SIEMENS

BACnet Programmable TEC

VAV Chilled Beam with Demand Control Ventilation (CO2) and Floating or Analog Output - Application 6658

Application Note

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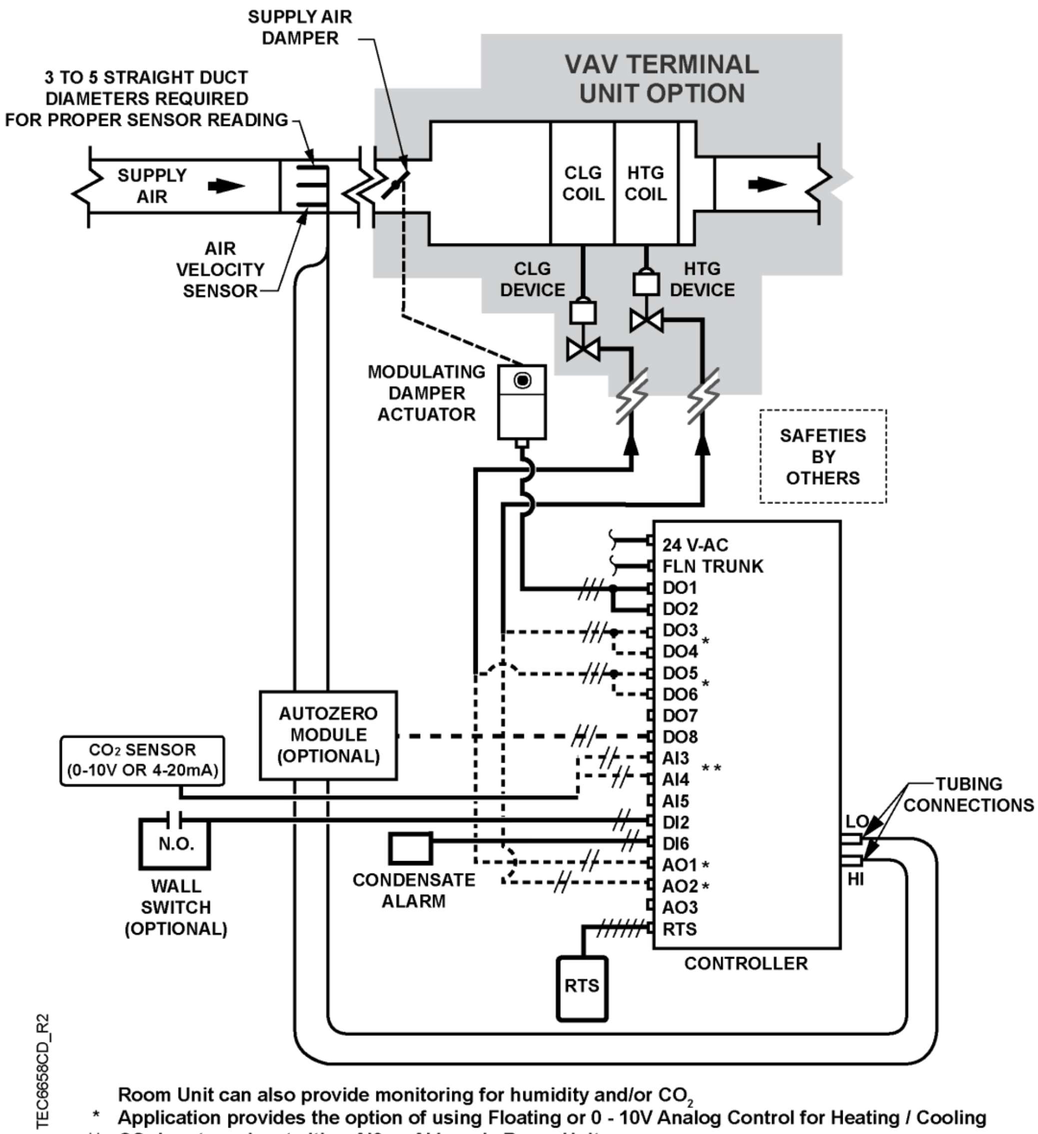
Overview

Application 6658 is a VAV controller used for temperature and ventilation control. This application is suitable for conventional VAV as well as chilled beam applications. In the cooling mode, the airflow and a chilled water valve can be modulated in series, in parallel or overlapped. If the VAV box airflow is to be modulated in heating mode, the airflow and the heating valve can be modulated in series, in parallel or overlapped. The heating coil and cooling coil valves can each be independently configured to be either floating control or analog control. This application also includes a Demand Control Ventilation (DCV) sequence that monitors CO2 levels within the space. If additional ventilation is required based on CO2 levels, the airflow setpoint for temperature control is temporarily overridden and is instead controlled to assure adequate ventilation. While in the ventilation mode, the temperature control is maintained via the heating and cooling coils.

