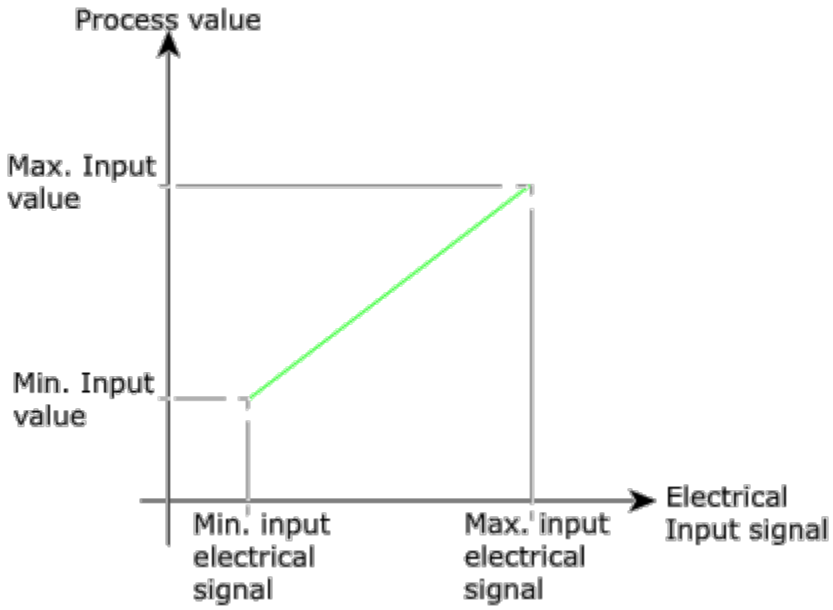
The list of engineering units is available in the section about Control Parameters.

3. The user must scale his process feedback value regarding the input variable scale of the loop feedback input:

- Minimum input electrical signal (mA, V, Hexa or decimal value of the read data from the comm. …)
- Minimum input value within the engineering unit.
- Maximum input electrical signal (mA, V, Hexa or decimal value of the read data from the comm. …)

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- Maximum input value within the engineering unit.



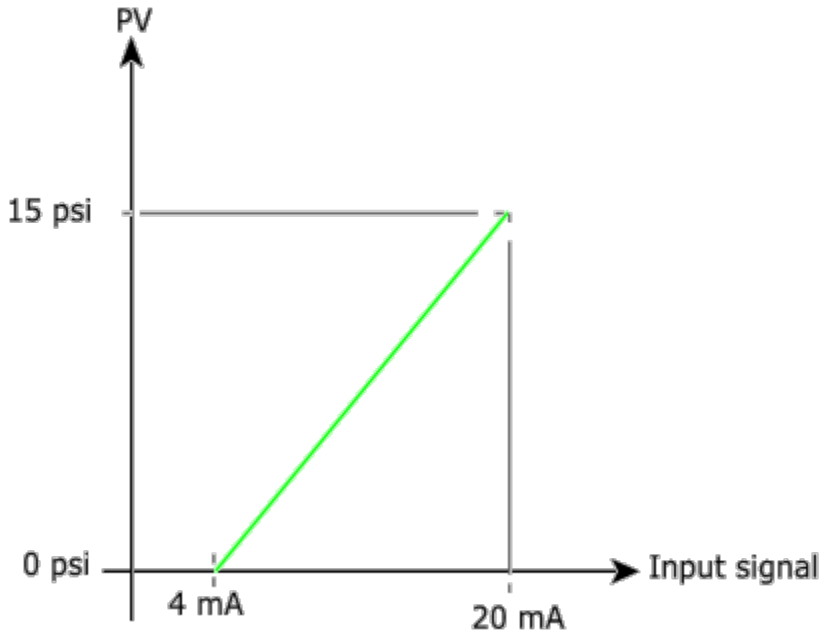
Example:

PID loop feedback is a pressure transducer. Range 0 to 15 psi. Output 4 to 20mA, connected to Analog input 1.

Then the user setting must be as follows:

- PID loop feedback input is assigned to Analog input 1
- Analog input 1 is set as a 4 to 20 mA input
- Minimum input value= 0 psi
- Maximum input value= 15 psi

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9.1.5. PID Control setpoint (SV)

The value read from the setpoint source is named the setpoint Value or SV

You must define the PID setpoint input by choosing either an

- analog input,
- the user-written value from the HMI
- or data received from the communication media.

The setpoint value has two limits that you can define.

If the PID receives a setpoint value out of those limits, it generates an alarm and limits the used value to the closest defined limit.

Minimum and maximum PID setpoint limits: These limits are adjustable between the minimum and maximum values of the process (defined in the process value feedback parameters).

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9.1.5.1. PID Setpoint Ramps

Overview

The Ramp Up and Ramp Down functionality allows users to define the rate at which the control variable transitions between setpoints.
This feature ensures smooth and controlled changes, preventing sudden spikes or drops in the process variable, which could potentially disrupt system stability or cause damage.

Definition of Ramp Up and Ramp Down

The Ramp Up and Ramp Down between two setpoints are defined by the rate of change of the control variable over time. These two ramps are set independently.
This rate of change is expressed in user-defined engineering units of the control variable per second.

Example:

If the control variable is pressure measured in Pascals (Pa) and time is measured in seconds (s), then the ramp-up/down rate could be specified in Pascals per second (Pa/s).

User-Settable Parameter: PID Ramp Time

- Range: The PID Ramp Time can be set between 0 to 600 units per second.

- Default Value: The default value is 0 units per second.

Note: When the PID Ramp Time is set to 0, the new PID setpoint will be immediately applied without any ramping.

Impact of PID Ramp Time

The PID Ramp Time directly influences how the control variable transitions from one setpoint (SV) to another:

- PID Ramp Time = 0 The setpoint change is instantaneous, with no ramping applied. Depending on the system dynamics, the process variable will attempt to reach the new setpoint as quickly as possible, following the PID parameters.

- PID Ramp Time > 0 The setpoint transitions to its new value over the specified ramp time, ensuring a smooth and controlled change in the process variable.

Calculating Transition Time

The time required to transition from one setpoint (A) to another (B) is determined by the following equation:

$t = (B - A)/\text{ramp rate}$

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Where:

- t is the transition time in seconds.

- (B-A) is the absolute difference between the two setpoints.

- The ramp rate is defined by the PID Ramp Time.

Example Calculation:

Suppose a system is controlling the temperature of a chemical reactor. If the PID Ramp Time is set to 5 units per second and the setpoint changes from 300°C to 350°C, the transition time can be calculated as follows:

t = (350 - 300)/5 = 50/5 = 10 seconds

In this example, the PID controller will gradually transition the temperature setpoint from 300°C to 350°C over 10 seconds, ensuring a smooth and controlled adjustment in the reactor's temperature.

Practical Considerations

- System Dynamics: The effectiveness of ramping may depend on the system's dynamics. Rapid transitions, even with ramping, can still cause instability in systems with slow response times.

- Safety: In safety-critical applications, carefully select the ramp time to avoid undesired oscillations or delays in reaching the desired setpoint.

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9.1.6. PID modes direct and reverse

PID mode is a user-configurable parameter between reverse mode and direct mode.

The default value is the reverse mode.

The error signal is the difference between the setpoint (SV) and the process value (PV): Error= SV-PV.

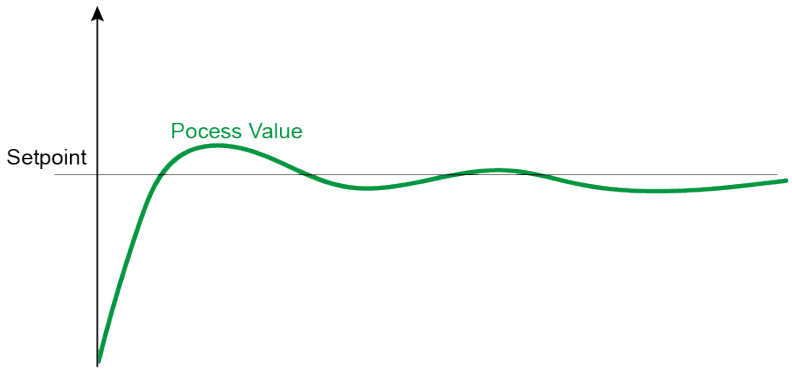
This error signal can be positive or negative: depending on whether PV is greater or lower than SV.

The choice between direct and reverse mode depends on the specific application and system requirements.

Reverse mode:

The VFD output is active when the process value is smaller than the setpoint value. PV < SV

The output of the VFD decreases as the process variable increases.

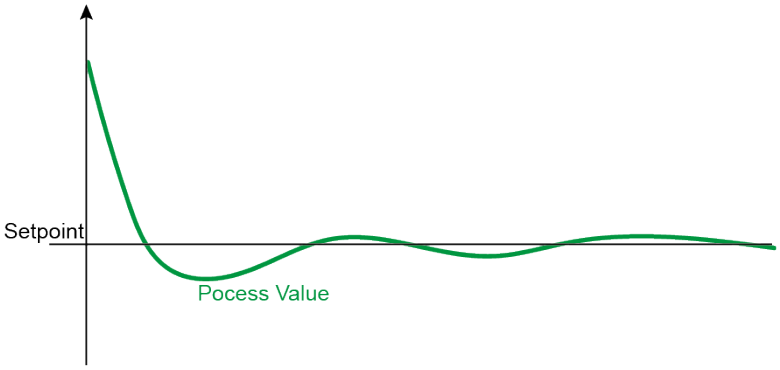


Direct mode:

The VFD output is active when the process value is greater than the setpoint value. PV > SV

The output of the VFD decreases as the process variable decreases.

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9.1.7. PID Correction

- Introduction
- Correction parameters
- Equation
- Application views:
- Application Scenarios and Why to Compensate
- Recommended Offset Map by Application
- Putting It All Together – Example

Introduction

PID correction enhances control performance by

- Adding a *Process-value offset* to fix sensor drift,
- Adjusting the output to account for real-world imperfections, such as mechanical friction, static resistance, or torque dead zones.

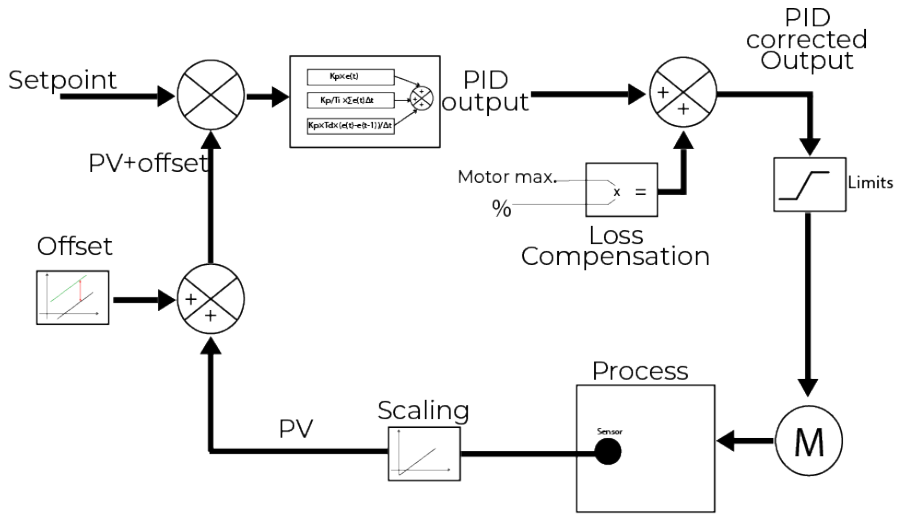
These small adjustments make the system behave more predictably, especially when tuning alone isn't enough.

This section explains how PID correction works and provides guidance on configuring the settings.

The correction adds two terms to the calculated PID output:

- **Process value offset**: A constant added to the process value to overcome errors in the loop feedback..
- **PID Loss Compensation**: A dynamic correction scaled as a percentage of the PID output.

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Correction parameters

Parameter	Description	Range	Default
Process Value Offset	Adds a fixed value to the PV. Example: -10 … +10 bar, -100 … +100 °C	Depending on the engineering units and scaling of the analog input used as loop feedback	0
PID Loss Compensation	Simplified friction loss model	-100% to +100% of the motor's max speed	0%

Equation

Compensation aims to approximate real-world losses, such as friction, by allowing for a **simplified loss-based compensation**.

$$PID_{Compensated\ Output} = PID_{Calculated\ Output} + PID_{Losses\ Compensation}$$

where

$PID_{Losses\ Compensation}$: A simple percentage-based approximation of dynamic losses (e.g., friction, resistance).

The system's loss compensation uses a configurable percentage of the maximum. output. This approach simplifies tuning for most applications while still addressing common compensation needs

$PID_{Losses\ Compensation} = (x\%) \times$ Motor max. speed

This acts as a Bias on the PID Output, helping overcome static system behavior: Like friction, backlash, gravity, or startup inertia — things PID might struggle to correct on its own.

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Application views:

In theory, a perfectly tuned PID controller should regulate your process precisely. But in the real world, friction, dead zones, load variation, and mechanical delays all get in the way.

That's where **PID compensation** comes in:

- **Static resistance**: Motors often need a base torque or speed to overcome friction or hold a load
- **Dead zones**: A small PID output might not be enough to move the actuator at all
- **Lag under load**: Systems with changing inertia or friction (e.g. pumps, fans, conveyors) need dynamic help
- **Imperfect tuning**: Even with good PID gains, some processes need a small bias or nudge

By enabling compensation, you allow the PID loop to "push" the system past these barriers without constantly tweaking the gains.

Application Scenarios and Why to Compensate

Application	Why Use Offset / Compensation
Centrifugal Pumps	Prevent stalling, maintain priming, and overcome system resistance at low flow
HVAC Fans	Overcome inertia, damper friction, or windmilling in ducted systems
Vertical Conveyors	Compensate for gravity and ensure the load starts moving without delay
Column Pumps	Avoid backflow and air pockets by maintaining minimum pressure
Hoists / Cranes	Hold position with torque offset, provide lift force before PID reacts
Packaging Systems	Smooth startup under belts or chains, overcome friction without sudden jumps
Pressure Boosters	Reduce hunting and instability when the flow drops and the pressure quickly fluctuates

Recommended Offset Map by Application

Application	Recommended compensation	Control Mode	Unit	Why
Centrifugal Pump	`8 Hz`	Speed	Hz	Maintains flow at low demand, avoids full stops and restart cycles
HVAC Fan	`15 %`	Output %	% of speed	Overcomes fan bearing friction and damper stiction
Vertical Conveyor	`10 %`	Output %	%of speed	Provides baseline torque to overcome gravity or lift the load
Column Pump	`15 Hz`	Frequency	Hz	Prevents reverse flow in long vertical piping

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Application	Recommended compensation	Control Mode	Unit	Why
Conveyor / Packaging	`5 Hz`	Speed	Hz	Smoothens startup under load without shock or backlash
Pressure Booster	`25 %`	Output %	% of speed	Avoids pressure surging and helps regulate downstream buffer pressure

Putting It All Together - Example

- **Set-point** = 40 psi
- **Sensor drift** = –1.5 psi → PV Offset = +1.5 psi
- **Minimum pump speed to move water** = 10 Hz
- **Loss Compensation %** = +17 % (≈ 10 Hz on a 60 Hz max drive)

Step	Result
Corrected PV	PV + 1.5 psi
Raw PID output	3 Hz
Bias	17 % × 60 Hz = 10 Hz
Drive command	3 + 10 = **13 Hz**

Outcome: pump spins immediately, pressure builds with minimal overshoot.

Previous Next

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9.1.8. Min and Max PID Output

If the controlled process requires some operating limits, the output of the PID (energy delivered to the motor) can be user-defined between a max and a min value:

Min and Max PID output

Can be user-configured from 0 to 100% of the max frequency/velocity output of the VFD, consistent with the motor parameters settings.

Default setting=0%

Previous Next

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9.1.9. PID Deadband

The deadband is a crucial feature designed to improve system efficiency and longevity in the PID controller.

The deadband refers to a predefined range around the setpoint where the controller does not act in response to small fluctuations in the process value (PV).

This section explains the concept, purpose, and configuration of the deadband in your VFD's PID controller.

What is a Deadband?

A deadband is a range of input-measured process values that do not produce a change in the PID controller's output.

Essentially, when the PV is within this range, the PID control output is "frozen" and remains constant, preventing unnecessary adjustments and wear on the system components.

This feature is particularly useful in systems where minor deviations from the setpoint are acceptable.

Why Use a Deadband?

Prevent Unnecessary Adjustments:
Without a deadband, the PID controller would continuously make small adjustments in response to minor fluctuations, leading to excessive wear and tear on system components.

Improve System Efficiency:
By avoiding constant adjustments, the system operates more efficiently, reducing energy consumption and prolonging the lifespan of components.

Stabilize Operation:
The deadband helps maintain stable operation by ignoring insignificant changes, thus avoiding over-correction and oscillations.

Configuring the Deadband

Deadband Range: The deadband is centered around the setpoint, creating a range where the PID control output remains constant. This range is defined as the setpoint value plus or minus the deadband value (setpoint ± deadband). Within this effective deadband range, the PID controller does not adjust the output, preventing unnecessary small corrections when the process variable is close to the setpoint.

Engineering Units: The deadband is expressed in the same units as the measured variable (e.g. psi for pressure).

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Range and Default:

Default value: 0 (deadband inactive)

Range: 0 up to the Max PV value, symmetrical around the setpoint.

Timer Delay

The delay timer ensures the deadband effect only activates after a specified duration.

Configurable from 0.0 seconds to 3600.0 seconds.

Default value: 0.0 seconds.

1: Setpoint SV

2: Deadband Range

3: Process Value PV

4: PID output

5: Deadband Timer Delay

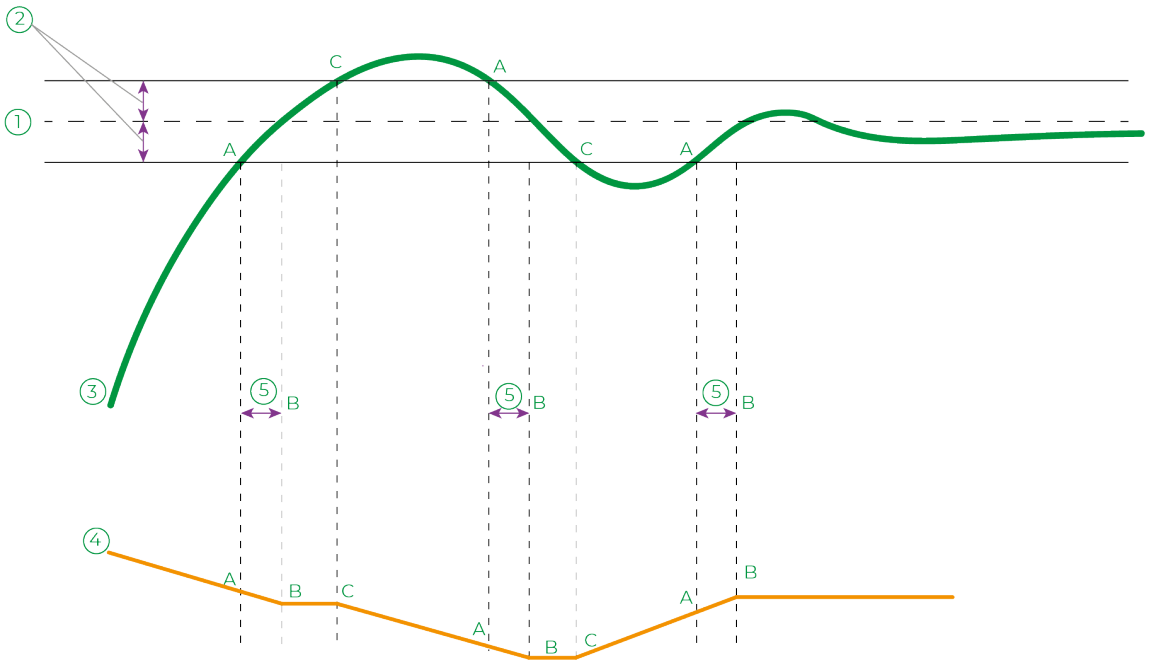
The PID controller outputs the command to the motor controller of the VFD according to the PID actions.

A: When the Process Value PV enters the deadband area, the timer delay starts.

B: When the time has elapsed and the PV is still in the deadband area, the PID controller output is frozen in its actual state.

C: When the Process Value moves out of the deadband area, the PID controller outputs the command to the motor controller according to the PID action

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Previous Next

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9.1.10. PID forced output

The loop itself may require some maintenance. For example, to replace/clean a feedback sensor in the controlled process.

In some applications, this operation should not stop the process from running.

Forced Output Command

A forced output command can be configured to force the output of the VFD to a speed output despite the loop being “broken“ during the maintenance operation.

The user can enable the forced output command. The forced output is "disabled" by default.

When the forced output command is enabled, the VFD output applies the forced output value.

Forced Output Value

The forced output value can be configured between the minimum and maximum of the PID output values predefined by the user.

The forced output source could come from:

- a fixed preset value,
- an analog input,
- data from the communication network,
- or a variable written from the user interface (HMI or mobile App).

Its default value is " a fixed preset value"

Note that the analog input 1, 2, or 3 can be assigned to the forced output source during the I/Os configuration process.

Previous Next

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9.1.11. PID Sleep Wake-up

Introduction to PID Sleep and Wake-Up Functionality

The PID Sleep and Wake-Up feature is designed to enhance the efficiency and longevity of motor-driven systems controlled by a PID loop.

This functionality transitions the motor to a pause mode when the PID output remains below a specified sleep trigger threshold for a predefined trigger delay.

Once in sleep mode, the motor will automatically restart when the error in the PID loop exceeds the wake-up threshold for a duration greater than the wake-up delay.

This intelligent functionality is particularly useful in applications where motors frequently run at low loads or are idling unnecessarily, helping to save energy and reduce wear and tear on the motor.

Example: Energy Optimization in Pumping Systems

Consider a water distribution system where a pump, controlled by a VFD using PID, maintains a target pressure in a pipeline.

During periods of low demand, such as late at night, the required output pressure drops significantly. The PID output might fall below the sleep trigger threshold for an extended period, indicating that the pump is no longer required to run continuously.

When this happens, the PID Sleep function pauses the motor, preventing energy waste and unnecessary mechanical strain.

Later, when water demand increases, such as in the morning when residents use water, the system pressure starts to drop. Once the PID error exceeds the wake-up threshold for the wake-up delay period, the motor resumes operation automatically, ensuring that the target pressure is maintained.

This functionality not only reduces energy costs but also minimizes wear on the pump and motor, extending their operational lifespan while maintaining system reliability.

PID sleep threshold

It’s a frequency or velocity value (depending on the motor control mode setting)

- The user can enable/disable the PID sleep & wake feature. When enabled, the sleep threshold must be greater than 0
- Adjustable from 0.1 Hz / 1 RPM(according to the motor control mode) to the max frequency/velocity output defined in the user settings.

PID Sleep time delay

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Sleep Time Delay is the duration after which the VFD will enter a low-power 'sleep' mode if the output (like motor speed or torque) falls below a certain threshold.

- Adjustable from 0 to 6000s
- Default value = 0s

When the PID output frequency or velocity is lower than the sleep threshold value for a time longer than the PID sleep time delay, the VFD switches into sleep mode, resulting in a motor not being energized.

PID wake-up threshold

This threshold applies to the calculated PID error.

When the error exceeds this threshold, it signals that the process requires PID control to return to the desired state.

The threshold must be set in user-defined engineering units and must be greater than 0.

PID wake-up time delay

Wake Up Time Delay is the time the VFD takes to 'wake up' or transition from a low-power state to an active state when there is a demand.

- Settable from 0 to 600 s
- Default value = 0

When the VFD is in sleep mode and the wake-up threshold is exceeded for a duration longer than the wake-up time delay, the PID ‘wakes up’, which means it starts controlling the outputs to achieve the setpoint defined by the user.

The sleep time delay range is greater than wake up time delay range

The usual range for sleep time delay can vary based on the application and the specifics of the process control system.

However, common ranges are typically from a few seconds to several minutes.

For instance, in applications where quick responsiveness is not critical, a longer sleep time delay (like several minutes) might be set.

The wake-up time delay is generally shorter than the sleep time delay and is often in the range of a few seconds.

The wake-up time is critical to ensure that the process is not adversely affected by the delay in the VFD responding to a change in demand.

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Sleep/wake configuration check

The wake-up function cannot operate if there isn't a sleep mode activated.

If the sleep mode is configured, then the wake-up mode must also be configured, else the process will fail when being in sleep mode for an infinite time.

Errors that forbid downloading the configuration:

- The sleep mode is activated but not the wake-up mode.
- The wake-up mode is activated but not the sleep mode.
- The sleep threshold or wake-up threshold equals zero.

Previous Next

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9.1.12. PID Glossary

Here's an English list of common terms used in PID control systems:

- **Setpoint (SP):** This is the **target value** that the loop aims to reach, such as a desired temperature, speed, or pressure.
- **Process Variable (PV):** This is the **actual measured value** of the process, sent back to the controller, typically obtained from a sensor.
- **Feedback:** Feedback is not just the PV itself, but the **entire signal path and mechanism** by which the PV is returned to the controller for comparison against the setpoint. A PID loop is fundamentally a **feedback control system** because it uses the output of the process to correct its input..
- **Control Output (CO)/Manipulated Variable (MV):** This is the **signal sent to the actuator** (e.g., a Variable Frequency Drive, valve) to influence the process and bring it closer to the set point.
- **Error:** This is simply the **difference between the setpoint and the process variable** (SP - PV).
- **Deadband:** This is a **range around the setpoint** where no corrective action is taken, preventing minor fluctuations from triggering control responses.
- **Proportional Gain (Kp):** This control parameter causes the output to **react proportionally to the current error**. A larger Kp means a stronger response to the error.
- **Integral Gain (Ki):** This parameter **accumulates past errors** over time to eliminate any steady-state offset, ensuring the PV eventually reaches the SP.
  Note: Conventions vary: some controllers use **Ki = Kp/Ti**, others **Ki = 1/Ti**.
- **Derivative Gain (Kd):** This parameter **reacts to the rate of change of the error**, helping to dampen oscillations and improve the system's responsiveness.
  Note: Conventions vary: Often **Kd = Kp·Td**.
- **Integral Time (Ti):** This specifies the **time required for the integral action to match the proportional action** when a constant error is present.
- **Derivative Time (Td):** This represents the **time over which the rate of change of the error is calculated** for the derivative action.
- **Manual Mode:** In this mode, the user **manually controls the output** without any intervention from the PID controller (the forced output of the Clean Power VFD embedded PID).
- **Automatic Mode:** In contrast, the PID controller **automatically adjusts the output** based on the calculated error.

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- **Bumpless Transfer:** This refers to the ability to **smoothly switch between manual and automatic modes** without any sudden jumps or disturbances in the control output.
- **Anti-windup:** This feature **prevents the integral term from accumulating excessively** when the control output reaches its limits or is "clamped," which can otherwise lead to large overshoots.
- **Sampling Period:** This is the **interval between two consecutive PID calculations**, determining how frequently the controller updates its output.
- **PID Loop (Closed Loop):** This describes the **complete feedback system**, encompassing the sensor, the PID controller itself, and the actuator.
- **Process Dynamics:** This refers to the **inherent behavior of the system's response over time** when subjected to control inputs.
    - **Dead Time (τd)**: The delay between when the controller sends a signal (MV change) and when the process variable (PV) *first begins* to respond. It's a pure transport lag. Analogy: The time it takes for hot water to travel from your water heater to the shower head. No matter how much you open the valve, you have to wait for the hot water already in the pipe to clear.
    - **Time Constant (τ)**: A measure of how quickly the process responds *after* the dead time. Specifically, it's the time required for the PV to reach 63.2% of its total final change. It represents the inherent sluggishness of the system.
- **Controller Tuning:** This is the **process of adjusting the PID gains (Kp, Ki, Kd)** to optimize the system's performance, balancing responsiveness, stability, and accuracy.
- **Overshoot:** This occurs when the **process variable temporarily exceeds the setpoint** before eventually settling at the target value.
- **Direct / Reverse Acting**: This setting determines the controller's response direction.
    - **Reverse Acting:** An increase in the PV causes a decrease in the MV. This is the most common type. **Example:** A heating process. If the temperature (PV) goes *above* the setpoint, you *decrease* the heater output (MV).
    - **Direct Acting:** An increase in the PV causes an increase in the MV. **Example:** A cooling process. If the temperature (PV) goes *above* the setpoint, you *increase* the chiller output (MV).
- **Output Limits (Saturation)**: Min/max bounds applied to the MV.
- **Measurement Filter**: Low-pass filtering of the PV to reduce noise (trade-off: adds lag).
- **Derivative Filter (sometimes noted by N)**: Limits D's sensitivity to high-frequency noise; implements a filtered derivative.
- **Feedforward (FF)**: A strategy that measures a potential disturbance *before* it affects the process and takes pre-emptive corrective action. Unlike feedback (which reacts to an error), feedforward is **proactive**. It's often combined with a PID loop to handle any remaining errors.
- **Analogy:** When driving, you see a hill ahead (a measurable disturbance). You press the accelerator *before* your car starts to slow down, rather than waiting for your speed to drop and then reacting.

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- **Proportional Band (PB)**: An alternative to Kp, often expressed as a percentage of span; PB is inversely related to proportional gain (smaller PB → larger Kp). Exact scaling depends on the controller.
- **Rise Time / Settling Time**: Speed metrics—time to first reach the setpoint; time to stay within a tolerance band.
- **Steady-State Offset (Bias/Offset)**: Residual error in steady state (ideally removed by integral action).
- **Hysteresis**: Separate on/off (or up/down) thresholds to reduce rapid toggling.
- **Open Loop / Closed Loop**: Without feedback vs. with feedback (open loop: no error-based correction).
- **Cascade control**: An advanced control strategy using two nested PID loops. The **master (outer) loop** controls the primary variable (e.g., temperature) and provides the setpoint for the **slave (inner) loop**. The slave loop controls a secondary variable that is faster and has a more direct influence on the primary one (e.g., steam flow).
  Benefit: It corrects for disturbances in the inner loop *before* they can significantly affect the primary process variable, leading to much tighter control.
- **Gain scheduling**: A technique used for controlling non-linear processes where the process dynamics change depending on the operating point. The controller uses different sets of PID tuning parameters (Kp,Ti,Td) for different ranges of the setpoint or process variable.
  A classic example of **gain scheduling** is **pH neutralization** in industrial wastewater treatment. In pH neutralization, the process is highly sensitive near the neutral setpoint (pH 7) but sluggish far from it, making a single PID tune ineffective. Gain scheduling solves this by automatically applying aggressive PID tuning parameters for a fast response when the pH is far from the target, then switching to conservative gains as it approaches the setpoint to ensure stability and prevent overshoot. This allows the controller to be both fast and precise across the process's entire non-linear operating range.

Previous Next

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9.2. HVAC

Heating, ventilation, and air conditioning (HVAC)

Damper control

Damper control alarms

Previous Next

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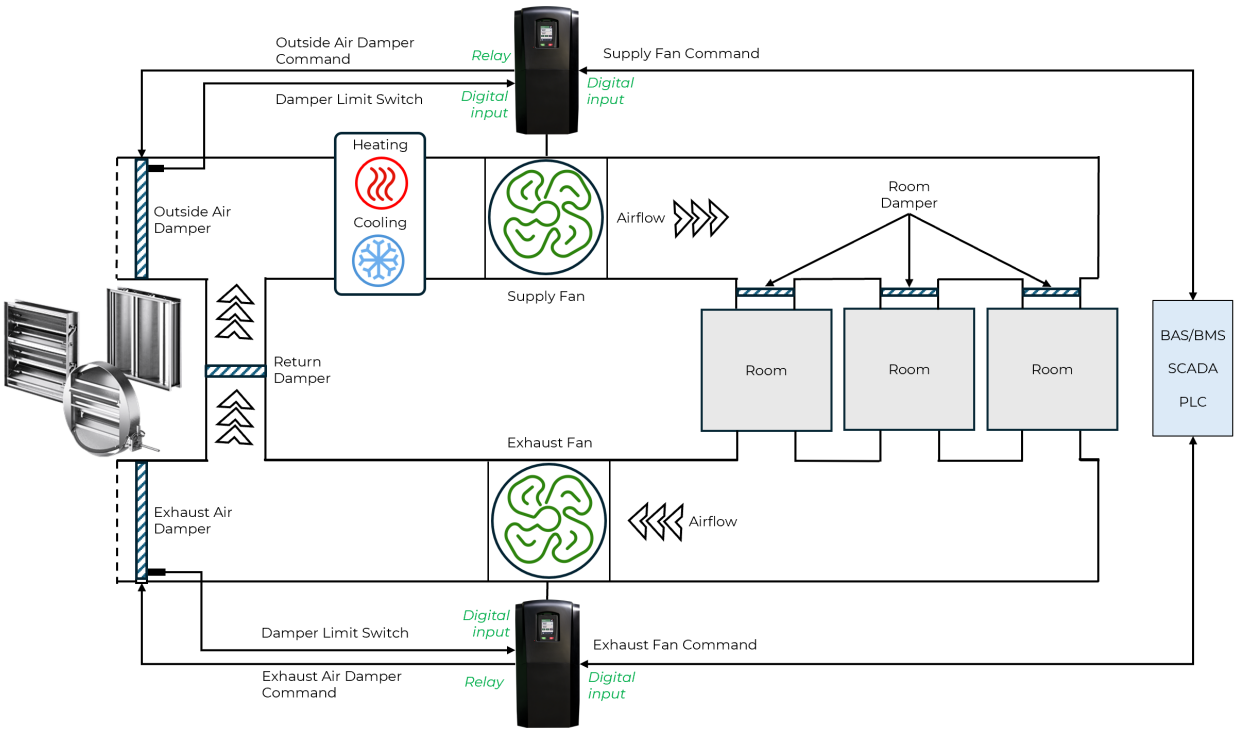
9.2.1. Damper control

HVAC Fan & Damper Control

The Clean Power VFD provides natively a simple fan and damper control logic using its embedded I/Os. It is available in version 2025.04.00 and later.

In HVAC systems, damper integration with VFDs is a common approach to achieve precise control of airflow and maintain energy efficiency. This setup typically involves VFDs controlling fan motors while dampers regulate the airflow within ductwork, allowing the system to adjust to fluctuating heating, cooling, and ventilation demands.

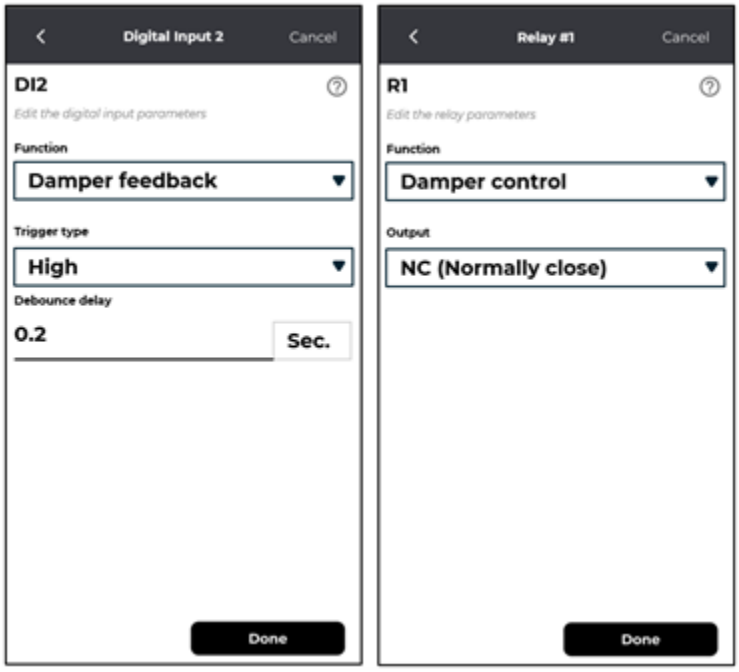
This combination of VFD and damper integration in HVAC is a widely adopted strategy for reducing operating costs, enhancing control, and improving the overall sustainability of building systems.



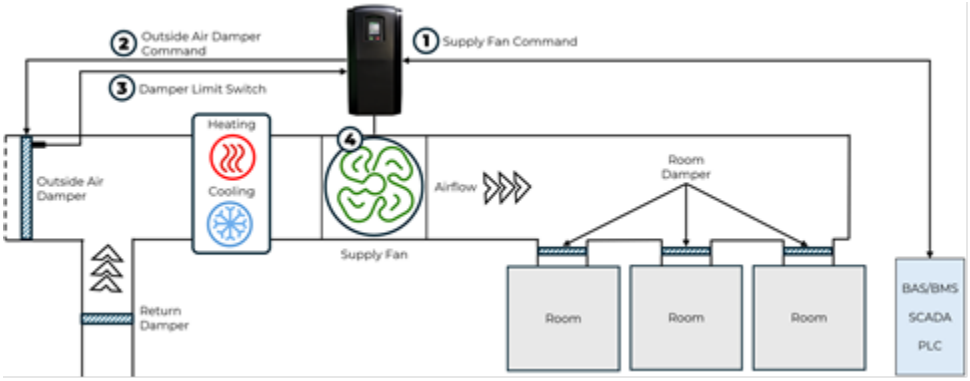
The native fan and damper control is automatically enabled when one of the VFD's digital inputs is configured for damper limit switch feedback and one relay for damper control.

- One relay: It is recommended to use the normally closed contact of R1, as this ensures the damper remains closed by default. When R1 is energized, the damper opens; when de-energized, it returns to the closed position..
- One digital input (DI) for the damper limit switch feedback (providing the damper open/close state).
- One digital input (DI) for start/stop motor.

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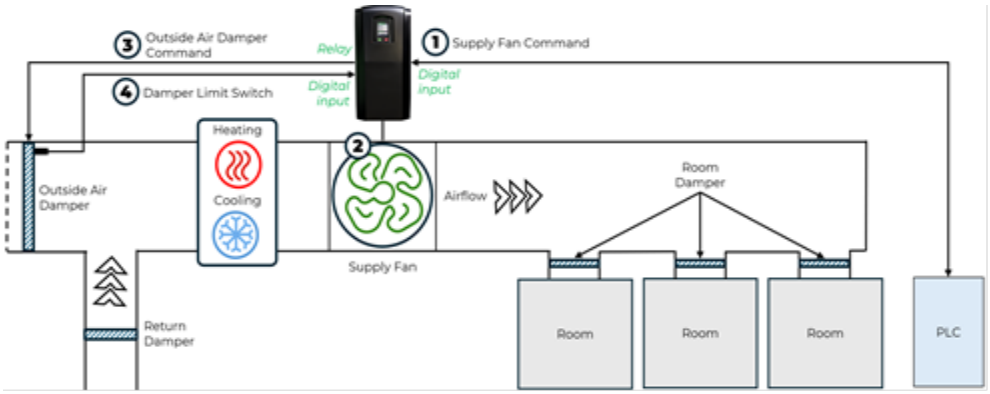
Fan and damper start sequence:



1. The fan command is wired directly into one of the VFD's digital inputs. The digital input indicates a start fan command.
2. The VFD controls the configured relay (R1), which energizes to open the damper.
3. The damper limit switch is wired back to another VFD's digital input, indicating that the damper is in the proper position, and it is safe to start the fan.
4. Upon receiving the damper open indication, the VFD increases the fan speed to the configured setpoint.

Fan and damper stop sequence:

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1. The fan command digital input indicates a stop fan command.
2. The VFD decelerates and stops the fan.
3. Once the fan is stopped, the VFD de-energizes the configured relay to close the damper.
4. The damper limit switch indicates that the damper is closed.

The native fan and damper control also includes three (3) new alarms, Please refer to the Damper control alarms section for more details.

Previous Next

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9.2.1.1. Damper control alarms

Native fan and damper control alarms

To ensure safe operation, three (3) new alarms have been added for the native function "fan and damper control."

- Damper open timeout
- Damper close timeout
- The damper is closed while the fan is running

Critical alarm: Damper open timeout alarm

External start feedback timeout (Code: 70).

After energizing the configured relay to open the damper, the Clean Power VFD starts a timer, ensuring the damper is opened before starting the fan.

If the damper limit switch does not indicate that the damper is opened before the configured damper open timeout, the Clean Power VFD generates a critical alarm.

It is recommended to investigate the possible causes and resolve the issue before resetting the Clean Power VFD to restore normal operation.

Medium alarm: Damper close timeout alarm

External post stop feedback timeout (Code: 71).

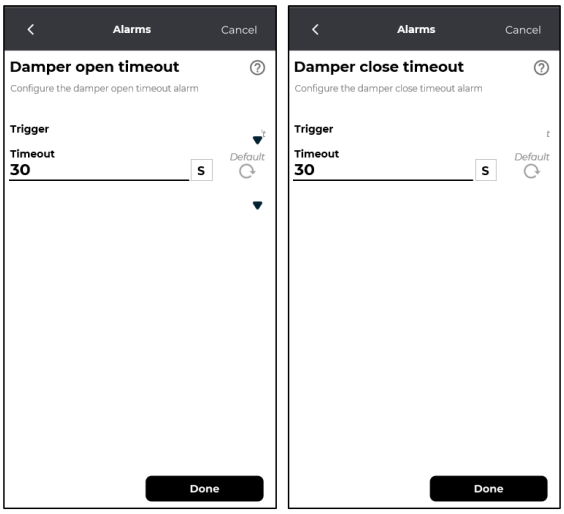
After stopping the fan, the Clean Power VFD de-energizes the configured relay to close the damper and starts a timer, ensuring the damper is properly closed.

If the damper limit switch does not indicate that the damper is closed before the configured damper close timeout, the Clean Power VFD generates a medium alarm.

It is recommended to investigate the possible causes and fix the problem.

These timeouts could be configured in the Advanced configuration alarms section

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Critical alarm: The Damper is closed while the fan is running

While the controlled fan is running and the damper limit switch indicates the damper is closed or a damper feedback signal is lost, the Clean Power VFD generates a critical alarm and stops the fan in freewheeling to avoid high or low pressure in the duct.

It is recommended to investigate the possible causes and resolve the issue before resetting the Clean Power VFD to restore normal operation.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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9.2.1.2. Warning: Use with Non-Fail-Safe Dampers



The Clean Power VFD Damper Control function energizes a single output to command OPEN and relies on a “Damper Open Proved” input to allow the fan to start.

It does not generate an active CLOSE command and does not hold the damper to a position after stop or during a power outage.

Limits when the actuator is non-fail-safe (no spring/electronic return):

- On STOP: the drive de-energizes the damper output. A non-fail-safe actuator may remain in its last position (often still open). Closure is not guaranteed by the VFD.
- On POWER LOSS: all outputs turn OFF. A non-fail-safe actuator will stay where it was until power and an external close command are available. The VFD cannot move it to a safe position without power.
- During START/RUN: the prove-open interlock still prevents the fan from starting unless the damper is proved open, but this does not ensure safe closure afterward.
- Alarm behavior: Damper Feedback Loss (Code 69) indicates missing/lost proof; it does not close a non-fail-safe damper. Reaction (start inhibit/stop) follows configuration and may leave the damper open.

Designer/installer responsibilities:

Do not use this configuration where a defined fail position on stop or blackout is required by code or risk assessment (e.g., life-safety smoke control) without additional measures.

If a defined position is required, provide one of the following at the system level:

- an actuator with a built-in fail-safe (spring-return or electronic), or
- an external device that actively drives the damper CLOSED on stop or power restoration, or
- backup power to support a close command during outages.

Commissioning:

Verify the open-proof input wiring and logic (NO/NC), set the open-proof timeout ≥ actuator travel time + margin, and test STOP and loss-of-power scenarios; document the final damper position for the site commissioning documentation.

Summary:

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With non-fail-safe actuators, this function ensures “prove-open before fan start,” but it does not ensure closure on STOP or POWER LOSS. External means are required if a defined safe position is mandated.

Previous Next

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10. Networks and communication

The Clean Power VFD has a dual port Ethernet that can be used in Modbus TCP communication protocol. or BACnet IP communication protocol.

Modbus TCP

Bacnet IP

Previous Next

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10.1. Network settings

To configure the network on the mobile app, go to **Advanced Configuration → System → Network**

You'll see the **Network Manager.** It shows **IPv4 only** and supports **switch mode only** (IPv6 is **not supported**).

