P1 TEC

VAV with 0-10V Series-Fan Speed Output, Occupancy Sensor and 3-Stage Electric Heat

Building Technologies

Table of Contents

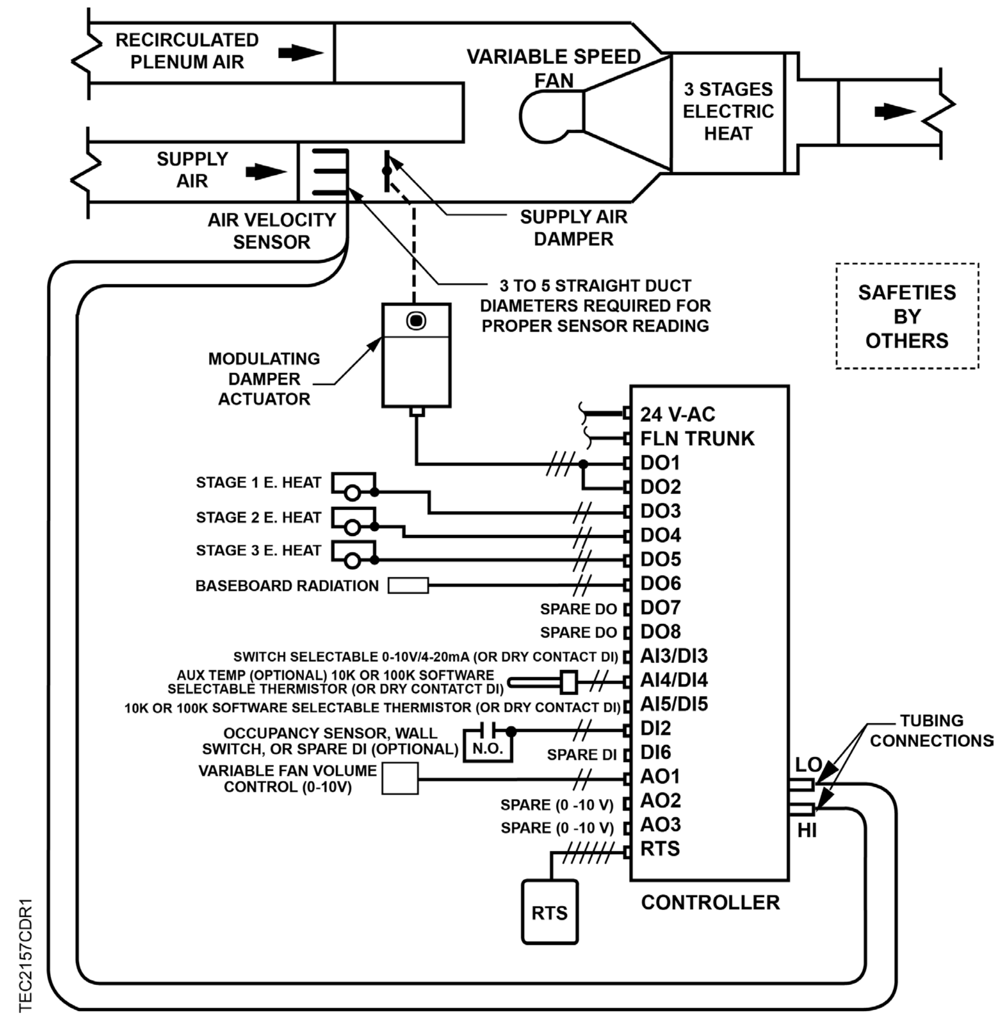
Overview 4
Hardware Inputs 9
Hardware Outputs 9
Ordering Notes 9
Sequence of Operation 10
Definition of MODE Point 10
Summary of Equipment Action During Different Optional Modes 10
Occupied and Unoccupied Modes 12
Occupancy Sensor 12
Unoccupied Mode Override Switch 14
Control Temperature Setpoints 14
  Optional Occupied Standby HTG / CLG Setpoints 16
Room Temperature, Room Temperature Offset and CTL TEMP 16
Heating/Cooling Switchover 16
Ventilation Demand Minimum 17
Night Flow Minimum 17
Control Loops 18
Electric Heat 20
Fan Operation 25
  Fan Flow 25
  FAN AOV1 32
Warm-Up Mode 33
Baseboard Radiation 33
Flow Temperature Alarm 34
Calibration 34
Fail Mode Operation 34
Room Unit Operation 35
  Stat Supervision 35
  CO2 Monitoring 35
  Room RH 35
Application Notes 36
Wiring Diagram 36
Application 2157 Point Database 39