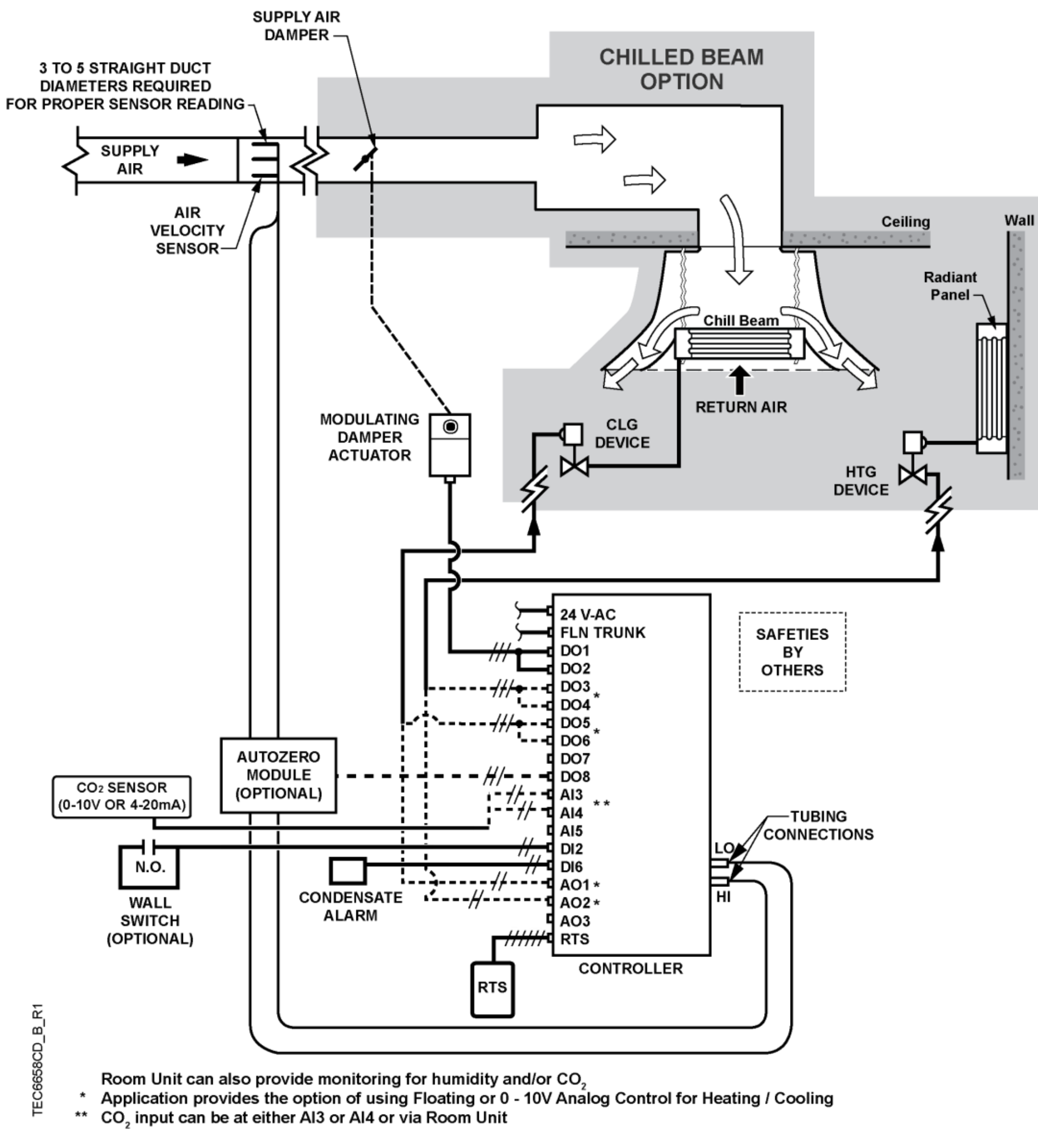


Room Unit can also provide monitoring for humidity and/or CO_2

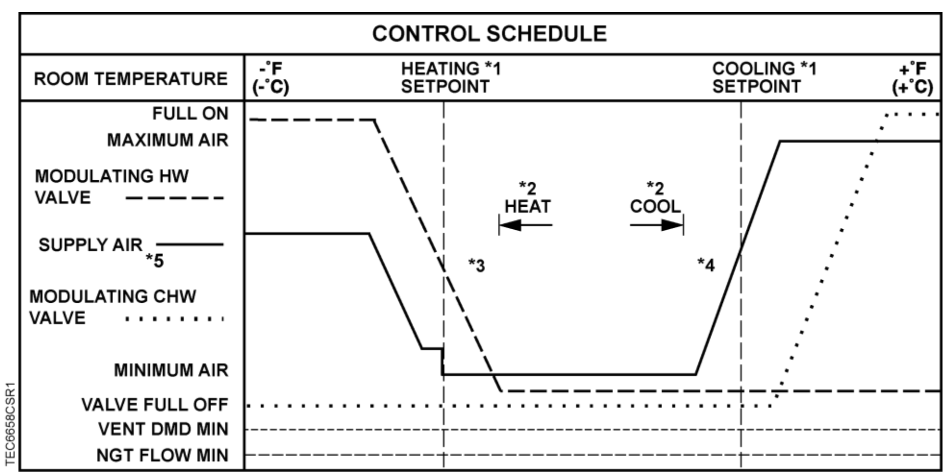
* Application provides the option of using Floating or 0 - 10V Analog Control for Heating / Cooling

** CO_2 input can be at either AI3 or AI4 or via Room Unit

Control Diagram – VAV with Demand Control Ventilation.



Control Diagram – Chilled Beam with Demand Control Ventilation.



Control Schedule.

NOTES:
1. See *Sequence of operation, Control Temperature Setpoints*.
2. See *Sequence of operation, Heating/Cooling Switchover*.
3. The airflow for temperature control operates in parallel with the hot water valve (default). However, since the default value for HTG FLOW MAX = HTG FLOW MIN, the airflow would be a constant minimum flow throughout the entire heating mode. The airflow can operate sequenced, parallel or overlapping with the hot water valve. See *Sequencing Logic (Optional)*.
4. *(Optional)* The airflow for temperature control is shown sequenced with the chilled water valve (default). The airflow can operate sequenced, parallel or overlapping with the chilled water valve. See *Sequencing Logic*.
5. The supply air as shown is for the temperature control. When the application is in the Demand Control Ventilation mode, the damper may modulate more open than is shown in the diagram. As the increased ventilation affects room temperature, the hot water and chilled water valves will adjust accordingly to maintain temperature setpoint.
6. VENT DMD MIN can be set above, below (or equal to) MINIMUM AIR FLOW (CLG and/or HTG minimum flow setpoint) and can be controlled (reset) externally for ventilation demands. Minimum airflow would be the larger of the temperature minimum airflow setpoint and the ventilation demand flow setpoint (from VENT FLOW MIN to VENT FLOW MAX).
7. NGT FLOW MIN can be set equal to, below cooling minimum flow setpoint or at zero to be used as the minimum flow during night modes.

BACnet

The controller communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.

Product	Supported BIBBs	BIBB Name
BTEC/PTEC	DS-RP-B B	Data Sharing-Read Property-B
	DS-RPM-B	Data Sharing-Read Property Multiple-B
	DS-WP-B	Data Sharing-Write Property-B
	DM-DDB-B	Device Management-Dynamic Device Binding-B
	DM-DOB-B	Device Management-Dynamic Object Binding-B
	DM-DCC-B	Device Management-Device Communication Control-B
	DM-RD-B	Device Management-Reinitialize Device-B
	DM-BR-B	Device Management-Backup and Restore-B
	DM-OCD-B	Device Management-Object Creation and Deletion-B

Hardware Inputs

Analog

- Airflow sensor
- Room temperature sensor with optional CO2 and Humidity sensing
- Room temperature setpoint dial (optional)
- Auxiliary temperature sensor (optional)
- Two 0-10V/4-20 mA switch selectable inputs (AI 3/AI 4). Either is configurable for use with a CO2 sensor for ventilation control. If one input is assigned as a CO2 input, there other input is spare. If neither is assigned as a CO2 input both are spare (alternately, the room module with CO2 sensor can be configured for this input).

Digital

- Condensate alarm (DI 6) dry contact
- Wall switch (optional)

Hardware Outputs

NOTE:
If AOs are used for modulating valves, the associated DOs are spare but unavailable for motor control of an actuator. If DOs are used for floating control, the associated AOs are spare.
For example, Motor 2 (DO 3 and DO 4) is configured to be used for floating control of a Heating Valve actuator, and AOV 1 to be used for modulating control of a Cooling Valve. In this case, DO 5 and DO 6, and AOV 2 are all spare.

Analog

- AOV 1 - analog cooling. (Spare if DO 5, DO 6 are used for floating control of chilled water valve)
- AOV 2 - analog heating. (Spare if DO 3, DO 4 are used for floating control of hot water valve)
- AOV 3 - spare

OR

- Up to three spare 0 to 10V AOVs if floating point control is used for heating and cooling

Digital

- DO 1, DO 2 damper actuator
- DO 3, DO 4 hot water valve (spare if AO 2 is used for hot water valve)
- DO 5, DO 6 chilled water valve (Spare if AO 1 is used for chilled water valve)
- DO 7 spare
- DO 8 Autozero (optional)

Ordering Notes

550-494P	Siemens BACnet PTEC VAV with Chilled Beam, Demand Control Ventilation (CO2) and Floating or Analog Output Controller

Sequence of Operation

The following paragraphs present the sequence of operation for Siemens BACnet PTEC VAV with Chilled Beam, Demand Control Ventilation (CO2) and Floating or Analog Output ControllerApplication 6658.

Control Temperature Setpoints

This application has a number of different room temperature setpoints (DAY HTG STPT, NGT CLG STPT, RM STPT DIAL, etc.). The application actually controls to CTL STPT. CTL STPT is set to different values depending on its override status, the time of day, whether or not a temperature deadband (zero energy band) has been configured, and the type of RTS used.

CTL STPT is Overridden:

If CTL STPT is overridden, that value is used regardless of any other settings. This disables the setpoint deadband feature.

CTL STPT in Night Mode:

The controller is in Night Mode if DAY.NGT = NGT and NGT OVRD = NGT.

When the controller is in night mode, CTL STPT holds the value of NGT CLG STPT or NGT HTG STPT depending on the value of HEAT.COOL. When the controller is in night mode the value of RM STPT DIAL is ignored.

CTL STPT in Day Mode:

The controller is in Day Mode if DAY.NGT = DAY or NGT OVRD = DAY.

Without setpoint dial:

When the controller is in day mode and STPT DIAL = NO, CTL STPT holds the value of DAY CLG STPT or DAY HTG STPT depending on the value of HEAT.COOL.

With setpoint dial:

When the controller is in day mode and STPT DIAL = YES. CTL STPT is set based on the value of the setpoint dial and the setpoint deadband. The setpoint deadband exists to allow the controller to provide a separation of the heating and cooling temperature setpoints when a setpoint dial is enabled. The setpoint deadband is the difference between the cooling and heating day setpoints (DAY CLG STPT - DAY HTG STPT). The setpoint deadband can be disabled by setting DAY HTG STPT equal to DAY CLG STPT. When DAY HTG STPT does not equal DAY CLG STPT, a setpoint deadband (or zero energy band) is used.