- Mode: DHCP/Manual
- When Manual is selected, the user must set :
    - Manual IP address
    - Network mask
    - Gateway IP address
    - DNS servers list (may be left empty, up to 2 entries)

WARNING: If you're connected to the Clean Power VFD over Wi-Fi, changing these settings can drop the connection. If that happens, just pair the app again.

Previous Next

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10.1.1. Enable/Disable Wi-Fi

WARNING

When the Wi-Fi is diabled, the VFD is no longer accessible from the mobile app through Wi-Fi.

Before disabling this function, make sure another access method remains available, such as:

- the local HMI
- BLE, if enabled

Purpose

Use this setting to allow or block mobile access to the Clean Power VFD over Wi-Fi.

This function is intended to control the Wi-Fi access path used by the mobile app, while keeping other supported communication functions available as applicable.

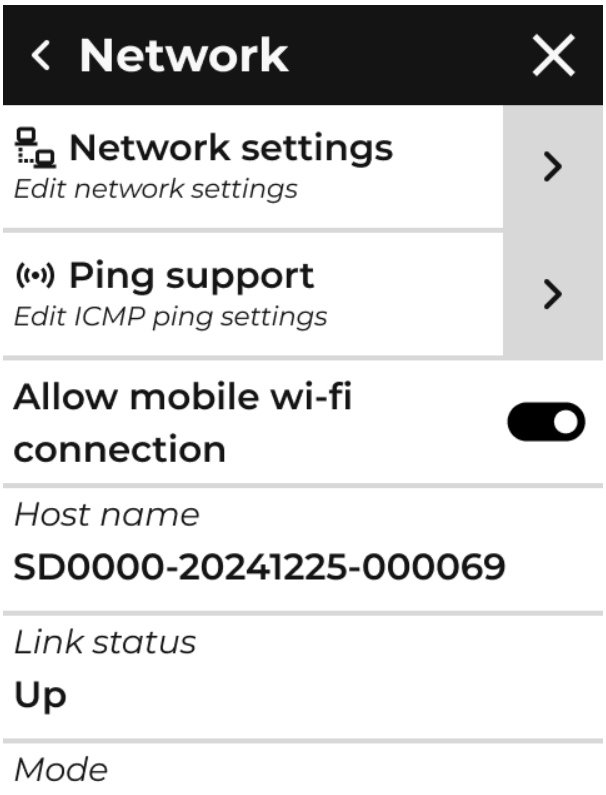
Location

This setting is available from:

- HMI
- Mobile App

Menu path: **Advanced Configuration >> System >> Network**

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Parameter and behavior

Allow mobile wi-fi connection

When the Wi-Fi Mobile Access toggle switch is set to **ON**:

- the mobile app can access the VFD through the Wi-Fi connection

When the Wi-Fi Mobile Access toggle switch is set to **OFF**:

- the VFD does not answer HTTP or HTTPS requests used for Wi-Fi mobile access
- the mobile app can no longer access the VFD through Wi-Fi

  the mobile app displays a warning before applying the change

- if BLE is enabled, BLE can still be used to pair with the VFD

Turning the toggle switch OFF does not disable the full network stack of the VFD.

The following functions continue to work if they are enabled:

- NTP client
- Modbus TCP

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- BACnet/IP
- EtherNet/IP

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10.2. Display network information

The status of the Network is displayed in the Clean Power VFD. To access the information, on the HMI select "Menu", then "About", then "Network Status".

The network Manager displays the operational data (only displays IPv4 and supports only switch mode), hereby follows:

- Hostname (current hostname)
- Mode: DHCP/Manual (When the selected mode is DHCP, the renew button appears just nearby)
- Link: Up/Down
- IP address: Current IP address
- Network Mask: Current network mask
- Gateway: Gateway IP address
- DNS server: List of DNS servers (up to 2 entries)

It also displays the button to edit Network configuration (open menu>>Configuration>>Network settings)

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10.3. Renew the IP address

If the interface is configured as DHCP (Dynamic Host Configuration Protocol), the IP address can be renewed.

From the HMI menu, select "About" then select "network".

Tap the "Renew" button.

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10.4. Network Topologies

Network Topologies

The Clean Power VFD provides you with two ports with a single IP address, allowing a linear (daisy-chain) topology.

Star (Recommended)

The star topology is the recommended network topology to be used when you have multiple VFDs on the network.

This topology offers centralized management and troubleshooting, and it is more reliable in case of VFD failure, with no impact on the entire network. It is easy to expand by adding new VFDs to the switch.

However, the number of VFDs connected is limited to the available ports on the switch. The central switch becomes a single point of failure (unless redundancy of the switch is added).



Daisy Chain

The daisy chain topology is simple and cost-effective to set up. It is easy to expand by adding new VFDs to the end of the chain.

However, if one VFD or cable fails, all downstream VFDs are disconnected from the network.

It is recommended to daisy-chain **up to 8 VFDs maximum.** As more VFDs are added, they may increase latency and potentially create bandwidth bottlenecks.



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Please note that these instructions are general guidelines. Refer to your particular hardware and application.

Ring RSTP (Rapid Spanning Tree Protocol)

The ring RSTP topology is more reliable than the daisy chain topology, if one VFD fails, the other VFDs can still reach by traveling in the opposite direction. It is easy to expand by adding new VFDs into the ring.

However, due to the circular aspect of the ring, it is mandatory to have loop prevention and traffic flow management on the Ethernet switch; **you must use a network switch that is compatible with IEEE 802.1w**



Please note that these instructions are general guidelines. For specific instructions related to your particular hardware and application, refer to the manufacturer's documentation.

Previous Next

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10.5. Modbus TCP

While setting the Clean Power VFD with the mobile App, the Modbus communication can be disabled by the user (or enabled if previously disabled)

Note: If Modbus is disabled, remote control from Modbus is impossible, thus protecting workers who may work locally on the power drive system from an unexpected operation.

However, for a flexible choice of remote and local control, the Clean Power VFD provides users with settings for the control source.

The communication speed selection is Automatic.

The Mac Address is written on the product label.

The Modbus application layer is standard.

Mode: DHCP only.

Device ID: MODBUS/TCP server accepts requests with slave ID=0x01

Parameters, Addresses, and Format

Other clients/servers see the Clean Power VFD as a table of parameters.

This table can be downloaded as an Excel file, from the SmartD website, on the page download, section Engineering tools: Download Engineering Tools

Registers MCx - Motor Control

The registers MCx are dedicated to Motor Control

The command register MCC can be used to change the Clean Power VFD status from "Ready to run" to running.

The command register MCD can be used to run the motor in the forward or reverse direction.

The command register MCS can be used to read the motor status.

Register SYSx - System State

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The registers SYSx are dedicated to the System State

The command register SYS can be used to read the system state

The command register SYSR can be used to reset the system after a lockout.

Registers ALxy - Alarms

The registers ALxy are dedicated to alarms.

Supported functions

Code	Function
03	Read holding registers.
06	Write a single register.
16	Write multiple registers
23	Read/Write multiple registers.
43	Read Device Identification

Note: Heartbeat Register

The Heartbeat register is a communication integrity indicator between a PLC and a VFD within a MODBUS/TCP network.

Its primary purpose is to confirm an active and stable connection by requiring periodic polling.

The Clean Power VFD's Modbus socket will close with an inactivity of 30 seconds. To keep the TCP socket open, we recommend reading the Heartbeat register regularly, typically every 10 seconds.

If the Heartbeat register is not polled within the recommended time, the VFD will interpret the lack of response as a communication failure, triggering a MODBUS Communication Loss alarm.

Previous Next

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10.5.1. Modbus TCP Exception Codes

This section helps you understand and resolve exception codes you may encounter when using Modbus TCP to communicate with the Clean Power VFD.

Exception codes indicate that the VFD received your request but was unable to process it as expected.

- 1. What is an exception code?
- 2. Understanding Modbus TCP exception codes
- 3. Troubleshoot – What to do when exceptions occur
- 4. When to contact SmartD Support:

1. What is an exception code?

When you send a Modbus TCP request and the VFD replies with a code like `0x83 0x02`, it means something went wrong.

This is referred to as an "exception response".

What does it look like?

In a typical exception response:

- The function code is returned with its most significant bit set (adds `0x80`).

Example: `0x03` (Read Holding Registers) becomes `0x83`.

- The exception code gives the reason for the failure.

This is how the device communicates that it understood your request, but couldn’t execute it.

2. Understanding Modbus TCP exception codes

Here is a table of all common exception codes you may see when working with the Clean Power VFD over Modbus TCP:

Code	Hex	Name	Description	Common Cause	What You Can Do
1	0x01	Illegal Function	The requested function is not supported by the VFD.	Unsupported function code (e.g., writing coils).	Use only supported function codes like `0x03`, `0x06`, or `0x10

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Code	Hex	Name	Description	Common Cause	What You Can Do
2	0x02	Illegal Data Address	The register address does not exist or is not allowed.	Typo in address, or access to a reserved register.	Double-check the register address in SmartD's Modbus register map.
3	0x03	Illegal Data Value	The data sent is not allowed, or the register is read-only.	Writing an out-of-range value or a protected parameter.	Verify the data value and confirm the parameter is writable
4	0x04	Device Failure	An internal error prevented the VFD from completing the request.	Memory busy, hardware fault, or firmware issue.	Retry once. If it persists, check the VFD's fault log and contact support.
5	0x05	Acknowledge	Request accepted, but processing will take more time.	Parameter saving in progress.	Wait 50 – 100 ms before retrying.
6	0x06	Device Busy	The VFD is currently handling another task.	Requests are sent too quickly.	Increase the delay between requests or poll at a slower rate.
8	0x08	Memory Parity Error	The VFD detected a memory integrity problem.	Corrupted flash or EMI interference.	Power cycle the VFD. If repeated, update firmware.
10	0x0A	Gateway Path Unavailable	The gateway (if any) cannot route the request.	Incorrect Unit ID or IP settings.	Confirm the correct Unit ID and verify routing.
11	0x0B	Gateway Target Failed to Respond	No response from the VFD within the timeout	VFD overloaded or network issue.	Check the network, reduce traffic, and confirm VFD is responsive.


Modbus TCP uses port 502. Ensure that the port is open and not blocked by a firewall.

3. Troubleshoot - What to do when exceptions occur

☑ Check the register address

Make sure it matches exactly with the SmartD Modbus register list.

☑ Use valid data

Avoid sending out-of-range or invalid values.

☑ Use supported function codes

For example, Clean Power VFD supports:

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0x03 Read Holding Registers

0x06 Write Single Register

0x10 Write Multiple Registers

0x17 Read/Write multiple registers.

☑ Respect the timing

Do not poll the VFD faster than every 10 ms.

Use the heartbeat register to monitor connection health.

☑ Capture traffic

Use a network analyzer such as Wireshark with a filter tcp.port = 502 to analyze what is being sent and received.

4. When to contact SmartD Support:

- The same exception keeps repeating even after checking the basics.

- You see exception `0x04` with no fault code on the drive.

- You suspect firmware issues or corrupted memory.

Provide the following when reaching out:

- The exact request that triggers the exception

- The exception response (raw frame or screenshot)

- The VFD firmware version and serial number

Previous Next

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10.6. BACnet IP

BACnet IP

BACnet is a standard data communication protocol that enables interoperability between different building systems (e.g. fire, security, lighting, HVAC, elevator, etc.) and devices in building automation and control applications. It allows data sharing among different types of devices from a wide range of suppliers.

The Clean Power VFD can be connected to a BACnet IP network using its Ethernet port.

Previous Next

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BACnet Objects Supported

Each BACnet object has a type and a set of properties. There is always at least one object in a device – it is used to represent the device itself. The other objects represent the device's data.

The Clean Power VFD supports the following BACnet objects:

- Device
- Binary Input
- Binary Output
- Binary Value
- Analog Input
- Analog Output
- Analog Value
- Multi-state Value

The table containing the last updated list of objects can be downloaded as an Excel file from the SmartD website, on the page download, section Engineering tools: Download Engineering Tools

Clean Power VFD BACnet Object Definitions

The table below defines the BACnet Object Identifiers for the Clean Power VFD.

BACnet Object Type(s)	BACnet Identifiers	Definition
BI	0..5	BACnet objects used for the Clean Power VFD physical digital inputs DI1..DI6
BO	0..2	BACnet objects used for the Clean Power VFD physical relays R1..R3
AI	0..2	BACnet objects used for the Clean Power VFD physical analog inputs AI1..AI3
AO	0..1	BACnet objects used for the Clean Power VFD physical analog outputs AO1..AO2

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BACnet Object Type(s)	BACnet Identifiers	Definition
AV, BV, MV	0..29	BACnet objects used for motor control
AV, BV, MV	30..49	BACnet objects used for system data
AV, BV. MV	50..99	BACnet objects used for power meter data (line, DC bus, and motor)
AV, BV, MV	100..199	BACnet objects used for power meters
AV, BV, MV	200..399	BACnet objects used for configuration
AV, BV, MV	400..449	BACnet objects used for cooling
AV, BV, MV	450..499	BACnet objects used for PID
AV, BV, MV	500..699	BACnet objects used for alarms active state
AV, BV, MV	700..899	BACnet objects used for alarms acknowledgement
AV, BV, MV	900..1099	BACnet objects used for metrics

Supported Properties of Objects

The table below provides the supported properties per BACnet object.

Property	Device	Binary Input	Binary Output	Binary Value	Analog Input	Analog Output	Analog Value	Multi-state Value
Object Identifier	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object Name	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Object Type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Description	Yes	-	-	-	-	-	-	-
System Status	Yes	-	-	-	-	-	-	-
Location	Optional							
Vendor Name	Yes	-	-	-	-	-	-	-
Vendor Identifier	Yes	-	-	-	-	-	-	-
Model Name	Yes	-	-	-	-	-	-	-
Firmware Revision	Yes	-	-	-	-	-	-	-

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Property	Device	Binary Input	Binary Output	Binary Value	Analog Input	Analog Output	Analog Value	Multi-state Value
Application Software Revision	Yes	-	-	-	-	-	-	-
Protocol Version	Yes	-	-	-	-	-	-	-
Protocol Revision	Yes	-	-	-	-	-	-	-
Service Supported	Yes	-	-	-	-	-	-	-
Object Types Supported	Yes	-	-	-	-	-	-	-
Object List	Yes	-	-	-	-	-	-	-
Max APDU Length Accepted	Yes	-	-	-	-	-	-	-
Segmentation Supported	Yes	-	-	-	-	-	-	-
APDU Timeout	Yes	-	-	-	-	-	-	-
Number of APDU Retries	Yes	-	-	-	-	-	-	-
Max Master	Yes	-	-	-	-	-	-	-
Max Info Frames	Yes	-	-	-	-	-	-	-

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Property	Device	Binary Input	Binary Output	Binary Value	Analog Input	Analog Output	Analog Value	Multi-state Value
Device Address Binding	Yes	-	-	-	-	-	-	-
Present Value	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Status Flags	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Event State	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reliability	-	-	-	-	Yes	Yes	Yes	Yes
Out of Service	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Units	-	-	-	-	Yes	Yes	Yes	-
Priority Array	-	-	Yes	Only if writable	-	Yes	Only if writable	Only if writable
Relinquish Default	-	-	Yes	Only if writable	-	Yes	Only if writable	Only if writable
Polarity	-	Yes	Yes	-	-	-	-	-
Active Text	-	Yes	Yes	Yes	-	-	-	-
Inactive Text	-	Yes	Yes	Yes	-	-	-	-
Number of States	-	-	-	-	-	-	-	Yes
State Text	-	-	-	-	-	-	-	Yes

Present Value Access

The Present Value (PV) of BACnet objects can always be read. In addition, some PVs can be written or commanded. A commandable PV is similar to writing the value, but the value is actually written into a priority array. The value occupying the highest priority in the array will be used by the bypass. The convention for showing how the PV is accessed is shown in table below and will be noted for the PV of each object.

PV Access	Name	Description
C	Commandable	Value can be written to a priority array

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PV Access	Name	Description
R	Readable	Value is read-only
W	Writable	Value can be written

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Clean Power VFD Digital Inputs

BACnet Binary Input (BI) objects are used for the Clean Power VFD physical Digital Inputs: DI1..DI6.

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10.6.1.2. Clean Power VFD Device

Device Object

The BACnet Device object is the first object read after a device is discovered because it has lots of interesting information for the client. For example, the Device object has properties that report supported BACnet services, whether more than one property can be read in a single message.

The BACnet Device object defines the Device object ID for BACnet devices. The Device Object ID must be unique across all BACnet devices in the building network. The valid values are 0..4194302.

Please refer to the BACnet IP specifications.

The Clean Power VFD supports the following Device object properties:

Device object property	Value	Access type	Notes
Object Identifier	0..4194302	Writable	User-defined Identifier. Default: 0
Object Name	Clean Power VFD {serial number}	Writable	User-defined name (Maximum length: 255 characters). Default: Clean Power VFD {serial number} Valid characters: 0-9, a-z, A-Z, Space, -, _ *Example: Clean Power VFD 000020220505000201*
Object Type	8	Read-only	DEVICE
Description	Clean Power VFD {Input voltage} {kW}kW {HP}HP	Writable	User-defined description (Maximum length: 255 characters) Default: Clean Power VFD {*Input voltage*} {*kW*}kW {*HP*}HP. Valid characters: 0-9, a-z, A-Z, Space, -, _

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Device object property	Value	Access type	Notes
			Example: Clean Power VFD 480V 18.5kW 25HP
System Status	{Current VFD system status}	Read-only	*0-2: Reserved* 3: Ready to run 4: Running auto-tuning 5: Running 6: Emergency mode 7: Out of Service mode 8: Lockout *9: Reserved* 10: Factory reset 11: Fault
Location (Optional)		Writable	User-define location (Maximum length: 50 characters). Default: Blank Valid characters: 0-9, a-z, A-Z, Space, -, _ Example: Mechanical room #1
Vendor Name	SmartD Technologies	Read-only	
Vendor Identifier	SmartD BACnet identifier (to check)	Read-only	

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Device object property	Value	Access type	Notes
Model Name	{Clean Power VFD part number}	Read-only	Example: SDB-1-2185-A for 480V 3PH 18.5kW-25HP
Firmware Revision	{Active software version}	Read-only	Example: 2023.09.00-40
Application Software Revision	{Active software version}	Read-only	Example: 2023.09.00-40
Protocol Version	1	Read-only	BACnet protocol version
Protocol Revision	14	Read-only	BACnet protocol revision (at least 14)
Services Supported	ReadProperty, WriteProperty	Read-only	
Object Types Supported	Binary Input, Binary Output, Binary Value, Analog Input, Analog Output, Analog Value, Multi-state Value	Read-only	
Object Lists	List of all BACnet objects defined in the Clean Power VFD	Read-only	
Max APDU Length Accepted	480	Read-only	

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Device object property	Value	Access type	Notes
Segmentation Supported	3	Read-only	3: No segmentation
APDU Timeout	10000	Writable	User-defined timeout in milliseconds between 1000-65535. Default: 10000ms
Number of APDU Retries	3	Writable	User-defined number of retries between 2 and 10. Default: 3
Max Master	127	Writable	127. Not writable via BACnet services
Max Info Frames	1	Writable	1: Not writable
Device Address Binding	None	Read-only	Not supported

Previous Next

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Clean Power VFD Relays (COMING SOON)

BACnet Binary Output (BO) objects are used for the Clean Power VFD physical relays: R1..R3.

Please refer to the BACnet IP specifications

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Clean Power VFD Analog Inputs

BACnet Analog Input (AI) objects are used for the Clean Power VFD physical analog input AI1..AI3.

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Clean Power VFD Analog Outputs (COMING SOON)

BACnet Analog Output (AO) objects are used for the Clean Power VFD physical analog output A01..A02.

Please refer to the BACnet IP specifications

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Motor Control Objects

The list of the Clean Power VFD motor controller parameters accessible via BACnet is available in the BACnet IP specifications.

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Clean Power VFD System

The list of the Clean Power VFD system parameters accessible via BACnet is available in the BACnet IP specifications.

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Clean Power VFD Power Meter

The list of the Clean Power VFD power meter measurements accessible via BACnet is available in the BACnet IP specifications.

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Clean Power VFD Configuration

The list of the motor nameplate parameters accessible via BACnet is available in the BACnet IP specifications. They will be used as well for Clean Power VFD configuration.

Previous Next

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Clean Power VFD Cooling

The list of the Clean Power VFD cooling parameters accessible via BACnet is available in the BACnet IP specifications.

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10.6.1.11. Clean Power VFD PID

Clean Power VFD PID

The list of the Clean Power VFD PID parameters accessible via BACnet is available in the BACnet IP specifications.

Previous Next

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Clean Power VFD Alarms

The Clean Power VFD uses BACnet Binary Values to map its alarms. The list of the Clean Power VFD alarms accessible via BACnet is available in the BACnet IP specifications.

Previous Next

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Clean Power VFD Metrics

The list of the Clean Power VFD metrics accessible via BACnet is available in the BACnet IP specifications.

Previous Next

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10.6.2. BACnet IP Configuration

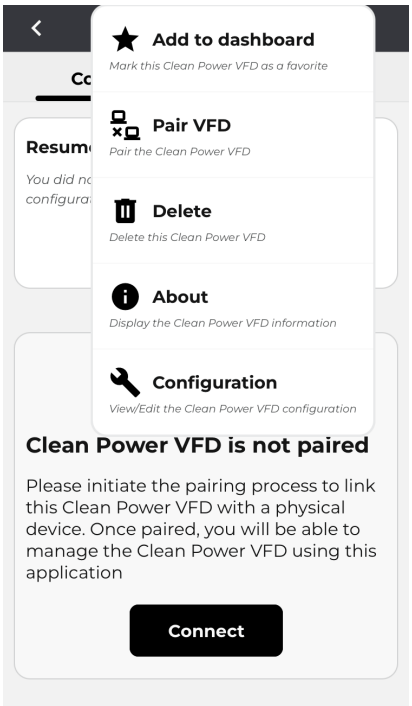
BACnet IP Configuration

The Clean Power VFD supports BACnet IP over the UDP protocol. By default, the UDP port is set to 47808.

You can enable BACnet and change the device ID and device name.

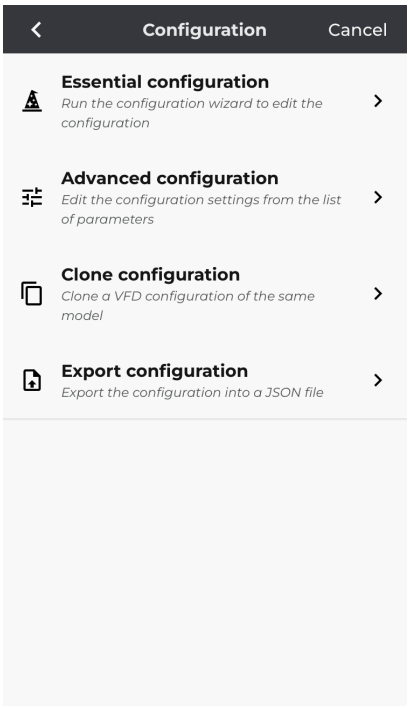
Configuration BACnet via mobile application:

- Open the Clean Power VFD application on your mobile device.
- Click on the upper-right corner of the app to open the menu.
- Select the ***Configuration*** menu item as shown below.

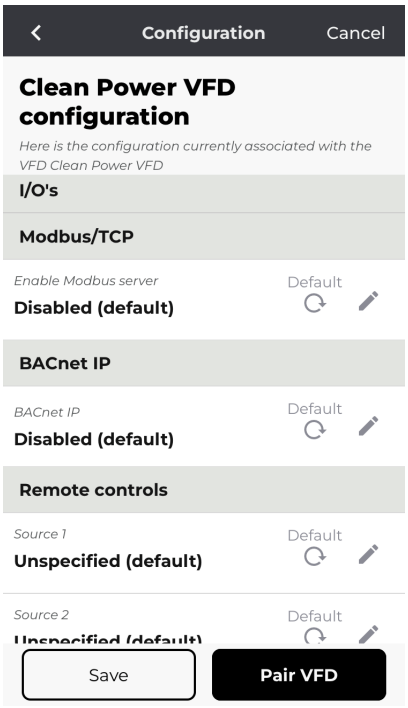


- On the Configuration screen, click on ***Advanced configuration***

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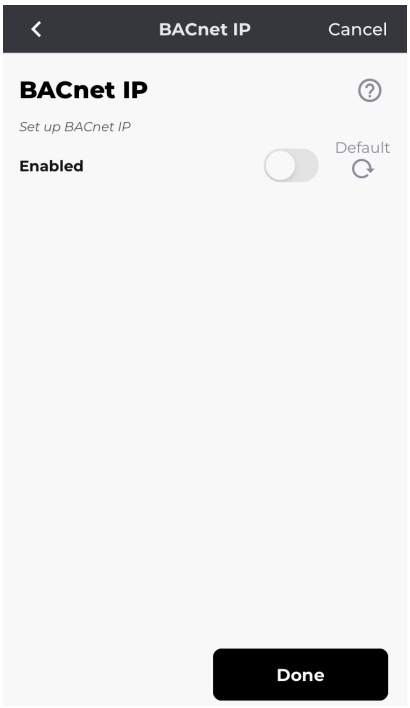


- Scroll down until you have the ***BACnet IP*** and click on the pencil

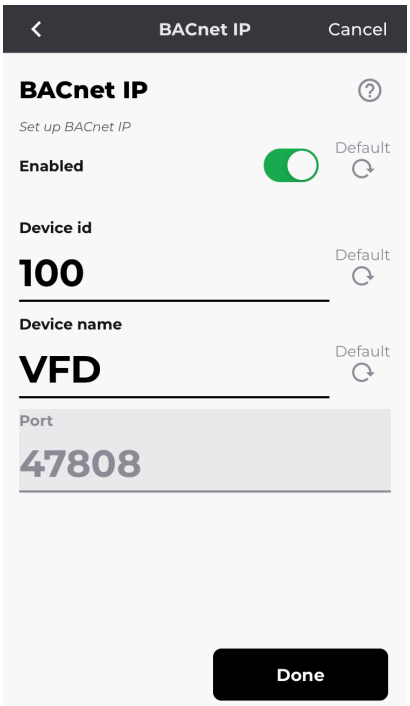


- Slide the Enabled switch to enable BACnet IP

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- Once enabled, you can specify the BACnet device identifier (Device ID) and device name



- Click on Done and Save, or Transfer the new configuration to the Clean Power VFD.
- Please remember to select BACnet IP in the Remote Control Source to use BACnet IP as a remote control.

Previous Next

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10.7. EtherNet/IP-Overview and Capability

NOTICE

The EtherNet/IP documentation is based on the SmartD implemented **revision 1.0.12 on 2026 May 5th**.

What You Can Do with EtherNet/IP (and When to Use It)

EtherNet/IP provides two complementary ways to interact with the Clean Power VFD:

1. **Cyclic I/O (Class 1)** – for real-time control and monitoring. Use cyclic I/O when you need deterministic exchange between a PLC/Scanner and the drive, such as:

- Start/stop, forward/reverse, fault reset, and interlocks using a **Control Word / Status Word**
- Send a **speed reference** (and, where supported by firmware/profile, a torque reference)
- Read back **actual values** (speed, current, power) and drive status

2. **Explicit messaging (Class 3)** – for on-demand reads/writes (commissioning & diagnostics). Use explicit messaging when you need parameter access, change management, or one-time reads such as:

- Reading device identity and network configuration
- Reading drive monitoring attributes (current, power, torque, mode)
- Reading (and, where supported) writing configuration attributes

Important: The Clean Power VFD supports the following CIP explicit services::

- **Get_Attributes_All (0x01)** - returns the full set of supported attributes for objects where this service is implemented.
- **Get_Attribute_Single (0x0E)** - reads one specific attribute.
- **Set_Attribute_Single (0x10)** - writes one specific attribute, where write access is supported by the object and firmware.

i The service **Get_Attributes_All (0x01)** is supported on

- Motor Data Object,

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- Control Supervisor Object,
- AC/DC Drive Object,
- Identity Object,
- ethernet_link Object, and
- TCP/IP Object.

For other objects, or when a client tool receives an Attribute Not Supported or Online Read Rejected response, use Get_Attribute_Single instead.

Supported CIP objects (summary)

The Clean Power VFD implements the ODVA **CIP AC/DC Drive profile** plus standard EtherNet/IP network objects. The main objects used by an automation engineer are:

- **Identity Object (0x01)** – device identification
- **Message Router (0x02)** – CIP routing *(Limitation: Not yet supported)*
- **Assembly Object (0x04)** – cyclic I/O assemblies (Class 1)
- **Motor Data Object (0x28 / 40 dec)** – motor nameplate data (read/write depends on firmware support) *(Limitation: only read)*
- **Control Supervisor Object (0x29 / 41 dec)** – run/stop, direction, state, reset, and fault/warning status.
- **AC/DC Drive Object (0x2A / 42 dec)** – speed reference, actual speed, current, power, drive mode, ramps, and scaling.
- **TCP/IP Interface Object (0xF5 / 245 dec)** – IP addressing and TCP/IP settings
- **Ethernet Link Object (0xF6 / 246 dec)** – Ethernet link speed, link flags, and MAC address.

Cyclic I/O assemblies (Class 1)

The drive supports multiple I/O assembly pairs. Conceptually:

- **Output Assembly (O→T)**: PLC → Drive (what the drive consumes)
- **Input Assembly (T→O)**: Drive → PLC (what the drive produces)

Supported assembly instance numbers include (availability depends on firmware “phase”):

- **Basic Speed Control**: Output **20**, Input **70**
- **Extended Speed Control**: Output **21**, Input **71**
- **Extended Speed + Torque Control**: Output **23**, Input **73***(phase dependent)* *(Limitation: not yet supported)*

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- **Extended Process Control**: Output **25**, Input **75***(phase dependent)* *(Limitation: not yet supported)*
- **SmartD (vendor) variants**: Outputs **120/121/123/125**, Inputs **170/171/173/175***(phase dependent)* *(Limitation: 123/125 and 173/175 not yet supported)*

The SmartD variants add extra cyclic data beyond the standard ODVA words (example: output frequency, motor current, power, alarm words, and configurable words), depending on the selected assembly.

Producer-Consumer model and Listen-Only connections

The Clean Power VFD acts as an **Adapter**:

- It **consumes** the PLC's Output Assembly (O→T) and
- **produces** the Input Assembly (T→O)

The **PLC/Scanner owns the connection** and typically sends O→T as **unicast**.

Additional devices (HMI, historian, gateway) may establish **Listen-Only** connections to the drive's produced Input data when the scanner is configured for multicast production.
Listen-only devices do **not** control the drive; they "listen" to the same produced data stream.

Network ports and physical interfaces

The product provides **two RJ-45 Ethernet ports** with auto-negotiated speed/duplex. There are **no physical port LEDs** on the product.

Electronic Data Sheet (EDS)

EDS file are provided for PLC integration and device discovery.
Download location: **SmartD services website** – Network parameter data files

Previous Next

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Ports & Transports

Transport	Port	Purpose	Notes
TCP	44818	EtherNet/IP Encapsulation for Explicit Messaging (Class 3)	Used for commissioning, configuration reads/writes, diagnostics, and “one-shot” data access. Requires a TCP connection and an EtherNet/IP session (RegisterSession).
UDP	44818	Discovery and network browse(ListIdentity)	Used by EtherNet/IP discovery tools (e.g., *ListIdentity*) to find devices on the network. These messages do not require a session.
UDP	2222	Cyclic I/O (Class 1, Implicit Messaging)	Cyclic I/O data (real-time control, (O→T and T→O)). Connection-oriented at the CIP layer, carried over connectionless UDP for performance.

> **Tip:** If discovery tools fail to find the drive, ensure **UDP/44818** is permitted on the commissioning VLAN and your PC firewall isn’t blocking broadcast/multicast.

Multicast vs Unicast for cyclic I/O (Class 1)

EtherNet/IP Class 1 I/O can produce as **Multicast** or **Unicast**:

- **Multicast**
  - The drive (Producer) sends one T→O stream to a multicast group.
  - Multiple consumers (scanner + listen-only HMIs/historians) can subscribe to the same produced data.
  - Recommended for larger cells **if your switches support IGMP Snooping** (and typically an IGMP Querier) to prevent multicast flooding.
- **Unicast**:
  - Point-to-point T→O stream from the drive to a single consumer.
  - Simpler for small skids and point-to-point setups.
  - If you add additional consumers, each one typically creates an additional stream and increases adapter load.

Where this is configured: The unicast/multicast choice is typically made in the **PLC/scanner connection parameters** (not by a “drive parameter”). Use multicast when you need listen-only clients on the produced data; use unicast for simple single-scanner topologies.

Recommendation:

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- **Large cells / multiple listeners:** use **Multicast** + ensure **IGMP Snooping/Querier** is correctly configured on managed switches.
- **Isolated skid / single scanner:** use **Unicast** to simplify networking.

TCP/IP Interface Object quick reference - Class 0xF5, Instance 1

The TCP/IP Interface Object exposes IPv4 network configuration and interface status.

Attribute	Name	Access	Notes
1	Status	Get	Interface status.
2	Configuration Capability	Get	Reports interface capability flags.
3	Configuration Control	Get	Reports configuration control flags.
4	Physical Link Object	Get	Path to the Ethernet Link Object.
5	Interface Configuration	Get	IP address, subnet mask, gateway, DNS, and domain information.
6	Host Name	Get	Host name, where supported.

Implementation note: The current EtherNet/IP implementation is IPv4-based. IPv6 is not part of the current published scope.

Previous Next

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10.7.2. Supported CIP Objects

The Clean Power VFD exposes the CIP objects listed below for EtherNet/IP explicit messaging (Class 3) and cyclic I/O (Class 1).

Availability of some objects and features may depend on firmware phase/revision.

Implemented objects

CIP Class	Object	Implementation Revision 1.0.12	Instances	Typical use
0x01	Identity Object	Partially implemented	1	Device identification: Vendor ID, Product Code, Revision, Serial Number, Product Name.
0x02	Message Router Object	Partially implemented	1	CIP message routing (required for explicit messaging). Required by the CIP architecture. The class is online, but public instance attributes may return Online Read Rejected.
0x04	Assembly Object	Implemented	Multiple	Cyclic I/O assemblies (O→T outputs and T→O inputs). Basic and Extended assemblies are available in Phase 1; Torque and Process assemblies are phased in later.
0x28	Motor Data Object	Implemented	1	Motor nameplate data (read/write support depends on the attribute and firmware maturity).
0x29	Control Supervisor Object	Implemented	1	Control commands. Run/stop, direction, reset, state, fault/warning status, and control-from-network status.
0x2A	AC/DC Drive Object	Implemented	1	Drive reference and actual values: speed, current, power, drive mode, ramps, scaling, and reference-from-network status.
0xF5	TCP/IP Interface Object	Implemented	1	IP addressing and TCP/IP configuration attributes.
0xF6	Ethernet Link Object	Implemented	Up to 2	Ethernet port/link information (speed, link flags, MAC address). *One instance per physical RJ-45 port; availability of the second instance may depend on firmware.*

Present but limited / phased objects

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CIP Class	Object	Implementation Revision 1.0.12	Instances	Notes
0x05	Connection Object	Not implemented	2	Currently not exposed with full attribute support (phased).
0x06	Connection Manager Object	Partially implemented	1	used by the scanner during connection setup (Forward Open / I/O connection management).

Supported explicit services (common behavior)

For explicit messaging, the drive supports:

- **Get_Attribute_Single (0x0E)**
- **Set_Attribute_Single (0x10)**
- **Get_Attributes_All (0x01)**

Conformance and safety

ODVA Declaration ID, drive profile revision, and CIP Safety support ***(Limitation : not yet certified)***

Previous Next

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CIP Object Definitions

EtherNet/IP uses CIP objects to organize device identity, cyclic I/O data, network configuration, drive control, drive monitoring, and diagnostics. Each object is identified by a CIP class code. Most drive-related objects use **Instance 1**. Link-related objects may use one instance per Ethernet port.

The table below explains the role of each CIP object exposed or used by the Clean Power VFD. Use this table as a navigation reference before reading the detailed object attribute tables.

CIP Class	Object Name	Definition	Main Use in the Clean Power VFD	Typical User Action	Implementation Notes
0x01	Identity Object	Standard CIP object used to identify the device.	Provides Vendor ID, Device Type, Product Code, Revision, Serial Number, Product Name, and device status.	Read during device discovery, commissioning, asset inventory, support diagnostics, and EDS/tool validation.	Partially implemented in revision 1.0.12. See the Identity Object quick reference table for supported attributes.
0x02	Message Router Object	CIP object used to route explicit messages to the target object.	Allows explicit messaging requests to reach objects such as Identity, Motor Data, Control Supervisor, AC/DC Drive, TCP/IP Interface, and Ethernet Link.	Usually not accessed directly by the user. It is used by the EtherNet/IP stack and commissioning tools.	Partially implemented. The class is online, but public instance attributes may return **Online Read Rejected**.
0x04	Assembly Object	CIP object that groups cyclic I/O data into input and output assemblies.	Defines the data exchanged through Class 1 I/O, including Control Word, Status Word, speed reference, actual speed, current, power, and SmartD alarm words.	Select the correct Output/Input assembly pair in the PLC scanner configuration. For example, Output 120 must be paired with Input 170.	Implemented. Basic and Extended Speed assemblies are available in the current phase. Torque and Process variants are planned for later phases.
0x05	Connection Object	CIP object representing connection-related information.	Intended to represent connection instances such as I/O or explicit connections.	Do not rely on this object for user diagnostics until full	Not implemented for user access in revision 1.0.12. Keep documented as

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CIP Class	Object Name	Definition	Main Use in the Clean Power VFD	Typical User Action	Implementation Notes
				attribute support is confirmed.	phased or internal only.
0x06	Connection Manager Object	CIP object responsible for opening, closing, and supervising CIP connections.	Used during Forward Open / Forward Close when a PLC establishes a Class 1 I/O connection with the drive.	Usually not accessed directly by the user. PLC software and EtherNet/IP scanners use this object during connection setup.	Partially implemented. Used by the scanner during I/O connection setup.
0x28	Motor Data Object	CIP AC drive profile object containing motor nameplate information.	Provides motor type, rated current, rated voltage, rated power, rated frequency, pole count, and base speed.	Read motor nameplate values for commissioning checks, diagnostics, and configuration verification.	Implemented. Read support is available. Set/write support is not yet implemented for several attributes and must be confirmed before publication as writable.
0x29	Control Supervisor Object	CIP AC drive profile object used for drive control state, run commands, reset, and status feedback.	Provides Run1, Run2, BNetCtrl, State, Running1, Running2, Ready, Faulted, Warning, Reset Faults, Fault Code, Warning Code, and CtrlFromNet.	Use for explicit-message control and diagnostics. Use BNetCtrl to request network control authority when EtherNet/IP is the selected remote control source.	Implemented. Some attributes are Set-only, such as Run1 and Run2.
0x2A	AC/DC Drive Object	CIP AC drive profile object used for drive reference values, actual values, scaling, ramps, and reference authority.	Provides AtRef, NetRef, DriveMode, SpeedActual, SpeedRef, CurrentActual, PowerActual, AccelTime, DecelTime, scaling attributes, and RefFromNet.	Use for explicit-message reads/writes of speed reference, actual values, drive mode, ramp values, and network reference authority.	Implemented: speed-related functions. Torque and Process attributes are planned for later phases. Scaling attributes may exist but are not yet applied firmware release.
0xF5	TCP/IP Interface Object	Standard CIP object used for IPv4 network configuration and interface status.	Provides interface status, configuration capability, configuration control, physical link object path, interface	Read to verify IP address, subnet mask, gateway, and network configuration during commissioning or troubleshooting.	Implemented. The current EtherNet/IP implementation is IPv4-based. IPv6 is not part of the current published scope.

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CIP Class	Object Name	Definition	Main Use in the Clean Power VFD	Typical User Action	Implementation Notes
			configuration, and host name.		
0xF6	Ethernet Link Object	Standard CIP object used for Ethernet port/link information.	Provides interface speed, interface flags, and physical address (MAC address).	Read during troubleshooting to verify link state, negotiated speed, duplex status, and MAC address.	Implemented. The product has two physical RJ-45 ports. Confirm whether the current firmware exposes one or two Ethernet Link Object instances.

Previous Next

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10.7.3. Identity Object quick reference - Class 0x01, Instance 1

The Identity Object provides device identification information used by PLCs, commissioning tools, and diagnostic tools.

Attribute	Name	Data type	Access	Notes
1	Vendor ID	UINT	Get	SmartD ODVA Vendor ID: 1819
2	Device Type	UINT	Get	AC Drive device type: 0x02
3	Product Code	UINT	Get	Product code depends on the drive model. See Product Code table / EDS.
4	Revision	STRUCT	Get	Major and minor revision of the Clean Power VFD EtherNet/IP objects model.
5	Status	WORD	Get	Summary device status. See Identity Status bits. - Not implemented
6	Serial Number	UDINT	Get	Unique per device.
7	Product Name	SHORT_STRING	Get	Product name: "Clean Power VFD".
15	Assigned Name	STRING	Get	Drive assigned name.

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Attribute	Name	Data type	Access	Notes
20	Uptime	UDINT	Get	The period of time in seconds since power-up or restart of the VFD
21	Catalog Number	SHORT_STRING	Get	Drive catalog/model number.
31	Vendor Name	STRING	Get	SmartD Technologies Inc.
35	Manufacture Serial Number	SHORT_STRING	Get	Manufacturer serial number.

Previous Next

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10.7.4. I/O Assemblies (Class 1)

EtherNet/IP Class 1 I/O uses the **Assembly Object (Class 0x04)** to exchange cyclic data between a PLC/Scanner and the drive:

- **Output Assembly (O→T)**: PLC → Drive, Carries the **Control Word**, **Reference(s)**, and optional command fields.
- **Input Assembly (T→O)**: Drive → PLC. Returns the **Status Word**, **Actual values**, and (on SmartD variants) **alarm bitfields**.

All assemblies are structured as **16-bit words**. Word meaning and scaling depend on the selected assembly instance.

Supported Instance Pairs

Select one of the following **matching Output/Input pairs**. Do not mix variants (for example, Output 120 must be paired with Input 170).

Variant	Output Instance (O→T)	Input Instance (T→O)
Basic Speed Control	20	70
Extended Speed Control	21	71
Extended Speed & Torque Control (Limitation: not yet supported)	23	73
Extended Process Control *(Limitation: not yet supported)*	25	75
SmartD Basic Speed Control	**120**	**170**
SmartD Extended Speed Control	**121**	**171**
SmartD Extended Speed & Torque Control *(Limitation: not yet supported)*	**123**	**173**
SmartD Extended Process Control *(Limitation: not yet supported)*	**125**	**175**

Standard vs SmartD assemblies

- **Standard ODVA assemblies (20/70, 21/71, 23/73, 25/75)** are compact and intended for basic interoperability.
- **SmartD assemblies (120/170, 121/171, 123/173, 125/175)** extend the cyclic data with:
  - additional monitoring words (frequency, current, power, etc.)
  - **five alarm bitfield words** (AL1…AL5)
  - **configurable words** reserved for future use

Standard Basic Speed Control (Input 70 / Output 20)

Input Assembly - Basic Speed Control (T->O), Instance 70

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Word	Signal	Scaling / Units	Notes
1	**Basic Status Word**	–	ODVA Basic control word bit map: see section “Control & Status Word”.
2	Speed Reference	1 = 1 RPM	SpeedScale not yet implemented

Output Assembly - Basic Speed Control (O->T), Instance 20

Word	Signal	Scaling / Units	Notes
1	**Basic Control Word**	–	ODVA Basic control word bit map: see section “Control & Status Word”.
2	Speed Reference	1 = 1 RPM	SpeedScale not yet implemented

Scaling notes

For existing assemblies, the following scaling features are **not applied**:

- **SpeedScale** (speed words use the fixed scaling stated in each table, e.g., 1 = 1 RPM)
- **PowerScale**
- **TorqueScale**
- **ProcessScale**

Use the **fixed “Data Scaling” shown in the assembly tables**.

SmartD Basic Speed Control (Instance 170 / 120)

Input Assembly – SmartD Basic (T→O), Instance **170**

Data produced by the drive and read by the PLC.

