

APPLICATION NOTE AN001

Speed Control with Clean Power VFD & PLC

A practical guide to integrating the SmartD Clean Power VFD with a PLC for precise, repeatable motor speed control.



SECTION 1

Introduction

This application note describes how to integrate the SmartD Clean Power Variable Frequency Drive (VFD) with a Programmable Logic Controller (PLC) to achieve precise motor speed control.

The Clean Power VFD is designed to deliver near-sinusoidal output to the motor, helping reduce motor stress compared with conventional PWM output and helping simplify panel design by reducing reliance on external filters.

By the end of this note you will have a working understanding of the architecture, wiring, PLC program structure, and commissioning steps required to deploy a VFD + PLC speed control system using SmartD hardware.

SECTION 2

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The user must exercise caution and follow all safety protocols when working with VFDs. This includes, but is not limited to, wearing appropriate personal protective equipment (PPE), disconnecting power before working on equipment, and adhering to all applicable local and national electrical codes.

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VFDs in industry and the case for clean power

Variable Frequency Drives have become the standard method for controlling AC motor speed and torque, delivering significant energy savings and process control benefits across many industries.

Conventional VFDs, however, produce high-frequency switching waveforms that can introduce vibration, audible noise, heat, and harmonic distortion on both the input and output sides. These side effects can shorten motor insulation life, complicate harmonic mitigation work, and add external components (line reactors, dV/dt filters, sine-wave filters) to the panel.

The Clean Power VFD is SmartD's response to these system-level constraints: a drive designed to behave more like the ideal source the motor expects, while keeping the panel simpler.

Why Clean Power VFD

The Clean Power VFD is built around five practical design priorities.

1. **Improved energy efficiency.** Matches motor speed to process demand and helps reduce the wasted energy typical of fixed-speed or throttled systems.
2. **Low input and output harmonics.** Active front end and near-sinusoidal output help reduce electrical noise and help simplify harmonic mitigation work.
3. **Extended motor lifetime.** Near-sinusoidal output helps reduce motor insulation stress, bearing currents, and electrical noise compared with conventional PWM drives.
4. **Reduced reliance on external filters.** Can reduce the need for line reactors, dV/dt filters, or sine filters depending on the application, helping simplify panel design.
5. **Active Front End (AFE).** Enables power factor near unity, low harmonics, and regenerative braking where the application benefits from it.

Integrated into a system, these properties help reduce panel component count and help simplify the compliance conversation with the customer.

Product overview

The SmartD Clean Power VFD is a compact AC drive combining SmartD's patented control algorithms with Silicon Carbide (SiC) power transistor technology. It is designed to deliver near-sinusoidal three-phase output to AC induction motors.

Built-in features for space, wiring, and time savings help reduce the need for output filtering and help support longer motor lifetime in retrofit applications.

Main features

- Variable frequency drive for AC induction motors
- V/f and Field Oriented Control — open and closed loop
- Built-in Safe Torque Off (STO) inputs
- Dual Ethernet port
- Integrated EMC filters
- Pluggable display
- Near-sinusoidal three-phase power output
- Multifunctional digital and analog I/O
- 24 VDC control power supply input
- Configurable linear ramps
- Mobile app for setup, monitoring, and control
- Natural-language user interface

Models

The Clean Power VFD comes in several models with different input voltages and output currents. Examples:

- **SDB-1-2185-A:** 400–480 V three-phase input, 34 A output current (ND)
- **SDB-2-2220-A:** 600 V three-phase input, 34 A output current (ND)

For the complete model list, see: smartd.tech/clean-power-vfds

Controls

The Clean Power VFD provides the following control I/O:

- 24 VDC control power output to energize digital inputs or sensors
- 6 digital inputs — two of which support incremental encoder input

2 STO terminals for emergency stop category 0

- 3 relay outputs
- 3 analog inputs, 4–20 mA or 0–10 V
- 2 analog outputs, 4–20 mA or 0–10 V

For full specifications, see [smartd.tech](https://www.smartd.tech).

Application: VFD & PLC speed control

Application overview

The Clean Power VFD adjusts the frequency and voltage supplied to the motor, controlling its speed. In this application the VFD is remotely managed by a PLC.

The PLC provides a speed setpoint to the VFD. The setpoint can be generated automatically by the PLC, or set manually by an operator via a potentiometer or other HMI element.

