Technical Note 052

Advanced Damper Control

Damper control without additional devices

In many HVAC applications the dampers work in tandem with fans controlled by variable frequency drives (VFD) to regulate airflow. The control of the dampers for these applications is critical whether control originates in the building automation system (BAS) or as proposed in this document, control from the VFD. ABB recommends having the VFD handle the damper control logic, as that allows the logic to be fully functional in both Auto and Hand modes. Damper control schemes handled by the BAS are functional in Auto mode, but often are not functional in Hand mode. Damper configurations in air handling units (AHU) range from a simple isolation damper to more complex systems involving outside air dampers, discharge air dampers, and common plenum systems incorporating multiple fans.

The advanced damper control feature in the ACH580 makes it easy to integrate the damper controls into the VFD by allowing the VFD to initiate the opening of the damper by applying power to the actuator and monitoring the actuator position switches for open and closed status. The ACH580 monitors the position of the damper(s) by using the auxiliary switches in the damper's actuator and connecting those auxiliary switches to the VFD's digital inputs (DI). To control the position of the damper, the power wires of the damper actuator are wired through one of the VFD's integral relay outputs (RO), which in turn supplies or removes power to the actuator. The power supply itself, whether 24 V AC/DC, or 120 VAC, is typically provided from a source external from the VFD package and the VFD is simply making or breaking that power to the actuator.

Advanced damper control is located in Group 84 and contains three control strategies:

- Discharge Air Damper (DA) no pre-pressure
- DA Damper with pre-pressure
- Outside Air (OA) + DA dampers with pre-pressure

The three control strategies are selectable in parameter *84.01* and are discussed in further detail below. Also, supplemental wiring diagrams of these examples are provided at the end of this document.

Discharge air damper no pre-pressure

The DA damper control is used when there is one damper, typically downstream of a supply or exhaust fan. The damper isolates the fan from the plenum or from the outside air. In this no pre-pressure scenario, the damper needs to be opened to establish free area, but there is no need to create pressure in the duct before running the fan. This application utilizes one of the VFD's relay outputs, most commonly RO1 to control the damper actuation. The ROs can be found and configured in parameters *10.24, 10.27, and 10.30*. When configuring the ROs there are two new *RO sources* that have been added to the *RO source* selection list that are associated with Advanced Damper Control. These new sources are [63] *Discharge damper control* and [64] *Outside air damper control*. We will assume going forward for this section that the damper actuator will be controlled using RO1 (*10.24*) and be configured to [63] *Discharge damper control*.

The following is the starting sequence of discharge air damper (no pre-pressure):

- When a start command is sent to the VFD, the VFD will command the DA damper to open and wait for confirmation that the DA damper has achieved the fully open position. The VFD identifies damper position by monitoring the normally open (NO) end switch from the actuator wired to the VFD's digital input.
- The VFD confirms the DA damper is open by receiving confirmation by a closed DI which is configured in *84.03 DA damper open input*. In *84.03*, DI1 thru 6 are selectable.
- Once the selected DI is closed confirming that the DA damper is open, the VFD will continue to start rotating the motor.

An added feature in Advanced Damper Control is that a timeout function can be programed in to *84.04 DA damper open timeout. 84.04* monitors the closure of the DI selected in *84.03*. The default setting is 30 seconds but can be customized between 0 seconds and 90 seconds to match the actuators cycle time. If the DA damper fails to open in the timeout window the VFD can be programed in *84.05* to generate a warning (which is default), fault the VFD, or no action.

When the start command is removed from the VFD, the following sequence will occur:

- The DA damper will remain open until the minimum output frequency is achieved.
- Once the fan reaches the minimum output frequency the VFD will de-energize the relay output and the DA damper will then move to its closed position.
    - Note: If the VFD is programmed with a *Coast* stop mode, then the VFD will de-energize the relay output immediately upon start command removal

Advanced Damper Control also has the functionality to monitor a damper's closing actions. The VFD confirms that the DA damper has fully closed by monitoring a closed DI, which is configured in *84.06 DA damper closed input* allowing DI1 thru 6 to be selected. There is a separate timeout feature for the closing of the DA damper which can be configured in *84.07 DA damper closed timeout* and is defaulted to 20 seconds but can be customized to be between 0 seconds and 90 seconds to match the actuators cycle time. If the DA damper fails to close in the timeout window the VFD can be programed in *84.08* to generate a warning (which is default), fault the VFD, or no action.

