

Discharge Air Controller (DAC)

Installation and Operation User Manual



FW Version 1.04F05

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1 Introduction

The Discharge Air Controller (DAC) (P/N 818-9001) is a packaged HVAC control board for use either as a standalone controller or connected to a zone application in a Copeland supervisory controller. Site Supervisor and E2 BX building control systems both provide support for HVAC Zone applications. The DAC is capable of controlling heat and cool stages, fans, dehumidification devices, and economizers using on-board I/O and control algorithms, as well as monitor and interact with other building control systems and peripherals (such as smoke alarms and CO2 sensors).

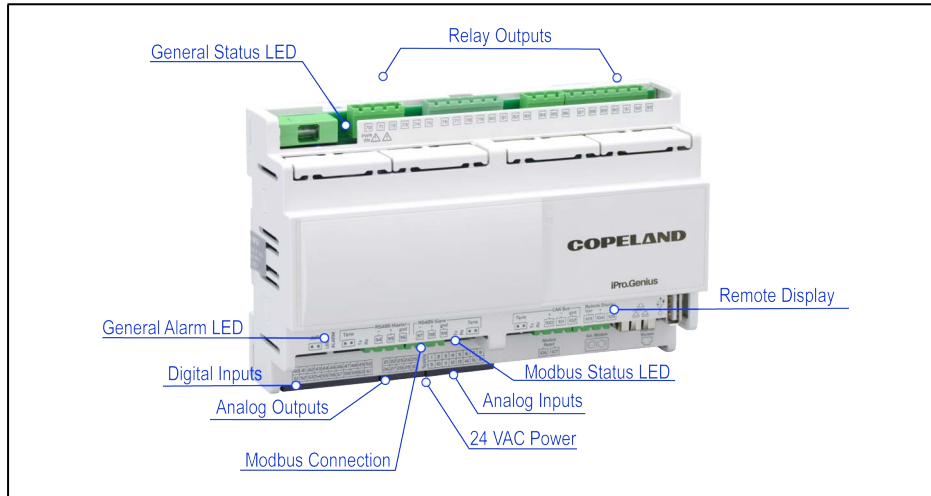


Figure 1-1 - DAC

The DAC supports local physical inputs and outputs and communicates with the E2 controller (version 3.00 and higher) via the RS485 MODBUS network.

The E2 will support a maximum of 32 instances of the DAC to be added to a BX-300 or CX-300. The E2 will support a maximum of 50 DAC devices on a BX-400 or CX-400.

The DAC supports 15 relay outputs, 6 analog outputs, 10 analog inputs, and 10 digital inputs.

1.1 The DAC's I/O Points

The compact size of the DAC allows technicians to field-mount the DAC in a rooftop unit or enclosure close to it, allowing for local connection of sensors and transducers. The board has 10 analog inputs and 20 digital inputs, with default configurations pre-loaded for quick connection to space temperature sensors, supply and return air temperature sensors, and fan proofs. Its 15 relay outputs, rated 2.0 amps max, are used for activating and deactivating fans, heat and cool stages, economizers, and other systems or devices. Its 6 analog outputs may be used for air damper, modulated heat and cool control, and variable-speed fan control.

1.2 Independent System Control

The DAC can control a rooftop unit independently without the need of a central controller (such as the E2 BX Building Controller). However, the DAC is designed to interface with an E2 to allow it to work with other DACs together to control large zones. Networking the DAC to a central controller also allows you to view status on E2 and UltraSite32 Site Manager status screens, report alarms, and log point values.

The DAC's configuration can be programmed through the E2 front panel.

The DAC was designed to be used with a Copeland supervisory controller, and one of these supervisory controllers is the only method for configuring the DAC. If there is no supervisory controller, the DAC can be standalone, but in reduce capacity. However, if the supervisory controller goes offline, the DAC operates standalone using the last configuration received from it. While in standalone, the DAC will continue to control heating/cooling but will remain in occupied mode only (no scheduling) until communication is reestablished. The supervisory controller maintains the occupancy schedule and is responsible for sending the occupancy signal over ModBus to the DAC.

2 Mounting and Powering

The DAC is usually mounted by the HVAC equipment manufacturer. Therefore, the installer need only make the necessary connections between the boards and the site controller(s).

In some instances, an installer may be required to mount the DAC. There are no restrictions on the location of the DAC; however, the controller should be mounted in a location protected from moisture. Typically, mounting inside the electrical control panel of a package unit is acceptable. If there is no room to mount the controller inside the HVAC unit, it may be mounted inside a weatherproof enclosure on the outside of the unit.

2.1 Installation

The DAC uses a DIN mount installation.

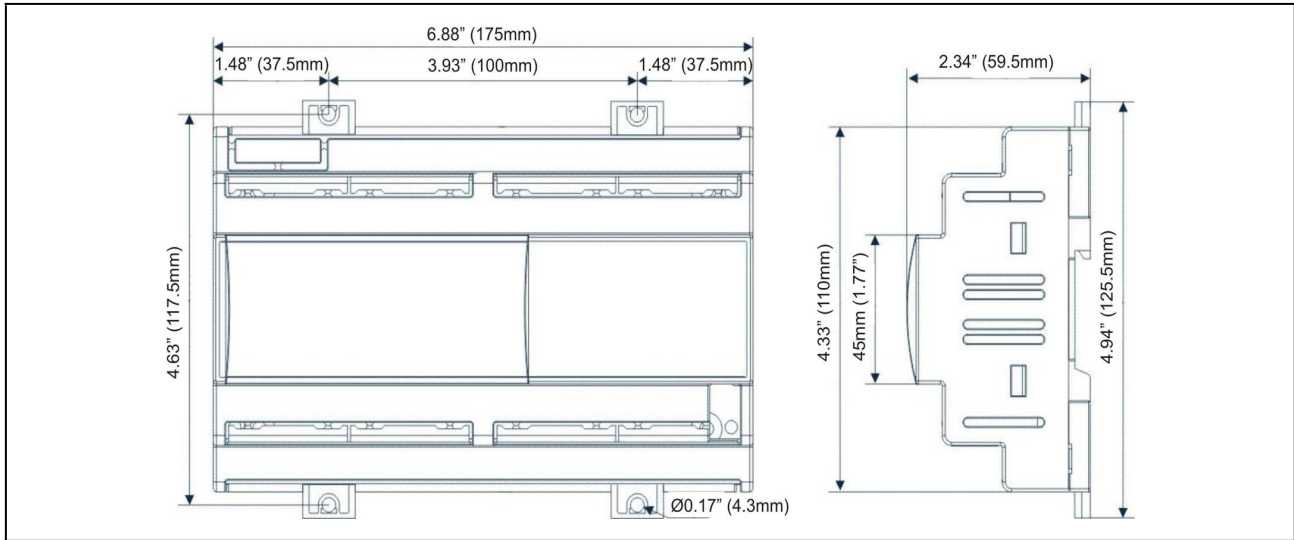


Figure 2-1 - DIN Mounting

Table 2-1 - DAC Enclosure Specifications

Mount:	On a DIN rail (EN 50022, DIN 43880) Fastened with screws via the removable plastic flaps.
Material:	PC-ABS Thermoplastic
Self-extinguishing:	V0 (UL94)
Comparative Tracking Index (CTI):	300V
Color:	White

2.2 Powering the DAC

Copeland supplies a wide variety of 24VAC transformers with varying sizes without center taps. **Table 2-2** shows the transformer sizes and are non-center-tapped.

2.2.1 Choosing Transformer Sizes

The transformer used to power the DAC should have at least a 20VA rating. The DAC should not share a transformer with any other devices.

Table 2-2 - Transformers Compatible with DAC

Transformer P/N	VA Rating	Primary Voltage
640-0041	50 VA	110 VAC
640-0042	50 VA	220 VAC

2.2.2 The DAC Power Wiring

The DACs can be powered by one of the 50VA non-center-tapped transformers listed in **Table 2-2**. **Figure 2-2** shows how to wire the transformers to the DAC boards.

Neither side of the secondary should be connected to ground. Also, do not connect the center tap (if provided on the transformer) to ground. The entire secondary of the transformer should be isolated from any ground.

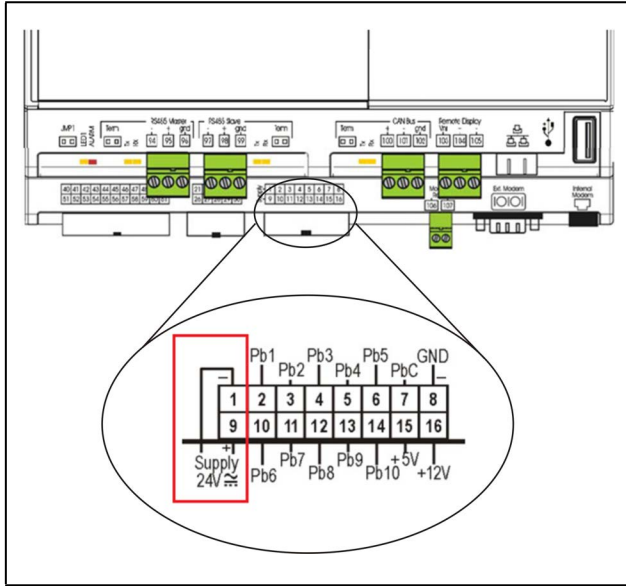


Figure 2-2 - Non-Center-Tapped Transformer Wiring

2.2.3 Wire Types and Maximum Distances

For powering I/O boards, use only the listed wire types in **Table 2-3**. Two-conductor non-shielded cables are the recommended wire for connecting the transformer to the DAC. Shielded cable should not be used for power wiring. The center tap should be left disconnected, if present on the transformer.

Table 2-3 - Power Wiring Types

Power Wiring Types	
14 AWG	Belden 9495
18 AWG	Belden 9495

The wire length from the transformer determines the type wire gauge used. In most cases, the distance between the DAC and the transformer that supplies power to it is not enough to be of concern; however, it is very important NOT to exceed this maximum wire length or the controller will not operate correctly.

Use these formulas to determine if the wire gauge you are using fits within specification:

Table 2-4 - Power Wire Lengths

14 AWG:

Feet = 1920/VA

18 AWG:

Feet = 739/VA

(VA is the total VA rating of the controller)

For example, if you had an 80 VA load:

14 AWG: 24 ft.

18 AWG: 9 ft. (rounded down)

Sensors requiring 24VAC should not be powered from the same transformer powering the input board. Any devices that will be connected to the DAC's inputs or outputs must be powered with a separate 24VAC transformer.

3 The MODBUS Network

Although the DAC can operate as a stand-alone controller, it relies on an E2 unit for advanced features such as remote dial-in/ dial-out, logging, and alarm control. The DAC uses an RS485 network connection to communicate with E2 site controllers.

3.1 Wiring Types

Copeland specs Belden #8761 shielded twisted pair cables for use as MODBUS wiring (or Belden #82761 and Belden #88761 for plenum installations).

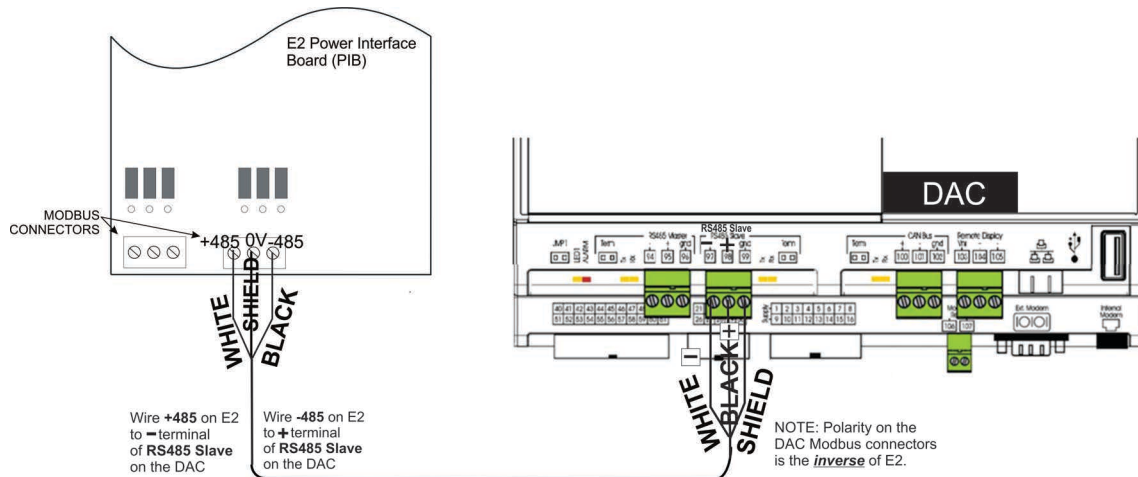
If the recommended cable is not available in your area, be sure the wiring meets or exceeds the following specs:

Shielded?	Yes
Conductor Type	Twisted Pair
Gauge	18 - 24 AWG
Capacitance between signal wires	31 pF/ft or less (9.45 m) or less
Capacitance between signal and shield	59 pF/ft or less (17.98 m) or less
Nominal Impedance	120Ω±50Ω

3.1.1 Daisy Chains

Connect the MODBUS network cable to the three-terminal connector on the E2 COM port you wish to assign as MODBUS. Reverse the polarity of +/- on the RS485 cable between the E2 and the DAC.

Figure 3-1 - MODBUS Networking



3.1.2 Network Addressing - Visograph

The network address makes a board unique from other boards on the network of the same type. This allows the site controller to find it and communicate with it easily.

The network address of the DAC is set using add-on devices called visographs (P/N 318-7272).

3.1.2.1 Connecting the Visograph

The Visograph is connected with a 3-wire connection on pins 103, 104, and 105.