This note focuses on a simple HMI: a potentiometer for manual setpoint, plus a three-position selector switch for predefined speeds (Slow / Medium / Fast).

On receiving the setpoint, the PLC commands the VFD, and the VFD regulates motor speed to that setpoint. The result is a repeatable speed control loop that can be tuned for energy efficiency and process precision.

When to add a PLC, and when not to

SmartD VFDs include enough built-in functionality for many basic motor control jobs without a PLC — but not for every job. The table below summarizes the tradeoff.

PLC + VFD	PROS • Flexibility — complex control algorithms, sensor data, safety logic • Scalability — one PLC can control multiple VFDs and devices • Data logging and monitoring for analysis and preventive maintenance • Communication — integrates into larger automation networks	CONS • Higher initial system cost • PLC programming expertise required
VFD only	PROS • Simpler setup for basic on/off and speed control	CONS • Limited control logic and integration capability

	• Lower cost for simple applications	• Scalability difficult — each VFD wired and configured independently • Data monitoring limited to drive's built-in parameters
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In short: a VFD on its own is often enough for basic operations. Add a PLC when the application needs:

- Precise control with complex logic
- Scalability across multiple devices
- Data recording and communication
- Integration into a larger automation system

Implementation guide — VFD & PLC

Step-by-step instructions for integrating and configuring the Clean Power VFD with a PLC.

1. **Prepare the hardware.** Gather the Clean Power VFD, the PLC, the human-machine interface for the manual setpoint, the motor to control, and the protections required by local and international regulations.
2. **Connect the hardware.** Connect the Clean Power VFD to the motor following the user manual. Connect the PLC to the VFD and to the HMI.
3. **Program the PLC.** Write a program that delivers a setpoint to the VFD. The setpoint can be generated automatically or set manually through the HMI.
4. **Configure the VFD.** Set input voltage, output current, and other parameters in line with the user guide and the connected motor.
5. **Test the system.** With the program running, adjust the setpoint and verify that the motor follows it correctly.
6. **Monitor and adjust.** After commissioning, monitor system behavior and fine-tune the setpoint logic or the PLC program as needed.

NOTE

These steps are general guidelines. For specific instructions related to your hardware and application, refer to the manufacturer’s documentation.

6.1.1 Prepare the hardware

The table below lists each component class, the usual selection rule, and how the Clean Power VFD changes the conversation.

Component	Usual selection rule	With Clean Power VFD
Motor	Selection depends on application: load type (constant or variable torque), required speed range, power rating, and operating environment.	Compatibility with non-VFD-rated motors. The near-sinusoidal output is closer to the motor’s natural supply waveform than conventional PWM, helping reduce stress on motor insulation from high-voltage switching spikes.

Component	Usual selection rule	With Clean Power VFD
	Verify VFD compatibility — not all motors are designed to be driven from a VFD.	Always confirm compatibility with the motor manufacturer for non-VFD-rated motors before commissioning.
VFD	Start with line and motor voltage. Then size for the motor's full-load current and inrush current under normal operating conditions. Example: a motor with 28 A full-load current is covered by the SDB-1-2185-A (34 A output, ND).	Faster VFD selection. Match the Clean Power VFD rating to motor power, then verify the rated current against the motor's operating profile.
PLC	List the inputs and outputs required by the application, then select a PLC architecture that fits the I/O count, communication protocols, and processing needs.	—
PLC I/O list	Digital inputs: Run Auto, Run Manual, Start, Stop, VFD Ready, VFD Alarm, Speed Selection Digital outputs: Motor Run Forward, Tower light (Equipment Running, Fault, Powered) Analog inputs: Manual speed setpoint (0–10 V), VFD speed feedback Analog outputs: Speed reference (4–20 mA)	—
Electrical distribution and protection	Power main switch at the system entry point. 24 VDC supply sized for the connected devices. Circuit breaker on the input of the DC power supply. Circuit breaker and fuses on the VFD input, as recommended in the user guide.	—

