

AN006 - Simple HVAC Fan & Damper Control using Digital Inputs and Relays



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1. AN006 – Simple HVAC Fan & Damper Control using Digital Inputs and Relays

1.1. Disclaimer: HVAC Fan & Damper Control

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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.

These application notes should not be used as a substitute for professional engineering advice, inspection, or consultation. The user is solely responsible for ensuring that any practices, installations, or actions taken based on these application notes meet all safety and operational requirements.

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1.2. Native HVAC Fan & Damper Control

Application Overview

This application note provides a step-by-step guide to implement HVAC fan and damper control using the Clean Power VFD's embedded Damper functionality.

It covers how to wire and configure Clean Power VFD.

HVAC Fan & Damper Control

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.

Safety compliance is the responsibility of the user, not the VFD manufacturer.

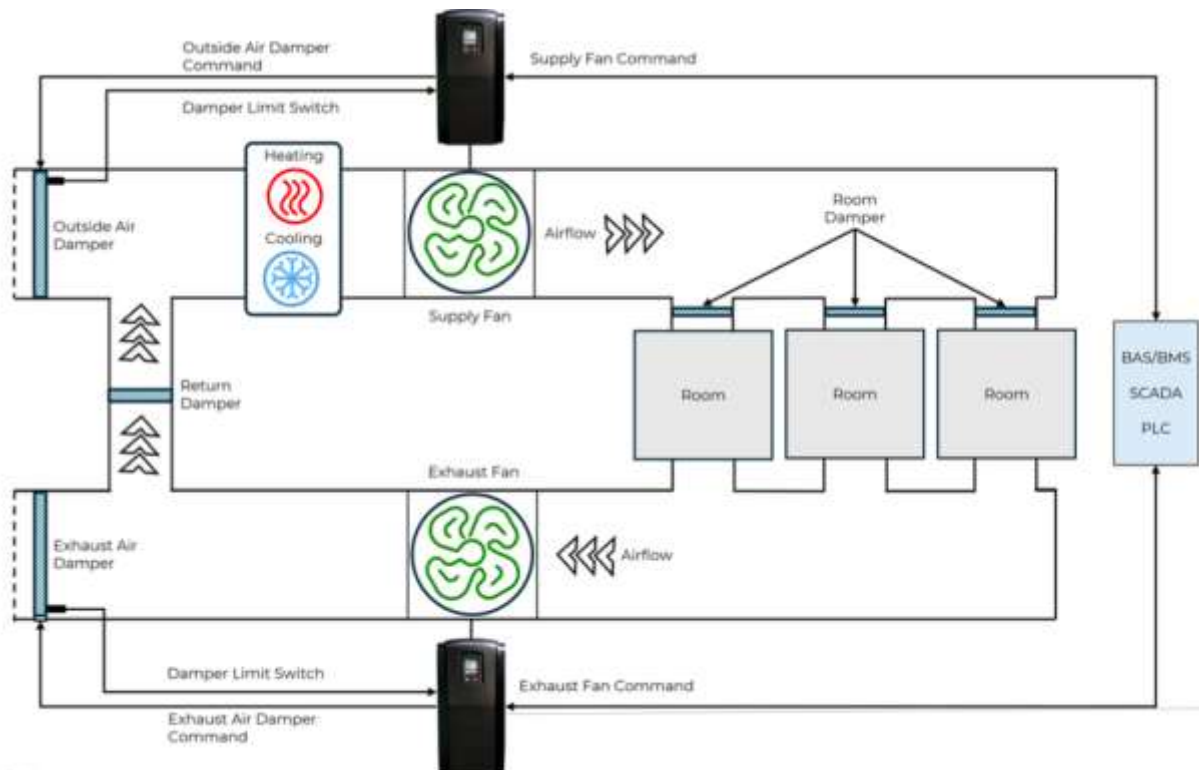
1.3. Implementation Guide: Native FAN & Damper Control

Software Compatibility

Please make sure to [update your Clean Power VFD's firmware](#) to version 2025.04.00 or later to use the fan & damper control functionality.

You can find the link to download the firmware in the latest release notes on the [SmartD Help Center](#).

