Technical Note 137

HVACR AHU controls with ACH580

Programming details for VFD I/O and PIDs

Air Handling Unit (AHU) controls range from basic space mounted thermostats to Building Automation System (BAS) controllers with dozens of inputs, outputs and complex programs. Variable frequency drives (VFDs) are used to vary the speed of the supply fan motor, providing energy savings and improving space comfort. Rather than requiring a separate BAS controller, the ACH580 series of drives is capable of controlling the entire AHU operation. Adding a CAIO-01 Analog Extension module can increase the drive capabilities for more complex AHUs. This technical note will step through programming for several AHU system types.

In the below examples, the drive will be configured as a direct digital controller (DDC) for the AHU including PID loops using space temperature or duct static pressure feedback. Cooling and heating modes will use the drive's External PIDs for controlling water valves, DX compressors or electric reheat. An outdoor air damper will be modulating to adjust the amount of outdoor air for economizing. Programming will assume motor data has already been entered and first startup has been completed. The following examples use North American (imperial) units though the drive supports global (SI) units as well.

01 Single zone variable air volume (SZVAV), hydronic coils
02 Multi zone variable air volume (MZVAV), duct static pressure
03 SZVAV with DX (direct expansion) cooling, electric reheat

Programming changes

For each application example, the parameters listed are changed from the drive's HVAC default values. To complete this programming, options are available to use the control panel and navigate to the parameters menu. An advanced control panel with Bluetooth can link to the Drivetune mobile app available for download. Keypad menu navigation to the parameter groups is listed first followed by the parameter number, name and new value. The Primary Settings menu navigation is referenced for adjusting several other settings and text fields.

Drive Composer Entry or Pro

The recommended programming method will be the PC based software Drive Composer using a USB cable to connect with the drive's control panel. This software provides access to the Adaptive Programming described below. Downloads are available here for both the free Entry version and trial Pro version.

https://new.abb.com/drives/software-tools/drive-composer

01 Single zone variable air volume (SZVAV), hydronic coils

For this AHU type represented in Figure 1, the drive will be setup for space temperature control using *Supervision* (group 32) and *Process PIDs* (group 40, 41). Discharge air temperature will be used as feedback to modulate cooling and reheat water valves with *External PIDs* (group 71,72). A schedule will be created with *Timed functions* (group 34) to operate continuously during occupied periods. While unoccupied, *Supervision* will again be used to cycle the unit on/off with unoccupied setpoints.

A freezestat, condensate pan overflow, and duct smoke detector safeties will be wired to *Start interlocks* (group 20). A dirty filter pressure switch will be wired to provide a user warning to inspect the air filters using *External events* (group 31). A local timed override button can be installed in the space to activate the AHU after hours using *Boost timed function* (group 34). The outdoor air and return air dampers are physically connected with linkage arms so one analog output will be used labelled Mixed Air Damper. Economizing mode will modulate the mixed air damper to maintain a discharge air temperature setpoint with *External PID* (group 73) providing free cooling when outdoor conditions are appropriate, monitored with *Supervision* (group 32).

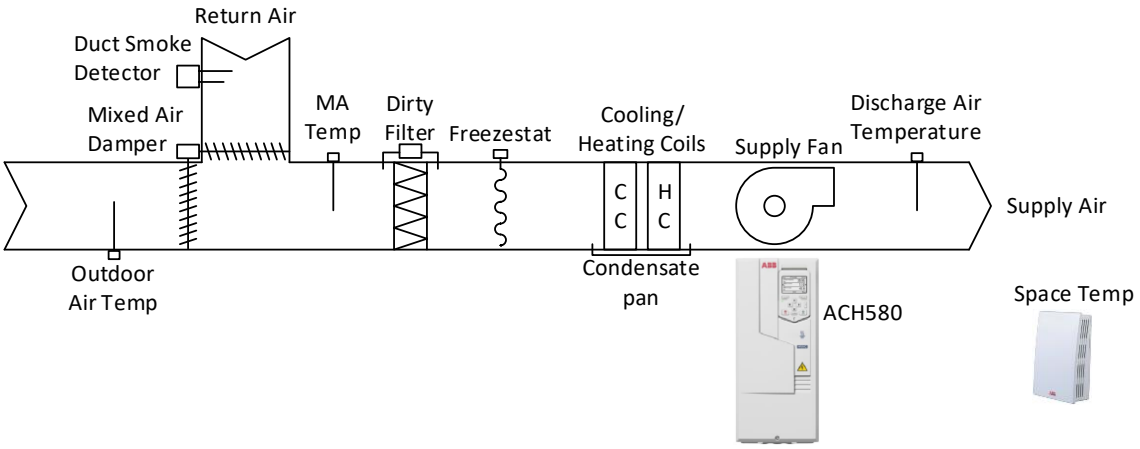
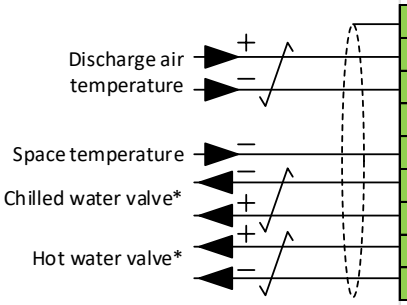
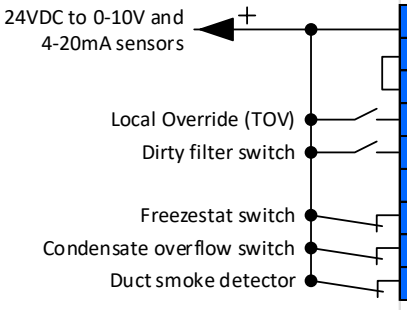


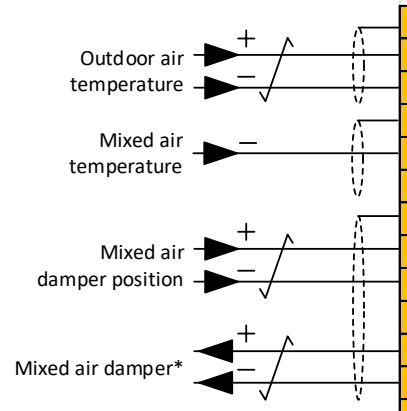
Figure 1: Flow diagram, single zone VAV, chilled and hot water coils

01 SZVAV wiring diagram

Figure 2 represents the wiring terminations on the drive for analog and digital I/O. The CAIO-01 extension module is installed to increase the drive's capacity for monitoring and controlling analog signals. The temperature ranges shown are for common duct mounted, space mounted and duct averaging temperature sensors used for HVAC applications. While the drive is capable of reading temperature inputs of RTDs or thermistors, in this example we are using sensors that output 0-10 V and 4-20 mA signals.