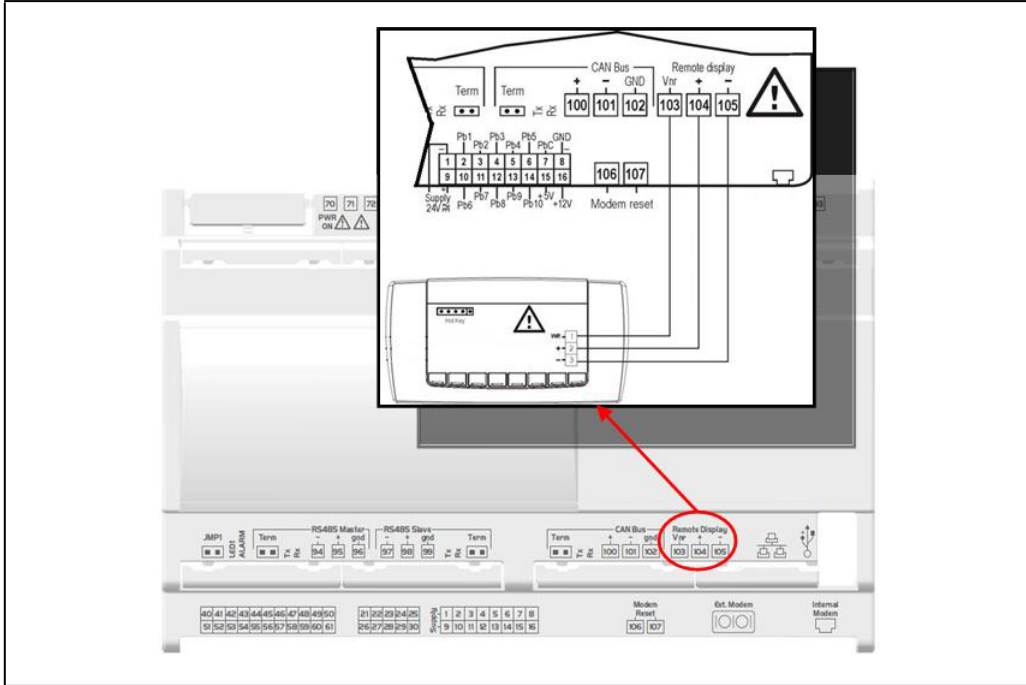


Figure 3-2 - Network ID Settings

CAUTION

The DAC may be damaged if the wires are crossed when connecting the visograph, especially if pin 103 (Vnr) is accidentally connected to + or -

3.1.2.2 Visograph Navigation

- Six menu items are available to choose from.
- Shows current MODBUS address and application version (see **Figure 3-4**).
- Press corresponding button along the bottom (**T1-T6**) to navigate to desired item.

Navigation Buttons in Visograph

- MENU** Press to go back to the main menu.
- ENTER** Selects a field for editing or saves a changed field.
- Left/Right Arrow** Navigate to next or previous field. During edit mode, increases or decreases value.
- Up/Down Arrow** Navigate to next or previous screen.

Figure 3-3 - Visograph Buttons

3.1.2.3 Setting the MODBUS Address

Boards of the same type are typically numbered in sequence, starting with one and continuing with two, three, and so forth.

Note, all DAC setpoints must be viewed/modified through the user interface of the connected supervisory controller. The Visograph interface is intended to be used primarily to check unit status and perform temporary output overrides. Configuration of the physical inputs and outputs is also possible.

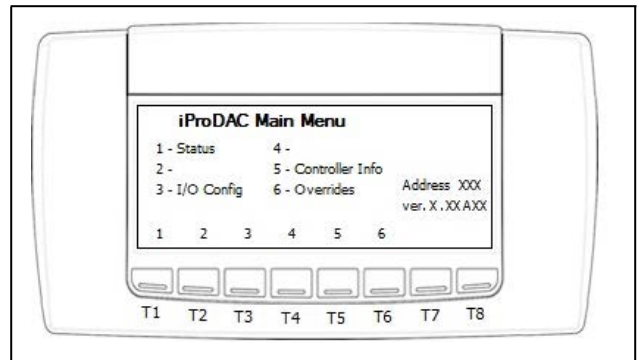


Figure 3-4 - Main Menu - Press 5 to Set Address

1. Press **5 - Controller Info** on the main menu to see Controller Info screen.

The first field highlighted by the cursor is the Modbus Address. To change the address:

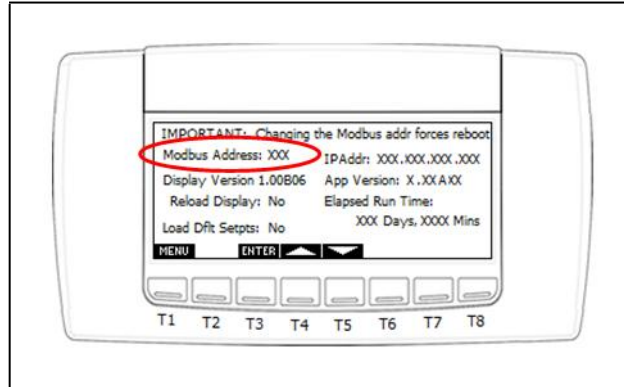


Figure 3-5 - Controller Info - Modbus Address

2. Press the **ENTER** key (**T3**). The address field should start blinking.
3. Using the **UP** and **DOWN** arrows (**T4** and **T5**), change the address to the desired value.
4. Press **ENTER** to save new address. The address field should stop blinking.
5. Press **MENU** (**T1**) to go back to main menu.

NOTE

When the MODBUS address is changed, the DAC will automatically reboot.

Versions

The DAC and Visograph versions are also shown on the Controller Info screen.

If the Visograph version shown is not the most recent, set the **Reload Display** field to **Yes**. This will cause the display to download the latest screens contained in the DAC.

3.2 MODBUS Termination

The DAC has on-board termination capability. A single termination jumper is located next to the RS485 slave connector. If the DAC is located at the physical end of the MODBUS network, the termination jumper should be applied.

4 Input and Output Setup

4.1 The DAC Inputs

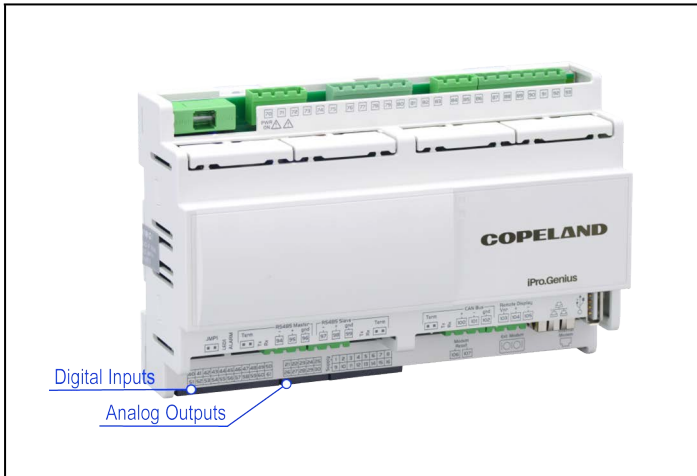


Figure 4-1 - DAC Input Locations

The DAC will be able to use input data from either physical or network inputs. The DAC has connections to analog and digital sensors, transducers, switches, and other input types typically used in a rooftop HVAC unit application. The input type and function for each point must be programmed in the DAC software by the installer.

The DAC application will support the following analog inputs:

Table 4-1 - DAC Analog Inputs

Analog Input	Type	Description
CO2 Level	Local or Network	Network CO2 Level
Duct Pressure	Physical	Local Duct Static Pressure Sensor
Inside Humidity	Local or Network	Network Inside Humidity
Mixed Air Temp	Physical	Local Mixed Air Temperature Sensor
OAH	Local or Network	Outside Humidity
OAT	Local or Network	Outside Air Temperature
Return Air Temp	Local	Local Return Air Temperature Sensor
Setpoint Reset (slider)	Local	Local Setpoint Reset Slider
Space Temp (2)	Local	Local Space Temperature Sensor
Suction Pressure (2)	Local	Local Suction Pressure Sensor (used for Dehumidification control with Digital Scroll Compressors)
Supply Temp	Local	Local Supply Air Temperature (mandatory sensor - required for control)
Zone Temp	Network (DAC only)	Network Space Temperature
Auxiliary (2)	Local	Satellite Inputs used by E2

The DAC will support the following digital inputs.

NOTE The Digital Inputs of the DAC are pre-defined and cannot be changed.

Table 4-2 - DAC Digital Inputs

Digital Input	Point Number	Description
Fan Proof	1	Local Fan Proof Sensor
Smoke Detector	2	Local Smoke Detector
Dirty Filter	3	Local Dirty Filter Sensor
Freeze Stat	4	Local Freeze Stat
Phase Loss	5	Local Phase Loss Sensor
VFD Alarm	6	Variable Frequency Drive Alarm
Exhaust Hood On	7	Local Exhaust Hood Sensor
Bypass to Occ	8	Local Occupancy Bypass Switch
Auxiliary A	9	Satellite Inputs used by E2
Auxiliary B	10	Satellite Inputs used by E2

4.1.1 Wiring Analog Inputs on the DAC

The analog inputs are located on the same connector as the controller power supply.

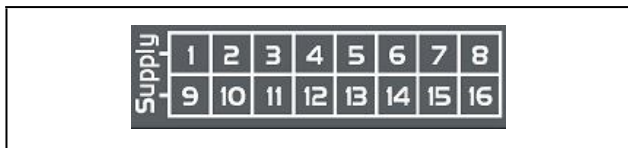


Figure 4-2 - Analog Input Connectors

The DAC provides separate input commons depending on the type of sensor connected. For temperature probes, all commons should be wired to PbC on terminal 7. For voltage output transducers, all commons should be wired to GND on terminal 8.

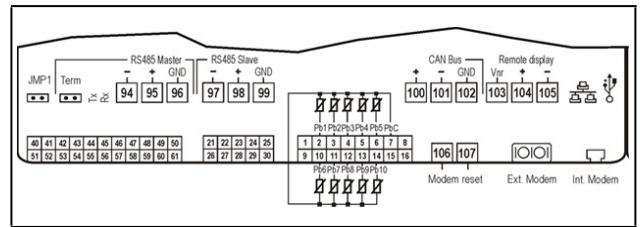


Figure 4-3 - Temperature Probe Wiring

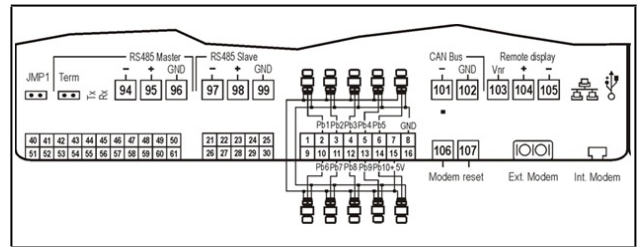


Figure 4-4 - Transducer Wiring for +5V Powered Devices

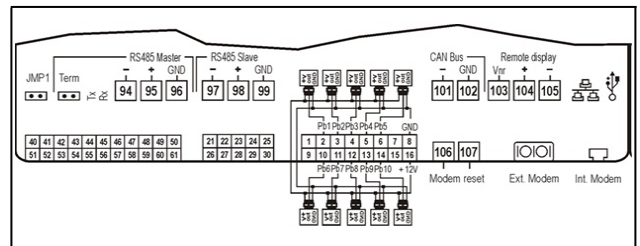


Figure 4-5 - Transducer Wiring for +12V Powered Devices

CAUTION Mis-wiring a sensor to the wrong common can result in damage to the DAC.

CAUTION Any inputs that are powered with a voltage that differs from that supplied by the DAC (+12V or +5V) must be powered separately with another transformer in order to prevent the inputs from malfunctioning or being damaged. Do not use the same secondary of the controller's power to power the sensors.

Table 4-3 - Analog Input Connector Terminal Numbers

Terminal Number on Connector	Name
1	24VAC Supply -
2	Probe Input 1
3	Probe Input 2
4	Probe Input 3
5	Probe Input 4
6	Probe Input 5
7	Temperature Common
8	GND
9	24VAC Supply +
10	Probe Input 6
11	Probe Input 7
12	Probe Input 8
13	Probe Input 9
14	Probe Input 10
15	+5VDC
16	+12VDC

4.1.2 Wiring Digital Inputs on the DAC

The digital inputs are located on a separate 22-pin connector.

The DAC hardware provides a maximum of 20 opto-insulated digital inputs. However, for the DAC, only the first ten inputs are currently available for use (see **Table 4-2**). All digital inputs are voltage-free and are intended to have dry contact devices connected.

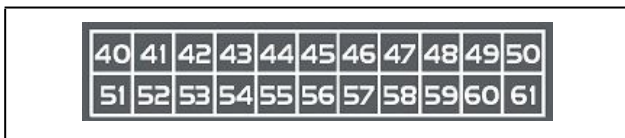


Figure 4-6 - Digital Input Connectors

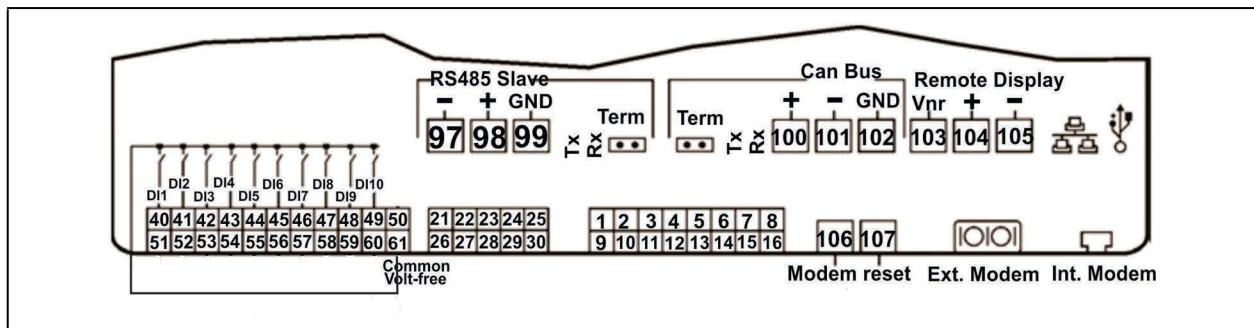


Figure 4-7 - Digital Input Wiring

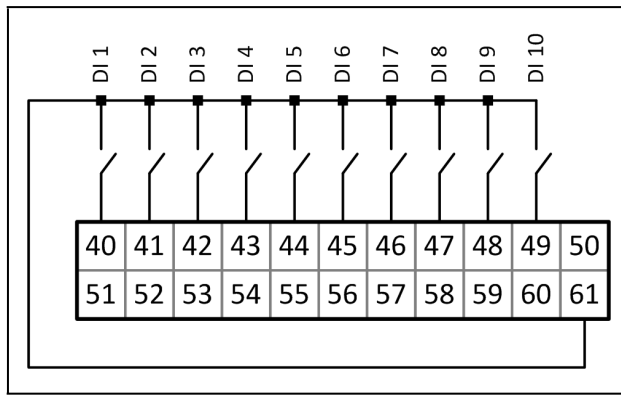


Figure 4-8 - Digital Inputs

Table 4-4 - Digital Input Connector Terminal Numbers

Terminal Number on Connector	Name
40	Digital Input 1
41	Digital Input 2
42	Digital Input 3
43	Digital Input 4
44	Digital Input 5
45	Digital Input 6
46	Digital Input 7
47	Digital Input 8
48	Digital Input 9
49	Digital Input 10
50	
51	Digital Input 11 (unsupported)
52	Digital Input 12 (unsupported)
53	Digital Input 13 (unsupported)
54	Digital Input 14 (unsupported)
55	Digital Input 15 (unsupported)
56	Digital Input 16 (unsupported)
57	Digital Input 17 (unsupported)
58	Digital Input 18 (unsupported)
59	Digital Input 19 (unsupported)
60	Digital Input 20 (unsupported)
61	Volt-free Digital Common

4.2 The DAC Outputs

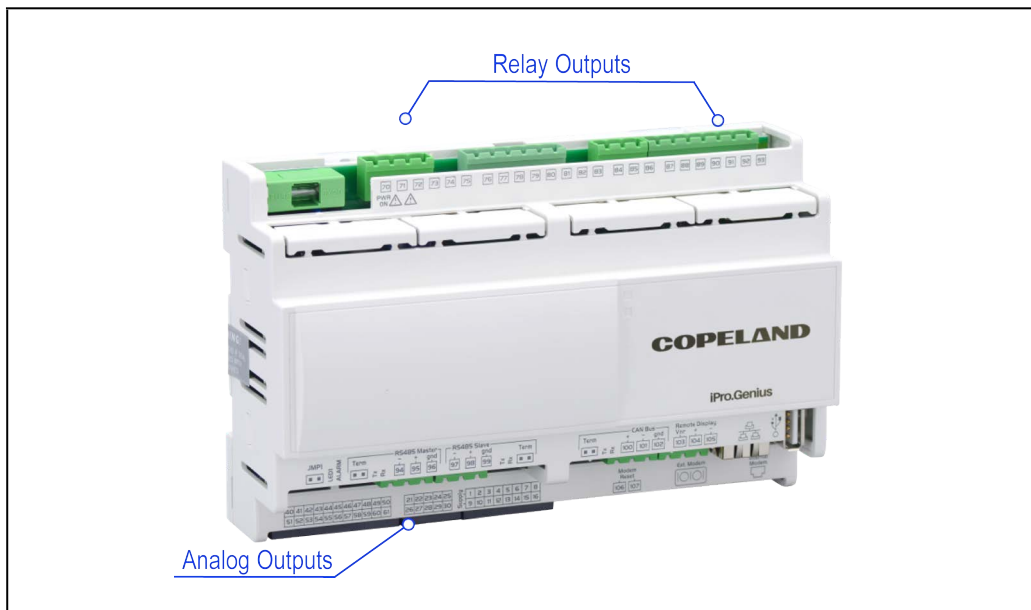


Figure 4-9- DAC Output Locations

The DAC has 15 relay outputs for connection to all loads that are typically present for a rooftop unit. The relay output type and function for each point must be programmed in the DAC software by the installer.

