SIEMENS

P1 TEC

Dual Duct 2 AVS - VAV Two Inlet Sensors with Optional Reheat and Optional Occupancy Sensor

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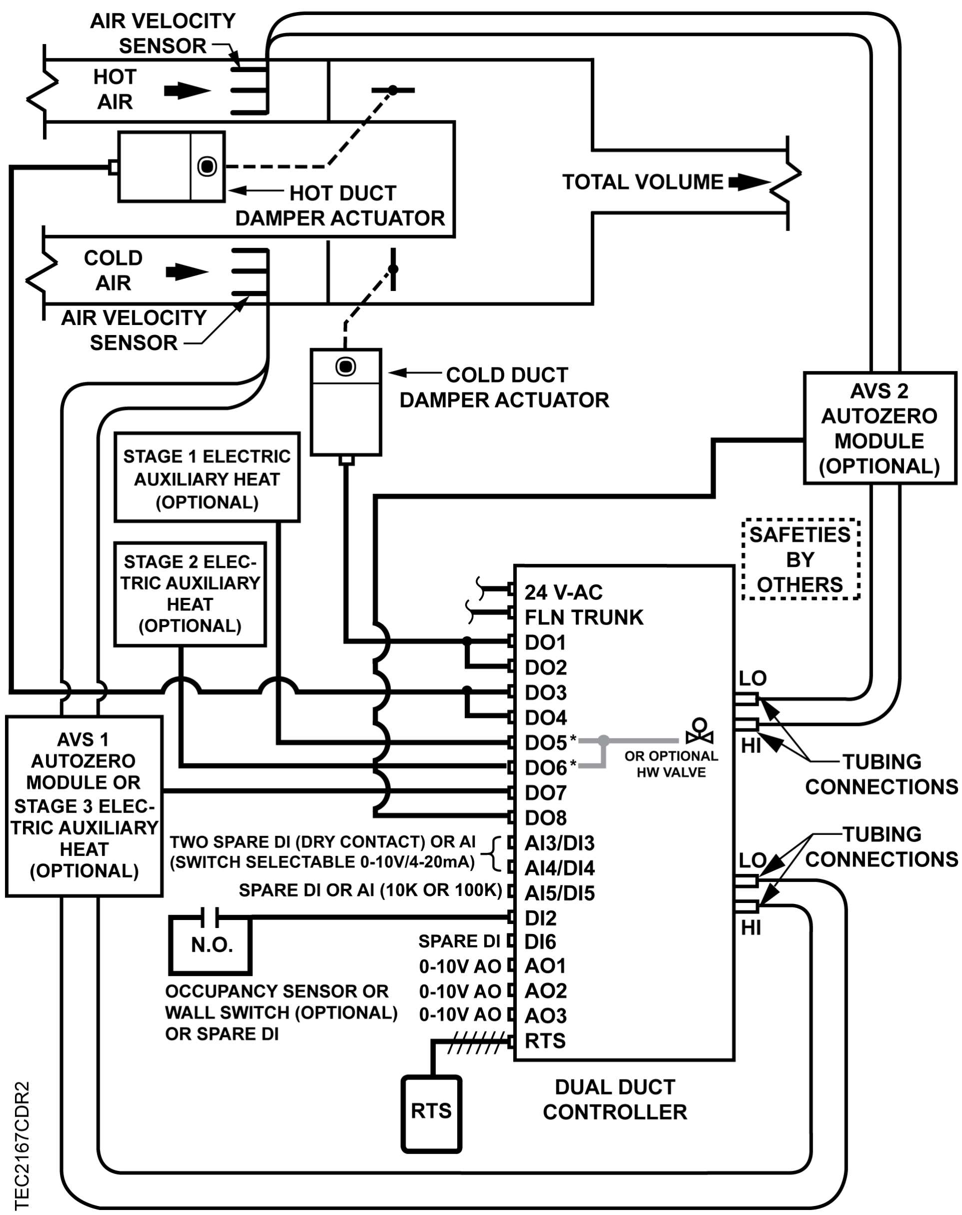
Building Technologies

Table of Contents

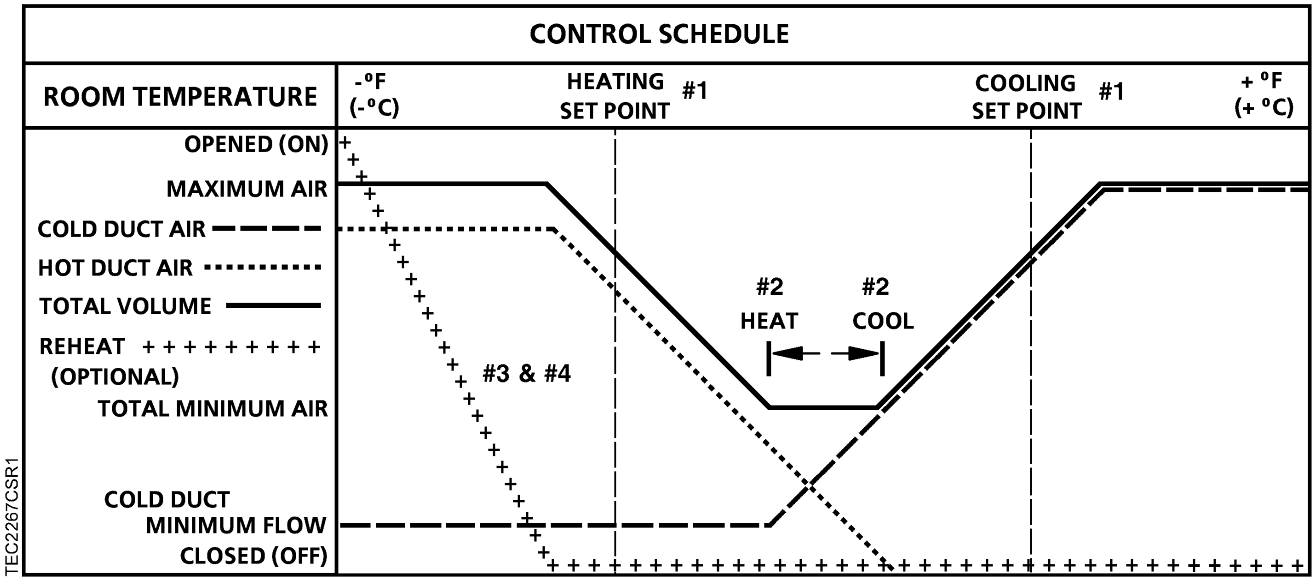
Overview

In Application 2167, the controller modulates two inlet damper actuators–one for the hot duct and one for the cold duct.