Word	Signal	Scaling / Units	Notes
1	**Basic Status Word**	–	ODVA Basic status word bit map: see Appendix “Control/Status Word Bit Definitions”.
2	Actual Speed	1 = 1 RPM	SpeedScale not yet implemented.
3	Output Frequency	1 = 1 Hz	SpeedScale not yet implemented.
4	Motor Current	1 = 0.1 A	Average VFD output current (RMS).
5	Actual Power	1 = 1 W	PowerScalenot yet implemented.
6	Tripping Faults 1 (**AL1**)	bitfield	Alarm mapping: see “Alarm Words (AL1-AL5)”.
7	Tripping Faults 2 (**AL2**)	bitfield	–

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Word	Signal	Scaling / Units	Notes
8	Tripping Faults 3 (**AL3**)	bitfield	–
9	Tripping Faults 4 (**AL4**)	bitfield	–
10	Tripping Faults 5 (**AL5**)	bitfield	–
11-16	Configurable (future)	–	Reserved; planned to become configurable in a later phase.

Output Assembly – SmartD Basic (O→T), Instance **120**

Data sent by the PLC to the drive.

Word	Signal	Scaling / Units	Notes
1	**Basic Control Word**	–	ODVA Basic control word bit map: see Appendix “Control/Status Word Bit Definitions”.
2	Speed Reference	1 = 1 RPM	SpeedScale not yet implemented.
3-16	Configurable (future)	–	Reserved; planned to become configurable in a later phase. Write 0 until the words are documented for use.

Extended and Process variants (summary)

Extended Speed (171 / 121)

Same structure as SmartD Basic, but Word 1 uses **Extended Control/Status Word** (ODVA extended bit map). Monitoring and AL1–AL5 words remain present on SmartD variants.

Extended Speed & Torque (173 / 123) (Limitation : not yet supported)

Adds a **Torque Reference** word in the Output assembly:

- **Output Word 3: Torque Reference** (1 = 1 N·m; TorqueScale not yet implemeted)

Extended Process (175 / 125)

Adds **Process Reference / Actual** words:

- **Input Word 3: Actual Process** (1 = 1 %; ProcessScale not yet implemeted)
- **Output Word 3: Process Reference** (1 = 1 %; ProcessScale not yet implemeted)

Alarm words (AL1-AL5)

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In SmartD assemblies, AL1…AL5 are **16-bit alarm flag words**. Each bit represents one alarm condition.

Bit numbering note: alarm flag bits are defined using **little-endian bit numbering. This means that Bit 0 corresponds to the least significant bit (LSB) of the 16-bit word.**

Full alarm-to-bit mapping is provided in the "Alarms" chapter/appendix.

Previous Next

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10.7.5. Control & Status Words

This section defines the Basic and Extended control/status word bit maps used by the Clean Power VFD EtherNet/IP Class 1 I/O assemblies.

Basic control/status words are used by Basic assemblies. Extended control/status words are used by Extended, Torque, and Process assemblies. Some Extended assembly variants are planned for later firmware phases.

Word order and bit numbering

- **Control Word** is the **first 16-bit word** in the Output Assembly (PLC → Drive).
- **Status Word** is the **first 16-bit word** in the Input Assembly (Drive → PLC).
- **Bit 0** is the **LSB** of the word (rightmost bit).
- Unless noted otherwise, **unused bits must be written as 0** and should be ignored when read.

ODVA Basic Control Word (Basic assemblies: 20 / 120)

Bit	Name	Meaning	PLC guidance
0	**RunFwd**	1 = run forward command, 0 = stop	Maintain (level) while you want the drive to run
2	**FaultReset**	Rising edge triggers a fault reset	Send as a **one-shot pulse** (one scan)
Others	Reserved	Not used	Write 0

ODVA Basic Status Word (Basic assemblies: 70 / 170)

Bit	Name	Meaning	PLC guidance
0	**Faulted**	1 = drive is faulted (tripping)	Use to block start and prompt reset workflow
2	**Running1 (Fwd)**	1 = running forward	Use as “running” feedback in Basic mode
Others	Reserved	Not used	Ignore

ODVA Extended Control Word (Extended assemblies: 21/23/25 and 121/123/125)

Bit	Name	Meaning	PLC guidance
0	**RunFwd**	1 = run forward, 0 = not commanded	Mutually exclusive with RunRev
1	**RunRev**	1 = run reverse, 0 = not commanded	Mutually exclusive with RunFwd
2	**FaultReset**	Rising edge triggers a fault reset	One-shot pulse
5	**NetCtrl**	Enables network control authority (I/O control word accepted)	Keep = 1 during normal PLC control

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Bit	Name	Meaning	PLC guidance
6	**NetRef**	Enables network reference authority (I/O reference accepted)	Keep = 1 during normal PLC reference control
Others	Reserved	Not used	Write 0

Direction rule: `RunFwd` and `RunRev` must not be 1 at the same time. If both are set, treat it as an invalid PLC output state (do not rely on drive behavior).

ODVA Extended Status Word (Extended assemblies: 71/73/75 and 171/173/175)

Byte 0 (bits 0…7): status flags

Bit	Name	Meaning
0	**Faulted**	Drive has a tripping fault
1	**Warning**	Non-tripping warning active
2	**Running1 (Fwd)**	Running forward
3	**Running2 (Rev)**	Running reverse
4	**Ready**	Ready to run (not faulted, enabled path OK)
5	**CtrlFromNet**	Control is currently taken from network (remote control active)
6	**RefFromNet**	Reference is currently taken from network
7	**AtReference**	Actual is within the drive's "at speed/at reference" band

Byte 1 (bits 8…15): Drive State code

In Extended Status, the **high byte** contains a **Drive State code** (not individual bits). This code mirrors the **Control Supervisor Object – State**.

Recommended codes to document (current implementation):

- **0 = Vendor specific / N/A**
- **1 = Startup**
- **2 = Not Ready**
- **3 = Ready**
- **4 = Enabled**
- **5 = Stopping**
- **6 = Fault Stop**
- **7 = Faulted**

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10.7.6. Commissioning

Configure network settings from the drive interface (HMI)

Use the drive HMI menus to configure the EtherNet/IP network interface before connecting from a PLC or commissioning tool.

1) Choose the addressing method

Select one of the following:

- **DHCP** – the drive requests an IP address from a DHCP server.
- **Manual (Static)** – you enter a fixed IP address.

Recommendation: Use **static addressing** for PLC-controlled systems unless your site has a managed DHCP scheme with reserved leases.

2) Enter IP parameters (static mode)

If **Manual (Static)** is selected, configure:

- **IP address**
- **Subnet mask**
- **Default gateway**

Apply/save the settings per the HMI prompts.

3) Hostname (if supported)

If the HMI provides a hostname field, you may assign a descriptive name (example: `PUMP-BOOST-01`). Hostname support and visibility depend on firmware.

4) Verify link and reachability

After applying settings:

- Confirm the drive is visible from the commissioning PC (ping the IP address).
- Use an EtherNet/IP discovery tool (ListIdentity) to confirm the device responds on the network.

Tip: If discovery fails, check that **UDP/44818** is allowed on the commissioning VLAN and that your PC firewall is not blocking broadcast/multicast discovery traffic.

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10.7.7. EtherNet/IP Glossary and Dictionary (CIP / ODVA Vocabulary)

This glossary defines the most common EtherNet/IP terms you will see in PLC software, device manuals, and diagnostic tools. Terms are listed alphabetically; acronyms are expanded where relevant.

A

Adapter

A CIP device that **responds** to a PLC/Scanner. In EtherNet/IP, the drive is typically an **Adapter** that consumes outputs (O→T) and produces inputs (T→O).

Attribute

A data item within a CIP object instance. Addressed as **Class / Instance / Attribute** (e.g., Class 0x2A, Instance 1, Attribute 8).

Assembly Object (Class 0x04)

CIP object that defines the **cyclic I/O data layout** used for Class 1 (implicit) messaging. An “assembly instance” is the chosen I/O structure.

B

Broadcast

A message sent to all nodes on a subnet (e.g., discovery request). Often used by **ListIdentity**. Broadcast traffic may be blocked by VLAN rules or PC firewalls.

C

CIP (Common Industrial Protocol)

The application-layer protocol used by EtherNet/IP (and also by DeviceNet and ControlNet). EtherNet/IP is essentially **CIP transported over Ethernet**.

CIP Class

Same as “Object Class.” Identifies the object type (e.g., Identity Object = Class 0x01).

CIP Data Types

Standardized data representations used in attributes and I/O:

- **BOOL** (1 byte logical)
- **SINT/USINT** (8-bit signed/unsigned)
- **INT/UINT** (16-bit signed/unsigned)

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- **DINT/UDINT** (32-bit signed/unsigned)

- **REAL** (32-bit float)

  Tools must send the correct **byte count** and type for Set_Attribute requests.

Class 1 Messaging (Implicit I/O)

Cyclic, real-time I/O data exchange using assemblies. Transported over **UDP/2222**. Used for control words, references, and fast feedback.

Class 3 Messaging (Explicit Messaging)

On-demand reads/writes to object attributes. Transported over **TCP/44818** (encapsulation + CIP). Used for commissioning and diagnostics.

Client

The device or software that initiates communication (PLC/Scanner, Hilscher tool, EIPExplorer, etc.).

Connection

A logical communication relationship (explicit or I/O). Class 1 I/O connections are negotiated (Forward Open) and supervised (timeouts).

Connection Manager (Class 0x06)

CIP object responsible for creating and managing connections (Forward Open/Close and connection-related behavior).

Control Word / Status Word

16-bit words exchanged in cyclic I/O. The Control Word commands the drive; the Status Word reports the drive's state.

D

Device (Target)

The device being accessed (the VFD). In tools, this is often the "target" of explicit messages.

DLR (Device Level Ring)

An EtherNet/IP ring redundancy protocol (not the same as RSTP). Only relevant if the device explicitly supports DLR.

E

EDS (Electronic Data Sheet)

A file used by PLC/engineering tools to identify the device and present configuration options (assemblies, identity, parameters).

Encapsulation

EtherNet/IP "wrapper" protocol used on **TCP/44818** (and some discovery services on UDP/44818). Encapsulation messages include **RegisterSession** and **SendRRData**.

Explicit Message

A Class 3 message that reads/writes one attribute (or performs a service) on a CIP object.

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EtherNet/IP

ODVA industrial networking technology: CIP over standard Ethernet (TCP/UDP/IP).

F

Forward Open / Forward Close

CIP services used by the scanner to establish or close a Class 1 I/O connection (and sometimes connected explicit connections). Forward Open sets RPI, connection sizes, and timing.

G

General Status (CIP Status Code)

A one-byte status returned by CIP responses (e.g., **0x00 = Success**, 0x14 Attribute Not Supported, 0x16 Object Instance Does Not Exist). Used heavily for troubleshooting explicit messaging.

H

Heartbeat

A periodic “I’m alive” signal. In EtherNet/IP this can mean:

- the natural supervision of a Class 1 I/O connection (timeouts), or
- a vendor-specific heartbeat mechanism (if implemented).
  Always confirm what “heartbeat” means in your product/firmware.

I

IGMP (Internet Group Management Protocol)

Used by IP networks to manage multicast membership.

IGMP Snooping

Switch feature that listens to IGMP messages and forwards multicast only where needed. Without it, multicast can flood an entire VLAN.

IGMP Querier

A device that periodically queries multicast membership. Many networks require a querier for stable multicast behavior.

Implicit Messaging

Another name for Class 1 cyclic I/O.

Input Assembly (T→O)

The data produced by the drive (Adapter) and consumed by the PLC (Scanner). “T→O” means **Target to Originator**.

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Instance

A specific instance of a CIP object class. Most drive objects use Instance 1; Ethernet Link often uses Instance 1/2 for Port 1/Port 2.

L

Listen-Only

A type of Class 1 I/O connection where a device subscribes to the produced input data (T→O) but does not control the drive (no O→T ownership). Often used by HMIs/historians when multicast is enabled.

ListIdentity (Encapsulation command)

A discovery command (commonly UDP/44818). Tools use it to find devices and display vendor/product identity.

ListServices (Encapsulation command 0x0004)

A command that returns which EtherNet/IP services are supported. Also typically carried over UDP/44818.

M

MAC Address

Hardware address of the Ethernet interface. Often visible via Ethernet Link Object or the device UI.

Multicast

One-to-many IP delivery model. In EtherNet/IP I/O, multicast allows multiple listeners to receive the same produced I/O stream without creating additional streams from the producer.

O

Object (CIP Object)

A standardized grouping of attributes and services (Identity Object, TCP/IP Interface Object, AC/DC Drive Object, etc.).

ODVA

The organization that defines and maintains EtherNet/IP and CIP specifications.

Originator

The device that initiates a connection (usually the PLC/Scanner). In I/O naming, Originator receives T→O input data and sends O→T output data.

Output Assembly (O→T)

The data consumed by the drive (Adapter) and produced by the PLC (Scanner). “O→T” means **Originator to Target**.

P

Produced / Consumed

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- The drive **produces** Input data (T→O)
- The drive **consumes** Output data (O→T)

Producer–Consumer model

CIP model where a produced data stream can be consumed by one or many devices (especially with multicast).

Port 2222

UDP port used for Class 1 cyclic I/O (implicit messaging).

Port 44818

TCP port used for explicit messaging (encapsulation + CIP). UDP/44818 commonly used for discovery (ListIdentity/ListServices).

R

RegisterSession (Encapsulation command)

A TCP/44818 step required before sending most explicit messages. The client obtains a session handle.

RPI (Requested Packet Interval)

The scanner's requested update rate for cyclic I/O, typically in milliseconds (e.g., 20 ms). Lower RPI = higher traffic and higher load.

Run/Stop Ownership

Typically only one controller should own O→T control. Additional clients should be listen-only (read-only).

S

Scanner

The PLC/controller that "scans" I/O connections. It owns the Class 1 connection and sends cyclic outputs to the adapter.

SendRRData (Encapsulation command)

Encapsulation message used to carry **unconnected** CIP explicit messages over TCP/44818.

Service (CIP Service Code)

The operation being performed, such as:

- **Get_Attribute_Single (0x0E)**
- **Set_Attribute_Single (0x10)**

  Other services exist for connection management, but these are the core explicit attribute services.

Session (Encapsulation Session)

A TCP/44818 encapsulation session created by RegisterSession. Multiple explicit messages can occur within one session.

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Status Word

Drive feedback in I/O (faulted, running, ready, etc.). Bit definitions depend on Basic vs Extended profile.

T

Target

The device being commanded (the drive). In I/O naming, Target = Adapter.

T→O (Target to Originator)

The produced Input data stream from the drive to the PLC.

TCP/IP Interface Object (Class 0xF5)

Standard CIP object for IP addressing and TCP/IP settings.

Timeout (I/O watchdog)

If cyclic I/O stops arriving within a calculated time window, the connection times out and the drive executes its configured “comms loss” action (behavior depends on firmware/parameterization).

U

UDP

Connectionless transport used for cyclic I/O (2222) and discovery (44818). CIP I/O still has connection semantics above UDP.

Unicast

One-to-one IP delivery model. Often simpler, but each additional consumer can create additional load/streams.

UnregisterSession (Encapsulation command)

Closes an encapsulation session. In packet traces, this often results in TCP teardown (FIN/ACK).

V

VLAN

Virtual LAN. A logical separation of an Ethernet network into **isolated broadcast domains** (often also different IP subnets). Devices on different VLANs behave like they are on different networks unless routing/firewall rules allow traffic between them.

W

Wireshark

A network capture tool used to record and inspect EtherNet/IP traffic. Useful for confirming ports, message sequences, and error responses.

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Acronyms quick list (most used)

- **CIP**: Common Industrial Protocol
- **EDS**: Electronic Data Sheet
- **HMI**: Human-Machine Interface
- **IGMP**: Internet Group Management Protocol
- **O→T**: Originator to Target (PLC → Drive outputs)
- **T→O**: Target to Originator (Drive → PLC inputs)
- **ODVA**: Standards organization for EtherNet/IP
- **RPI**: Requested Packet Interval
- **TCP/UDP**: Transport protocols used by EtherNet/IP

Previous Next

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11. Metrics

In the upcoming sections of this user guide, we will describe various key metrics that are instrumental in evaluating the performance and operational health of your VFD, motor, and control system.

Understanding these metrics is crucial for maximizing efficiency, prolonging VFD lifespan, and ensuring system reliability.

These indicators provide insights into how effectively the VFD converts input energy into output power, the system's usage patterns including duration and frequency, and the operational dynamics over its service life.

By closely monitoring these parameters, you can make informed decisions about maintenance schedules, predict potential failures, and optimize energy consumption to reduce costs.

This section aims to empower you by providing users with the knowledge to not only interpret these metrics but also to leverage them for proactive system management and troubleshooting.

Motor number of starts

Motor runtime

VFD runtime

Fans runtime

Previous Next

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11.1. Motor number of starts

Monitoring Motor Starts

The Clean Power VFD automatically keeps the number of times the connected motor has been started. You have access to this data through four different methods :

- HMI (Human Machine Interface): You can directly view the number of motor starts on the Clean Power VFD's HMI display.
- Mobile App: You can directly view the number of motor starts in the mobile App
- Modbus TCP: The number of motor starts is accessible through the Clean Power VFD's Modbus TCP communication protocol. This allows integration with monitoring systems. Please refer to the latest Modbus TCP specifications on the Engineering Tools webpage
- BACnet IP: The number of motor starts is accessible through the Clean Power VFD's BACnet IP communication protocol. Please refer to the latest BACnet IP specifications on the Engineering Tools webpage

Resetting the Number of Motor Starts

The number of motor starts can be reset when necessary. This is typically done when you change the motor connected to the Clean Power VFD.

This action ensures that the number of motor starts of the newly installed motor is accurate.

Important: Please do not reset this number of motor starts unless the motor has indeed been replaced.

Access to the Motor metrics

On Mobile, go to Menu >> About >> Diagnostic >> System Metrics

On HMI, go to Menu >> About >> Diagnostic >> VFD Metrics

Previous Next

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11.2. Motor runtime

Monitoring Motor Operating Hours

The Clean Power VFD keeps the cumulative operating hours of the connected motor. You have access to this data through four different methods:

- HMI (Human Machine Interface): You can view the cumulative operating hours of the connected motor on the Clean Power VFD's HMI display.
- Mobile App: You can view the cumulative operating hours of the connected motor in the mobile App
- Modbus TCP: The cumulative operating hours of the connected motor are accessible through the Clean Power VFD's Modbus TCP communication protocol. This allows integration with monitoring systems. Please refer to the latest Modbus TCP specifications on the Engineering Tools webpage
- BACnet IP: The cumulative operating hours of the connected motor are accessible through the Clean Power VFD's BACnet IP communication protocol. Please refer to the latest BACnet IP specifications on the Engineering Tools webpage

Resetting the Cumulative Operating Hours of the Connected Motor

The cumulative operating hours of the connected motor can be reset, but only when necessary. This is typically done when you replace the motor connected to the Clean Power VFD.

This action ensures that the cumulative operating hours of the newly installed motor are accurate.

Important: Please do not reset these cumulative operating hours unless the motor has been replaced.

Access to the motor metrics

On Mobile go to Menu >> About >> Diagnostic >> System Metrics

On HMI go to Menu >> About >> Diagnostic >> VFD Metrics

Previous Next

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11.3. VFD runtime

Monitoring Clean Power VFD Operating Hours

The Clean Power VFD keeps its total operating hours.

Monitoring VFD Operating Hours

The Clean Power VFD keeps its cumulative number of operating hours. You have access to this data through four different methods:

- HMI (Human Machine Interface): You can view directly the cumulative VFD operating hours on the Clean Power VFD's HMI display.
- Mobile App: You can view the cumulative VFD operating hours in the mobile App
- Modbus TCP: The number of cumulative VFD operating hours is accessible through the Clean Power VFD's Modbus TCP communication protocol. This allows integration with monitoring systems. Please refer to the latest Modbus TCP specifications in the Engineering Tools webpage
- BACnet IP: The number of cumulative VFD operating hours is accessible through the Clean Power VFD's BACnet IP communication protocol. Please refer to the latest BACnet IP specifications in the Engineering Tools webpage

Important Note: This data represents the total operating hours of the Clean Power VFD itself, not the connected motor.

For information on monitoring the connected motor's operating hours, please refer to the section titled 'Motor runtime' in this user guide.

Access to the VFD metrics

On Mobile go to Menu >> About >> Diagnostic >> System Metrics

On HMI go to Menu >> About >> Diagnostic >> VFD Metrics

Previous Next

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11.4. Fans runtime

Monitoring Internal Cooling Fans Operating Hours in Clean Power VFD

The Clean Power VFD monitors the total operating hours of its internal cooling fans.

You can view this data and reset it under certain circumstances.

Monitoring Cooling Fan Operating Hours

The Clean Power VFD keeps the cumulative runtime of its internal fans. You have access to this data through four different methods:

- HMI (Human Machine Interface): You can directly view the cumulative operating hours of the cooling fans on the Clean Power VFD's HMI display.
- Mobile App: You can view the cumulative operating hours of the cooling fans in the mobile App
- Modbus TCP: The cumulative operating hours of the cooling fans are accessible through the Clean Power VFD's Modbus TCP communication protocol. This allows integration with monitoring systems. Please refer to the latest Modbus TCP specifications in the Engineering Tools webpage
- BACnet IP: The cumulative operating hours of the cooling fans are accessible through the Clean Power VFD's BACnet IP communication protocol. Please refer to the latest BACnet IP specifications in the Engineering Tools webpage

Resetting the cumulative operating hours of the cooling fans

The cumulative operating hours of the cooling fans can be reset, but only when necessary. This is typically done when you replace the internal cooling fans of the Clean Power VFD.

This action ensures that the cumulative operating hours of the newly installed cooling fans are accurate.

Important: Please do not reset these cumulative operating hours unless the cooling fans have been replaced.

On HMI go to Menu >> About >> Diagnostic >> VFD Cooling >> Fan Details

On mobile go to Menu >> About>> Diagnostic >> System Cooling Metrics

Previous Next

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12. Alarms and Protections

To protect your investment, the Clean Power VFD provides two categories of protection:

- protection from overheating damage to the motor, and

- protection against the Clean Power VFD malfunction.

In both cases, when protection is triggered the related alarm notifies the user, and the event is logged.

Previous Next

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12.1. If the Clean Power VFD is not configured

If the Clean Power VFD is not configured (no settings have been uploaded into the VFD), the alarms coming from the motor control are not reported.

But some alarms are independent of that state. e.g. if a service fails to start during boot, it will be reported right away instead of waiting for a configuration (which might never get accepted if it's the wrong service that failed).

The monitoring function during boot can generate the following alarms if they happen:

- Booted from backup software copy and restored factory settings.
- Booted from backup software,
- System degraded,
- Unknown boot state.

Previous Next

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12.2. How alarms are triggered

An alarm is raised when its monitored value crosses a threshold for a sufficiently long period.

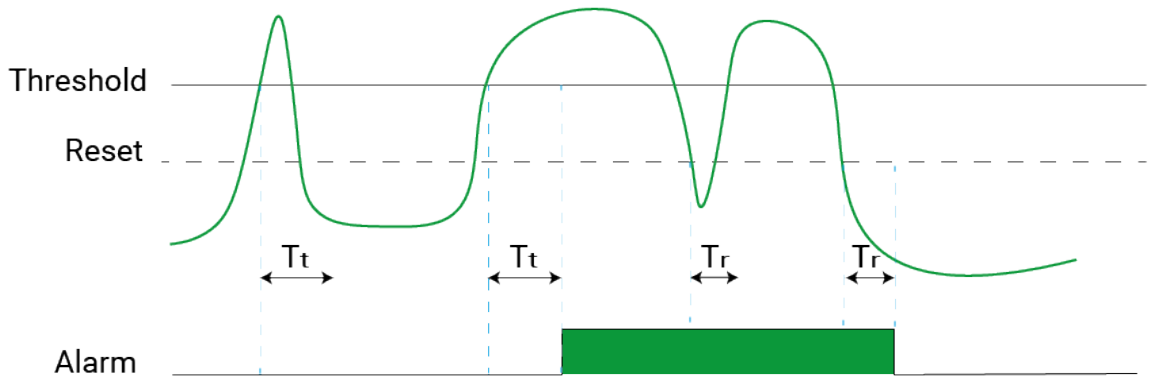
If the value exceeding the threshold lasts less than the trigger delay (Tt), then the alarm doesn't trigger.

The trigger delay acts as a filter for transient short-duration faults.

The alarm resets when the monitored value crosses the reset threshold for a sufficiently long period.

If the value lowering the reset lasts less than the reset delay (Tr), then the alarm doesn't reset.

The reset delay acts as a filter for transient, short-duration corrected signals.



Previous Next

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12.3. Alarms Severity

The Clean Power VFD manages its alarms on 4 levels of severity.

To catch the user's attention, the alarm displays different colors depending on the severity level.

Severity	Purpose	Default Action
Minor	A transitory fault with little impact on the drive and the process (such as a transient voltage drop).	The motor does not stop. The fault is reset automatically when the cause disappears and does not need any acknowledgment.
Medium	The application can generate a fault or a non-destructive electrical fault (such as a missing phase). These are faults that may disappear without the need for human intervention.	The motor stops when the fault occurs and lasts longer than the filter timer if one is configured. The user configures restart behavior during setup: - Automatic restart, or - Manual Restart with acknowledgment. **Automatic Re-Start:** The Clean Power VFD will attempt 4 times to detect whether the fault has been cleared, with each attempt separated by a time delay. If the fault is still present, the drive elevates the event to a critical failure. If not, the drive restarts. **Manual Re-Start with Acknowledge:** The drive will restart only with a reset (acknowledgment) of the fault. To use this mode, the user must have configured the way to trigger the acknowledgment. If the fault has been cleared, the drive goes into a ready-to-run state, and the motor can be re-started.

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		If the fault is still present, the drive goes to the standby position.
Major	This can be a fault from the drive or an external fault (such as a loss of a Torque Deactivation channel). The generated fault could be destructive and/or dangerous to human beings. This is an abnormal situation with imminent danger risk	Example: one Torque Deactivation channel is missing (mostly coming from a disconnected wire) The user must analyze and fix the issue. When fixed the VFD goes into the ready-to-run state, and the motor can be restarted.
Critical	This can be a fault from the drive or an external fault (such as a short circuit). The generated fault can be immediately destructive. This is a hazardous condition.	The fault cannot be reset automatically. The user must identify and fix the issue. The drive restarts if the fault is cleared, and after a full reset from the user (a power off / power on cycle is the default reset operation for a critical fault).

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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12.4. Alarms actions

When an alarm is raised, the Clean Power VFD changes the state of both the motor control and the relay outputs.

When a fault is cleared and its related alarm is removed, the Clean Power VFD will operate as described in the section on alarm severity.

Some actions are configurable by the user, while others are fixed and cannot be changed.

The 3 actions are

- Stop/Start the motor,
- Change motor speed,
- and Lockout.

The Clean Power VFD changes the state of its output relays in response to an alarm.

While creating the VFD's configuration, the user can choose which relay will receive the alarm and whether the relay will be energized or de-energized in response to an alarm.

By default, relay 1 is assigned to alarms and de-energizes in response to an alarm.

When the “de-energize on fault “ setting is selected, this output relay also de-energizes if the control board is not powered. This allows the Clean Power VFD to issue an alarm if the control board is not operating due to a power issue.

Stop/ start the motor.

The motor stops as soon as an alarm is raised.

The user may configure whether the stop is coasting or with a deceleration ramp. (The default setting is deceleration ramp.)

If the Clean Power VFD is not in a lockout state and the alarms have been cleared, the motor will restart after the delay-restart time has elapsed.

Delay-restart is configurable, and the default is set to 60s.

Change motor speed.

The user can choose to reduce motor speed to a user-defined speed setpoint when an alarm is triggered.

When the alarm disappears, the Clean Power VFD resumes normal operating speed.

Lockout

If a critical alarm occurs, the Clean Power VFD goes into a lockout state.

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The motor can only be restarted once the fault is cleared and the user performs a complete system reset.

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12.5. System reset

Before executing a system reset, please carefully read the safety messages about powering the Clean Power VFD.

Note: if there are active alarms of severity major or critical when you execute the reset, the VFD will go back into the lock-out state at the end of the reset action.

Before executing a reset, check and fix all faults that have generated alarms.

How to reset a locked-out Clean Power VFD?

There are three ways to reset a locked-out Clean Power VFD.

- by sending the reset command to the Clean Power VFD.

- by sending a reset command from a digital input assigned to this function.

- by executing a complete power cycle.

Reset by sending the reset command from the mobile App

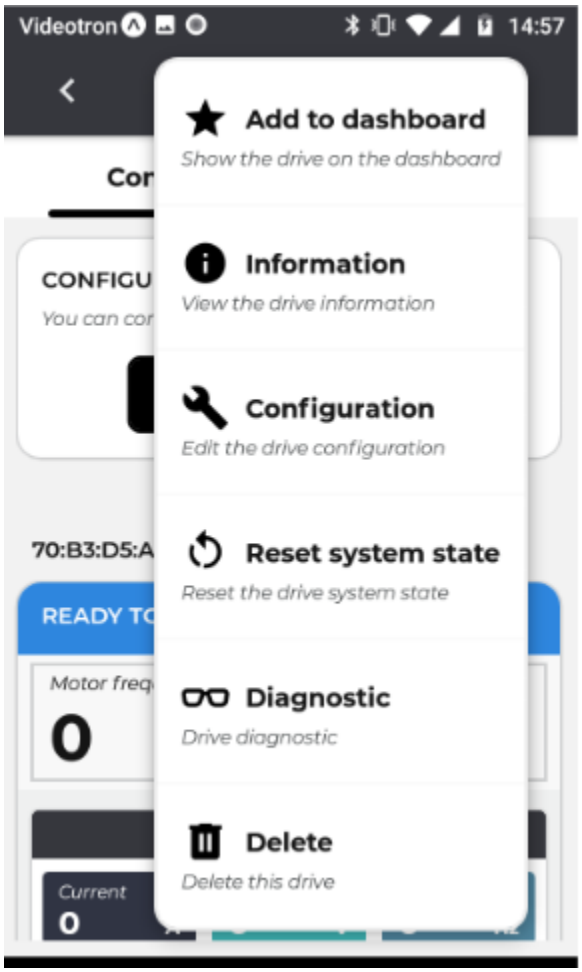
The reset can be executed through a paired smartphone:

From the connected Clean Power VFD dashboard screen, select Menu.

in the displayed action lists, select Reset system state.

Follow the instructions displayed on the screen.

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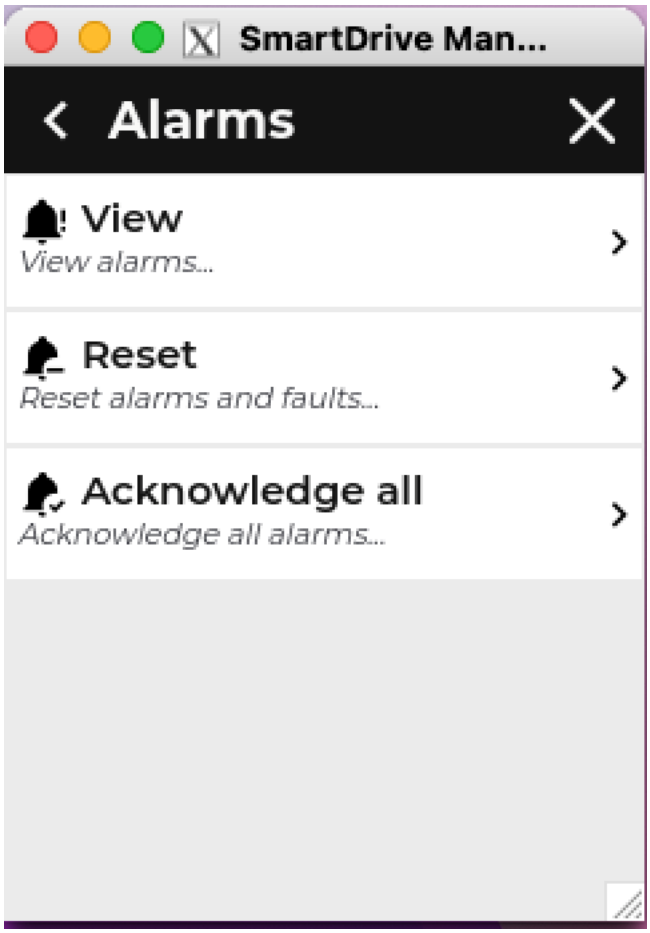


Reset by sending the reset command using the VFD's HMI.

From the alarms page, go into the menu.

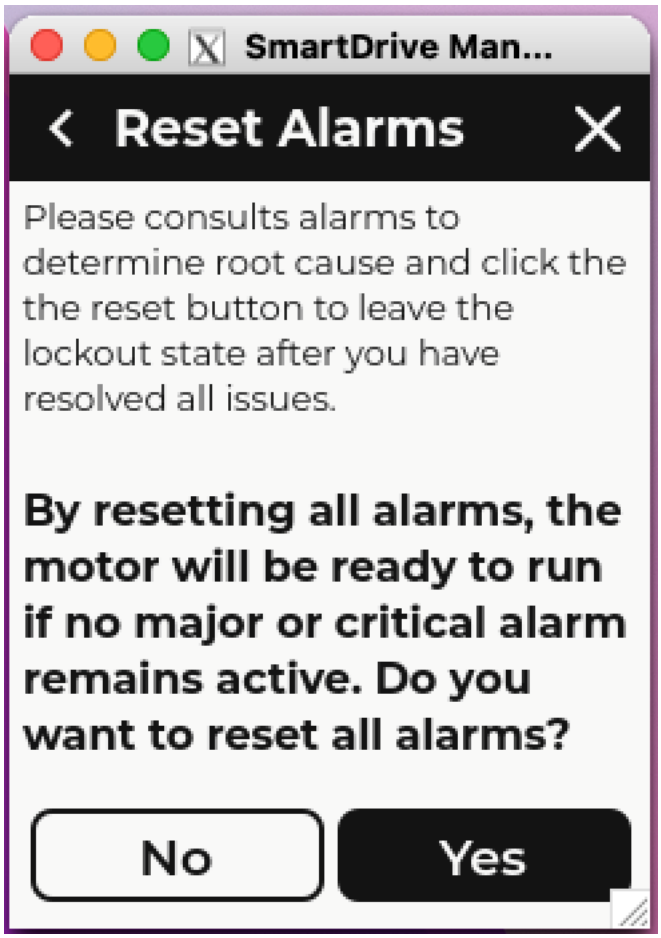
Then select reset.

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and confirm that you want to reset all the alarms.

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Reset by sending the reset command using the Modbus TCP register SYSR

The reset can be executed remotely by sending the system reset command from a connected Ethernet network, using the appropriate Modbus command.

A description of the Modbus system reset can be found in this document, section Networks, and communication>Modbus TCP

Reset by sending the reset command using a digital input

The reset can be executed remotely by sending the system reset command from digital input if the user has configured this digital input as the function " reset lockout".

Any available digital input can be assigned to reset the VFD from a lockout state.

The assignment is a configuration of the digital input.

Reset with a Power cycle.

To execute a reset system of your Clean Power VFD, you must do a complete off/on power cycle of the Clean Power VFD.

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If your Clean Power VFD is connected to an external 24VDC power supply, you must power off this power supply before powering off the main supply power to the Clean Power VFD.

Power off the main input AC power and wait for 5 minutes to ensure all capacitors are discharged.

Power on the main input AC power and the external 24VDC power supply if any. Your Clean Power VFD will reboot and then will go into ready-to-run status.

Previous Next

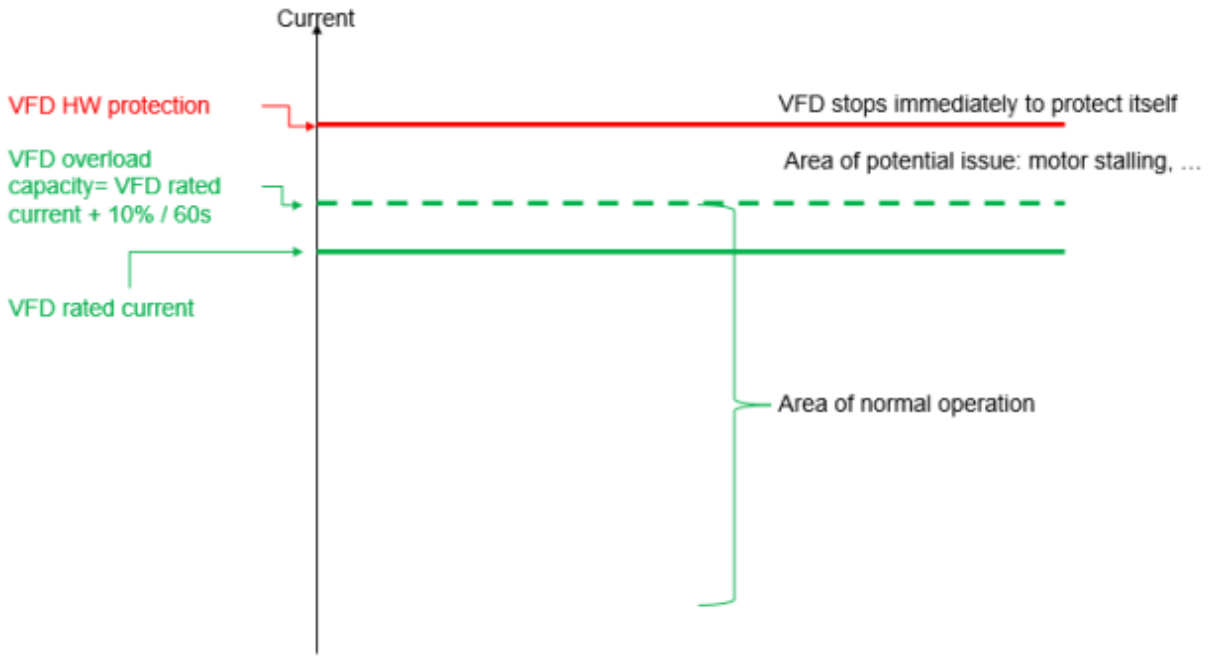
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12.6. Clean Power VFD protection against short-circuits

The Clean Power VFD integrates its own protection against short circuits.

This protection is set at manufacturing and can not be modified by the user.

If the output current exceeds this protection value, the Clean Power VFD stops immediately. (reaction time is about one micro-second)



Previous Next

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12.7. Protection of the 24 VDC supply

Introduction

The Clean Power VFD is designed with built-in safety measures to protect both the device and connected systems in case of an overcurrent detected on the 24VDC supply.

This functionality mitigates potential damage by immediately shutting down.

What Happens During an Overcurrent Event?

When the system detects an overcurrent on the 24VDC supply, the following actions are triggered:

1- System and I/O Shutdown:

All systems and input/output (I/O) components powered by the 24VDC supply are immediately shut down to prevent further damage.

2- Latched Shutdown:

The system latches this shutdown state, requiring user intervention to reset it after the root cause of the overcurrent is resolved.

3- Torque Off (STO) Activation:

The Torque Off functionality is engaged automatically, cutting power to the motor. An STO alarm will be raised to indicate the shutdown.

Troubleshooting and Fixing the Issue

To resolve the overcurrent issue and restore normal operation:

1- Identify the Cause of the Overcurrent

Common causes include:

- Short Circuits on I/Os
    - Inspect all connections to ensure there are no exposed copper wires or accidental contact between terminals.
- Improper Use of Tools

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- Be cautious when using voltage probes or multimeters to check the I/O terminals. Incorrect handling can lead to unintended shorts.

- Damaged Components
  - Examine the connected devices and cables for any signs of damage or wear that could lead to overcurrent conditions.

2- Fix the Identified Problem

- Repair or replace any faulty components, and ensure all connections are correctly installed and insulated.

3- Reset the VFD

After fixing the cause of the overcurrent:

- Turn off the VFD completely.
- Wait for a few seconds until the power red LED is OFF.
- Turn the VFD back on to reset the latched shutdown state.



- Always **disconnect power** before inspecting or working on the VFD or its connected systems to avoid electrical hazards.
- Use **appropriate tools and safety measures** when diagnosing I/O connections or any electrical components.
- If the issue persists after resetting the system, contact SmartD Technical Support for assistance.

By addressing the overcurrent condition promptly and following the outlined steps, you can ensure the continued safety and reliability of the Clean Power VFD and connected systems.

Previous Next

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13. List of alarms sorted by code with their severity level

Name	Code Number	Severity	Short description
STO	1	Critical	Safe Torque Off (STO) is an emergency stop triggered by the hardware using the STO1 or STO2 digital input.
STO LOSS	2	Critical	Defect in the STO1 or STO2 circuit. Contact customer support.
LINE PHASE INVERSION	3	Medium	The grid has been incorrectly wired to the drive. Please swap two phases. • Prior to 2025.13.01 - Always triggered • From 2025.13.01 - Triggered in case of an input power source change with phase inversion. Example: switching from a utility power source to a generator with phase inversion.
DC UNDERVOLTAGE	4	Major	The DC bus voltage is too low to maintain operation.
DC OVERVOLTAGE	5	Major	The DC bus voltage is dangerously high.
LINE VOLTAGE SAG	6	Minor	Line voltage is low.
LINE VOLTAGE BALANCE	7	Minor	Line voltage unbalance between phases.
HMI COMM LOSS	9	Critical	There is a communication problem between the control board and the HMI. From firmware version 2026.08.01, that this alarm can be set by user to Minor to keep normal operation and allow the VFD to operate without HMI. Prior firmware version: the severity is Minor.
LINE OVERCURRENT	11	Major	Hardware protection for grid-side overcurrent.
MOTOR CURRENT BALANCE	12	Major	Motor current unbalance between phases.
MOTOR OVERCURRENT	13	Major	Sustained current on the load. Compared to MOTOR OVERLOAD, MOTOR OVERCURRENT is of higher intensity for a shorter period.

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MOTOR OVERTEMP	14	Critical	Overtemperature detected on the motor.
MOTOR OVERLOAD	15	Major	Sustained current on the load, which is above the motor's nominal current. Compared to MOTOR OVERCURRENT, MOTOR OVERLOAD is of lower intensity for a longer period.
DRIVE OVERTEMP	16	Critical	Hardware protection for overtemperature.
UNKNOWN BOOT STATE	17	Major	Something went wrong during boot; a reboot is required. This alarm gets resolved after a reboot.
BOOTED BACKUP SOFTWARE	18	Minor	Booted on the backup version, which is compatible with the current config. This alarm gets resolved after a reboot.
BOOTED BACKUP SOFTWARE WITH FACTORY DEFAULT CONFIG	19	Critical	Booted on the backup version, which is incompatible with the current config. Causes a factory reset. This alarm gets resolved after a reboot.
DRIVE HIGH TEMPERATURE	20	Major	The temperature of the power electronics is too high.
LINE VOLTAGE SWELL	21	Minor	Line voltage is high.
SOFTWARE UPDATE FAILED	22	Minor	Software upgrade failed. When triggered, the alarm is immediately resolved.
DC SINGLE PHASED	23	Major	[ONLY SDB-1-2185] Voltage ripple on the DC bus, AND that the line voltage is unbalanced (ex: phase loss).
COOLING FAN1 FAULT	24	Minor	Cooling fan #1 is not operating as expected.
COOLING FAN2 FAULT	25	Minor	Cooling fan #2 is not operating as expected.
COOLING FAN3 FAULT	26	Minor	Cooling fan #3 is not operating as expected.
COOLING FAN4 FAULT	27	Minor	Cooling fan #4 is not operating as expected.
COOLING FAN CAPACITY FAULT	28	Major	Not enough fans are operating.
LINE UNEXPECTED VOLTAGE	29	Medium	Line voltage measured from the grid does not match the voltage from the user’s line config.
LOW LEVEL COMM ERRORS	30	Critical	Severe internal communication errors between drive components. Contact customer support.