The DAC supports the following relay outputs:

Table 4-5 - DAC Relay Outputs

Relay Output	Description
Alarm Active	Alarm Active Output
Cool Stage 1-4	Cool Stage Output
Dehumidifier Digital	Dehumidification Active
Econ Enable	Economization Enabled
Fan Enable	Fan Enable
Primary Heat Stage 1-2	Primary Heat Stage Output
Secondary Heat Stage 1-2	Secondary Heat Stage Output
Reversing Valve	Heat Pump Reversing Valve Output
Auxiliary (2)	Satellite Outputs Controlled by E2
Reheat	Reheat Output

The DAC supports the following analog outputs:

Table 4-6 - DAC Analog Outputs

Analog Output	Description
Mod Fan (VS)	Modulating Fan
Mod Cool (2)	Modulating Cool Stages (including Digital Scroll compressors)
Mod Heat	Modulating Heat
Mod Outdoor Air Damper	Modulating Outdoor Air Damper
Mod Return Air Bypass	Modulating Return Air Bypass
Mod Return Air Damper	Modulating Return Air Damper
Mod VAV Bypass Damper	Modulating Variable Air Volume Bypass Damper
Supply Air SP Reset	Supply Air Setpoint Reset
Auxiliary (2)	Satellite Outputs Controlled by E2

For both relay and analog outputs, the DAC will drive physical points as well as send the current output value over MODBUS to E2.

4.2.1 Wiring Digital Loads on the DAC

The digital output relays are located across four separate connectors along the top side of the DAC.

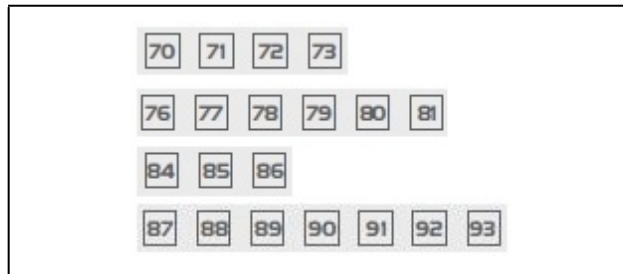


Figure 4-10 - Digital Load Connectors

The normally-open relay outputs on each connector share the same common and are not fused. Make sure to use the same voltage for all loads connected to the relays.

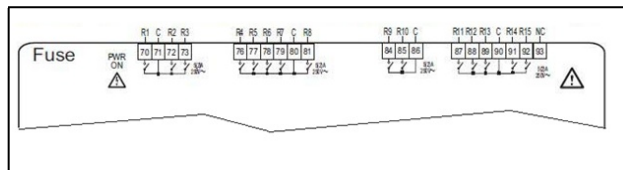


Figure 4-11 - Relay Output Wiring

Table 4-7 -Digital Relay Output Connector Terminal Numbers

Terminal Number on Connector	Name
70	Relay 1
71	Common for Relays 1-3
72	Relay 2
73	Relay 3
76	Relay 4
77	Relay 5
78	Relay 6
79	Relay 7
80	Common for Relays 4-8
81	Relay 8
84	Relay 9
85	Relay 10
86	Common for Relays 9-10
87	Relay 11
88	Relay 12
89	Relay 13
90	Common for Relays 11-15
91	Relay 14
92	Relay 15
93	

4.2.2 Wiring Analog Outputs on the DAC

The analog outputs are located on a separate 12-pin connector.

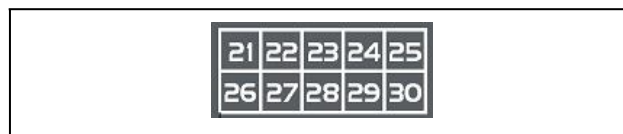


Figure 4-12 - Analog Outputs Connectors

The DAC provides six opto-isolated analog outputs. Because the analog outputs are opto-isolated, they must be separately powered by a 24V supply. *For the outputs to function properly, connect a 24VAC supply (separate from the controller's main*

supply) to terminals 28 and 29. The same transformer used to power the devices controlled by the analog outputs (e.g., damper actuator) may be used to supply power to terminals 28 and 29.

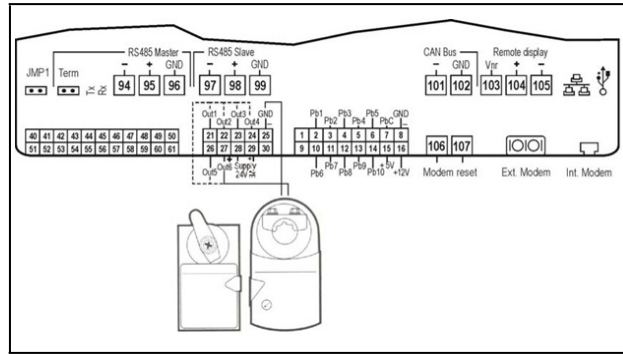


Figure 4-13 - Analog Output Wiring

CAUTION

The devices controlled by these analog outputs must be powered separately with another transformer (do not use the same secondary of the controller’s power) in order to prevent the outputs from malfunctioning or being damaged.

Table 4-8 -Digital Relay Output Connector Terminal Numbers

Terminal Number on Connector	Name
21	Analog Output 1
22	Analog Output 2
23	Analog Output 3
24	Analog Output 4
25	Analog Out Common
26	Analog Output 5
27	Analog Output 6
28	24VAC or 24VDC(-)
29	24VAC or 24VDC(+)
30	Analog Out Common

5 Wiring Connection to Site Supervisor

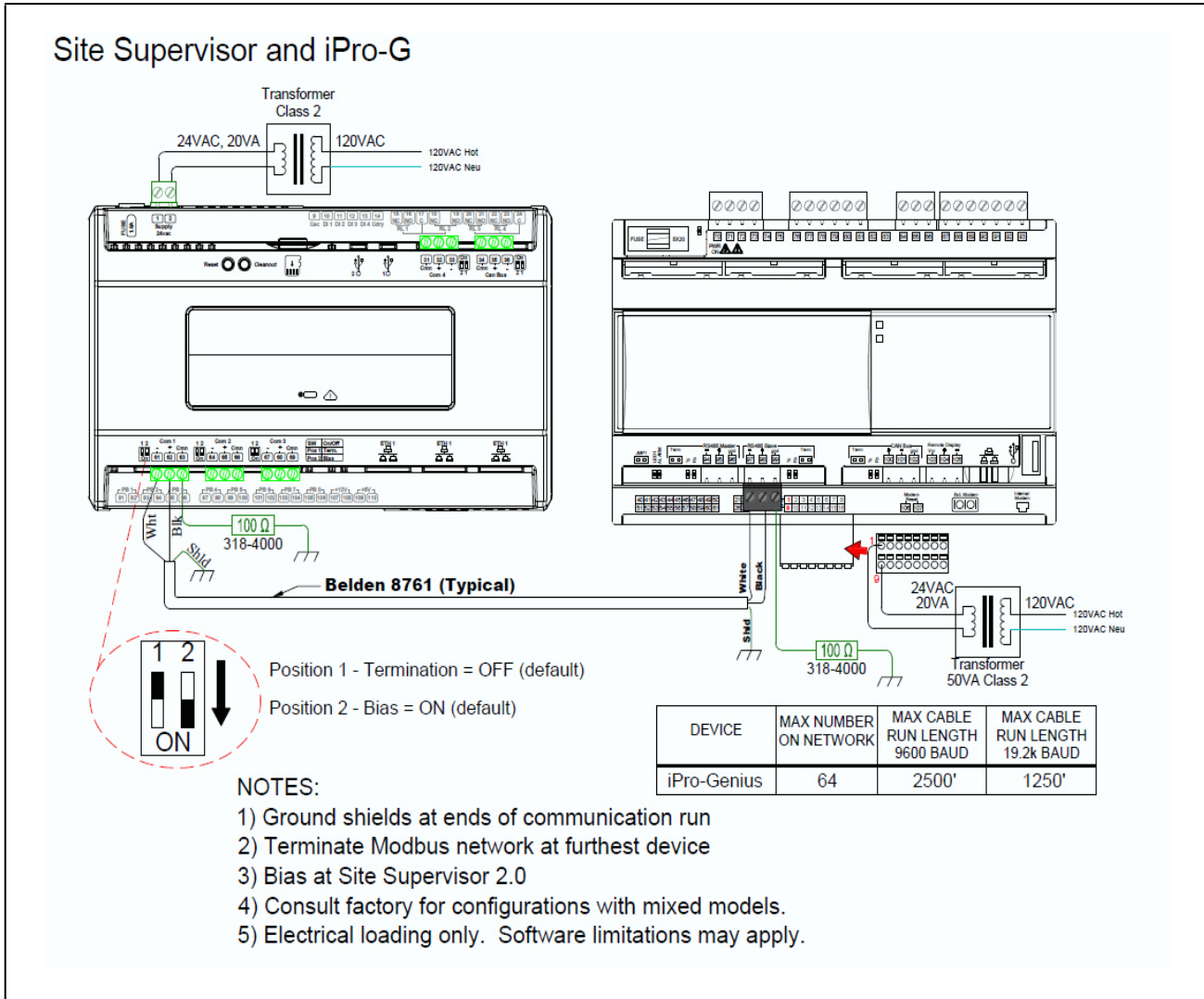


Figure 5-1 - Site Supervisor Wiring

6 DAC Status LEDs

When a DAC board is powered up, you will be able to determine the operating status of the board by observing its status LEDs.

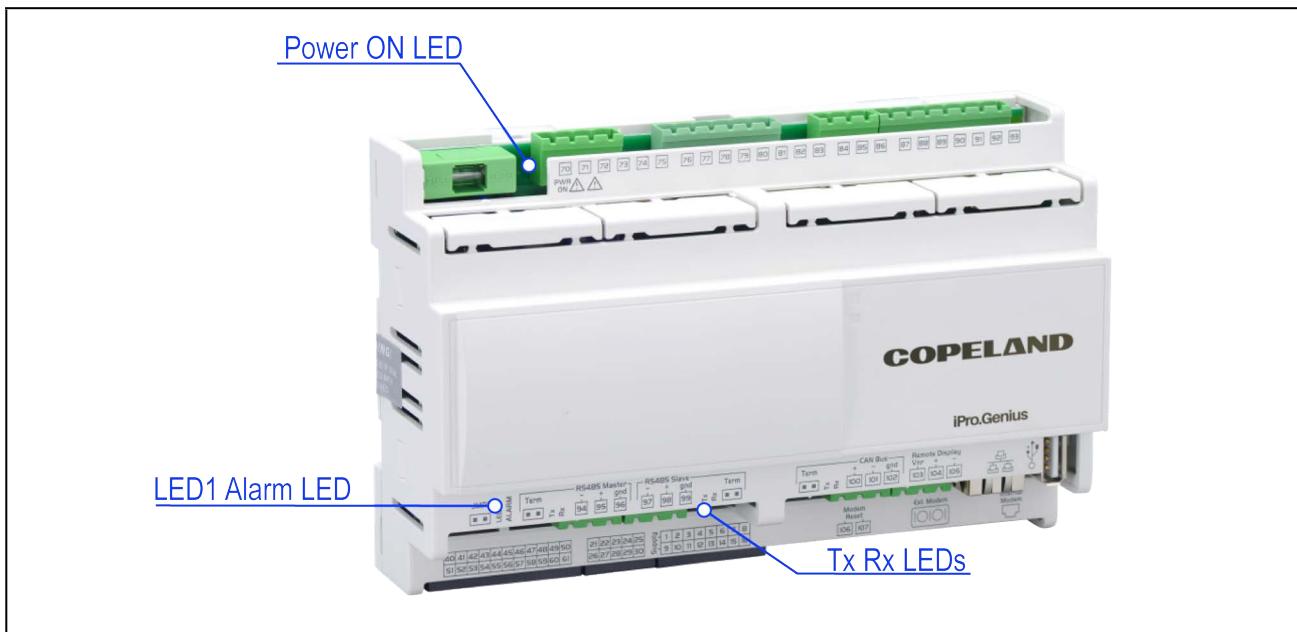


Figure 6-1 - DAC Status LED Locations

6.1 PWR ON LED

The PWR ON LED stays on continuously to show that the board is powered and operational. If this light is dark, the board has likely lost power.

6.2 Tx and Rx LEDs

The Tx and Rx LEDs indicate when the DAC is sending or receiving messages on the RS485 network.

The Tx LED blinks once every time the DAC sends a response to the E2. The Rx LED blinks once when the DAC receives a message.

If the DAC is connected to the network and set up to communicate with the controller, you should see these lights blinking regularly. If they do not blink regularly, there may be a problem with the network.

6.3 LED1 Network Status

The amber colored LED1 indicates whether the DAC is online or offline with the E2. When the DAC is online, the LED1 will turn on for one second and off for one second. However, if the DAC is offline, the LED1 will turn on for half a second and off for half a second (blink twice as fast). When the DAC is offline, it reverts to standalone control, using only the locally connected inputs to control the HVAC unit. In this state, the controller reverts to an Occupied mode.