Overview

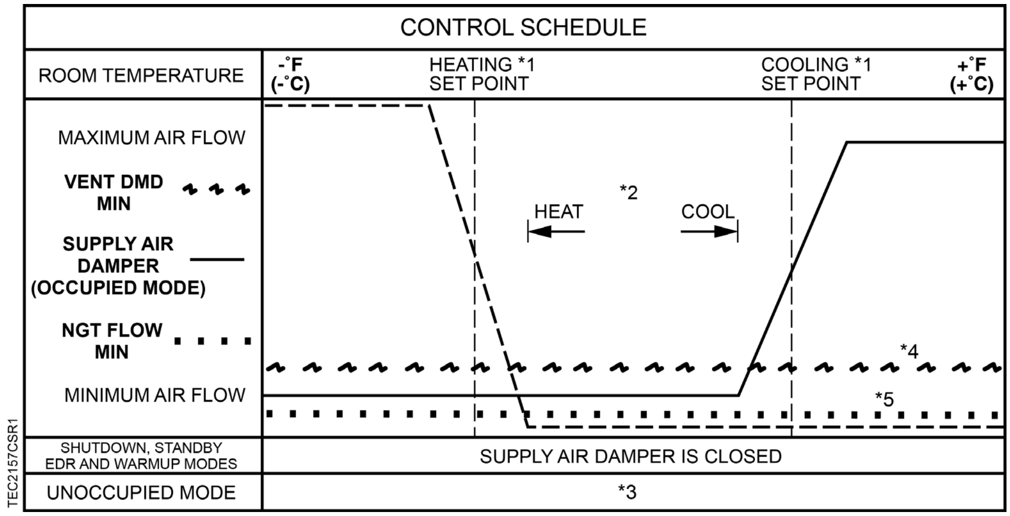
In Application 2157, the supply air damper of the terminal box is modulated for cooling, and up to three stages of electric heat are controlled for heating. When in heating, the terminal box will typically be setup to maintain a minimum airflow out of the supply air duct or can be configured to provide modulating supply air flow. The terminal box also has a variable air volume series fan for air circulation (an option exists to run this series fan at constant volume). In order for the terminal box to work properly for cooling, the central air handling unit must provide supply air.

Certain control features of Application 2157 depend on whether the central air handling unit is ON or OFF. Application 2157 monitors VAV AHU for this information. Application 2157 does not command VAV AHU — it only reacts to it. To command VAV AHU, it must be unbundled at the field panel and PPCL must be written for it.

FAN MODE has two possible settings, CONST or VARI (constant or variable—the default = VARI). It is configurable during controller start-up and can also be overwritten by the customer during operation.



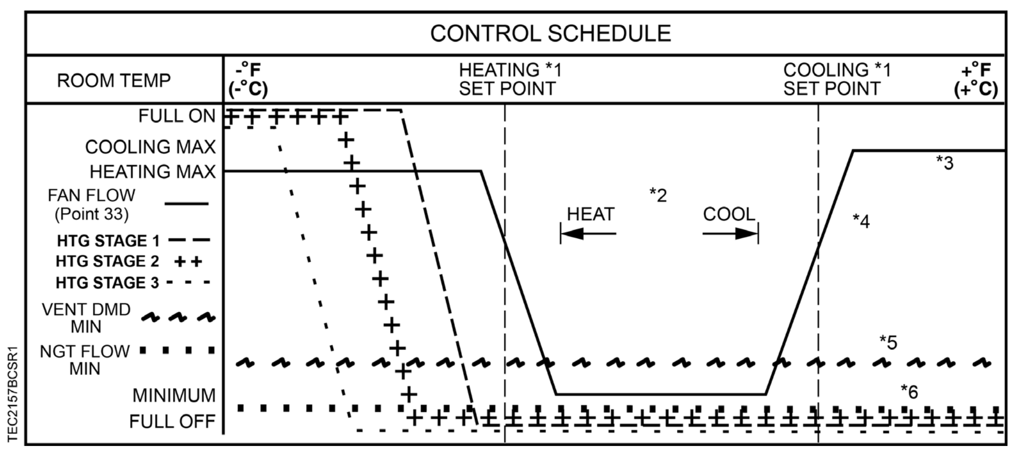
Application 2157 Control Diagram.