In cooling mode, the controller modulates the cold duct damper to maintain the room temperature setpoint and modulates the hot duct damper to ensure minimum airflow. In heating mode, the controller modulates the hot duct damper in order to maintain the room temperature setpoint and modulates the cold duct damper to ensure minimum airflow. If auxiliary heat is used, the controller modulates an optional hot water valve or up to three stages of electric reheat to maintain the room temperature setpoint.



Application 2167 Control Drawing.



Application 2167 Control Schedule.

NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. The electric reheat is time modulated. This allows it to be controlled proportionally rather than with deadbands.
4. The airflow is shown modulating in the entire heating mode (default setting). The airflow can operate sequenced, parallel, or overlapping with the electric reheat (optional). See *Sequencing Logic*.

Hardware Inputs

Analog

- Air velocity sensor (two required)
- Room temperature sensor
- Room temperature setpoint dial (optional)

Digital

- Night mode override (optional)
- Wall switch (optional)
- Occupancy Sensor (optional)

Hardware Outputs

Analog

- None

Digital

- Damper actuator (two required)
- Stage 1 electric heat (optional)
- Stage 2 electric heat (optional)
- Stage 3 electric heat (optional) or Autozero modules (optional)
- Valve actuator (optional)

Ordering Notes

540-506MD	Application 2167: Siemens TEC Dual Duct 2AVS - VAV Two Inlet Sensors with Optional Reheat

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2167 -- Dual Duct 2AVS - VAV Two Inlet Sensors with Optional Reheat and Optional Occupancy Sensor.

NOTE:
The controller first meets the volume setpoint requirement of the space and then it controls to the room temperature setpoint requirement. The controller satisfies the airflow requirement of the dual duct even if doing so causes the temperature of the space to drift from its temperature setpoint.

Day and Night Modes

The operational status of the space is determined by the DAY.NGT point. Control of this point differs depending on whether it is being controlled by a wall switch or by a field panel. If a wall switch is controlling this point, it should not also be controlled by a field panel.

When a wall switch is physically connected to the controller at DI 2 and WALL SWITCH = YES, the controller monitors the status of DI 2. When DI 2 is ON (switch is closed), DAY.NGT will be set to DAY. When DI 2 is OFF (switch is open), DAY.NGT will be set to NIGHT.

When WALL SWITCH = NO, the controller will not monitor the status of a wall switch, even if one is connected at DI 2. 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 (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* (125-3020) for more information.

In addition to DAY.NGT, OCC STBY (occupied standby) will also affect control if an optional occupancy sensor is being used. OCC STBY works in conjunction with DAY.NGT to reduce airflow when no one is present in the zone during occupied times. See *Occupancy Sensor* for more information.

	CAUTION
	Do not turn a Wall Switch On and Off numerous times in rapid succession. This can wear out the contactor of the 1st heating stage.

Occupancy Sensor

The occupancy sensor option provides a means to reduce airflow while using the occupied temperature setpoints. To enable this option, set WALL SWITCH = NO and OCC SWITCH = YES, and connect an occupancy sensor to the controller at DI 2.

When a zone is in a normal occupancy state (DAY.NGT = DAY) and people are present, the enabled occupancy sensor will keep OCC STBY equal to NO (space is occupied). If at some point people leave and the occupancy sensor senses no activity, OCC STBY will be set to YES. With OCC STBY set to YES, zone temperature setpoint(s) will equal their occupied value (or an optional configurable offset) while airflow setpoints change to the unoccupied NGT FLOW MIN. If people return and the occupancy sensor senses activity, OCC STBY changes to NO and the zone returns to normal occupied control. See the table below for additional information.

Delay of activation and deactivation for detection of occupancy is not controlled by the application. If required, occupancy sensors should be selected to provide any of these delays.

Additional energy reduction can be achieved by changing the STBY OFFSET default of 0.0 deg to an offset that will be used to increase the cooling temperature setpoint and decrease the heating temperature setpoint. For example, with STBY OFFSET set to 1.0 deg, a cooling setpoint of 76 deg will be incremented to 77 deg and a heating setpoint of 70 deg will be decremented to 69 deg.

WALL SWITCH and OCC SWITCH Operation							
Conditions				Result			Comment
WALL SWITCH	OCC SWITCH	DAY.NGT	DI2	OCC STBY	Airflow minimum	Temp. control	
= NO **Note** WALL SWITCH must equal NO for occupancy sensor option.	= YES	DAY	OFF (no presence detected)	= YES	Minimum airflow setpoint changed from occupied calculation to NGT FLOW MIN	Remains at occupied temperature setpoints	Optional shift of temperature setpoints can be achieved by setting STBY OFFSET. For example, setting STBY OFFSET to 1.0 deg would raise a cooling setpoint of 76 deg to 77 deg (and lower a heating setpoint by 1.0 deg).
			ON (presence detected)	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	
		NIGHT	Status of DI2 does not affect control	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	
	= NO	DAY	Status of DI2 does not affect control	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	
		NIGHT	Status of DI2 does not affect control	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	
= YES	na (ignored)	DAY	ON	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	Wall switch connected to DI2 sets DAY.NGT to DAY
		NIGHT	OFF	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	Wall switch connected to DI2 sets DAY.NGT to NIGHT

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.

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 several factors. These factors include override status of CTL STPT, time of day, the status of occupancy standby mode, and whether a temperature deadband (a zero energy band) has been configured for use with a room temperature setpoint dial.

CTL STPT Overridden – If CTL STPT is overridden, that value is used regardless of any other settings.

CTL STPT not Overridden – CTL STPT holds the value of one of the occupied, unoccupied, or standby cooling/heating setpoints, or it holds the value of the room setpoint dial calculation.

When STPT DIAL equals NO (default), CTL STPT holds the value of DAY CLG STPT or DAY HTG STPT (depending on HEAT.COOL) if:

- DAY.NGT equals DAY (or NGT OVRD = DAY)
- OCC STBY equals NO

In Night mode (DAY.NGT = NGT or NGT OVRD = NGT), 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.

Room Setpoint Dial

When the controller is in day mode and STPT DIAL = YES, cooling and heating day setpoints are based on the value of the setpoint dial and a calculated setpoint deadband. The setpoint deadband allows the controller to separate the heating and cooling temperature setpoints when the dial is enabled. The setpoint deadband is derived from the difference between the day cooling and heating setpoints. If desired, the deadband can be eliminated by setting DAY HTG STPT equal to DAY CLG STPT. See the illustration below.