6.4 ALARM LED Status

When the red ALARM LED is turned on, the DAC has an active alarm. When in this state, the Alarm relay output (if defined) will turn on. Check the E2 advisory log for details on the type of alarm.

7 Software Overview

The DAC maintains space temperature setpoints by modulating heating or cooling stages to maintain a desired supply air temperature. For this reason, a supply air temperature sensor must be connected to the controller. The desired supply air temperature is primarily determined by a setpoint and can be automatically adjusted based on changes in building load.

7.1 Application Mode

The DAC supports packaged HVAC control in either Constant Air Volume (CAV) or Variable Air Volume (VAV) applications. The main difference between the two modes is how the variable speed fan will be controlled. When CAV is selected, the variable speed fan is modulated based on the number of heating or cooling stages that are currently active. When VAV is selected, the variable speed fan modulates to maintain a static duct pressure. See **Section 7.5, Fan Control** for more details.

Also, VAV mode does not require a local space sensor to be connected to the controller. Instead, the system terminal load is calculated by the E2 and is sent over the network to the DAC so the operational mode can be determined. Note that the primary control of heating and cooling stages using the supply air temperature sensor is identical for either CAV or VAV mode.

7.2 Operational Modes

The DAC will be in one of nine possible modes of operation at any given time. All modes have different priorities so if conditions warrant two modes to be operational at the same time, one of the modes will win and become active. In the table, the modes are shown in ascending priority with the exception of Cooling and Dehum. For example, Idle is the lowest priority and Emergency Shutdown is the highest priority, but if both cooling and dehumidification are called for, the larger of the two calculated loads will take priority and activate the proper mode of operation.

Table 7-1 - DAC Operational Modes with Corresponding Site Manager Mode

Corresponding Site Manager Mode	Operating Mode	Description	Outputs Active
0	Idle	Default mode if no other modes are active	None
1	Ventilation	Space air recirculation only	Indoor Fan
2	CO2 Purge	Max CO2 level reached and fresh air must be brought in to building	Indoor Fan, Outdoor Air Damper
3	Economizing	Outdoor air free cooling active	Indoor Fan, Outdoor Air Damper
4	Make-up Air	Exhaust Fan detected and make-up air must be brought in to building	Indoor Fan, Outdoor Air Damper
5	Heating	Heating is active	Indoor Fan, Heat Stages, Modulating Heat
6	Cooling	Cooling is active	Indoor Fan, Cool Stages (Fixed or Modulating),
7	Dehum	Dehumidification is active	Indoor Fan, Cool Stages or Dehum Output, Reheat Output
8	Emergency Shutdown	One of the following is active: Smoke Detected, Phase Loss Active, Fan Proof Failure	None

7.3 Space Temperature Control

There are two active space temperature setpoints in a DAC: a cooling setpoint and a heating setpoint. In general, when the input rises above the cooling setpoint, cooling mode begins, and when the input falls below the heating setpoint, heating mode begins.

7.3.1 Terminal Load Calculation

As the space temperature rises above the active cooling setpoint, or falls below the active heating setpoint, the system's terminal load will increase, either positively for cooling, or negatively for heating. The terminal load can range from -100% to +100%, where all negative values indicate a demand for heating and all positive values indicate a demand for cooling.

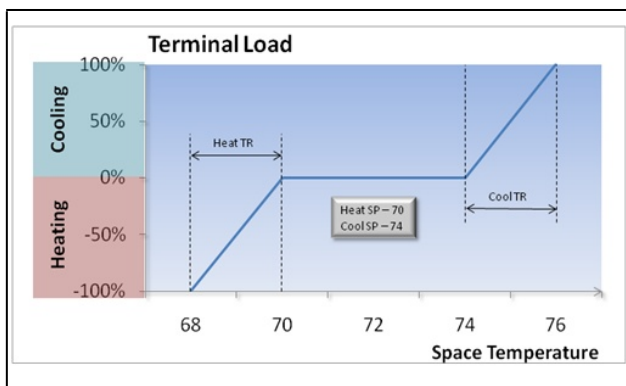


Figure 7-1 - Terminal Load Graph

When the terminal load rises above 20%, cooling mode will be activated. Conversely, when the terminal load falls below -20%, heating mode will be activated. Once activated, both cooling and heating modes will deactivate if the terminal load goes back to 0%.

7.4 Supply Temperature Control

The DAC will determine the active supply air temperature setpoint based on whether heating or cooling is active as well as the amount of terminal load.

When heating mode is active, the controller will use the supply temperature heating setpoint as the active supply temperature setpoint. Heat stages will be turned on to maintain the supply air temperature at the active setpoint. Conversely, when cooling mode is active, the controller will use the supply temperature cooling setpoint as the active supply temperature setpoint. Cool stages will be turned on to maintain the supply air temperature at the active setpoint.

7.4.1 Supply Air Setpoint Reset

The active supply air setpoint may be automatically adjusted (reset) based on the heating or cooling terminal load present. The active setpoint will be increased or decreased up to the maximum amount specified by the heating and cooling reset setpoints. The maximum amount will be used when the terminal load reaches +100% for cooling and -100% for heating.

7.4.2 Cooling Mode

The DAC supports both staged and modulating mechanical cooling devices. Modulating devices are treated as a cooling stage in the case of a unit having a mixture of fixed and variable capacity compressors.

7.4.2.1 Staged Cooling

Up to four stages of cooling can be used. Each compressor stage can be configured to be fixed size, digital scroll, VS, double size, or heat pump. The fixed size and heat pump compressors assume a fixed capacity while the digital scroll and VS compressors assume a modulating capability. The double size compressor indicates a fixed compressor which is double in capacity compared to the other fixed compressors.

NOTE

The application supports a maximum of two digital/VS compressor stages.

When a compressor stage is defined as a heat pump, it will turn on for both cooling and heating. A reversing valve must also be used and can be defined as active cooling or active heating.

Staging On

When cooling is required, the cool stages will stage on if the current supply air temperature is above the active supply air cooling setpoint. The lowest stage that is off will be turned on first. Additional stages will be brought on according to the Cool On-Delay setpoint. A cooling stage will not be turned on unless it has satisfied its minimum off time.

Staging Off

When the current supply air temperature drops below the active supply air cooling setpoint minus the Cool Stage Deadband, cooling stages will begin to stage off. The highest stage that is currently on will be turned off first. Additional stages will be turned off according to the Cool Off-Delay parameter. A cooling stage will not be turned off unless it has satisfied its minimum run time.

7.4.2.2 Modulating Cooling

Up to two cooling stages may be defined as variable capacity (VS or digital scroll). Variable capacity stages should be assigned the lowest numbered cool stages. As with fixed capacity staging, variable capacity stages will be activated if the supply air temperature is above the active supply air cooling setpoint. However, the next higher stage after a variable capacity stage will start its On-Delay only after the variable stage is at its maximum capacity. Likewise, the next lower stage before a variable capacity stage will start its Off-Delay only after the variable stage is at its minimum capacity.

When a variable capacity compressor is activated, it will modulate to maintain the supply air temperature at the active supply air cooling setpoint. A PID loop will be used to determine the capacity output.

If the first two stages are both variable capacity compressors, the lower stage will turn on first and ramp up. When the second modulating stage is activated, the first modulating stage will remain at its maximum percent while the PID loop controls the second modulating stage. Once the second modulating stage has turned off, the first modulating stage will be allowed to modulate again.

The variable capacity compressors have both minimum and maximum capacity setpoints. In the case of multiple modulating stages, all stages will use the same minimum and maximum settings.

7.4.2.3 Cooling OAT Lockout

Cooling will only be allowed when the outside air temperature is above the cooling lockout temperature setpoint. If the outside temperature falls below this setpoint, cooling will be deactivated. Cooling will only be re-enabled when the outside temperature rises back above the lockout setpoint plus 2°F.

7.4.3 Heating Mode

The DAC supports both staged and modulating mechanical heating devices. A modulating device, such as a hot water valve, is treated as a heating stage in the case of a unit having a mixture of fixed and modulating heating sources.

7.4.3.1 Staged Heating

Up to two stages of primary heating and two stages of secondary heating can be defined for a total of four heating stages. Lower operating cost heat stages, e.g., reclaim heat, should be connected to the primary heat outputs on the controller. Higher operating cost heat stages, e.g., gas or electric heat, should be connected to the secondary heat outputs. The controller will always activate all primary heat sources before activating secondary heat sources.

Staging On

When heating is required, the heat stages will stage on if the supply air temperature is below the active supply air heating setpoint. The lowest primary heat stage that is off will be turned on first. Additional primary stages will be brought on according to the Heat On-Delay setpoint as long as the supply temperature remains below the active supply temperature heating setpoint. A heating stage will not be turned on unless it has satisfied its minimum off time. Once all primary heating stages are on, secondary heating stages will begin to stage on in the same manner as the primary heating stages.

Staging Off

When the supply air temperature rises above the active supply air heating setpoint plus the Heat Stage Deadband, heating stages will begin to stage off. The highest active secondary heating stage will be turned off first. Additional secondary stages will be turned off according to the Heat Off-Delay setpoint as long as the supply temperature remains above the supply temperature heating setpoint plus the Heat Stage Deadband. A heating stage will not be turned off unless it has satisfied its minimum run time as specified by the parameter Heat Min On. Once all secondary heating stages are off, primary heating stages will begin to stage off in the same manner as the secondary heating stages.

7.4.3.2 Modulating Heating

In addition to the primary and secondary heat stages, the DAC supports one modulating heating output. This modulating output must be classified as either a primary or secondary heat source.

Primary Mod Heat

If the modulating heat output is classified as a primary heating source, it will be activated before any other primary heat stages when the application calls for heating. Once activated, the modulating heat output will modulate to maintain the supply air temperature at the active supply air heating setpoint. A PID loop will be used to determine the capacity output. If the modulating heat output reaches 100% and remains there for the Heat On-Delay period, the first primary heating stage will be activated. Additional primary heating stages will be brought on according to the Heat On-Delay as long as the modulating heating output remains at 100%. No additional stages of heating will be brought on while the modulating heat output is less than 100%. When all primary heating stages have been activated, secondary heat stages will be allowed to stage on similar to the primary heating stages.

Secondary and primary heat stages will be sequentially turned off as demand for heating is reduced. The highest secondary stage will turn off after the modulating heat output has been at minimum capacity for the Heat Off-Delay. Additional heat stages will be turned off in the same way.

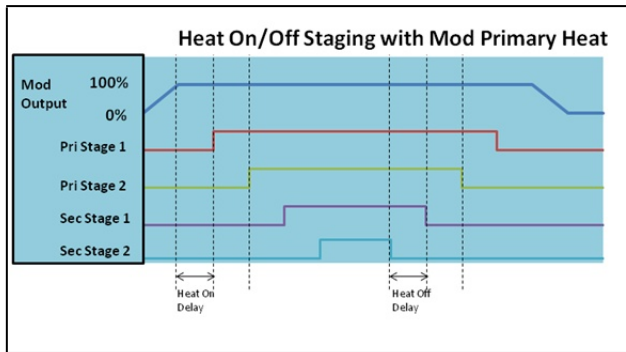


Figure 7-2 - Heat Staging Primary Graph

Secondary Mod Heat

If the modulating heat output is classified as a secondary heating source, it will be activated only after all primary heat stages have staged on, but before any defined secondary heat stages are activated. Once activated, the modulating heat output will modulate to maintain the supply air temperature at the active supply air heating setpoint. A PID loop will be used to determine the capacity output. If the modulating heat output reaches 100% and stays there for the Heat On-Delay period, the first secondary heating stage will be activated. Additional secondary heating stages will be brought on according to the Heat On-Delay as long as the modulating heating output remains at 100%. No additional stages of heating will be activated while the modulating heat output is less than 100%.

Secondary heat stages will be sequentially turned off as demand for heating is reduced. The highest secondary stage will turn off after the modulating heat output has been at minimum capacity for the Heat Off-Delay period. Additional heat stages will be turned off in the same way. Once all secondary heat stages are off, the modulating heat output will remain on until it goes to minimum capacity and stays there for at least the Heat Off-Delay period. After this time, the modulating heat output will turn off, leaving only the primary

heat stages still active. The primary heat stages will then stage off as previously described.

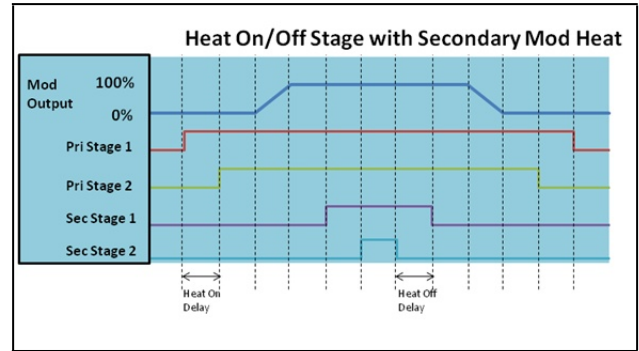


Figure 7-3 - Heat Staging Secondary Graph

7.4.3.3 Heating OAT Lockout

Heating will only be allowed when the outside air temperature is below the heat lockout temperature setpoint. If the outside temperature rises above this setpoint, heating will be deactivated. Heating will only be re-enabled when the outside temperature falls 2°F below the lockout setpoint.

7.5 Fan Control

The DAC supports control of either a single speed fan or a variable speed (VS) indoor fan. The method used to control the fan depends on the application mode setting (CAV or VAV – see **Section 7.1, Application Mode** for more information).

7.5.1 CAV Mode

The indoor fan will be controlled in one of three ways:

- **Continuous** – The fan is always on, even when the controller is not in heating, cooling, or dehumidification mode. In variable speed fan control, when heating or cooling is not active, the fan will be ON at a fixed, user-defined idle speed.
- **Auto** – The fan is only on when the controller is in heating, cooling, dehumidification, or outside air damper operation mode.
- **Summer ON, Winter Auto (SOWA)** – This mode allows the fan to operate in Continuous mode during the summer months and in Auto mode during the winter months (based on the season passed to the DAC from the E2 controller).
- If desired, activation and deactivation delays may be set up for the DAC application for both heating and cooling mode.

7.5.1.1 Variable-Speed Fan Control in CAV

When using a variable-speed fan, each heat and cool stage has its own individual VS fan speed setpoint. When one or more stages are active, the DAC will look at the setpoints of all active stages and operate the VS fan at the highest setpoint value.

Example: A DAC is controlling two heat stages. Heat stage #1's VS fan setpoint is 50%, and Heat stage #2's VS fan setpoint is 100%. When heating mode first begins and the heat stage #1 becomes ACTIVE, the fan will increase speed from idle to 50%. When heat stage #2 is activated for more heating, the DAC looks at both heat stage #1 and #2's setpoints, determines that the highest setpoint belongs to stage #2 (100%), and increases the fan speed to 100%.

Economization VS Fan Speed

Because the controller treats economization separately from mechanical cooling, the economization damper has its own fan speed setpoint. When economization is enabled and no other cooling stages are active, the VS fan will operate at the economization fan speed setpoint.