The following values are used in the calculation of CTL STPT:

- *Dial value* is the value of RM STPT DIAL limited between the value of RM STPT MIN and RM STPT MAX.
- *Deadband* is the value of the difference between DAY CLG STPT and DAY HTG STPT, half of which is applied to establish the current heating and cooling setpoints.
  - *Deadband* = (DAY CLG STPT – DAY HTG STPT)

CTL STPT is calculated as follows:

With Deadband Disabled:

CTL STPT = *Dial value*

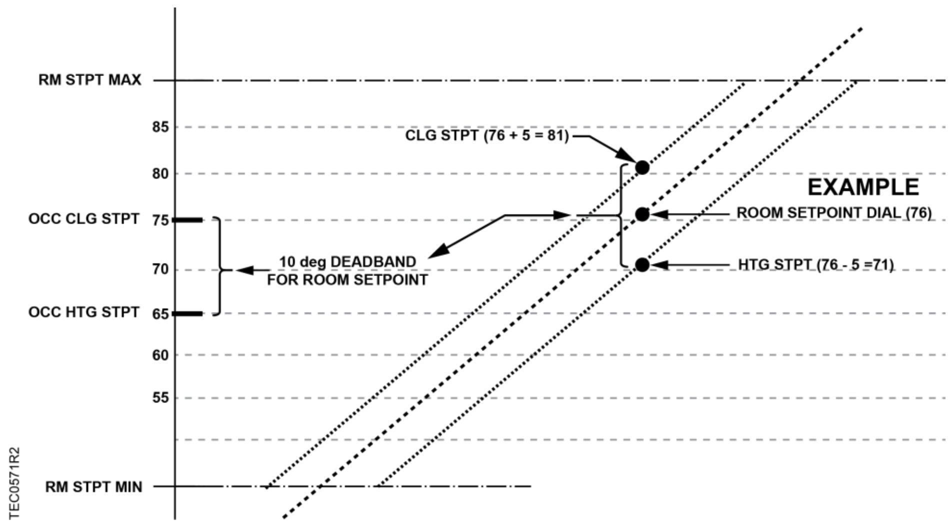
With Deadband enabled in Heat Mode:

CTL STPT = *Dial value* – 0.5 * *Deadband* (limited between the value of RM STPT MIN and RM STPT MAX)

With Deadband enabled in Cool Mode:

CTL STPT = *Dial value* + 0.5 * *Deadband* (limited between the value of RM STPT MIN and RM STPT MAX).

NOTE:
If RM STPT DIAL is failed, it maintains the last known value.



Room Temperature, Room Temperature Offset and CTL TEMP

ROOM TEMP is the temperature that is being sensed by the room temperature sensor (the RTS).

RMTMP OFFSET (or TEMP OFFSET) is a user-adjustable offset that will compensate for deviations between the value of ROOM TEMP and the actual room temperature.

CTL TEMP is the room temperature that is used for control purposes. In other words, what the application is trying to do is to maintain CTL TEMP at CTL STPT.

When CTL TEMP is not overridden, CTL TEMP and ROOM TEMP are related by the following equation:

CTL TEMP = ROOM TEMP + RMTMP OFFSET (or TEMP OFFSET)

If CTL TEMP is not overridden, then:

- The current value of ROOM TEMP (normal or overridden) will be used to determine the value of CTL TEMP.
- If ROOM TEMP has a status of Failed the last known good value of ROOM TEMP will be used to determine the value of CTL TEMP.

If CTL TEMP is overridden then:

- CTL TEMP equals its overridden value and the points ROOM TEMP and TEMP (RMTMP) OFFSET have no effect on the value of CTL TEMP.

Day and Night Modes

The day/night status of the space is determined by the status of DAY.NGT. The control of this point differs depending on whether the controller is monitoring the status of a wall switch or if the controller is connected to a field panel.

When a wall switch is physically connected to the termination strip on the controller at DI 2 (see the *Control Diagram* in Overview), and WALL SWITCH = YES, the controller monitors the status of DI 2 . When the status of DI 2 is ON (the switch is closed), then DAY.NGT will be set to DAY indicating that the controller is in day mode. When the status is OFF (the switch is open), then DAY.NGT will be set to NIGHT indicating that the controller is in night mode.

When WALL SWITCH = NO, the controller does not monitor the status of the wall switch, even if one is connected to it. In this case, if the controller is operating stand-alone, then the controller stays in day mode all the time. If the controller is operating with centralized control (that is, it is connected to a field panel), then the field panel can send an operator or PPCL command to override the status of DAY.NGT. See *Powers Process Control Language (PPCL) User's Manual* (125-1896) and the APOGEE P2 ALN Field Panel User's Manual (125-3019) or the APOGEE BACnet ALN Field Panel User's Manual (125-3020) for more information.

Night Mode Override Switch

If an override switch is present on the room temperature sensor and a value (in hours) other than zero has been entered into OVRD TIME, pressing the override switch will reset the controller to DAY operational mode for the time period that is set in OVRD TIME. The status of NGT OVRD changes to DAY. After the override time elapses, the controller returns to night mode and the status of NGT OVRD changes back to NIGHT.

The override switch on the room sensor will only affect the controller when in night mode.

Heating/Cooling Switchover

The heating/cooling switchover determines whether the controller is in heating or cooling mode by monitoring the room temperature and the demand for heating and cooling (as determined by the temperature control loops).

If the following conditions are met for the length of time set in SWITCH TIME, the controller switches from heating to cooling mode by setting HEAT.COOL to COOL:

- HTG LOOPOUT < SWITCH LIMIT.
- CTL TEMP > CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP > the appropriate (defined in *Control Temperature Setpoints* section) cooling setpoint minus SWITCH DBAND.

If the following conditions are met for the length of time set in SWITCH TIME, the controller switches from cooling to heating mode by setting HEAT.COOL to HEAT:

- CLG LOOPOUT < SWITCH LIMIT.
- CTL TEMP < CTL STPT by at least the value set SWITCH DBAND.
- CTL TEMP < the appropriate (defined in *Control Temperature Setpoints* section) heating setpoint plus SWITCH DBAND.

Application 6658 performs heating/cooling switchover based on room load. To perform heating/cooling switchover based on some other criteria, such as time of year, outside air temperature or supply air temperature, unbundle the HC.ENDIS point at a field panel and use PPCL to control it.

Heating only - HC.ENDIS = 1.

Cooling only - HC.ENDIS = 2.

Heating and Cooling - HC.ENDIS = 3.

Modulating Damper During Heating Mode (Optional)

⚠ CAUTION

The heating/cooling switchover mechanism is not affected by the air temperature in the supply duct.

To change the value of HEAT.COOL based on the supply air temperature, you must command HEAT.COOL through PPCL. This is required when the flow loop will be used as a source of cooling in cooling mode and a source of heat in heating mode (see Examples 1 through 3 in *Sequencing Logic*). If the flow loop is used in heating mode just to meet minimum air requirements, the heating/cooling switchover mechanism operates as described in this section to control HEAT.COOL (see Example 4 in *Sequencing Logic*).

Control Loops

Application 6658 is controlled by four Proportional, Integral, and Derivative (PID) control loops; two temperature loops, a flow loop, and a CO_2 (ventilation) loop.

Temperature Loop

Each loop uses CTL STPT and CTL TEMP to modulate the value of its respective loopout point, CLG LOOPOUT or HTG LOOPOUT.

The cooling loop is active whenever HEAT.COOL = COOL. The heating loop is active whenever HEAT.COOL = HEAT.

NOTE:
Loops contain advanced PID algorithms that limit motor movement when the temperature is close to setpoint.

Flow Loop

The flow loop maintains FLOW STPT by modulating the supply air damper, DMPR COMD. The flow loop maintains the airflow between CTL FLOW MIN and CTL FLOW MAX.

Day Mode

When the controller is in the day cooling mode:

- CTL FLOW MIN = larger of CLG FLOW MIN and VENT DMD MIN, and CTL FLOW MAX = CLG FLOW MAX (when FLO CTL MODE = TEMP)

OR

- CTL FLOW MAX = VNT FLOW MAX (when FLO CTL MODE = VENT).