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

- *Dial value* is the value of RM STPT DIAL, limited to the range between RM STPT MIN and RM STPT MAX.
- *Deadband* is the value difference between DAY CLG STPT and DAY HTG STPT: (DAY CLG STPT - DAY HTG STPT)

CTL STPT is calculated as follows:

With Deadband in Heat Mode:

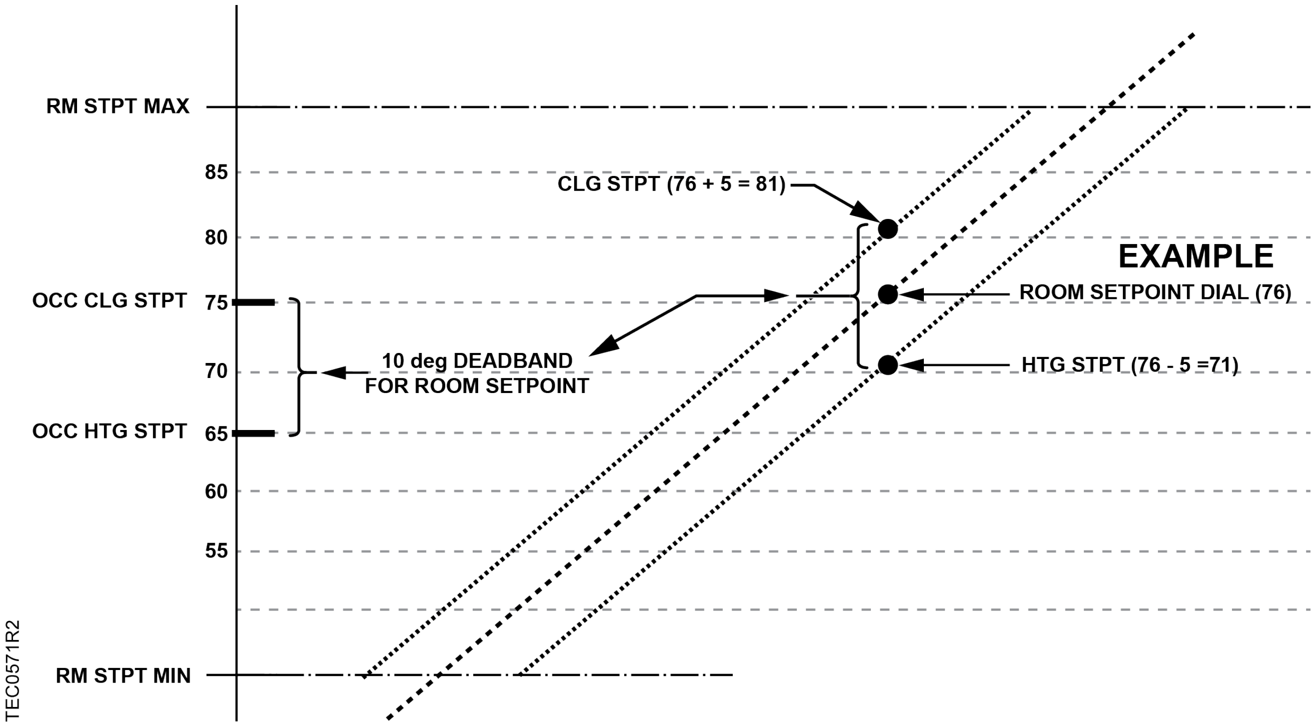
- CTL STPT = Dial value – (0.5 *Deadband)

With Deadband in Cool Mode:

- CTL STPT = Dial value + (0.5 *Deadband)

With Deadband Disabled (DAY HTG STPT = DAY CLG STPT):

- CTL STPT = Dial value



NOTE:
RM STPT DIAL must stay between the values of RM STPT MIN and RM STPT MAX or CTL STPT will use those values instead.

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

Optional Occupied Standby HTG / CLG Setpoints

When an occupancy sensor is present and enabled and no one is currently in the zone (OCC STBY = YES), the cooling and heating setpoints will be the day setpoints with the optional STBY OFFSET applied (cooling setpoint increased by the STBY OFFSET and heating setpoint decreased by the STBY OFFSET). For example, with STBY OFFSET set to 1.0 deg, a cooling setpoint of 76 deg will be incremented to 77 deg and the heating setpoint of 70 deg will be decremented to 69 deg.

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.

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 < 5.2%.
- CTL TEMP > CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP > the appropriate cooling setpoint minus SWITCH DBAND.

If AUX HTG USED = YES, and 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 < 5.2%.
- CTL TEMP < CTL STPT by at least the value set SWITCH DBAND.
- CTL TEMP < the appropriate heating setpoint plus SWITCH DBAND.

Ventilation Demand Minimum

For flexible ventilation control, a ventilation demand minimum setpoint (VENT DMD MIN) is provided. If used, VENT DMD MIN operates only during occupied modes.

VENT DMD MIN can be controlled externally using demand control ventilation (DCV) or an indoor air quality (IAQ) program (from a field panel or PPCL). The regular minimum airflow setpoint (CLG FLOW MIN) can be set lower than VENT DMD MIN or to zero, and VENT DMD MIN can modulate in response to CO_2 or other indoor air quality ventilation requirements.

Note that the control maximum flow setpoints are not affected by VENT DMD MIN.

NOTE:
If using optional occupancy sensor, the occupied minimum airflow is defined as above when OCC STBY = NO. When OCC STBY = YES (occupied mode but no one in the zone), the occupied minimum airflow will be set to NGT FLOW MIN.

Night Flow Minimum

Some applications do not provide separate occupied and unoccupied minimum airflow setpoints. For day operation in these applications, the minimum flow setpoints were designed for minimum cooling and ventilation or to make sure TOT FLOW MIN was being provided. At night the air handling unit was typically not running, making night/unoccupied airflow setpoints unnecessary.

In application 2167, using the additional flow setpoint (NGT FLOW MIN) in place of TOT FLOW MIN addresses this limitation. Since the flow during unoccupied times does not need to address the ventilation needs for personnel, it can be set below other minimums or to zero. The configured maximum heating and cooling flow setpoints will still be used when the zone temperature exceeds (goes out of bounds) the night cooling or heating setpoints.

Control Loops

The dual duct is controlled by four Proportional, Integral, and Derivative (PID) control loops: two temperature loops and two flow loops.