X1	Reference voltage and analog inputs and outputs	
1	SCR	Signal cable shield (screen)
2	AI1	**Temperature Scaled, 0-10 V, -40-140 °F**
3	AGND	Analog input circuit common
4	+10V	Reference voltage 10 VDC
5	AI2	**Temperature Scaled, 4-20 mA, 23-131 °F**
6	AGND	Analog input circuit common
7	AO1	**External PID 1 out: 2-10 V, 0-100%**
8	AO2	**External PID 2 out: 4-20 mA, 0-100%**
9	AGND	Analog input circuit common
X2 & X3	Aux voltage outputs and programmable digital inputs	
10	+24V	Aux voltate output +24 VDC, max 250 mA
11	DGND	Aux voltage output common
12	DCOM	Digital input common for all
13	D1	**Boost time activation**
14	D2	**External event 1 (DI2 (-1) inverted)**
15	D3	Not used
16	D4	**Start interlock 1 (1 - allow start)**
17	D5	**Start interlock 2 (1 - allow start)**
18	D6	**Start interlock 3 (1 - allow start)**
CAIO-01	Extension module programmable analog inputs and outputs	
80	SHD	Signal cable shield
81	AI3 +	**Temperature Scaled, 0-10 V, -40-140 °F**
82	AI3 -	Analog input circuit negative
83	SHD	Signal cable shield
84	AI4 +	**Temperature Scaled, 4-20 mA, 20-120 °F**
85	AI4 -	Analog input circuit negative
86	SHD	Signal cable shield
87	AI5 +	**Position feedback scale: 2-10 V, 0-100%**
88	AI5 -	Analog input circuit negative
90	SHD	Signal cable shield
91	AO3 +	**External PID 3 out: 2-10 V, 0-100%**
92	AO3 -	Analog output circuit negative
93	SHD	Not used
94	AO4 +	Not used
95	AO4 -	Not used

* Damper/valve actuators will require 24V power source separate from signal to not overload the 24V aux output of the control board

Figure 2: SZVAV wiring diagram for ACH580, chilled and hot water coils

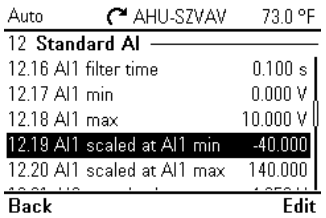
01 SZVAV space temperature control

A wall mounted, space temperature sensor will be setup in *Standard Analog Inputs*; scaled for output type and temperature range depending on your specific device. HVAC default programming is for AI2 to be used as feedback for *Process PID 1 and 2* to control the supply fan. As space temperature deviates from the setpoint, fan speed will increase to supply more conditioned air to the space. As feedback returns to setpoint the supply fan will slow down to maintain a minimum speed for air circulation.

Supervision 1 will be used to decide which mode, heating or cooling, the drive should use for PID setpoints. For the heat/cool mode, the setpoint is a single value then using an offset to determine when to switch modes. The drive logic will use a hysteresis, or offset, divided by 2 and add that to the setpoint. In this example, the AHU will switch to and enable cooling at 73 °F, switch to heating at 69 °F, and run at minimum speed in between.

Menu > Parameters > Complete List > **12 Standard AI**

- 12.29 AI2 scaled at AI2 min: 23.0
- 12.30 AI2 scaled at AI2 max: 131.0



Menu > Parameters > Complete List > **32 Supervision**

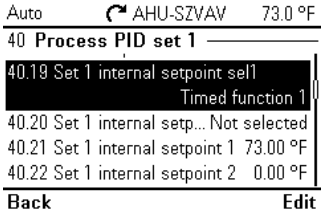
- 32.5 Supervision 1 function: Low *(heat/cool mode)*
- 32.7 Supervision 1 signal: Process PID feedback
- 32.9 Supervision 1 low: 71.0 *(setpoint)*
- 32.11 Supervision 1 hysteresis: 4.0 *(offset)*

Menu > Parameters > Complete List > **28 Frequency reference chain**

- 28.11 Ext1 frequency ref1: PID
- 28.16 Ext2 frequency ref1: PID

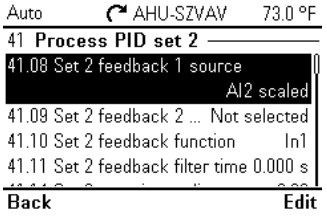
Menu > Parameters > Complete List > **40 Process PID set 1** *(cooling)*

- 40.07 Process PID operation mode: On
- 40.19 Set 1 internal setpoint sel1: Timed function 1
- 40.21 Set 1 internal setpoint 1: 73 °F
- 40.23 Set 1 internal setpoint 0: 80 °F
- 40.32 Set 1 gain: 4.0
- 40.36 Set 1 output min: 20 Hz
- 40.57 PID set1/set2 selection: Supervision 1
- 40.79 Set 1 units: °F *(°C also available)*



Menu > Parameters > Complete List > **41 Process PID set 2** *(heating)*

- 41.8 Set 2 feedback 1 source: AI2 scaled
- 41.19 Set 2 internal setpoint sel1: Timed function 1
- 41.21 Set 2 internal setpoint 1: 69 °F
- 41.24 Set 2 internal setpoint 0: 60 °F
- 41.32 Set 2 gain: 4.0
- 41.36 Set 2 output min: 25 Hz
- 41.79 Set 1 units: °F *(°C also available)*



01 SZVAV discharge air temperature control

A duct mounted, discharge air temperature sensor will be setup similar to space temp in *Standard AIs* as AI1. External PID loops will be used to modulate chilled water and hot water valves to maintain desired discharge air temperature setpoints optimized for space comfort. Setup *Standard Analog Outputs* for valve actuator control type and range.

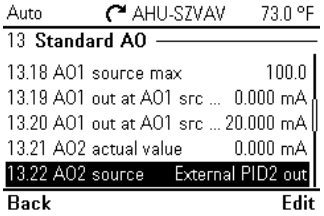
Menu > Parameters > Complete List > **12 Standard AI**

- 12.19 AI1 scaled at AI1 min: -40.0
- 12.20 AI1 scaled at AI1 max: 140.0

Menu > Parameters > Complete List > **13 Standard AO**

- 13.12 AO1 source: External PID1 out
- 13.17 AO1 source min: 0
- 13.19 AO1 out at AO1 src min: 2.0 V

- 13.22 AO2 source: External PID2 out
  - *AO2 is mA only, review valve control documentation for converting mA to Volts or use AO4*
- 13.27 AO2 source min: 0
- 13.30 AO2 out at AO2 src min: 4.0



01 SZVAV Adaptive Programming

Two external PID loops will be used to control the cooling and heating outputs. Since both are using the same feedback, discharge air temperature, there will be a conflict if cooling and heating are enabled at the same time. To prevent this condition a simple program can be created using the drive's Adaptive Programming available with Drive Composer software. Figure 3 is the block diagram to control which PID loop to enable based on space temp *Supervision 1* used for heat/cool mode. When *Supervision 1* equals true and supply fan is running, heating *External PID2* will be enabled and cooling *External PID1* will be disabled. When *Supervision 1* is false and supply fan is running, cooling will be enabled and heating disabled.