Component	Usual selection rule	With Clean Power VFD
Safety	Select a safety relay and emergency-stop actuator based on the application's risk assessment.	Integrated STO. For low-risk processes requiring a simple stop category 0, the Clean Power VFD provides two STO terminals.
Control and interface	3-position selector: Manual / Auto / Off 3-position selector: Speed selection (Slow / Medium / Fast) Potentiometer for manual setpoint Stack light or pilot lights Push-buttons: Start, Stop, Reset	—
Control cables	Select per control voltage and applicable regulations. Shield cables and ground at both ends to improve noise immunity.	Recommended. Double-shielded cable for low-voltage digital signals. Single-shielded twisted pair is also acceptable in many cases.
Power cables	Use 600 V, 75 °C rated copper. Size per local and international regulations. Insulation must withstand the transients produced by PWM output. Use three symmetrically arranged insulated grounding conductors — added harmonic currents in the grounding circuit can lead to premature bearing failures.	Standard motor cable compatibility. The near-sinusoidal output can reduce the need for special low-capacitance VFD cables in many applications. Harmonic reduction. Low input and output harmonics help reduce electrical noise and help improve system efficiency. The active front end supports power factor near unity. Shielding. Use shielded cables to protect nearby low-voltage and communications cables from electromagnetic interference. Ground all parts (motor, VFD, control wiring, panel) consistently.
Power cable length	High-voltage spikes increase with cable length, making longer runs more prone to motor insulation failure.	Extended cable length capability. The near-sinusoidal output helps limit voltage reflections on long runs, so the practical limit is typically driven by voltage drop rather than

Component	Usual selection rule	With Clean Power VFD
	For runs over 300 ft (about 100 m), special considerations may be needed.	insulation stress — depending on the application.

6.1.2 Connect the hardware

Architecture layout

The control panel selects the operating mode of the system: Automatic, Manual, or Off.

- In Automatic mode, Start and Stop command the motor; speed is selected between Slow / Medium / Fast.
- In Manual mode, Start and Stop command the motor; speed is set by the potentiometer.
- An optional emergency-stop pushbutton can be added for stop category 0, depending on the required safety level.
- System status is shown by a three-stage stack light.
- The VFD is protected by fuses (per the user guide) and a mechanical circuit breaker.
- A main switch powers the whole system on and off.
- The PLC is powered by a 24 VDC auxiliary supply, which also feeds the VFD control inputs and other automation devices.

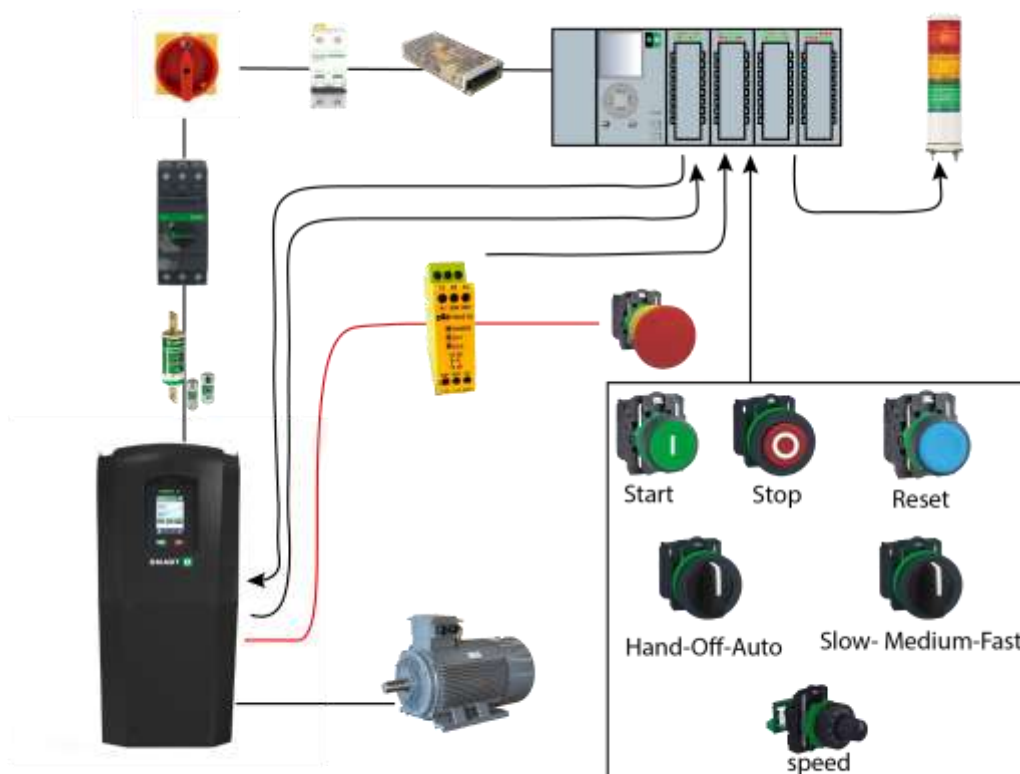


Figure 1 — System architecture: power distribution, safety, PLC, VFD, motor, and operator controls.