Temperature Loops – The two temperature loops are a cooling loop and a heating loop. The active temperature loop maintains CTL STPT. See Control Temperature Setpoints.

Flow Loops – The two flow loops are a cooling flow loop and a heating flow loop.

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

NOTE:
The following guidelines apply to the control flow setup points, CLG FLOW MAX, HTG FLOW MAX, TOT FLOW MIN and VENT DMD MIN:

- Do not set CLG FLOW MAX to 0 cfm (0 lps).
- The value of TOT FLOW MIN or VENT DMD MIN must not be greater than the values of CLG FLOW MAX or HTG FLOW MAX.
- If desired, CLG FLOW MAX, HTG FLOW MAX, and TOT FLOW MIN may be set equal to each other.

Cooling Operation

The output of the cooling loop (CLG LOOPOUT) is used to calculate the setpoint for the cooling flow loop (CLG FLO STPT).

Day Cooling Operation

During day cooling, CLG FLO STPT is based on CLG LOOPOUT 0 to 100%, as scaled from CLG FLOW MIN to CLG FLOW MAX.

If an optional occupancy sensor is being used, and OCC STBY = YES (no one in the zone), CLG FLO STPT is scaled from 0 cfm to CLG FLOW MAX (the temperature setpoint will remain DAY CLG STPT). The optional offset STBY OFFSET can be used to provide a small raise in cooling and drop in heating day setpoints when OCC STBY = YES. See *Optional Occupied Standby CLG / HTG Setpoints* for more information.

Additional Airflow from Hot Duct

During day cooling, if the airflow out of the cold duct is not enough to satisfy TOT FLOW MIN or VENT DMD MIN (whichever is greater), then the hot duct must make up the difference. In this case, the flow setpoint for the hot duct (HTG FLO STPT) will be based on the following difference value:

- (TOT FLOW MIN or VENT DMD MIN, whichever is greater) minus CLG VOLUME

In this way, the hot duct makes up any deficit airflow volume not being supplied by the cold duct, so that the dual duct box will always provide an airflow volume that is at least equal to TOT FLOW MIN or VENT DMD MIN (whichever is greater).

See the following table for examples of how the cold duct and hot duct airflow setpoints relate to TOT FLOW MIN, CLG FLOW MIN and VENT DMD MIN during day cooling. The table includes the following points:

- CLG VOLUME: the measured airflow volume out of the cold duct
- TOT FLOW MIN: the minimum airflow setpoint for the dual duct box
- CLG FLOW MIN: a configurable minimum occupied airflow setpoint
- VENT DMD MIN: a configurable Ventilation Demand Minimum setpoint
- CLG FLO STPT: the cold duct airflow setpoint
- HTG FLO STPT: the hot duct airflow setpoint

Day Cooling mode – additional airflow from Hot Duct
(values in cfm)

IF					THEN
CLG VOLUME	TOT FLOW MIN	CLG FLOW MIN	VENT DMD MIN	CLG FLO STPT	HTG FLO STPT
320	220	0	0	320	0(1)
220	220	220	380	220	160(2)
340	440	320	420	400	100(3)
400	440	320	420	400	40(4)

1) In this example, the cooling load is calling for 320 cfm of cooling air (CLG FLO STPT), and the cold duct damper has been modulated to provide that amount (CLG VOLUME = 320). Since CLG VOLUME is greater than TOT FLOW MIN (and since VENT DMD MIN is 0), no additional airflow is needed and the hot duct damper is allowed to close (HTG FLO STPT = 0).

2) VENT DMD MIN (380) minus CLG VOLUME (220) = 160 cfm.

In this example, both TOT FLOW MIN and CLG FLOW MIN have been left at default. There is no cooling demand, so the cold duct delivers the CLG FLOW MIN default (220 cfm). However, VENT DMD MIN is being controlled externally using a demand control ventilation (DCV) program, and has risen in response to an increase in CO_2. VENT DMD MIN is now calling for a minimum of 380 cfm, so the hot duct must make up the 160 cfm airflow deficit not being supplied by the cold duct.

3) TOT FLOW MIN (440) minus CLG VOLUME (340) = 100 cfm.

In this example, TOT FLOW MIN has been set to 440 cfm. The cooling load is requesting 400 cfm of cooling air (CLG FLO STPT), but the cold duct damper is in transition (or unable for some reason to provide the requested volume) and the measured airflow (CLG VOLUME) equals only 340 cfm. The total combined flow of warm and cold air from the dual duct box must be at least 440 cfm (TOT FLOW MIN). Therefore the hot duct setpoint (HTG FLO STPT) has been set to 100 cfm to make up the difference.

4) TOT FLOW MIN (440) minus CLG VOLUME (400) = 40 cfm.

In this example, the cold duct damper has caught up with the previous example’s call for cooling, and is satisfying the CLG FLO STPT with 400 cfm as measured from the cold duct (CLG VOLUME). However, TOT FLOW MIN is still set to 440, so the hot duct setpoint is attempting to make up the 40 cfm difference.

Night Cooling Operation

At night, CLG FLO STPT is based on CLG LOOPOUT 0 to 100%, as scaled from 0 cfm to CLG FLOW MAX. The temperature setpoint will be NGT CLG STPT.

During night cooling, NGT FLOW MIN is used for the combined hot duct / cold duct flow minimum instead of TOT FLOW MIN or VENT DMD MIN. If the airflow out of the cold duct is not enough to satisfy NGT FLOW MIN, then the hot duct must make up the difference. In this case, HTG FLO STPT will equal NGT FLOW MIN minus CLG VOLUME.

Heating Operation

The output of the heating loop (HTG LOOPOUT) is used to calculate the setpoint for the heating flow loop (HTG FLO STPT).

Day Heating Operation

During day heating, HTG FLO STPT is based on HTG LOOPOUT (typically 0 to 100%), as scaled from 0 cfm to HTG FLO MAX. The portion of HTG LOOPOUT used depends on FLOW START and FLOW END. If auxiliary heat is not used, these points are typically left at default.

If optional auxiliary heat is used, the heating flow loop can work in sequence, parallel, or overlapping with the auxiliary heat for space temperature control. See *Sequencing Logic* and *Optional Auxiliary Heat* for more information.

If an optional occupancy sensor is used, then the optional offset STBY OFFSET can be used to provide a small raise in cooling and drop in heating day setpoints when OCC STBY = YES. See *Optional Occupied Standby CLG / HTG Setpoints* for more information.