Application 2157 Supply Air Damper Control Schedule with HTG FLOW MAX = CLG FLOW MIN.

NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. If NGT FLOW MIN has been set to 0, the supply damper remains closed in the unoccupied mode unless the room temperature rises above TEMP HLIMIT while VAV AHU = ON. If this happens (room temp > TEMP HLIMIT) then the supply damper is controlled as in the occupied cooling mode for as long as HEAT.COOL stays equal to COOL and VAV AHU remains ON. (See note 4 in the Application Notes section for more information on VAV AHU.) If NGT FLOW MIN > 0, then the fan will be ON during unoccupied mode if the primary airflow is greater than 50% of the NGT FLOW MIN setting.
4. VENT DMD MIN can be set above, equal to, or below the cooling minimum flow setpoint (CLG FLOW MIN) and can be controlled (reset) externally for ventilation demands. During occupied modes, minimum airflow will be the larger of CLG FLOW MIN and the ventilation demand flow setpoint VENT DMD MIN.
5. NGT FLOW MIN can be set equal or below CLG FLOW MIN, or to zero, to be used for minimum flow during night modes.



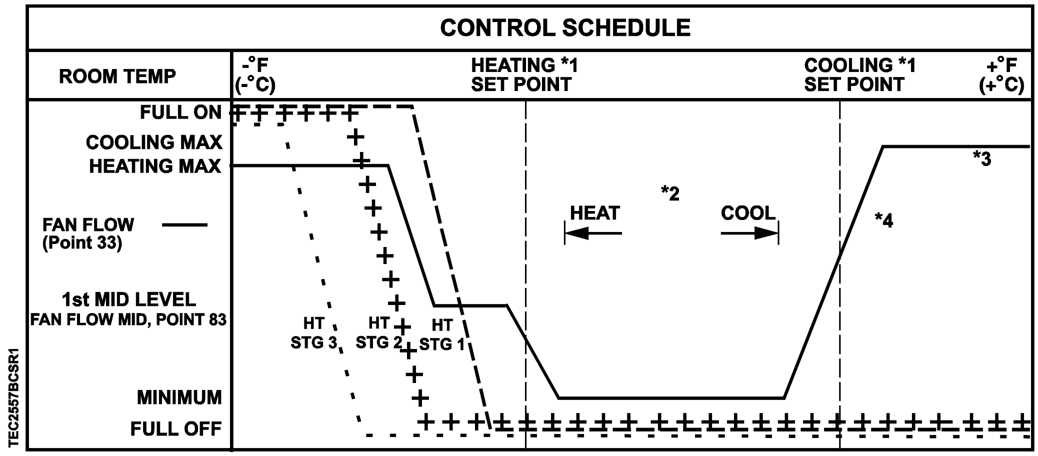
Application 2157 FAN FLOW control and up to 3 Stages of Electric Heat Operation in Occupied Mode.

Heating Option 1: The application has been set up so that no stage of electric heat can turn ON until the airflow out of the fan is at FAN FLO HMAX.