Wiring — grounding

Connect the Clean Power VFD to the earth ground of the AC supply.

- Grounding wires must meet the technical standards for electrical equipment.
- Impedance must conform to national and local regulations, safety regulations, and electrical codes.
- Keep grounding wire length to a minimum.

Wiring — power connections

Follow the [user guide recommendations for power wiring](#).

Wiring — control connections

The control wiring shown below combines the digital inputs (Start, Stop, Reset, Auto/Off/Manual selector, Slow/Medium/Fast selector) with the analog input for manual setpoint and the relay feedback from the VFD.

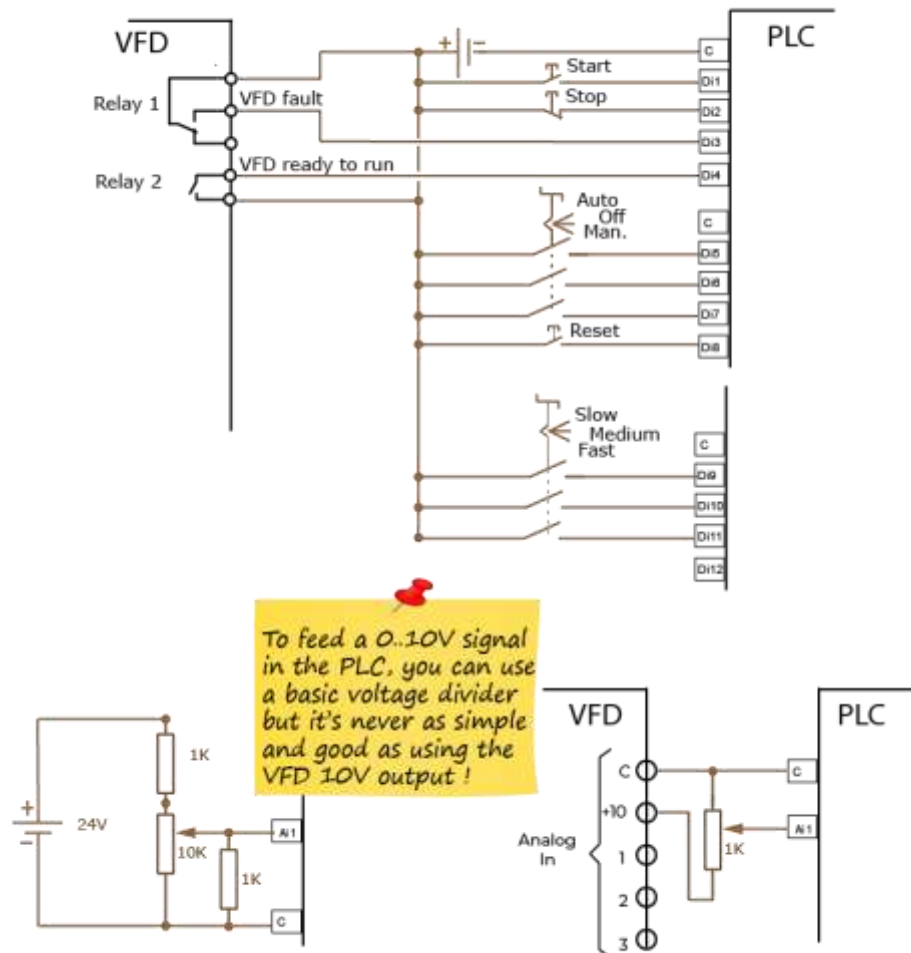


Figure 2 — Control wiring: PLC to VFD digital and analog connections.