Menu > Parameters > Complete List > **96 System**

- 96.70 Disable adaptive program: No

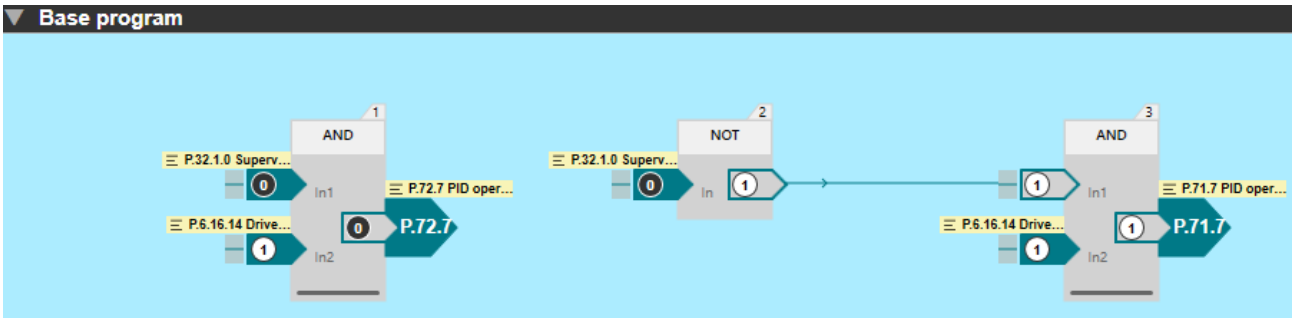
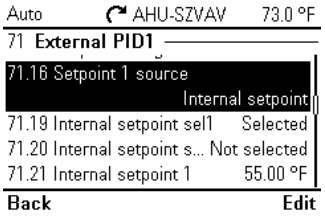


Figure 3: Enable Heat or Cool PID from Space Temp Supervisor and Fan running.

Typical discharge air temperature setpoint values of 55.0 °F for cooling and 100.0 °F for heating are used. Adjust these depending on your equipment, system design or space conditions. PID gains provided are starting values and will need to be adjusted during the commissioning process to verify the PID outputs can maintain desired discharge air temperature setpoint.

Menu > Parameters > Complete List > **71 External PID1** *(CHW valve)*

- 71.7 PID operation mode: Don't adjust, controlled from Adaptive Programming
- 71.8 Feedback 1 source: AI1 scaled
- 71.16 Setpoint 1 source: Internal setpoint
- 71.19 Internal setpoint sel1: Selected
- 71.21 Internal setpoint 1: 55.0 °F
- 71.31 Deviation inversion: Inverted (Fbk – Ref)
- 71.32 Gain: 1.0
- 71.33 Integration time: 30 sec
- 71.36 Output min: 0%
- 71.37 Output max: 100%
- 71.79 External PID units: °F *(°C also available)*



Menu > Parameters > Complete List > **72 External PID2** *(HW valve)*

- 72.7 PID operation mode: Don't adjust, controlled from Adaptive Programming
- 72.8 Feedback 1 source: AI1 scaled
- 72.16 Setpoint 1 source: Internal setpoint
- 72.19 Internal setpoint sel1: Selected
- 72.21 Internal setpoint 1: 100.0 °F
- 72.32 Gain: 1.0

- 72.33 Integration time: 30 sec
- 72.36 Output min: 0%
- 72.37 Output max: 100%
- 72.79 External PID units: °F *(°C also available)*

01 SZVAV occupied, unoccupied scheduling and local timed override

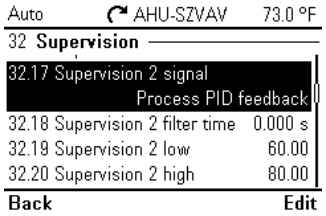
To control the AHU according to an adjustable schedule for building occupied periods and unoccupied night setback setpoints, *Timed function 1 and 2* will be setup with a start time, duration, and weekdays versus weekends. During this occupied schedule, the supply fan will run continuously. When the timer is not active, drive start control will switch to *Supervision 2* and use unoccupied setpoints. The supply fan will now only run when the space temperature has gone beyond the heating and cooling setpoints. The logic may seem counter intuitive, but the default mode will be Unoccupied. During the unoccupied period, timed function not active, a local override push button can be used to enable the AHU to run for an adjustable time period. This feature allows after hour operation on an as needed basis.

Menu > Parameters > Complete List > **19 Operation mode**

- 19.11 Ext1/Ext2 selection: Timed function 1
  - *(Timer acts as schedule Ext2 = Occ, Ext1 = UnOcc)*

Menu > Parameters > Complete List > **20 Start/stop/direction**

- 20.3 Ext1 in1 source: Supervision 2
- 20.6 Ext2 commands: In1 Start
- 20.8 Ext2 in1 source: Always on

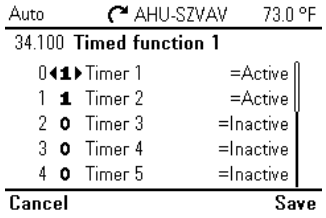


Menu > Parameters > Complete List > **32 Supervision**

- 32.15 Supervision 2 function: Both *(unoccupied setpoints)*
- 32.17 Supervision 2 signal: Process PID feedback
- 32.19 Supervision 2 low: 60.0 *(heating)*
- 32.20 Supervision 2 high: 80.0 *(cooling)*
- 32.21 Supervision 2 hysteresis: 1.0 *(deadband)*

Menu > Parameters > Complete List > **34 Timed functions** *(Occupied schedules)*

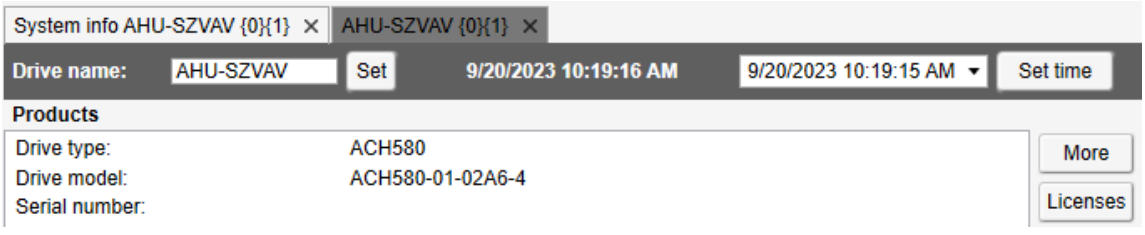
- 34.11 Timer 1 configuration: Mon, Tues, Wed, Thurs, Fri, Season 1-4 *(Mon-Fri 7a-5p)*
- 34.12 Timer 1 start time: 07:00:00
- 34.13 Timer 1 duration: 00 10:00
- 34.14 Timer 2 configuration: Sat, Sun, Season 1-4 *(Sat-Sun 8a-4p)*
- 34.15 Timer 2 start time: 08:00:00
- 34.16 Timer 2 duration: 00 08:00
- 34.100 Timed function 1: Enable Timer 1, Timer 2
- 34.110 Boost time function: Enable Timed function 1
  - *(If timed override push button is used for after hour operation)*
- 34.111 Boost time activation source: DI1
- 34.112 Boost time duration: 00 02:00



Menu > Primary Settings > Advanced functions > **Clock, region, display**

- Date & time: set time for Timed function, event log, show Clock
- Drive name: AHU-##

To access drive name and clock with Drive Composer, right click the drive in the left navigation tree and select System Information.