When the controller is in the day heating mode:

- CTL FLOW MIN = larger of HTG FLOW MIN and VENT DMD MIN, and CTL FLOW MAX = HTG FLOW MAX (when FLO CTL MODE = TEMP)

OR

- CTL FLOW MAX = VNT FLOW MAX (when FLO CTL MODE = VENT)

Night Mode

When the controller is in the night mode:

CTL FLOW MIN = NGT FLOW MIN and CTL FLOW MAX is either CLG FLOW MAX or HGT FLOW MAX (when FLO CTL MODE = TEMP)

Note that in night mode, the Demand Control Ventilation program will still be able to take over control of the flow, if the FLO CTL MODE changes to VENT. In that mode, the CTL FLOW MAX will be set to VNT FLOW MAX.

The temperature loops will control flow (to CLG FLOW MAX or HTG FLOW MAX) when the room temperature exceeds the night mode temperature setpoint and FLO CTL MODE = TEMP.

To enhance stable flow control, an advanced algorithm is used to calculate a controllable setpoint as the value approaches zero cfm (lps).

CO2 (Ventilation) Loop

When the application is in the Ventilation mode (FLO CTL MODE = VENT), the damper is no longer controlled by the temperature loops. Instead, the damper is modulated to assure adequate ventilation.

- CO2DIFF STPT is the desired CO2 concentration differential between RM CO2 and OUTDOOR CO2 (OUTDOOR CO2 receives its value from PPCL or manual command).
- CO2DIFF is the measured CO2 concentration differential between the room and outdoors.

The CO2 loop brings the measured CO2 differential to the desired CO2 differential by adjusting the damper position. When the damper is being modulated during ventilation mode, temperature control is maintained by modulating the chilled water and hot water valves.

Modulating Heat

CAUTION

As a safety feature, the application includes MODHTG FLOW to ensure that adequate airflow is present before an electric heating element is energized. The standard default for MODHTG FLOW is 20, ensuring adequate airflow (20% of Max setpoint) is provided before a heating coil is enabled.
For installations that include radiant heating panels or hot water coils (either ceiling or wall mounted), MODHTG FLOW should be set to zero

If the application does use electric heat, it is imperative that MODHTG FLOW be set to a value such as 5 which means that airflow must be at least 5% of maximum heating flow before H VLV COMD will turn on.

In Application 6658, the value of MTR SETUP determines the type, not the number, of output control signals generated by the application. The output signals for H VLV COMD and C VLV COMD can be floating or 0 to 10V analog. Use the additive values in the *MTR SETUP Value* table, along with the output signal logic in the *MTR SETUP Values and Corresponding Output Signals* table to arrive at the MTR SETUP value needed for your job.

The MTR SETUP values in the *MTR SETUP Value* table are additive. For example, if you needed Motor 1 (DOs 1 and 2) enabled, Motor 2 (DOs 3 and 4) enabled, and Motor 3 (DOs 5 and 6) disabled, you would set MTR SETUP equal to 5. This is because the Motor 1 (for the damper) enable value is 1, the Motor 2 enable value is 4, and the Motor 3 disable value is 0. 1 + 4 + 0 = 5. In this case, you would have a floating signal for the damper (DOs 1 and 2) and heating (DOs 3 and 4), and a 0 to 10V analog signal for cooling (AOV1).

Motor Enable/Reverse Values for MTR SETUP			
	MTR SETUP Value [a]		
	Disabled	Enabled	Enabled and Reversed
Motor 1	0	1	3
Motor 2	0	4	12
Motor 3	0	16	48

[a] The values in this table are additive and must be added per the requirements of the job.

Example motor setup configurations for floating damper with hot water and chill water valves. In each case, motor 1 for the damper, is controlled by DO1 and DO2.

MTR SETUP Sample Configurations.		
MTR SETUP [a] [b]	HVLV COMD	CVLV COMD
Motors 1 and 2 Enabled, Motor 3 Disabled	Motor 2 (DO 3 and DO 4)	AOV1

MTR SETUP Sample Configurations.		
MTR SETUP [a) b)]	HVLV COMD	CVLV COMD
Motor 1 Enabled, Motor 2 Disabled, Motor 3 Enabled	AOV2	Motor 3 (DO 5 and DO 6)
Motors 1, 2, and 3 Enabled	Motor 2 (DO 3 and DO 4)	Motor 3 (DO 5 and DO 6)
Motor 1 Enabled, Motors 2 and 3 Disabled	AOV2	AOV1

a) Motor 1 is reserved for the damper. The default value of MTR SETUP is 0 - it must be changed to enable the damper.

b) The MTR SETUP values given in this table assume none of the actuators are reverse acting. If any actuators must be reverse floating acting, use the additive values in the *Motor Enable/Reverse Values for MTR SETUP* table to arrive at the correct value for MTR SETUP.

NOTE:
If Motor 2 (DOs 3 and 4) is being used for floating point control of a valve for heating, then AOV 2 is spare. In this case, although AOV 2 is spare, AOV 2 OPEN and AOV 2 CLOSE are not used for control of the output for this spare analog. Likewise, if Motor 3 is being used for Floating Control of cooling, AOV 1 would be spare but AOV 1 OPEN and AOV 1 CLOSE would not be used for control of AO1 output.
If AOs are used for modulating heating/cooling devices, the associated DOs are spare but unavailable for motor control.

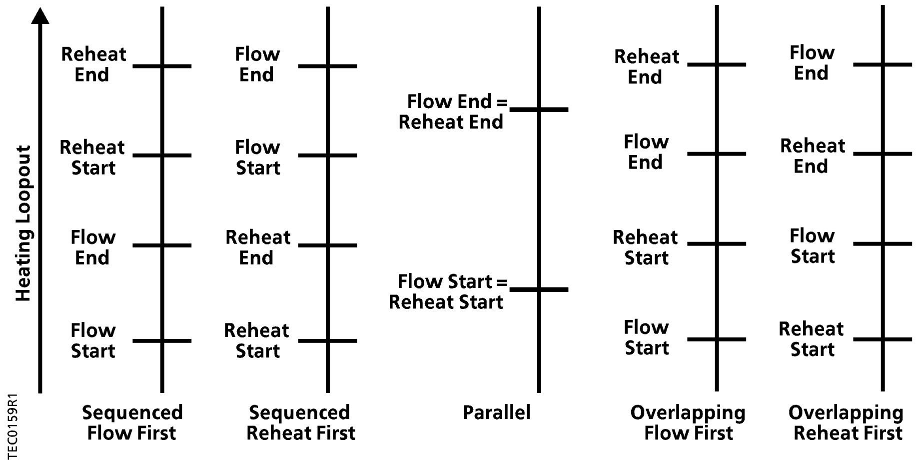
Sequencing Logic (optional)

Heating

NOTE:
The default setups for H FLOW START and H FLOW END are 0 and 100 respectively.
This will provide airflow during heating mode from HTG FLOW MIN to HTG FLOW MAX.

In heating mode, this application includes logic that allows the flow loop to operate in sequence, parallel, or overlapping with the modulating heating device. Portions of the output of the heating loop, HTG LOOPOUT, will drive both the flow loop and the modulating heating device from 0 to 100%. See the examples.

The ladder diagram shows sequenced, parallel, and overlapping flow loop operations with the heating device(s). The vertical bars show the output of heating loopout from 0 to 100%. The horizontal bars (reheat start, flow start, etc.) show the action that occurs when the loop output rises above the horizontal bar. The relative positions shown on the graphs are for illustration purposes only and may differ from the examples.



For simplicity, assume that in these examples:

- HTG FLOW MIN = 0 cfm.

Example 1

Assume that your system has a modulating heating device that is to operate in sequence with the flow loop. If:

- H FLOW START = 0%
- H FLOW END = 50%
- REHEAT START = 50%
- REHEAT END = 100%

then,

- When HTG LOOPOUT = 0%, FLOW STPT will equal 0% flow.
- When HTG LOOPOUT = 25%, FLOW STPT will equal 50% flow.
- When HTG LOOPOUT ≥ 50%, FLOW STPT will equal 100% flow.
- When HTG LOOPOUT ≤ 50%, H VLV COMD will equal 0% open.
- When HTG LOOPOUT = 75%, H VLV COMD will equal 50% open.
- When HTG LOOPOUT = 100%, H VLV COMD will equal 100% open.