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DC UNBALANCED	31	Major	DC bus voltage is unbalanced about its neutral point (DC+ vs DC-).
DRIVE OUTPUT OVERCURRENT	32	Critical	Hardware protection for load-side overcurrent.
SIMULTANEOUS FORWARD AND REVERSE COMMAND	33	Medium	Reverse and forward I/O commands are detected simultaneously.
SYSTEM BOOT TIME EXCEEDED	34	Major	The system took too long to boot.
SYSTEM DEGRADED	35	Major	The system is degraded.
ABNORMAL CPU USAGE	36	Minor	CPU usage is too high.
ABNORMAL MEMORY USAGE	37	Minor	Memory usage is too high.
DC OVERVOLTAGE STALL PREVENTION	38	Minor	The drive is actively limiting deceleration because the DC bus voltage is too high.
MOTOR OVERCURRENT STALL PREVENTION	39	Minor	The drive is actively limiting acceleration because the motor current is too high.
LINE UNEXPECTED FREQUENCY	40	Medium	The line frequency measured from the grid does not match the frequency specified in the user's line configuration.
DC UNEXPECTED VOLTAGE	41	Medium	The DC bus voltage is not high enough compared to the measured grid voltage. It is not safe to enable the bypass relay.
AFE FAULT	42	Critical	The active Front-End cannot operate due to an important fault.
AFE LOW VOLTAGE RIDE THROUGH	43	Minor	Active Front-End detected line voltage sag or line voltage unbalance. Motor control is being adapted to keep the drive operating.
REMOTE TO LOCAL OVERRIDE	44	Critical	User intentionally forced the drive to local mode while the remote control selector was configured to IO / MODBUS / other than local
ANALOG OUTPUT SENSOR LOSS	45	Medium	An analog output sensor is defective.

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PID 1 LOW PROCESS VALUE	46	Medium	Process feedback value of PID #1 is too low.
PID 1 HIGH PROCESS VALUE	47	Medium	Process feedback value of PID #1 is too high.
CONTROL BOARD POWER LOSS	48	Minor	The control board power supply has been lost.
MOTOR CONTROL INSTABILITY	49	Major	Unstable motor control conditions were detected, and the drive must immediately stop operating to protect itself.
MOTOR OVERSPEED	50	Medium	The motor is spinning too fast.
MOTOR UNDERSPEED	51	Medium	The motor is spinning too slowly.
MOTOR WRONG DIRECTION	52	Medium	The motor is turning in the wrong direction.
ENCODER SPEED ERROR	53	Medium	The encoder is not measuring the speed of the motor correctly.
ENCODER COMMUNICATION FAILURE	54	Medium	The encoder is not wired properly or is defective.
ANALOG INPUT 1 SENSOR LOSS	55	Medium	Analog input 1 sensor is defective.
ANALOG INPUT 2 SENSOR LOSS	56	Medium	Analog input 2 sensor is defective.
ANALOG INPUT 3 SENSOR LOSS	57	Medium	Analog input 3 sensor is defective.
MODBUS COMM LOSS	58	Medium	Modbus TCP communication has been interrupted.
HIGH AMBIENT TEMPERATURE	59	Medium	The ambient Temperature is too high
MOTOR TEMP SENSOR SHORTED	60	Medium	Motor Temperature Sensor is Shorted
MOTOR PHASE LOSS	61	Major	No current reading on one of the motor phases.
MOTOR STALLED	62	Major	Motor shaft is stalled (applies only when using a velocity setpoint).

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MOTOR DISCONNECTED	63	Major	No current readings on all motor phases (open-circuit between VFD and motor).
MOTOR APPLICATION UNDERLOAD	64	Medium	Motor underload is defined by the user's application.
MOTOR AUTO RESTART FAILURE	65	Critical	Motor Auto restart failure.
AFE LOW VOLTAGE RIDE THROUGH CANNOT RECOVER	66	Major	Active Front-End detected line voltage sag or line voltage unbalance, and the drive was unable to recover.
DRIVE OVERLOAD	67	Major	Sustained current on the load that is above the drive's capability.
PIN INVALID	68	Minor	User entered an invalid PIN
DAMPER FEEDBACK LOSS	69	Critical	Triggered when using the Digital Input function, if the input signal is lost while the motor is running
EXTERNAL START FEEDBACK TIMEOUT	70	Critical	The maximum delay for the external feedback to be received while energized and waiting to drive the motor.
EXTERNAL POST STOP FEEDBACK TIMEOUT	71	Medium	The maximum allowed delay for the external feedback to be removed.
MOTOR GROUND FAULT	72	Critical	Motor ground fault.
EMERGENCY MODE FORBIDDEN	73	Major	Emergency mode forbidden (e.g., VFD in lockout or in maintenance mode).
EXTERNAL 1	74	Critical	External alarm 1
EXTERNAL 2	75	Major	External alarm 2
EXTERNAL 3	76	Medium	External alarm 3
EXTERNAL 4	77	Minor	External alarm 4
MOTOR THERMAL OVERLOAD	78	Medium	Motor is too hot to be kept operating
INTERNAL MCU COMM LOSS	79	Critical	The watchdog of the motor-control MCU has triggered

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BACnet IP COMM LOSS	80	Medium	BACnet IP communication has been interrupted.

Previous Next

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14. List and Details of alarms and protections

The details of alarms and protections are organized in ascending order of their code number

Previous Next

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14.1. DC undervoltage (Code: 4)

A DC Undervoltage fault occurs when the DC bus voltage drops below the required level for normal operation. This can lead to system instability or shutdown.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.2. DC Overvoltage (Code: 5)

The DC bus voltage is way above the line-nominal-voltage side, and the DC overvoltage stall prevention function did not succeed in limiting the rise of the DC bus voltage.

The overvoltage value is checked on both +DC and -DC.

The threshold value is not settable by the user.

The motor and its load most likely cause this alarm.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.3. Line voltage sag (Code: 6)

A temporary drop in input voltage that may disrupt VFD operation or cause faults like undervoltage or AFE ride-through failure.

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14.4. Line voltage balance (Code: 7)

One or more phases of the incoming supply voltage deviate significantly from the average of the line input voltage.

When the Clean Power VFD sees a sustained line imbalance:

- System-wide, you may see ripples, alarms, and unresponsive regen.
- Upstream, power quality may degrade, and the installation may violate THDi or voltage symmetry requirements (IEC 61000-3-12, IEEE 519).

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14.5. HMI communication loss (Code: 9)

Communication problem between the control board and the HMI.

From firmware version 2026.08.01, that this alarm can be set by user to Minor to keep normal operation and allow the VFD to operate without HMI.
Prior firmware version: the severity is Minor

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14.6. Line Overcurrent (Code: 11)

The VFD continuously monitors the input current. If this current exceeds safe limits for a predefined duration, the drive will trip to protect internal power components such as the input rectifier and DC bus capacitors.

This fault indicates that the VFD has detected an excessive current on its input terminals. It is a hardware-level protection designed to prevent damage to internal components and upstream power systems.

Possible Causes:

- Ground fault or short circuit on the input wiring.
- Sudden grid voltage variations due to unstable power supply or switching events.
- Connection to a high-impedance or weak grid that cannot sustain regenerative or fluctuating loads.

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14.7. Motor currents unbalanced (Code: 12)

The Unbalanced Current Deviation Alarm is a major feature designed to protect the motor from potential damage due to overheating.

This alarm is triggered when the current on any phase deviates above a certain threshold from the maximum mean of the three phases' nominal value.

Alarm Trigger Condition:

The alarm is triggered when the current on any phase deviates more than 10% of the nominal current from the mean of the three phases.

This condition indicates that the motor is starting to overheat, which can potentially damage the motor's insulation.

Alarm Actions:

Upon triggering the alarm, the motor stops in freewheeling mode.

Troubleshooting:

The user is required to physically verify the motor connection, inspect the motor's winding, and check the motor for mechanical issues such as bearing wear, rotor misalignment, or physical damage.

Troubleshooting details are explained in the section Alarms and troubleshooting suggestions

Once the alarm rises, the motor is put in freewheeling because it's an alarm of severity Major.

The current readings go to zero, and the alarm is automatically reset. The motor can be restarted

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.8. Motor overheating protection (code: 14)

Introduction:

Overtemperature poses a significant risk to electric motors.
If not adequately monitored and addressed, it can lead to catastrophic consequences, including the destruction of motor insulation and even motor failure.
To mitigate this risk, many motors incorporate thermal sensors within their windings.

PTC sensors stand out among the various sensors used for this purpose.

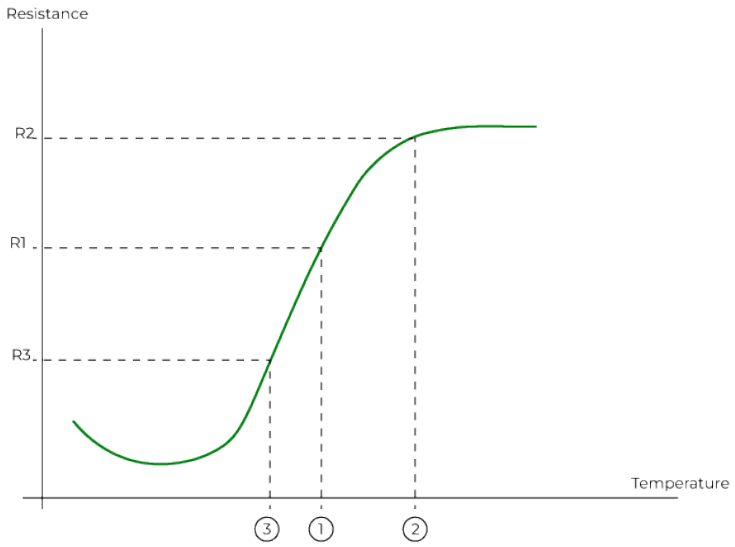
What Are PTC Sensors?

- PTC sensors are Positive Temperature Coefficient devices.
- Their resistance increases significantly with rising temperature.
- When embedded in motor windings, they act as reliable temperature monitors.

How PTC Sensors Work:

- At normal operating temperatures, PTC sensors exhibit low resistance. (3)
- However, as the motor temperature rises due to increased load or other factors, the resistance of the PTC sensor starts climbing.
- Once the temperature surpasses a critical threshold, the PTC sensor’s resistance sharply spikes (1)
- Exceeding its maximum resistance (2) allows to detect if a PTC is disconnected
- A resistance lower than its minimal resistance allows to detect a short-circuited PTC

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The Clean Power VFD can be connected to the PTC sensors of the motor to achieve thermal protection, using one of its analog inputs.

Implement motor thermal protection (Motor Overtemperature alarm)

When the user wants to enable the motor thermal protection using a windings-embedded thermal sensor, the first action he'll have to do is to configure an input to be wired and configured.

The choice can be made between

- Analog input 1
- Analog input 2
- Analog input 3

If an analog input has been configured as a PTC temperature sensor, then the thermal protection function of the motor is enabled by default.

This thermal protection function of the motor can be enabled/disabled by the user.

The user can set a time delay to prevent unwanted motor overtemperature alarms, acting as a filter. This delay is settable between 0.0 and 10.0 s, its default value is 0.2 s.

Memory

A memory behavior can be set as enabled or disabled by the user during the VFD settings phase (but cannot be changed when the VFD is in operation).

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Default value: Enabled.

- When the **Motor_overtemperature_memory is enabled**, if the VFD is powered off and on after an overtemperature alarm, and before the sensor resistance crosses down the reset threshold, then the VFD remains in alarm status and can not restart the motor.
  When the resistance value crosses the reset threshold, then the alarm can be reset.
- When the **Motor_overtemperature_memory is disabled**, if the VFD is powered off and on after an overtemperature alarm, then the VFD returns to a ready status if the sensor resistance is lower than the overtemperature trigger point.
  Without a power cycle, the VFD returns to a ready status when the sensor resistance decreases to a lower value than the reset threshold of the sensor curve.

These settings are accessible during the VFD settings, not during the VFD operation.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

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14.8.1. PTC sensor health (PTC short circuited) (Code: 60)

If the whole PTC chain is short-circuited, the resistance is null and an alarm is raised: "**Temperature sensor short-circuited**"

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14.9. Application overload prevention (Code: 15)

The Clean Power VFD monitors the motor current to detect an application overload.

If the current drawn by the motor exceeds the threshold value, which lasts longer than the inhibition delay, then the fault is triggered.

When a fault is triggered, the action can be selected between:

- Ramp down to stop
- coast to stop (default setting)

The value of the overload threshold can be set by the user between 100% and 150% of the motor FLA (Full Load Amp), its default value is 110%.

A settable inhibition delay prevents false fault triggering. This delay can be set by the user from 1s to 600s, its default value is 60 s.

Fault reset and motor restart:

When the current drawn by the motor falls below the overload threshold value, a fault reset time is started.

When this timer has elapsed, the motor can be restarted.

The value of the overload fault reset threshold can be set by the user between 70 % and 150% of the motor FLA (Full Load Amp), its default value is 70%.

Fault reset time is settable between 0 to 600 s, its default value is 60s

Recommended settings:

For normal duty light loads, set the threshold between 110% and 120% of motor FLA with a 60s delay.

For heavy-duty loads: set the threshold between 140% and 150% of motor FLA with a 60s delay.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.10. VFD internal over temperature (Code: 16)

The temperature inside the Clean Power VFD is monitored through internal sensors.

When the Clean Power VFD internal temperature rises above a certain level, the overheat critical alarm is activated.

Then the output is deactivated due to the activation of overheat protection, and the VFD goes into a locked-out state.

Check the troubleshooting suggestions

Once the issue is fixed, the user MUST reset the Clean Power VFD.

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14.11. Unknown boot state (Code: 17)

This alarm arises if something goes wrong during boot.

This alarm gets resolved after a reboot.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.12. Booted from backup software (Code: 18)

Booted on the backup version, which is compatible with the current configuration of the VFD.

This alarm gets resolved after a reboot.

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14.13. Booted from backup software copy and restored factory settings (Code: 19)

The VFD fails to boot with the active version; it boots from the backup version, but the active configuration is incompatible, so it uses the factory default configuration. This alarm gets resolved after a reboot.

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14.14. VFD high temperature (Code: 20)

The temperature inside the Clean Power VFD is monitored through internal sensors.

When the Clean Power VFD internal temperature rises above 75 °C for more than 5s, the high temperature alarm is activated, and the VFD applies the strategy defined for medium alarm.

This alarm allows for the protection of the Clean Power VFD before the internal temperature increases to a level that could be destructive.

The VFD will also raise a minor alarm if it detects that one of the cooling fans is defective.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.15. Line voltage swell (Code: 21)

Description: One or more line voltages momentarily rise significantly above nominal for a brief period, often caused by capacitor bank switching, large motor shutdown, or utility faults.

Possible consequences:

- DC bus overvoltage
- Component overstress (e.g., AFE switches, capacitors)
- Trip on “Overvoltage Fault” or “AFE Input Fault”
- Increased EMI and possible insulation breakdown

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14.16. Software update failed (Code: 22)

The software or firmware upgrade process was unsuccessful, which could lead to system instability, outdated features, or malfunctioning of control functions.

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14.17. Cooling fan (1-4) fault (Code: 24 to 27)

At least one cooling fan (1-4) is defective.

Possible causes :

1. Blocked or dirty fan. Ensure no debris or obstruction is in the fan mechanism.

2. Fan motor failure or mechanical.

3. Fan electrical connection issue.

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14.18. Cooling fan capacity fault (Code: 28)

The VFD has detected that the cooling fan is either not working properly or is providing inadequate airflow, which may lead to overheating of internal components.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.19. Line unexpected voltage (code: 29)

This could happen when the line configuration does not match the actual line values.

The alarm may happen when the motor is not running.

It informs the user that it is unsafe to start the motor.

This alarm triggers as soon as the measured line RMS voltage is not within 15% of what is user-defined in the configuration

To resolve this alarm, the user may have to push a new line configuration or check the grid.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.20. Internal error (Code: 30)

The firmware or the FPGA watchdog raises this alarm to indicate an issue with the Interrupt Service Routine (ISR).

The ISR is a process invoked by an interrupt request from some hardware sub-system of the VFD.

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14.21. DC unbalanced (Code: 31)

This alarm indicates the DC bus voltage on one side of the drive's floating neutral point is too high compared to the other.

This fault may be caused by:

- Motor control is unstable, for example, at low speeds. Try decreasing start/stop ramp durations, and try decreasing torque boost percentage.
- DC bus voltage is not measured correctly.
- A hardware issue.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.22. Drive output overcurrent (Code: 32)

Acceleration overcurrent prevention

To prevent the Clean Power VFD from going into an overcurrent alarm during acceleration, at the starting phase, or the speed change phase, the acceleration is automatically paused if the output current reaches a trigger threshold.

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14.23. Simultaneous forward and reverse command (Code: 33)

The VFD has been configured to generate an alarm when receiving both forward and reverse run signals simultaneously via digital inputs.

The alarm is generated because a user activated forward and reverse run signals simultaneously.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.24. System boot time exceeded (Code: 34)

The system remained booting for too long.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.25. System degraded (Code: 35)

One or more services repeatedly failed during booting.

The VFD is functioning with reduced performance or limited functionality due to internal hardware, configuration, or communication issues.

It may still operate, but with impaired control or monitoring features

The Clean Power VFD must be powered off and then powered on to reboot.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

If the issue happens again, call the technical support of SmartD.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.26. Abnormal CPU usage (Code: 36)

This alarm is raised when the CPU usage is abnormally high (> 300%)

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14.27. Abnormal memory usage (Code: 37)

The internal memory usage of the VFD is unusually high or behaves erratically, which may lead to control instability, configuration loss, or VFD resets.

This alarm is triggered when the used memory reaches about 25 MB.

Monit will attempt a cleanup by removing everything in /var/data/iot-update-service/packages.

Monit is a utility for managing and monitoring processes, programs, files, directories, and filesystems on the clean power VFD Unix system.

Monit conducts automatic maintenance and repair and can execute meaningful causal actions in error situations.

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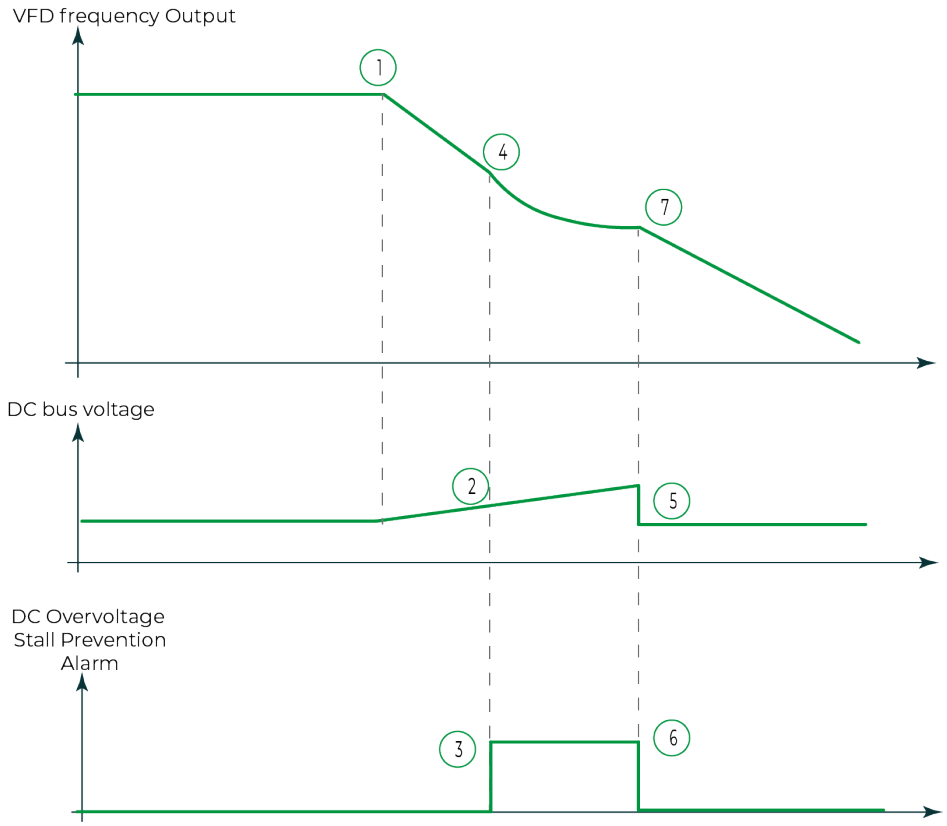
14.28. DC OverVoltage stall prevention (Code: 38)

When the motor is decelerating and the voltage on the DC bus is too high, the "DC Overvoltage stall prevention" alarm is raised and an automatic action is executed to prevent the VFD from going into a DC overvoltage alarm.

This alarm is automatically reset when the voltage of the DC bus falls back to normal value

Automatic limitation of deceleration:

The rate of deceleration is limited when the DC bus voltage is 10% greater than the expected value reading.



1- The VFD frequency output decreases to make the motor decelerate.

2- In the deceleration phase, the motor acts as a generator. The regenerated voltage increases the DC bus voltage.

3- If the DC bus voltage reaches a value higher than normal the "DC Overvoltage Stall prevention" alarm raises.

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4- At the same time, the Clean Power VFD automatically limits the rate of deceleration to prevent going into a DC overvoltage alarm.

5- The DC bus voltage value falls back to a normal value.

6- The alarm is automatically reset

7- The preset deceleration resumes

Note that this function increases the ramp-down duration to avoid falling into alarm conditions and lock the variable frequency drive. It is recommended to modify the ramp-down duration setting to avoid this condition.

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14.29. Motor overcurrent stall prevention (Code: 39)

In the acceleration phase or the constant speed phase:

The VFD detects that the motor current is approaching or exceeding the overcurrent threshold during acceleration, deceleration, or constant speed, and it engages a protective function to reduce torque or slow acceleration to prevent a trip

When the motor current exceeds 150% (of the inverter's permissible load amount), the output frequency is reduced to prevent an overcurrent trip from occurring.

During constant speed operation, the inverter returns the output frequency to the original value when the motor current becomes smaller than 150%.

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14.30. Line unexpected frequency (Code: 40)

This could happen when the line configuration does not match the actual line values.

The alarm may happen when the motor is not running.

It prevents enabling the internal bypass relay during the startup sequence and informs the user that it is unsafe to start the motor.

This alarm triggers as soon as the measured line frequency is not within 10% of what is user-defined in the configuration.

To resolve this alarm, the user may have to push a new line configuration or check the grid.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.31. DC unexpected voltage (Code: 41`)

This could happen when the line configuration does not match the line values.

The alarm may happen when the motor is not running.

It prevents enabling the internal bypass relay during the startup sequence and informs the user that it is unsafe to start the motor.

This alarm is triggered when the DC bus voltage is too low compared to the input line voltage.

To resolve this alarm, the user may have to push a new line configuration or check the grid.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.32. AFE fault (Code: 42)

The Active Front-End (AFE) is unable to operate due to a critical fault.

Possible causes include:

- Excessive line impedance causing AFE instability
- AFE hardware malfunction

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14.33. AFE low voltage ride-through (Code: 43)

Active Front-End detected line voltage sag or line voltage unbalance. Motor control is being adapted to keep the drive operating.

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14.34. Remote to local override (Code: 44)

This alarm triggers when a user forces the VFD to go back to local mode while the VFD is remotely controlled.

If the remote control is active and the remote control source selector is set to a remote source, the alarm gets triggered if a user forces the drive to go back to local mode.

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14.35. Analog output sensor loss (Code: 45)

The VFD detects a failure or disconnection in the analog output signal path to a connected actuator.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.36. PID process value alarms (Code: 46 and 47)

Depending on the application, users may need to set alarms on the feedback loop. These alarms help maintain control over the process and detect sensor issues.

PID Low Process Value (PV) Alarm (Code: 46)

This is the minimum threshold for monitoring the process value.

Users can define it within the range of minimum and maximum input values (in user-defined engineering units).

The alarm can be enabled or disabled. By default, it is disabled.

The default threshold is the minimum input value.

When the Low PV alarm is triggered, the Variable Frequency Drive reacts based on the user's preset. Options include:

- Stopping the motor (coasting)
- Maintaining the current output speed: The VFD keeps the motor at the speed setpoint, which the PID controller set before the alarm.
- Forcing the output to a fixed user-preset value (refer to the Maintenance section for "forced output value")

The alarm reset threshold is 5% above the minimum process value alarm.
Upon alarm reset, if the previous action was to stop the motor, the VFD returns to "ready to run" and awaits the run command. Otherwise, the VFD continues with PID control.

PID High Process Value (PV) Alarm (Code: 47)

This is the maximum threshold for monitoring the process value.

Users can define it within the range of minimum and maximum input values (in user-defined engineering units).

The alarm can be enabled or disabled. By default, it is disabled.

The default threshold is the maximum input value.

When the High PV alarm is active, the VFD reacts according to the user's preset. The options are similar to those for the Low PV alarm.

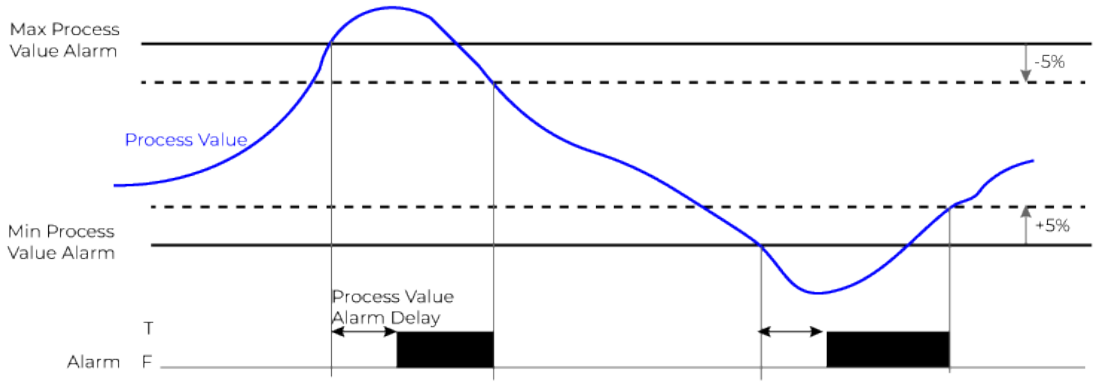
The alarm reset threshold is 5% below the maximum process value alarm. Upon alarm reset, the VFD's behavior depends on the previous action, similar to the Low PV alarm.

Delay

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The corresponding alarm is triggered if the process value crosses an alarm threshold and stays there longer than the preset delay.

Users can set the Process Value Alarm Delay from 0 to 600 seconds. The default value is 10 seconds.



Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.37. Control board power loss (Code: 48)

The control board power supply has been lost.

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14.38. Motor control instability (Code: 49)

The Clean Power VFD has detected conditions that could lead to motor control instability and has stopped operating to prevent any damage.

Here are the possible issues:

- The voltage command for U/V/W is changing too quickly.

- The Flux, I_d, and I_q controllers in the Indirect Field Oriented Control (iFOC) are not stable.

To fix these issues, please check the following settings:

- Make sure the motor's nameplate information is correct.

- Review the autotuning parameters.

- Check other advanced iFOC parameters.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.39. Motor over speed and under speed (Code: 50 and 51)

The motor’s speed is monitored by the VFD.

Regardless of whether an encoder is used, the speed is always estimated by the algorithm. However, when an encoder is correctly wired and configured, the estimated speed is more accurate.

Monitoring the speed allows for triggering a speed alarm in case of overspeed or underspeed conditions.

Overspeed (Code: 50) :

Trigger:

When the motor speed is higher than the Overspeed set value, for a longer time than the Overspeed detection delay time, the VFD raises the Overspeed alarm.

The value of Overspeed can be set as a percentage of the user-configured motor's max. frequency (Hz).

It can be set by the user from 100 to 150%.

The default value is 115%.

Reset:

The alarm is reset when the motor speed exceeds the user-defined reset threshold for a duration longer than the reset delay.

The reset threshold can be set by the user from 0 to 100%.

The default value is 100%

Note: the reset threshold must be smaller than the trigger threshold

Overspeed detection and reset delays:

The Overspeed detection and reset delays are the time durations for the speed value exceeding the Overspeed threshold, respectively the reset threshold, to trigger, reset, the Overspeed alarm.

They can be independently set by the user from 0 to 10 seconds.

Their default value is 2 seconds.

Underspeed (Code: 51):

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Trigger:

When the motor speed is lower than the Underspeed set value, for a longer time than the Underspeed detection delay time, the VFD raises the Underspeed alarm.

The value of underspeed is a percentage of the user-configured motor's min. frequency (Hz).

It can be set by the user from 0 to 100%.

The default value is 100%.

Underspeed detection delay:

The Underspeed detection delay is the length of time for the speed value to lower the Underspeed threshold to trigger the Underspeed alarm.

It can be set by the user from 0 to 10 seconds.

The default value is 2 seconds.

Action when the alarm arises

When one of the above alarms arises (overspeed, underspeed, wrong direction), the VFD stops the motor in a freewheeling mode (it de-energizes its output).

The event is logged.

To restart the motor,

- The fault must be cleared,
- And the alarm must be acknowledged
- and the VFD must receive the command "Run"

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.40. Motor wrong direction (Code: 52)

Wong direction rotation (only with an encoder):

If the detected motor rotation is opposite to the actual rotation direction (command + active output) for a longer time than the reverse rotation detection delay, the reverse rotation alarm raises.

To avoid some false alarms during any transient period of the system (for example, the actual command is Reverse and the motor is still spinning in the Forward direction, decelerating to coast from the previous command), the reverse rotation alarm must check consistency between the actual command and the actual signal generated on the output.

Wrong direction rotation detection delay:

The reverse rotation detection delay is the length of time for the reverse rotation detection to trigger the reverse rotation alarm.

It can be set by the user from 0 to 300 seconds.

The default value is 0 seconds.

Action when the alarm arises

when the alarm arises, the VFD stops the motor in a freewheeling mode (it de-energizes its output).

The event is logged.

To restart the motor,

- The fault must be cleared,
- And the alarm must be acknowledged
- and the VFD must receive the command "Run"

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.41. Encoder speed error (Code: 53)

Encoder speed error

Previous Next

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14.42. Encoder communication failure (Code: 54)

Encoder communication failure

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14.43. Analog input loss (Code: 55, 56, and 57)

This alarm applies to each of the 3 analog inputs that are configured.

Trigger condition:

This alarm arises if the analog input is configured for a 4..20 mA input signal and the current value falls under 3 mA for a duration longer than the triggering time delay

Reset condition:

The alarm resets when the signal returns to a value equal to or greater than 4mA for a duration longer than the user-defined reset delay.

Delay on triggering:

The time delay for alarm triggering is settable from 0.00s to 10.00s / default value = 0.15s

Delay on reset:

The time delay for alarm reset is settable from 0.00s to 10.00s / default value = 0.05s

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.44. Modbus comm loss (Code: 58)

This alarm warns the user if Modbus communication has been interrupted for some time.

Once communication is restored, the alarm is resolved.

Configuration:

The configuration of this alarm is accessible in the advanced parameters:

- Click on the 3 dots to open the mobile App menu and select configuration, then advanced configuration.
- Scroll down to the end of the displayed list until you see the chapter control. If not yet opened, open it.
- Then click on the pencil icon to edit the Modbus comm. loss alarm.

Then activate the alarm function:

- Enable the Alarm: Activate the "MODBUS Comm Loss" alarm, which also activates the register ALM4, bit 10.
- Ensure your PLC client application reads the "Heartbeat Register (16#FF03)" at least every 2.5 seconds. This register is incremented by the VFD approximately every 1 second.
- Adjust Timeout Settings: The default timeout is 5 seconds, indicating the VFD will trigger an alarm if it does not receive a read command within this period. You can customize this timeout via the mobile application.

This setup helps monitor communication and promptly alerts you to any loss of connection.

VFD behavior:

When the alarm arises, the VFD stops the motor according to the user-defined stop action for the alarm.

It can either stop in ramp-down (default setting) or coasting (freewheeling).

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.45. VFD high ambient temperature (Code: 59)

The Clean Power VFD generates an alarm when it detects that the Clean Power VFD's ambient temperature exceeds the acceptable temperature.

This alarm is raised if the internal temperature of the Clean Power VFD is higher than 75 degrees Celsius for more than 5 seconds.

When this alarm is raised, the VFD goes into a fault state and stops the motor following the user-defined ramp-down.

The alarm is reset when the VFD cools down, and its internal temperature is lower than 65 degrees Celsius for more than 5 seconds.

The VFD can then receive a command RUN.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.46. Motor phase loss (Code: 61)

If an accidental disconnection of one phase between the drive and the motor happens, then the motor is single-phasing.

The current in the remaining connected windings increases, the motor's internal temperature increases, and the motor may even stall due to a lack of torque.

The Clean Power VFD is permanently monitoring the motor current in each phase.

As soon as the loss of phase fault is detected, the Clean Power VFD stops the motor in freewheeling mode, stopping to delivery of energy to the motor.

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.47. Motor stalled (Code: 62)

Motor Stall Alarm:

The motor stall alarm is an important safety feature that protects your motor and ensures efficient operation.

What it Does:

The alarm activates when the motor fails to reach or maintain the speed commanded by the VFD. This prevents the motor from running at incorrect speeds, which can cause increased wear and tear, or even lead to breakdowns.

How it Works:

In the most extreme case, the motor might completely stop even with proper voltage. This happens when the load on the motor demands more torque (turning force) than the motor can provide (breakdown torque). This overload condition causes the motor to draw maximum current and stall.

What to Do When the Alarm Activates:

The motor stall alarm will stop the VFD in freewheeling mode (where the motor spins freely without power).

You'll need to:

- Physically check the motor connection for any problems.
- Fix the issue
- Restart the VFD once you've confirmed everything is in order.

By understanding the motor stall alarm and responding appropriately, you can keep your motor running smoothly and efficiently.

Parameters

Trigger Threshold

Defines the speed limit used by the VFD to identify a possible stall condition.

If the actual motor speed is equal to or lower than this value, the VFD starts evaluating the delay timer.

Range: 60 to 200 RPM
Default: 60 RPM

When to use a higher value

- when the application should not remain at very low speed for long

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- when earlier stall detection is required
- when the driven equipment is expected to accelerate quickly above low speed

When to use caution

- do not set the threshold too high for applications that normally operate at low speed
- an excessively high threshold can cause unwanted stall detection during normal operation

Trigger Delay

Defines how long the motor speed must remain at or below the trigger threshold before the VFD declares a motor stall.

This delay helps avoid nuisance detection during short transients such as startup, momentary load changes, or temporary process disturbances.

Range: 1 to 200 s
Default: 10 s
Resolution: 1 s

When to use a longer delay

- when the application has slow acceleration
- when temporary low-speed operation is normal
- when brief process disturbances should not trigger the function

When to use a shorter delay

- when fast protection is preferred
- when a stalled condition must be detected quickly to protect the machine or process

Typical applications

The Motor stall function can be useful in applications such as:

- pumps that may become blocked or run against abnormal process conditions
- conveyors or mechanical systems that may jam
- fans or rotating equipment that should not remain at very low speed under command

Setting recommendations

Start with the default values, then adjust according to the actual application behavior.

A good setting should:

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- avoid nuisance trips during normal startup and low-speed transitions
- detect a real blocked or stalled condition early enough to protect the machine and process

Symptoms of a possible motor stall condition

A motor stall condition may be suspected when:

- the motor does not accelerate as expected
- the motor remains at very low speed while run command is active
- the driven machine is mechanically blocked
- the process load is too high for the motor to continue rotating normally

Troubleshooting checklist

If motor stall detection occurs:

1. Check whether the driven equipment is mechanically blocked.
2. Verify that the motor can rotate freely.
3. Check the load condition of the application.
4. Verify that the commanded operating speed is above the configured trigger threshold when normal running is expected.
5. Review the **Trigger Threshold** and **Trigger Delay** settings.
6. Confirm that the acceleration behavior of the application is compatible with the configured delay.
7. Check for motor sizing, load sizing, or process issues that could prevent normal acceleration.

Note

A motor running intentionally at very low speed may be interpreted as stalled if the **Trigger Threshold** and **Trigger Delay** are not set appropriately for the application.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.48. Motor disconnected (Code: 63)

A "motor disconnected" alarm on a Variable Frequency Drive (VFD) indicates that the VFD cannot detect the motor connected to its output terminals.

If the 3 wires (at least 2) are not connected, the alarm triggers without delay and forbids any action attempting to run a motor.

The VFD continuously monitors the current flowing to the motor. When the VFD operates, a certain minimum current is expected. If the current falls below this threshold, the drive triggers the "motor disconnected" alarm.

VFD behavior:

1- Being not powered, a disconnected motor can not start or will stop in freewheeling mode, depending on whether the issue appears at the starting time or when the motor is spinning.

2- The VFD stops delivering energy to its output

3- The VFD triggers an internal flag: “Inhibit restart”

Fix the alarm "motor disconnected":

The user needs to verify the motor connection and fix the issue. When finished, the alarm resets, and the user can restart the VFD.

Previous Next

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14.49. Motor application underload (Code: 64)

The motor application underload protection is a valuable feature that helps prevent damage to your motor by detecting situations where it's running without a proper load.

What it Does:

Imagine a pump running dry, a snapped drive belt on a machine, or a malfunctioning gear motor.

These situations can all cause the motor to operate with little to no load, leading to inefficiencies and potential overheating. Underload protection helps identify these scenarios.

How it Works:

This feature continuously monitors the motor's current draw. It compares this current to a user-defined minimum load current threshold ("Min Load Current").

If the current falls below the "Min Load Current" for the duration of the trigger delay, an alarm named "Motor application underload" is triggered (configurable as enabled or disabled).

If the current level rises above the "Min Load Current" threshold during the delay period, the timer resets, and no alarm is triggered.

By default, underload protection is disabled.

Once the alarm activates, you can choose how the VFD responds:

- Ramp Down: The VFD gradually reduces the motor speed until it stops. (default)
- Freewheeling: The VFD cuts power to the motor, allowing it to spin freely without resistance.

Benefits of Using Underload Protection:

It prevents motor overheating and potential damage from running unloaded.

It improves efficiency by identifying situations where the motor is working unnecessarily.

It provides valuable information about potential issues with your driven equipment.

Customizing Underload Protection:

Min Load Current: This is a user-defined percentage (10% to 90%) of the motor's rated current. The alarm triggers when the actual current falls below this value. (default = 10%)

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Trigger Delay: This sets the time (adjustable between 1 and 600 seconds with 1-second increments) that the current needs to stay below the threshold before the alarm activates. (default = 10 seconds)

Alarm Actions: Choose between "Ramp Down" or "Freewheeling" to define how the VFD reacts to underload.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.50. Motor auto-restart failure (Code: 65)

Fail to restart the motor after the specified number of restarts.

Previous Next

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14.51. AFE Low Voltage Ride Through Cannot Recover (Code: 66)

An AFE low-voltage ride-through condition was detected, and the VFD was unable to recover from it.

The voltage drop was either too severe or lasted too long. The compensation on the VFD's motor control was insufficient and the DC bus voltage became too low, leading to the inability to maintain normal operation.

Frequent occurrences of this alarm may indicate a broader issue with the power quality or the VFD setup. It's essential to address the root cause to prevent future interruptions and potential damage to the VFD or motor.

Recommended Actions:

Check the Power Supply:

Inspect the incoming power supply for signs of instability, such as voltage fluctuations, sags, or outages. Verify if there were any recent power disturbances in the area.

Evaluate the Severity of the Voltage Dip:

Determine the cause and duration of the low voltage condition. If the dip was caused by a transient event, you may need to monitor the power supply more closely or consider additional protective measures.

Consult with Your Power Provider:

If the low voltage event is related to the quality of the external power supply, you may need to contact your power provider for further investigation or mitigation.

Consider Power Conditioning Solutions:

If low-voltage events are frequent, you might want to consider installing additional power conditioning equipment, such as voltage stabilizers, uninterruptible power supplies (UPS), or line conditioners to protect against such events.

Restart the System:

After addressing the issue, the alarm resets automatically, and the VFD can restart the system.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.52. Drive Overload (Code: 67)

Drive overload occurs when the current drawn by the motor and load exceeds the maximum output current capability of the VFD for an extended period.

The VFD is designed to protect itself and the motor by monitoring the output current. If this current remains above the rated limit for too long, the drive triggers an overload fault and shuts down or limits operation to prevent overheating or permanent damage.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

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14.53. PIN invalid (Code: 68)

Setting and Managing the HMI Lock PIN

Setting and Changing the PIN:

To enhance security, you can set and manage a 6-digit Personal Identification Number (PIN) for access protection.

The following guidelines apply:

- Set PIN: You can set a unique 6-digit PIN for the admin account. This PIN is required to enable the HMI lock feature.

- Change PIN: You can change the existing PIN if necessary.

- PIN Storage: The PIN is not stored in clear text for security reasons. It is encrypted and not saved in the VFD's standard configuration file.

Enabling/Disabling the HMI Lock:

If a PIN has been defined, you can enable or disable the Lock HMI feature. Without a PIN, this feature is inaccessible.

- Audit Logging: Every time the HMI lock is enabled or disabled, the event is logged in the system audit log for traceability.

Lock HMI Functionality:

When the inactivity timer expires and the Lock HMI feature is enabled, the VFD enters screensaver mode (either blackout or blur, as defined by the user) and locks the HMI.

HMI's Buttons Behavior:

When the HMI is locked, the following button behaviors apply:

- STOP Button: Pressing the HMI's STOP button will stop the motor according to the user-defined STOP behavior. You will be prompted to enter the PIN.

- START Button: Pressing the HMI's START button will not start the motor, and a PIN prompt will appear. After successful unlock, you must press start again to run the motor.

Unlocking the HMI:

To unlock the HMI, the following steps apply:

- Touchscreen: Pressing the touchscreen will prompt you to enter the PIN to unlock the HMI.

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- Successful Unlock: If the correct PIN is entered, the HMI will unlock and return to the last screen displayed before the screensaver was activated. This event is logged in the audit log.

- Failed Unlock Attempts:

    - If an incorrect PIN is entered, the HMI will display the message “Invalid PIN. Please try again.”

    - You must acknowledge this message and re-enter the correct PIN.

    - Each invalid attempt will trigger a minor alarm labeled "Unlock HMI failed."

Resetting the PIN:

A factory reset will clear all defined PINs and will disable the Lock HMI feature.

PINs During Software Upgrades and Reverts:

- Upgrade: The configured PIN will be retained after a software upgrade.

- Even after a software revert or update, the latest PIN remains active.

Rebooting the VFD:

If the Lock HMI feature is enabled and a PIN has been set, the HMI will prompt the user to enter the PIN after a reboot.

Previous Next

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14.54. Damper feedback loss (Code: 69)

Native fan and damper control alarms

To ensure safe operation, three (3) new alarms have been added for the native function "fan and damper control."

- Damper open timeout
- Damper close timeout
- The damper is closed while the fan is running

Critical alarm: Damper open timeout alarm

External start feedback timeout (Code: 70).

After energizing the configured relay to open the damper, the Clean Power VFD starts a timer, ensuring the damper is opened before starting the fan.

If the damper limit switch does not indicate that the damper is opened before the configured damper open timeout, the Clean Power VFD generates a critical alarm.

It is recommended to investigate the possible causes and resolve the issue before resetting the Clean Power VFD to restore normal operation.

Medium alarm: Damper close timeout alarm

External post stop feedback timeout (Code: 71).

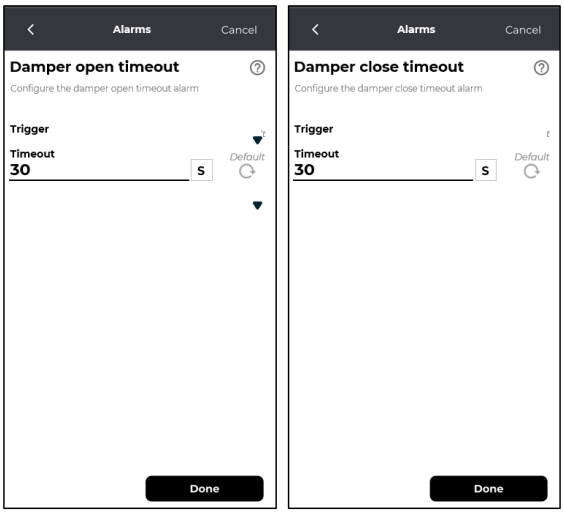
After stopping the fan, the Clean Power VFD de-energizes the configured relay to close the damper and starts a timer, ensuring the damper is properly closed.