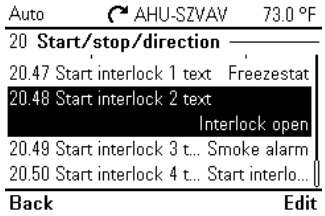


01 SZVAV safety interlocks and monitoring

To protect internal equipment of the air handler, several devices are installed to monitor conditions and prevent operation that could cause failures or shutdowns. Input logic can be inverted if your status switch closes on change of state (normally open). In this example, the dirty filter switch contact will be open until there is sufficient pressure drop, closing the contact to provide the warning.

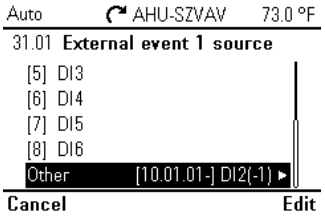
Menu > Parameters > Complete List > **20 Start/stop/direction**

- 20.42 Start interlock 2: DI5
- 20.43 Start interlock 3: DI6
- 20.47 Start interlock 1 text: Freezestat
- 20.48 Start interlock 2 text: Interlock open
- 20.49 Start interlock 3 text: Smoke alarm



Menu > Parameters > Complete List > **31 Fault functions**

- 31.01 External event 1 source: Other > 10.01 DI status > DI2 (-1)
- 31.02 External event 1 type: Warning
- Label: Dirty filter
- Instruction line 1: Inspect or replace filter



Menu > Primary settings > Advanced functions > External events > **External event 1**

- Edit texts: Start interlock 2: Condensate overflow

01 SZVAV economizing

The outdoor air damper will open for minimum ventilation requirements when the supply fan is running, and the schedule is occupied. When outdoor air conditions are favorable, economizing can be enabled for free cooling. Adding to the Adaptive Programming in Figure 4, the drive will measure the outdoor air temperature, enable *External PID3* with *Supervision 3* when OA temp is between a low and high setpoint, the unit is in cooling mode, supply fan running, and schedule occupied. When OA temp goes above the high limit, additional mechanical cooling will be required to meet the discharge temp setpoint. When below the low limit, reheat may be required or could cause damage the air hander coils. Enthalpy can also be used to measure optimal temperature and humidity and is useful in some climates but will not be used in this example.

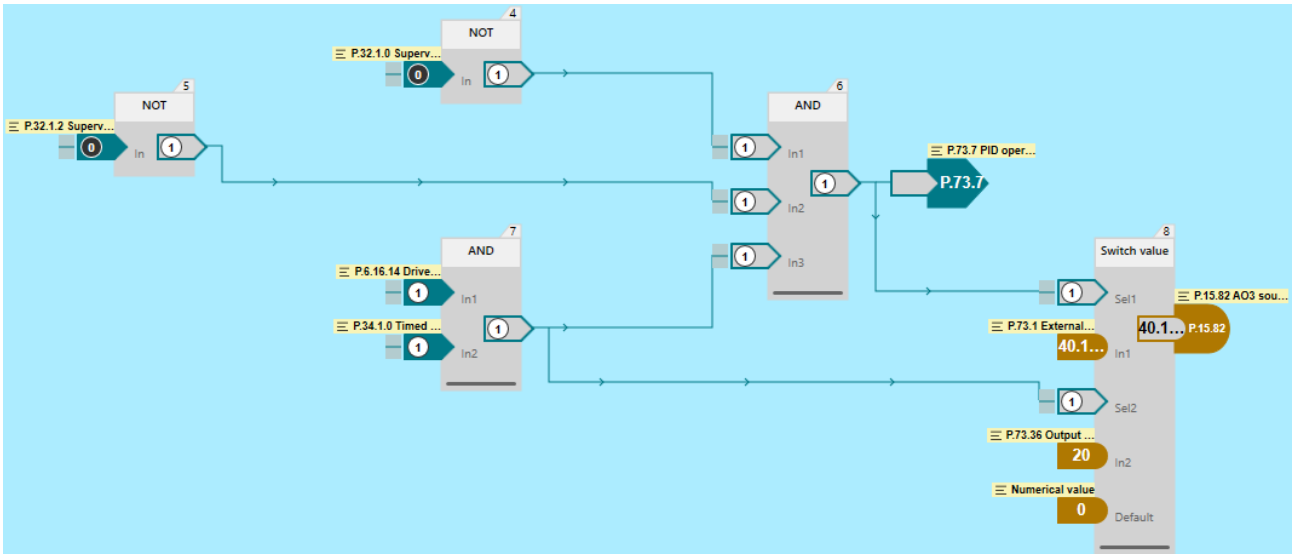


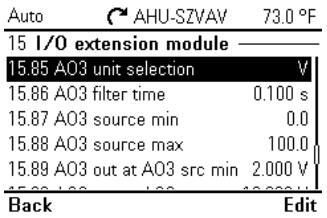
Figure 4: Outdoor air damper control with economizing

Setup outdoor air temperature, mixed air temperature, mixed air damper command and status in the CAIO-01 parameters found in group 15.

Menu > Parameters > Complete List > **15 I/O extension module**

Install CAIO-01 extension module then power up drive to auto-detect

- 15.59 AI3 scaled at AI3 min: -40.0
- 15.60 AI3 scaled at AI3 min: 140.0
- 15.65 AI4 unit selection: mA
- 15.69 AI4 scaled at AI4 min: 20.0
- 15.70 AI4 scaled at AI4 max: 120.0
- 15.77 AI5 min: 2.0
- 15.80 AI5 scaled at AI5 max: 100.0
- 15.82 AO3 source: External PID3 out
- 15.85 AO3 unit selection: V
- 15.87 AO3 source min: 0.0
- 15.89 AO3 out at AO3 src min: 2.0



Menu > Parameters > Complete List > **32 Supervision**

- 32.25 Supervision 3 function: Both *(Econ setpoints)*
- 32.27 Supervision 3 signal: P.15.52 *(AI3 scaled, outdoor air temp)*
- 32.29 Supervision 3 low: 45.0 *(low OA temp)*
- 32.30 Supervision 3 high: 65.0 *(high OA temp)*
- 32.31 Supervision 3 hysteresis: 1.0 *(deadband)*

Menu > Parameters > Complete List > **73 External PID3** *(Mixed Air Damper)*

- 73.7 PID operation mode: Don't adjust, controlled from Adaptive Programming
- 73.8 Feedback 1 source: AI1 scaled
- 73.16 Setpoint 1 source: Internal setpoint
- 73.19 Internal setpoint sel1: Selected
- 73.21 Internal setpoint 1: 55.0 °F
- 73.31 Deviation inversion: Inverted (Fbk – Ref)
- 73.32 Gain: 4.0
- 73.33 Integration time: 10 sec
- 73.36 Output min: 20% *(OA or Econ minimum damper position, adj.)*
- 73.37 Output max: 100%
- 73.79 External PID units: °F *(°C also available)*

02 Multi zone variable air volume (MZVAV), duct static pressure

For a zoned VAV system with damper boxes installed for space temperature control, the AHU supply fan speed control will use a duct mounted differential pressure sensor as feedback for the *Process PID* (group 40), see Figure 5. Space cooling and heating setpoints will not be controlled from the drive as these will be handled by each VAV box controller integrated with a Building Automation System. Discharge air temperature will be used as feedback to modulate cooling and reheat water valves with *External PIDs* (group 71,72). Discharge air temperature setpoints can be programmed into each PID or referenced to be adjustable from the BAS. Occupancy commands from the BAS using its scheduling and overrides will control the start/stop signal to the drive, either hardwired and/or over communications.