Key Aspects of Damper and VFD Integration



Control and Communication

VFDs can be programmed to operate in response to signals from the building automation system (BAS), programmable logic controller (PLC), sensors, or directly from the dampers. For example, as the damper opens to increase airflow, the VFD adjusts the fan speed to meet the demand. Similarly, if the damper closes, the VFD slows the fan motor down, conserving energy.

Often, a PID loop is used to control the fan speed based on input from pressure or airflow sensors, ensuring consistent airflow and reducing unnecessary energy use. Usage of embedded PID is not covered in this application note.

Pressure Control

Many HVAC systems are designed to maintain a certain static pressure within the ducts. As dampers open and close, this pressure can vary. The VFD adjusts fan speed to maintain optimal static pressure, enhancing comfort while avoiding excessive strain on components.

Using VFDs and dampers together provides better control over pressure fluctuations, reducing the likelihood of air leaks and duct damage.

Energy Efficiency

Integrating VFDs with dampers can significantly reduce energy consumption in HVAC systems. By modulating fan speed according to the actual demand, energy wastage from fans running at full speed is minimized.

Energy savings are especially notable in variable air volume (VAV) systems, where demand for airflow varies throughout the day. The VFD reduces motor speed in line with the reduced airflow requirements when certain zones or areas require less ventilation.

Reduced Wear and Tear

With dampers and VFDs working together, the system avoids unnecessary strain on motors and fans, as it operates only at the required speed. This leads to less wear on the components, potentially extending their operational lifespan. Additionally, VFDs provide smoother ramp-up and ramp-down, reducing sudden changes in fan speed that could otherwise cause mechanical stress on the HVAC system.

Enhanced Control Options

The integration allows for advanced HVAC zoning, where dampers control airflow to specific areas while the VFD modulates fan speed according to demand. This setup supports precise temperature and ventilation control in different zones.

It is also possible to link VFD control to environmental or occupancy sensors, enabling further energy savings by reducing airflow in unoccupied areas.

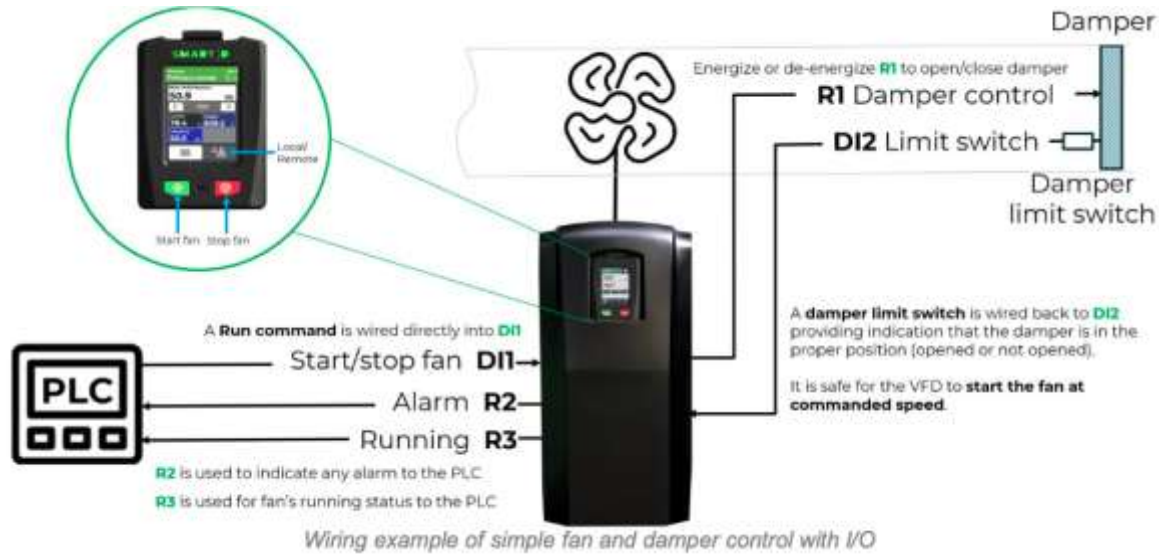
Applications in HVAC Systems

- **Commercial Buildings**
VFD-damper integration is common in large commercial buildings where varying airflow is needed across multiple zones.
- **Industrial Facilities**
In spaces where ventilation requirements fluctuate, this integration helps maintain air quality and regulate temperature effectively.
- **Data Centers**
Precise airflow control is critical for temperature-sensitive environments like data centers, where VFD-damper setups ensure reliable cooling at optimal efficiency.