Additional Airflow from Cold Duct

During day heating, if the airflow out of the hot duct (HTG VOLUME) is not enough to satisfy TOT FLOW MIN or VENT DMD MIN (whichever is greater), then the cold duct must make up the difference. In this case, the flow setpoint for the cold duct (CLG FLO STPT) will be based on the larger of:

- CLG FLOW MIN*
  or
- (TOT FLOW MIN or VENT DMD MIN, whichever is greater) minus HTG VOLUME

In this way, the cold duct makes up any deficit airflow volume not being supplied by the hot duct, so that the dual duct box will always provide an airflow volume that is at least equal to TOT FLOW MIN or VENT DMD MIN, whichever is greater.

*Note: CLG FLOW MIN is a constant airflow value regardless of whether it is needed to provide deficit airflow. In other words, even if HTG VOLUME is equal or greater than TOT FLOW MIN or VENT DMD MIN, CLG FLOW MIN will still provide additional airflow out of the cold duct. CLG FLOW MIN, when set to a value greater than zero, provides a steady minimum flow during occupied modes.

See the following table for examples of how the hot duct and cold duct airflow setpoints relate to TOT FLOW MIN, CLG FLOW MIN and VENT DMD MIN during day heating. The table includes the following points:

- HTG VOLUME: the measured airflow volume out of the hot duct
- TOT FLOW MIN: the minimum airflow setpoint for the dual duct box
- CLG FLOW MIN: a configurable minimum occupied airflow setpoint
- VENT DMD MIN: a configurable Ventilation Demand Minimum setpoint
- HTG FLO STPT: the hot duct airflow setpoint
- CLG FLO STPT: the cold duct airflow setpoint

Day Heating mode – additional airflow from cold Duct (values in cfm)

IF					THEN
HTG VOLUME	TOT FLOW MIN	CLG FLOW MIN	VENT DMD MIN	HTG FLO STPT	CLG FLO STPT
400	300	0	280	400	0(1)
350	300	0	450	350	100(2)
160	400	200	0	100	240(3)
300	400	220	200	300	220(4)

1) In this example, CLG FLOW MIN has been set to 0, and HTG VOLUME (400 cfm) is more than enough to satisfy TOT FLOW MIN or VENT DMD MIN, so no additional airflow is needed from the cold duct.

2) VENT DMD MIN (450) minus HTG VOLUME (350) = 100 cfm.

In this example, the 350 cfm HTG VOLUME is more than enough to satisfy TOT FLOW MIN, but VENT DMD MIN is calling for 450 cfm and the cold duct must make up the 100 cfm difference not being supplied by the hot duct.

3) TOT FLOW MIN (400) minus HTG VOLUME (160) = 240 cfm.

In this example, TOT FLOW MIN has been set to 400 cfm. The heating load is requesting 100 cfm of heating air (HTG FLO STPT), but the hot duct damper is in transition (or unable for some reason to reduce flow to the requested volume) and the measured airflow (HTG VOLUME) equals 160 cfm. The total combined flow of warm and cold air from the dual duct box must be at least 400 cfm (TOT FLOW MIN). Therefore the cold duct setpoint (CLG FLO STPT) has been set to 240 cfm to make up the difference.

4) Cold duct airflow = CLG FLOW MIN (220 cfm).

In this example, the hot duct airflow (HTG VOLUME 300 cfm) needs only 100 more cfm from the cold duct to satisfy TOT FLOW MIN (400 cfm). But CLG FLOW MIN has been set to 220 cfm, so that is what CLG FLO STPT is set to. In this case, the total flow from the dual duct box is greater than TOT FLOW MIN: HTG FLO STPT (300 cfm) + CLG FLOW MIN (220 cfm) = 520 cfm

Night Heating Operation

At night, HTG FLO STPT is based on HTG LOOPOUT as scaled from 0 cfm to HTG FLO MAX. The temperature setpoint will be NGT HTG STPT.

During night heating, NGT FLOW MIN is used for the combined hot duct / cold duct flow minimum instead of TOT FLOW MIN or VENT DMD MIN. If the airflow out of the hot duct is not enough to satisfy NGT FLOW MIN, then the cold duct must make up the difference. In this case, CLG FLO STPT will equal NGT FLOW MIN minus HTG VOLUME.

Optional Auxiliary Heat

If AUX HTG USED = YES, this application also controls auxiliary heat. The value of AUX HTG TYPE indicates the type of auxiliary heat control.

CAUTION

If using electric heat, verify that the equipment is supplied with safeties by others to ensure that there is airflow across the heating coils when they are to be energized or equipment damage may result.

Do not set TOT FLOW MIN to zero.

Hot Water Auxiliary Heat – If AUX HTG TYPE = HW, the application controls auxiliary hot water heat. The heating loop modulates the heating valve point, VALVE COMD in order to warm the space. When the controller is in cooling mode, the heating valve is closed.

Electric Auxiliary Heat – If AUX HTG TYPE = ELEC, the heating loop controls up to three stages of electric reheat to warm up the room. The electric reheat is time modulated using a duty cycle as shown in the following example. When the controller is in cooling mode, the electric heat is OFF at all times. STAGE COUNT must be set equal to the number of stages of electric reheat being used.

Example

If the duty cycle is 10 minutes (STAGE TIME = 10 minutes) and the heating loop is calling for 60% of heating (HTG LOOPOUT = 60%), for every 10-minute period, the stages of electric auxiliary heat cycle as follows:

	Stage 1: minutes		Stage 2: minutes		Stage 3: minutes	
	ON	OFF	ON	OFF	ON	OFF
With 1 stage of electric heat:	6	4	--	--	--	--
With 2 stages of electric heat:	10	0	2	8	--	--
With 3 stages of electric heat:	10	0	8	2	0	10

NOTE:
If three stages of electric heat are used, Autozero Modules cannot be used. If two stages or less are used, Autozero Modules can be used.