A freezestat, condensate pan overflow, and duct smoke detector safeties will be wired to *Start interlocks* (group 20). A dirty filter pressure switch will be wired to provide a user warning to inspect the air filters using *External events* (group 31). Monitoring the status of these points will be configured for the BAS. The outdoor air and return air dampers are physically connected with linkage arms so one analog output will be used labelled Mixed Air Damper. Economizing mode will modulate the mixed air damper to maintain a discharge air temperature setpoint with *External PID* (group 73) providing free cooling when outdoor conditions are appropriate, monitored with *Supervision* (group 32).

Technical note 44 Enabling BACnet MS/TP or IP communications covers steps to wire and configure the drive for a BAS.

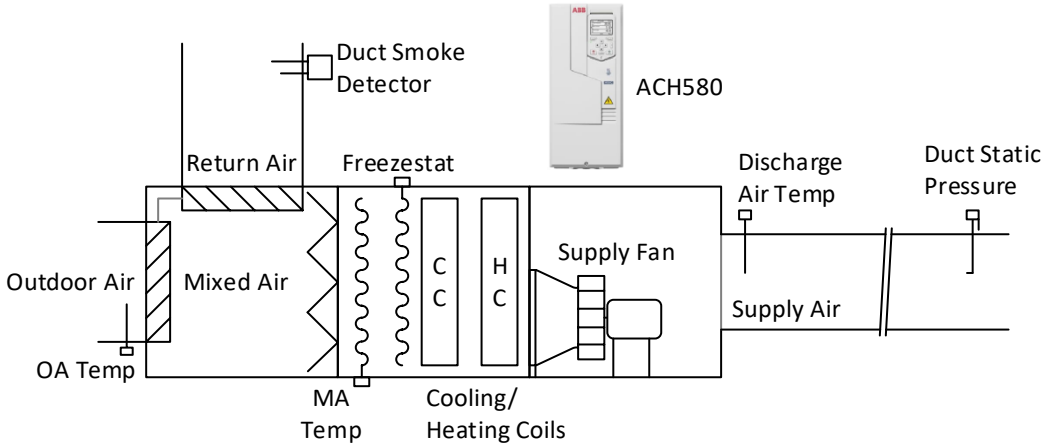
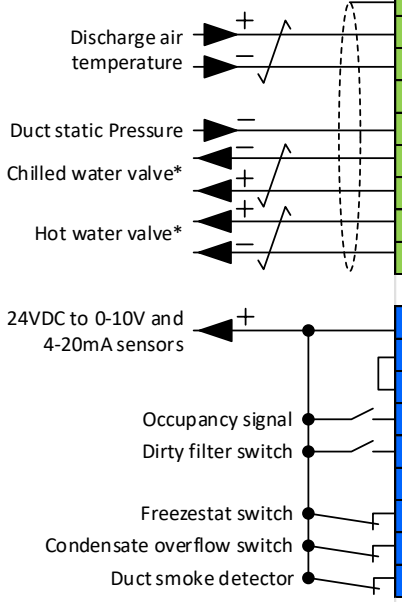


Figure 5: Flow diagram, multi zone VAV unit

02 MZVAV wiring diagram

Figure 6 represents the wiring terminations on the drive for analog and digital I/O. The CAIO-01 extension module is installed to increase the drive's capacity for monitoring and controlling analog signals. The pressure and temperature ranges shown are for typical duct mounted differential pressure and duct mounted or averaging temperature sensors used for HVAC applications. While the drive is capable of reading temperature inputs of RTDs or thermistors, in this example we are using sensors that output 0-10 V and 4-20 mA signals.



X1	Reference voltage and analog inputs and outputs	
1	SCR	Signal cable shield (screen)
2	AI1	**Temperature Scaled, 0-10 V, -40-140 °F**
3	AGND	Analog input circuit common
4	+10V	Reference voltage 10 VDC
5	AI2	**Pressure Scaled, 4-20 mA, 0-5.0 inWC**
6	AGND	Analog input circuit common
7	AO1	**External PID 1 out: 2-10 V, 0-100%**
8	AO2	**External PID 2 out: 4-20 mA, 0-100%**
9	AGND	Analog input circuit common
X2 & X3	Aux voltage outputs and programmable digital inputs	
10	+24V	Aux voltate output +24 VDC, max 250 mA
11	DGND	Aux voltage output common
12	DCOM	Digital input common for all
13	D1	**Unoccupied (0) / Occupied (1)**
14	D2	**External event 1 (DI2 (-1) inverted)**
15	D3	Not used
16	D4	**Start interlock 1 (1 - allow start)**
17	D5	**Start interlock 2 (1 - allow start)**
18	D6	**Start interlock 3 (1 - allow start)**
CAIO-01	Extension module programmable analog inputs and outputs	
80	SHD	Signal cable shield
81	AI3 +	**Temperature Scaled, 0-10 V, -40-140 °F**
82	AI3 -	Analog input circuit negative
83	SHD	Signal cable shield
84	AI4 +	**Temperature Scaled, 4-20 mA, 20-120 °F**
85	AI4 -	Analog input circuit negative
86	SHD	Signal cable shield
87	AI5 +	**Position feedback scale: 2-10 V, 0-100%**
88	AI5 -	Analog input circuit negative
90	SHD	Signal cable shield
91	AO3 +	**External PID 3 out: 2-10 V, 0-100%**
92	AO3 -	Analog output circuit negative
93	SHD	Not used
94	AO4 +	Not used
95	AO4 -	Not used

* Damper/valve actuators will require separate 24V power source separate from signal to not overload the 24V aux output of the control board

Figure 6: MZVAV wiring diagram for ACH580

02 MZVAV duct static pressure control

For a VAV system, the AHU will supply a consistent flow of air to the VAV boxes for each space measure by duct static pressure. The *Process PID* (group 40) will be set to control the supply fan speed to meet a setpoint of 2.0 inWC (inches of water column). This can also be set to 'Embedded Fieldbus reference 1' and allow the BAS to provide over the network communication a static setpoint or implement a duct static pressure reset algorithm for further energy savings. Feedback for the PID will be a duct mounted, differential pressure transducer providing a 4-20 mA signal to AI2 (default feedback for Process PID). PID gains provided are starting values and will need to be adjusted during the commissioning process to verify the PID outputs can maintain desired setpoints.