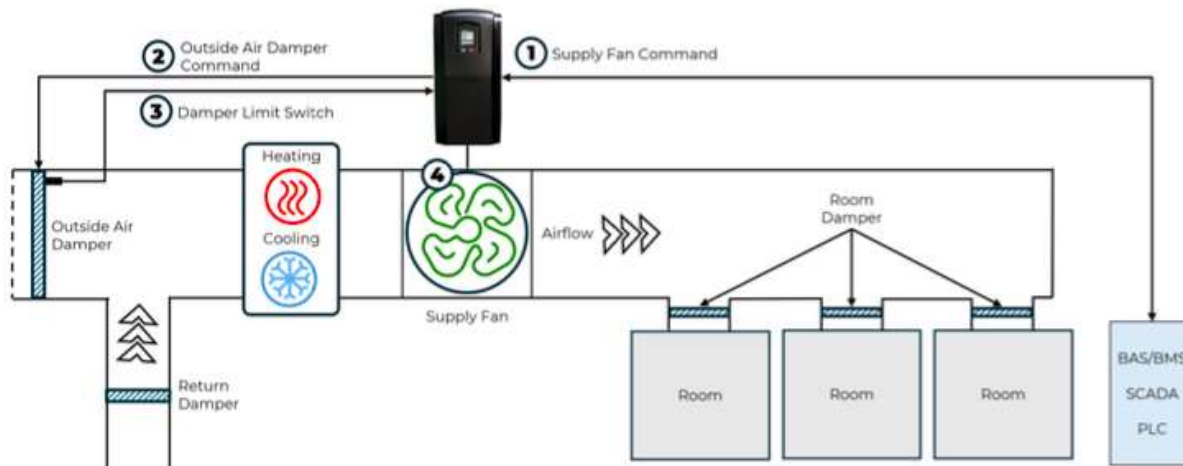
1.3.1. Simple Fan & Damper Start Sequence using I/O

Simple Fan and Damper Start Sequence using I/O

The Clean Power VFD provides natively damper control logic using I/O, reducing cost that is associated with external control hardware and software.



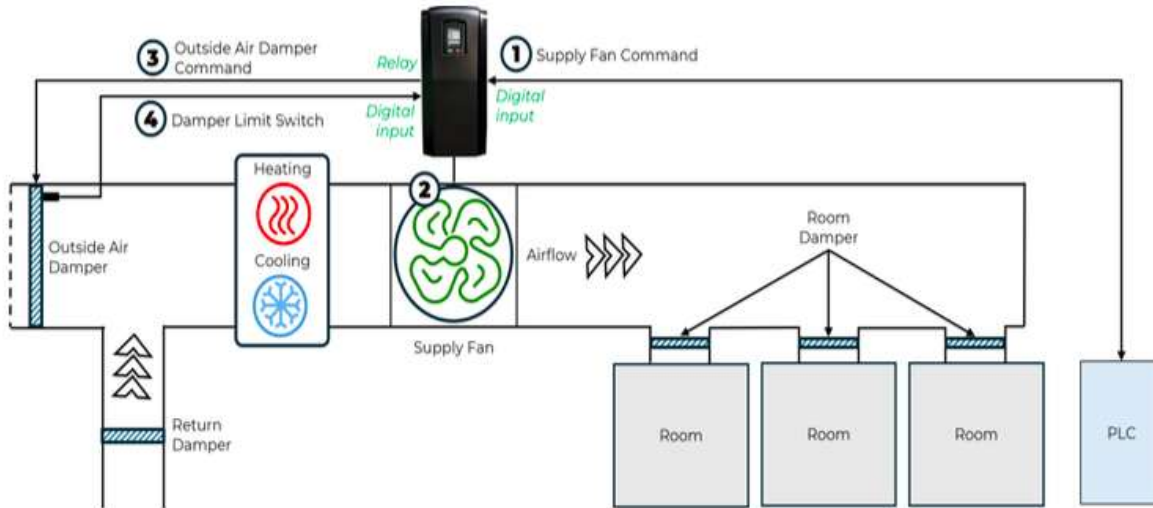
Start fan and damper control with the I/Os



- (1) The fan command is wired directly into one of the Clean Power VFD's digital inputs. The digital input indicates a start fan command.
- (2) The VFD uses its configured output relay to energize the relay that opens the damper.
- (3) The damper limit switch is wired back to another Clean Power VFD's digital input providing indication that the damper is in the proper position, and it is safe to start the fan.
- (4) Once the damper-opened status is confirmed, the VFD accelerates the fan to its setpoint speed.