NOTES:
1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. **Occupied Mode** — If FAN MODE = CONST, FAN FLOW remains at the highest possible maximum flow (FAN FLO CMAX) throughout the entire occupied mode.
4. To regulate fan speed, Application 2157 uses **FAN FLOW** and embedded table statements to modulate the voltage of FAN AOV1. The particular table statement used depends on the box size or custom configuration. The following describes the operation of the fan and electric heat during the controller's other modes:
Shutdown Mode — The fan (see note 7) and electric heating stages are OFF.
Unoccupied Mode — See note 8 for fan operation. See note 9 for operation of heating stages.
Electrical Demand Reduction (EDR) Mode — The fan is controlled as in the occupied heating mode. The heating stages are OFF.
Standby Mode — Both the fan and first heating stage are controlled as in the occupied heating mode. The second and third heat stages remain OFF.
Warm-up Mode — Both the fan and the heating stages are controlled as in the occupied heating mode.
5. **VENT DMD MIN** (ventilation demand flow setpoint) — VENT DMD MIN can be set above, equal to, or below CLG FLOW MIN and can be controlled (reset) externally for occupied ventilation demands. Minimum airflow will be the larger of CLG FLOW MIN and VENT DMD MIN.
6. **NGT FLOW MIN** can be set equal or below CLG FLOW MIN, or to zero, to be used for minimum flow during night modes.
7. FAN FLOW is set to 0 in shutdown mode, provided that all of the electric heating stages have been off for at least 30 seconds. If all of the electric heating stages have not been off for at least 30 seconds, then the fan's airflow remains where it was before the shutdown mode was entered. When FAN FLOW = 0, the fan is completely OFF.
8. During unoccupied mode the fan stays OFF* (see note) if the room temperature remains between TEMP LLIMIT and TEMP HLIMIT, provided that all of the electric heating stages have been off for at least 30 seconds. If all of the electric heating stages have not been off for at least 30 seconds, then the fan's airflow remains where it was before the unoccupied mode was entered. If the room temperature drops below TEMP LLIMIT, the fan is controlled like it is during occupied heating for the remainder of the unoccupied mode. If the room temperature rises above TEMP HLIMIT—and VAV AHU is ON—the fan is controlled like it is during occupied cooling for the remainder of the unoccupied mode. (See note 4 in the Application Notes section for more information on VAV AHU.)

***NOTE:** NGT FLOW MIN must equal zero for the fan to stay OFF during unoccupied mode. If NGT FLOW MIN > 0 during unoccupied mode, the fan will be ON if the primary airflow is greater than 50% of the NGT FLOW MIN setting.

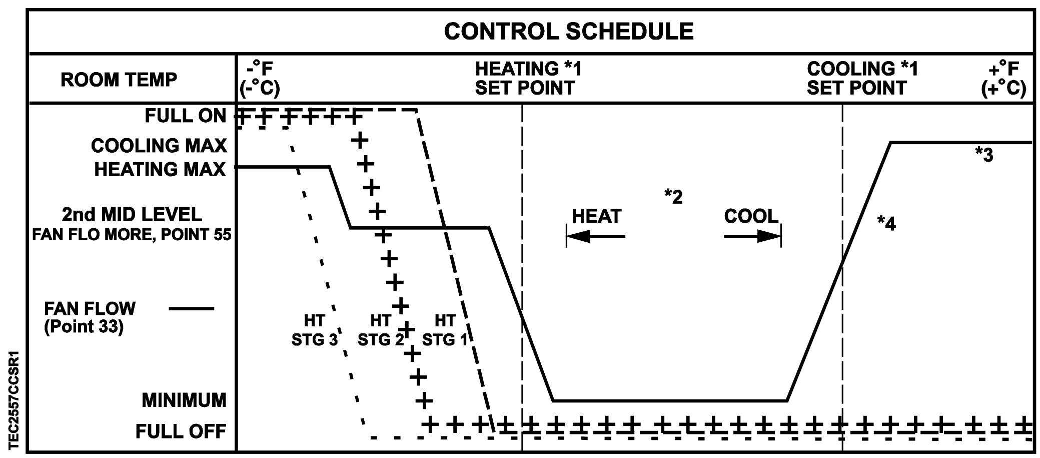
9. In the unoccupied mode, the electric heat stages remain OFF unless the room temperature drops below TEMP LLIMIT. If this occurs, the electric heat stages are controlled like they are during occupied heating for the remainder of the unoccupied mode.
10. Regardless of the operational mode, the application will shut off all stages of electric heat if FAN FLOW is 0, even if the electric heat stages were overridden to ON. In other words, the application prevents any electric heating stages to be ON when there is no airflow coming out of the fan.



Application 2157 Fan and up to 3 Stages of Electric Heat Operation in Occupied Mode.

Heating Option 2: The application has been set up so that the first stage cannot start until the fan flow is at the mid level setpoint (FAN FLOW MID), and the remaining stages cannot start until the fan flow is at FAN FLO HMAX.