Menu > Parameters > Complete List > **12 Standard AI**

- 12.29 AI2 scaled at AI2 min: 0
- 12.30 AI2 scaled at AI2 max: 5.0

Menu > Parameters > Complete List > **28 Frequency reference chain**

- 28.11 Ext1 frequency ref1: PID

Menu > Parameters > Complete List > **40 Process PID set 1**

- 40.07 Process PID operation mode: On
- 40.16 Set 1 setpoint 1 source: EFB ref 1 *(or Internal setpoint)*
- 40.21 Set 1 internal setpoint 1: 2.0 inWC
- 40.32 Set 1 gain: 1.0
- 40.36 Set 1 output min: 20 Hz
- 40.79 Set 1 units: inWC *(kPa also available)*

02 MZVAV discharge air temperature control

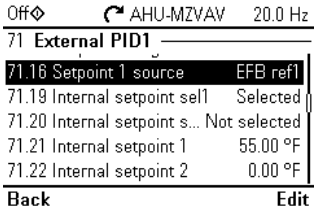
See section 1, SZVAV for discharge air control I/O configuration, Adaptive Programming and PID setup. If the BAS is configured to provide only discharge air temp setpoints, the following needs to be program for the drive to decide when to switch between heat or cool mode. If the BAS has been setup to measure the average space temperature from all VAV space sensors, the system heat/cool mode status should be sent to the drive as a binary point and monitored in the Adaptive Programming. Technical Note 130 User-configurable BACnet Objects provides instruction of how to setup the drive to receive this data from the BAS.

Menu > Parameters > Complete List > **32 Supervision**

- 32.5 Supervision 1 function: Low *(heat/cool mode)*
- 32.7 Supervision 1 signal: Process PID feedback
- 32.9 Supervision 1 low: 71.0 *(setpoint)*
- 32.11 Supervision 1 hysteresis: 4.0 *(offset)*

Menu > Parameters > Complete List > **71 External PID1** *(CHW valve)*

- 71.8 Feedback 1 source: AI1 scaled
- 71.16 Setpoint 1 source: EFB ref 1
- 71.19 Internal setpoint sel1: Selected
- 71.21 Internal setpoint 1: 55.0 °F



Menu > Parameters > Complete List > **71 External PID2** *(HW valve)*

- 71.8 Feedback 1 source: AI1 scaled
- 71.16 Setpoint 1 source: EFB ref 2
- 71.19 Internal setpoint sel1: Selected
- 71.21 Internal setpoint 1: 100.0 °F

02 MZVAV VAV system occupancy

AHU operation will be tied to system occupancy. When any space requires heating or cooling either during the occupied period or when space temperature is outside of unoccupied setpoints, the BAS will start the AHU to supply airflow to the spaces.

Menu > Parameters > Complete List > **20 Start/stop/direction**

- 20.1 Ext1 commands: Embedded Fieldbus

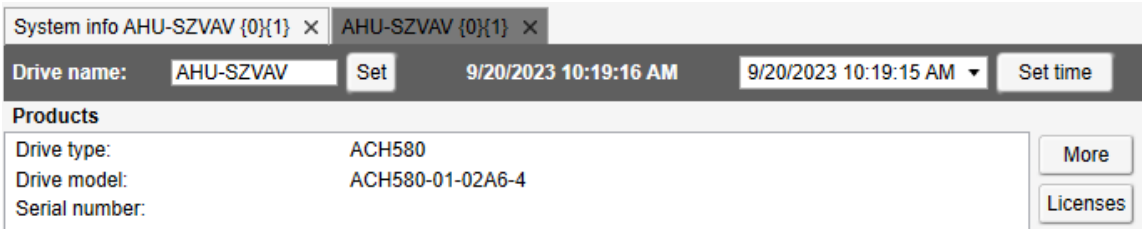
02 MZVAV safety interlocks and monitoring

See section 1, SZVAV safety interlocks and monitoring for input setup to monitor AHU sensor values and status. Setup the Clock time sync with the BAS for accurate event log information. Edit the drive name to match the AHU tag for easy recognition while programming and troubleshooting support.

Menu > Primary Settings > Advanced functions > **Clock, region, display**

- Date & time: set time for event log
- Drive name: AHU-##

To access drive name and clock with Drive Composer, right click the drive in the left navigation tree and select System Information.



02 MZVAV economizing

See section 1, SZVAV for outdoor air economizing I/O configuration, Adaptive Programming and PID setup. If the BAS will have a standalone Outdoor Air Temperature sensor and setpoints, adjust the Adaptive Programming logic to monitor this enable signal which can replace the *Supervisor 3* (group 32) logic. See steps from discharge air temp control programming integration with BAS. Discharge air temperature setpoint for the mixed air damper PID will also need to be referenced if being adjusted by the BAS.

Menu > Parameters > Complete List > **73 External PID3** *(Mixed Air Damper)*

- 73.8 Feedback 1 source: AI1 scaled
- 73.16 Setpoint 1 source: EFB ref 1
- 73.19 Internal setpoint sel1: Selected
- 73.21 Internal setpoint 1: 55.0 °F
- 73.36 Output min: 20% *(OA or Econ minimum damper position, adj.)*
- 73.37 Output max: 100%

03 SZVAV with DX (direct expansion) cooling, electric reheat

If your air handler is configured with one or more stages of DX (direct expansion) cooling with packaged compressors or a split system, configure the relay outputs with *Supervision* (group 32) points to measure the cooling External PID loop. As the PID output increases, Supervision 4 will activate to bring on the first and then Supervisor 5 for second stage of cooling. This could also be done for stages of electric reheat if not using an SCR controlled heater.

For this AHU type represented in Figure 7, the drive will be setup for space temperature control using *Supervision* (group 32) and *Process PIDs* (group 40, 41). Discharge air temperature will be used as feedback to modulate cooling and reheat with *External PIDs* (group 71,72). A schedule will be created with *Timed functions* (group 34) to operate continuously during occupied periods. While unoccupied, *Supervision* will again be used to cycle the unit on/off with unoccupied setpoints.

A freezestat, condensate pan overflow, and duct smoke detector safeties will be wired to *Start interlocks* (group 20). A dirty filter pressure switch will be wired to provide a user warning to inspect the air filters using *External events* (group 31). A local timed override button can be installed in the space to activate the AHU after hours using *Boost timed function* (group 34). The outdoor air and return air dampers are physically connected with linkage arms so one analog output will be used labelled Mixed Air Damper. Economizing mode will modulate the mixed air damper to maintain a discharge air temperature setpoint with *External PID* (group 73) providing free cooling when outdoor conditions are appropriate, monitored with *Supervision* (group 32).