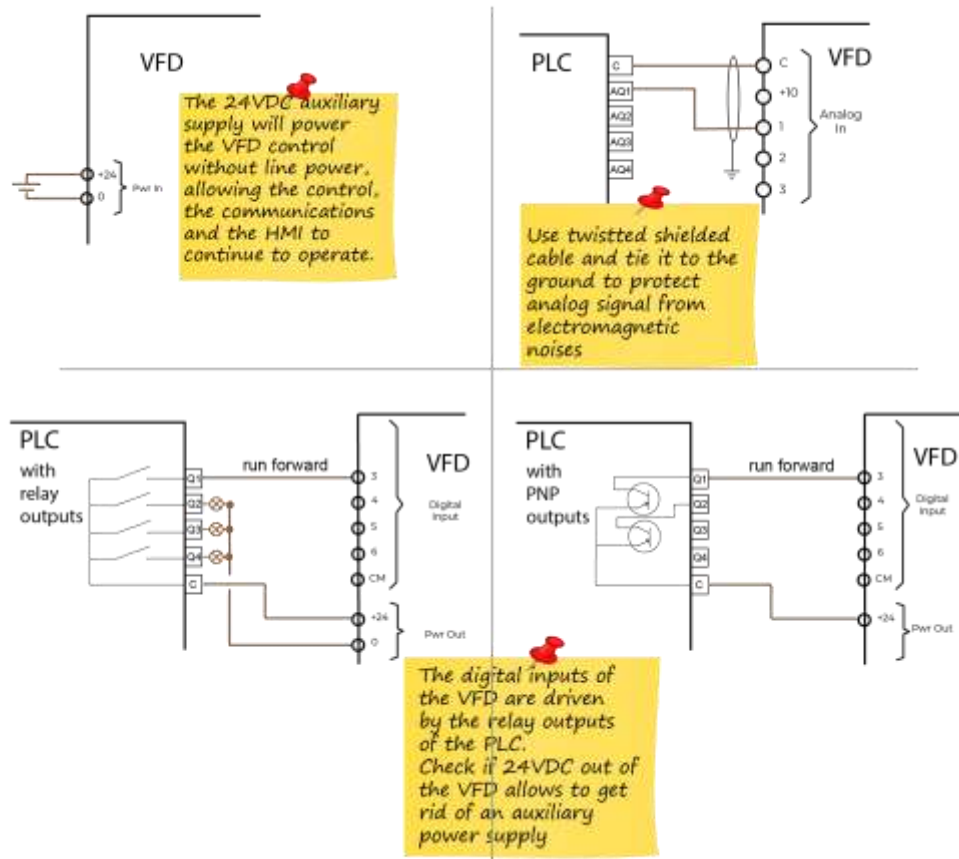


Figure 3 — Power and signal wiring details (auxiliary supply, analog reference, relay vs PNP output configurations).

6.1.3 Program the PLC

Program overview

The system controls motor speed via a VFD interfaced with a PLC. The PLC receives operator inputs, applies the control logic, and sends the speed command to the VFD.

PLC inputs

- **Start.** Initiates motor operation.
- **Stop.** Halts motor operation.
- **Speed Selector.** Selects one of three preset speeds.
- **Auto Command.** Enables automatic speed control based on preset values.
- **Manual Command.** Enables manual speed control via the potentiometer.
- **Off.** Disables motor operation.
- **Analog Input.** Receives the analog speed setpoint in manual mode.
- **VFD Ready.** Indicates that the VFD is ready for operation.
- **VFD Fault.** Signals a fault condition in the VFD.
- **Reset.** Clears faults and resets the system to a known state.

PLC outputs

- **VFD Run / Stop.** Commands the VFD to start or stop.
- **VFD Speed Setpoint.** Sends the analog speed setpoint to the VFD.
- **Stack light indicators.** Three-level stack light on the PLC's digital outputs:
 - **Green** (System On) — system is powered and ready.
 - **Yellow** (System Run) — motor is currently running.
 - **Red** (System Fault) — fault condition in the system.

Ladder program structure (high level)

- **Start / Stop control.** First rung: start button energizes a holding relay; stop button de-energizes it.
- **Speed selection.** Each position of the selector switch maps to one preset speed, written to the VFD speed reference.
- **Auto / Manual mode.** Selector chooses whether the speed reference comes from the preset words or from the analog input.
- **Fault handling.** An active VFD Fault input stops the motor and activates the red stack light.
- **Stack light control.** Drives green / yellow / red outputs based on system state.
- **Reset.** Clears faults and prepares the system to restart.

Why ladder logic for this application

Ladder logic is well suited to this kind of program for several practical reasons.