Monitoring the damper position provides visibility of the damper's actions to the BAS while also helping to reduce the time needed to troubleshoot damper or air flow issues. When a start command is sent to a VFD and the cycle time exceeds the timeout allotment, the drive can flag that as a malfunction in the actuator or that service may be required on that actuator in the near future. Benefits of monitoring for the closed position can also provide information if the actuator has failed in the open position or if the damper mechanical components have become bound. Reference Figure 1 as an example of a warning image.

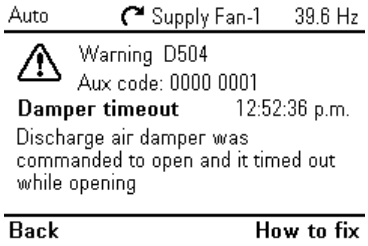


Figure 1

Discharge air damper with pre-pressure

In applications where multiple fans are supplying air to a common plenum and/or fans are staged depending on demand, a common issue can occur when the isolation damper opens. The issue occurs if the damper opens before the fan is brought up to speed and the pressure from the common plenum forces the fan to rotate backwards or freewheel. Advanced Damper Control can eliminate this issue by using DA damper with pre-pressure, *84.01* [2]. This feature allows the fan to come up to speed in a forward rotation while creating enough pressure to then join the plenum without freewheeling backwards. The DA damper timeout protection is also available in this pre-pressure mode.

When the VFD is configured for DA damper with pre-pressure, this is the start sequence:

- The VFD will ramp the motor up to the minimum output frequency.
- Once the minimum output frequency is achieved, the VFD will command the discharge damper to open.
- When the DA damper is fully open and confirmed to be open through the end-switch, the VFD is released to follow the commanded reference.

When stop is requested by the removal of a start command:

- The VFD will keep the RO active and follow the stop mode.
- Once the motor has slowed down to minimum output frequency, the VFD will de-energize the RO to command the DA damper to close.
    - Note: If the VFD is programmed with a *Coast* stop mode, then the VFD will de-energize the relay output immediately upon start command removal

Outside air + discharge air dampers with pre-pressure

The OA + DA damper with pre-pressure is used in applications where a fan is isolated from the outside air, or an outside air make-up plenum, with a damper installed upstream of the fan and a damper installed downstream of the fan. The configuration of OA damper control in *Group 84* is identical to setting up the DA damper control except OA uses parameters *84.13-84.18*. There is also OA damper timeout protection. Once all parameters are set in *Group 84*, the final step will be to configure the RO in *Group 10* to control the additional OA damper actuator.

When the VFD is configured for OA+DA with pre-pressure, this is the start sequence:

- A start command is requested to the VFD, the VFD will command the OA damper to open.
- When the OA damper is fully open and confirmed to be open through the open end-switch (*84.13*), the VFD will ramp to the minimum frequency.
- Once minimum frequency is achieved the VFD will command the DA damper to open and will hold at minimum frequency until the DA damper open end switch is confirmed.
- When the DA damper open end switch is confirmed, the VFD will follow the commanded reference.

When stop is requested by the removal of the start command:

- The VFD will keep both ROs energized while the motor speed slows until minimum frequency is achieved.
    - Note: If the VFD is programmed with a *Coast* stop mode, then the VFD will de-energize the DA relay output immediately upon start command removal
- Once achieved the VFD will de-energize the RO for DA damper commanding DA damper to close.
- After DA damper is confirmed to be closed, the VFD will de-energize the RO for OA damper commanding OA to close.

Damper time-based control

In some applications it might not be feasible to wire all the damper position switches back to the VFD due to other devices or safeties needing to be integrated into the VFD's DIs. In these cases, Advance Damper Control is still a viable and useful feature. When parameters *84.03*, *84.06*, *84.13*, or *84.16* associated with assigning a specific DI to an open/closed input are selected as *[0] Not used*, then Advanced Damper Control repurposes the programed timeout values *84.04, 84.07, 84.14, and 84.17*. Advanced Damper Control utilizes these values as a set of timers for the opening or closed sequences.