Example 2

Assume that your system has a modulating heating device that is to operate in parallel with the flow loop. If:

- H FLOW START = 0%
- H FLOW END = 100%
- REHEAT START = 0%
- REHEAT END = 100%

then,

- When HTG LOOPOUT = 0%, FLOW STPT will equal 0% flow.
- When HTG LOOPOUT = 50%, FLOW STPT will equal 50% flow.
- When HTG LOOPOUT = 100%, FLOW STPT will equal 100% flow.
- When HTG LOOPOUT = 0%, H VLV COMD will equal 0% open.
- When HTG LOOPOUT = 50%, H VLV COMD will equal 50% open.
- When HTG LOOPOUT = 100%, H VLV COMD will equal 100% open.

Example 3

Assume that your system has a modulating heating device that is to operate overlapping with the flow loop. If:

- H FLOW START = 0%
- H FLOW END = 75%
- REHEAT START = 25%
- REHEAT END = 100%

then,

- When HTG LOOPOUT = 0%, FLOW STPT will equal 0% flow.
- When HTG LOOPOUT = 37.5%, FLOW STPT will equal 50% flow.
- When HTG LOOPOUT ≥ 75%, FLOW STPT will equal 100% flow.
- When HTG LOOPOUT ≤ 25%, H VLV COMD will equal 0% open.
- When HTG LOOPOUT = 62.5%, H VLV COMD will equal 50% open.
- When HTG LOOPOUT = 100%, H VLV COMD will equal 100% open.

Another option that the sequencing logic provides is to have the flow loop provide airflow equal to HTG FLOW MIN throughout the heating mode with all of the temperature control being done by the modulating heating device(s). The airflow minimum will be maintained by setting the FLOW START and FLOW END to a value of 0%, resulting in the corresponding minimum flow throughout the entire heating mode, regardless of the value of HTG LOOPOUT. Example 4 clarifies this.

Example 4

Assume that your system has a modulating heating device that provides the temperature control in the heating mode, while the flow loop provides for the minimum air requirements. Assume:

- HTG FLOW MIN = 170 cfm
- HTG FLOW MAX = 1000 cfm

If:

- H FLOW START = 0%
- H FLOW END = 0%
- REHEAT START = 0%
- REHEAT END = 100%

then,

- When HTG LOOPOUT = 0%,
  FLOW STPT will equal (170 cfm/1000 cfm) × 100% flow = 17% flow. This will cause the flow loop to maintain airflow of 170 cfm out of the terminal box.
- When HTG LOOPOUT = 50%, FLOW STPT will equal 17% flow.
- When HTG LOOPOUT = 100%, FLOW STPT will equal 17% flow.
- When HTG LOOPOUT = 0%, H VLV COMD will equal 0% open.
- When HTG LOOPOUT = 50%, H VLV COMD will equal 50% open.
- When HTG LOOPOUT = 100%, H VLV COMD will equal 100% open.

Cooling

Cooling sequencing operates similar to the Sequencing Logic in Example 4 of *Sequencing Logic Heating* by using the configuration parameters C FLOW START, C FLOW END, CHW START (chilled water start), and CHW END (chilled water end). The second stage of cooling can be delayed by setting CLG STG DLY to the number of delay seconds.

If CHW START > C FLOW END, the chilled water valve will not begin to open until both of the following are true:

- CLG LOOPOUT > CHW START, for a time longer than CLG STG DLY seconds.
- FLOW is at max cooling (FLOW > 90%), or the damper is fully open (DMPR POS > 99%), or DMPR COMD status is OVERRIDE, for a time longer than CLG STG DLY seconds.

If C FLOW START > CHW END, flow will not begin modulating until both of the following are true:

- CLG LOOPOUT > C FLOW START, for a time longer than CLG STG DLY seconds.
- C VLV POS > 95%, or COND ALARM is ALARM, or C VLV COMD status is OVERRIDE, for a time longer than CLG STG DLY seconds.

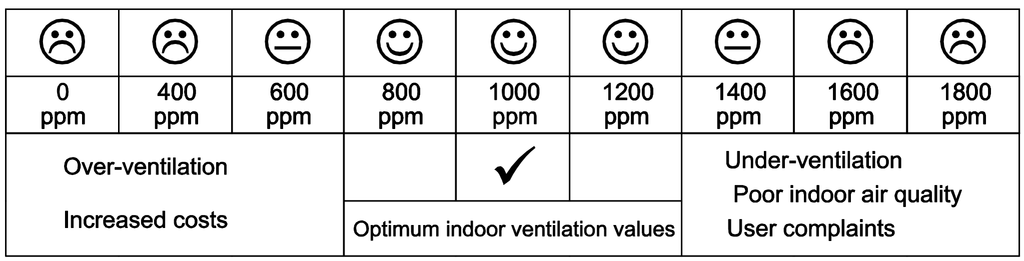
Ventilation Control

This application includes Demand Control Ventilation (DCV). For DCV to be available, CO2 CONFIG must equal 1, 3 or 4.

CO2 CONFIG values for Demand Control Ventilation	
CO2 CONFIG value	Application Operation
0	Demand Control Ventilation feature is disabled.
1	CO2 based demand control ventilation is enabled. AI3 and AI4 are spare. The value of RM CO2 that is used for CO2 control is set via PPCL from a field panel or in the 3 way digital room unit.
2	Not used (returns to 0).
3	CO2 based demand control ventilation is enabled. AI3 is the input used for calculating RM CO2.
4	CO2 based demand control ventilation is enabled. AI4 is the input used for calculating RM CO2.

NOTES:
If RM CO2 is overridden while in modes 1, 3 or 4, the overridden value is used for CO2 control purposes. If RM CO2 is overridden while in mode 0, there will be no CO2 control, even with large values.
If AI 3 or AI4 is used for CO2 sensing, set the associated DIP switch (located on circuit board) to indicate the sensor type, either current or voltage, voltage is default.
Since CO2 sensors may have an accuracy of + or – 50 PPM, some CO2 default values may need adjustment. Ventilation mode default values are: 500 PPM for entering the Demand Control Ventilation mode; 400 PPM for leaving the Demand Control Ventilation mode; 100 PPM is the default CO2DIFF STPT. Refer to the appropriate industry standards and guidelines when configuring the CO2 differential levels and setpoints.

With a known ventilation rate and number of occupants, a predictable steady state concentration of CO2 can be maintained. DCV uses this principle to modulate ventilation to acceptable levels based on CO2 concentrations within the space. Rather than having a minimum ventilation based on full occupancy of a space such as 15 or 20 cfm per person, DCV allows ventilation airflow to be modulated below what otherwise would be the full occupancy ventilation minimum, provided that CO2 concentration (in ppm) indicates adequate ventilation.



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This figure shows indoor CO2 PPM values. CO2DIFF STPT should typically be set to a value that equates to an acceptable difference between indoor/outdoor CO2 PPM levels.

If ventilation levels are acceptable, the application operates as outlined in the previous sections of this document. However, if the difference between indoor and outdoor CO2 concentration levels rises above a configurable threshold, the damper control is switched from temperature control to ventilation control.

FLO CTL MODE designates whether the application is in the normal temperature control mode (FLO CTL MODE = TEMP) or in the ventilation mode (FLO CTL MODE = VENT). The ventilation mode is entered whenever CO2DIFF (the difference between RM CO2 and OUTDOOR CO2) is greater than CO2DIFF HLIM.

NOTE:
The value of OUTDOOR CO2 is reported to the controller using the field panel and PPCL or manually set, since there is no outdoor CO2 sensor connected to the controller.

Once the threshold is reached, a CO2 PID is invoked which increases the airflow to bring in more fresh air to control the CO2 concentration to the target CO2 difference value set in CO2DIFF STPT.

While in the ventilation mode, the heating and cooling PIDs are still active and temperature will be maintained by the heating and cooling coils. If the heating or cooling demand is such that the damper should open more than required for ventilation, damper control will revert to temperature control. The damper will switch back and forth between ventilation and temperature control modes as needed until the ventilation mode is eventually exited. This will happen as occupants leave the room causing the CO2 level to naturally drop. When the level drops below a configurable threshold (such as 400 ppm above outside air) for a configurable time delay, the ventilation mode is exited. The threshold for exiting the ventilation mode is set via CO2DIFF LLIM and the time delay is set via CO2 RST DLY.