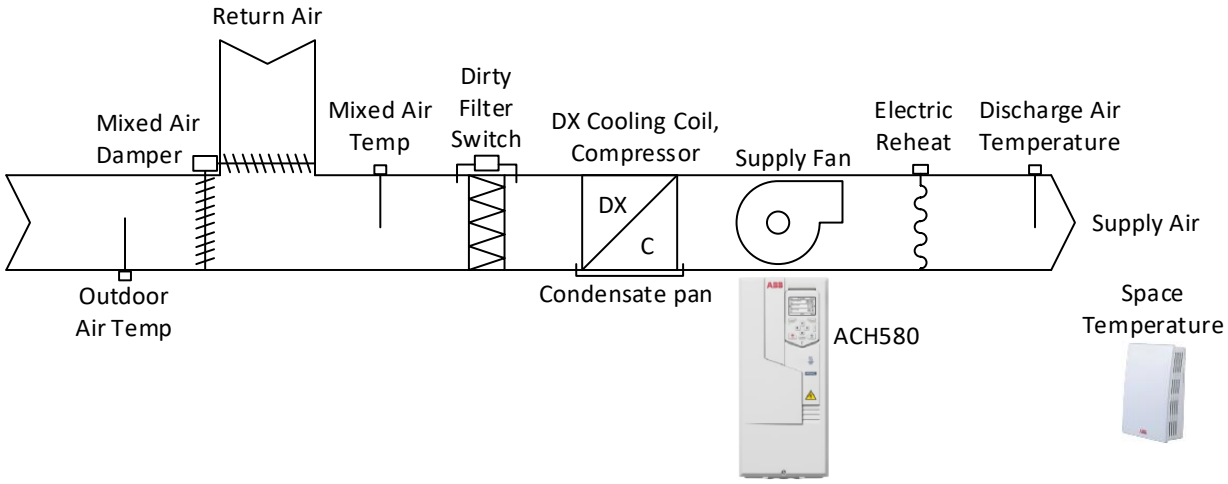
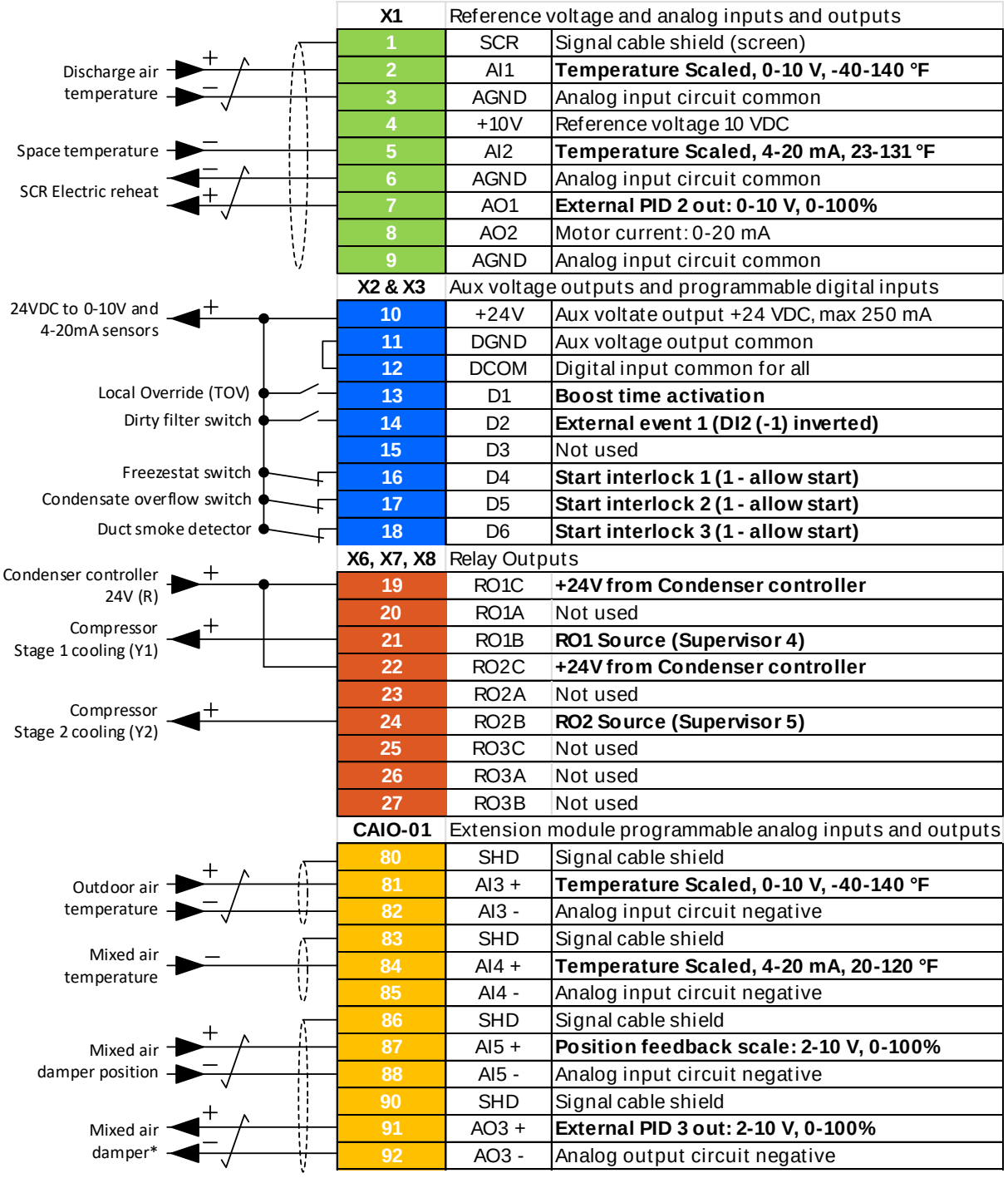


Figure 7: Flow diagram, single zone VAV with Dx cooling

03 SZVAV, Dx cooling wiring diagram

Figure 8 represents the wiring terminations on the drive for analog and digital I/O. Relay outputs will enable 2 stage cooling from a staged or multiple compressors. The CAIO-01 extension module is installed to increase the drive's capacity for monitoring and controlling analog signals. The temperature ranges shown are for common duct mounted, space mounted and duct averaging temperature sensors used for HVAC applications. While the drive is capable of reading temperature inputs of RTDs or thermistors, in this example we are using sensors that output 0-10 V and 4-20 mA signals.



X1	Reference voltage and analog inputs and outputs	
1	SCR	Signal cable shield (screen)
2	AI1	**Temperature Scaled, 0-10 V, -40-140 °F**
3	AGND	Analog input circuit common
4	+10V	Reference voltage 10 VDC
5	AI2	**Temperature Scaled, 4-20 mA, 23-131 °F**
6	AGND	Analog input circuit common
7	AO1	**External PID 2 out: 0-10 V, 0-100%**
8	AO2	Motor current: 0-20 mA
9	AGND	Analog input circuit common
X2 & X3	Aux voltage outputs and programmable digital inputs	
10	+24V	Aux voltate output +24 VDC, max 250 mA
11	DGND	Aux voltage output common
12	DCOM	Digital input common for all
13	D1	**Boost time activation**
14	D2	**External event 1 (DI2 (-1) inverted)**
15	D3	Not used
16	D4	**Start interlock 1 (1 - allow start)**
17	D5	**Start interlock 2 (1 - allow start)**
18	D6	**Start interlock 3 (1 - allow start)**
X6, X7, X8	Relay Outputs	
19	RO1C	**+24V from Condenser controller**
20	RO1A	Not used
21	RO1B	**RO1 Source (Supervisor 4)**
22	RO2C	**+24V from Condenser controller**
23	RO2A	Not used
24	RO2B	**RO2 Source (Supervisor 5)**
25	RO3C	Not used
26	RO3A	Not used
27	RO3B	Not used
CAIO-01	Extension module programmable analog inputs and outputs	
80	SHD	Signal cable shield
81	AI3 +	**Temperature Scaled, 0-10 V, -40-140 °F**
82	AI3 -	Analog input circuit negative
83	SHD	Signal cable shield
84	AI4 +	**Temperature Scaled, 4-20 mA, 20-120 °F**
85	AI4 -	Analog input circuit negative
86	SHD	Signal cable shield
87	AI5 +	**Position feedback scale: 2-10 V, 0-100%**
88	AI5 -	Analog input circuit negative
90	SHD	Signal cable shield
91	AO3 +	**External PID 3 out: 2-10 V, 0-100%**
92	AO3 -	Analog output circuit negative