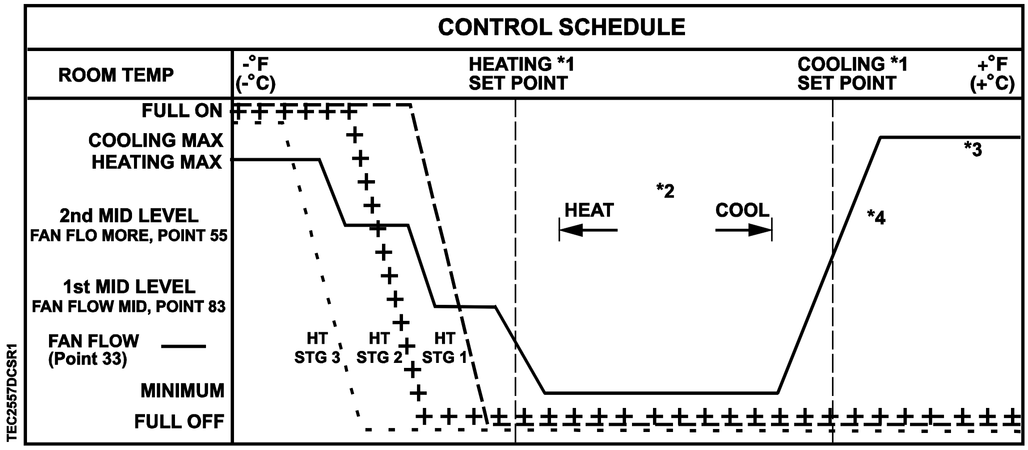
Although VENT DMD MIN and NGT FLOW MIN are not shown in this illustration, these optional flow levels operate as described in the illustration notes for Heating option 1.



Application 2157 Fan and up to 3 Stages of Electric Heat Operation in Occupied Mode.

Heating Option 3: The application has been set up so that stages 1 and 2 of electric heat cannot turn ON until the airflow out of the fan is at FAN FLOW MORE and the third stage cannot turn ON until the fan is at FAN FLO HMAX. (Set FAN FLOW MID = FAN FLOW MORE.)

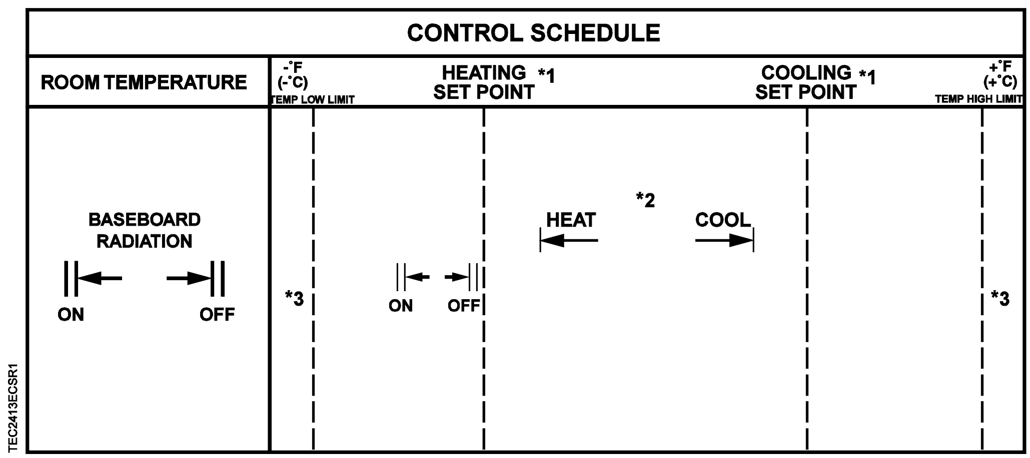
Although VENT DMD MIN and NGT FLOW MIN are not shown in this illustration, these optional flow levels operate as described in the illustration notes for Heating option 1.



Application 2157 Fan and up to 3 Stages of Electric Heat Operation in Occupied Mode.

Heating Option 4: The application has been set up so that stage 1 electric heat cannot turn ON until the airflow of the fan is at FAN FLOW MID, stage 2 cannot turn on until the airflow of the fan is at FAN FLOW MORE and stage 3 cannot turn on until the fan flow is at FAN FLO HMAX.