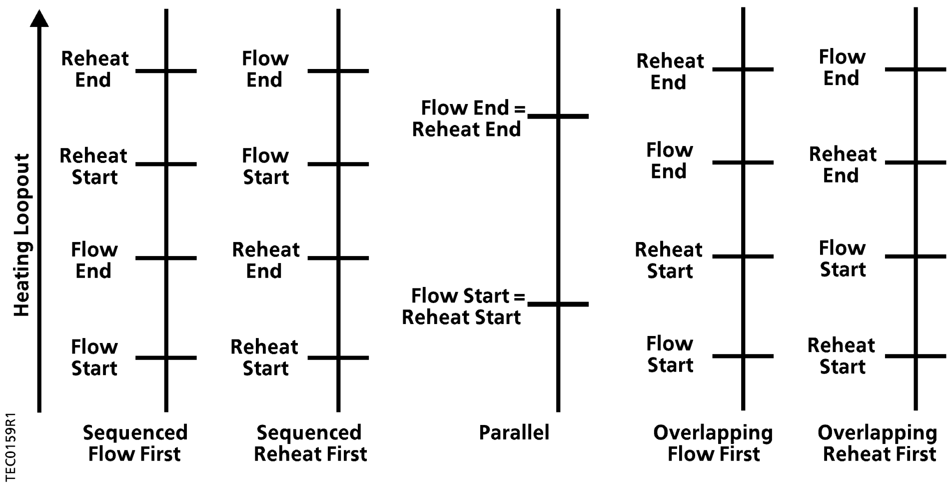
Sequencing Logic

In heating mode, this application includes logic that allows the flow loop to operate either in sequence, parallel, or overlapping with the auxiliary reheat. This algorithm is very similar to the spring range sequencing of valves and dampers. Portions of the output of the heating loop, HTG LOOPOUT, will drive both the flow loop setpoint and the auxiliary heat (if used) from 0 to 100%.

For simplicity, assumethe following:

- TOT FLOW MIN = 0 cfm
- CLG FLOW MIN = 0 cfm
- AUX HTG USED = YES
- AUX HTG TYPE = HW

The ladder diagrams show sequenced, parallel, and overlapping flow loop operations with heating stages. 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.



Example 1 (Airflow Sequenced First)

Assume that your system has a hot water valve that is to operate in sequence with the flow loop. If:

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

then,

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

Example 2 (Airflow and Heat Sequenced Together)

Assume that your system has a hot water valve that is to operate in parallel with the flow loop. If:

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

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

then,

- When HTG LOOPOUT = 0%, HTG FLO STPT will equal 0% flow.
- When HTG LOOPOUT = 50%, HTG FLO STPT will equal 50% flow.
- When HTG LOOPOUT = 100%, HTG FLO STPT will equal 100% flow.
- When HTG LOOPOUT = 0%, VALVE COMD will equal 0% open.
- When HTG LOOPOUT = 50%, VALVE COMD will equal 50% open.
- When HTG LOOPOUT = 100%, VALVE COMD will equal 100% open.

Example 3 (Airflow Sequenced First with Overlap for Heating)

Assume that your system has a hot water valve that is to operate overlapping with the flow loop. If:

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

then,

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

Another option that the sequencing logic provides is to have the flow loop provide an airflow equal to TOT FLOW MIN throughout the heating mode with all of the temperature control being done by the hot water valve(s). The airflow minimum will be maintained by setting the FLOW START and FLOW END to 0% which will cause HTG FLO STPT to hold the value corresponding to minimum flow throughout the entire heating mode, regardless of the value of HTG LOOPOUT.

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.

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.

The Autozero Modules are used during calibration when they are wired to DO 7 and DO 8 and CAL MODULE = YES.

NOTE:
The first time after startup or initialization, the controller will calibrate the dampers as if not using Autozero Module(s), although the Autozero Module(s) will be activated. All subsequent calibrations will use the Autozero Module(s) only.

If auxiliary hot water heating is used, calibration of the valve is not affected by the presence of Autozero Modules.

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 point (values are additive). Configuration will differ depending on the type of room unit (stat) being used. (Note: If the room unit is analog, STAT SUPV is used **only** to specify thermistor inputs as 10K or 100K.Therefore for analog room units the only values possible for STAT SUPV are 0, 8, or 16. See the table below.

If the room unit is digital, STAT SUPV defines the thermistors **and also** enables the room unit temperature, humidity and/or CO_2 points to be read by the controller. For digital room units, if a temperature, humidity, or CO_2 value (see table) is not included in the configured value for STAT SUPV, then the related point cannot be read (or ever display as failed). Conversely, if you enable supervision for a feature that the room unit does not support, then the related point will always display as failed.

Example: If you are using a digital room unit and need temperature and CO_2 sensing and a 100K thermistor on AI 5, you would set STAT SUPV = 13 (1 + 4 + 8 = 13). See the table below.

STAT SUPV Additive Values	
Value	**Description**
0 (default)	10K Ω thermistor(s)
1	Temperature sensing [1]
2	Relative Humidity (RH) sensing [1]
4	CO_2 sensing [1]
8	If short board: 100K Ω thermistor on AI 3 If long board: 100K Ω thermistor on AI 5
16	Long board only: 100K Ω thermistor on AI 4 (AI 4 must be a thermistor input, not a 0-10V/4-20 mA input.)

1) Additive values 1, 2, 4 **must not** be used with Series 1000 / 2000 analog room units.

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.

Room RH

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

Fail Mode Operation

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

If the air velocity sensor points, HTG VOLUME and CLG VOLUME are failed, the dampers are controlled in one of two ways:

- If FAIL MODE = OPEN, the controller sets CLG DMP CMD and HTG DMP CMD to 100% open.
- If FAIL MODE = CLOSED, the controller sets CLG DMP CMD and HTG DMP CMD to 0% open.

If the room temperature sensor fails, the controller operates using the last known temperature value.

Application Notes

- If the temperature swings in the room are excessive or there is trouble maintaining the setpoint, then either the cooling loop, the heating loop, or both need to be tuned. If CLG FLOW is oscillating while CLG FLO STPT is constant, then the flow loop requires tuning. If HTG FLOW is oscillating while HTG FLO STPT is constant, the heating flow loop requires tuning. See the *APOGEE Automation Service Procedures* on InfoLink for more information.
- The controller as shipped from the factory keeps all associated equipment OFF. See the *Start-up* document for 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. DO 5 and DO 6 may be used as auxiliary motor points. If using a pair of spare DOs to control a motor, you must unbundle the corresponding motor command point.