- **Familiar to technicians and electricians.** Ladder logic resembles relay schematics, so it can be read and modified by people familiar with electrical schematics, not just programmers.
- **Visual logic flow.** Rungs directly correspond to sequential steps in the control logic, which makes cause-and-effect easy to follow.
- **Easier debugging.** The visual nature of ladder logic makes troubleshooting and live monitoring straightforward on the PLC.
- **Strong fit for boolean logic.** Most of this program is ON/OFF conditions — exactly what ladder rungs and contacts represent best.

FBD and Structured Text are stronger options when:

- The program needs heavy math or complex data manipulation (Structured Text)
- The codebase is large enough that subroutines, functions, and code reuse matter more (FBD or Structured Text)

For the audience of this application note — commissioning engineers and maintenance technicians — ladder is the most accessible representation, so this is the language used in the examples that follow.

6.1.3.3 Ladder program — VFD & PLC

Start / Stop sequence

The motor start is initiated by a pulse on the Start input %I0.1, conditional on three logic states.

- Stop is inactive
- VFD is not at fault
- VFD is ready to run

A parallel branch of the coil motor_run holds the run command until one of the stop conditions becomes true. The start input is ignored while any of the three conditions blocks operation.

The same command-and-latch principle can be extended if the application requires two directions of rotation.



Figure 4 — Start / Stop rung with permissive conditions (VFD ready, no fault, stop inactive).

Speed command

Preset speeds are stored in memory words %MWO, %MW1, and %MW2. The selected value is written to the analog output reference when Auto mode is active and the matching selector input is asserted.

Negated contacts of the non-selected values prevent two speeds from being commanded at the same time if the selector switch is tampered with. The same negated-contact pattern is applied to the operating mode (Auto / Manual) to prevent simultaneous selection.

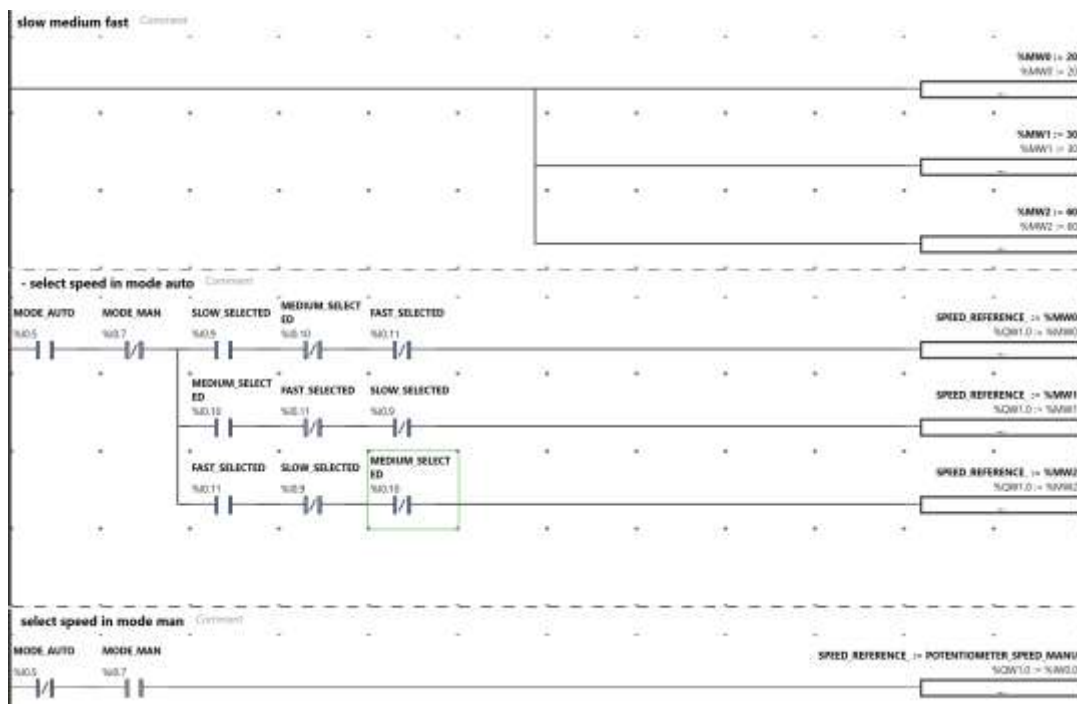


Figure 5 — Speed selection ladder: preset writes to %MW0/%MW1/%MW2 plus mode-aware reference assignment.