If the damper limit switch does not indicate that the damper is closed before the configured damper close timeout, the Clean Power VFD generates a medium alarm.

It is recommended to investigate the possible causes and fix the problem.

These timeouts could be configured in the Advanced configuration alarms section

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Critical alarm: The Damper is closed while the fan is running

While the controlled fan is running and the damper limit switch indicates the damper is closed or a damper feedback signal is lost, the Clean Power VFD generates a critical alarm and stops the fan in freewheeling to avoid high or low pressure in the duct.

It is recommended to investigate the possible causes and resolve the issue before resetting the Clean Power VFD to restore normal operation.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.55. External start-stop feedback timeout (Code: 70, and 71)

Native fan and damper control alarms

To ensure safe operation, three (3) new alarms have been added for the native function "fan and damper control."

- Damper open timeout
- Damper close timeout
- The damper is closed while the fan is running

Critical alarm: Damper open timeout alarm

External start feedback timeout (Code: 70).

After energizing the configured relay to open the damper, the Clean Power VFD starts a timer, ensuring the damper is opened before starting the fan.

If the damper limit switch does not indicate that the damper is opened before the configured damper open timeout, the Clean Power VFD generates a critical alarm.

It is recommended to investigate the possible causes and resolve the issue before resetting the Clean Power VFD to restore normal operation.

Medium alarm: Damper close timeout alarm

External post stop feedback timeout (Code: 71).

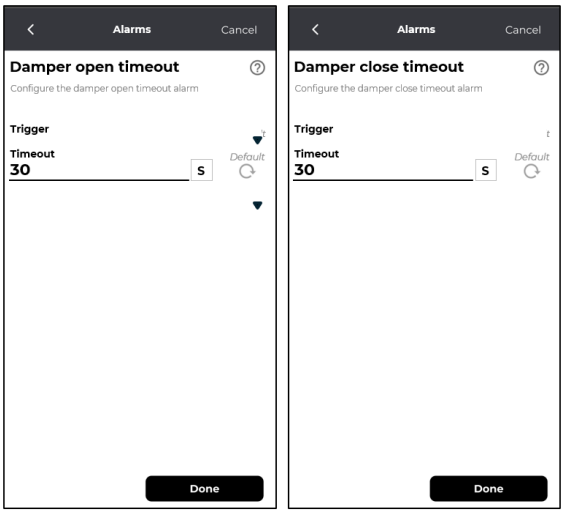
After stopping the fan, the Clean Power VFD de-energizes the configured relay to close the damper and starts a timer, ensuring the damper is properly closed.

If the damper limit switch does not indicate that the damper is closed before the configured damper close timeout, the Clean Power VFD generates a medium alarm.

It is recommended to investigate the possible causes and fix the problem.

These timeouts could be configured in the Advanced configuration alarms section

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Critical alarm: The Damper is closed while the fan is running

While the controlled fan is running and the damper limit switch indicates the damper is closed or a damper feedback signal is lost, the Clean Power VFD generates a critical alarm and stops the fan in freewheeling to avoid high or low pressure in the duct.

It is recommended to investigate the possible causes and resolve the issue before resetting the Clean Power VFD to restore normal operation.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

.

Previous Next

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14.56. Motor ground fault (Code: 72)

Overview

The VFD includes built-in protection against motor ground faults to enhance system safety and protect equipment.

A ground fault occurs when there is an unintended connection between an energized conductor and the ground. Such faults may result from insulation breakdown, moisture ingress, contamination, or physical damage to cables or motor windings.

Detecting and reacting to ground faults is critical to prevent further equipment damage, fire hazards, and electrical shocks.

Description

When a ground fault occurs, the VFD triggers the alarm. This alarm indicates that the vector sum of the currents in the three motor output phases has exceeded a threshold percentage of the VFD’s nominal current rating.

The alarm is triggered after a start request when the calculated vector sum of the three output phase currents exceeds the internal detection threshold.

- Fixed Threshold: 30% of the VFD nominal current rating
- Trigger Response: The drive stops the motor in freewheel.
- Reset Condition: The fault clears automatically when the motor is no longer being controlled , but the system remains in lock out as the severity of the fault is critical and requires a manual reset.
- Audit Log: The occurrence of the alarm is logged automatically.
- External Protocol Reporting: The alarm is communicated via all supported fieldbus protocols.



In systems configured for 2-wire control mode, a sustained run command may immediately trigger a new motor start after the fault clears and the user reset the lockout . This can cause unintended attempts to run the motor, potentially increasing the risk of equipment damage or safety hazards.

Always investigate and correct the root cause of a ground fault before attempting to restart the motor. Consider removing the run command signal or isolating the motor from the drive until the issue is resolved.

Previous Next

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14.57. Fire Emergency Inhibited (Code: 73)

The trigger condition exists, but a concurrent status actively blocks the activation of Emergency Fire mode.

This happens when the VFD is in **Maintenance Mode or in lockout.**

Previous Next

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14.58. External alarm (Code: 74 to 77)

Overview

The External Alarm, also referred to as the User-Defined Alarm, is a flexible alarm feature that allows Clean Power VFD users to trigger internal VFD alarms based on events occurring outside the drive. It enables external devices, such as safety systems, controllers, or sensors, to initiate specific alarm behaviors on the VFD.

This capability enables integrators and administrators to utilize the drive's built-in alarm and logging systems, ensuring that the drive responds appropriately to external conditions and provides a consistent and traceable alarm history in the audit logs.

Purpose

- Integrate external fault or status signals into the VFD alarm system.
- Trigger predefined alarm actions inside the VFD from user-configured digital inputs.

Key Features

- Supports up to 4 user-defined alarms.
- Supports user-defined names up to 255 UTF-8 characters.
- Each alarm is associated with a unique code, name, severity, and predefined action.
- Alarms are logged in the audit log.
- On boot, the alarm state either persists from the previous session or starts as disabled.
- Configurable trigger and reset delay.
- Triggered by digital inputs.

Available Alarms

Alarm Code	Name	Severity	Action (Default)	Logged
74	Ext. Critical Alarm	Critical	Freewheel + Lockout	Yes
75	Ext. Major Alarm	Major	Freewheel	Yes
76	Ext. Medium Alarm	Medium	Ramp-down to stop	Yes
77	Ext. Minor Alarm	Minor	No action	Yes

Configuration Parameters

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Parameter	Editable	Description	Range / Values	Default
Enable	Yes	Enables or disables the external alarm	Enable / Disable	Disable
Trigger Delay	Yes	Delay before the alarm is triggered	0.0s to 120.0s	0.2s
Reset Delay	Yes	Delay before the alarm is reset after the source is cleared	0.0s to 120.0s	0.2s
Boot State	Yes	On boot, the alarm state either persists from the previous session or starts as disabled.	Enable / Disable	Disable
User defined name	Yes	User-defined alarm name	Up to 255 characters	-

Input Source and Activation Rules

Alarms are triggered by configured digital inputs. Only inputs explicitly assigned to the alarm can activate it.

Digital inputs must be configured as state-based.

Audit Logging

Each activation and reset of a user-defined alarm is logged into the VFD audit log with a timestamp, alarm code, severity, and action performed.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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14.59. Motor Thermal Overload (Code: 78)

The **Motor thermal overload** alarm indicates the drive's protection has determined the motor is **too hot for continued operation**

This alarm raises when the estimated motor thermal load (TCU%) reaches the trigger threshold.

It auto-clears when thermal load falls below the reset threshold.

See also Motor Thermal Protection (theory & parameters): Motor Thermal Protection

⚠ WARNING

Multi-motor on one drive.

This function estimates the thermal energy of a **single motor**. If you run multiple motors from one VFD, per-motor thermal protection is not possible—you must use **external thermal relays (one per motor).**

⚠ CAUTION

A higher overload trip class allows the motor to remain overloaded for a longer time. Select the trip class according to the motor thermal capability and the application starting profile

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This function prevents motor overheating by combining:

1. a temperature-based thermal model (with fixed time constant and cooling-type compensation),
2. an I^2t (current-squared–time) accumulator, and
3. the Motor Load Curve, which tells the drive how hard the motor is expected to work at different speeds so the model can predict heating realistically—especially at low speed.

When the model determines the motor is too hot, the drive raises **Motor thermal overload** and executes the configured stop action.

Power-Up Behavior (Temperature at Start)

Set how the drive interprets motor temperature when it powers up:

- **Cold Start (default):** The drive assumes the motor is at the ambient temperature at power-up, regardless of prior operation.

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- **Retain Last Temperature:** The drive restores the previously estimated motor temperature exactly as it was before power-down (thermal memory).

Tip: Use **Retain Last Temperature** for short power outages or frequent on/off cycles application. Use **Cold Start** for applications where the motor fully cools between start or when conservative behavior is required.

How It Works

1) Temperature-based model + I²t

- Copper heating ≈ **I²·R**. The drive integrates RMS current squared and feeds it to a first-order thermal model (τ = 256 s, fixed).
- The model outputs both Estimated Motor Temperature and Thermal Load, internally computed as TCU% (Thermal Capacity Used).

TCU value	Typical meaning
0%	Motor is considered cold, close to ambient temperature.
50%	Motor has used approximately half of its thermal capacity.
88%	Default warning threshold, if the warning function is available.
100%	Default trip threshold.
> 100%	Motor is above the default thermal capacity limit. Operation depends on the configured thresholds and action.

The VFD continuously updates the TCU value while the motor is running.

When the motor is stopped, the VFD estimates cooling and decreases the TCU value over time.

2) Motor Load Curve

- The Motor Load Curve tells the VFD how much current the motor normally needs across speed, so the thermal model can weight heating realistically and avoid false confidence at low speed.
- You don't draw the curve or set breakpoints. Instead, the drive derives the curve from two inputs: **Cooling Type** and **Motor Load Nominal (I/IN)**.
- **Cooling Type** defines the assumed zero-speed load point (no separate parameter to edit):
    - **Self-cooled (default): Zero-speed load = 70%** of *Motor Load Nominal*
    - **Forced-cooled: Zero-speed load = 100%** of *Motor Load Nominal*
- **Motor Load Nominal (I/IN)** tells the model the typical continuous operating load vs the motor nameplate current. It adjusts the whole curve vertically.

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Why this matters:

Self-cooled motors have little airflow at low speed, they heat faster.

The 70% zero-speed reference prevents the model from assuming “zero current” at zero speed and reflects real workload/torque needs for many applications.

Forced-cooled motors keep airflow, a 100% zero-speed reference is safe.

3) Overload trip class

The **Overload Trip Class** defines the inverse-time overload behavior of the motor thermal model.

A lower class trips faster.

A higher class allows a longer overload time.

Trip class	Behavior	Typical use
Class 5	Very fast overload protection	Very light loads or motors that require fast thermal protection
Class 10	Fast overload protection	Standard pump, fan, and general-purpose applications
Class 20	Medium overload delay	Applications with longer acceleration time
Class 30	Long overload delay	Higher inertia loads or difficult starts
Class 40	Very long overload delay	Special applications only; verify motor thermal capability

Changing the trip class updates the inverse-time curve immediately.

Parameters

Parameter	options	Default	Notes
Motor Thermal Time Constant (τ)	100 to 10 000 s	256 s	Sets heating/cooling dynamics (~63% step response). Larger = slower temp change; influences TCU rise/decay
Motor Temperature at Power Up	Cold Start / Retain Last Temperature	Cold start	Controls thermal memory at boot.
Overload Trip Class	5 / 10 / 20 / 30 / 40 / Undefined	10	Updates the inverse-time curve immediately. If Overload Trip Class is Undefined, the Motor Thermal Time Constant will be used for triggering the alarm.
Cooling Type	Self-cooled / Forced-cooled	Self-cooled	Also defines the zero-speed load assumption (no separate parameter):

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Parameter	options	Default	Notes
			Self-cooled → 70% of Motor Load Nominal; Forced-cooled → 100%.
Motor Load Nominal (I/IN)	Settable 50…150%	100%	Ratio of typical operating current to nameplate FLA. Influences the entire load curve (and thus heating predictions).
Alarm: Motor thermal overload	Enable / disable	Enable	Disable for multi motor applications
	Trigger delay	0	Settable from 0 to 120 s
	Action: ramp down / freewheeling	Ramp down	
	Trigger Condition: Thermal load ≥ Trigger threshold	100 %	Settable from 80% to 150% of the motor's thermal load capacity
	Reset Condition: Thermal load < Reset threshold	88 %	Settable from 30% to 100% of the motor's thermal load capacity
	Reset delay	0	Settable from 0 to 120 s
	Alarm Persistence option: • Cleared at boot • Persistent to reboots	Cleared at VFD boot	Even if alarm is selected non-persistent; logs remain.
Audit Log	Enabled by default		

What Happens on Alarm

1. **Trigger:** When Thermal Load ≥ Trigger threshold (default 100%), the drive raises Motor thermal overload (medium) and executes selected action
2. **While active:** The alarm stays active while Thermal Load ≥ Reset threshold.
    a. **Reset:** The alarm auto-clears when Thermal Load < Reset threshold (default 88%). The alarm also clears on power-up (non-persistent).
3. **Restart eligibility:** General restart/interlock policy applies. If your system allows restart on alarm clear and all interlocks are healthy, the motor can start once below the reset threshold.

Commissioning Checklist (with Load Curve)

1. **Select power-up mode:** *Cold Start* (default) or *Retain Last Temperature*.

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2. **Select Cooling Type:**
    - *Self-cooled* (default) → zero-speed load = 70% × Motor Load Nominal
    - *Forced-cooled* → zero-speed load = 100% × Motor Load Nominal
3. **Set Motor Load Nominal (I/IN):**
    - Default 100%; set 50…150% based on expected continuous duty.
    - 100% can be used (e.g., nameplate service factor) only if motor and installation permit—verify manufacturer limits.
4. **Choose Action on Trigger:** Stop – ramp down (default) or Stop – freewheel.
5. **Verify on a warm test:** Run typical load at low and nominal speeds; watch current value that triggers the alarm. Adjust **I/IN** if the model persistently over/underestimates heating.



Equipment damage risk
Do not repeatedly restart after a thermal overload without investigating the load, duty, airflow, and acceleration settings.

Previous Next

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14.60. Internal MCU comm loss (Code: 79)

This alarm indicates that the motor-control MCU (M4) is no longer executing correctly (its watchdog has triggered) or is no longer communicating as expected with the application/control MCU (A7). When this happens, the A7 reports Alarm 79 as a critical alarm.

This is an internal control integrity fault. The drive can no longer guarantee safe/accurate motor control.

Previous Next

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14.61. BACnet IP communication loss (Code: 80)

Overview

The **BACnet IP Communication Loss** alarm supervises the communication between the Clean Power VFD and the BACnet client, typically the Building Management System (BMS).

The supervision is based on a **heartbeat object**. The BACnet client must write periodically to this object. If the drive does not receive an update within the configured delay, it declares a communication loss and triggers the alarm.

Use this function when the drive depends on BACnet IP communication for control or supervision.

Function Description

The drive monitors the activity of the BACnet client through the heartbeat object.

- If the BACnet client writes to the heartbeat object within the allowed time, communication is considered valid.
- If the BACnet client stops writing to the heartbeat object for longer than the configured trigger delay, the drive triggers the **BACnet IP Communication Loss** alarm.
- When the alarm is triggered, the drive applies the configured trigger action.

This function confirms that the BACnet client is still active and responsive, not only that the Ethernet link is present.

Parameters

The configuration of this alarm is accessible in the advanced parameters:

- Click on the hamburger menu to open the mobile App menu and select configuration, then advanced configuration.
- Scroll down to the end of the displayed list until you see the chapter Alarm. If not yet opened, open it.
- Then click on the pencil icon to edit the BACnet IP communication loss

Enable

Enables or disables supervision of BACnet IP communication loss.

Default value: Enable

Notes

- When BACnet is enabled, this alarm is intended to remain enabled.

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- If BACnet is enabled and the BACnet communication loss alarm is disabled, the system enables the alarm automatically.

Trigger Delay

Defines the maximum time allowed without a heartbeat update before the drive declares a BACnet communication loss.

Range: 10 to 300 s

Default value: 60 s

Notes

- Set this delay longer than the normal BACnet heartbeat write interval, this helps prevent nuisance alarms caused by normal network variations or controller scan jitter.
- Add margin for network latency, BMS scan time, and system load.
- Example:
    - heartbeat written every 20 s
    - trigger delay set to 60 s

Trigger Action

Defines the action applied by the drive when BACnet IP communication loss is detected.

You can select either "Stop ramp-down" or "Stop freewheel"

Default value: "Stop ramp-down"

VFD behavior:

When the alarm arises, the VFD stops the motor according to the user-defined stop action for the alarm.

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

Previous Next

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15. Troubleshooting

To help the user solve issues he may encounter when using the Clean Power VFD, this section explains how to troubleshoot a problem when a protective function, alarm, or warning message occurs.

If the Clean Power VFD does not work normally after following the suggested troubleshooting steps, don't hesitate to get in touch with the SmartD customer service center.

When the Clean Power VFD detects a fault, it sends a warning to the HMI and the SmartDrive app (if a smartphone with the SmartDrive app is connected to the drive).

The drive may also modify or stop its operation, depending on the criticality of the fault.

Previous Next

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15.1. I/O's status monitoring

During commissioning, troubleshooting, or routine checks, it’s important to verify the status of all digital and analog I/O connections to ensure the VFD is operating correctly and that signals from external devices (e.g., sensors, switches, controllers) are properly recognized and processed.

The VFD provides a dedicated I/O Status Page available both on the local HMI and in the Mobile App. This page gives a live, consolidated view of all configured digital and analog inputs and outputs.

Accessing the I/O Status Page

On Mobile, go to Menu >> About >> Diagnostic >> I/O's status

On HMI, go to Menu >> About >> Diagnostic >> I/O's status

Digital Inputs

All digital I/Os are displayed together in a list showing their live logical state. The indicators are:

- Logic State = H (High level)
- Logic State = L (Low level)
- Encoder set
- Channel unconfigured

Even if a digital I/O is unconfigured, its current electrical state is still shown (grayed out) for diagnostic purposes.

This visualization makes it easy to:

- Confirm activation of external signals such as limit switches or interlocks.
- Detect wiring errors, stuck inputs, or unexpected logic states.

Analog Inputs

Analog channels are displayed as bar graphs, providing a clear, visual representation of the measured signal.

Each bar is scaled from 0% to 100% based on the following standard signal ranges:

- Voltage: 0–10 V
- Current: 4–20 mA
- Impedance: 0–10 kΩ

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The bars show the live numeric value of the signal with one decimal point, in the units selected by the user.

Example:

If an analog input is reading 6.5 V in a 0–10 V range:

The bar graph displays approximately 65% fill.

The numeric readout shows 6.5 V.

Unconfigured analog I/Os are displayed as an empty bar graph with an indication that the channel is unconfigured.

Communication and Latency

HMI Display Update Rate:

Status updates occur with a latency of about 0.5 s, ensuring near-real-time feedback for diagnostics.

Mobile App Update Rate:

Expect a longer latency than HMI when connected via Wi-Fi or Bluetooth

If real-time data becomes temporarily unavailable (e.g., network disconnection), the display is frozen.

Integration with Networks

All I/O status data is accessible via:

- Modbus TCP
- BACnet IP

This allows external systems such as PLCs, SCADA, or BMS platforms to read live I/O status for remote monitoring or advanced troubleshooting.

Previous Next

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15.2. Versioning

If you need to connect with SmartD's customer support, you will be requested to tell them about the version of your product.

Here is the method to find the version of your product:

Clean Power VFD software version

1. From the HMI display, open the menu by tapping on the hamburger icon ≡
2. Then tap on "About",
3. and then "Software".



SmartDrive Mobile Application version

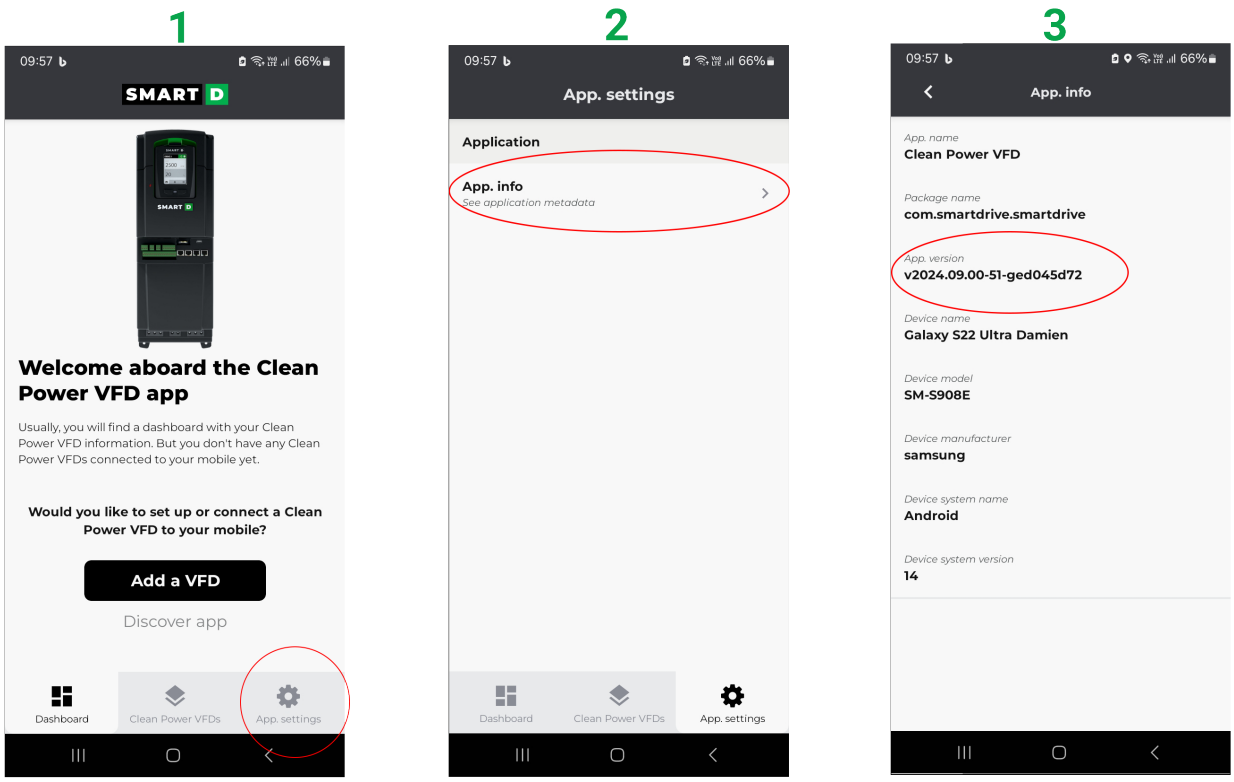
Run the application on your smartphone, and follow the steps as illustrated hereafter:

1- tap on the button App. settings.

2- select App.info

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3. the App. version is displayed



Previous Next

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15.3. Audit logs

What is the function Audit Log?

For traceability, technical support troubleshooting, and legal reasons the SmartDrive keeps a persistent log of auditable events on the systems.

administrators or qualified SmartD personnel can refer to these logs for diagnosing any issues that may arise. These logs provide valuable information for troubleshooting and identifying potential problems.

What are the logged events?

The logged events are the following:

- Start-up and shut-down of the system
- Start-up and shut-down of a service
- Network connection changes or failures
- Configuration change
  See the new configuration and previous configuration
- Set point changes
  See new setpoint and previous setpoints
- Alarm transitions
- Changes to, or attempts to change, system security settings and controls
  Make sure firewall service start/stop is logged
  Detecting firewall rules modification
  Enabling/Disabling remote SSH access
  Enabling/Disabling remote gRPC access
- Create/Delete users
- Log-on attempts (successful or unsuccessful) and logoff
  SSH
  Console
  gRPC session start/end (including authentication failure)
- Software Update progress events
  Start/end/reboot/power interrupts
  Accept new version
  Revert to the backup version

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- Errors (Persistent storage)
- Boot for backup software
- Backup configuration events
- Reset metrics
  Examples: fans, start motor counter...

What is the content of a logged event?

The event contains the following information:

- Date/Time (UTC time)
- Type of Event(see logged events list above)
- Severity:

Use standard Syslog severities (limits to INFO, WARNING, ERROR, EMERGENCY)

- Short Message describing the request and response to the request
- Origin:

gRPC API, Mobile, WEB, HMI, I/O module, MODBUS, BLE ...

Example of a logged event

{

"time": "2022-05-09T19:08:18.000Z",

"event": "EVENT_ALARM",

"severity": "PRIORITY_INFO",

"message": "Alarm Cooling fan 2 fault has been acknowledged by user 1.",

"origin": "ORIGIN_SYSTEM"

},

{

"time": "2022-05-09T19:08:18.000Z",

"event": "EVENT_SETPOINTS_CHANGE",

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"severity": "PRIORITY_INFO",

"message": "Alarm service responded to Set Setpoints request with status RESPONSE_STATUS_OK",

"origin": "ORIGIN_GRPC_API"

},

Logged events capacity

The audit log is kept in persistent storage on the SmartDrive and the drive can store up to 250,000 events (or 300MB of data).

The audit log is not affected by the restore factory settings.

The SmartDrive brownout ensures that no audit log events are lost and stored on persistent before the end of the brownout period.

Audit Log Export

Users can export the audit log in JSON format compressed and encrypted via the smartphone app.

The exported file is available and shared via the mobile app.

1. Go to the Clean Power VFD main menu (click on the hamburger menu in the upper right corner of the Smart App screen)
2. select audit log
3. select your filter
4. start the download

A JSON file is created in the app (phone)

1. Select share (with your usual sharing interface and function from your Ios or Android device)
2. Select your preferred app to share the file
3. and send/share

when exiting the share step, the generated file is deleted from the phone.

Issue when sharing the file

If you have trouble exporting the file, make sure you are properly authenticated to the service you want to use to share the file.

e.g: check that you are correctly identified in the e-mail application of your smartphone to ensure that you can share the file by e-mail.

Previous Next

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15.4. Troubleshooting Operation Issues

When a fault other than those identified alarms occurs, refer to the following table for possible causes and suggested remedies.

- Can not modify the settings
- The motor does not run
- The motor rotates in the opposite direction of the command.
- The motor rotates in one direction only
- The motor is overheating
- The motor does not accelerate or stop during acceleration
- Motor speed varies during operation.

Can not modify the settings

Possible Cause

1. The Clean Power VFD is in RUN mode.
2. The access parameters are incorrect.

Suggested remedy

1. Stop the Clean Power VFD to download the changed parameters from the SmartD app on your smartphone.
2. Check your ID and password.

The motor does not run

Possible Cause

1. The frequency setpoint is not set correctly.
2. The frequency selected setpoint is too low.
3. The RUN/STOP I/O's are not wired accordingly to their preset functions.
4. Power is not supplied to R/L1, S/L2, T/L3
5. The power supply is not correct

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6. The motor is not connected properly
7. Two-wire or three-wire type connection is wrong.
8. The I/O's defined as the RUN command is off.
9. Both the forward and reverse rotation start signals are activated simultaneously.
10. The motor is mechanically locked.
11. The emergency STO1 or STO2 is activated
12. The source/Sink (PNP/NPN) selection is not consistent with the wiring of the I/Os

Suggested remedy

1. Check the selection of the frequency setpoint.
2. Check that the value of the selected frequency setpoint is above the minimum frequency.
3. Check the I/O's wiring and their preset functions.
4. Check the terminal connections R/L1, S/L2, T/L3 and U/T1, V/T2, and W/T3.
5. Check for decreased input voltage, input phase loss, and proper wiring.
6. Check the wiring between the Clean Power VFD and the motor.
7. Check the connection, two-wire or three-wire type.
8. Turn on the RUN I/O.
9. Turn ON either the forward or reverse rotation start signal.
10. Unlock the motor or lower the load.
11. Check the STO1 and STO2 wiring. Fix the Emergency signal that may have activated STO1 or STO2. Check the +24V on STO1 and STO2.
12. Check the wiring mode selection setting.

The motor rotates in the opposite direction of the command.

Possible Cause

1. The wiring for the motor output cable is incorrect.
2. The signal connection between the control circuit terminal (forward/reverse rotation) of the Clean Power VFD and the forward/reverse rotation signal on the control panel side is incorrect.

Suggested remedy

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1. Check if the cable on the output is wired with the correct sequence to the phase (U/V/W) of the motor.
2. Check the forward/reverse rotation wiring.

The motor rotates in one direction only

Possible Cause

1. The single rotation direction has been selected in the Clean Power VFD settings.
2. The reverse and/or forward input is not wired consistently with the I/O's setting.

Suggested remedy

1. Change to 2-direction rotation in the settings. Upload the new setting in the Clean Power VFD.
2. Check the forward/reverse rotation wiring.

The motor is overheating

Possible Cause

1. The load is too high.
2. The ambient temperature of the motor is too high.
3. The motor fan has stopped, or a foreign object obstructs the fan.

Suggested remedy

1. Reduce the load.
2. Increase acceleration/deceleration time.
3. Check the motor parameters and set the correct values.
4. Replace the motor and the Clean Power VFD with models with appropriate capacity for the load.
5. Lower the environment temperature of the motor to operate within the motor manufacturer's specifications.
6. Check the motor fan and remove any foreign objects.

The motor does not accelerate or stop during acceleration

Possible Cause

1. The load is too high.

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2. The frequency setpoint is too low.
3. The acceleration time is too long.
4. The starting torque is too low.

Suggested remedy

1. Reduce the load.
2. Replace the motor and the Clean Power VFD with models with appropriate capacity for the load.
3. Set an appropriate value of the speed setpoint.
4. Increase the acceleration time.
5. Increase the starting boost torque value.

Motor speed varies during operation.

Possible Cause

1. There is a high variance in load
2. The input voltage varies.

Suggested remedy

1. Replace the motor and the Clean Power VFD with models with appropriate capacity for the load.
2. Check your input power lines.

The motor vibrates and does not rotate normally.

Possible Cause

The voltage between phases is not balanced.

Suggested remedy

1. Check the input and output voltage balance.
2. Check the motor's insulation.

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15.5. Troubleshooting the alarms

When an alarm occurs, refer to the following tables for possible causes and suggested remedies.

- Reminder — Automatic Restart:
- STO (Code: 1)
- Line phases inversion (Code: 3)
- DC Overvoltage (Code: 5)
- Line voltage sag (Code: 6)
- Line voltage balance (Code: 7)
- HMI communication loss (Code: 9)
- Line Overcurrent (Code: 11)
- Motor currents unbalanced (Code: 12)
- Motor overtemperature (Code: 14)
- Application Overload Prevention (Code: 15)
- VFD over temperature (Code: 16)
- Unknown boot state (Code: 17)
- VFD high temperature (Code: 20)
- Line voltage swell (Code: 21)
- Software update failed (Code: 22)
- Cooling fan (1-4) fault (Code: 24 to 27)
- Cooling fan capacity fault (Code: 28)
- Line unexpected voltage (Code: 29)
- Internal Error (Code: 30)
- DC unbalanced (Code: 31)
- Drive Output Overcurrent (Code 32) / Acceleration overcurrent prevention
- Simultaneous forward and reverse command (Code: 33)

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- System boot time exceeded (Code: 34)
- System degraded (Code: 35)
- Abnormal CPU usage (Code: 36)
- Abnormal memory usage (Code: 37)
- DC overvoltage stall prevention (Code: 38)
- Motor overcurrent stall prevention (Code: 39)
- Line unexpected frequency (Code: 40)
- DC unexpected voltage (Code: 41)
- AFE fault (Code: 42)
- AFE low voltage ride-through (Code: 43)
- Remote to local override (Code: 44)
- Analog output sensor loss (Code: 45)
- PID process value alarms (Code: 46 and 47)
- Control board power loss (Code: 48)
- Motor control instability (Code: 49)
- Motor overspeed (Code: 50)
- Motor underspeed (Code: 51)
- Motor wrong direction (Code: 52)
- Encoder speed error (Code: 53)
- Encoder communication error (Code: 54)
- Modbus Comm Loss (Code: 58)
- VFD High ambient temperature (Code: 59)
- Motor temperature sensor shorted (Code: 60)
- Motor phase loss (Code: 61)
- Motor Stalled (Code: 62)
- Motor disconnected (Code: 63)
- Motor application underload (Code: 64)

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- Motor auto-restart failure (Code: 65)
- AFE low voltage ride through cannot recover (Code: 66)
- Drive overload (Code: 67)
- PIN invalid (Code: 68)
- Damper feedback loss (Code: 69)
- External start-stop feedback timeout (Code: 70 and 71)
- Motor ground fault (Code: 72)
- Motor Thermal Overload (Code: 78)
- BACnet IP communication loss (Code: 80)

Reminder – Automatic Restart:

If you want the drive to restart automatically when a **Medium** or **Major** fault/alarm clears itself, you must enable Automatic Restart. Otherwise, the drive stays stopped until you reset it and issue a new run command.

STO (Code: 1)

Safe Torque Off digital input (STO1 or STO2), deactivation of the VFD output, is triggered.

Possible causes and suggested remedies:

1. Emergency stop activated
    - Make sure to resolve all the risks before resetting the STO and the VFD
2. STO input terminals are left out of power or wired incorrectly.
    - Verify the STO circuit wiring and ensure that the STO inputs are connected and energized properly

Line phases inversion (Code: 3)

The VFD detects a phase inversion in the incoming power supply. This typically happens when the phase sequence is reversed, causing potential loss of synchronization.

Possible causes and suggested remedies:

1. Incorrectly wired input phases (phase sequence reversed).
    - Verify and correct the wiring of the incoming power supply to ensure correct phase sequence (L1, L2, L3)
2. Power supply phase sequence reversal due to a fault or change in the electrical network.

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- Use a phase sequence indicator to verify the proper order; correct the supply line configuration

3. Loose or faulty wiring or connectors are causing intermittent phase inversion.
    - Inspect and tighten all incoming power supply connections; check for worn or damaged wires

DC Undervoltage (Code: 4)

The DC bus voltage drops below the required level for normal operation.

Possible causes and suggested remedies:

1. The input voltage is too low or unstable.
    - Check if the input voltage is below the Clean Power VFD specifications. To protect against such events, install additional power conditioning equipment, such as voltage stabilizers, uninterruptible power supplies (UPS), or line conditioners.
2. Input phase loss or open circuit.
    - If there's a contactor upstream of the Clean Power VFD, it may be defective. Check the operation and connection of the upstream contactor. If defective, replace it. Inspect input terminals and circuit breakers.
3. Sudden disconnection of motor/load.
    - Verify for sudden load drop and ensure stable load connection.

DC Overvoltage (Code: 5)

The DC bus voltage is way above the line-nominal-voltage side, and the DC overvoltage stall prevention function did not succeed in limiting the rise of the DC bus voltage.

Possible causes and suggested remedies:

1. Deceleration time is too short compared to load inertia.
    - Increase deceleration time.
2. The input voltage is too high.
    - Check if the input voltage is above the Clean Power VFD specifications

Line voltage sag (Code: 6)

A temporary drop in input voltage may disrupt VFD operation or cause faults like undervoltage or AFE ride-through failure.

Possible causes and suggested remedies.

1. Utility power disturbance (grid fluctuation or switching)..
    a. Install voltage monitoring equipment; work with the utility provider to identify the root cause

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2. Large motor or equipment starting on the same power line.
    a. Use soft starters or VFDs for large loads; stagger startup sequences.
3. Undersized transformer or excessive impedance upstream.
    a. Upgrade transformer or cabling; reduce length or improve conductor sizing.
4. A fault or short circuit elsewhere in the facility is drawing current.
    a. Inspect the facility's power distribution for abnormal loads or faults.
5. Shared power source with high inrush loads.
    a. Separate sensitive loads or use dedicated circuits.
6. Loose or poor supply terminals or breakers.
    a. Inspect and tighten all line-side connections.

Line voltage balance (Code: 7)

One or more phases of the incoming supply voltage deviate significantly from the average of the line input voltage.

Possible causes and suggested remedies:

1. Upstream voltage imbalance (utility or transformer)
    a. Check phase-to-phase voltages with a power analyzer. Contact the utility provider or adjust transformer tap settings to balance voltages within ±2%.
2. Asymmetric source impedance (unequal cable lengths or impedance)
    a. Use identical cable lengths and cross-sections for all three phases. Match upstream fuses or circuit breakers phase by phase.
3. Nearby large single-phase loads
    a. Redistribute single-phase loads across phases. Consider adding load-balancing transformers or power conditioners if redistribution isn’t possible.
4. Harmonics from other nonlinear loads (welders, other drives, etc.)
    a. Remedy: Install line reactors or active harmonic filters upstream.
5. Improper grounding or bonding (e.g., high impedance in return paths)
    a. Verify TN-S or HRG grounding is correctly implemented. Ensure clean bonding at the drive cabinet and the upstream panel. Follow SmartD grounding best practices.
6. Internal AFE fault or hardware asymmetry
    a. Run diagnostics from the SmartD HMI or app. Measure per-phase current draw. Contact SmartD for test procedures or replacement.

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7. Loose or corroded terminal connections
    a. Inspect and retighten all power connections. Clean terminals and apply an antioxidant compound if required. Follow torque specs.
8. Damaged transformer windings or taps
    a. Perform transformer testing (e.g., TTR, insulation resistance). Replace or service the faulty transformer.
9. Shared neutral or undersized grounding conductor (in rare cases)
    a. Use a separate, properly sized PE conductor per IEC 60364 and UL 508A. Avoid shared neutrals in three-phase systems.

HMI communication loss (Code: 9)

Communication problem between the control board and the HMI

Possible causes and suggested remedies:

1. Communication cable or connector failure (e.g., loose or broken cable).
    - Inspect and replace any damaged cables or connectors; ensure a secure connection.
2. Grounding or electrical noise issues are causing communication interference.
    - Improve grounding; use only SmartD HMI cable. Do not use a standard Ethernet RJ-45 cable
3. Hardware failure.
    - Please escalate this issue to the SmartD support team

Line Overcurrent (Code: 11)

The VFD has triggered its self-hardware protection for grid overcurrent

Possible causes and suggested remedies:

1. Ground fault or short circuit on the input wiring.
    - Power off the system and visually inspect the input wiring for damage, loose connections, or signs of insulation breakdown.
2. Sudden grid voltage swell due to unstable power supply or switching events.
    - Check for ground faults using an insulation tester (megohmmeter) between each input phase and ground.
3. Connection to a high-impedance or weak grid that cannot sustain regenerative or fluctuating loads.
    - If connected to a generator or weak grid, verify the voltage stability and consider enabling specific VFD settings for generator compatibility (if available).
4. Confirm proper input fuse or circuit breaker sizing per the drive's installation guide.

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Preventive Recommendations:

- Ensure correct grounding and shielding of the power cables.

Motor currents unbalanced (Code: 12)

The current on any phase deviated above a certain threshold from the maximum mean of the three phases' nominal value.

Possible causes and suggested remedies

- Winding Problems: Shorted or open windings can cause unbalanced currents. This could be due to insulation failure, aging, or physical damage to the motor.
    - Check Motor Connections:
        - Inspect and tighten all motor and VFD terminal connections.
        - Ensure that all connections are clean and free from corrosion
- Uneven Air Gap: A non-uniform air gap between the rotor and stator can cause magnetic field distortion, leading to current imbalance.
    - Measure and Compare Phase Currents: Use a clamp meter or other suitable instruments to measure the current in each motor phase. Compare the readings to determine the level of imbalance.
- Bearing Issues: Worn or damaged bearings can lead to rotor misalignment, resulting in uneven magnetic pull and current unbalance.
    - Inspect Motor Windings:
        - Perform a resistance test on the motor windings to check for open or short circuits.
        - Consider performing an insulation resistance test to check for potential insulation failures.
- Rotor Bar Issues: Broken or cracked rotor bars can cause unequal current distribution within the rotor, leading to unbalanced currents in the stator.
    - Examine the Motor Mechanically:
        - Inspect the motor for mechanical issues such as bearing wear, rotor misalignment, or physical damage.
        - Check for even air gaps and rotor conditions, particularly the rotor bars.
- Poor Connections: Loose or corroded connections in the motor terminals or VFD output terminals can cause an imbalance.
- Inspect and tighten all motor and VFD terminal connections.
- Ensure that all connections are clean and free from corrosion
- Incorrect Cable Sizing: Cables that are undersized or of different lengths can cause unequal voltage drops, leading to current imbalance.
    - Check Cabling and Grounding:
        - Inspect motor cables for damage, proper sizing, and ensure they are of equal length.

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- Verify proper grounding and shielding to minimize the effect of electrical noise.

Motor overtemperature (Code: 14)

The VFD, connected to the PTC sensors of the motor to achieve thermal protection, has detected that the motor exceeds its maximum operating temperature.

Possible causes and suggested remedies

1. The motor has overheated due to mechanical issues or improper selection.
    - Reduce the load or operating frequency.
2. The PTC sensors are defective.
    - Disconnect the sensors from the Clean Power VFD and check their resistance. If defective, replace them.
3. At low speeds, the motor's fan does not provide sufficient airflow.
    - Check the motor, and avoid prolonged low-speed operation.
4. Improper acceleration or deceleration settings.
    - Adjust acceleration/deceleration times.
5. Voltage drop or high capacitive charging current can lead to heat (inadequate cable sizing).
    - Verify the cable with the proper size.
6. Incorrect motor information.
    - Ensure all motor parameters (voltage, current, frequency, RPM) are correctly configured.
7. The ambient temperature is too high, the motor is operating in an environment that exceeds its thermal rating.
    - Improve ventilation or air conditioning in the motor room, and consider a motor with a higher insulation class.

Application Overload Prevention (Code: 15)

The Clean Power VFD monitors the motor current to detect an application overload.

If the current drawn by the motor exceeds the threshold value, which lasts longer than the inhibition delay, then the fault is triggered.

Possible causes and suggested remedies:

1. The motor is drawing current above the set overload threshold for longer than the set inhibition delay.
2. The overload threshold may be set too low for the application, causing nuisance tripping.
3. The inhibition delay may be set too short, not allowing for normal load fluctuations.
4. Actual application overload due to mechanical binding, increased load, or a process issue.

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5. The motor FLA (Full Load Amp) value is programmed incorrectly in the VFD.
6. A faulty current sensor or wiring in the VFD can lead to incorrect readings.

1. Check Application Load:
    - Inspect the mechanical system for any signs of binding, excessive load, or process issues causing the motor to draw excess current.
    - Resolve any mechanical or process problems as necessary.
2. Verify VFD Settings:
    - Ensure that the motor's FLA (Full Load Amps) is programmed correctly in the VFD.
    - Adjust the overload threshold according to your application:
        - For normal/light duty: set threshold to 110–120% of FLA, inhibition delay at 60s.
        - For heavy-duty loads: set threshold to 150–160% of FLA, inhibition delay at 60s.
    - Avoid setting the threshold too low or the inhibition delay too short, as this may cause nuisance tripping.
3. Check Fault Reset and Restart Settings:
    - Confirm that the fault reset time is suitable for your application (the default is 60 seconds).
    - After a fault, ensure that the motor current falls below 10% of the overload threshold before attempting a restart.

VFD over temperature (Code: 16)

Embedded temperature sensors monitor the level of heat applied to the electronic components of the VFD.

3 levels of temperature allow for maximizing the availability of the VFD.

The VFD detected that the pre-warning, the warning level, or the overtemperature level has been exceeded

Possible causes and suggested remedies

1. Blocked or dirty ventilation.
    - Check if a foreign object is obstructing the air inlet or outlet.
2. A cooling fan is defective.
    - Inspect and replace defective internal cooling fans.
3. The ambient temperature is too high.

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- Keep the ambient temperature below the specified maximum operating temperature of the Clean Power VFD.

4. VFD is continuously running at or beyond its rated output current
    - Check the motor load and reduce the load if necessary. Consider using a higher-rated drive.
5. Inadequate ventilation or airflow around the drive.
    - Ensure minimum clearance around the VFD; install in a temperature-controlled and ventilated enclosure.
6. Excessive load on the VFD.
    - Reduce motor load or check application demands vs drive rating

Unknown boot state (Code: 17)

Something goes wrong during boot.

Possible causes and suggested remedies

1. Corrupted firmware or software.
    - Reinstall the VFD software and reboot the VFD. If the alarm is still activated, please escalate to the SmartD support team.
2. Incomplete or interrupted boot process due to unstable power.
    - Ensure stable input voltage during boot-up; install a line conditioner if needed

VFD high temperature (Code: 20)

Embedded temperature sensors monitor the level of heat applied to the electronic components of the VFD.