As an example, if the OA and DA damper position switches are not wired back to the VFD and a start command is received the VFD will:

- Command the OA Relay to open the damper and wait for the amount of time configured in *84.14* OA damper open timeout.
- Once the OA damper open timeout time has passed, the VFD then commands the motor to operate at the minimum output frequency.
- After minimum output frequency has been achieved, the VFD commands the DA Relay to open the damper and maintain minimum output frequency for the amount of time configured in *84.04* DA damper open timeout.
- Once the DA damper open timeout time has passed, the VFD then is released to follow the commanded reference.

When stop is requested by removal of the start command, Advanced Damper Control will follow the sequence stated above in reverse order but using the equivalent *84.07* and *84.17* damper closed timeout parameters.

Conclusion

As stated above, Advanced Damper Control is a feature that can easily integrate into new and existing systems while also providing valuable real time information. The ability of this feature to work both in Auto and Hand mode provides the user all the benefits independent of what control strategy they need at a given time. Figure 2 summarizes the differences between a building automation system, traditional VFD based damper control, and the ACH580's Advanced Damper Control. Integrating Advanced Damper Control reduces the time of trouble shooting damper related issues and reduces the probability of nuisance trips.

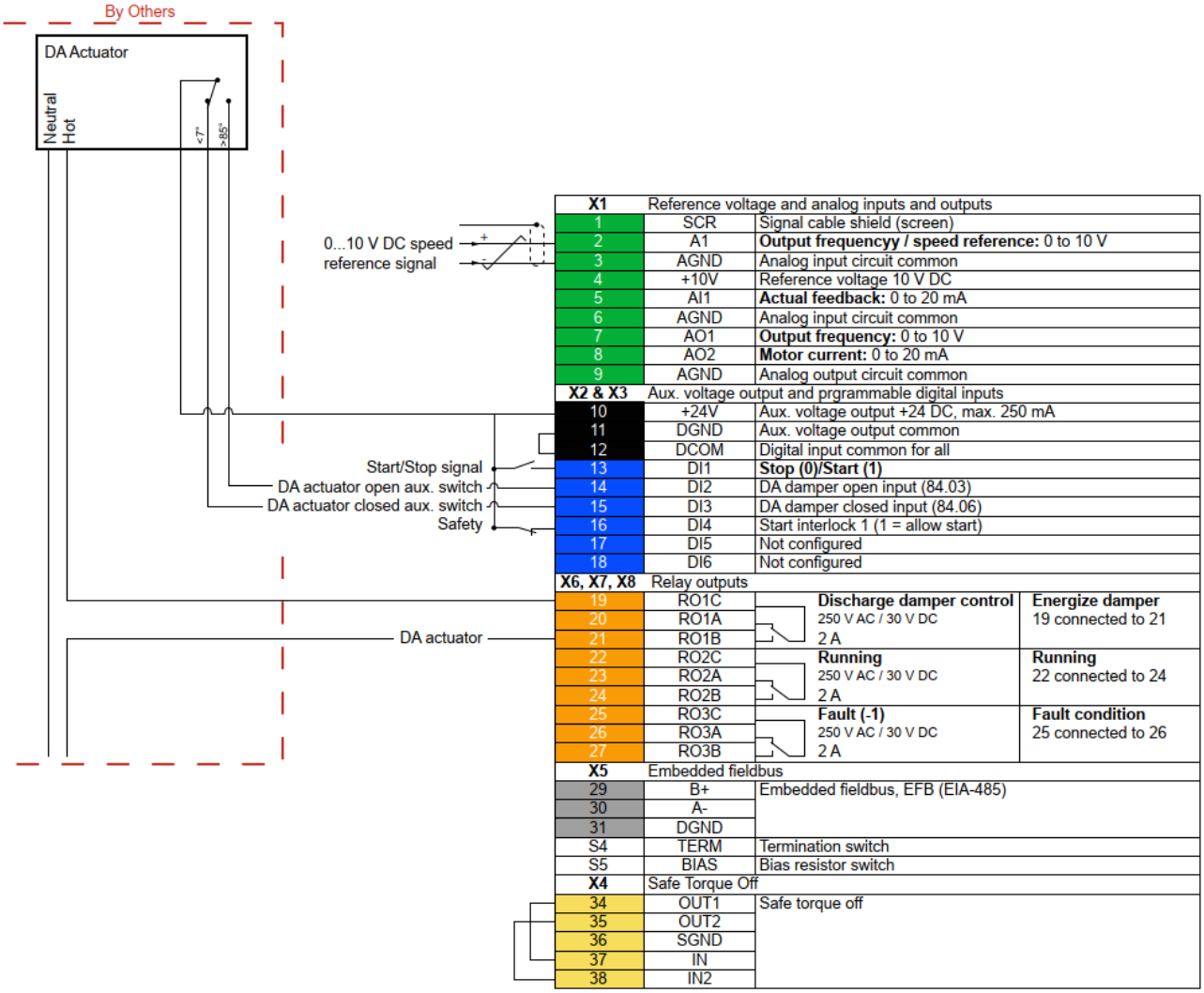
Control Method	Supports Hand & Auto	Control of (1) damper	Control of (2) dampers	Pre-pressure	Timeout protection	Descriptive warning text
Building automation system	No	Yes	Yes	Yes	Yes	Yes
Traditional VFD damper control	Yes	Yes	No	No	No	No
DA damper[1]	Yes	Yes	No	No	Yes	Yes
DA damper with pre-pressure[1]	Yes	Yes	No	Yes	Yes	Yes
OA & DA dampers with pre-pressure[1]	Yes	Yes	Yes	Yes	Yes	Yes