Although VENT DMD MIN and NGT FLOW MIN are not shown in this illustration, these optional flow levels operate as described in the illustration notes for Heating option 1.



Application 2157 Baseboard Radiation Operation in Unoccupied Mode.

NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. The baseboard radiation remains OFF for the remainder of the unoccupied period if the room temperature drops below TEMP LLIMIT or rises above TEMP HLIMIT. (If the room temperature drops below TEMP LLIMIT, the regular heating stage(s) are then controlled in order to maintain room temperature.)
4. Baseboard radiation is allowed ON only during unoccupied mode (see *Baseboard Radiation* section for more information).

Hardware Inputs

Analog

- Airflow sensor
- Room temperature sensor
- Room temperature setpoint dial (optional)
- Auxiliary temperature sensor (100K or 10K selectable thermistor, optional)
- Spare temperature sensor (100K or 10K selectable thermistor, optional)
- Spare 0-10V or 4-20 mA (optional)

Digital

- Night/Unocc mode override (optional)
- Wall switch (optional)
- Occupancy sensor (optional)

Hardware Outputs

Analog

- Fan AOV
- Spare 0-10 Vdc AO (two)

Digital

- Damper actuator
- Stage 1 electric heat (optional)
- Stage 2 electric heat (optional)
- Stage 3 electric heat (optional)
- Baseboard radiation (optional)
- Spare DOs (two)

Ordering Notes

540-865DMD	Application 2157: Siemens VAV with 0-10V Series-Fan Speed Output, Occupancy Sensor and 3-Stage Electric Heat

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2157, Siemens VAV with 0-10V Series-Fan Speed Output, Occupancy Sensor and 3-Stage Electric Heat.

Definition of MODE Point

The DAY.NGT point is not used. A virtual AO point (MODE, Point 3) is used instead.

The *MODE Point* table shows the values that MODE can have, as well as the names of the modes that correspond to these different values.

MODE Point	
Value of MODE point	**Corresponding Mode**
0	Shutdown Mode
10	Unoccupied Mode
20	Electric Demand Reduction Mode (EDR)
30	Standby Mode
60	Occupied Mode

NOTE:
For the rest of this document, the names of modes will be used instead of numeric values (for example, MODE = Standby instead of MODE = 30). This should make the application easier to understand.

In addition to the indicated modes, this application will vary flow control depending on OCC STBY. When an optional occupancy sensor is enabled during occupied mode and no one is present in the zone, OCC STBY will be set to YES (occupied standby), reducing airflow to a configurable minimum flow level. See *Occupancy Sensor*.

Summary of Equipment Action During Different Optional Modes

The following table provides a brief summary of equipment actions during the different operational modes. Full descriptions of detailed interactions between equipment pieces are provided in the related sections of the text.

Summary of Equipment Action During Different Operational Modes					
Operational Modes	**Fan constant volume configuration**	**Fan variable volume configuration**	**Supply Damper**	**Electric Heat** [(a)]	**Baseboard Radiation**
Shutdown	OFF [(b)]	OFF [(b)]	Closed	OFF	OFF
Unoccupied [(c)] Room temp stays between TEMP LLIMIT and TEMP HLIMIT	OFF [(b)]	OFF [(b)]	Closed	OFF	See [(d)]
Unoccupied Heating [(e)] Room temp has dropped below TEMP LLIMIT	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on heating demand	Closed	See [(f)]	OFF
Unoccupied Cooling [(g)] Room temp has risen above TEMP HLIMIT	At max flow if VAV AHU is ON. (OFF if VAV AHU is OFF) See [(b)]	See [(h)]	See [(i)]	OFF	OFF
Electrical Demand Reduction (EDR)	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on heating demand	Closed	OFF	OFF
Standby	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on heating demand	Closed	1st stage is time modulated based on heating demand. 2nd and 3rd stages remain OFF.	OFF
Warm-up Occurs, if needed, at start of occupied mode	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on heating demand	Closed	See [(f)]	OFF
Occupied Heating	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on heating demand	Provides minimum airflow for ventilation	See [(f)]	OFF
Occupied Cooling		Modulates from min to max flow based on cooling demand	Modulates from min to max flow based on cooling demand	OFF	

(a) Regardless of the operational mode, the application will shut off all stages of electric heat if FAN FLOW is 0, even if the electric heat stages were overridden to ON. In other words, the application will not allow any electric heating stages to be ON when there is no airflow coming out of the fan.