3 levels of temperature allow for maximizing the availability of the VFD.

The VFD detected that the pre-warning, the warning level, or the overtemperature level has been exceeded

Possible causes and suggested remedies

1. Blocked or dirty ventilation.
    - Check if a foreign object is obstructing the air inlet or outlet.
2. A cooling fan is defective.
    - Inspect and replace defective internal cooling fans.
3. The ambient temperature is too high.
    - Keep the ambient temperature below the specified maximum operating temperature of the Clean Power VFD.
4. VFD is continuously running at or beyond its rated output current
    - Check the motor load and reduce the load if necessary. Consider using a higher-rated drive.

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5. Inadequate ventilation or airflow around the drive.
    - Ensure minimum clearance around the VFD; install in a temperature-controlled and ventilated enclosure.
6. Excessive load on the VFD.

Line voltage swell (Code: 21)

One or more line voltages momentarily rise significantly above nominal for a brief period.

Possible causes and suggested remedies.

1. Utility capacitor bank switching, sudden energizing of capacitor banks by the utility, can cause brief voltage surges.
    - Request switching coordination or delay from the utility.
    - Use surge protection devices (SPDs) on the VFD input panel.
2. Sudden disconnection of large inductive loads. When large motors or transformers are disconnected, stored magnetic energy may spike the voltage upstream.
    - Use controlled shutdown procedures.
    - Add snubber circuits or damping devices if switching is frequent.
    - Coordinate start/stop sequences of large equipment.
3. Generator overshoot or AVR malfunction, poor voltage regulation, or sudden load shedding may cause a voltage swell.
    - Calibrate or upgrade the generator's AVR.
4. fault clearing or reclosure events on the utility side, when a utility breaker recloses after a fault, a temporary voltage swell may occur.
    - Use input surge arresters (MOVs or TVSS).
    - Enable “overvoltage delay”.
5. Poorly tuned or oversized power factor correction banks can cause overcorrection or resonance with inductive loads can raise voltage levels.
    - Use detuned or passive filter PFC systems.
    - Recalculate and retune the capacitor bank size and switching steps.
    - Coordinate with the utility or facility power quality team.
6. Lightning or nearby surge events
    - Install SPD (surge protective device) compliant with IEC 61643-11.
    - Ensure proper bonding and grounding system integrity.
    - Use shielded input cables with proper termination to ground

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Software update failed (Code: 22)

The software or firmware upgrade process was unsuccessful, which could lead to system instability, outdated features, or malfunctioning of control functions.

Possible causes and suggested remedies

1. Power loss during the upgrade process.
    a. Use a stable power supply during the upgrade process.
2. Upgrade process interrupted by external factors.
    a. Avoid interrupting the upgrade process; if an interruption occurs, restart the process after fixing the issue.

Cooling fan (1-4) fault (Code: 24 to 27)

Cooling fan (1-4) is defective.

Possible causes and suggested remedies:

1. Blocked or dirty fan. Ensure no debris or obstruction is in the fan mechanism.
    - Verify if the cooling fan is not obstructed.
2. Fan motor failure or mechanical.
    - Inspect and replace the faulty fan.
3. Fan electrical connection issue.
    - Verify and tighten all electrical connections to the fan.

Cooling fan capacity fault (Code: 28)

The VFD has detected that the cooling fan is either not working properly or is providing inadequate airflow.

Possible causes and remedies:

1. Fan speed is too low or zero.
    - Inspect fan operation and replace any faulty fan(s).
2. Fan obstructed by dust, debris, or a foreign object.
    - Clean the fan blades and airflow path; remove any obstructions or buildup.
3. Fan wiring is loose or disconnected.
    - Check and secure all electrical connections to the fan terminals.

Line unexpected voltage (Code: 29)

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Possible causes and suggested remedies:

1. Incoming line voltage is outside the specified range (either too high or too low).
    - Verify the input voltage and ensure it is within the VFD's rated voltage range.
2. Voltage spikes or surges from the utility grid.
    - Install surge protection devices or voltage suppressors on the incoming supply line.
3. Power supply instability (e.g., fluctuating voltage from generator or transformer).
    - Use voltage stabilizers or ensure a stable power supply from the generator or transformer.
4. Loose or poor connections at the incoming power supply terminals.
    - Inspect and tighten all power supply connections; clean and secure connections.
5. High line impedance causes a voltage drop under load.
    - Ensure proper wire size and reduce the distance between the VFD and power source if possible

Internal Error (Code: 30)

The firmware or the FPGA watchdog raises this alarm to indicate an issue with the Interrupt Service Routine (ISR).

Low-level communication error

Possible causes and suggested remedies:

- Hardware failures, corrupted firmware, or software.
- Reinstall the VFD software and reboot the VFD if the alarm is still activated. Please escalate to the SmartD support team.

DC unbalanced (Code: 31)

The DC bus voltage on one side of the drive's floating neutral point is too high compared to the other.

Possible causes and suggested remedies:

1. Motor control is unstable, for example, at low speeds.
    - Adjust Motor Control Settings: Reduce the start/stop ramp times to prevent rapid changes in current.
2. The DC bus voltage is not measured correctly.
    - Lower the torque boost percentage, especially at low speeds, to avoid unbalanced currents.
3. A hardware issue.
    - Restart and Retest: If the issue persists, consult the drive manufacturer's technical support for further troubleshooting

Drive Output Overcurrent (Code 32) / Acceleration overcurrent prevention

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To prevent the Clean Power VFD from going into an overcurrent alarm during acceleration, at the starting phase, or the speed change phase, the acceleration is automatically paused if the output current reaches a trigger threshold.

Possible causes and suggested remedies:

1. Drive acceleration/deceleration is too aggressive.
    - Increase acceleration/deceleration times to reduce inrush current and prevent torque spikes.
2. Sudden mechanical load spike or locked rotor.
    - Inspect the driven load for jamming, mechanical seizure, or sudden torque spikes.
3. Motor too large for VFD rating.
    - Verify the motor FLA vs. VFD rated output. Resize the drive or motor for proper capacity.
4. Loose output terminals.
    - Inspect and tighten motor terminals at both the VFD and motor ends.
5. Incorrect VFD control mode (e.g., sensorless vector vs. V/f).
    - Select an appropriate control method for motor/load type. Use sensorless/vector for torque-sensitive loads.

Simultaneous forward and reverse command (Code: 33)

The alarm is generated because a user activated forward and reverse run signals simultaneously, while the VFD has been configured to generate an alarm when receiving both forward and reverse run signals simultaneously via digital inputs.

Possible causes and suggested remedies

1. Both forward and reverse digital inputs are active at the same time
    - Review wiring and PLC logic to ensure only one direction signal is active at a time
2. Incorrect control logic in the PLC or relay contact bouncing
    - Add interlocking logic in the PLC or relay circuit to prevent both signals from being active simultaneously
3. A faulty switch or relay contacts closing both inputs
    - Inspect and replace faulty mechanical switches, contactors, or relays
4. Misconfigured input function mapping and/or priority of spinning direction in VFD parameters
    - Verify the VFD digital input assignments and priority of spinning direction to ensure correct forward/reverse mapping
5. Short circuit or wiring error connecting both direction signals.
    - Inspect wiring for shorts, miswiring, or incorrect terminal connections
6. A floating or noisy signal on digital inputs

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- Use pull-up/pull-down resistors or shielding to eliminate noise; verify clean control signals

System boot time exceeded (Code: 34)

The system remained booting for too long.

Possible causes and suggested remedies:

1. Corrupted firmware or software.
    - Reinstall the VFD software and reboot the VFD. If the alarm is still activated, please escalate to the SmartD support team.
2. Incomplete or interrupted boot process due to unstable power.
    - Ensure stable input voltage during boot-up; install a line conditioner if needed.

System degraded (Code: 35)

The VFD is functioning with reduced performance or limited functionality due to internal hardware, configuration, or communication issues.

It may still operate, but with impaired control or monitoring features

Possible causes and suggested remedies:

1. One or more services repeatedly failed during booting.
    - The Clean Power VFD must be powered off and then powered on to reboot.
    - After addressing the issue, the alarm resets automatically, and the VFD can restart the system.
    - If the issue happens again, call the technical support of SmartD.

Abnormal CPU usage (Code: 36)

The CPU usage is abnormally high.

Possible causes and suggested remedies:

- Firmware bugs or memory leaks
- Please escalate this issue to the SmartD support team if it is frequent

Abnormal memory usage (Code: 37)

The internal memory usage of the VFD is unusually high or behaves erratically.

Possible causes and suggested remedies:

- Firmware bugs or memory leaks
- Please escalate this issue to the SmartD support team if it is frequent

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DC overvoltage stall prevention (Code: 38)

The motor is decelerating, and the voltage on the DC bus is too high; the "DC Overvoltage stall prevention" alarm is raised, and an automatic action is executed to prevent the VFD from going into a DC overvoltage alarm.

Possible causes and suggested remedies:

1. The deceleration rate is too fast, causing regenerative energy to be fed into the DC bus.
    - Increase deceleration time.
2. Load has high inertia (e.g., fan, centrifuge).
    - Tune deceleration to match mechanical characteristics.

Motor overcurrent stall prevention (Code: 39)

The VFD detected that the motor current is approaching or exceeding the overcurrent threshold during acceleration, deceleration, or constant speed, and it engaged a protective function to reduce torque or slow acceleration to prevent a trip

Possible causes and suggested remedies.

1. The acceleration rate is too fast, causing high current draw
    - Increase acceleration time
2. Motor starting under heavy mechanical load
    - Reduce initial load where possible; use torque boost features
3. Load requires more torque than the motor can supply (e.g., jam, too heavy)
    - Check for mechanical obstructions or size mismatch; consider upsizing motor/VFD
4. Incorrect motor parameters configuration
    - Verify motor nameplate data; ensure proper tuning and autotuning if available
5. Motor wiring issue or partial phase loss
    - Inspect motor leads and terminal connections; check for phase imbalance
6. High inertia load causing excessive current during rapid speed change
    - Lengthen acceleration/deceleration ramps; apply torque limits
7. Improper torque or current limit settings in the VFD
    - Review and adjust torque and current limit parameters in the drive configuration

Line unexpected frequency (Code: 40)

The line configuration does not match the actual line values.

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Possible causes and suggested remedies:

1. Misconfigured VFD settings for the expected input frequency.
    - Ensure VFD is correctly set to expect the proper input frequency (50 Hz or 60 Hz, as applicable).
2. The input power source is providing incorrect frequency (e.g., generator instability).
    - Verify and stabilize the generator or alternate power source to ensure proper output frequency.
3. Utility power grid frequency fluctuation or fault.
    - Verify grid stability; install power monitoring equipment if needed.

DC unexpected voltage (Code: 41)

The line configuration does not match the line values.

Possible causes and suggested remedies:

1. An incorrect or unstable AC supply voltage causes the bus voltage to deviate.
    - Verify stable input voltage; use voltage stabilizers or correct upstream power issues.
2. Sudden load drops during braking cause bus voltage spikes.
    - Verify the application load requirements.

AFE fault (Code: 42)

Active Front-End detected line voltage sag or line voltage unbalance.

Possible causes and suggested remedies:

1. Incorrect line configuration.
    - Verify and change the input line configuration.
2. Line dips or unstable supply prevent proper AFE operation.
    - Verify the input line voltage and install line conditioners or voltage stabilizers.
3. High line impedance destabilizes the AFE
    - Analyze the grid impedance with a power quality meter and consider using isolation transformers if the impedance is too high
4. AFE hardware failure
    - Please escalate this issue to the SmartD support team

AFE low voltage ride-through (Code: 43)

Active Front-End detected line voltage sag or line voltage unbalance.

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Possible causes and suggested remedies:

1. Utility grid voltage sag or temporary drop.
    - Install line voltage monitoring; consult the utility provider if sags are frequent.
2. Excessive load during a voltage dip.
    - Reduce momentary load demand or use load shedding strategies.
3. Weak or unstable grid source.
    - Add voltage stabilizers; reinforce grid connection.
4. Poor grounding or interference affecting LVRT detection.
    - Verify and improve grounding/shielding to ensure accurate voltage sensing

Remote to local override (Code: 44)

A user has forced the VFD to go back to local mode while the VFD is remotely controlled

Possible cause and suggested remedy

The user uses the HMI or mobile app to switch back to local control mode.

Reset the lockout to resume local control

Analog output sensor loss (Code: 45)

The VFD detects a failure or disconnection in the analog output signal path to a connected actuator.

Possible causes and suggested remedies:

1. The actuator is disconnected from the analog output circuit.
    - Verify and resecure actuator wiring at both the VFD and actuator terminals.
2. Broken or loose wiring in the analog output circuit.
    - Inspect and repair any damaged cables or loose connectors.
3. Analog output misconfigured (e.g., wrong mode or range).
    - Verify analog output configuration (e.g., 0–10 V, 4–20 mA); adjust settings if needed.
4. Analog output is short-circuited or overloaded.
    - Disconnect load and test output; ensure connected device is within output capacity.

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5. Signal interference or grounding issues.
    - Improve grounding and isolation; check for noise sources.

6. Incorrect wiring polarity (e.g., reversed 4–20 mA loop wiring).
    - Recheck the polarity of analog connections, especially in current loop systems

PID process value alarms (Code: 46 and 47)

The VFD detected that the process value has crossed the minimum or the maximum user-defined alarm thresholds.

Possible causes and suggested remedies

1. Process sensor (e.g., pressure, flow, temperature) giving incorrect readings
    - Calibrate or replace the sensor; verify signal range (e.g., 4–20 mA, 0–10 V)
2. Sensor disconnected, failed, wiring open or short-circuited.
    - Inspect wiring; resecure or replace the failed sensor.
3. PID loop tuning is too aggressive or poorly set.
    - Re-tune PID gains (P, I, D); use trial-and-error method.
4. The setpoint is configured too high or too low for the current process conditions.
    - Adjust the setpoint to a realistic target for the current operating state.
5. The motor is not responding or is undersized.
    - Verify the motor’s status; confirm it can deliver the required output for control.
6. Analog input is misconfigured (wrong scaling or mode).
    - Verify analog input range and signal type; correct scaling parameters.
7. Actuator (e.g., valve, motor) not responding or stuck open.
    - Inspect and service the actuator; ensure it is functioning and controllable.
8. Incorrect PID tuning is causing overshoot or instability.
    - Re-tune the PID gains to prevent excessive overshoot; reduce proportional/integral gains.
9. Control direction set incorrectly (direct vs. reverse action mismatch).
    - Verify control direction matches the process behavior.
10. Process disturbance or load decrease causes the output to exceed the target.

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- Identify and stabilize external conditions influencing the process.

11. Feedback signal delay or sensor location causing lag.
    - Improve sensor placement or adjust derivative time to compensate for response lag.

Control board power loss (Code: 48)

The control board power supply has been lost.

Possible causes and suggested remedies:

1. Control power input (external 24 VDC) is missing or unstable
    - Verify the 24 VDC supply source; measure voltage and inspect wiring
2. Grounding issues are causing voltage reference instability
    - Ensure proper chassis and control ground connections
3. Hardware failure
    - Please escalate this issue to the SmartD support team

Motor control instability (Code: 49)

The Clean Power VFD has detected conditions that could lead to motor control instability and has stopped operating to prevent any damage.

Possible causes and suggested remedies

1. The voltage command for U/V/W phases is changing too rapidly, causing instability.
    - Verify Motor and System Parameters:
        - Double-check that all motor nameplate data (voltage, current, frequency, speed) is entered correctly into the VFD.
        - Ensure that the motor is appropriately sized for the application and load.
2. Incorrect control mode selected for the application (e.g., V/Hz mode used instead of vector control).
    - Review and Adjust Control Mode:
        - Confirm that the selected control mode matches the application requirements (e.g., use vector control for dynamic loads).
        - Switch from V/Hz to iFOC mode if more precise control is needed.
3. Instability in the Flux, Id, and Iq controllers within the Indirect Field Oriented Control (iFOC) scheme.
    - Perform Autotuning: Run the VFD's autotuning procedure to accurately measure motor parameters.

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4. Load inertia mismatch—motor is too small for the load, or control loop gains are set too aggressively.
    - Fine-Tune Advanced iFOC Parameters:
        - Check and adjust controller gains for Flux, Id, and Iq loops to achieve stable operation.
        - Reduce control loop aggressiveness if oscillations or instability are observed.
5. Presence of mechanical resonance or shaft torsional oscillations.
    - Address Mechanical Issues:
        - Inspect the system for mechanical resonance or torsional oscillations and take corrective actions (e.g., add dampers, change coupling).
        - Ensure the load inertia matches the motor capabilities, or adjust VFD parameters for high-inertia loads.
6. Encoder feedback signal noise, poor wiring, or encoder failure (in closed-loop systems).
    - Check Encoder Feedback (for closed-loop systems):
        - Inspect encoder wiring and connections for noise or intermittent contact.
        - Replace or repair faulty encoders as needed.
        - Use shielded cables and proper grounding to reduce signal noise.

Motor overspeed (Code: 50)

The motor speed is higher than the Overspeed set value, for a longer time than the Overspeed detection delay time.

Possible causes and suggested remedies:

1. Incorrect maximum speed setting in VFD parameters.
    - Verify and correct the maximum frequency or RPM limit in the VFD configuration.
2. External control signal (e.g., analog input) commanding speed above limit.
    - Scale and clamp analog input limits in VFD configuration.
3. Mechanical load disconnected (no load condition).
    - Check for coupling or load failure; confirm the motor is connected to the driven system.
4. Motor inertia is too low to resist acceleration during regenerative events.
    - Use ramp-down profiles or add mechanical damping.
5. Incorrect motor parameters in the configuration.
    - Verify the motor nameplate and the information entered in the VFD.

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6. Sudden drop in load torque (e.g., belt snap, valve opens).
    - Inspect the mechanical load for inconsistencies or failures.
7. Improper deceleration settings (too aggressive stop leads to overshoot).
    - Adjust the deceleration ramp time or enable deceleration control features.

Motor underspeed (Code: 51)

The motor speed is lower than the Underspeed set value, for a longer time than the Underspeed detection delay time

Possible causes and suggested remedies

1. Insufficient torque available from the VFD.
    - Increase motor drive capacity or check for VFD undersizing. Verify that the VFD is suitable for the motor's torque demands.
2. The mechanical load is too heavy.
    - Reduce the load on the motor or adjust system parameters to reduce torque requirements. Ensure that the motor is not overloaded.
3. The motor is not receiving sufficient power.
    - Verify the motor and VFD wiring for issues like voltage drops, poor connections, or damaged cables.
4. VFD speed reference not set correctly.
    - Verify that the reference input (e.g., analog input, Modbus, or setpoint) is configured correctly.
5. Incorrect motor or VFD settings.
    - Verify the motor's rated speed and the VFD's speed settings (e.g., min/max frequency limits, ramp-up time, etc.).
6. Inadequate acceleration/deceleration ramp settings.
    - Increase the acceleration ramp time to allow the motor to reach speed gradually without overloading.
7. Loss of motor load (e.g., motor uncoupled from driven equipment).
    - Ensure the motor is properly coupled to the driven equipment. Check for mechanical disconnections or failures.
8. Power supply issues (voltage sag, imbalance, etc.).
    - Verify the power supply for voltage dips, imbalances, or other power quality issues that might be affecting motor speed.

Motor wrong direction (Code: 52)

The detected motor rotation is opposite to the actual rotation direction (command + active output) for a longer time than the reverse rotation detection delay.

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Possible causes and suggested remedies:

1. The incorrect motor rotation direction is set in the VFD.
    - Verify the VFD settings for motor rotation direction. Reverse the motor rotation direction in the VFD configuration if necessary.
2. Incorrect wiring of motor leads (phases swapped).
    - Inspect the motor connections. Swap any two of the three motor leads (phases) or reverse the motor rotation direction in the VFD configuration to reverse the direction of rotation.
3. Control signal error.
    - Verify the input control signals (e.g., digital inputs, Modbus, etc.). Check if the wrong direction command is being sent to the VFD.
4. Faulty or incorrect direction command (e.g., 2-wire or 3-wire control).
    - Verify the control logic wiring for proper configuration (e.g., ensure correct start/stop and direction control). Adjust wiring for 2-wire or 3-wire control as required.
5. Reversed connections at the control terminals.
    - Verify if any reversed connections at the control terminals might cause the motor to rotate in the opposite direction. Reverse the motor rotation direction in the VFD configuration if necessary.

Encoder speed error (Code: 53)

The discrepancy between the speed feedback by the encoder and the speed estimated by the VFD is high.

Possible causes and suggested remedies:

1. Incorrect encoder wiring (A/B/Z phases reversed or disconnected)
    - Verify all encoder connections. Ensure correct wiring of A, B, and Z (index) channels according to the user guide
2. Faulty encoder or signal degradation
    - Test the encoder for proper output signals using an oscilloscope or encoder tester. Replace the encoder if the signals are weak or erratic
3. Encoder not mounted securely or misaligned
    - Verify the mechanical alignment between the motor shaft and the encoder. Re-align or re-mount securely
4. Electrical noise or interference
    - Ensure proper shielding of encoder cables. Use twisted pair, grounded shielded cables, and route away from power lines
5. Incorrect encoder settings in the VFD

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- Confirm encoder PPR (pulses per revolution) and direction settings in the VFD parameters.

6. The encoder signal polarity is inverted
    - Reverse encoder signal phase wiring (e.g., swap A+ and A−) to correct direction mismatch
7. Broken encoder cable or loose connector
    - Inspect the encoder cable and connectors for signs of wear, damage, or loose connections. Replace if needed.

Encoder communication error (Code: 54)

The signal on phase A or B is missing while the motor is running. Or the pulse frequencies between channels A and B are different.

Possible causes and suggested remedies:

1. Disconnected or loose encoder cable.
    - Inspect all encoder cables and connectors. Reseat or replace any loose or damaged connectors.
2. Broken or damaged encoder cable
    - Check for cuts, pinches, or internal breaks in the encoder cable. Replace the cable if faulty.
3. Electrical noise or interference
    - Route encoder cables away from high-voltage or switching power cables. Add ferrite cores if needed.
4. Encoder power supply issue (voltage too low or unstable)
    - Measure the encoder supply voltage. Verify it's within tolerance and stable.
5. Faulty encoder hardware
    - Test or replace the encoder. Use a working encoder of the same type to confirm the issue.

Analog input loss (Code: 55, 56, 57)

This alarm arises if the analog input is configured for a 4..20 mA input signal and the current value falls under 3 mA for a duration longer than the triggering time delay.

Possible causes and suggested remedies:

1. Faulty wiring or loose connections: The wiring connecting the analog input to the VFD could be faulty, or there could be a loose connection.
    - Check the wiring and connections: Inspect the wiring and ensure all connections are secure.
2. Signal interference: There could be interference affecting the 4-20mA signal.
    - Check the 4-20mA signal: Use a multimeter to check the 4-20mA signal for any possible interference. Ensure proper grounding and shielding of analog cables. Avoid routing near high-voltage or switching circuits.

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3. Faulty sensor or transmitter: The device providing the 4-20mA signal could be faulty.
    - Test the sensor independently or replace it with a known good unit to verify function.
4. Sensor power supply failure (24V DC or loop power).
    - Verify that the sensor's power supply is active and providing the correct voltage. Replace if needed.
5. Incorrect sensor type selected (voltage vs current)
    - Ensure the VFD analog input is configured for the correct signal type: 0–10 V, 4–20 mA, etc.
6. Short circuit or open circuit in the sensor loop
    - Measure resistance and continuity in the analog loop. Repair or replace faulty wiring.

Modbus Comm Loss (Code: 58)

The Modbus TCP communication has been interrupted for some time.

Possible causes and suggested remedies:

1. The most common cause is network connectivity issues, which could be caused by faulty Ethernet cables, switches, or routers.
    - Ensure all network equipment (cables, switches, routers) functions correctly. Replace any faulty equipment.
2. The Modbus TCP device could malfunction or be powered off.
    - Ensure that the Modbus TCP devices are powered on and functioning correctly. Restart the devices if necessary.
3. If the network is overloaded with traffic, it could cause delays or interruptions in communication.
    - If the network is overloaded, try to reduce the network traffic. This could involve moving some devices to a different network or increasing the network’s capacity.
4. Incorrect or unsupported Modbus function codes.
    - Ensure the TCP client sends only supported function codes (e.g., 03, 06, 16). Consult the Modbus specifications

VFD High ambient temperature (Code: 59)

Embedded temperature sensors monitor the level of heat applied to the electronic components of the VFD.

3 levels of temperature allow for maximizing the availability of the VFD.

The VFD detected that the pre-warning, the warning level, or the overtemperature level has been exceeded

Possible causes and suggested remedies

1. Blocked or dirty ventilation.
    - Check if a foreign object is obstructing the air inlet or outlet.

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2. A cooling fan is defective.
    - Inspect and replace defective internal cooling fans.
3. The ambient temperature is too high.
    - Keep the ambient temperature below the specified maximum operating temperature of the Clean Power VFD.
4. VFD is continuously running at or beyond its rated output current
    - Check the motor load and reduce the load if necessary. Consider using a higher-rated drive.
5. Inadequate ventilation or airflow around the drive.
    - Ensure minimum clearance around the VFD; install in a temperature-controlled and ventilated enclosure.
6. Excessive load on the VFD.

Motor temperature sensor shorted (Code: 60)

The VFD detects a short circuit condition in the motor's temperature sensor circuit.

Possible causes and suggested remedies

1. Sensor wires are shorted (either internally or externally)
    - Inspect the wiring between the motor and VFD for shorts. Repair or replace damaged cables
2. The temperature sensor is internally shorted or has failed
    - Test the sensor resistance with a multimeter. Replace the sensor if it measures near zero ohms or out of spec
3. Wrong wiring configuration (e.g., grounded lead)
    - Verify wiring matches the VFD's requirements.
4. Sensor wiring pinched or damaged during motor installation
    - Trace the wiring from the motor to the drive to check for mechanical damage or improper routing
5. Faulty analog input on the VFD
    - If wiring and sensor are verified good, test another sensor input on the VFD or use an external sensor. If the cause is a faulty analog input, please escalate this issue to the SmartD support team

Motor phase loss (Code: 61)

A disconnection of one phase between the drive and the motor happened.

Possible causes and suggested remedies

1. The output wiring is faulty (Loose or disconnected terminal at the VFD or motor).

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- Check the output wiring on the Clean Power VFD side and the motor side. Tighten all output terminal connections at both the VFD and motor ends.

2. If you use a contactor between the Clean Power VFD and the motor, it may be defective.
    - Check the contactor wiring. Replace the contactor.
3. Fuse blown, connectors untightened, cut cable.
    - Check the wiring and fuses, fix the issue, and then restart the VFD after the alarm is acknowledged and reset.
4. Faulty VFD output stage.
    - Look at the VFD’s output waveforms, and if missing, please escalate this issue to the SmartD support team

Motor Stalled (Code: 62)

The motor failed to reach or maintain the speed commanded by the VFD.

Possible causes and suggested remedies

1. Mechanical Issues:
    - Excessive Load: This could be due to the driven mechanism being overloaded or jammed, which impedes the motor's function.
        - The solution to this issue could be to reduce the load on the motor. This could involve adjusting the driven mechanism to ensure it is not overloaded or jammed. Regular maintenance and inspection can also help prevent this issue.
    - Seized Bearings: If the motor bearings are worn out or damaged, they can cause the motor to bind and stall.
        - If the motor bearings are worn out or damaged, they should be replaced. Regular lubrication and maintenance of the bearings can also help prevent them from seizing. Faulty bearings, misalignment, or excessive friction in the driven machine can reduce the load on the motor.
2. Electrical Issues:
    - Insufficient Power Supply: An inadequate power supply can prevent the motor from reaching the necessary speed.
        - This issue could be resolved by ensuring the VFD is delivering the proper power supply in voltage and current. It might also be worth checking the VFD settings for any issues that could be causing a drop in power
    - VFD Setting Errors: Incorrect configuration of VFD parameters can result in inadequate motor control.
        - If the VFD parameters are incorrectly configured, they will need to be adjusted. This might involve consulting the motor and VFD manuals or contacting a professional.
    - Wiring Faults: Poor electrical connections can disrupt the flow of power to the motor, leading to stalling.
        - Poor electrical connections should be repaired to ensure a consistent flow of power to the motor. Regular inspection of the wiring can help identify any potential issues before they lead to a stall.

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Motor disconnected (Code: 63)

The VFD cannot detect the motor connected to its output terminals.

Possible causes and suggested remedies

1. The motor is physically disconnected from the VFD.
    - The connection between the motor and VFD is faulty (loose wires, damaged terminals).
    - Verify the motor connection, then the VFD can be restarted.
2. Motor internal open circuit (e.g., broken winding).
    - Perform motor winding resistance check; repair or replace motor.
3. There's an internal issue with the VFD's motor detection circuit.
    - Please escalate this issue to the SmartD support team

Motor application underload (Code: 64)

The current has fallen below the "Min Load Current" for the duration of the trigger delay.

Possible causes and suggested remedies

1. Broken or disconnected mechanical load (e.g., belt, coupling, gearbox).
    - Inspect the mechanical connection between the motor and load. Reattach or replace failed mechanical parts.
2. Loose or slipping coupling or belt.
    - Tighten or replace any worn or loose mechanical transmission components.
3. The motor is oversized for the application
    - If this is not a fault condition, consider adjusting trip thresholds or using a smaller motor.
4. Incorrect motor parameters were entered during tuning.
    - Verify and correct motor nameplate data in VFD settings; re-run auto-tuning if needed
5. For a pumping application, the pump runs dry (no fluid to move)
    - Check for fluid supply issues (valve closed, empty tank). Refill or fix the supply path.
6. Fan or blower obstruction removed (e.g., air damper opened unexpectedly).
    - Verify air path integrity. Inspect dampers, vents, and filters for correct positioning.
7. Process line interruption or no material present (e.g., conveyor empty).
    - Ensure the material feed is functioning correctly. Resume normal process input.

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Motor auto-restart failure (Code: 65)

The VFD failed to restart the motor after the specified number of restarts.

Possible cause and suggested remedy:

- Auto-restart configuration issues: restart delay too short or maximum number of restart attempts too low
- Increase the restart delay or maximum number of restart attempts

AFE low voltage ride through cannot recover (Code: 66)

The VFD was unable to recover from an AFE low-voltage ride-through condition due to a severe or prolonged voltage drop.

Possible causes and suggested remedies:

1. Prolonged voltage sag beyond ride-through capacity. The voltage drop was either too severe or lasted too long. The compensation on the VFD's motor control was insufficient, and the DC bus voltage became too low, leading to the inability to maintain normal operation.
    - Check the Power Supply: Inspect the incoming power supply for signs of instability, such as voltage fluctuations, sags, or outages. Verify if there were any recent power disturbances in the area.
    - Evaluate the Severity of the Voltage Dip: Determine the cause and duration of the low-voltage condition. If a transient event caused the dip, you may need to monitor the power supply more closely or consider additional protective measures.
2. Faulty grid or unstable power source. Frequent occurrences of this alarm may indicate a broader issue with the power quality or the VFD setup. It's essential to address the root cause to prevent future interruptions and potential damage to the VFD or motor.
    - Consult with Your Power Provider: If the low voltage event is related to the quality of the external power supply, you may need to contact your power provider for further investigation or mitigation.
    - Consider Power Conditioning Solutions: If low voltage events are frequent, you might want to consider installing additional power conditioning equipment, such as voltage stabilizers, uninterruptible power supplies (UPS), or line conditioners to protect against such events.

Drive overload (Code: 67)

The current drawn by the motor and load exceeds the maximum output current capability of the VFD for an extended period.

Possible causes and suggested remedies:

1. Sustained current on the load is above the VFD’s capability.
    - Check Motor Load vs. VFD Capacity: Ensure the actual motor load does not exceed the VFD’s rated output. If the load consistently exceeds the drive’s capability, consider upgrading to a higher-capacity VFD.
2. Short acceleration time causes excessive current surge.
    - Adjust Acceleration Ramp Time: Increase the acceleration ramp time in the VFD settings to reduce current surges during startup.

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3. The drive is improperly sized for the motor or application.
    - Verify Drive Sizing: Compare the VFD's output rating with the motor's full load amps (FLA) and the application's duty cycle.
4. Mechanical load torque spikes, intermittent jams, or binding.
    - Inspect Mechanical System: Check for any signs of mechanical binding, irregularities, or impact loading in the driven equipment. Address any issues causing torque spikes or intermittent jams.

PIN invalid (Code: 68)

An incorrect PIN has been entered, the HMI displays the message "Invalid PIN. Please try again."

Possible causes and suggested remedies

The user entered an invalid PIN

Verify the PIN entered by the user and try again; ensure no typos or incorrect digits (reset to default factory while disabled, and reset the PIN).

Damper feedback loss (Code: 69)

The controlled fan is running, and the damper limit switch indicates the damper is closed, or a damper feedback signal is lost.

Possible cause and suggested remedy:

- The digital input connected to the damper feedback sensor indicates that the damper is closed, even though the motor is still running—the damper feedback sensor has a connection issue.
- Verify the damper feedback sensor or its connection.

External start-stop feedback timeout (Code: 70 and 71)

The damper limit switch does not indicate the expected position of the damper within the user-defined time.

Possible causes and suggested remedies:

1. The damper feedback signal was not received by the VFD when the motor was already magnetized.
    - Verify the damper feedback sensor or its connection
2. Verify the damper mechanism, the damper feedback sensor, and its connection.
    - Inspect the damper and actuator for mechanical obstruction or motor failure. Manually test the damper movement.
3. No power to the damper actuator.
    - Check the power supply and control signals to the actuator. Restore power or replace the fuse/relay.
4. Faulty damper position switch (feedback device failed)

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- Test the feedback switch manually. Replace if not switching or giving the correct signal

5. Incorrect digital input assignment in VFD settings
    - Verify that the correct digital input is configured as the "Damper Closed" feedback in VFD parameters.
6. The timeout period is set too short.
    - Extend the damper feedback timeout delay to accommodate longer damper closing times.

Motor ground fault (Code: 72)

A ground fault happens when an energized conductor unintentionally contacts the ground, often due to insulation failure, moisture, or wiring issues. It can cause equipment damage, fire hazards, and electric shock, so prompt detection and correction are vital for safety and reliability.

Possible causes and suggested remedies

1. Damaged insulation: This is the most frequent culprit. Over time, insulation on motor windings or cables can degrade due to heat, vibration, exposure to chemicals, or simply age. When the insulation weakens, the current can "jump" to the ground.
2. Moisture ingress: Water or other liquids entering the motor can cause a path for current to leak to the ground. This can happen due to condensation, leaks, or improper installation in a humid environment.
3. Contamination: Dust, dirt, or metallic debris inside the motor can bridge the gap between the windings and the ground, causing a fault.
4. Manufacturing defects: In rare cases, the motor itself might have a manufacturing defect that leads to a weak spot in the insulation, predisposing it to ground faults.
5. Damaged cable sheath: The cable connecting the motor to the power source might have a damaged outer sheath, exposing the live wires and increasing the risk of a ground fault.

If the MOTOR GROUND FAULT alarm occurs:

1. **Power off the VFD completely.**
2. Disconnect the motor cables from the drive output terminals (U, V, W).
3. Perform an insulation resistance test on the motor and cables to ground using a megohmmeter.
4. Inspect for:
    - Damaged or degraded insulation
    - Moisture ingress or condensation inside the motor
    - Dirt, dust, or contamination
    - Visible damage to cables or connections

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- Manufacturing defects in the motor

5. Repair or replace damaged components as necessary:
   - Rewind or replace motors with compromised insulation.
   - Replace damaged cables.
   - Resolve environmental issues like moisture or excessive dust.
6. Reconnect and retest before returning the drive to service.

Motor Thermal Overload (Code: 78)

What happens: The **Motor thermal overload** alarm indicates the drive's protection has determined the motor is **too hot for continued operation**.

Possible causes and suggested remedies

1. **High demand at start/acceleration**
   due to short accel time, heavy inertia, high friction, or jammed load.
   - you should lengthen the acceleration time; smooth the acceleration with the multi-segment ramp; avoid repeated start/stop bursts.
2. **Low-speed heating on self-cooled motors**
   Poor airflow at low RPM; extended low-speed dwell.
   - you should limit long runs at very low Hz for self-cooled motors or add forced cooling.
   - Inspect airflow & ambient: Clear vents/filters, confirm fan operation, measure enclosure temperature.
3. **Motor Load Curve not representative of the duty**
   - The Motor Load Nominal (I/IN) is set too high (overstates typical load) or too low (understates load, then acceleration overheats).
4. **Forced cooling not enabled** (when a blower/aux cooling actually exists)
   - Cooling Type left at *Self-cooled*
5. **Mechanical issues**
   Misalignment, bearing wear, product buildup increasing torque, partially blocked pump/duct.
   - you should verify alignment, bearings, belt tension, product buildup, valve/impeller obstruction.
6. **Electrical issues**
   Phase imbalance/phase loss, incorrect motor data, undersized cables, weak supply leading to high current.

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- you should check electrical health: Verify phase balance, terminals, cable sizing, supply stability; compare measured FLA to nameplate.

7. **Frequent hot restarts**
   Settings for *Cold Start* on a still-hot motor or short off-time between cycles.
   - For frequent brief outages, set Motor Temperature at Power-Up = Retain Last Temperature to avoid “cold” assumptions on a hot motor.

If the alarm occurs immediately on start:

- Increase accel time; ensure load can move freely (no jam).
- Confirm motor is correctly sized; reduce commanded torque if possible.
- Verify **I/IN** isn’t grossly under-set (which would make the model too strict during start).

If the alarm clears too slowly:

- Allow more cool-down time; reduce ambient temperature; improve ventilation/airflow.
- For self-cooled motors, avoid prolonged low-speed operation right after a hot stop.

If alarms are frequent at “normal” load:

- Measure actual continuous current with a clamp meter and **re-set I/IN** accordingly.
- Confirm cooling type; consider adding/enabling forced cooling.
- Re-evaluate process setpoints causing persistent high torque.

When to escalate:

- Repeating alarms after steps above, or rapid heating with normal current.
- Provide support with: motor nameplate, measured I/phase currents vs speed, TCU% trend around the event, ambient/enclosure temps, Cooling Type/I/IN settings, and mechanical load description.

BACnet IP communication loss (Code: 80)

BACnet IP Communication Loss alarm is triggered unexpectedly

Possible causes:

- the BACnet client is not writing periodically to the heartbeat object

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- the correct heartbeat object is not used
- the BACnet client write rate is shorter than the trigger delay
- the Ethernet network is not stable
- there is excessive network delay or packet loss
- the trigger delay is too short

Communication is lost but no alarm is triggered

Possible causes:

- is BACnet enabled ?
- is the BACnet IP Communication Loss alarm enabled ?
- is the heartbeat object correctly implemented by the BACnet client ?
- is the trigger delay is set too high ?

Intermittent BACnet IP Communication Loss alarms occur

Possible causes:

- unstable network traffic
- inconsistent BMS task execution
- heartbeat writes that are too slow or irregular
- trigger delay too close to the actual heartbeat interval

Previous Next

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15.6. Alarms reset/acknowledgment

Acknowledgment

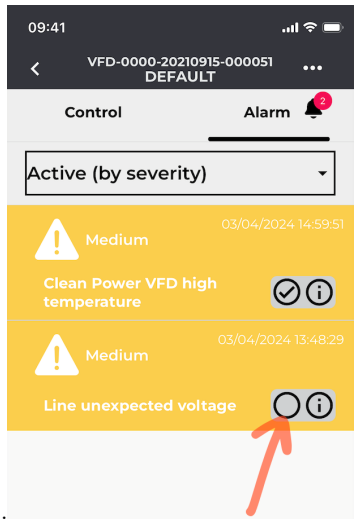
Alarm acknowledgment is a function to let other users know that you have seen the alarm.

Alarm acknowledgment does not remove nor reset the alarm.

It is recommended to visit the alarm page and acknowledge each alarm one by one after reviewing the potential root cause of each alarm.

How to acknowledge alarms?

Open the alarm page in the App or the HMI. The active alarms are displayed with their criticality color code.



By clicking on the button ...

How to reset alarms?

see the section "System reset"

Previous Next

Previous Next

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15.7. Bluetooth pairing issue

The mobile app may crash if it has not been granted permission to use the Bluetooth connection of your smartphone.

To fix this, you must allow SmartDrive App to connect to nearby devices.

To find and connect to nearby devices over Bluetooth, your phone asks for Location permission. This is an operating-system requirement on some versions of Android and iOS. We do not use your location for anything else.

Android:

1. Accessing Settings:

Unlock your Android device and locate the "Settings" icon, which typically looks like a gear or cogwheel. Tap on it to open.

Scroll down until you find "Connections" or "Connected devices" (the naming may vary based on the device).

2. Turning Bluetooth On:

Tap on "Bluetooth".

Toggle the switch to the "On" position, usually represented by a blue color.

3. Granting App Permissions:

Go back to the main "Settings" menu.

Locate and tap on "Apps" or "Apps & notifications".

Find and select the app "SmartDrive" to grant Bluetooth permissions.

Tap on "Permissions".

Find "Bluetooth" in the list and toggle the switch to allow the app to use Bluetooth.

Then allow Nearby devices, then reopen the app.

iOS:

1. Accessing Settings:

Unlock your iOS device and locate the "Settings" app, which is represented by a gear icon. Tap on it to open.

2. Turning Bluetooth On:

In the "Settings" menu, tap on "Bluetooth".

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Toggle the switch to the "On" position. When it's on, the switch will turn green.

3. Granting App Permissions:

Go back to the main "Settings" menu.

Scroll down and find the app you want to grant Bluetooth permissions to from the list of installed apps.

Tap on the app's name: "SmartDrive".

Under the "ALLOW SMARTDRIVE TO ACCESS" section, toggle the switch next to "Bluetooth" to the "On" position, turning it green.

And enable the location.

Note: Always ensure that your Bluetooth permissions are only granted to trustworthy apps, and always turn off Bluetooth when not in use to save battery and enhance security.

Previous Next

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15.8. Export support package

This feature allows a user to export a technical support package, which is a file containing all useful debugging information at a snapshot in time to assist the SmartD team with addressing issues.

The user can generate a technical support package from any system state and can generate multiple packages as needed.

The name of the generated file follows the pattern `sd-sp-<drive_serial_number>-<date>-<unique_integer>.tar.gz`

Export a support package to a USB drive for the HMI menu

The support package is created from the HMI.

Go to **Menu > About > Diagnostic**.

In the menu Diagnostic, select Export support package and follow the displayed instructions.

The packages are saved on a USB drive; the number of packages is just limited by the size of the USB drive.



Download a support package with the mobile app

You can also export and download the support package directly to your phone using the SmartD mobile app.

On the app, go to **About > Diagnostic > Export Support Package**,

choose Mobile as the target location, and start the export.

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The app will download the file to the phone and allows you to share it (email, cloud drive, messaging, etc.) on both iOS and Android. A progress indicator is shown during transfer.

This method is useful when a USB drive is not available. Only one support package is stored on the VFD at a time; creating a new one overwrites the previous package.

Previous Next

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15.9. Ping Support Configuration

The VFD provides the ability to enable or disable Ping support for network diagnostics and security. By default, the Ping support is enabled for continuous monitoring. Users can modify Ping support settings via the HMI or mobile app.

Enabling/Disabling Ping

Users can enable or disable ping (ICMP requests) through the HMI or the mobile app.

- **When enabled**, the VFD will respond to ICMP ping requests.
- **When disabled**, the VFD will stop responding to ICMP ping requests and close the ICMP port.

Each change in Ping support settings is recorded in the audit log for security and traceability purposes.

Default Ping Behavior

- Ping support (ICMP) is **enabled by default** to allow continuous network monitoring.
- Users can override this setting through the HMI or mobile app as needed.