CO2 Purge VS Fan Speed

When a CO2 purge is active and heating and cooling are not active, the DAC will operate the VS fan at the CO2 Purge VS Fan Speed setpoint.

Make-up Air Offset VS Fan Speed

When make-up air is active, the current VS fan speed will be increased by the Make-up Air Offset% setpoint.

Idle VS Fan Speed

When using the "Continuous" fan mode, the DAC will use the Idle VS Fan Speed setpoint when no cooling or heating stages are active.

Dehumidification Offset

During dehumidification, a lower VS fan speed is typically desired. The DAC uses a dehumidification offset parameter to achieve this. When an offset greater than 0% is specified in the DAC, the offset is subtracted from the final VS fan speed when dehumidification is active.

For example, if the dehumidification offset is 5%, and cool stage 1's VS fan speed setpoint is 50%, when dehumidification is active with one cooling stage ON, the VS fan speed will be adjusted down to 45% (50% - 5%). If a second cool stage with a setpoint of 100% were to turn ON, the VS fan speed would increase to 95% (100% - 5%).

VAV Mode

For VAV applications, the supply duct static pressure must be controlled to avoid over pressurization of the ductwork. The DAC can support control of the duct static pressure using either a variable speed fan or a single speed fan in conjunction with a bypass damper.

7.5.1.2 Single Speed with Bypass Damper

The single speed fan will activate as described in **Section 7.5.1, CAV Mode**. When the fan is active, the duct static pressure will be controlled using a modulating bypass damper. When the bypass damper is at 0%, it is considered fully closed, meaning no supply air is bypassed to the return. As the static pressure in the duct rises above the static pressure setpoint, the bypass damper will begin to open based on the output from a PID loop (direct acting), thus relieving the pressure in the duct.

7.5.1.3 Variable-Speed Fan Control in VAV

The variable-speed fan will activate as described in **Section 7.5.1, CAV Mode**. Once active, the speed of the fan will modulate to maintain the duct pressure setpoint. As the static pressure falls below the setpoint, the VS fan will increase in speed (reverse acting). A user parameter will specify the minimum speed that the VS fan is allowed to operate at when active.

7.5.2 Fan Proofing

For both CAV and VAV modes, fan proofing may be enabled. When enabled and a fan proof failure is detected, heating and cooling loads will be shut down until the proof failure goes away or the fan proof alarm is reset or cleared. The fan may be configured to shut down on a fan proof failure. In this case, the fan proof alarm must be reset or cleared in order to restart the system.

7.6 Dehumidification Control

The DAC dehumidifies by using either mechanical cool stages or a separate dehumidification device. When dehumidification is needed, the DAC will generally turn on the dehumidification device or activate stages of cooling up to a user-defined maximum number of cool stages to be used for dehumidification.

For units equipped with hot gas reheat, the supply air setpoint reset analog output will modulate any time the reheat relay is activated, which occurs when the space temperature drops below the cooling space temperature setpoint. Additionally, the unit's primary heating outputs may be used to augment or replace the hot gas reheat function.

7.6.1 Enabling Dehumidification

The DAC can use several methods to determine if the controlled space requires dehumidification. If the sensor needed for the method selected is not valid, dehumidification will not be available until the sensor operation is corrected or a different method is selected. The methods supported are:

- Dehum by Inside RH
- Dehum by Outside RH
- Dehum by Inside Dewpoint
- Dehum by Outside Dewpoint

7.6.1.1 Dehumidification Setpoint

The active dehumidification setpoint that the controller uses is based on the occupancy state and the method of determining when dehumidification is required. Both occupied and unoccupied relative humidity and dewpoint setpoints are available, depending on the dehumidification method selected. A dehumidification RH or dewpoint throttling range will determine the range of humidity or dewpoint that represents the full dehumidification load. The dehumidification load can range from 0% (no dehumidification needed) to 100% (full dehumidification needed). Once the dehum load rises above 20%, the controller will activate dehumidification. Once activated, dehumidification will remain active until the dehum load goes back to 0%.

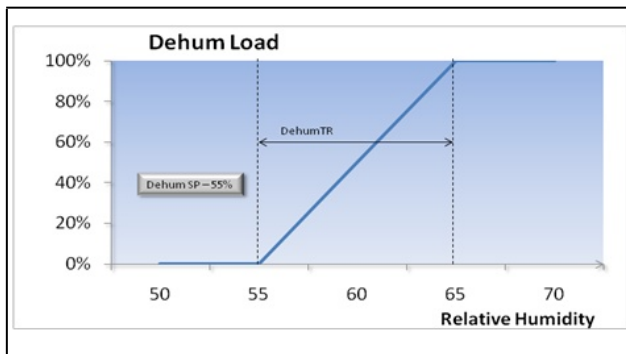


Figure 7-4 - Dehumidification Graph

7.6.1.2 Dehumidification by Dewpoint

If the selected dehumidification method is by Inside Dewpoint or Outside Dewpoint, the controller will calculate the dewpoint using the appropriate temperature and humidity inputs. If either the temperature or humidity input is not valid, dehumidification will be disabled until the inputs are corrected or the method is changed.

7.6.1.3 Low Temperature Lockout

To preserve occupant comfort, dehumidification will be disabled if the control temperature falls below the minimum space during dehumidification setpoint. Dehumidification will be allowed again when the control temperature rises 2°F above this setpoint.

7.6.2 Dehumidifying Using Cool Stages

The DAC activates the cooling stages specified for dehumidification based on the calculated evaporator coil temperature compared to the evaporator coil temperature setpoint. The evaporator coil temperature is calculated by converting the suction pressure to a temperature based on the refrigerant type. For units with a digital or VS compressor, the application will modulate the compressor to maintain the evaporator coil temperature setpoint and activate additional fixed capacity compressors as necessary based on the calculated dehumidification load. In all units, the first cooling stage will activate once the load reaches 20%. As the dehumidification load increases, it will be distributed proportionally across cooling stages based on the magnitude of the load and the number of available cooling stages.

For example, in a two-stage unit, the first cooling stage will activate at 20% dehumidification load, and the second cooling stage will activate at 60% load. Similarly, in a four-stage unit, the first stage will again activate at 20% load, followed by the second stage at 40%, the third stage at 60%, and the fourth and final stage at 80%. Thus, the maximum load will be distributed across all available cooling stages.

The cooling stage will remain active until the load drops to the activation point for the prior stage or to 0% in the case of the first stage. The sequence of activation of additional compressors is similar to the staging during cooling mode, including using the same cooling stage delays and the cooling PID settings.

7.6.2.1 Digital Scroll Operation During Dehumidification

Adjusted Minimum Percentage

If additional fixed compressor stages are required to be brought on during dehumidification, the digital compressor will only be allowed to modulate down to a minimum of 70%, even if the minimum capacity setpoint for the digital compressor is set to a lower value. This will reduce the loss of reheat capacity during low load conditions. If the digital compressor stays at 70% for the duration of the cool stage-off delay, the fixed compressor will be turned off.

Multiple Digital Compressors

If two digital compressors are defined and both are configured to be used for dehumidification, the second digital compressor will not turn on until the first digital compressor has reached its maximum capacity, similar to how digital compressors stage up in cooling mode. Two suction pressure inputs are supported, so when the second digital compressor is activated, the controller will use the second suction pressure transducer to calculate the coil temperature.

7.6.3 Reheat Output

When dehumidification is active, the Reheat output will activate when the space temperature drops 1°F below the cooling space temperature setpoint. However, if a return air bypass damper is configured, the Reheat output will not be permitted to activate until the return air bypass damper reaches 100%. Once activated, the Reheat output will remain active until the space temperature either rises above the cooling space temperature setpoint, or falls below the heating space temperature setpoint (at which point heating mode will activate).

7.6.3.1 Supply Air Setpoint Reset

When the Reheat output is active, and the Supply Air Setpoint Reset output is defined, the Reset output will modulate proportionally based on the space temperature. Specifically, as the space temperature drops from the Cooling setpoint to the Heating setpoint, the Reset output will increase from 0% to 100%.

7.6.4 Primary Heat Used as Reheat

Primary heating stages can be used instead of or in addition to the reheat output in order to maintain a dehumidification supply air setpoint. When used in addition to the reheat output, the primary heat will only stage on if the reheat output has been on for the Heat On-Delay period. Primary heat stages will then stage on according to the Heat On-Delay time as long as the supply temperature remains below the dehumidification supply setpoint. The heat stages will stage off if the supply temperature rises above the dehumidification supply setpoint plus the dehumidification supply deadband, according to the Heat Off-Delay setpoint.

7.6.5 Return Air Bypass Damper

The return air bypass (RAB) damper is only used on constant air volume units and only during dehumidification mode. When defined, the RAB damper acts as the first form of reheat. The RAB damper modulates from 0-100% as the space temperature falls below the cooling setpoint. When the space temperature is equal to the cooling setpoint, the RAB damper will be at 0%. When the space temperature falls to halfway between the active cooling and heating setpoints, the RAB damper will be at 100%.

7.6.5.1 Return Air Damper During Dehumidification

If the unit has a separate actuator for the return air (RA) damper (i.e., not linked to the outdoor air damper), the return air damper will proportionally close more as the RAB damper opens during dehumidification mode. The rate at which the RA damper will close is determined by the RA Damper multiplier setpoint. For example, if the RAB damper is at 50% and the RA damper multiplier is 10%, the RA damper will close an additional 5% from its current position.

7.7 Outside Air Control

The outside air damper can be used for several strategies. They are:

- Economization
- Indoor Air Quality (CO2 Control)
- Make-up Air Control

When the outside air damper does not have any functions calling for it to be open, the modulating damper will move to its minimum position and the two-position damper will close. During occupancy, the minimum position will be specified by a user setpoint. During unoccupied, the modulating damper will fully close to 0%.

7.7.1 Indoor Air Quality

When a CO2 sensor input is present on the DAC or a CO2 value is received from the E2, the outside air damper may be used to bring fresh air into the building to reduce CO2 levels. The CO2 sensor's value is compared to the DAC's CO2 setpoint. If the reading exceeds the setpoint:

- The damper will OPEN and remain open until the CO2 value drops below the setpoint (for two-position dampers).
- The damper will open and modulate its position based on a PID comparison of the CO2 sensor reading and the CO2 setpoint (for variable-position dampers). The damper will open to a user-specified maximum position.

7.7.2 Make-up Air Control

When an exhaust fan input is present on the DAC or an exhaust fan active signal is received from the E2, the controller will activate make-up air control. When make-up air becomes active, the modulating damper will open to the make-up air minimum damper position setpoint if it is currently less than that position. If the current modulating damper position is already greater than or equal to the make-up air minimum position setpoint, no adjustment to the damper position will occur.

For the two-position damper, when make-up air control is active, the damper will be set open. When make-up air control is inactive, the damper will close.

7.7.3 Economizer Control

Economizer dampers on rooftop HVAC units are used to bring outside air into the building for use in cooling. The DAC supports control of two-position outside air dampers as well as variable-position (analog) dampers.

The DAC controls economization by first determining whether the outside air conditions are favorable for bringing in outside air (see **Section 7.7.3.3, Economization Enabling Strategy**). If the air is not favorable for economization, the DAC will close the dampers. If the air is favorable for economization, the DAC will use the dampers like a preliminary stage of cooling, opening them first when cooling is first called for, and then activating more cool stages only if necessary to maintain the setpoint.

7.7.3.1 Operation of Two-Position Dampers During Economization

Two-position dampers are set to the OPEN position when economization is enabled and the space temperature is above the space economization setpoint. The damper will remain OPEN until cooling is not required, or until the DAC determines the outside air is not favorable for economization, at which time the dampers will be set to the CLOSED position.

7.7.3.2 Operation of Variable-Position Dampers During Economization

When economization is enabled and the space temperature is above the space economization setpoint, the DAC controls the position of the damper using a PID algorithm, using a mixed air temperature sensor (mounted where the sensor may measure the mixture of outside air and return air) and a mixed air temp setpoint.

The DAC opens and closes the damper incrementally to attempt to maintain the mixed air temp setpoint. The DAC will close the damper when the mixed air is below the setpoint to keep cooler air from entering, and open the damper when

the mixed air is above setpoint and requires cooler air from outside.

If the space temperature becomes too cold, or the DAC determines outside air conditions are not favorable for economization, the DAC will close the damper to a user-defined minimum damper position.

7.7.3.3 Economization Enabling Strategy

When communicating with the E2, the DAC only allows economization if it receives an economizer enable signal from the E2. It does not use other strategies to enable the economizer. However, in standalone mode, the DAC has multiple user selectable strategies available for determining whether outside air conditions are favorable for economization. Each method of economization checking has a failsafe in case one of the sensors required for the strategy becomes unavailable.

1. **Dewpoint Setpoint** – When selected, this method requires an outside temperature and humidity sensor to be connected to the controller. Using these sensors, an outside dewpoint value is calculated. When the outside dewpoint is less than the dewpoint setpoint, economization will be enabled. If the outside humidity sensor fails, the controller will revert to the Dry Bulb Compare method. If the outside temperature sensor fails, economization will be disabled.
2. **Enthalpy Comparison** – When selected, this method requires an inside and outside humidity sensor as well as an outside temperature sensor to be connected to the controller. Using these sensors, both inside and outside enthalpy values are calculated. When outside enthalpy is less than inside enthalpy, economization will be enabled. If the outside humidity sensor fails, the application will revert to the Dry Bulb Compare method. If an inside temperature or humidity sensor fails, the application will revert to using the Enthalpy Setpoint method. If the outside temperature sensor fails, economization will be disabled.
3. **Enthalpy Setpoint** – When selected, this method requires an outside humidity and temperature sensor to be connected to the controller. Using these sensors, an outside enthalpy is calculated. When the outside enthalpy is less than the enthalpy setpoint, economization will be enabled. If the outside humidity sensor fails, the application will revert to the Dry Bulb Compare method. If the outside temperature sensor fails, economization will be disabled.
4. **Dry Bulb Compare** – When selected, this method requires an outside temperature sensor to be connected to the controller. When the outside temperature is less than the inside temperature by at least 2°F, economization will be enabled. If the outside temperature sensor fails, economization will be disabled.

5. **E2 Zone Enable (BAS)** – This method is always used when the DAC is connected to the E2. The controller will read the value of the ECONOMIZATION output from the E2 zone and enable economization based on that value. The E2 zone must be programmed with its own method of economization checking (*refer to the E2 user manual 026-1610/1614 and on-line help for HVAC Zone application setup instructions*).

7.7.4 Smoke Detection

The DAC may be programmed with a Smoke Detector input, which accepts a dry-contact digital signal from a smoke alarm or a building control network. When the smoke detector contact closes to indicate smoke has been detected, the controller will enter the Emergency Shutdown mode and all of the DAC's heating/cooling and fans will be overridden OFF and the outside air damper will be closed.