[1] Functions of ACH580 Advanced Damper Control

Figure 2

Advanced Damper Control

Supplemental wiring diagrams



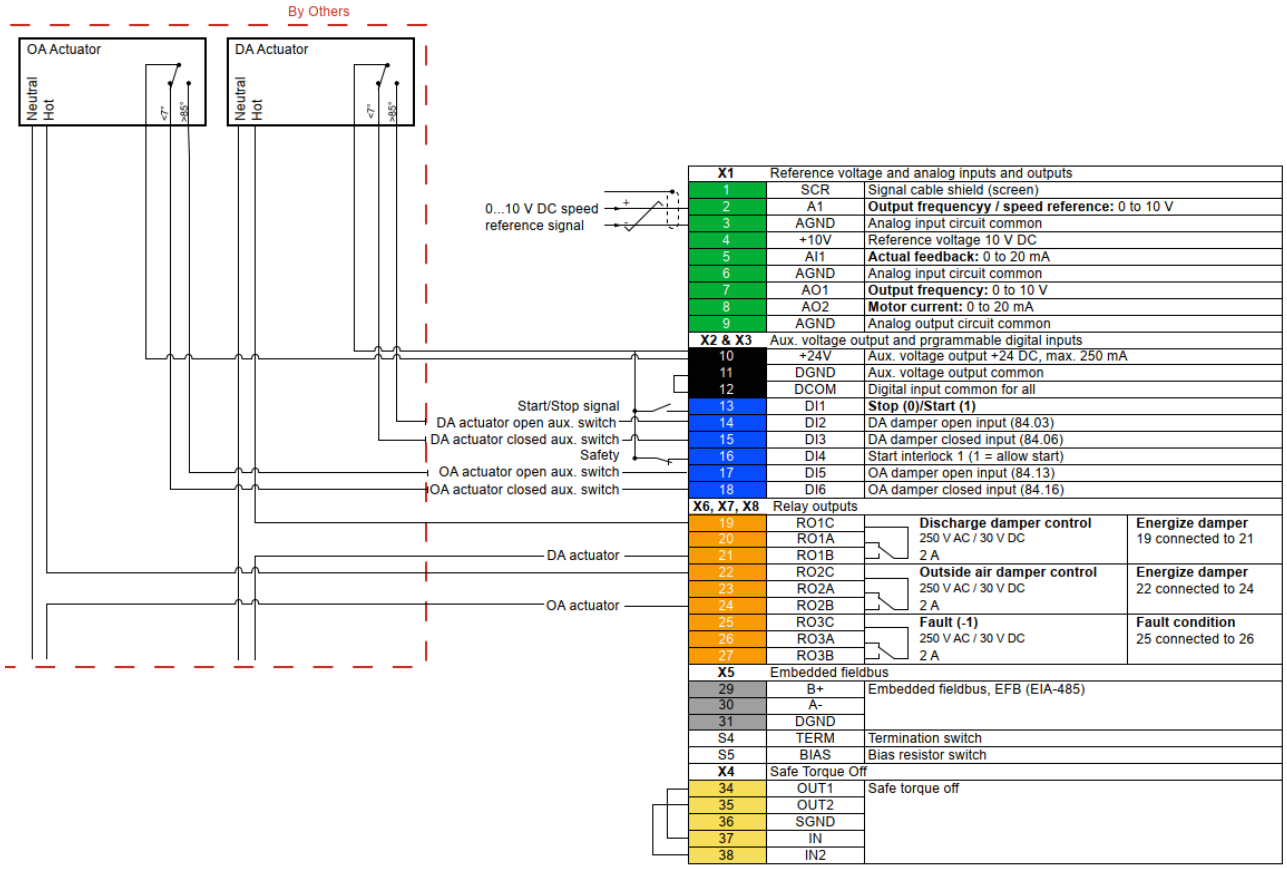
X1	Reference voltage and analog inputs and outputs	
1	SCR	Signal cable shield (screen)
2	A1	**Output frequencyy / speed reference:** 0 to 10 V
3	AGND	Analog input circuit common
4	+10V	Reference voltage 10 V DC
5	AI1	**Actual feedback:** 0 to 20 mA
6	AGND	Analog input circuit common
7	AO1	**Output frequency:** 0 to 10 V
8	AO2	**Motor current:** 0 to 20 mA
9	AGND	Analog output circuit common
X2 & X3	Aux. voltage output and prgrammable digital inputs	
10	+24V	Aux. voltage output +24 DC, max. 250 mA
11	DGND	Aux. voltage output common
12	DCOM	Digital input common for all
13	DI1	**Stop (0)/Start (1)**
14	DI2	DA damper open input (84.03)
15	DI3	DA damper closed input (84.06)
16	DI4	Start interlock 1 (1 = allow start)
17	DI5	Not configured
18	DI6	Not configured
X6, X7, X8	Relay outputs	
19	RO1C	**Discharge damper control** 250 V AC / 30 V DC 2 A — **Energize damper** 19 connected to 21
20	RO1A	
21	RO1B	
22	RO2C	**Running** 250 V AC / 30 V DC 2 A — **Running** 22 connected to 24
23	RO2A	
24	RO2B	
25	RO3C	**Fault (-1)** 250 V AC / 30 V DC 2 A — **Fault condition** 25 connected to 26
26	RO3A	
27	RO3B	
X5	Embedded fieldbus	
29	B+	Embedded fieldbus, EFB (EIA-485)
30	A-	
31	DGND	
S4	TERM	Termination switch
S5	BIAS	Bias resistor switch
X4	Safe Torque Off	
34	OUT1	Safe torque off
35	OUT2	
36	SGND	
37	IN	
38	IN2	