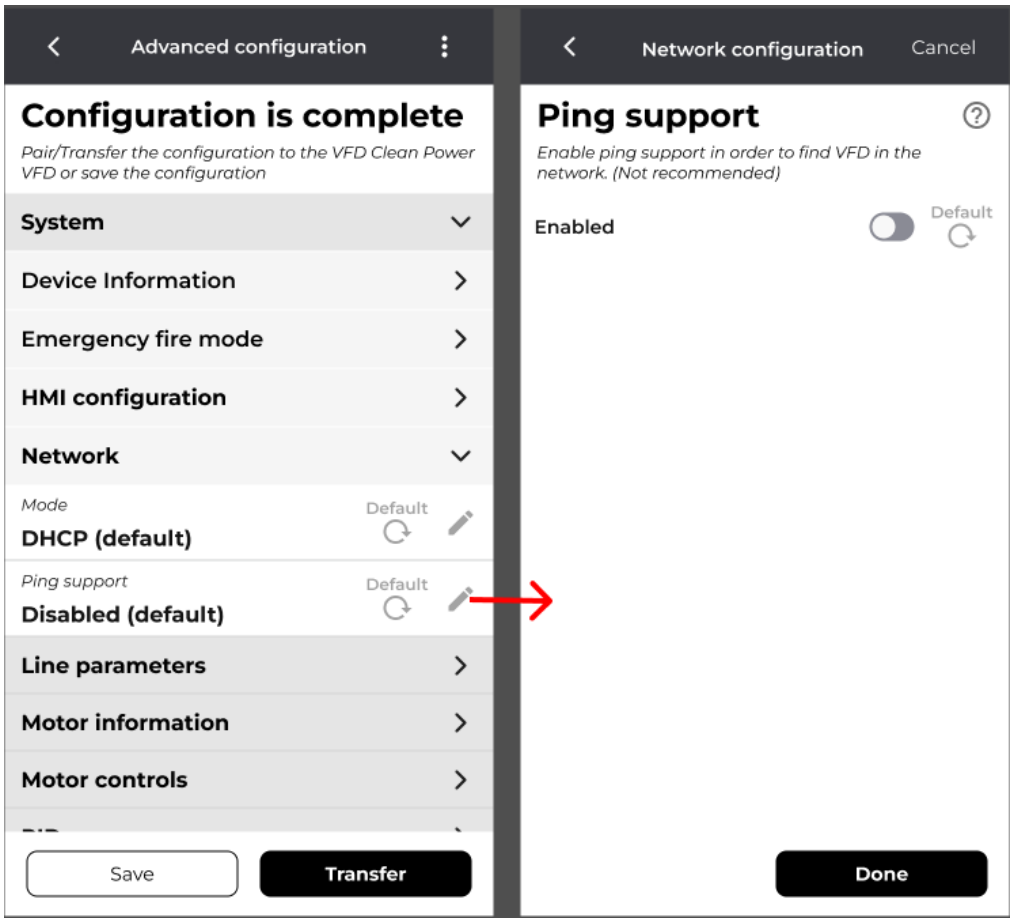
Accessing Ping support Settings

To modify Ping support settings:

1. Navigate to **Network** settings under **System** in the HMI or mobile app.
2. Select **Ping support**.
3. Toggle the **Enabled** switch to enable or disable Ping support feature.
4. Confirm the setting to apply changes.

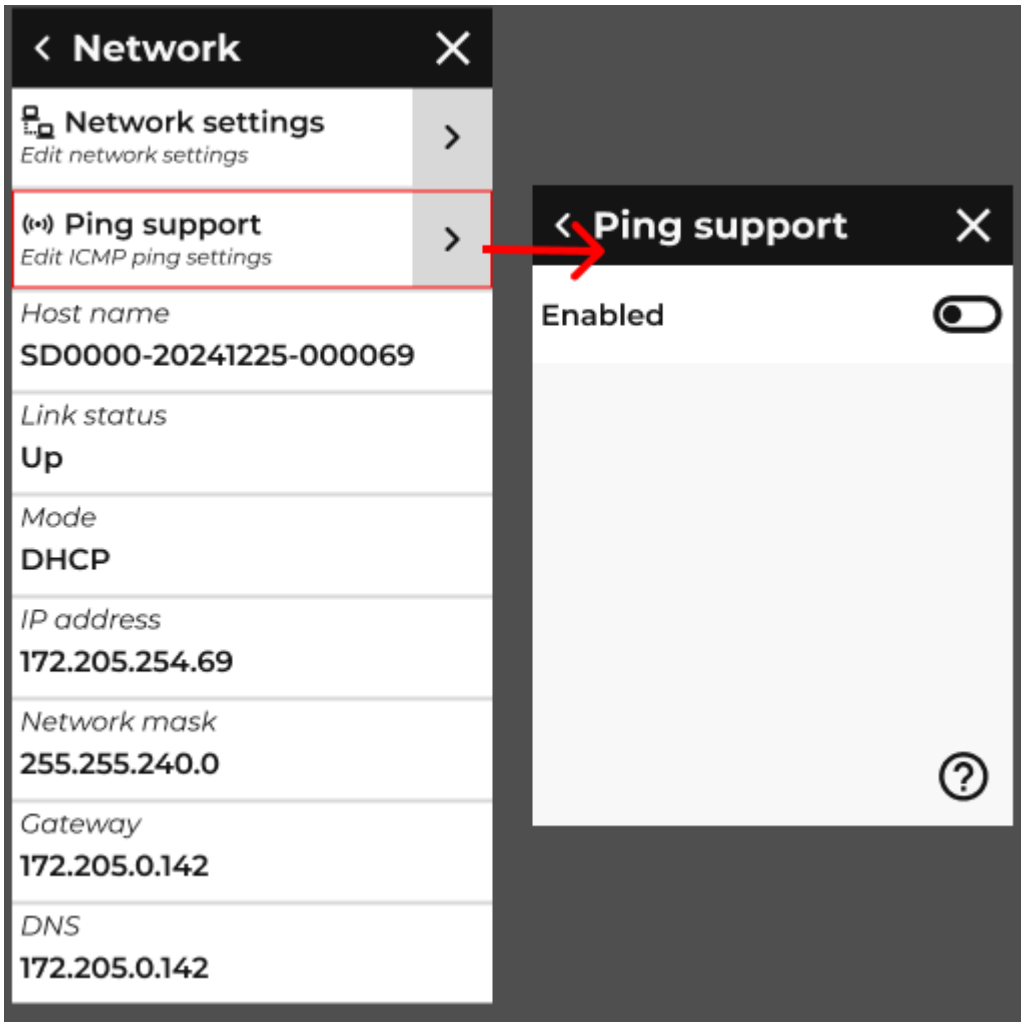
Mobile application:

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HMI:

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Audit Logging

Each change in Ping support settings is logged in the VFD's audit log, including:

- Timestamp of the change
- Whether Ping support (ICMP) was enabled or disabled
- If enabled for a specific duration, the configured duration

This ensures transparency and traceability of network configurations.

Notes

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- Continuous Ping (ICMP) monitoring helps diagnose network connectivity but may pose a security risk if enabled in unsecured environments.
- Users should disable Ping support when not required to enhance network security.

Previous Next

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16. Clean Power VFD operation

This section explains how the Clean Power VFD is operating.

The explanations aim to give more information to variable frequency drive experts.

Previous Next

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16.1. VFD IoT Health Monitor

The Health Monitor is responsible for system state management and transitions coordination, as well as for handling system state transitions based on faults, alarms, and defined system service behavior.

As such, it forms a central component in the Clean Power VFD operation and can be seen as the control center for all of the other modules and the central point of coordination between the IoT subsystem and the OS and related system processes at the lower level.

IoT services start-up sequence

The IoT services follow this order when they get started:

- IoT-health-monitor: this gives the health monitor time to verify the status of the banks and to get ready to receive messages from other services
- IoT-alarm-service: this makes the alarm service ready before the other services, allowing it to catch alarms and report them to the already-started health monitor
- All the other services can then boot, with some dependencies for some of them (e.g. the iot-vfd-service comes after the iot-firmware-proxy)

Booting

The health monitor starts with several checks when booting.

It first verifies the status of the banks. If the VFD unexpectedly booted from the backup bank an alarm is raised. Another one is raised if the VFD was forced to restore the factory settings due to the backup bank being incompatible with the data present in the database.

Then, it checks if all the services seem to boot properly, it verifies that the allowed boot time is not exceeded and raise an alarm if the system is degraded (one or more service cannot start properly).

Normal operation

Once the system has exited the booting state, the health monitor keeps monitoring the system state (see the section on system states)

It also keeps track of the status of the services:

Each service is responsible to ping the health monitor at regular intervals, showing it is responsive and running normally. If no new ping is received after 60 seconds, the service is considered unresponsive.

Previous Next

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16.2. Emergency Fire Mode

DANGER

Emergency Fire Mode unavailable condition may not be signalled

Emergency Fire Mode must be available and correctly monitored before it is relied on for a fire response application.

If Emergency Fire Mode is enabled but is not available, and if the alarm relay is not configured to signal **Any alarm above Minor**, the unavailable condition may not be reported to the fire alarm system, building management system, or emergency response personnel.

This can create a false indication that Emergency Fire Mode is ready while the function is not available. In a fire event, this can prevent the expected fan or motor operation and can lead to smoke control failure, loss of pressurization, equipment damage, serious injury, or death.

When the system could trigger the Emergency Fire Mode, configure the alarm relay to signal **Any alarm above Minor.**

Before commissioning the installation, test the Emergency Fire Mode unavailable condition and verify that the alarm is correctly signalled to the required fire safety interface and to emergency response personnel.

Overview of Emergency Fire Mode (EFM):

The Emergency Fire Mode (EFM) is an essential safety feature designed to keep critical systems operational during a fire event.

In applications where continuous operation of certain systems is critical for life safety—such as smoke extraction fans or pressurization fans—the EFM function of the Clean Power VFD enables these systems to operate under adverse conditions, even if that means bypassing typical safety protocols.

Standard VFD Operation vs. Emergency Fire Mode:

Under normal circumstances, the VFD controls the speed and torque of an electric motor by adjusting the frequency and voltage supplied to the motor. This allows for efficient control of motor performance and energy usage.

However, in the event of a fire, specific systems must continue running at full capacity to help manage smoke levels and improve visibility, potentially aiding in evacuation and rescue efforts.

When EFM is activated, the VFD temporarily overrides its usual control settings. It keeps the motor running at full speed, irrespective of any faults or abnormal conditions that might typically trigger a shutdown.

This override helps maintain essential building ventilation during a fire, supporting efforts to limit smoke spread and, in turn, enhancing life safety.

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Emergency Fire Mode (EFM):

To initiate the Emergency Fire Mode, the VFD relies on an integrated response to signals from the building's fire alarm system. The activation process follows these steps:

1. **Fire Alarm System Integration:** The VFD is typically connected to the building's fire alarm system. Upon fire alarm activation, a signal is sent directly to the VFD.
2. **Signal Interpretation:** The VFD recognizes this input as a command to enter EFM mode.
3. **Mode Activation:** Once the signal is received, the VFD immediately overrides its standard operation, attempting to run the connected motor at full speed.
   In this mode, the VFD disregards any faults or conditions that would normally trigger a shutdown, ensuring continuous operation of the motor.

Due to the high-stakes nature of EFM, automatic activation via the fire alarm system is usually prioritized to ensure a quick response. However, depending on specific regulations, user preferences, or system design, a manual activation option may also be included.

! Important Safety and Compliance Considerations:

While the Emergency Fire Mode provides critical operational support in fire events, it is essential to recognize that compliance with local safety regulations is the responsibility of the user or building operator, not the VFD manufacturer.

The system's design, integration, and periodic testing to ensure its proper function fall under the user's purview to maintain compliance and safety standards.

Configuration:

EFM can be activated and deactivated by

- a digital input
- the local HMI and mobile app
- Modbus if Modbus TCP is enabled
- BACnet IP if BACnet IP is enabled

The user can select the emergency fire mode action via the local HMI and mobile app.

The action options are:

1- Keep current motor operation (default action)

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2- Fire mode speed and direction

- Depending on the configured motor control mode, the user can define the emergency fire mode preset value (RPM or Hz or %).
- The emergency fire mode preset value must be within the minimum and maximum value of the motor speed frequency or torque limits.
- The user can define the motor direction: forward or reverse if the “allow reverse” configuration parameter is enabled.

3- Coast to stop

When the PID function is enabled, the user must define the emergency fire mode PID setpoint (default value: 0).

Audit logs:

The emergency fire mode action changes are logged in the audit log.

Dependencies:

If the “allow reverse” is disabled in the motor controls, the user can not select the option " Fire mode speed and direction".

If the “bump-less change of direction” is disabled in motor controls, the user can not select the option " Fire mode speed and direction".

Operation:

When the **emergency fire mode is activated**, the VFD changes to the emergency fire mode state.

In the emergency fire mode state:

- The VFD ignores all alarms (no alarms are raised and logged) except critical and hardware alarms.
- The VFD ignores all commands from the remote control source (except the DI assigned for emergency fire mode)
- The VFD ignores all commands from the local control (HMI and mobile app) including STOP.
- The VFD executes the configured emergency fire mode action.
- The mobile app and local HMI display the emergency fire mode state
- The HMI LED IS blinking red.

Once the emergency fire condition is cleared and the **emergency fire mode is deactivated**, the user must perform a reset to exit the emergency fire mode and go back to normal operation.

Previous Next

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16.3. Maintenance Mode

The Maintenance Mode allows users to temporarily disable specific motor-related alarms and place the Clean Power VFD into a maintenance state.

This mode is designed for troubleshooting, commissioning, or performing system maintenance without triggering nuisance alarms.

While in Maintenance Mode, the VFD remains operational and fully controllable by the user, but key motor protection features are deactivated.

- When to Use Maintenance Mode
- Key Effects of Maintenance Mode
- Disabling Maintenance Mode
- Audit Logging

When to Use Maintenance Mode

- During **motor maintenance** or **commissioning.**
- When performing **system diagnostics.**
- To **avoid false alarms** during expected off-nominal motor behavior.
- For **temporary manual operation** without fault interruption.

Key Effects of Maintenance Mode

When activated:

- The VFD enters the **Maintenance** state.
- The motor **stops by using the normal ramp-down profile** if it is running.
- The following alarms are **disabled**:
    - Motor Current Balance
    - Motor Overcurrent
    - Motor Phase Loss
    - Motor Stalled

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- Motor Disconnected
- Motor Wrong Direction
- Encoder Speed Error
- Encoder Communication Failure
- Motor Overload
- Motor Overspeed
- Motor Underspeed
- Motor Application Underload
- Motor Ground Fault

- The **user retains full control** of the VFD.
- The **VFD status** is displayed as "Maintenance" on both the mobile app and the HMI.

If the forced value falls outside the user-defined process value limits, leading to a low or high process value condition, it indicates a configuration issue. As a result, the VFD will operate in degraded mode and trigger an alarm. The action taken by the alarm will depend on the following:

- Stop freewheeling: The motor will come to a halt.
- Forced value: Output the forced value (which is already in force).
- Keep actual speed: This action will not be executed.

Enabling Maintenance Mode

From HMI or Mobile App

1. Navigate to:
   - **Menu > About > Diagnostic > Maintenance Mode**
2. Toggle the **Enable Maintenance Mode** switch
3. A **warning message** will be displayed listing the deactivated alarms and potential risks
4. You must **acknowledge and confirm** to proceed

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5. Once confirmed:
    - The VFD enters the OOS state
    - The top banner turns **gold**
    - VFD will stop (if running) and be ready for manual operation

From Remote Control Sources

You can also enable/disable Maintenance Mode via remote control, depending on your configuration:

- **Digital Input** (if the remote control source is set to I/O)
- **Modbus TCP** register (if source is Modbus)
- **BACnet IP** object (if source is BACnet)

Consult your control system integration guide for the correct register/object mapping.

Disabling Maintenance Mode

To exit Maintenance Mode and return the VFD to normal operation:

1. Toggle **Disable Maintenance Mode** from the same menu or the remote interface
2. If the motor is running, the VFD will stop using the normal ramp-down profile
3. The VFD state will return to **Ready to Run**
4. All previously disabled alarms will be **re-enabled**
5. If PID was active, it will **resume normal PID control**

Audit Logging

Every enable/disable operation of Maintenance Mode is automatically recorded in the system **Audit Logs** for traceability and compliance.

Previous Next

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17. Maintenance

This section explains how to perform regular inspections as well as how to safely execute prescribed maintenance.

A Clean Power VFD is vulnerable to environmental conditions, and faults may also occur due to component wear and tear.

To prevent breakdowns, please follow the maintenance recommendations in this section.

After each maintenance operation, a Torque Deactivation acceptance test must be executed by an operator skilled, trained, and knowledgeable about functional safety.

Previous Next

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17.1. Maintenance: Safety messages

DANGER

- Maintenance and inspection can only be performed by skilled professionals.

  Risk of personal injury.

- Maintain and inspect devices after power is off.

  Risk of electric hazard.

- Repair or maintain the AC drive after a minimum of 5 minutes have passed since it is powered off.

  This allows for the residual voltage in the capacitors to discharge to a safe value.

  Failure to comply will result in personal injury.

- If you replace the Clean Power VFD with a new one, set and check the parameters again after the AC drive is replaced.

  Failure to comply will result in personal injury.

WARNING

- The VFD becomes hot during operation.

  Avoid touching the VFD until it has cooled to avoid burns.

CAUTION

- Lock out and tag out all potential energy sources before working on the Clean Power VFD.
- Before inspecting the product, read all safety instructions in this manual.
- Before you clean the product, ensure that the power is off.

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- Clean the Clean Power VFD with a dry cloth. Cleaning with wet cloths, water, solvents, or detergents may result in electric shock or damage to the product.
- When a motor is used for the first time or when a motor is reused after being kept unused for a long time, or when a periodical inspection is performed, an insulation inspection shall be conducted, so as to avoid damaging the Clean Power VFD because of the insulation failure of the motor windings.
- During the insulation inspection, the motor wires must be disconnected from the Clean Power VFD.
- It is recommended to use a 500V mega meter, and the insulating resistance measured shall be 5MΩ.

Previous Next

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17.2. Routine inspections

Regular checks of the following should be carried out to ensure the Clean Power VFD and installation reliability is maximized.

Item	Inspection	Methods and tools	Expected results
Environment	Is the ambient temperature and humidity within the specifications range, and is there any dust, dirt, corrosive gas, oil mist, or foreign objects present?	Visual, Thermometer, Hygrometer, Recorder	There must be no danger of freezing with an ambient temperature of -10 to 55˚C and no condensation with ambient humidity of less than 95%.
Enclosure door filters and fans	Check the airflow in the enclosure.	Visual Replace or clean the filters if needed. Replace the fans if needed.	Airflow from the enclosure door (in and out) is not obstructed.
Clean Power VFD overview	Is there any abnormal vibration or noise?	Visual and acoustic	No abnormality.
Power voltage	Are the input voltages within the specifications range?	Measure voltages between R/ S/ T (phase to phase)	Values are within the specifications range.
Cooling fan	Is there any abnormal vibration or noise?	Manual validation Turn off the system and check the operation by rotating the fan manually.	The fan rotates smoothly.
HMI	Is the display value normal?	Visual Check the displayed values and compare them with readings from external meters (voltmeter, ammeter, etc)	If there are variations, it should not be more than xx%

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Item	Inspection	Methods and tools	Expected results
Motor mechanical health	Is there any abnormal vibration or noise?	Visual and acoustic	No abnormality.

Previous Next

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17.3. Annual inspection

Item	Inspection	Methods and tools	Expected results
Input/output Circuitry insulation	Insulation between input/output terminals and earth terminal	• Measure • Disconnect the Clean Power VFD and short R/S/T/U/V/W terminals, and then measure from each terminal to the ground terminal. Use a DC 500V insulation meter.	Must be above 5 MΩ
Input/output terminals	Tightening torque of all screw terminals.	Manual validation Is there anything loose in the device?	All screws are tightened at the specified torque.
Connections and cables	• Are there any corroded cables? • Is there any damage to the cable insulation? • Check cable for breakage and deterioration (crack, discoloration, etc.).	Visual	No abnormality
Terminal blocks	Check for damage.	Visual	No abnormality
Motor	Insulation resistance	• Measure • Disconnect the cables for terminals U/V/W and test the windings. Measure the insulation between U/V/W and the earth terminals with a DC 500V insulation meter.	Must be above 5 MΩ

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Item	Inspection	Methods and tools	Expected results
Torque Deactivation (to be done for STO1 and STO2)	Check the power output	• Turn off the main power supply of the Clean Power VFD and then on again. • Activate the Torque Deactivation function and the RUN function. • Connected test: While the motor is running, activate the Torque Deactivation function.	A torque deactivation alarm is displayed, and no voltage between U/V/W terminals.

Previous Next

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17.4. RTC Battery replacement

Clean Power VFDs have a real-time clock (RTC) feature.

The Clean Power VFD includes a supercapacitor to keep the time of the real-time clock (RTC) for 24 hours.

If 24 hours is enough for the application, then there's no need to add a CR2032 battery.

Otherwise, please check the following instructions

A battery, type CR2032, ensures the clock works when the drive is powered down.

The battery is not sold with the Clean Power VFD.

The battery has a long life time but if the battery needs to be replaced or removed, follow the instructions below.

instruction:

To remove the battery push smoothly on it until the spring pushes it slightly outside its slot.

Check the polarity + and - of the battery.

Replace the battery by inserting a new one in its slot and push smoothly until the spring locks it inside its slot

Previous Next

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17.5. Update the software from the HMI

- Software version.
- Step-by-step operation to update the Clean Power VFD software
- Get the updated files
- How to set up a USB drive for the software update?
- Perform the Software Update
- Finalize the update (Accept or Revert)

Smartd can update the Clean Power VFD software. This will add new options and functions to your VFD.

The software version in your drive can be read through the embedded HMI or the SmartDrive App.

Before performing a software update, ensure that the date and time in the VFD are valid. You can set the proper date and time via one of the 3 following methods:

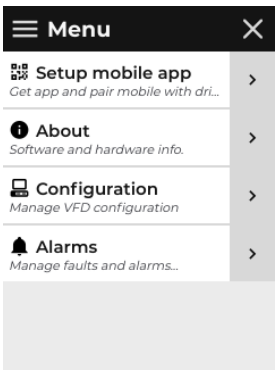
- Connect your drive to an Ethernet network with access to the Internet
- Or connect the mobile application with the drive via BLE
- Or edit the date/time using the HMI

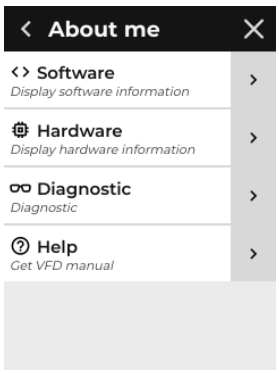
Software version.

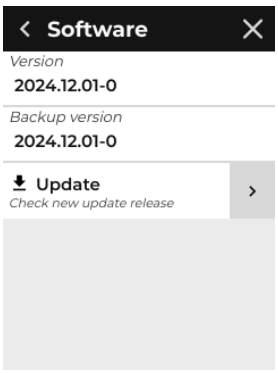
Go to the software Information from the HMI menu :

Menu >> About >> Software

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It displays whether your version is OK or a new version is available.

Step-by-step operation to update the Clean Power VFD software

The software update is performed via a USB drive. When a USB drive is inserted into the VFD's USB port, the Clean Power VFD looks for the software update file. If it is found, then the VFD downloads and installs it on the backup bank.

This means the user does not need to stop the motor or any other process currently running on the active boot bank.

Once the installation is complete, the user must reboot the Clean Power VFD for the update to be effective.

Get the updated files

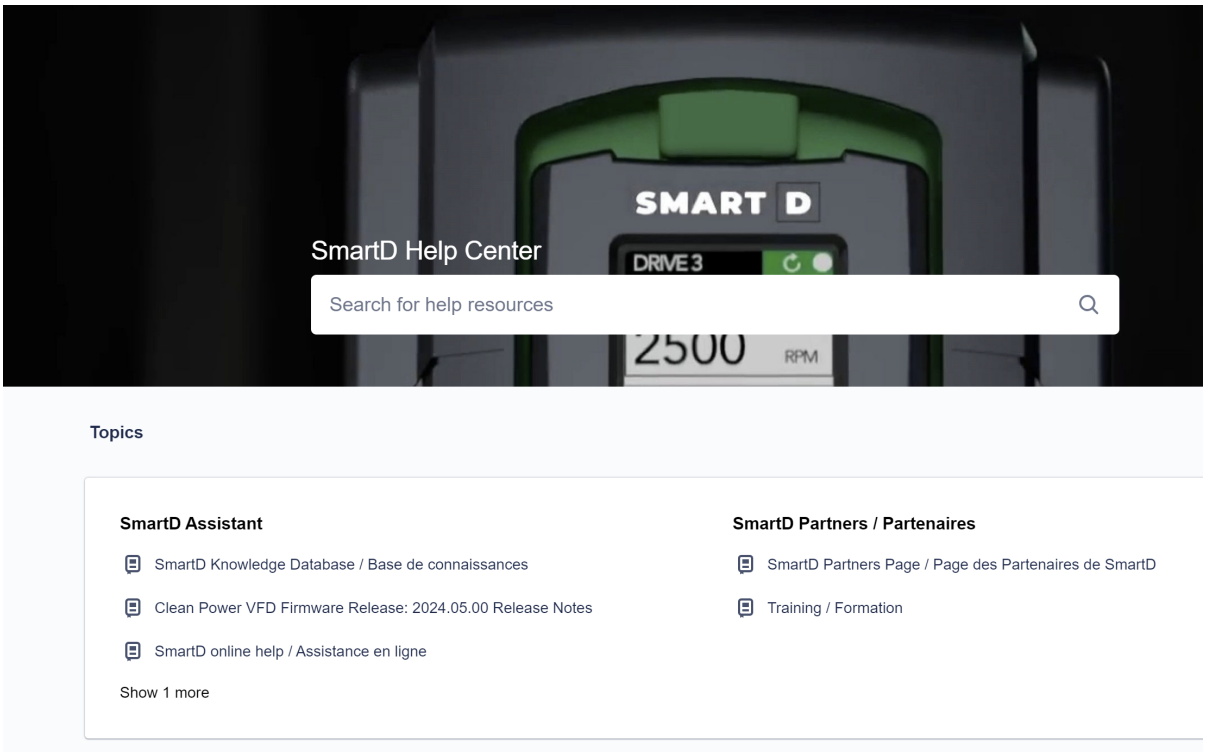
The newest VFD firmware file is included in the latest release note. To access it, connect to the SmartD Help Center from the SmartD Website: https://smartd.tech/technical-support-portal/

Or to the direct link: https://smartd.atlassian.net/servicedesk/customer/portals

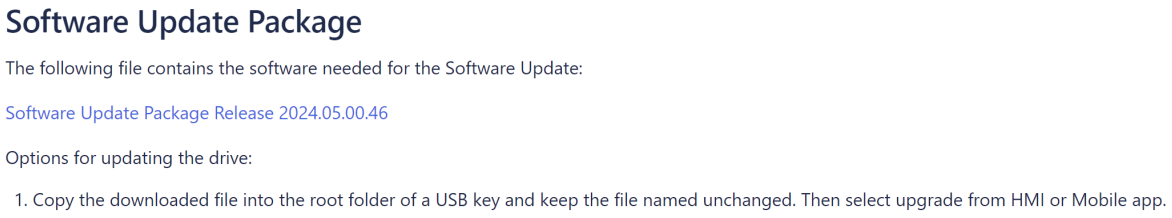
Sign in with your details, or make an account if you don't have one yet.

On the opened page, click on the release note link

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Then, scroll down until you reach Software Update Package Release and download the file



How to set up a USB drive for the software update?

USB drive system format:

The Clean Power VFD supports the following file system formats for the USB key: FAT, FAT32, ext3, ext4, and ExFAT.

Software update package:

The software update package must be located in the root folder of the USB drive and must have the following name: **smartd-vfd-linux-software-update.tar.xz**

! If you are reusing a USB drive that was previously used to update the Clean Power VFD, make sure to check the file name. If you copied the file from a Windows computer, the Windows File Explorer might have added a suffix to the new file while keeping the old one.

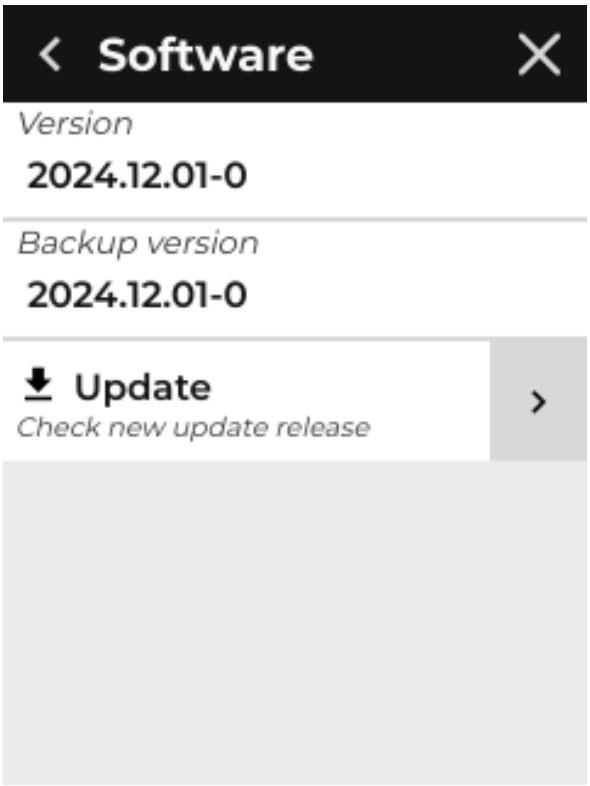
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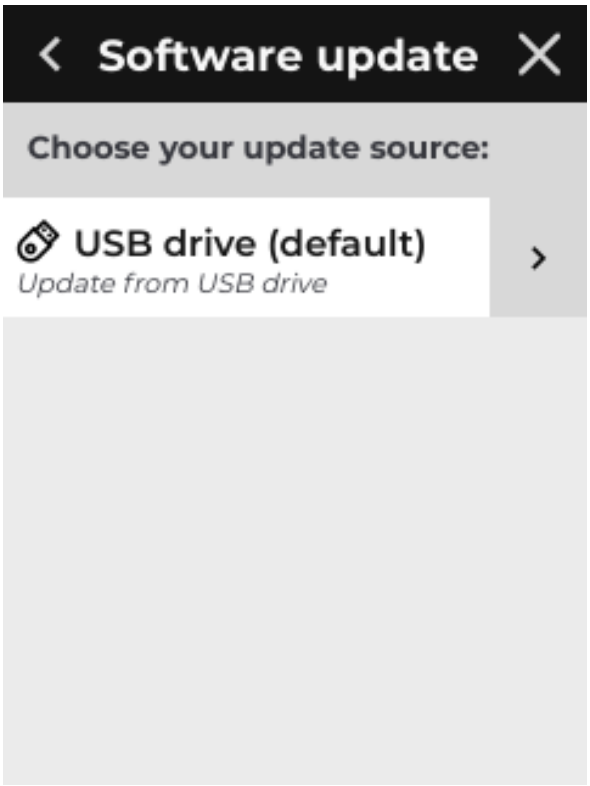
Perform the Software Update

Plug the USB drive into your Clean Power VFD.

From the Software menu, tap on Update.

Then tap on "USB drive".

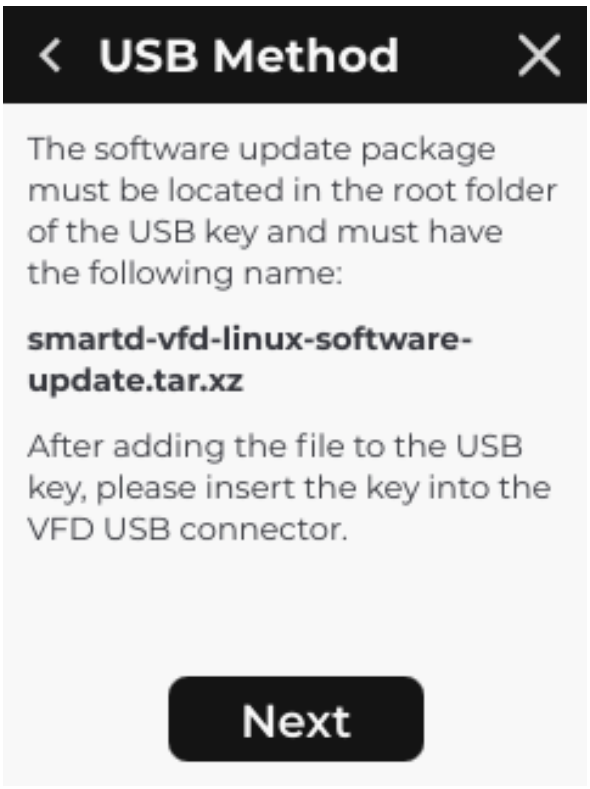




The user interface will display a message to remind you of the file location and name.

Tap on "Next". The software update process should then proceed by fetching the packages. Follow the steps displayed by the HMI.

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After a few minutes, the new software version is ready.

Tap on "reboot" to restart your VFD using the new version of the software.

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Finalize the update (Accept or Revert)

After the download and installation step, choose how to finalize:

Accept

- Make the newly installed version your active firmware.
- **At the same time, the device updates the Backup version to match the active one.**
    - Result: *Version* and *Backup version* display the **same** number (e.g., `2024.09.00-26`).
    - Why: the system refreshes the backup so future rollbacks return to this accepted, known-good release.
- **Important:** After you tap **Accept**, you can no longer roll back to the previous (older) release that was on the device before the update.

Revert

- Discard the newly installed firmware and boot the **Backup version**.
- Use this if testing reveals an issue with the new release.

Tip: If you plan to keep the option to downgrade later, do **not** press **Accept** until you've validated the new version in your application.

Previous Next

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17.6. Update the software from the mobile App

Smartd can update the Clean Power VFD software. This will add new options and functions to your VFD.

The software version in your drive can be read through the embedded HMI or the SmartDrive App.

Information about the version is accessible from the changelog database.

Before performing a software update, ensure that the date and time in the VFD are valid. You can set the proper date and time via one of the 3 following methods:

- Connect your drive to an Ethernet network having access to the Internet
- Or connect the mobile application with the drive via BLE
- Or edit the date/time using the HMI

Find the Software version using the mobile App.

Go to the software Information from the Smartphone App menu :

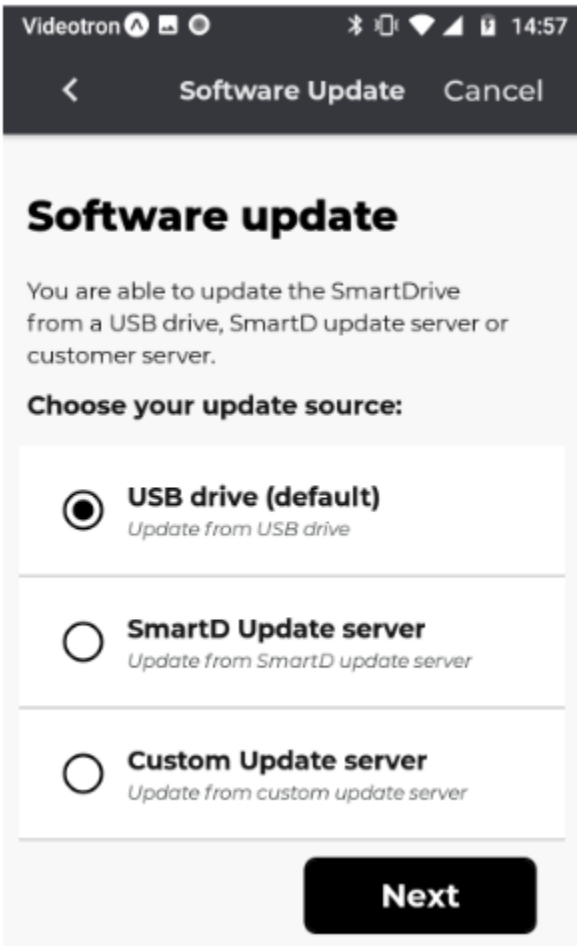
(accessible by clicking on the hamburger in the upper right corner)

Select Update

Select from "SmartD Update server"

Note: you need your Smartphone connected to the internet to perform this operation.

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It displays whether your version is OK or a new version is available.

The step-by-step operation to update/upgrade the Clean Power VFD software

The software update is performed by pulling all the files from a distant server or a USB drive and installing them on the backup bank of the Clean Power VFD.

This means the user does not need to stop the motor or any other process currently running on the boot bank.

Once the installation is complete, the user must reboot the Clean Power VFD for the update to be effective.

Get the updated files

The latest update of the VFD firmware file is attached to the latest release note.

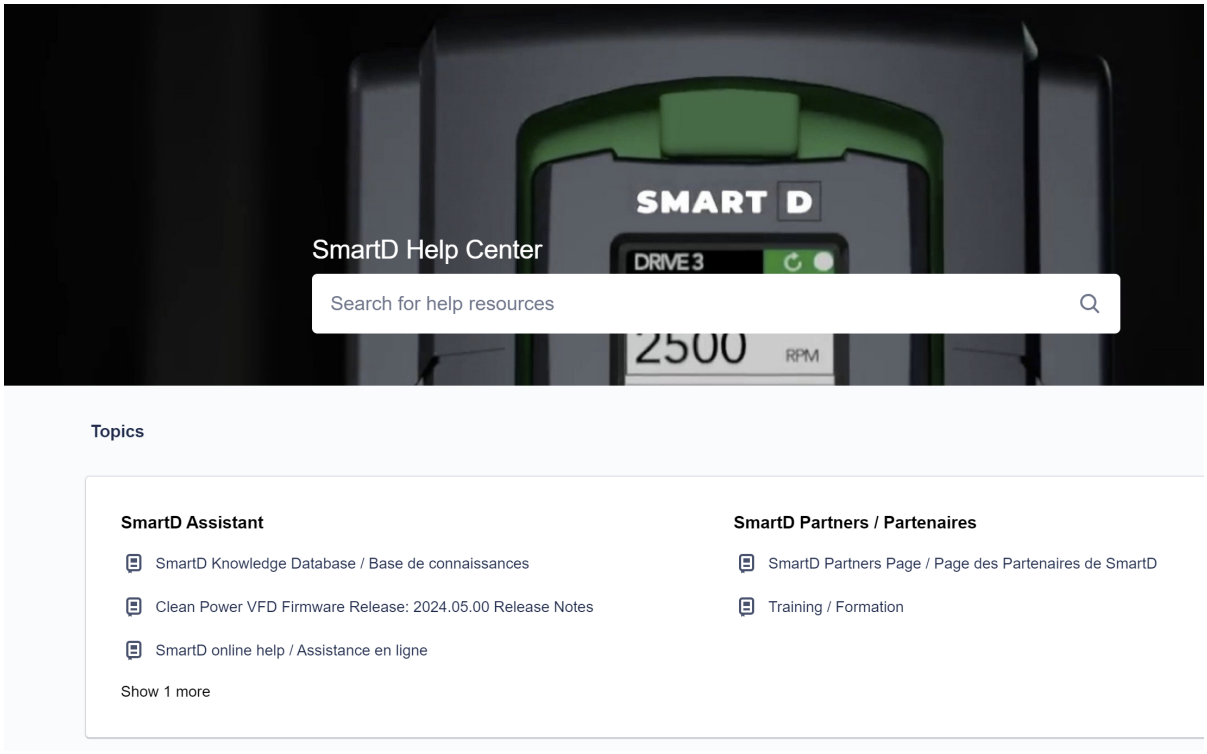
To access it, connect to the SmartD Help Center from the SmartD Website: https://smartd.tech/technical-support-portal/

Or to the direct link: https://smartd.atlassian.net/servicedesk/customer/portals

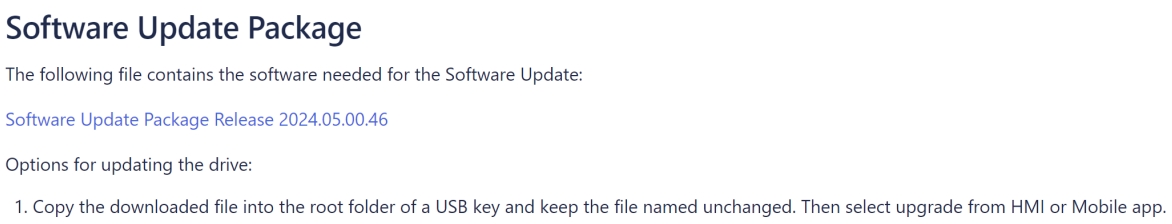
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Log in with your credentials, or create an account if you don't yet have one.

On the opened page, click on the release note link



Then, scroll down until you reach Software Update Package Release and download the file



How do you set up a USB drive for the software update?

USB drive system format:

The Clean Power VFD supports the following file system formats for the USB key: FAT, FAT32, ext3, ext4, and ExFAT.

Software update package:

The software update package must be located in the root folder of the USB drive and must have the following name:

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smartd-vfd-linux-software-update.tar.xz

Perform the Software Update

Plug the USB drive into your Clean Power VFD.



The software update process should then proceed by fetching the packages, and will be ready to start after a few minutes.

Previous Next

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17.7. Torque Deactivation acceptance test

Follow each step of the following procedure:

1- Stop the Clean Power VFD if it is running.

Give a stop command.

Switch off the power input line.

Isolate the Clean Power VFD from the main line by a disconnector.

RESULT: The motor is stopped and is safely disconnected from power.

2- Wait 5 minutes for the Clean Power VFD capacitors to be discharged.

3- Check that the Torque Deactivation circuit is correctly wired against the wiring diagram.

4- Check that proper cables are used and terminals are tightened with the recommended torque.

5- When previous steps have been checked and passed the verification, then switch on the disconnector to power up the Clean Power VFD.

6- Check the prevention to start

Open the Torque Deactivation circuit.

Give a start command to verify that the Torque Deactivation function blocks the Clean Power VFD's operation.

RESULT: the drive displays a warning. The motor should not start.

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7- Reset and restart.

Close the Torque Deactivation circuit.

Reset the Clean Power VFD status.

Give a start command.

RESULT: Check that the motor runs normally.

8- Test during running.

While the motor is running normally,

open one of the Torque Deactivation inputs.

RESULT: The motor should stop

Give a start command.

RESULT: The motor must remain standstill.

9- Reset and restart.

Close the Torque Deactivation circuit.

Reset the Clean Power VFD status.

Give a start command.

RESULT: The motor runs

10- Test Torque Deactivation channel lost.

Open one of the Torque Deactivation inputs.

RESULT: The motor stops and the alarm of the lost Torque Deactivation channel is raised

---

11- Reset and restart

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Close the Torque Deactivation input.

Reset the Clean Power VFD status.

Give a start command.

RESULT: The motor runs normally.

12- Test Torque Deactivation second channel lost.

Open the other Torque Deactivation input.

RESULT: The motor stops and the alarm of the lost Torque Deactivation channel is raised

---

13- Reset and restart.

Close the Torque Deactivation input

Reset the Clean Power VFD status.

Give a start command.

RESULT: The motor runs normally.

Previous Next

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17.8. Reset to factory settings

To delete the user's settings from the Clean Power VFD, it's possible to reset it to factory settings.

Reset to the factory default configuration is possible via the Mobile, Clean Power VFD, or the communication network API when your role allows it.

Note that resetting the configuration will reboot the Clean Power VFD.

Before executing a reset to factory settings, please read the safety messages carefully.

When executing a factory reset, the fans' running time is also reset

Previous Next

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17.8.1. Reset to factory settings- Safety messages

NOTICE

- After a reset to factory default settings, the Clean Power VFD starts with settings that may not fit your application.
- Prior to initiating a reset, it is highly recommended that the user download the current configuration to the SmartDrive app and store it under a meaningful name.
- Prior to running a factory reset it is highly recommended that the motor be disconnected from the Clean Power VFD.
- When you execute a reset to factory default settings, the Clean Power VFD will stop all ongoing actions.

Previous Next

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17.8.2. Reset to factory settings from the mobile App.

Prerequisite.

Make sure that you are running the latest software version on your smartphone.

Make sure that your Clean Power VFD is also running the latest software version.