(b) The fan will be OFF only after all of the electric heating stages have been OFF for at least 30 seconds. If all of the electric heating stages have not been OFF for at least 30 seconds, then the fan's airflow remains where it was before this condition was entered.

(c) Since the unoccupied mode is more complex than the other modes, three separate table rows are used to make it easier to understand. "Unoccupied," as described in this table, means that the room temperature never goes outside the range of TEMP LLIMIT to TEMP HLIMIT. Notes 2 (*Control Temperature Setpoints*(and 3 (*Heating/Cooling Switchover*) (for Unoccupied Heating and Cooling, respectively) summarize what happens if it does leave this range.

(d) Baseboard radiation is OFF in the unoccupied mode if HEAT.COOL equals COOL. If HEAT.COOL equals HEAT, the baseboard radiation cycles to maintain the room temperature at CTL STPT.

(e) Once the room temperature drops below TEMP LLIMIT, this sequence of operation remains in effect for the remainder of the entire unoccupied period so long as the room temperature never rises as high as TEMP HLIMIT.

(f) During all heating modes (warm-up, occupied heating, and unoccupied heating), the 1st Stage, 2nd Stage and 3rd Stage of electric heat are time modulated based on heating demand.

(g) Once the room temperature rises above TEMP HLIMIT, this sequence of operation remains in effect for the remainder of the entire unoccupied period so long as the room temperature never falls all the way down to TEMP LLIMIT.

(h) If VAV AHU is ON during unoccupied cooling, the fan — when configured for variable volume operation — modulates from minimum to maximum flow based on cooling demand. The fan is OFF during unoccupied cooling if VAV AHU is OFF, provided that all of the electric heating stages have been off for at least 30 seconds. If all of the heating stages have not been OFF for at least 30 seconds, then the fan's air volume (FAN FLOW) remains where it was before VAV AHU shut OFF.

(i) If VAV AHU is ON during unoccupied cooling, the supply damper modulates from minimum to maximum flow based on cooling demand. The supply damper is closed during unoccupied cooling if VAV AHU is OFF.

Occupied and Unoccupied Modes

The operational status of the space is determined by the MODE 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), MODE will be set to occupied. When DI 2 is OFF (switch is open), MODE will be set to unoccupied.

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 occupied 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 MODE. 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 MODE, OCC STBY (occupied standby) will also affect control if an optional occupancy sensor is being used. OCC STBY works in conjunction with MODE 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 the primary and terminal fan air flows 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 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	MODE	DI2	OCC STBY	Airflow minimum	Temp. control	
= NO **Note** WALL SWITCH must equal NO for occupancy sensor option.	= YES	= 60 (Occupied)	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	
		= 10 (Unoccupied)	Status of DI2 does not affect control	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	
	= NO	= 60 (Occupied)	Status of DI2 does not affect control	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	
		= 10 (Unoccupied)	Status of DI2 does not affect control	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	
= YES	na (ignored)	= 60 (Occupied)	ON	= NO	Minimum airflow setpoint, larger of VENT DMD MIN and minimum flow setpoint	Occupied temperature setpoints	Wall switch connected to DI2 sets MODE point to 60 (Occupied)
		= 10 (Unoccupied)	OFF	= NO	Minimum airflow set to NGT FLOW MIN	Unoccupied temperature setpoints	Wall switch connected to DI2 sets MODE point to 10 (Unoccupied)

Unoccupied 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, then by pressing the override switch, a room occupant can reset the controller to occupied mode for the length of time set in OVRD TIME. The status of UNOCC OVRD changes to OCC and remains there until OVRD TIME elapses, at which point UNOCC OVRD changes back to UNOCC and the controller returns to unoccupied mode.

NOTE:
Only during unoccupied mode (MODE = Unoccupied) can a room sensor’s override switch set the controller to occupied mode; if MODE equals anything other than Unoccupied, UNOCC OVRD will equal UNOCC.

Control Temperature Setpoints

This application has a number of different room temperature setpoints (OCC HTG STPT, UOC 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. This disables the setpoint deadband feature.