Tower light control

The stack light rungs drive each color based on system state, including a flashing red on fault. The example uses two TP (pulse) timers: %TM0 for 3 s on, %TM1 for 2 s off. The same pattern can be applied to any pilot light needing periodic behavior.

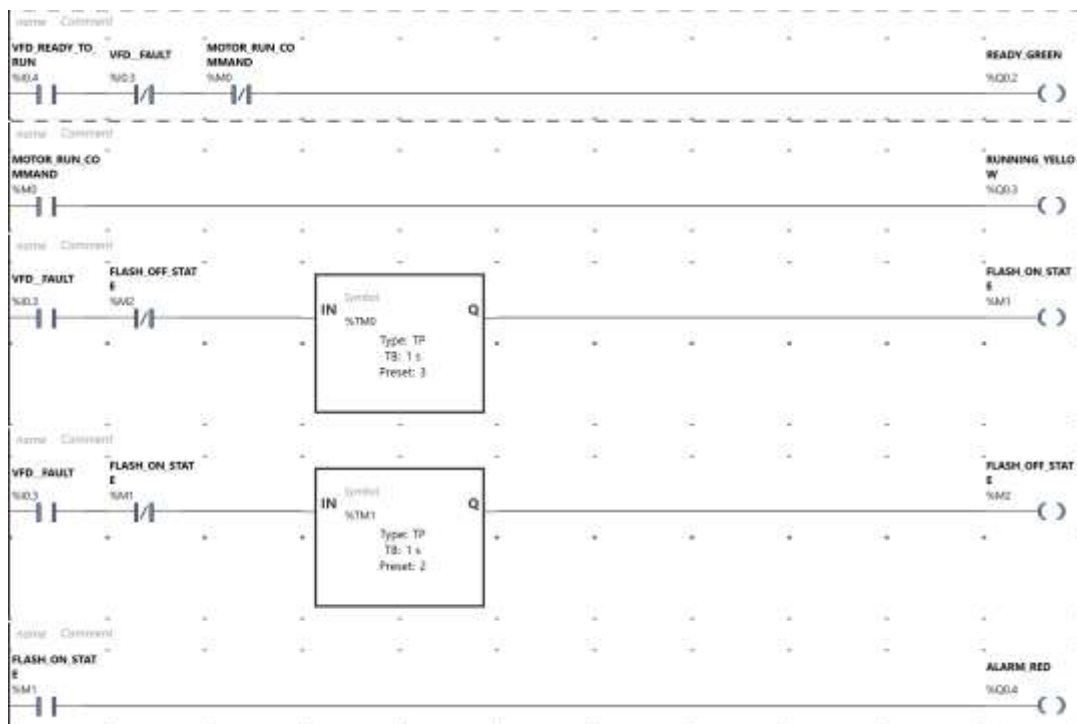


Figure 6 — Stack light rungs (green / yellow / flashing red) with timer-based flasher.

SECTION 7

Benefits and results

Deploying the Clean Power VFD in a PLC-controlled speed control application delivers benefits that are both quantifiable and structural.

Energy and operating cost

Matching motor speed to process demand helps reduce wasted power and helps reduce operating costs. Because the Clean Power VFD does not require external output filters in many applications, the system also avoids the losses those filters would otherwise introduce.

Motor lifetime and power quality

The near-sinusoidal output helps reduce electrical noise and helps reduce harmonic distortion compared with conventional PWM drives. This can help extend motor insulation life and helps reduce stress on bearings on long cable runs — with the qualifier that results depend on motor type, cable length, and grid conditions.

Panel simplicity and maintenance

The filter-light architecture helps reduce panel component count, which can help simplify maintenance and help reduce downtime. Specific results depend on the application — contact application engineering for site-specific evaluation.

SECTION 8

Conclusion

This application note has described how to integrate the SmartD Clean Power VFD with a PLC for precise motor speed control — from architecture and wiring through PLC program structure to commissioning.

The Clean Power VFD's near-sinusoidal output, integrated EMC filtering, and active front end help simplify panel design, help reduce reliance on external filters, and help support longer motor lifetime in retrofit applications. Combined with a PLC, the system supports the flexibility, scalability, and data visibility that complex motor control applications need.

For further information, detailed specifications, or to discuss a specific deployment, contact SmartD application engineering or visit the SmartD website.

TALK TO APPLICATION ENGINEERING

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