DCV Modes

Demand Control Ventilation can operate in two basics modes: threshold monitoring and PID control (proportional control only).

DCV Mode 1 – Threshold Monitoring

This is the factory default. In this mode, when the CO2 measurement for the indoor air becomes greater than the CO2 measurement for the outdoor air by a configurable amount, the damper will move to the ventilation maximum until the differential CO2 level drops below a second lower configurable limit. When the differential CO2 level has been at or below the lower limit for a specified number of minutes, the application returns to normal temperature control. If the CO2 differential rises again, the process repeats. With factory default settings, as the differential between indoor and outdoor CO2 concentrations rises above 500 ppm, the damper will open to the ventilation maximum until the CO2 differential level drops below 400 ppm for 10 minutes.

To operate in this mode:

- Set CO2 P GAIN equal to or greater than 1
- Set CO2DIFF STPT to a value at least 100 ppm below CO2DIFF LLIM

DCV Mode 2 – with PID Loop Proportional Control only

This mode allows you to adjust CO2 P GAIN and CO2DIFF STPT to establish a desired CO2 steady state level. For example, CO2DIFF STPT could be set to 250 and the gain set to 0.33. With these settings, a CO2 steady state level would establish itself somewhere between an indoor/outdoor differential of 250 and 550 ppm. In this example, the upper limit CO2DIFF HLIM should be set to slightly above 550 ppm to avoid alarms when the controller is controlling near the upper limit of its PID range.

NOTE:
Using I gain (CO2 I GAIN) is not recommended in this application.

The following table shows the relationship between gain and proportional band. Due to the tendency of CO2 levels to drift, the lowest gain possible is recommended when using proportional control.

CO2 P GAIN	Proportional Band
1	Control range will be from setpoint to 100 ppm above setpoint
0.33	Control range will be from setpoint to 300 ppm above setpoint
0.2	Control range will be from setpoint to 500 ppm above setpoint

To operate in DCV Mode 2 (PID Loop – Proportional Control only):

- Set CO2 P GAIN and CO2DIFF STPT as desired according to the above guidelines.

DCV Used/Not Used

DCV Used — When DCV is enabled (CO2 CONFIG = 1, or 3), set CLG FLOW MIN and HTG FLOW MIN to values that assure adequate ventilation for the building component. This is typically about 30% of a ventilation flow rate based on full occupancy. If 400 cfm is minimum flow based on occupancy, 120 cfm (30% of 400) might be used for the CLG FLOW MIN and HTG FLOW MIN values. The number of occupants will be inferred by measuring the level of CO2. In this case, as occupancy goes from no occupancy to full occupancy the ventilation would ramp from 120 to 400 cfm.

DCV Not Used — Setting CO2 CONFIG to zero disables the DCV feature. If CO2 CONFIG = 0, set CLG FLOW MIN and HTG FLOW MIN to values that will assure adequate ventilation based on full occupant capacity and the square footage of the space. Consult ASHRAE or other appropriate guidelines.

NOTE:
Always refer to the appropriate industry standards and design guides for selecting minimum ventilation levels. ASHRAE guidelines base ventilation needs on a building component and an occupant component.

Ventilation Alarm

CO2 ALARM will be set to ALARM if the CO2 concentration differential (CO2DIFF) between RM CO2 and OUTDOOR CO2 is greater than CO2DIFF HLIM for more than CO2 ALM DLY minutes.

Condensate Control and Alarming

Application 6658, when used with chilled beams, provides condensation protection by shutting the cooling valve for either of the following two conditions:

- If dew point calculations in the field panel determine that the chilled water valve should be closed, the field panel should command CHW DISABLE to YES. The application will set C VLV COMD to 0 when CHW DISABLE = YES.
- If the condensation alarm (COND ALARM) = ALARM, C VLV COMD will be set to 0. COND ALARM will be ALARM depending on the status of DI 6 and the type of condensate sensor as configured in point DI 6 TYPE. See the following table.

If DI6 TYPE =	and DI6 status =	then COND ALARM will be
NOPEN	OFF	NORMAL
	ON	ALARM
NCLOSE	OFF	ALARM
	ON	NORMAL

To prevent possible false alarms due to noisy or transient inputs, the application includes a time delay provision. The abnormal condition must persist for the number of seconds in COND ALM DLY before the alarm activates and the valve closes. For an immediate response to the condensate sensor, set COND ALM DLY to 1.

COND ALM DLY = 0 is a special case which is used to disable DI 6 as a condensate sensor input. When COND ALM DLY = 0, DI 6 becomes spare and does not affect the cooling valve, and COND ALARM will always stay normal. Regardless of the value of COND ALM DLY, a field panel command setting CHW DISABLE to YES will always immediately shut the chilled water valve.

Calibration

Calibration of the controller's internal air velocity sensor(s) is periodically required to maintain accurate air velocity readings. CAL SETUP is set with the desired calibration option during controller startup.

Depending on the value of CAL SETUP, calibration may be set to take place automatically or manually. If CAL AIR = YES, calibration is in progress.

- For a controller used without an Autozero Module (CAL MODULE, = NO), the damper is commanded closed to get a zero airflow reading during calibration.
- For a controller used with an Autozero Module (CAL MODULE = YES), calibration occurs without closing the damper.

Modulating Heating and Cooling Valves – Calibration of a modulating heating valve(s) is done by commanding the valve(s) to closed.

At the end of a calibration sequence, CAL AIR automatically returns to NO. A status of NO indicates that the controller is not in a calibration sequence.

During normal operation: To ensure that the damper opens and closes fully, the controller will provide additional opening or closing time when commanded DMPR POS = 100% and 0%.

Floating Control Actuation Auto-correct

In addition to the existing options for floating control actuator full stroke actions; all floating control actuators are provided with additional logic to fully drive open or closed when commanded to 100% or 0%.

Room Unit Operation

Stat Supervision

STAT SUPV is a configurable, enumerated point (values are additive). This point tells the controller what kind of room unit is connected and how to respond to thermistor inputs and the controller.

Room Temperature

- When the digital room unit (Series 2200/2300) is used, STAT SUPV enables:
  - Temperature sensing with value of 1.
  - Relative humidity sensing with value of 2.
  - CO2 sensing with value of 4.

- When the analog room unit (Series 1000/2000) is used, default temperature sensing (0) is enabled (relative humidity and CO2 sensing are not available).

Thermistor Inputs

- Default for either input is 10K.
- To enable 100K thermistor on input, see table for additive values of 8.

Other Inputs (only available on Digital Room Unit)

- Use the following able to enable relative humidity or CO2 for additive values of 2 or 4.

Value	Description (include values to enable feature)
1	Room temperature sensing (Digital Room Unit only)
2	Relative Humidity (RH) sensing
4	CO_2 sensing
8	Long board: 100K Ω thermistor on AI 5 (else input is 10K Ω)
16	(not used)

NOTE:
See CO2 CONFIG to enable and use C02 sensing and to select source from AI3 or AI4.

See *Sensors and Transducers Configuration and Sizing* for part numbers and ordering information.

CO2 Monitoring

RM CO2 displays the CO_2 value in units of parts-per-million (PPM). RM CO2 can be unbundled for monitoring purposes.

NOTE:
To use the room unit CO2 input for the demand control ventilation program, both STAT SUPV must be set (additive value 4) and CO2 CONFIG set to 1.

Room RH

RM RH displays the relative humidity value in percent. RM RH can be unbundled for monitoring purposes.

PPCL STATUS

PPCL STATUS displays LOADED or EMPTY.

LOADED = PPCL programming is present in the controller. A new application number must be assigned (12000 through 12999).

EMPTY = NO PPCL programming is present.

Fail Mode Operation

If the air velocity sensor fails, the controller uses pressure dependent control. The temperature loop controls the operation of the damper.

See the *Control Temperature Setpoints* section of this document for information on what happens if the room temperature setpoint dial fails.

See the *Room Temperature, Room Temperature Offset and CTL TEMP* section of this document for information on what happens if the room temperature sensor fails.