1.3.2. Simple Fan & Damper Stop Sequence using I/O

Stop fan and damper control with I/O

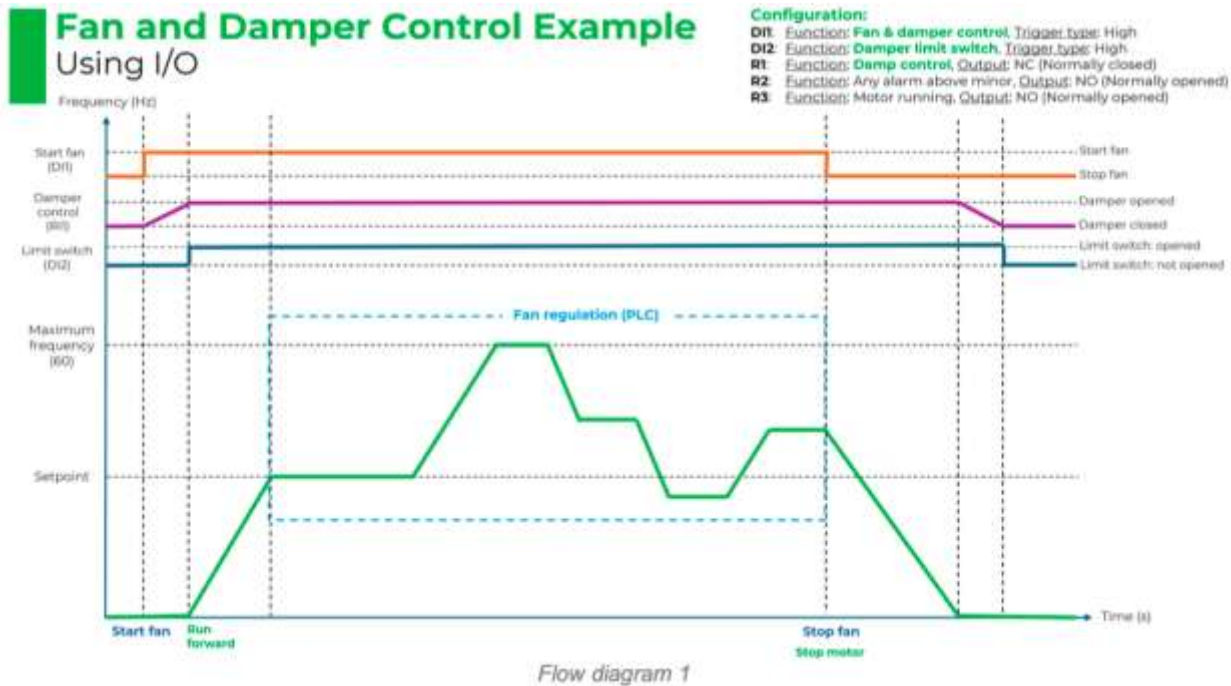


- (1) The fan command digital input indicates a stop fan command.
- (2) The Clean Power VFD decelerates and stops the fan.
- (3) Once the fan is stopped, the Clean Power VFD uses its configured output relay to de-energize the relay that closes the damper.
- (4) The damper limit switch indicates that the damper is closed.

1.3.3. Native Fan and Damper Control using I/O Sequence

Fan and Damper Control using I/O Sequence Diagram

The flow diagram 1 below provides the control sequence from the fan command from the digital input DI1 to start or stop the fan, the relay R1 to open the damper and the damper limit switch feedback wired to digital input DI2 to indicate the damper position.