7.7.5 Priority When Economization, CO2 Control, and Make-up Air are Used Together

When Economization, CO2 and Make-up Air control are used together in the same DAC, it will control a two-position damper using OR logic (OPEN if one or more strategies require it to be open, CLOSED if none do not require it to be open).

Variable-position dampers will be controlled based on which control calls for the highest percentage. In other words, if the damper needs to be set to 60% to satisfy CO2 fresh air requirements and 40% to satisfy the economization mixed air temperature setpoint, the damper will be opened to 60%.

7.7.6 Return Damper Control

An optional modulating return air damper may be connected to the DAC. When connected, the return air damper will modulate inversely proportional to the outside air damper. For example, if the outside air damper is at 10%, the return air damper will be at 90%. If the outside air damper goes to 100%, the return air damper will go to 0%.

During dehumidification, and if a return air bypass damper connected to the DAC, the return air damper may deviate from its standard calculated position to assist in the dehumidification process. See **Section 7.5.1.1, Variable-Speed Fan Control in CAV** for more details.

7.8 6.10 Reversing Valve Control

The DAC supports control of a heat or cool reversing valve. The type of reversing valve can be selected by the user. The valve may be connected to any relay output on a DAC designated as a reversing valve. If the valve is defined as a heating reversing valve, the relay will energize when heat is active, and will de-energize when cool is active. The valve will stay in its current position when the unit goes to idle mode. Likewise, if the valve is defined as a cooling reversing valve, the relay will energize only when cool is active, and will de-energize when heat is active.

7.9 Standalone Functionality

If for some reason a DAC board loses communications with its parent E2 unit for longer than two minutes, the board will go into Standalone mode.

In Standalone mode, the DAC will continue Temperature Control as normal using the space temperature and supply temperature as a control inputs. The DAC does not have an internal schedule and will therefore revert to occupied mode while operating standalone mode.

Dehumidification and Economization will occur during standalone mode only if the board is equipped with the right local sensors for the strategies selected.

Any control features that rely on communication with the E2 will not be available. This includes:

- Demand Shed
- Setpoint Reset
- Optimum Start/Stop
- Summer/Winter Setpoints
- Overrides Initiated by E2

7.10 Control Temperature Sensor Failures

In many cases, the DAC can compensate for sensor failures by substituting other sensor values. This allows the DAC to continue operating as close to normal as possible until the failed sensors can be fixed or replaced. However, it is important to note that if the supply temperature sensor fails, the unit will not be able to turn on any heating or cooling stages. This sensor must be repaired immediately.

Control Temp Failure

The preferred sensor to be used to control the space is user configured. By default, Space Temp 1 is the sensor used. However, Space Temp 2, the average of both Space Temps, Return Temp, calculated Apparent Temp or a Zone Temperature from the E2 can be selected as the primary control temperature.

If the preferred sensor fails, a backup sensor will be selected based on a user configured fallback sensor selection. If this sensor also fails, the DAC will use the following priority for selecting a control temperature:

- Space Temp 1
- Space Temp 2
- Return Temp
- Zone Temp (sent from E2)

If no valid control temperature is available, a failure alarm will be generated and sent to the E2 Alarm Advisory Log.

Outside Air Temp Failure

Failure of the outside air temperature sensor affects Economization only if the DAC is in standalone mode. In this case, the DAC will disable the economization strategy until the outside air temperature sensor is repaired.

Mixed Air Temperature Failure

If the DAC has a modulating outdoor air damper defined, it will use the mixed air temperature sensor as its control input for economization (free-cooling). If the mixed air temperature sensor fails, it will substitute the supply air temperature sensor as its control value and continue economization. If neither the mixed air temperature or supply air temperature sensors are available, economization will be locked OFF and the damper will be closed until the sensor failures can be addressed.

Inside Humidity Failure

The DAC will use the local indoor humidity sensor if it is defined. If no local indoor humidity sensor is defined, the DAC will use the indoor humidity value received from the E2. If no valid value is received from the E2, the dehumidification function will be disabled until a valid indoor humidity reading is detected. This applies only if the dehumidification strategy is configured to use inside humidity or inside dewpoint. Also, when in standalone mode, if no valid inside humidity is detected, the Enthalpy Compare economization strategy, if selected, will be disabled and the controller will revert to using the Enthalpy Setpoint method of economization.

Outside Humidity Failure

The DAC will use the local outdoor humidity sensor if it is defined. If no local outdoor humidity sensor is defined, the DAC will use the outdoor humidity value received from the E2. If no valid value is received from the E2, the dehumidification function will be disabled until a valid outdoor humidity reading is detected. This applies only if the dehumidification strategy is configured to use outdoor humidity or outdoor dewpoint. Also, when in standalone mode, if no valid outdoor humidity is detected, the economization method will revert to Dry Bulb Compare.

7.11 DAC Sensor Calibration Offsets in E2

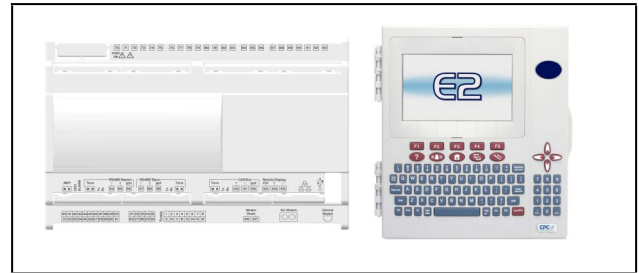




Figure 7-5 - DAC and E2

Sensor Calibration

To verify that sensor readings are accurate, calibration of sensors may be required. Sensor performance can be improved by limiting the differences between a sensor's expected output and its actual output. Once the sensor differential has been determined, enter the offset value into the appropriate offset parameter field to calibrate the sensor.

Steps

1. From the E2 Main Menu  select  - **Configured Applications** (Figure 7-6).
2. Select **iProDAC** from the list - the iProDAC Status screen will open (Figure 7-7).

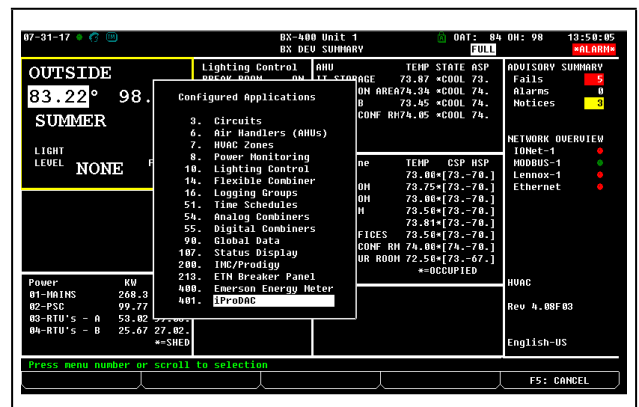


Figure 7-6 - E2 Configured Applications - Select iProDAC

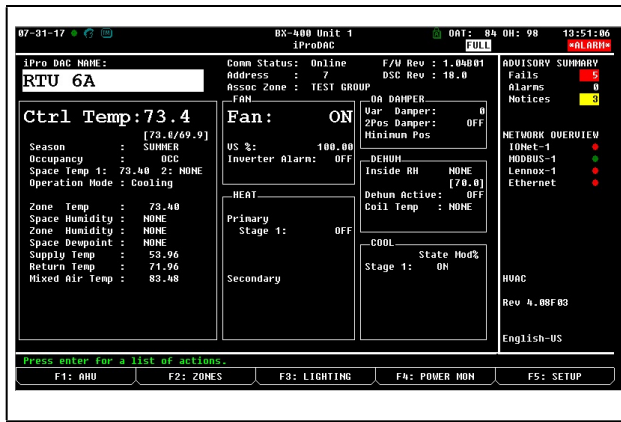


Figure 7-7 - iProDAC Status Screen - Press F5

- Press **F5** **SETUP** to access the iProDAC **Setup** screen (Figure 7-8).
- Press **Ctrl + 0** and select **F Sensor Offsets** or press **F2** to access the **C0: MORE** tab and scroll through the tabs to access the **Sensor Offsets** (Figure 7-9).

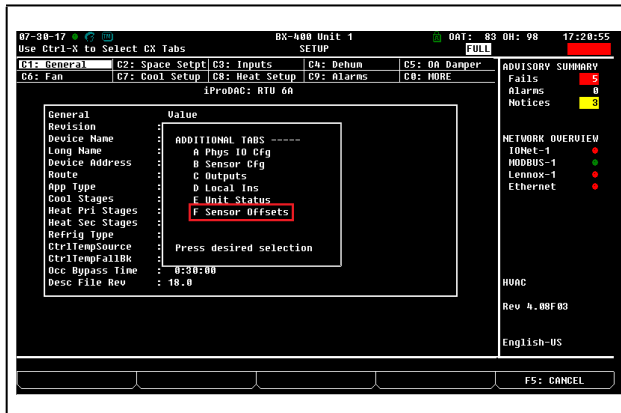


Figure 7-8 - iProDAC Setup Screen in E2 - Ctrl + 0 Tab Menu Sensor Offsets

- Enter the appropriate offset value (Figure 7-9).

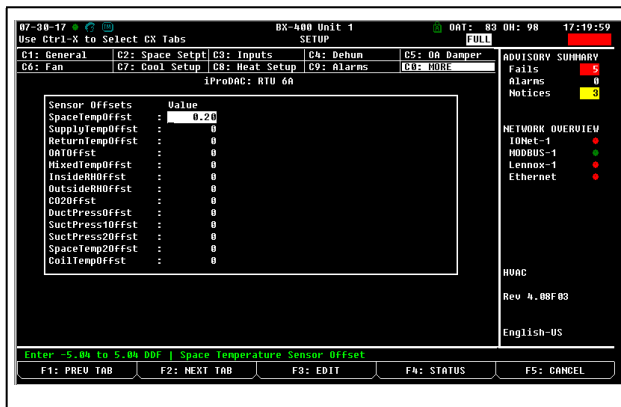


Figure 7-9 - Sensor Offset Properties in E2 - C0: MORE Tab

8 E2 Setup

The DAC is capable of communicating with an E2 version 3.0 or above.

Using DAC with a central E2 offers several benefits over simple standalone control, including:

- Reporting of DAC-related alarms in the Alarm Advisory Log.
- The ability to log DAC inputs in an E2 logging group.
- The ability to share outside air temperature values and control motor room temperature by sharing input values between the and the E2.
- Remote access to DAC status and programming from the E2 front panel.
- The ability to remotely access the DAC from UltraSite32 or Site Manager, and to back up, restore, and offline-program DAC configuration along with E2 site configuration.

Communication between E2 and an DAC takes place over the RS485 MODBUS. Follow the instructions in **Section 3, The MODBUS Network**, to connect an DAC to the E2 MODBUS network. Then, follow the instructions in this chapter to set up the DAC.

8.1 Network Connection to E2

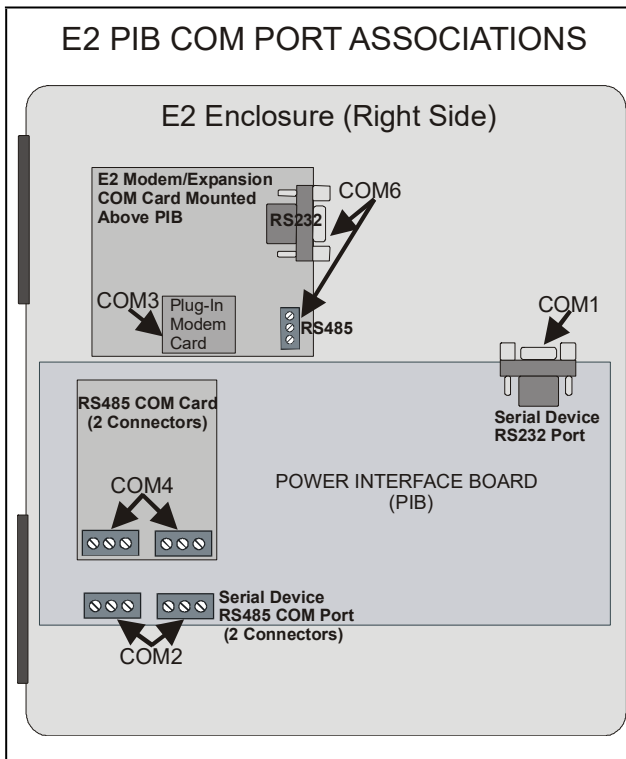


Figure 8-1 - Location of E2 COM Ports (E2 Versions 3.xx and Below)

Connecting a DAC to an E2 unit requires the E2 to be version 3.0 or above. Contact Copeland for upgrade information if the controller is a version prior to 3.0.

An E2 has up to three COM ports that can be assigned for MODBUS communication (COM2, an RS485 port on the E2 power interface board, and COM4 and COM6, which are optional ports requiring expansion cards). COM ports can only be used for one function; in other words, if COM2 is set up as the MODBUS, you cannot connect MODBUS devices to COM2. Ensure your E2 is equipped with an RS485 COM Card (P/N 637-4890) and configured in E2 General Services (Menu & 7 3 1, Serial tab) to enable COM4 or an E2 Expansion COM Card (P/N 637-4871) to enable COM6.

Connect the MODBUS network cable to the three-terminal connector on the COM port you wish to assign as MODBUS. Like other DAC connections, wire RS485+ to RS485+, RS485- to RS485-, and the shield cable to the middle terminal. If the E2 will be the first device in the daisy-chain, set the port's termination jumpers to the TERMINATED & BIASED position (all three jumpers UP); otherwise, set all jumpers DOWN if not the first device.

8.1.1 Setup Network Ports

Before setting up a DAC, the port on the E2 that has the MODBUS cable connected must be set up as a MODBUS port.

1. Log in to the E2 with Level 4 access.
2. Press **Menu** followed by **& 7 3 1** - **General Controller Info**.
3. Press **Ctrl + 3** to open the **Serial** tab of the **General Controller Info** setup screens:

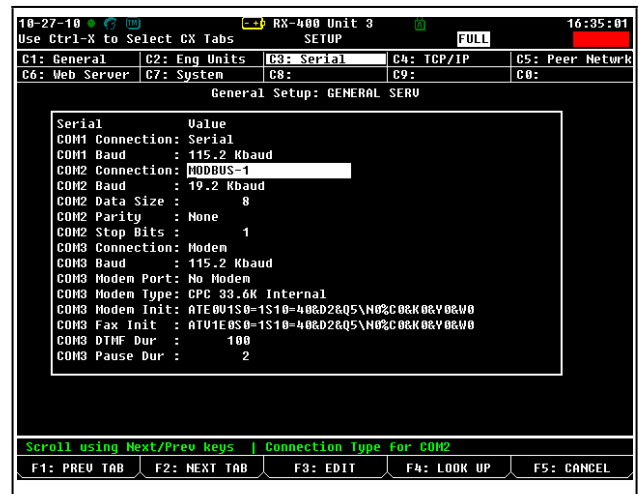


Figure 8-2 - Serial Communications Manager Screen

- This screen will have a **“Connection”** field for all COM ports on the E2. Highlight the COM port connection field that will be used for DAC, and press **F4** - **LOOK UP**. From the list of network types, select **MODBUS**.
- Four fields will become visible underneath the **COM port connection** field, which pertain to the way the device communicates:
 - Baud** - Default setting is **19.2k**. *This must be changed to 9600*. (All devices connected to the same COM port should be set to the same baud rate.)
 - Data Size** - Leave this field at the default value (**8**).
 - Parity** - Leave this field at the default value (**None**).
 - Stop Bits** - Leave this field at the default value (**1**).
- Press to save changes and exit.