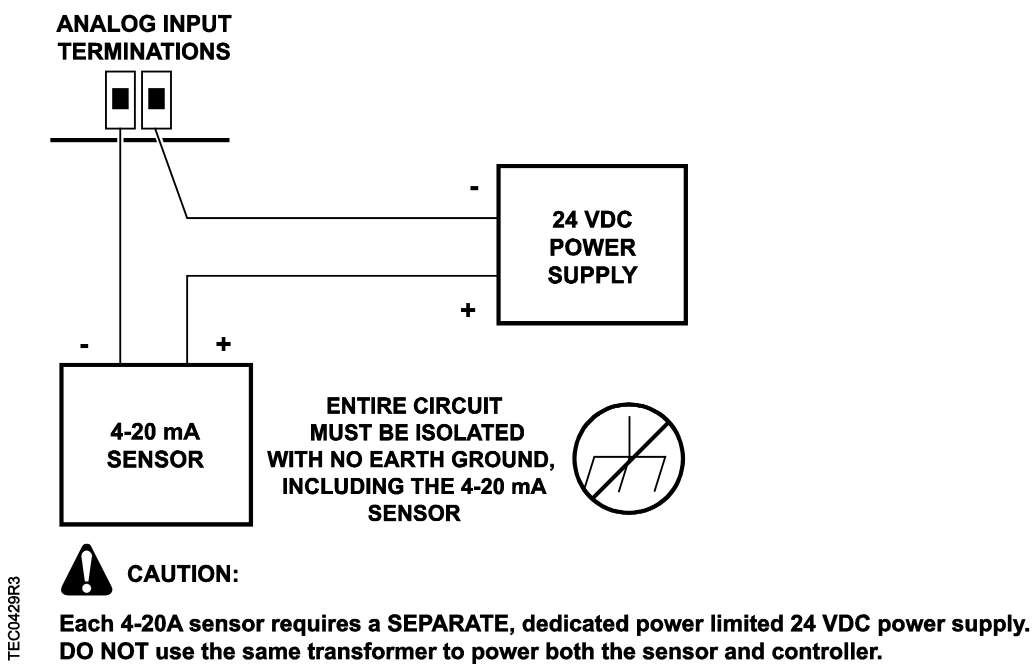
Wiring Diagrams

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:

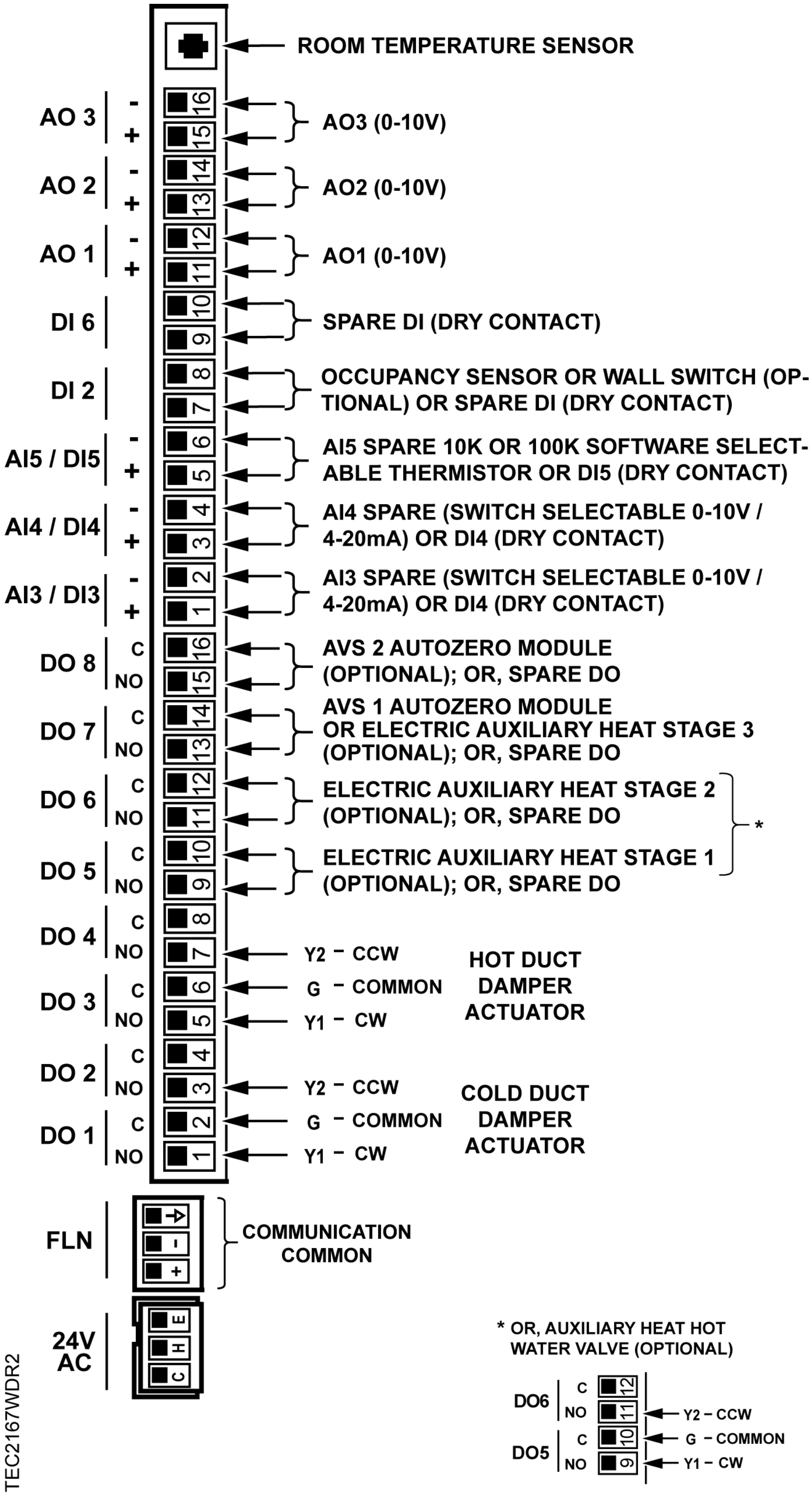
- VA requirements higher than the maximum
- 110 or 220 Vac requirements
- DC power requirements
- Separate transformers used to power the load (for example part number 540-147, Terminal Equipment Controller Relay Module)

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



Wiring for AI with a 4 to 20mA Sensor.

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



Application 2167 Wiring Diagram.