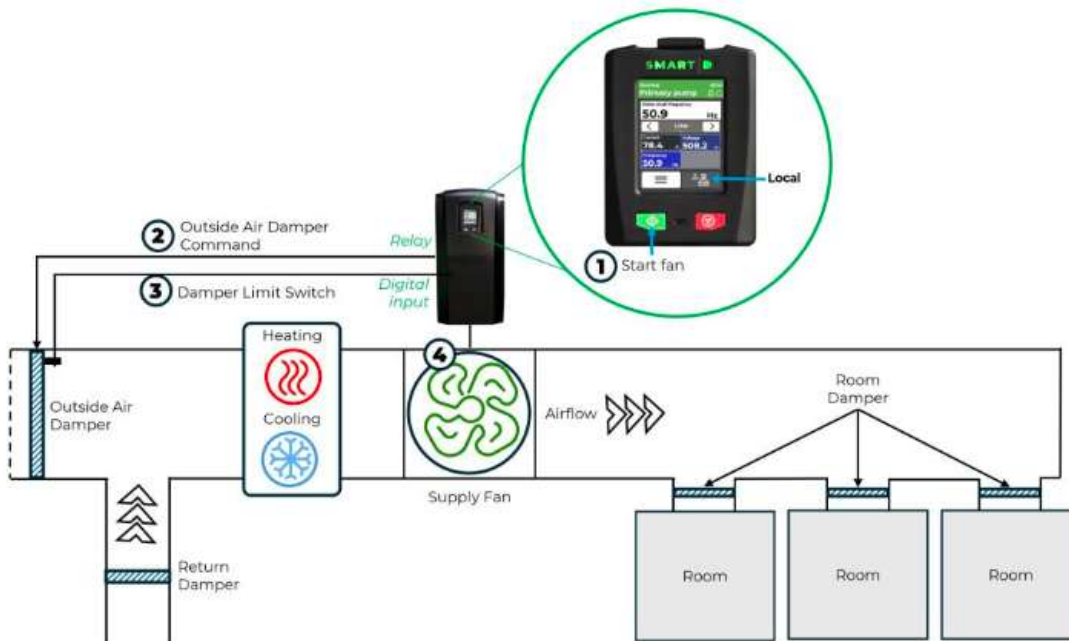


1.3.4. Manual Fan and Damper Start Sequence using HMI

Manual Fan & Damper Start Sequence using HMI

When the Clean Power VFD is in local control mode, the HMI's Start and Stop buttons can be used to perform the same fan and damper control sequence.

Start fan and damper control with HMI



(1) Pressing on the HMI's Start button issues a start fan command.

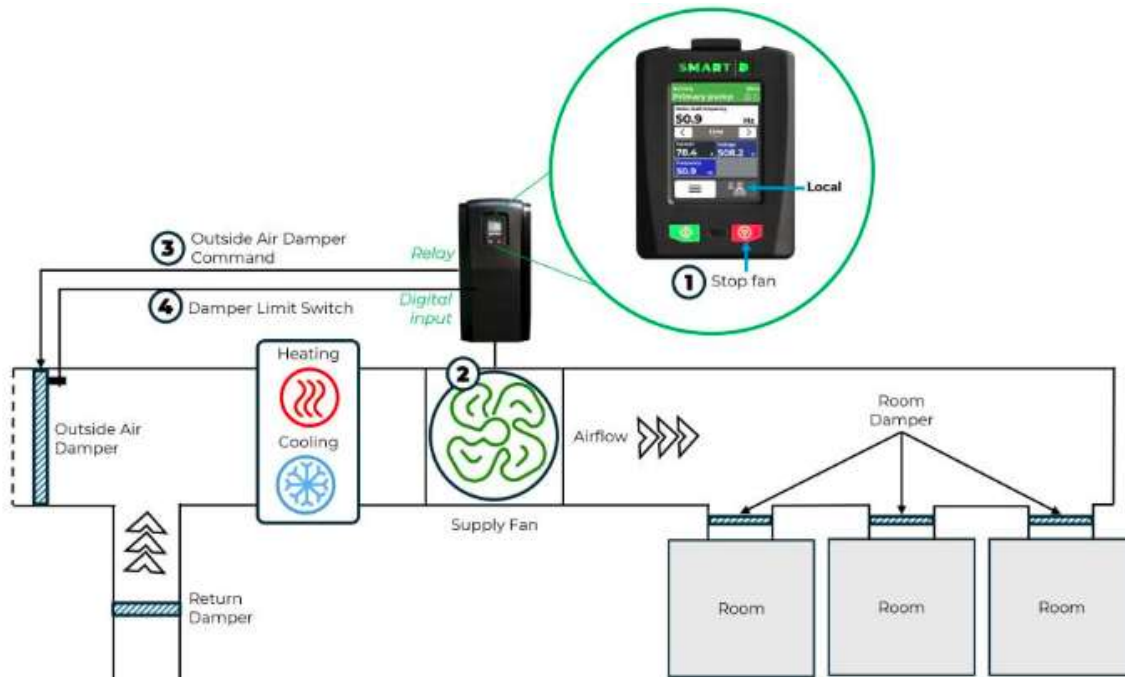
(2) The Clean Power VFD uses its configured relay to energize the relay that opens the damper.