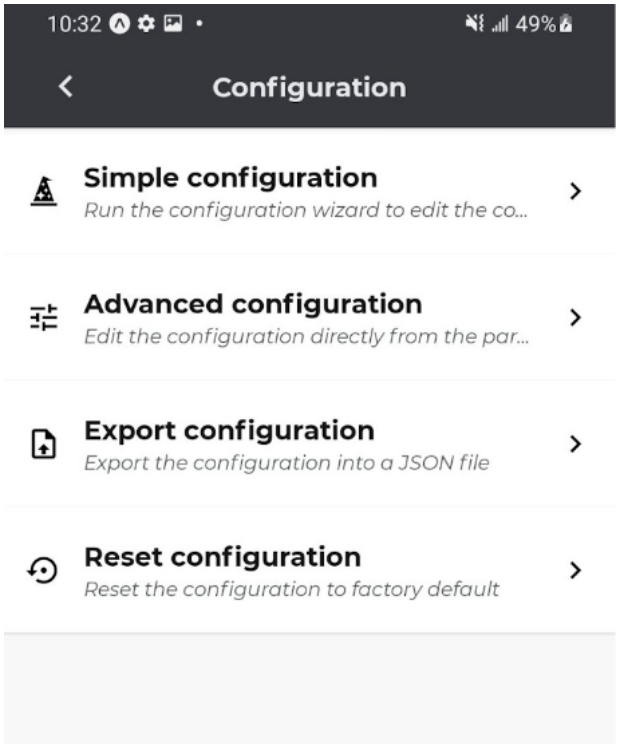
Your mobile App must be paired and connected to the Clean Power VFD via the same network.

Access the Reset function.

From the overall menu of the mobile App, select "Configuration"

Select the Reset function.

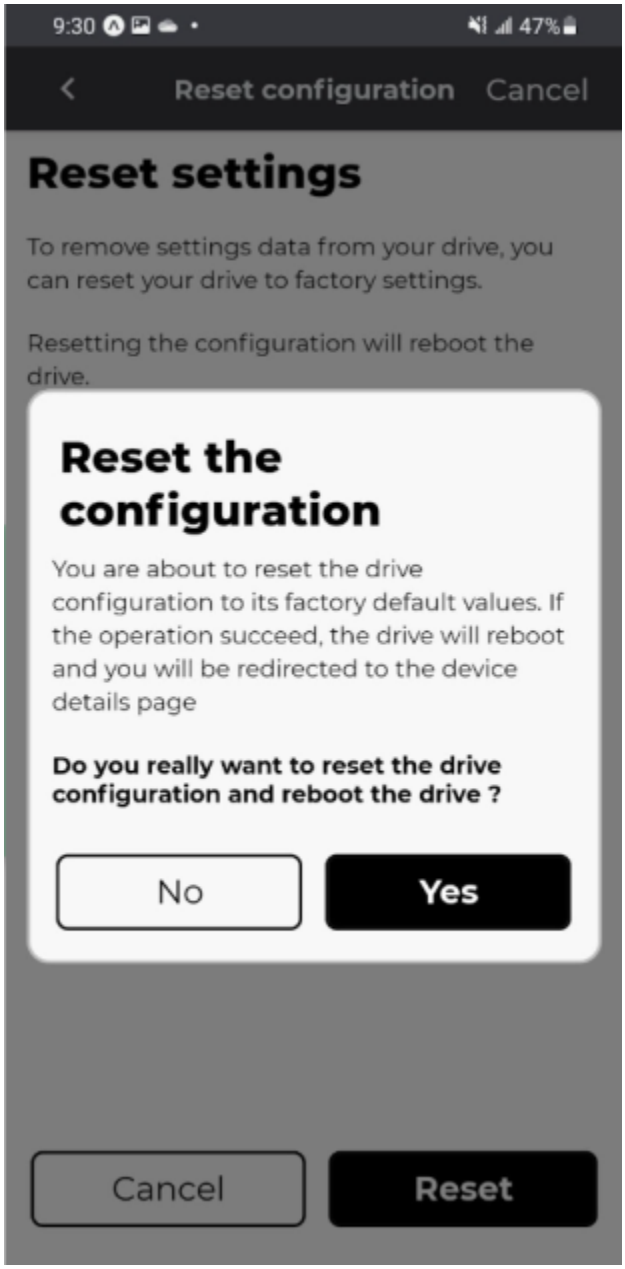
Select "Reset configuration".



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Start the reset.

Tap on the button reset, and confirm your action by tapping the button Yes inside the pop-up confirmation window.



Result:

The reset function is running and the Clean Power VFD is rebooted when the operation is complete.

Previous Next

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17.8.3. Reset to factory settings from the HMI

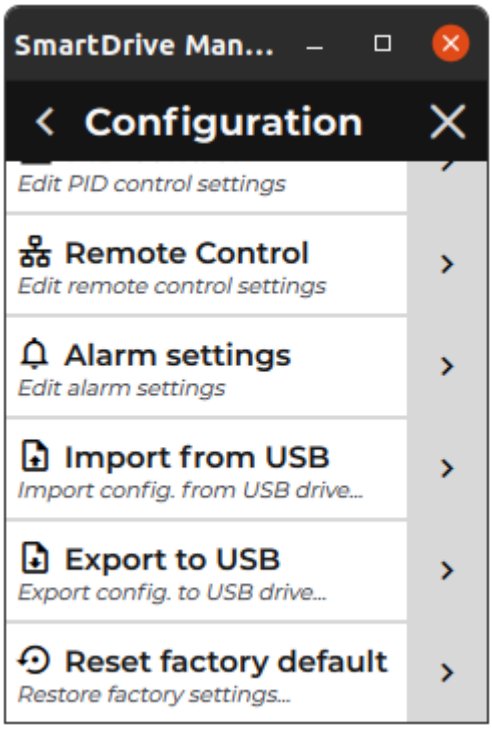
Prerequisite.

Make sure that your Clean Power VFD is running the latest software version.

Access the Reset function.

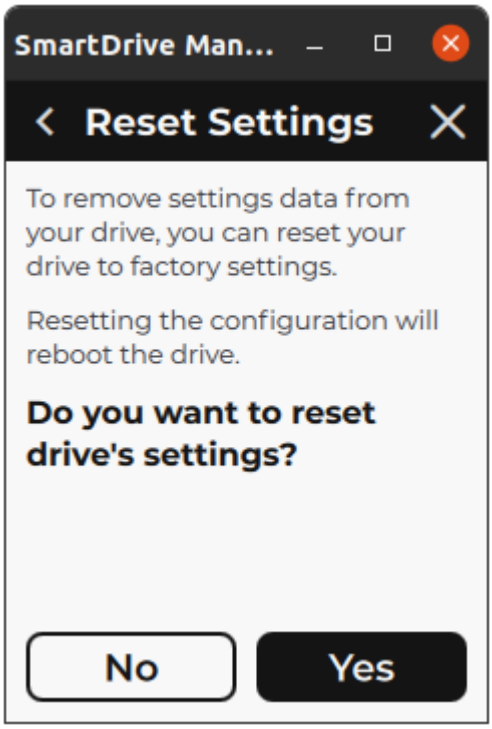
1- From the overall menu of the HMI, select "Configuration"

2- Select the " Reset factory default".



3- Then tap on the button " yes" to confirm the reset to factory default settings.

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Result:

The reset function is running and the Clean Power VFD is rebooted when the operation is complete.

Previous Next

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18. Disposal

If pollutant materials are disposed of improperly, they may cause lasting damage to human health and the environment.

Electrical and electronic equipment must be collected separately from unsorted waste so that it may be recycled or disposed of properly.

The packaging must be disposed of separately. Paper, cardboard, and plastics must be recycled.

- Restriction of Hazardous Substances (RoHS)
- WEEE - Waste Electrical and Electronic Equipment.
- Disposal instructions

Previous Next

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18.1. WEEE - Waste Electrical and Electronic Equipment.

This Clean Power VFD is an electrical and electronic device.

Used electrical and electronic devices must not be disposed with domestic waste.

This Clean Power VFD contains valuable raw materials that can be recycled.

It must be disposed according to the legislation of the country, in the EU user must dispose of the device at the appropriate collecting depot (EU directive 2012/19/EU).



Previous Next

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18.2. Disposal instructions

Some components such as electrolytic capacitors on the power circuit and PCBA may explode when burnt.

Emission of toxic gas may be generated when the plastic parts are burnt.

Please dispose of the Clean Power VFD as industrial waste.

Previous Next

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19. Technical Specifications

Electrical Ratings:

- SDB-1-2110-A
- SDB-1-2150-A
- SDB-1-2185-A
- SDB-1-2220-AL
- SDB-1-2220-A
- SDB-1-2300-A
- SDB-1-2375-A
- SDB-1-2450-A
- SDB-2-2150-A
- SDB-2-2185-A
- SDB-2-2220-A
- SDB-2-2300-A
- SDB-2-2375-A
- SDB-2-2450-A
- SDB-2-2550-A

- Deratings
- Control I/Os
- Operating environment
- Enclosure type

Previous Next

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19.1. Ratings SDB-1-2110-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	23
Apparent Power	kVA @ 480V	20
Prospective Line Isc (SCCR)	kA	50 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	22 @ 460 VAC 23 @ 400 VAC
Continuous Output Current - Heavy Duty	A	17 @ 460 VAC 17 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	25 @ 460 VAC 26 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	26 @ 460 VAC 26 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	11 - 3 ~ 400 VAC 50/60 Hz 11 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	15 - 3 ~ 400 VAC 50/60 Hz 15 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	7.5 - 3 ~ 400 VAC 50/60 Hz 7.5 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	10 - 3 ~ 400 VAC 50/60 Hz 10 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*

The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.

The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

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19.2. Ratings SDB-1-2150-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	30
Apparent Power	kVA @ 480V	25
Prospective Line Isc (SCCR)	kA	50 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	28 @ 460 VAC 29 @ 400 VAC
Continuous Output Current - Heavy Duty	A	22 @ 460 VAC 22 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	31 @ 460 VAC 32 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	33 @ 460 VAC 33 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	15 - 3 ~ 400 VAC 50/60 Hz 15 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	20 - 3 ~ 400 VAC 50/60 Hz 20 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	11 - 3 ~ 400 VAC 50/60 Hz 11 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	15 - 3 ~ 400 VAC 50/60 Hz 15 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

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19.3. Ratings SDB-1-2185-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	36
Apparent Power	kVA @ 480V	30
Prospective Line Isc (SCCR)	kA	50 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	34 @ 460 VAC 35 @ 400 VAC
Continuous Output Current - Heavy Duty	A	25 @ 460 VAC 25 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	38 @ 460 VAC 38 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	38 @ 460 VAC 38 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	18.5 - 3 ~ 400 VAC 50/60 Hz 18.5 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	25 - 3 ~ 400 VAC 50/60 Hz 25 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	15 - 3 ~ 400 VAC 50/60 Hz 15 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	20 - 3 ~ 400 VAC 50/60 Hz 20 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

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19.4. Ratings SDB-1-2220-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	43
Apparent Power	kVA @ 480V	36
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	41 @ 460 VAC 43 @ 400 VAC
Continuous Output Current - Heavy Duty	A	35 @ 460 VAC 35 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	46 @ 460 VAC 48 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	53 @ 460 VAC 53 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	22 - 3 ~ 400 VAC 50/60 Hz 22 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	30 - 3 ~ 400 VAC 50/60 Hz 30 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	18.5 - 3 ~ 400 VAC 50/60 Hz 18.5 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	25 - 3 ~ 400 VAC 50/60 Hz 25 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

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19.5. Ratings SDB-1-2220-AL

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	43
Apparent Power	kVA @ 480V	38
Prospective Line Isc (SCCR)	kA	50 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	41 @ 460 VAC 43 @ 400 VAC
Continuous Output Current - Heavy Duty	A	35 @ 460 VAC 35 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 40 °C (104 °F)	A	46 @ 460 VAC 48 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 40 °C (104 °F)	A	53 @ 460 VAC 53 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

Motor power - Normal Duty	kW	22 - 3 ~ 400 VAC 50/60 Hz 22 - 3 ~ 460 VAC 50/60 Hz

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Motor power - Normal Duty	hp	30 - 3 ~ 400 VAC 50/60 Hz 30 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	18.5 - 3 ~ 400 VAC 50/60 Hz 18.5 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	25 - 3 ~ 400 VAC 50/60 Hz 25 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.6. Ratings SDB-1-2300-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	58
Apparent Power	kVA @ 480V	49
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	55 @ 460 VAC 57 @ 400 VAC
Continuous Output Current - Heavy Duty	A	41 @ 460 VAC 41 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	61 @ 460 VAC 63 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	62 @ 460 VAC 62 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	30 - 3 ~ 400 VAC 50/60 Hz 30 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	40 - 3 ~ 400 VAC 50/60 Hz 40 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	22 - 3 ~ 400 VAC 50/60 Hz 22 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	30 - 3 ~ 400 VAC 50/60 Hz 30 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.7. Ratings SDB-1-2375-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	71
Apparent Power	kVA @ 480V	60
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	68 @ 460 VAC 71 @ 400 VAC
Continuous Output Current - Heavy Duty	A	55 @ 460 VAC 55 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	75 @ 460 VAC 79 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	83 @ 460 VAC 83 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	37.5 - 3 ~ 400 VAC 50/60 Hz 37.5 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	50 - 3 ~ 400 VAC 50/60 Hz 50- 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	30- 3 ~ 400 VAC 50/60 Hz 30- 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	40- 3 ~ 400 VAC 50/60 Hz 40- 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*

The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.

The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.8. Ratings SDB-1-2450-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3 ~ 400 .. 480 | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	86
Apparent Power	kVA @ 480V	72
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 400 .. 480, depending on input voltage
Continuous Output Current - Normal Duty	A	82 @ 460 VAC 85 @ 400 VAC
Continuous Output Current - Heavy Duty	A	68 @ 460 VAC 68 @ 400 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	91 @ 460 VAC 91 @ 400 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	102 @ 460 VAC 102 @ 400 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power*

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Motor power - Normal Duty	kW	45 - 3 ~ 400 VAC 50/60 Hz 45 - 3 ~ 460 VAC 50/60 Hz
Motor power - Normal Duty	hp	60 - 3 ~ 400 VAC 50/60 Hz 60 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	kW	37.5 - 3 ~ 400 VAC 50/60 Hz 37.5 - 3 ~ 460 VAC 50/60 Hz
Motor power - Heavy Duty	hp	50 - 3 ~ 400 VAC 50/60 Hz 50 - 3 ~ 460 VAC 50/60 Hz

** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.9. Ratings SDB-2-2150-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	23
Apparent Power	kVA @ 600V	24
Prospective Line Isc (SCCR)	kA	50 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	22 @ 575 VAC
Continuous Output Current - Heavy Duty	A	17 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	25 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	26 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	15 - 3 ~ 575 VAC 50/60 Hz
Motor power - Normal Duty	hp	20 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Heavy Duty	kW	11 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	15 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

*** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.10. Ratings SDB-2-2185-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	30
Apparent Power	kVA @ 600V	32
Prospective Line Isc (SCCR)	kA	50 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	28 @ 575 VAC
Continuous Output Current - Heavy Duty	A	22 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	31 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	33 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	18.5 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Normal Duty	hp	25 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	kW	15 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	20 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

***Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.11. Ratings SDB-2-2220-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	36
Apparent Power	kVA @ 600V	38
Prospective Line Isc (SCCR)	kA	50(see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	34 @ 575 VAC
Continuous Output Current - Heavy Duty	A	25 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	38 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	38 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	22 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Normal Duty	hp	30 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	kW	18.5 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	25 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

*** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.12. Ratings SDB-2-2300-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	47
Apparent Power	kVA @ 600V	49
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	44 @ 575 VAC
Continuous Output Current - Heavy Duty	A	33 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	49 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	50 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	30 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Normal Duty	hp	40 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	kW	22.5 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	30 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

*** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.13. Ratings SDB-2-2375-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	57
Apparent Power	kVA @ 600V	60
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	54 @ 575 VAC
Continuous Output Current - Heavy Duty	A	44 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	60 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	66 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	37.5 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Normal Duty	hp	50 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	kW	30 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	40 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

*** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.14. Ratings SDB-2-2450-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	69
Apparent Power	kVA @ 600V	72
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	66 @ 575 VAC
Continuous Output Current - Heavy Duty	A	54 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	73 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	81 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	45 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Normal Duty	hp	60 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	kW	37.5 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	50 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

*** Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.15. Ratings SDB-2-2550-A

Power Supply

Supply Type		Wye, solidly grounded. TT and TN systems
Input Voltage	VAC	3~ 600Y 347Δ * | -15% .. +10%
Input Frequency	Hz	50 .. 60 | -5% .. +5%
Input Current	A	83
Apparent Power	kVA @ 600V	87
Prospective Line Isc (SCCR)	kA	100 (see Protection guide–USA/Canada or IEC–for required upstream protective device)
THDi Total Harmonic Distortion (current)	%	<3 % at load levels of 50% or greater
Imbalance max. of nominal phase to phase input voltage	%	-/+ 3%
Power factor		near unity

Output capabilities

Output Voltage	VAC	up to 600, depending on input voltage
Continuous Output Current - Normal Duty	A	79 @ 575 VAC
Continuous Output Current - Heavy Duty	A	66 @ 575 VAC
Max Transient Output current - Normal Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	87 @ 575 VAC
Max Transient Output current - Heavy Duty During 60s, every 10 minutes at 50 °C (122 °F)	A	99 @ 575 VAC
Output Speed Frequency	Hz	0.1 .. 120
Nominal Switching Frequency	kHz	105
Effective Switching Frequency	kHz	210

Indicative Motor Power**

Motor power - Normal Duty	kW	55 - 3 ~ 575 VAC 50/60 Hz

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Motor power - Normal Duty	hp	75 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	kW	45 - 3 ~ 575 VAC 50/60 Hz
Motor power - Heavy Duty	hp	60 - 3 ~ 575 VAC 50/60 Hz

**600Y/347Δ identifies the certified electrical distribution system (600/347 V solidly grounded Wye supplied from a Delta-Wye transformer). It is not an indication that the Clean Power VFD is approved for direct connection to a 600 V Delta distribution system. Where the facility is supplied by a Delta system, an upstream transformer providing a solidly grounded Wye secondary is required.*

** *Motor power values are indicative. They vary depending on the motor type, technology, and manufacturer. The Clean Power VFD must not be selected based on the motor power rating.*
The Clean Power VFD must be selected based on the motor Full Load Amperage (FLA), the load's driving force, the movement cycle, and the operating environment.
The Clean Power VFD must be chosen by skilled and experienced personnel.

Efficiency

IE Class		2
Efficiency	%	96

Previous Next

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19.16. AFE performance and immunity

SmartD Clean Power VFDs use an **Active Front End (AFE)** to regulate the DC bus and draw current from the supply in a controlled, stable way. In the field, that matters for two things:

1. **Power quality**: how the drive behaves when the grid is not "perfect" (frequency drift, unbalance, dips, notches).
2. **Immunity**: how the drive tolerates electrical disturbances commonly found in industrial environments (EFT/burst, surge, conducted RF).

This page explains what we tested, what we observed, and what you should expect in real installations.

- What we tested
- Results
- 1) Frequency variations — no disruption observed
- 2) Voltage unbalance — no disruption observed
- 3) Notch-like disturbances (commutation notch environment) — no disruption observed
- 4) Long voltage deviations (> 60 s) — kept running
- 5) Voltage dips — ride-through depending on depth
- 6) Short interruptions — reboot can occur
- 7) EMC immunity (industrial disturbance tolerance)
- IEC 61000-4-4 EFT/Burst — PASS
- IEC 61000-4-5 Surge — PASS
- IEC 61000-4-6 Conducted RF (common-mode) — PASS
- Installation notes
- 8) Grid impedance range validated (line stiffness)

What we tested

- Frequency variations (IEC 61000-2-2):

  Utility and generators do not stay at exactly 60 Hz / 50 Hz. Frequency can drift during load changes, transfers, or weak generation.

- Voltage unbalance (IEC 61000-2-2):

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Unbalance happens when the three phase-to-phase voltages are not equal (common on heavily loaded feeders, uneven single-phase loading, or weak grids).

- Commutation notches (IEC 60146-1-1):

  Large rectifiers and thyristor equipment can create short, sharp “notches” on the voltage waveform during commutation. In practice, the drive sees this as brief phase dips and phase-angle disturbances.

- Long voltage deviations > 60 s (IEC 61000-2-4):

  Overvoltage/undervoltage that lasts minutes (or longer) can occur due to feeder loading, generator regulation, or utility conditions.

- Voltage dips and short interruptions (tested using IEC 61000-4-34 methods):

  Fast dips (short duration) and short interruptions are common during switching events, faults cleared upstream, or transfers.

- High-frequency disturbances / EFT-burst (IEC 61000-4-4):

  Fast repetitive pulses caused by contactors, relays, and arcing.

- Surge (IEC 61000-4-5):

  High-energy transients caused by switching, lightning, or large inductive loads.

- Conducted RF (common-mode) (IEC 61000-4-6):

  Radio-frequency energy coupled onto cables (VFD environment, long cables, nearby transmitters, switching noise).

Results

1) Frequency variations – no disruption observed

Applied: ±2% (±1.2 Hz) and ±4% (±2.4 Hz) around 60 Hz, with a 2 s transition.

Observed behavior: Drive continued operating normally (no abnormal behavior, no loss of control).

Customer takeaway: The AFE/drive control remains stable during realistic frequency drift and step changes.

2) Voltage unbalance — no disruption observed

Applied: 3% negative-sequence component (unbalance severity method).

Observed behavior: Drive continued operating normally (no abnormal behavior, no loss of control).

Customer takeaway: Typical supply unbalance conditions did not create instability.

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3) Notch-like disturbances (commutation notch environment) — no disruption observed

Applied: Phase dip and phase-change patterns representative of notch-like disturbances (brief phase dips / phase-angle disturbances).

Observed behavior: Drive continued operating normally across these events.

Customer takeaway: The drive tolerated notch-like profiles typically produced by line-commutated equipment.

4) Long voltage deviations (> 60 s) – kept running

Applied: +10% and −10% long-duration deviation.

Observed behavior: 24 V auxiliary remained OK, drive kept running, temperature stayed stable.

Customer takeaway: Normal utility/generator deviation bands did not force a shutdown.

5) Voltage dips – ride-through depending on depth

Applied (RMS dip levels):

- **80% of nominal Vrms**: kept running
- **70% of nominal Vrms** : alarm triggered, then cleared after recovery
- **40% of nominal Vrms** : alarm triggered, then cleared after recovery
- **0% of nominal Vrms, dip case (very short event):** kept running**.** For dips, the drive is generally ride-through capable; deeper dips may trigger alarms, but the drive recovers once voltage returns (no damage).

6) Short interruptions — reboot can occur

Applied: short interruption at 0% of nominal Vrms.

Observed behavior: drive rebooted; drive not damaged; recovery achieved after power returned.

Customer takeaway: If the supply goes to **zero** long enough to be classified as an interruption, the drive may reboot. This is expected protective behavior.

7) EMC immunity (industrial disturbance tolerance)

IEC 61000-4-4 EFT/Burst – **PASS**

- Tested on power ports and signal/aux ports at the specified levels.
- Observed effect in some cases: brief display flicker, then normal operation (no damage).

IEC 61000-4-5 Surge – **PASS**

- Tested line-to-line and line-to-ground at specified levels.

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- Observed behavior: the drive remained protected; in some cases it can self-recover after the event (depending on settings).

IEC 61000-4-6 Conducted RF (common-mode) – **PASS**

- Tested 10 Vrms from 150 kHz to 80 MHz on relevant ports.
- Drive continued operating as intended.

Installation notes

To comply with the required immunity levels, the installation must fulfill the recommendation from the chapter Selecting Power Cables in regions following IEC practices.

Immunity performance still depends on installation practices (cable routing, bonding, grounding, and any required ferrites on specific cables).

8) Grid impedance range validated (line stiffness)

In SmartD's lab validation (transformer-defined source), the drive was validated at 480 V with equivalent source impedance ranging from:

- **Stiff source: ≈ 0.079 Ω per phase, Isc ≈ 3.5 kA**
- **Weak source: ≈ 0.241 Ω per phase, Isc ≈ 1.15 kA**

How to interpret this: These values represent the transformer-defined source at its secondary (dominant component from transformer %Z). They do not include the customer's cable run from transformer to VFD.

Previous Next

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19.17. Deratings SDB-x-xxxx-A

Current ratings of the Clean Power VFD must be derated according to the environmental conditions.

Ambient temperature derating

-15 to 50 °C	without derating
50 to 60 °C	with derating 2% per °C

Altitude

The Clean Power VFDs are designed to operate at altitudes up to 2000 m (6600 ft) above sea level, there isn't any derating to apply to the maximum output current.

Previous Next

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19.18. Deratings SDB-x-xxxx-AL

Current ratings of the Clean Power VFD must be derated according to the environmental conditions.

Ambient temperature derating

-15 to 40 °C	without derating
40 to 50 °C	with derating 2% per °C

Altitude

The Clean Power VFDs are designed to operate at altitudes up to 2000 m (6600 ft) above sea level, there isn't any derating to apply to the maximum output current.

Previous Next

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19.19. Control I/Os

Auxiliary power input

Digital inputs

Torque Deactivation inputs

Digital outputs

Analog inputs

Analog outputs

Previous Next

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19.19.1. Auxiliary Power Input

Clean Power VFD auxiliary power input

The Clean Power VFD is equipped with an auxiliary DC power input.

While this input is properly powered, the Clean Power VFD's control functions operate even if the main power line is disconnected.

This auxiliary power input is protected against reverse polarity and overvoltage.

Voltage:	24 VDC
Limits:	20.4 VDC to 28.8 VDC

Previous Next

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Digital inputs

Digital inputs follow IEC 61131-2 type 1

Quantity		6 digital inputs named from DI1 to DI6. Their assignment is settable by the user. DI1 and DI2 can be assigned as encoder inputs. (1) Note for SDB-1-2185: DI1 and DI2 can only be used for encoder
Input logic		Wire-able as Sink or Source logic, configurable by software. Default: source.
Voltage levels in source mode	ON	18 .. 24 V
	OFF	0 .. 5V
Voltage levels in sink mode	ON	0 .. 5V
	OFF	18 .. 24 V
Current consumption		6 mA

Output power for digital inputs (2)	+24VDC (-20% .. +20%) / 100 mA

(1) Clean Power VFD versions and compatibility with encoder:

Digital inputs 1 and 2 (Di1 and Di2) on the Clean Power VFD are compatible with pulse train signals with a maximum frequency of 50 kHz.

This compatibility applies to hardware produced on or after June 14, 2024.

You can verify this by checking the VFD's serial number. Ensure that the middle segment of the serial number is "20240614" or later (e.g., 0001-20240614-000001).

If your Clean Power VFD was manufactured before this date, it does not support the pulse train signal for the incremental encoder function.

(2) This auxiliary output power is protected against short circuits.

Previous Next

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19.19.3. Torque Deactivation inputs

Torque Deactivation inputs

The torque deactivation inputs follow IEC 61131-2 type 1

Quantity		2
SIL capacity level	designed according to IEC61800-5-2	
Stop category		Category 0
Torque Deactivation input reaction time		20 ms
Torque Deactivation input filtering time		5 ms
Nominal voltage of Torque Deactivation enabling input		24 V
Maximum input voltage		28.8 V
Logic threshold		10V (+/- 5V)
Low state maximum voltage for disabling Torque		5 V

Previous Next

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Digital outputs

Quantity		3
Type		Relay
Relay 1	Contact arrangement	SPDT (Form C)
	NO contact features	Resistive load; AC:5A @ 250V; DC: 3A @ 30V
	NC contact features	Resistive load; AC: 3A @ 250V; DC: 3A @ 30V
Relay 2	Contact arrangement	SPST NO (Form A)
	NO contact features	Resistive load; AC: 3A @ 250V; DC: 3A @ 30V
Relay 3	Contact arrangement	SPST NO (Form A)
	NO contact features	Resistive load; AC: 3A @ 250V; DC: 3A @ 30V

Previous Next

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Analog inputs

Quantity		3 analog inputs. Programmable
Input types		0..10VDC 4..20mA 0..24VDC Impedance to read PTC temperature sensor Default settings: 0..10VDC
Input impedances	0..10VDC 4..20mA 0..24VDC Impedance	> 3.5k Ω 165 Ω 25 k Ω Supported external resistance range: 100 Ω to 100 kΩ. The input circuit includes an internal protection resistance of approximately 50 Ω
Insulation		None
Resolution		12 bits
Time response		50 ms
Accuracy		± 1% at 25 °C (77 °F) / ± 2% for a temperature variation of 60 °C (108 °F)
Reference power supply for analog inputs		+10 VDC Tolerance ± 2% for the temperature range of 20 °C to 30 °C. Current: maximum 10 mA, short circuit protected.

Previous Next

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19.19.6. Analog outputs

Analog outputs

Quantity		2 analog outputs. Programmable
Output types		0..10VDC (20 mA max.) 0..20mA / 4..20mA
Output impedances	0..10VDC 0..20mA / 4..20mA	500 ohms minimum 75 ohms maximum
Isolation		None
Resolution		12 bits
Response time		50 ms (worst case from 0 to max output)
Accuracy		± 1% at 25 °C (77 °F) / ± 2% for a temperature variation of 60 °C (108 °F)

Previous Next

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19.20. Motor cable length

Motor cable length

Max Motor Cable Length	m / ft	up to 4500 / 15,000 without output filter
Sine Wave Cable Compatibility		Standard industrial-grade cables (shielding optional)
Voltage Drop Limit	%	Max 3% of rated motor voltage (√3·R·L·I)

Important Installation Guidance for Clean Power VFD: Cable Selection, Performance Impacts, and Autotuning Tips:

The Clean Power VFD outputs a pure sine wave, allowing for very long cable lengths without the need for filters or VFD-rated cable. However, performance depends on proper cable sizing:

- Undersized cables increase voltage drop and motor heating
- Excessive length or shielding raises reactive current (charging)
- For best autotuning results, use short cable or manual motor data
- Always evaluate ampacity, voltage drop, and terminal compatibility before final installation.

Previous Next

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19.21. Operating environment

Environment and deratings

The Clean Power VFDs are manufactured with precision electronic components.

Therefore, the installation environment can impact the lifespan and reliability of the product.

The information below describes the recommended operation and installation conditions for the Clean Power VFD.

The user must comply with the environmental conditions listed below to ensure the Clean Power VFD operates safely and correctly.

Failure to adhere to these environmental conditions may shorten the device's lifespan, lead to malfunctioning and failure, and void the warranty.

Installation area	The Clean Power VFD must be mounted in a well-ventilated electrical cabinet, respecting the clearance distances described in this document.
Operating temperature	The normal operating range of the Clean Power VFD is **-15 to 50°C** without derating**, 50 to 60°C with derating of 2% per °C**. If not specified otherwise (e.g., SDB-1-2220-AL) The reliability of the Clean Power VFD increases in environments where temperature fluctuations are limited. When using an enclosure, install a cooling fan or air conditioner in the area to ensure the air temperature inside the housing does not exceed the specified levels. Do not allow ice to form on the frequency converter.
Relative humidity	Below 95% non-condensing.
Surrounding environment pollution degree	2, conforming to IEC61800-5-1
Storage temperature	-40...70 °C / -40...158 °F
Surrounding area	Mount in an area free of • oil mist and dust-metal shavings, oil, water, or other foreign materials • radioactive materials • combustible materials • toxic or corrosive gases and liquids • excessive vibration • chlorides

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	• direct sunlight • EMI source and other electronic devices that are sensitive to EMI
Altitude	**Lower than 2000 m/6600 ft.** Contact SmartD Technologies Inc. if you intend to use the Clean Power VFD at a higher altitude.
Vibrations	Mount in a location where vibrations are less than an amplitude of 1.5 mm peak to peak (f= 2...13 Hz) and acceleration lower than 1 gn (f= 13...200 Hz).

Best practices:

To prevent high surrounding air temperature, users should design their electrical panel following the listed best practices:

- No heat stagnation in the panel.
- Sufficient heat dissipation of the panel (Size not too small, proper ventilation).
- Ventilation slits of the Clean Power VFD are not blocked by any object such as cable or cable trays.
- Avoid the proximity of any exothermic device.
- Ensure the mounting orientation of the Clean Power VFD allows an optimized airflow.
- Respect the clearance distances.

Previous Next

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19.22. Enclosure type, rating, material and finishes

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19.22.1. Enclosure SDB-x-x-xxx-A

Enclosure type	UL type 1
Rating	IP 20 according to IEC60529
Material	UL94V0 Chassis: mild steel (galvanized) Body: ABS/PC

Previous Next

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19.22.2. Enclosure HMI

Enclosure type	UL type 1
Rating	IP 20 according to IEC60529
Material	Plastic UL94V0

Previous Next

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20. Compliances and certifications

Overview

SmartD Technologies is committed to delivering Variable Frequency Drives (VFDs) that meet the highest standards of safety, reliability, and sustainability.

The Clean Power VFD family has been designed and tested following globally recognized standards for safety, electromagnetic compatibility (EMC), environmental performance, and product safety certification.

Compliance with these standards ensures that our drives are suitable for use in industrial environments, are compatible with other electrical equipment, and meet international requirements for energy efficiency and environmental responsibility.

Traceability of Standard Revisions

Standards listed on this page represent the regulatory scope applicable to the Clean Power VFD family.

Note on Versioning: As standards evolve, the specific revision year (e.g., *Edition 2* vs. *Edition 3*) applied to a product depends on its certification date.

To identify the exact standard revisions applied to your specific SKU, please refer to our **SmartD VFD Certification Matrix.**

Safety Standards Compliance

The Clean Power VFD is built in conformity with both North American and international safety standards applicable to adjustable speed electrical power drive systems.

Standard	Description	Region
UL 61800-5-1	Safety requirements for electrical power drive systems	United States
CSA C22.2 No. 274	Canadian national standard equivalent to UL 61800-5-1	Canada
IEC 61800-5-1	International standard for safety requirements of adjustable speed electrical power drive systems	International

Certification File: cULus Listed — File Number **E5231214**

Markings: cULus Listed (U.S. and Canada)

Electromagnetic Compatibility (EMC)

The Clean Power VFD conforms to the EMC requirements applicable to adjustable speed power drive systems, as defined by the following standards:

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IEC 61800-3 – EMC requirements for variable speed electrical power drive systems

This includes both emission and immunity performance for second environment installations (all establishments other than those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes). The Clean Power VFD supports installations compliant with Category C3 environments, as defined by IEC 61800-3 (PDS of rated voltage less than 1,000 V, intended for use in the second environment and not intended for use in the first environment).

Immunity to Disturbances

The VFD has been tested and verified to ensure robustness in the presence of common electromagnetic disturbances. It complies with the following immunity standards:

Standard	Description
IEC 61000-4-2	Electrostatic discharge (ESD) immunity
IEC 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity
IEC 61000-4-4	Electrical fast transient/burst immunity
IEC 61000-4-5	Surge immunity
IEC 61000-4-6	Conducted disturbances induced by radio-frequency fields
IEC 61000-4-11 and -4-34	Voltage dips, short interruptions, and voltage variations

Environmental and Eco-design Standards

SmartD's environmental practices and product design conform to international regulations on energy efficiency and hazardous substances.

Standard	Description
IEC 61800-9-2	Eco-design requirements for power drive systems and motor systems
IEC 63000	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances (RoHS)

These standards align with broader sustainability and circular economy goals and support compliance with the European **Eco-design Directive** and **RoHS Directive**.

CE Marking and EU Directives

Where applicable, Clean Power VFDs are marked with the CE logo and comply with the following European Union directives:

Directive	Description
2014/35/EU	Low Voltage Directive (LVD)
2014/30/EU	Electromagnetic Compatibility Directive (EMC)

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Directive	Description
2019/1782/EC	Eco-design requirements for power supplies
2011/65/EU	Restriction of Hazardous Substances (RoHS) Directive

⚠ **Note**: CE marking is available only for specific part numbers. Please consult the Declaration of Conformity or check the Certification Matrix

REACH (EC 1907/2006)

SmartD's VFDs are supplied as articles under REACH and are not intended to release substances during normal or reasonably foreseeable use.

We maintain a supplier-to-product due diligence process to monitor the ECHA Candidate List of Substances of Very High Concern (SVHC) and Annex XVII restrictions.

To the best of our knowledge at the time of shipment, our products do not contain SVHCs above 0.1% w/w. If an SVHC were present above 0.1% w/w in any component, SmartD would fulfill Article 33 communication duties and, where applicable, submit a SCIP notification.

Note: REACH is separate from CE marking; a standalone REACH statement is available for download

Previous Next

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20.1. SmartD VFD Certification Matrix

SmartD is committed to meeting the highest standards of safety and quality.

This certification matrix serves as the official reference for the conformity of our Variable Frequency Drives to key international standards, including UL, cUL, CE marking, and REACH regulations.

All information is current as of January 9th, 2026.

Section 1: North American Safety (UL / CSA)

Applicable for markets requiring cULus Listing.

VFD Model	UL:	CSA:
SDB-1-2110-A	UL 61800-5-1, 1st Ed, Rev. 2021-02-11	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2150-A	UL 61800-5-1, 1st Ed, Rev. 2021-02-11	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2185-A	UL 61800-5-1, 1st Ed, Rev. 2021-02-11	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2220-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2220-AL	UL 61800-5-1, 1st Ed, Rev. 2021-02-11	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2300-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2375-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-1-2450-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2150-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2185-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2220-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2300-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2375-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2450-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04
SDB-2-2550-A	UL 61800-5-1, 2nd Ed, Rev. 2022-06-24	CSA C22.2 No. 274, 2nd Ed, Issued 2017-04

Section 2: International & European Compliance (IEC / EN)

Applicable for CE Marking and Global markets.

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VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2110-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2150-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge

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VFD Model	CE mark	Directive	Standard	Applied Version
				• IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2185-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst

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VFD Model	CE mark	Directive	Standard	Applied Version
				• IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2220-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short

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VFD Model	CE mark	Directive	Standard	Applied Version
				interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2220-AL	yes	**Low Voltage directive)**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short

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VFD Model	CE mark	Directive	Standard	Applied Version
				interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2300-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short

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VFD Model	CE mark	Directive	Standard	Applied Version
				interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2375-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short

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VFD Model	CE mark	Directive	Standard	Applied Version
				interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-1-2450-A	yes	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Electro-magnetic compatibility	IEC 61800-3	2022
			(Product Standard)	• IEC 61000-4-2 Electrostatic discharge • IEC 61000-4-3Radiated, radio-frequency, electromagnetic field • IEC 61000-4-4Electrical fast transient/burst • IEC 61000-4-5Surge • IEC 61000-4-6Conducted disturbances induced by radio-frequency fields • IEC 61000-4-11 and -4-34 Voltage dips, short

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VFD Model	CE mark	Directive	Standard	Applied Version
				interruptions, and voltage variations
		Eco Design	IEC 61800-9-2	Edition 2.0 2023-10
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2150-A	no	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2185-A	no	**Low Voltage directive**	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

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VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2220-A	no	Low Voltage directive	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2300-A	no	Low Voltage directive	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2375-A	no	Low Voltage directive	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2450-A	no	Low Voltage directive	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

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VFD Model	CE mark	Directive	Standard	Applied Version
SDB-2-2550-A	no	Low Voltage directive	IEC 61800-5-1	2007 - Including AMD1:2016
		Restriction of Hazardous Substances 2	IEC 63000	2018

Previous Next

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21. Warranty, Software License and Legal Provisions

Limited Warranty

SmartD Technologies Inc. ("**SmartD**") warrants that for a period of eighteen (18) months (except for plastic components (e.g. plastic cover) which are warranted for thirty (30) days only) from the date of shipment by SmartD (the "**Warranty Period**") the SmartD products purchased directly from it or from an authorized reseller of SmartD (the "**Product**") will conform to its respective specifications published on SmartD's website in effect on the date of purchase and be free from defects in manufacturing or workmanship. This limited warranty is only available to the original purchaser (the "**Purchaser**") of the Product and is non-transferable.

Warranty Limitations

This Limited Warranty does not apply where the Product, including the software embedded in it:

1. has been subject to abuse, misuse, neglect, negligence, accident, improper testing, improper installation, improper handling, subject to improper power supply, such as low voltage, defective wiring or inadequate fuse or use contrary to any instructions issued by SmartD;
2. was damaged by a power failure, during transit, when moving or installing, by fire, by water, other acts which are not attributable to SmartD; or
3. has been reconstructed, repaired or altered by any person other than SmartD or its authorized representative.

Exclusive Remedy

Purchaser's sole and exclusive remedy and SmartD's sole and exclusive obligation with regards to any claims that the Product breaches the limited warranty described herein as such shall be determined by SmartD at its exclusive discretion (thereafter "Defective Product") shall be: at SmartD's option, to: (i) repair or replace the Defective Product; or (ii) reimburse Purchaser the full purchase price paid by Purchaser for the Defective Product. Provided in both cases that (i) Purchaser provides SmartD with sufficient details to enable SmartD to recreate and diagnose the failure of the Product to function as warranted; (ii) as may be requested by SmartD, the Product is either shipped to SmartD or made available to SmartD for inspection; and (iii) the breach of the limited warranty is reported to SmartD within the Warranty Period. In no event shall SmartD be responsible for installation, dismantling or reinstallation costs or charges. THE PRECEDING SETS FORTH PURCHASER'S SOLE REMEDY AND SMARTD'S ENTIRE LIABILITY FOR ANY BREACH OF SMARTD'S LIMITED WARRANTY.

Additional Terms of the Limited Warranty

Parts, accessories or components that are new or reconditioned to perform as new, shall be furnished by SmartD on an exchange basis, and the exchanged parts shall become SmartD's property. The Warranty Period shall not be extended due to suspension of the use of the Product during repair, replacement, examination, or any other reasons. Purchaser shall bear all costs associated with transportation of returned Product, parts, accessories and components, and will bear all risk of loss or damage while in transit. In the event no breach of the limited warranty is discovered by SmartD but the returned Product nonetheless requires repair or replacement, SmartD shall, upon approval by Purchaser, repair or replace the Product, and return the same to Purchaser at Purchaser's expense and risk. Purchaser is responsible for the installation of any replacement Products

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provided pursuant to this Limited Warranty. SmartD reserves its right to charge a fee for any service calls resulting in customer education for Products that are not Defective Products.

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IN NO EVENT SHALL SMARTD BE LIABLE FOR CONSEQUENTIAL, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, AGGRAVATED, PUNITIVE OR ENHANCED DAMAGES, LOST PROFITS OR REVENUES OR DIMINUTION IN VALUE, ARISING OUT OF OR RELATING TO THE PURCHASE OF THE PRODUCTS, REGARDLESS OF (A) WHETHER SUCH DAMAGES WERE FORESEEABLE, (B) WHETHER OR NOT THE CUSTOMER WAS ADVISED OF THE POSSIBILITY OF SUCH DAMAGES OR (C) THE LEGAL OR EQUITABLE THEORY (CONTRACT, TORT OR OTHERWISE) UPON WHICH THE CLAIM IS BASED, AND NOTWITHSTANDING THE FAILURE OF ANY AGREED OR OTHER REMEDY OF ITS ESSENTIAL PURPOSE. IN NO EVENT SHALL SMARTD'S TOTAL LIABILITY ARISING OUT OF OR RELATED TO PRODUCTS, WHETHER ARISING OUT OF OR RELATED TO BREACH OF CONTRACT, TORT (INCLUDING NEGLIGENCE) OR OTHERWISE, EXCEED THE DOLLAR VALUE OF THE PRODUCT RELATED TO SUCH CLAIM.

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Export Controls

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Purchaser shall comply with all applicable regulations and laws in effect now and hereinafter, including compliance with all export controls on the distribution or dissemination of this Equipment, embedded software and documentation related to this Equipment.

General Provisions

SmartD shall not be responsible for delays or failures in performance resulting from acts beyond its reasonable control. If any part or provision of this section shall be found to be illegal or unenforceable therein, the remaining provisions of this Section shall remain in full force and effect and such part or provision shall be deemed stricken. The terms of this Section shall be governed by and construed in accordance with the laws of the province of Quebec, CANADA, applied without giving effect to any conflicts of law principles. The parties agree that all disputes relating to, or arising out of, this Section shall be subject to the exclusive jurisdiction and venue of the courts of the judicial district of Montreal (Quebec).

Previous Next

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Previous

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