Application Notes

- If temperature swings in the room are excessive or there is trouble maintaining the setpoint, the cooling loop needs to be tuned. If FLOW is oscillating while FLOW STPT is constant, the flow loop requires tuning.
- The controller, as shipped from the factory, keeps all associated equipment OFF. See the appropriate *Start-up Procedures* for information on how to release the controller and its equipment to application control.
- Spare DOs can be used as auxiliary points that are controlled by the field panel after being defined in the field panel's database.

AOV 1 and AOV 2 are not restricted to controlling valves; they can control SCRs if desired. In order to do this, the SCR must have its own controller that will modulate the SCR based on the value of a 0 to 10V input. In this case, the TEC can control the SCR by connecting either AOV 1 or AOV 2 on the TEC to the 0 to 10V input on the SCR.

Wiring Diagram

CAUTION

The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. An external interposing relay is required for any of the following:

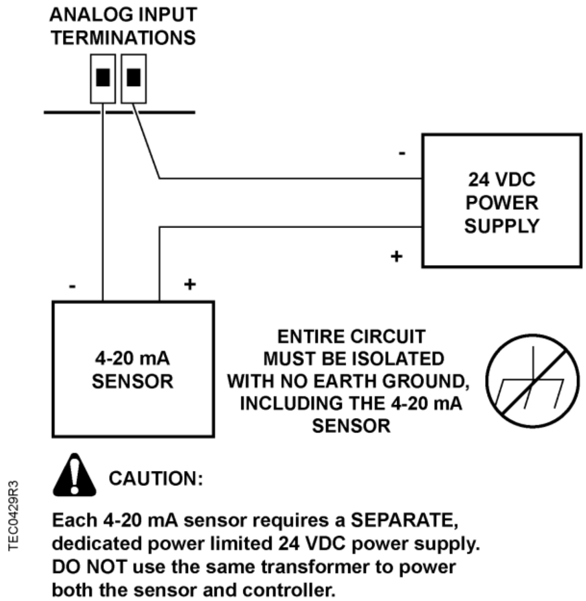
• VA requirements higher than the maximum

• 110 or 220 Vac requirements

• DC power requirements

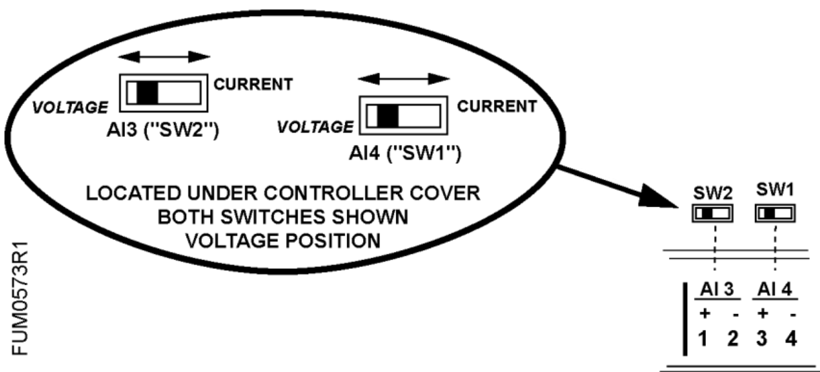
• Separate transformers used to power the load
(for example part number 540-147, Terminal Equipment Controller Relay Module)

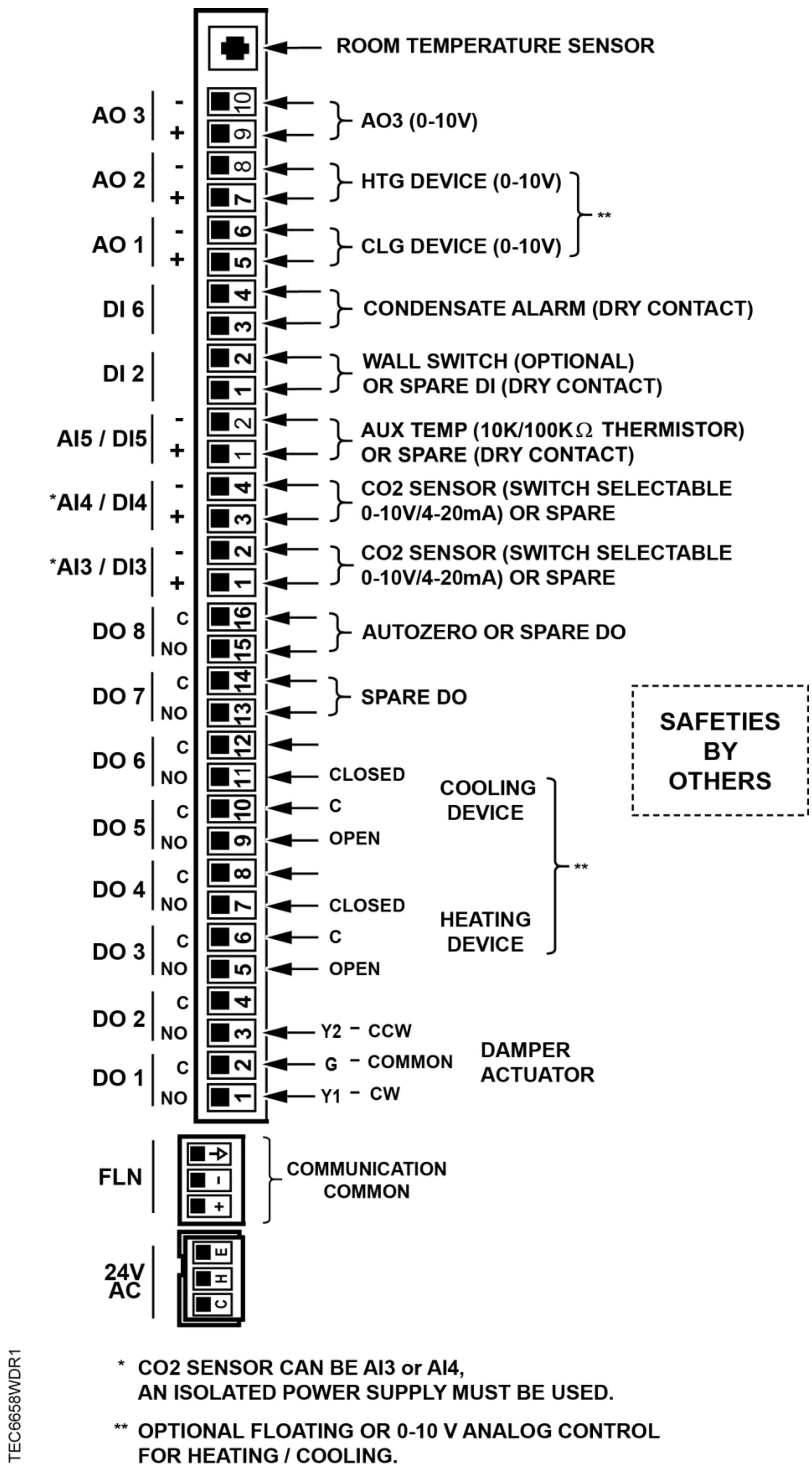
NOTE:
Thermistor inputs are 10K (default) or 100K software selectable (AUX TEMP AI X).



Wiring for AI with a 4 to 20 mA Sensor.

NOTE:
If the voltage/current switch is set to current and a 4 to 20 mA sensor is connected to an AI, then special wiring requirements must be followed.





Application 6658 - Wiring Diagram.