(3) The damper limit switch is wired back to another Clean Power VFD's digital input providing indication that the damper is in the proper position, and it is safe to start the fan.

(4) Once the damper-opened status is confirmed, the VFD accelerates the fan to its setpoint speed.

1.3.5. Stop Fan and Damper Stop Sequence using HMI

Stop fan and damper control with HMI



(1) Pressing on the HMI's Stop button issues a stop fan command.

(2) The Clean Power VFD decelerates and stops the fan.

(3) Once the fan is stopped, the Clean Power VFD uses its configured relay to de-energize the relay that closes the damper.

(4) The damper limit switch indicates that the damper is closed.

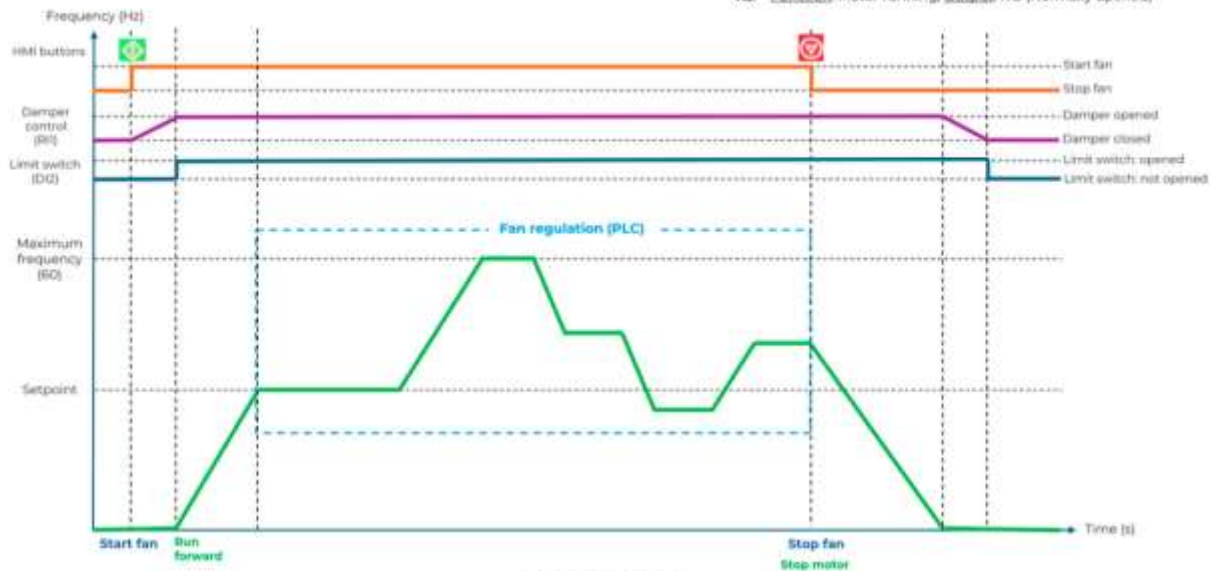
1.3.6. Native Fan and Damper Control using HMI sequence

Fan and Damper Control using HMI Sequence Diagram

The flow diagram 2 below provides the control sequence from the fan command from HMI's Start button to start the fan and the Stop button to stop the fan, the relay R1 to open the damper and the damper limit switch feedback wired to digital input DI2 to indicate the damper position.

Fan and Damper Control Example Using HMI

Configuration:
D12: Function: Damper limit switch, Trigger type: High
R1: Function: Damp control, Output: NC (Normally closed)
R2: Function: Any alarm above minor, Output: NO (Normally opened)
R3: Function: Motor running, Output: NO (Normally opened)



1.3.7. Clean Power VFD I/O Configuration

Clean Power VFD I/O Configuration

The Clean Power VFD automatically enables the fan and damper control features when:

- a relay output is assigned for damper control.
- a digital input is assigned for damper limit switch feedback

Both relay and digital input must be assigned to enable the native fan and damper control feature.