Diagram 1: Discharge Air Damper with or without pre-pressure

Note: actuator wiring of end switches may vary between manufactures

Advanced Damper Control

Supplemental wiring diagrams



X1	Reference voltage and analog inputs and outputs		
1	SCR	Signal cable shield (screen)	
2	A1	**Output frequencyy / speed reference:** 0 to 10 V	
3	AGND	Analog input circuit common	
4	+10V	Reference voltage 10 V DC	
5	AI1	**Actual feedback:** 0 to 20 mA	
6	AGND	Analog input circuit common	
7	AO1	**Output frequency:** 0 to 10 V	
8	AO2	**Motor current:** 0 to 20 mA	
9	AGND	Analog output circuit common	
X2 & X3	Aux. voltage output and prgrammable digital inputs		
10	+24V	Aux. voltage output +24 DC, max. 250 mA	
11	DGND	Aux. voltage output common	
12	DCOM	Digital input common for all	
13	DI1	**Stop (0)/Start (1)**	
14	DI2	DA damper open input (84.03)	
15	DI3	DA damper closed input (84.06)	
16	DI4	Start interlock 1 (1 = allow start)	
17	DI5	OA damper open input (84.13)	
18	DI6	OA damper closed input (84.16)	
X6, X7, X8	Relay outputs		
19	RO1C	**Discharge damper control** 250 V AC / 30 V DC 2 A	**Energize damper** 19 connected to 21
20	RO1A		
21	RO1B		
22	RO2C	**Outside air damper control** 250 V AC / 30 V DC 2 A	**Energize damper** 22 connected to 24
23	RO2A		
24	RO2B		
25	RO3C	**Fault (-1)** 250 V AC / 30 V DC 2 A	**Fault condition** 25 connected to 26
26	RO3A		
27	RO3B		
X5	Embedded fieldbus		
29	B+	Embedded fieldbus, EFB (EIA-485)	
30	A-		
31	DGND		
S4	TERM	Termination switch	
S5	BIAS	Bias resistor switch	
X4	Safe Torque Off		
34	OUT1	Safe torque off	
35	OUT2		
36	SGND		
37	IN		
38	IN2		