Application 6658 Point Database

Object Type	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units)	Engr Units (SI Units)	Range	Active Text	Inactive Text
AO	1	CTLR ADDRESS	99	--	0-255	--	--
AO	2	APPLICATION	6692	--	0-32767	--	--
AO	{03}	RM CO2	450	PPM	0-8191	--	--
AO	{04}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
BO	{05}	HEAT.COOL	COOL	--	Binary	HEAT	COOL
AO	6	DAY CLG STPT	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	7	DAY HTG STPT	70.0 (21.20888)	DEG F (DEG C)	48-111.75	--	--
AO	8	NGT CLG STPT	82.0 (27.92888)	DEG F (DEG C)	48-111.75	--	--
AO	9	NGT HTG STPT	65.0 (18.40888)	DEG F (DEG C)	48-111.75	--	--
AO	10	CO2 SCALE	2000	PPM	0-8191	--	--
AO	11	RM STPT MIN	55.0 (12.80888)	DEG F (DEG C)	48-111.75	--	--
AO	12	RM STPT MAX	90.0 (32.40888)	DEG F (DEG C)	48-111.75	--	--
AO	{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
BO	14	STPT DIAL	NO	--	Binary	YES	NO
AI	{15}	AI 3	0	PCT	0-102	--	--
AO	16	H FLOW START	0	PCT	0-102	--	--
AO	17	H FLOW END	100	PCT	0-102	--	--
BO	18	WALL SWITCH	NO	--	Binary	YES	NO
BI	{19}	DI OVRD SW	OFF	--	Binary	ON	OFF
AO	20	OVRD TIME	0	HRS	0-255	--	--
BO	{21}	NGT OVRD	NIGHT	--	Binary	NIGHT	DAY
AO	22	REHEAT START	0	PCT	0-102	--	--
AO	23	REHEAT END	100	PCT	0-102	--	--
BI	{24}	DI 2	OFF	--	Binary	ON	OFF
BI	{25}	DI 3	OFF	--	Binary	ON	OFF
BI	{26}	DI 4	OFF	--	Binary	ON	OFF
BI	{27}	DI 5	OFF	--	Binary	ON	OFF
BI	{28}	DI 6	OFF	--	Binary	ON	OFF

Object Type	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units)	Engr Units (SI Units)	Range	Active Text	Inactive Text
BO	{29}	DAY.NGT	DAY	--	Binary	NIGHT	DAY
BO	{30}	FLO CTL MODE	TEMP	--	Binary	VENT	TEMP
AO	31	CLG FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	32	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	33	HTG FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	34	HTG FLOW MAX	220 (103.818)	CFM (LPS)	0-131068	--	--
AI	{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	36	FLOW COEFF	1	--	0-2.55	--	--
BO	{37}	CHW DISABLE	NO	--	Binary	YES	NO
AO	{38}	AOV2	0	VOLTS	0-10.23	--	--
AO	{39}	C VLV POS	0	PCT	0-102	--	--
AO	{40}	H VLV POS	0	PCT	0-102	--	--
BO	{41}	DO 1	OFF	--	Binary	ON	OFF
BO	{42}	DO 2	OFF	--	Binary	ON	OFF
BO	{43}	DO 3	OFF	--	Binary	ON	OFF
BO	{44}	DO 4	OFF	--	Binary	ON	OFF
BO	{45}	DO 5	OFF	--	Binary	ON	OFF
BO	{46}	DO 6	OFF	--	Binary	ON	OFF
AI	{47}	AI 4	0	PCT	0-102	--	--
AO	{48}	DMPR COMD	0	PCT	0-102	--	--
AO	{49}	DMPR POS	0	PCT	0-102	--	--
AO	{50}	OUTDOOR CO2	450	PPM	0-8191	--	--
AO	51	DMPR TIMING	95	SEC	0-511	--	--
AO	{52}	H VLV COMD	0	PCT	0-102	--	--
AO	{53}	C VLV COMD	0	PCT	0-102	--	--
AO	{54}	AOV3	0	VOLTS	0-10.23	--	--
AO	55	CO2 RST DLY	10	MIN	0-255	--	--
AI	{56}	AIR VOL STPT	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	57	CO2 CONFIG	0	--	0-255	--	--
AO	58	MTR SETUP	0	--	0-255	--	--
AO	59	DO DIR.REV	0	--	0-255	--	--
AO	{60}	AOV1	0	VOLTS	0-10.23	--	--

Object Type	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units)	Engr Units (SI Units)	Range	Active Text	Inactive Text
AO	61	CO2DIFF LLIM	400	PPM	0-8191	--	--
AO	62	CO2DIFF HLIM	500	PPM	0-8191	--	--
AO	63	CLG P GAIN	20.0 (36.0)	--	0-63.75	--	--
AO	64	CLG I GAIN	0.01 (0.018)	--	0-1.023	--	--
BO	{65}	CO2 ALARM	NORMAL	--	Binary	ALARM	NORMAL
AO	66	TEMP OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75-32	--	--
AO	67	HTG P GAIN	10.0 (18.0)	--	0-63.75	--	--
AO	68	HTG I GAIN	0.01 (0.018)	--	0-1.023	--	--
BO	{69}	COND ALARM	NORMAL	--	Binary	ALARM	NORMAL
AO	70	COND ALM DLY	60	SEC	0-32767	--	--
AO	71	VNT FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	72	FLOW I GAIN	0.01	--	0-1.023	--	--
AO	73	CO2 P GAIN	1	--	0-20.47	--	--
AI	{74}	CO2DIFF	0	PPM	-2000-14383	--	--
AO	{75}	FLOW	0	PCT	0-1023.75	--	--
AO	{76}	CTL FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	{77}	CTL FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	{79}	CLG LOOPOUT	0	PCT	0-102	--	--
AO	{80}	HTG LOOPOUT	0	PCT	0-102	--	--
BO	{81}	DO 7	OFF	--	Binary	ON	OFF
AI	{82}	AUX TEMP AI5	74.0 (23.495556)	DEG F (DEG C)	37.5-165	--	--
AO	83	CLG STG DLY	60	SEC	0-32767	--	--
AO	{84}	NGT FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	85	SWITCH LIMIT	5.2	PCT	0-102	--	--
AO	86	SWITCH TIME	10	MIN	0-255	--	--
BO	87	CAL MODULE	NO	--	Binary	YES	NO
AO	88	CO2DIFF STPT	100	PPM	0-8191	--	--
BO	{89}	DO 8	OFF	--	Binary	ON	OFF
AO	90	SWITCH DBAND	1.0 (0.56)	DEG F (DEG C)	0-63.75	--	--
AO	91	HC.ENDIS	3	--	1-256	--	--

Object Type	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units)	Engr Units (SI Units)	Range	Active Text	Inactive Text
AO	{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	{93}	FLOW STPT	0	PCT	0-255.75	--	--
BO	{94}	CAL AIR	NO	--	Binary	YES	NO
AO	95	CAL SETUP	4	--	0-255	--	--
AO	96	CAL TIMER	12	HRS	0-255	--	--
AO	97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0-6.375	--	--
AO	98	LOOP TIME	5	SEC	0-255	--	--
AO	{99}	ERROR STATUS	0	--	0-255	--	--
AO	102	H VLV TIMING	130	SEC	0-511	--	--
AO	103	C VLV TIMING	130	SEC	0-511	--	--
AO	104	CHW START	50	PCT	0-102	--	--
AO	105	CHW END	100	PCT	0-102	--	--
AO	106	C FLOW START	0	PCT	0-102	--	--
AO	107	C FLOW END	40	PCT	0-102	--	--
AO	108	CLG D GAIN	0 (0.0)	--	0-510	--	--
AO	109	CO2 D GAIN	0	--	0-2046	--	--
AO	110	DMPR ROT ANG	90	--	0-255	--	--
AI	{111}	CO2 LOOPOUT	0	PCT	0-102	--	--
AO	112	AOV1 OPEN	10	VOLTS	0-10.23	--	--
AO	113	AOV1 CLOSE	0	VOLTS	0-10.23	--	--
AO	114	AOV2 OPEN	0	VOLTS	0-10.23	--	--
AO	115	AOV2 CLOSE	10	VOLTS	0-10.23	--	--
AO	116	CO2 ALM DLY	10	MIN	0-255	--	--
BO	117	DI6 TYPE	NOPEN	--	Binary	NCLOSE	NOPEN
AO	118	HTG D GAIN	0 (0.0)	--	0-510	--	--
AO	119	CO2 I GAIN	0	--	0-1.023	--	--
AO	120	MODHTG FLOW	20	PCT	0-1023.75	--	--
AO	{123}	VENT DMD MIN	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	{124}	STAT SUPV	0	--	0-255	--	--
AO	{126}	RM RH	50	PCT	0-102	--	--
BO	{127}	PPCL STATE	EMPTY	--	Binary	LOADED	EMPTY

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