Step-by-step mobile configuration

Configuration parameter

Assign a relay for damper control

Menu>>Configuration>>Advanced configuration>>I/O's>>Relays

- Select R1 and click on the pencil
- Select Damper control in the Function
- Select NC (Normally closed) output type
- Click on Done

Assign a digital input for damper's limit switch feedback

Menu>>Configuration>>Advanced configuration>>I/O's>>Digital inputs

- Select DI2 and click on the pencil
- Select Damper feedback in the Function
- Select High as output type
- Click on Done

Setting damper open timeout for alarm

Menu>>Configuration>>Advanced configuration>>Alarms>>Damper control

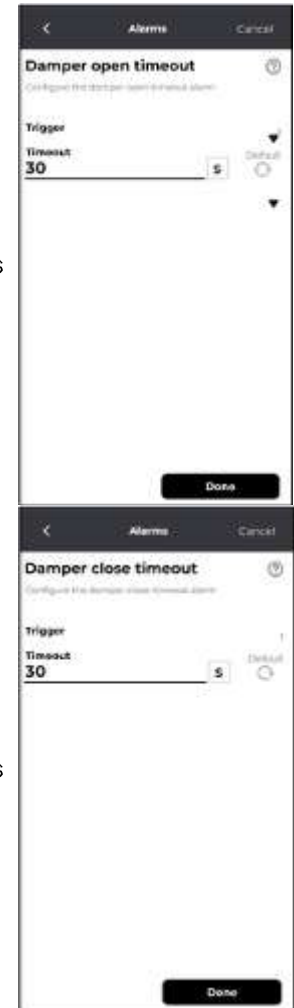
- Select Damper open timeout and click on the pencil
- Enter the timeout in seconds to generate an alarm if the damper feedback input does not indicate that the damper is opened in due time
- Click on Done

Setting damper close timeout for alarm

Menu>>Configuration>>Advanced configuration>>Alarms>>Damper control

- Select Damper close timeout and click on the pencil
- Enter the timeout in seconds to generate an alarm if the damper feedback input does not indicate that the damper is closed in due time
- Click on Done

- Click on Save
- Click on Transfer or Pair to connect and transfer the configuration to the VFD



1.4. Test the HVAC Fan & Damper Control

Test the system

Safety Precautions

- Ensure proper grounding of all electrical components.
- Make sure to have safety barriers and equipment to protect test personnel.
- Make sure that an emergency stop is available.

Pre-test setup

- Make sure that the damper control feature is configured and enabled.
- Make sure that the Clean Power VFD's Digital Input to start the motor is connected to the start/stop control signal.
- Make sure that the Clean Power VFD's Relay to open and close the damper is connected to the damper.
- Make sure that the damper limit switch is connected to the Clean Power VFD's digital input.

Damper control test procedure

Please follow the steps below to test the fan and damper control implementation:

Normal operation:

1. **Verify control connection:** Make sure that all control cables are securely connected to the VFD's inputs and outputs.
2. **Verify the VFD's configuration:** Confirm that a relay is assigned for damper control, and a digital input is assigned for damper feedback.
3. **Manual testing with HMI:** Put the VFD to local control mode and press on the Start button to validate that the start fan and damper control sequence are working. Press on the Stop button to validate that the stop fan and damper control sequence is working.
4. **Test with I/Os:** Switch to remote I/O control, activate the configured DI to issue the start fan command and validate that the start fan and damper control sequence are working. Deactivate the configured DI to issue the stop fan command and validate that the stop fan and damper control sequence is working.

1.5. Fan & Damper Control Alarm Handling

The Clean Power VFD includes three (3) alarms in the damper control logic.

Damper feedback indicates 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 lost, the Clean Power VFD generates a critical alarm to stop the fan in freewheeling to avoid high or low pressure in the duct.

It is recommended to investigate the possible causes and fix the problem before resetting the Clean Power VFD to put it back in normal operation.

Damper open timeout

After energizing the configured relay to open the damper, the Clean Power VFD starts a timer making sure that 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 fix the problem before resetting the Clean Power VFD to put it back in normal operation.

Damper close timeout

After stopping the fan, the Clean Power VFD de-energizes the configured relay to close the damper and starts a timer making sure that 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.