8.2 Add and Connect DACs

To enable communications between E2 and the DAC units, the devices must be added and addressed in E2.

- Log in to the E2 with Level 4 access.
- Press **&7 &7 @2** - **Connected I/O Boards and Controllers**.

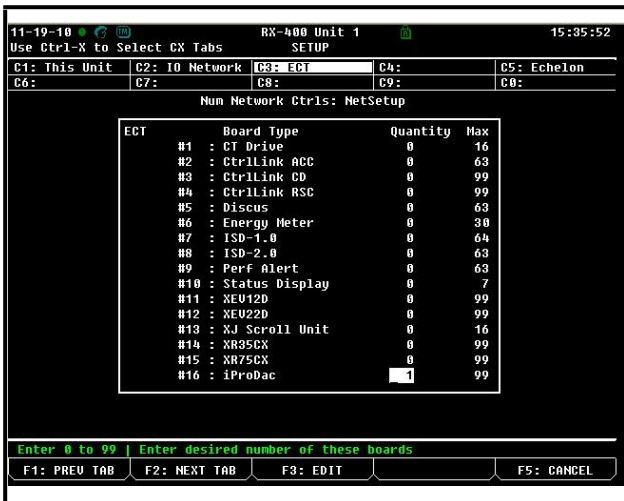


Figure 8-3 - Connected I/O Screen

- In the **Connected I/O** screen, under the **ECT** tab, Enter the number of DAC devices in the **iProDac** number field.
- Press to return to the **Network Setup** menu, then select **1** - **Network Summary**.
- After choosing the MODBUS network (if applicable), press Enter and a screen will open that allows you set the

- Locate the DAC units you added to the network list (press and to scroll through the list). The default name for a DAC increments up starting with **iProDAC001**.

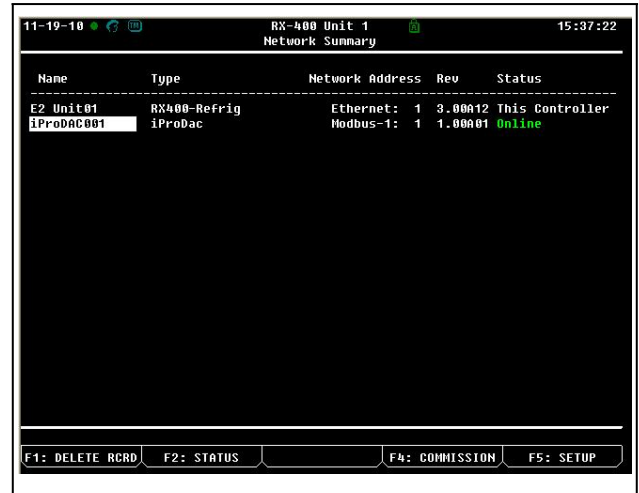


Figure 8-4 - Network Summary Screen

- By default, each DAC’s board number in the network list is indicated by a - **(dash)**. To set the address and begin communication, press **F4** to **Commission**. (If you have more than one MODBUS network, specify which network you want the device to belong to.)

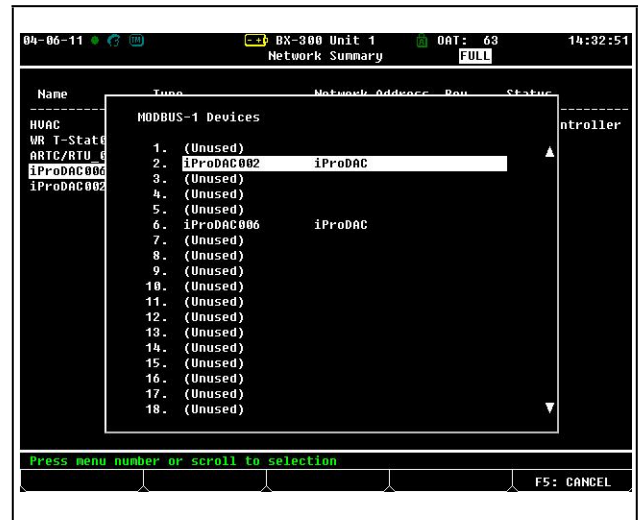


Figure 8-5 - Specify MODBUS Address

address:.



Figure 8-6 - Set the Address of the DAC

DAC with a new controller that has the latest version of firmware on it.



Figure 8-7 - Network Summary Screen

- When finished, press to return to the **Network Setup** menu, then press - **Network Summary**. Locate the DACs that you set up, and look at each device's status in the **Status** field. You will see one of the following messages:
 - Online** - The DAC is communicating normally.
 - Offline** - The DAC is not communicating, has not been commissioned, is not functional, or is not powered up. Verify the DAC is powered up, wired correctly, and has the proper network address, baud rate, and parity.
 - Unknown** - The DAC is not communicating or has not been commissioned. Verify if the DAC is powered up, wired correctly, and has the proper network address, baud rate, and parity.
 - No Port** - No port is set up in the E2 Serial Configuration Manager to be a MODBUS port.
 - Wrong FW Rev** - This message is likely caused by the DAC having a firmware version older than the minimum revision required by E2 for communication. Replace the

8.3 Viewing the DAC Status Screen

Once you have added an DAC to the E2, you will be able to see the status of the DAC board(s) from the front panel.

- From the **Main Status Screen**, press key and select - **Configured Applications**.
- Select **DAC** from the menu. If multiple DACs are associated with this E2, the DAC Summary Screen will be shown. To see a single DAC status screen, use the arrow keys to highlight the DAC you wish to view, and press .

9 Connections

9.1 The DAC Connector Descriptions

Table 9-1 - Descriptions of the Connections

Connector	Function
	Connector for 24VAC/DC power supply analog inputs (Pb1 - Pb10, PbC) Additional power (+5VDC, +12VDC, GND)
	Opto-insulated analog outputs (Out1 - Out6, GND) 24VAC/DC power supply for the opto-insulated analog output
	Volt-free opto-insulated digital inputs (DI1 - DI20, IDC)
	USB port for downloads (BIOS, ISaGRAF® application, maps of parameters, remote display applications, network configuration, website) and uploads (log files)
	TCP/IP Ethernet port
	Connector for remote terminal (VISOGRAPH), maximum 2 terminals per DAC.
	CANBUS connector for expansions (IPEXx0D) and drivers for electronic valves (XEVx0D) Rx and Tx LED to indicate that communication is active Closed circuit terminal (Term)
	RS485 Slave connector Rx and Tx LED to indicate that communication is active Closed circuit terminal (Term)
	RS485 Master connector Rx and Tx LED to indicate that communication is active Closed circuit terminal (Term)
	Digital relay outputs (for digital outputs with volt-free contacts) 3 NO relays, 1 common
	Digital relay outputs (for digital outputs with live contacts) 3 NO relays, 1 common and 2 volt-free (Neutral)
	Digital relay outputs (for digital outputs with volt-free contacts) 5 NO relays, 1 common
	Digital relay outputs (for digital outputs with live contacts) 5 NO relays, 1 common and 2 volt-free (Neutral)
	Digital relay outputs 2 NO relays, 1 common
	Digital relay outputs (only for 215D versions) 5 NO relays, 1 common and 1 volt-free (Neutral)

9.2 Terminal Number Descriptions

Table 9-2 - Terminal Number Descriptions

Terminal No.	Type of Input	Description
1	Supply	Power 24VAC or 24VDC(-)
2	Pb1	Analog Input 1 (Temperature, 0-10V, 0-1V, 0-5V)
3	Pb2	Analog Input 2 (Temperature, 0-10V, 0-1V, 0-5V)
4	Pb3	Analog Input 3 (Temperature, 0-10V, 0-1V, 0-5V)
5	Pb4	Analog Input 4 (Temperature, 0-10V, 0-1V, 0-5V)
6	Pb5	Analog Input 5 (Temperature, 0-10V, 0-1V, 0-5V)
7	PbC	Common for temperature inputs (<i>DO NOT TIE TO GROUND</i>)
8	GND(-)	Additional power reference 5VDC and 12VDC and analog inputs (0 -10V, 0 -1V, 0 -5V)
9	Supply	Power 24VAC or 24VDC(+)
10	Pb6	Analog Input 6 (Temperature, 0-10V, 0-1V, 0-5V)
11	Pb7	Analog Input 7 (Temperature, 0-10V, 0-1V, 0-5V)
12	Pb8	Analog Input 8 (Temperature, 0-10V, 0-1V, 0-5V)
13	Pb9	Analog Input 9 (Temperature, 0-10V, 0-1V, 0-5V)
14	Pb10	Analog Input 10 (Temperature, 0-10V, 0-1V, 0-5V)
15	+5V	Additional power +5VDC
16	+12V	Additional power +12VDC
21	Out1	Opto-insulated analog output 1, 0-10V
22	Out2	Opto-insulated analog output 2, 0-10V
23	Out3	Opto-insulated analog output 3, 0-10V
24	Out4	Opto-insulated analog output 4, 0-10V
25	GND(-)	Common opto-insulated analog output
26	Out5	analog output 5, 0-10V
27	Out6	analog output 6, 0-10V
28	Supply	Power for opto-insulated analog outputs at 24VAC or 24VDC(-)
29	Supply	Power for opto-insulated analog outputs at 24VAC or 24VDC(+)
30	GND(-)	Common opto-insulated analog output
40	DI1	Opto-insulated digital input 1
41	DI2	Opto-insulated digital input 2
42	DI3	Opto-insulated digital input 3
43	DI4	Opto-insulated digital input 4

Table 9-2 - Terminal Number Descriptions

Terminal No.	Type of Input	Description
44	DI5	Opto-insulated digital input 5
45	DI6	Opto-insulated digital input 6
46	DI7	Opto-insulated digital input 7
47	DI8	Opto-insulated digital input 8
48	DI9	Opto-insulated digital input 9
49	DI10	Opto-insulated digital input 10
50	GND(-)	Common opto-insulated digital inputs 1 to 20 (inputs 24VAC or 24VDC) <i>(unsupported)</i>
51	DI11	Opto-insulated digital input 11 <i>(unsupported)</i>
52	DI12	Opto-insulated digital input 12 <i>(unsupported)</i>
53	DI13	Opto-insulated digital input 13 <i>(unsupported)</i>
54	DI14	Opto-insulated digital input 14 <i>(unsupported)</i>
55	DI15	Opto-insulated digital input 15 <i>(unsupported)</i>
56	DI16	Opto-insulated digital input 16 <i>(unsupported)</i>
57	DI17	Opto-insulated digital input 17 <i>(unsupported)</i>
58	DI18	Opto-insulated digital input 18 <i>(unsupported)</i>
59	DI19	Opto-insulated digital input 19 <i>(unsupported)</i>
60	DI20	Opto-insulated digital input 20 <i>(unsupported)</i>
61	IDC	Common opto-insulated digital inputs 1 to 20 (volt-free, dry contact)
70	RL1	Relay 1 normally open contact
71	C	Common relays 1, 2, and 3
72	RL2	Relay 2 normally open contact
73	RL3	Relay 3 normally open contact
74	C	Not Used
75	C	Not Used
76	RL4	Relay 4 normally open contact
77	RL5	Relay 5 normally closed contact
78	RL6	Relay 6 normally closed contact
79	RL7	Relay 7 normally closed contact
80	C	Common relays 4, 5, 6, 7, and 8
81	RL8	Relay 8 normally closed contact
82	C	Not Used

Table 9-2 - Terminal Number Descriptions

Terminal No.	Type of Input	Description
83	C	Not Used
84	RL9	Relay 9 normally closed contact
85	RL10	Relay 10 normally closed contact
86	C	Common relays 9 and 10
87	RL11	Relay 11 normally closed contact
88	RL12	Relay 12 normally closed contact
89	RL13	Relay 13 normally closed contact
90	C	Common relays 11, 12, 13, 14, and 15
91	RL14	Relay 14 normally closed contact
92	RL15	Relay 15 normally closed contact
93	C	Not Used
94	RS485 Master	RS485 Master connection (-)
95	RS485 Master	RS485 Master connection (+)
96	RS485 Master	RS485 Master connection (insulated gnd)
97	RS485 Slave	RS485 Slave connection (-)
98	RS485 Slave	RS485 Slave connection (+)
99	RS485 Slave	RS485 Slave connection (insulated gnd)
100	CAN Bus	CAN Bus connection (+), not open
101	CAN Bus	CAN Bus connection (-), not open
102	CAN Bus	CAN Bus connection (insulated gnd), not open
103	Remote Display	Connection for VISOGRAPH remote terminal (Vnr)
104	Remote Display	Connection for VISOGRAPH remote terminal (+)
105	Remote Display	Connection for VISOGRAPH remote terminal (-)
106	Modem Reset	Not Used
107	Modem Reset	Not Used

9.3 Technical Specifications

9.3.1 Analog Inputs

Table 9-3 - Analog Input Specifications

Analog conversion type:	10-bit A/D converter
Number of inputs:	10
Type of analog input: (configurable via software parameter)	NTC Dixell (-50T110°C; 10K Ω ±1% at 25°C) PTC Dixell (-55T115°C; 990 Ω ±1% at 25°C) Digital input (voltage-free contact) Voltage: 0 - V, 0 - 5V, 0 - 10V (input resistance 3.7K Ω) Current: 0 - 20mA, 4 - 20mA (input resistance 100 Ω)
Digital input status variation detection time:	250ms
Accuracy:	NTC, PTC: ±1% 0-1V: ±20mV 0-5V: ±100mV 0-10V: ±200mV 2-20mA, 4-20mA: ±0.30mA
Additional power:	+12V: 200mA in total +5V: 100mA

CAUTION

Any inputs that are powered with a voltage that differs from that supplied by the device (+12V or +5V) must be powered separately with another transformer (do not use the same secondary of the controller's power) in order to prevent the inputs from malfunctioning or being damaged.

9.3.2 Digital Inputs

Table 9-4 - Digital Input Specifications

Type: (configurable via software parameter)	Opto-insulated voltage-free External power 24VAC/DC ±20%
Number of inputs:	20
Digital input status variation detection time:	250ms

CAUTION

If the digital inputs are used with voltage, use another transformer (do not use the same secondary of the controller's power) in order to prevent the inputs from malfunctioning or being damaged.