* Damper actuators will require separate 24V power source separate from signal to not overload the 24V aux output of the control board

Figure 8: SZVAV wiring diagram for ACH580, relay outputs for DX condensing unit

03 SZVAV, Dx cooling space temperature control

A wall mounted, space temperature sensor will be setup in *Standard Analog Inputs*; scaled for output type and temperature range depending on your specific device. HVAC default programming is for AI2 to be used as feedback for *Process PID 1 and 2* to control the supply fan. As space temperature deviates from the setpoint, fan speed will increase to supply more conditioned air to the space. As feedback returns to setpoint the supply fan will slow down to maintain a minimum speed for air circulation.

Supervision 1 will be used to decide which mode, heating or cooling, the drive should use for PID setpoints. For the heat/cool mode, the setpoint is a single value then using an offset to determine when to switch modes. The drive logic will use a hysteresis, or offset, divide by 2 and add that to the setpoint. In this example, the AHU will switch to and enable cooling at 73°F, switch to heating at 69 °F, and run at minimum speed in between.

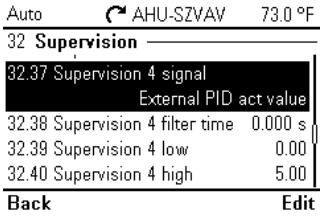
See section 1, SZVAV for space temperature control programming parameters.

03 SZVAV, Dx cooling discharge air temperature control

See section 1, SZVAV for discharge air control I/O configuration, Adaptive Programming and PID setup. The external PIDs will still use discharge air temperature feedback and output a 0-100% cooling or heating output. The SCR electric reheat section uses a 0-10V signal to modulate reheat rather than the hot water coil in the first example. For 2 stage cooling with a DX condensing unit, two more supervision functions will be setup to monitor the cooling PID output and enable relay outputs depending on the percentage of cooling. These values can be adjust depending on the application or system sizing.

Menu > Parameters > Complete List > **32 Supervision**

- 32.35 Supervision 4 function: High
- 32.37 Supervision 4 signal: P.71.1 = Other > External PID 1 > actual value
- 32.40 Supervision 4 high: 5.0 *(% cooling)*
- 32.45 Supervision 5 function: High
- 32.47 Supervision 5 signal: P.71.1 = Other > External PID 1 > actual value
- 32.50 Supervision 5 high: 50.0 *(% cooling)*



Menu > Parameters > Complete List > **10 Standard DI, RO**

- 10.24 RO1 source: P.32.1.3 = Other > Supervision > Status > bit 3
- 10.27 RO2 source: P.32.1.4 = Other > Supervision > Status > bit 4

03 SZVAV, Dx cooling occupied, unoccupied scheduling and local timed override

This section will program the appropriate parameter groups to control the AHU according to an adjustable schedule for building occupied periods and unoccupied night setback setpoints. The logic may seem counter intuitive, but the default mode will be Unoccupied. When the Timed function becomes active, the Ext1/Ext2 states will switch and the Occupied status will be come true. During the unoccupied period, timed function not active, a local override push button can be used to enable the AHU to run for an adjustable time period. This feature allows after hour operation on an as needed basis.

See section 1, SZVAV for occupancy scheduling programming parameters.

03 SZVAV, Dx cooling safety interlocks and monitoring

To protect internal equipment of the air handler, several devices are installed to monitor conditions and prevent operation that could cause failures or shutdowns. Input logic can be reversed if your status switch closes on change of state (normally open). In this example, the dirty filter switch contact will be open until there is sufficient pressure drop, closing the contact to provide the warning.

See section 1, SZVAV safety interlocks and monitoring for programming parameters.

03 SZVAV, Dx cooling economizing

The outdoor air damper will open for minimum ventilation requirements when supply fan is running, and the schedule is occupied. When outdoor air conditions are favorable, economizing can be enabled for free cooling. Adding to the Adaptive Programming in Figure 4, the drive will measure the outdoor air temperature, enable *External PID3* with *Supervision 3* when OA temp is between a low and high setpoint, the unit is in cooling mode, supply fan running, and schedule occupied. When OA temp goes above the high limit, additional mechanical cooling will be required to meet the discharge temp setpoint. When below the low limit, reheat may be required or could cause damage the air hander coils. Enthalpy can also be used to measure optimal temperature and humidity and is useful in some climates but will not be used in this example.

See section 1, SZVAV for outdoor air economizing Adaptive Programming and parameters.

Setpoints

Since there are no single global variables available to adjust each setpoint linked to multiple parameter values, this summary can be used for quick reference to adjust all parameters related to each setpoint.

Space cooling

- 32.09 Supervision 1 low: 71.0 *(setpoint)*
- 32.11 Supervision 1 hysteresis: 4.0 *(offset)*
- 32.20 Supervision 2 high: 80.0 *(unoccupied)*
- 40.21 Set 1 internal setpoint 1: 73 °F *(occupied)*
- 40.23 Set 1 internal setpoint 0: 80 °F *(unoccupied)*

Space heating

- 32.19 Supervision 2 low: 60.0 *(unoccupied)*
- 41.21 Set 2 internal setpoint 1: 69 °F *(occupied)*
- 41.24 Set 2 internal setpoint 0: 60 °F *(unoccupied)*

Outdoor economizing

- 32.29 Supervision 3 low: 45.0 °F
- 32.30 Supervision 3 high: 65.0 °F
- 73.21 Internal setpoint 1: 55.0 °F

Discharge air cooling

- 71.21 Internal setpoint 1: 55.0 °F

Discharge air heating

- 72.21 Internal setpoint 1: 100.0 °F

Conclusion

With standard analog and digital inputs/outputs of the ACH580, it is possible to configure the drive to be the DDC controller for many variations of air handling units. Adding extensions modules such as the CAIO-01, there are even more HVAC system that can be controlled directly from the drive. Use the above methods to retrofit existing equipment without controls systems in place to new energy efficient designs. Leverage the I/O and communications already available within one or more drives to save money and enhance integration with your Building Automation System.