Application 2167 Point Database

Point Number [1]	Descriptor	Factory Default (SI Units)[2]	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	--	1	0	--	--
02	APPLICATION	2179	--	1	0	--	--
{04} [3]	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
{06}	DAY CLG STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{07}	DAY HTG STPT	70.0 (21.20888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{08}	NGT CLG STPT	82.0 (27.92888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{09}	NGT HTG STPT	65.0 (18.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{11}	RM STPT MIN	55.0 (12.80888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{12}	RM STPT MAX	90.0 (32.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{14}	STPT DIAL	NO	--	--	--	YES	NO
{15}	AUX TEMP AI5	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
{16}	FLOW START	0.0	PCT	0.4	0.0	--	--
{17}	FLOW END	100.0	PCT	0.4	0.0	--	--
{18}	WALL SWITCH	NO	--	--	--	YES	NO
{19}	DI OVRD SW	OFF	--	--	--	ON	OFF
{20}	OVRD TIME	0	HRS	1	0	--	--
{21}	NGT OVRD	NIGHT	--	--	--	NIGHT	DAY
{22}	REHEAT START	50.0	PCT	0.4	0.0	--	--
{23}	REHEAT END	100.0	PCT	0.4	0.0	--	--
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
{26}	HTGFLO PGAIN	0.0	--	0.05	0.0	--	--
{27}	HTGFLO IGAIN	0.018	--	0.001	0.0	--	--
{28}	HTGFLO DGAIN	0	--	2	0	--	--
{29}	DAY.NGT	DAY	--	--	--	NIGHT	DAY
{30}	HTG VOLUME	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
{32}	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{33}	TOT FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
{34}	HTG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{35}	CLG VOLUME	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
{36}	CLG FLO COEF	1.0	--	0.01	0.0	--	--
{37}	VALVE COMD	0.0	PCT	0.4	0.0	--	--
{38}	VALVE POS	0.0	PCT	0.4	0.0	--	--
{39}	MTR3 TIMING	130	SEC	1	0	--	--
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	DO 3	OFF	--	--	--	ON	OFF

Point Number [1]	Descriptor	Factory Default (SI Units)[2]	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{44}	DO 4	OFF	--	--	--	ON	OFF
{45}	DO 5	OFF	--	--	--	ON	OFF
{46}	DO 6	OFF	--	--	--	ON	OFF
{47}	DO 7	OFF	--	--	--	ON	OFF
{48}	CLG DMP CMD	0.0	PCT	0.4	0.0	--	--
{49}	CLG DMP POS	0.0	PCT	0.4	0.0	--	--
{50}	DO 8	OFF	--	--	--	ON	OFF
{51}	MTR1 TIMING	95	SEC	1	0	--	--
{52}	HTG DMP CMD	0.0	PCT	0.4	0.0	--	--
{53}	HTG DMP POS	0.0	PCT	0.4	0.0	--	--
{54}	HTG FLO COEF	1.0	--	0.01	0.0	--	--
{55}	MTR2 TIMING	95	SEC	1	0	--	--
{56}	DPR1 ROT ANG	90	--	1	0	--	--
{57}	DPR2 ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR. REV	0	--	1	0	--	--
{60}	HTGDUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0.025 (0.002323)	0.0	--	--
{63}	CLG P GAIN	20.0 (36.0)	--	0.25 (0.45)	0.0	--	--
{64}	CLG I GAIN	0.012 (0.0216)	--	0.001 (0.0018)	0.0	--	--
{65}	CLG D GAIN	0 (0.0)	--	2 (3.6)	0	--	--
{66}	CLG BIAS	50.0	PCT	0.4	0.0	--	--
{67}	HTG P GAIN	10.0 (18.0)	--	0.25 (0.45)	0.0	--	--
{68}	HTG I GAIN	0.012 (0.0216)	--	0.001 (0.0018)	0.0	--	--
{69}	HTG D GAIN	0 (0.0)	--	2 (3.6)	0	--	--
{70}	HTG BIAS	50.0	PCT	0.4	0.0	--	--
{71}	CLGFLO PGAIN	0.0	--	0.05	0.0	--	--
{72}	CLGFLO IGAIN	0.018	--	0.001	0.0	--	--
{73}	CLGFLO DGAIN	0	--	2	0	--	--
{74}	HTG FLOW	0.0	PCT	0.25	0.0	--	--
{75}	CLG FLOW	0.0	PCT	0.25	0.0	--	--
76	NGT FLOW MIN	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
77	VENT DMD MIN	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{79}	CLG LOOPOUT	50.0	PCT	0.4	0.0	--	--
{80}	HTG LOOPOUT	0.0	PCT	0.4	0.0	--	--
{81}	AVG HEAT OUT	0.0	PCT	0.4	0.0	--	--
{82}	AUX HTG USED	NO	--	--	--	YES	NO
{83}	AUX HTG TYPE	ELEC	--	--	--	ELEC	HW
{84}	DMPR STATUS	CAL	--	--	--	RECAL	CAL
{85}	HTG FLO STPT	0.0	PCT	0.25	0.0	--	--
{86}	SWITCH TIME	10	MIN	1	0	--	--
{87}	CAL MODULE	NO	--	--	--	YES	NO

Point Number [1]	Descriptor	Factory Default (SI Units)[2]	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{88}	STAGE COUNT	1	--	1	0	--	--
{89}	STAGE TIME	10	MIN	1	0	--	--
{90}	SWITCH DBAND	1.0 (0.56)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
{91}	CLG FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{93}	CLG FLO STPT	0.0	PCT	0.25	0.0	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
{95}	CAL SETUP	4	--	1	0	--	--
{96}	CAL TIMER	12	HRS	1	0	--	--
{97}	CLGDUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0.025 (0.002323)	0.0	--	--
{98}	LOOP TIME	5	SEC	1	0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--
{102}	AOV 1	0.0	VOLTS	0.01	0.0	--	--
{103}	AOV 2	0.0	VOLTS	0.01	0.0	--	--
{104}	AOV 3	0.0	VOLTS	0.01	0.0	--	--
{105}	AI 3	0.0	PCT	0.4	0.0	--	--
{106}	AI 4	0.0	PCT	0.4	0.0	--	--
{107}	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	0.25 (0.14)	-31.75(-17.78)	--	--
{108}	DI 4	OFF	--	--	--	ON	OFF
{109}	DI 5	OFF	--	--	--	ON	OFF
{110}	DI 6	OFF	--	--	--	ON	OFF
111	OCC SWITCH	NO	--	--	--	YES	NO
{112}	OCC STBY	NO	--	--	--	YES	NO
113	STBY OFFSET	0.0 (0.0)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
{124}	STAT SUPV	0	--	1	0	--	--
{125}	RM CO2	1000	PPM	1	0	--	--
{126}	RM RH	50.0	PCT	0.4	0.0	--	--

1) Points not listed are not used in this application.

2) A single value in a column means that the value is the same in English units and in SI units.

3) Point numbers that appear in brackets { } may be unbundled at the field panel.

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Building Technologies Division
1000 Deerfield Pkwy
Buffalo Grove IL 60089
Tel. +1 847-215-1000

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