9.3.3 Analog Outputs

Table 9-5 - Analog Outputs Specification

Type:	Opto-insulated with separate 24VAC/DC power supply
Number of outputs:	10
Type of analog output: (configurable via software parameter)	4 fixed outputs 0-10VDC (Out1 - Out4) 2 configurable outputs 0-10VDC, 4-20mA (Out5 and Out6)
Maximum load:	40mA (Out1 - Out4) 20mA (Out5 and Out6) max with configured outputs 0-10VDC 400Ω max with configured outputs 4-20Ma 22Ω per live analog output
Accuracy:	Out1 - Out4: ±2% full scale Out5 - Out6: ±2% full scale
Resolution:	8bit

CAUTION

The electrical devices controlled by these analog outputs must be powered separately with another transformer (do not use the same secondary of the controller's power) in order to prevent the outputs from malfunctioning or being damaged.

9.3.4 Digital Outputs

Table 9-6 - Digital Outputs Specifications

Type:	Relays with NO contacts
Number of outputs:	10 or 15, depending on the model
Type of output: (configurable via software parameter)	Relays with normally open contact
Maximum load:	5A(250VAC) SPST 5(2)A

CAUTION

Verify the capacity of the output used. There is double insulation between the digital outputs and the low voltage of the rest of the circuit. Do not use different voltages for the various groups of relays nor within each group.

9.4 Wiring

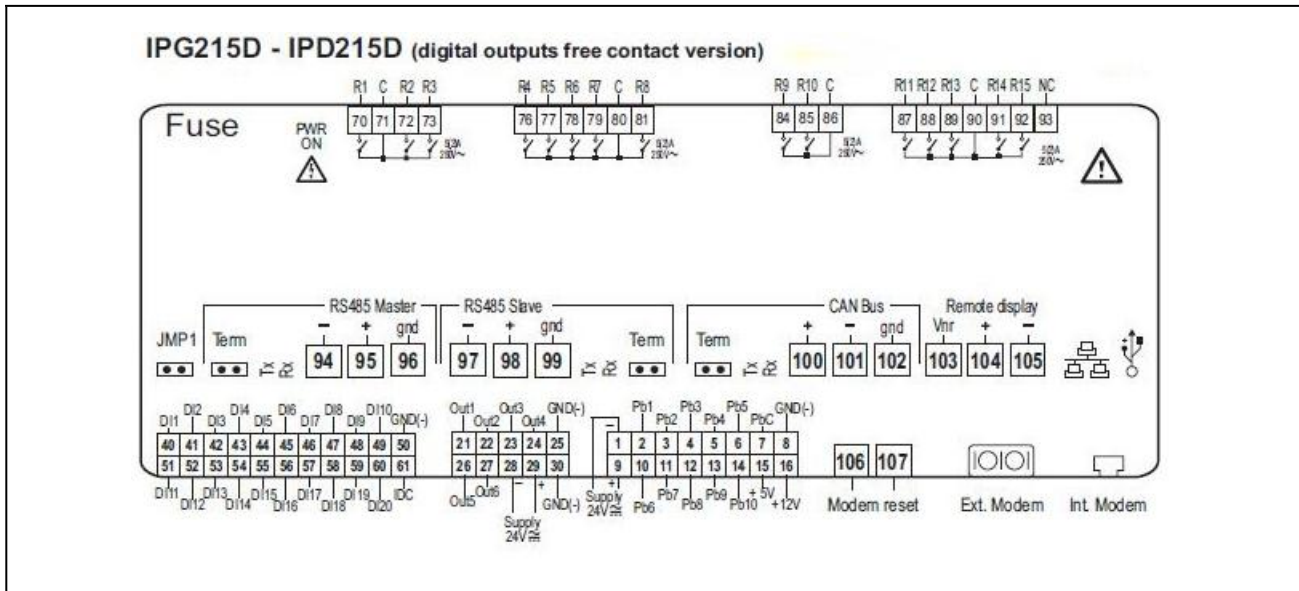


Figure 9-1 - DAC Detail

NOTE

DI11 through DI20 (pins 51-60) are not available for use in the DAC controller.

10 Using the Visograph

10.1 Viewing Status

For visograph button functionality, see **Section 3.1.2.2, Visograph Navigation** section.

10.1.1 Input Status

1. From the main menu, select **1** to navigate to the status screens
2. The status of the most common DAC inputs are shown on this screen
3. All temperature units are in °F. Suction pressures are shown in PSI.

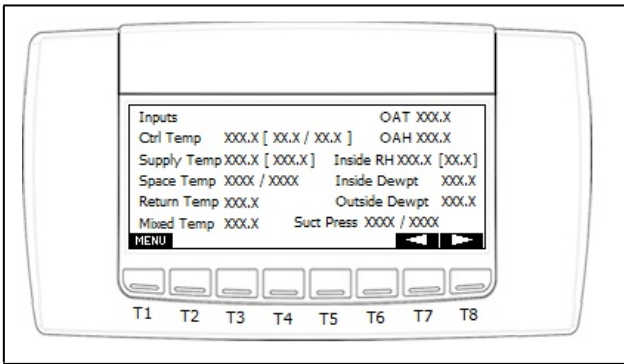


Figure 10-1 - Status - Inputs

10.1.2 Output Status

Press the **RIGHT** arrow to navigate to the output status screen. The status of the most common DAC outputs are shown on this screen:

- Operation mode of controller
- Heating/Cooling stages
- Fan/Outdoor Damper

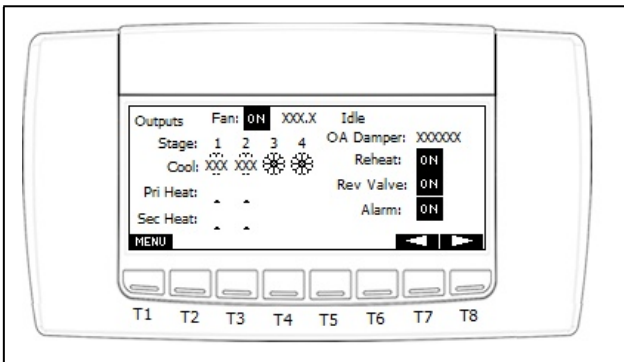


Figure 10-2 - Status - Outputs

10.1.3 VAV Fan Status

When the application is set to **VAV**, this screen will allow you to monitor the duct static pressure as controlled by the fan or relief damper.

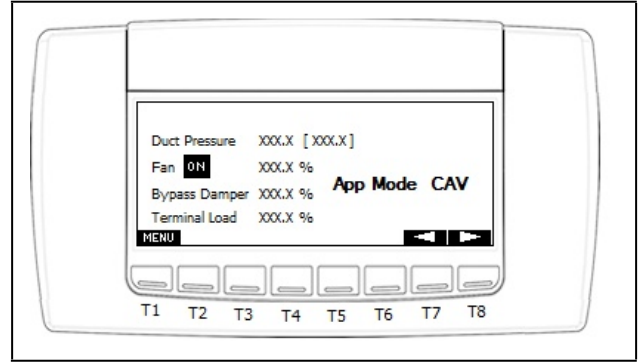


Figure 10-3 - Status - VAV Fan

10.2 Viewing I/O Configuration

10.2.1 Analog Inputs

From the main menu, select **3** to navigate to the **I/O Config** screens. The current configurations of the local analog inputs are shown on this screen.

These values may be edited using the visograph; however, if the DAC is communicating with E2, the E2 will override any changes made.

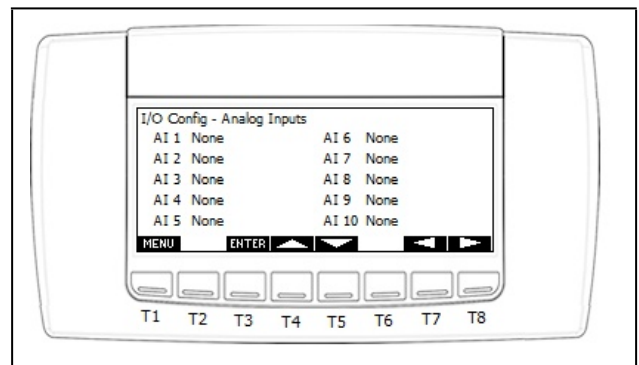


Figure 10-4 - I/O Config - Analog Inputs

10.2.2 Relay Outputs

1. Press the **RIGHT** arrow to navigate to the relay outputs configuration screen.

The current configuration of local relay outputs 1-10 are shown on this screen.

2. Press the **RIGHT** arrow to navigate to the next screen showing outputs **11-15**.

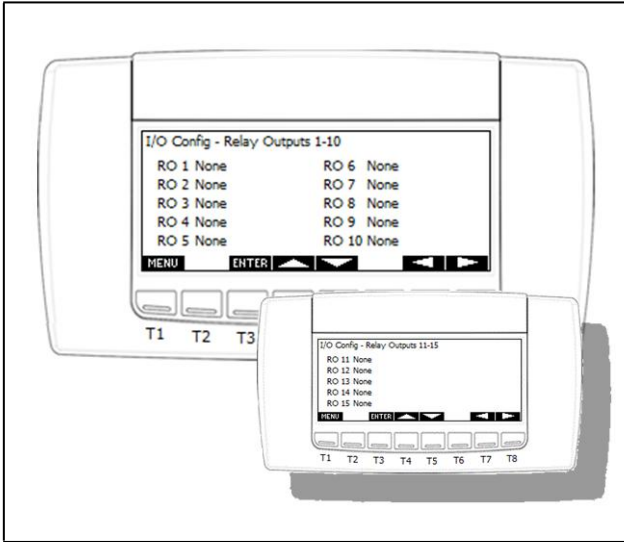


Figure 10-5 - I/O Config - Relay Outputs 1-10 and 11-15

10.2.3 Analog Outputs

Press the **RIGHT** arrow to navigate to the analog outputs configuration screen. The current configuration of all local analog outputs are shown on this screen:

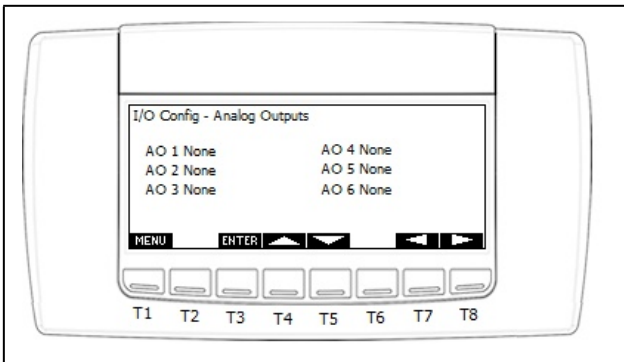


Figure 10-6 - I/O Config - Analog Outputs

10.2.4 Digital Inputs

Press the **RIGHT** arrow to navigate to the digital inputs configuration screen. The configuration of all supported digital inputs are shown on this screen.

All digital inputs are fixed in position and cannot be edited.

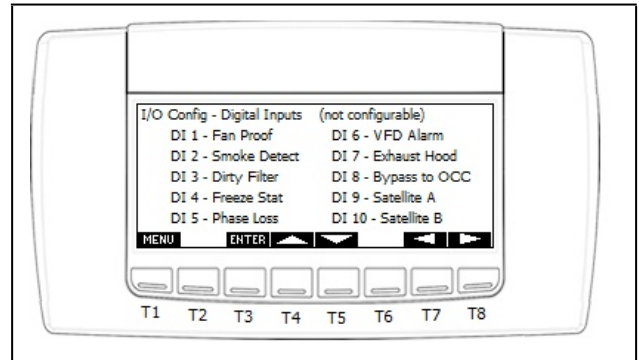


Figure 10-7 - I/O Config - Digital Inputs

10.3 Relay Output Overrides with Visagraph

1. Press **6** on the main menu to navigate to the output override screens

The first override page shows all of the relay outputs. To override a relay:

2. Use the **UP** and **DOWN** arrows to navigate to the desired relay output.
3. Press the **ENTER** key. The field will start blinking.
4. Use the **UP** and **DOWN** arrows (**T4** and **T5**), to change the override state to the desired value. The choices are **Auto**, **ON**, and **OFF**.
5. Press **ENTER** to activate the new override state.
6. Press **MENU** to go back to main menu screen.

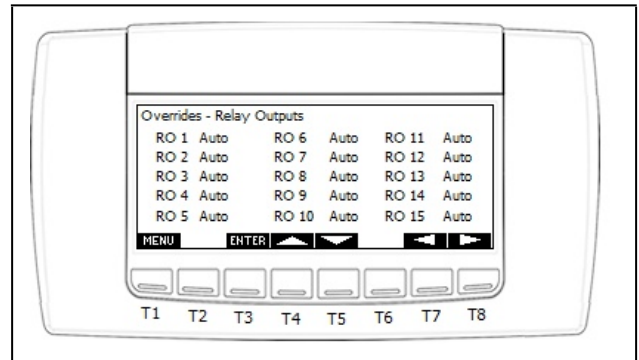


Figure 10-8 - Overrides - Relay Outputs

NOTE

Relay output overrides initiated with the visograph will automatically time out after one hour. The E2 interface may be used to activate fixed or timed overrides. The fixed overrides from E2 will not time out after one hour. The DAC will cancel any active E2 initiated overrides if it loses communication with the E2. To navigate to the Analog Output override screen on the next page, press the RIGHT arrow (T8).

10.3.1 Analog Output Overrides with Visograph

From the main menu, press 6 to navigate to the output override screens. Then press the **RIGHT** arrow (next page) to move to the analog output override screen:

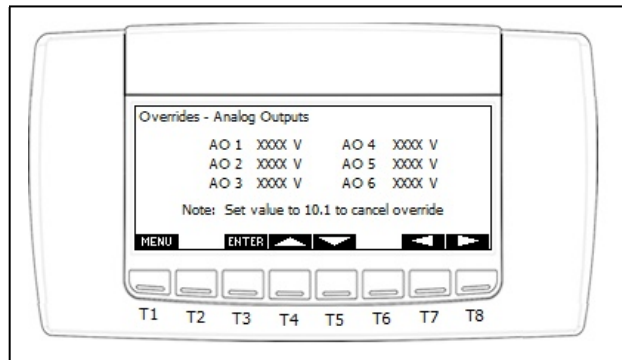


Figure 10-9 - Overrides - Analog Outputs

10.3.1.1 To Override an Analog Output

1. Use the **UP** and **DOWN** arrows to navigate to the desired analog output.
2. Press the **ENTER** key. The field will start blinking.
3. Use the **UP** and **DOWN** arrows (T4 and T5), to change the override to the desired voltage. The choices are **Auto**, **ON**, and **OFF**.
4. Press **ENTER** to activate the new override state.
5. Press **MENU** to go back to main menu screen.

10.3.1.2 To Clear an Analog Output Override

Change the override value back to **10.1 V**

The value 10.1 signifies that the output is not overridden but is under normal control of the application.

NOTE

Analog output overrides initiated with the visograph will automatically time out after one hour. The E2 interface may be used to activate fixed or timed overrides. The fixed overrides from E2 will not time out after one hour. The DAC will cancel any active E2 initiated overrides if it loses communication with the E2.

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