Diagram 2: Outside Air + Discharge Air Damper

Note: actuator wiring of end switches may vary between manufactures

Advanced Damper Control

Supplemental wiring diagrams

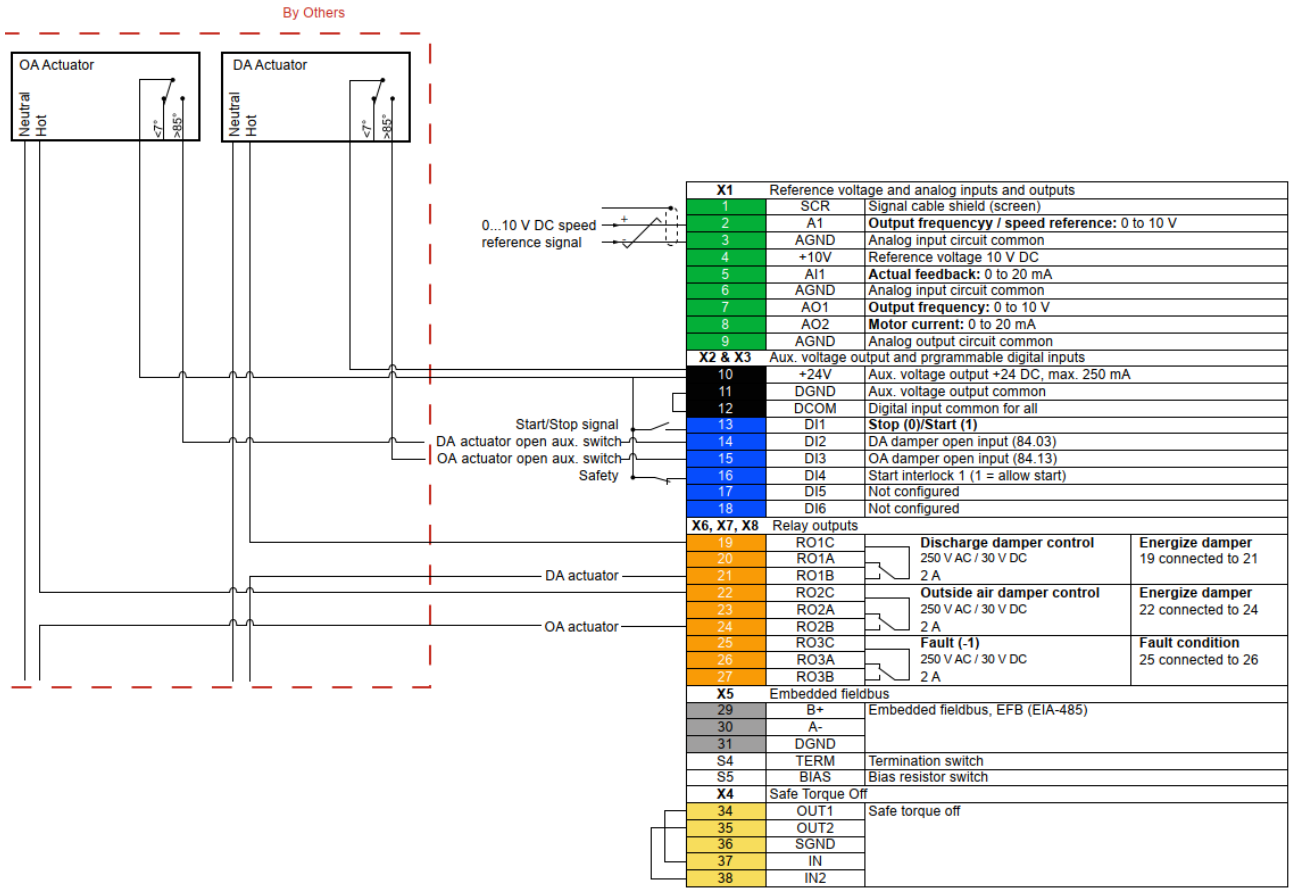


Diagram 3: Outside Air + Discharge Air Damper with only open auxiliary switch

Note: actuator wiring of end switches may vary between manufactures