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 OCC CLG STPT or OCC HTG STPT (depending on HEAT.COOL) if:

- MODE equals Occupied, EDR, or Standby
- MODE equals Unoccupied but UNOCC OVRD equals OCC
- OCC STBY equals NO

CTL STPT holds the value of UOC CLG STPT or UOC HTG STPT (depending on HEAT.COOL) if:

- MODE equals Shutdown or Unoccupied, or UNOCC OVRD equals UNOCC

Room Setpoint Dial

When the controller is in occupied mode and STPT DIAL = YES, cooling and heating occupied 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 occupied cooling and heating setpoints. If desired, the deadband can be eliminated by setting OCC HTG STPT equal to OCC 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 OCC CLG STPT and OCC HTG STPT: (OCC CLG STPT - OCC 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:

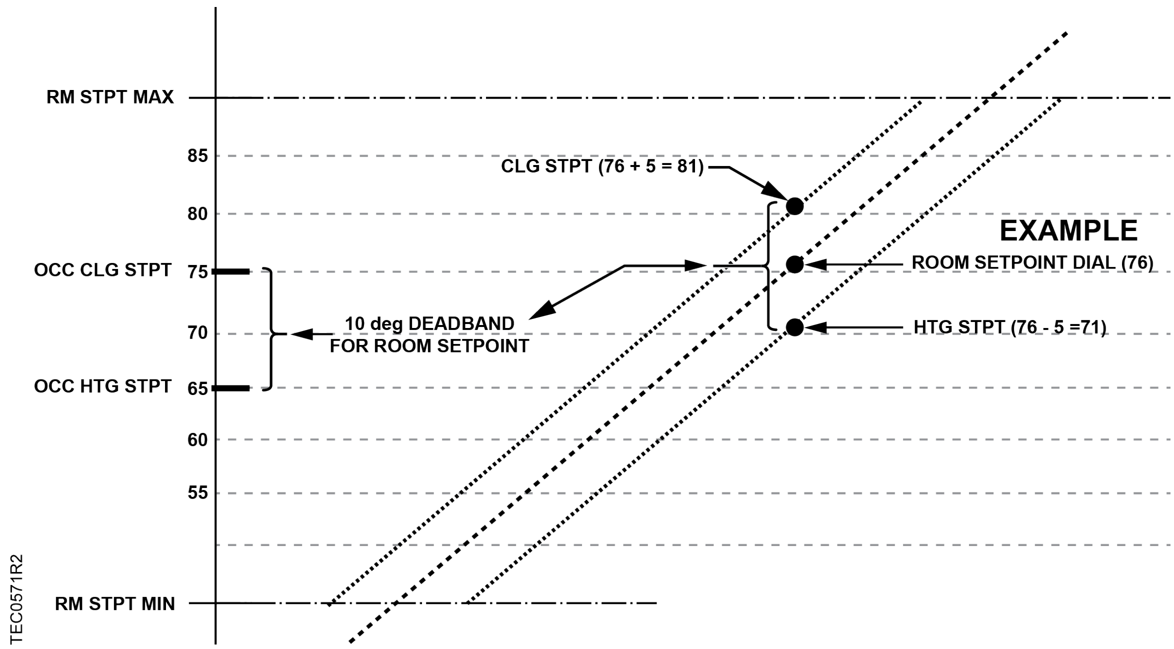
- CTL STPT = Dial value + (0.5 *Deadband)

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

- CTL STPT = Dial value

With STPT DIAL set to YES, CTL STPT holds the value of RM STPT DIAL if:

- MODE equals Occupied, EDR, or Standby
- MODE equals Unoccupied but UNOCC OVRD equals OCC
- OCC HTG STPT equals OCC CLG STPT
- OCC STBY equals NO



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

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

- HTG LOOPOUT is less than 5%.
- CTL TEMP is above CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP is greater than the appropriate cooling setpoint minus SWITCH DBAND.

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

- CLG LOOPOUT is less than 5%.
- CTL TEMP is below CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP is less than the appropriate heating setpoint plus SWITCH DBAND.

CAUTION

This 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 it through PPCL. (This is required if the flow loop is used as a source of cooling in cooling mode and as a source of heating in heating mode.)

If the flow loop is used during heating mode just to meet minimum air requirements, then the heating/cooling switchover mechanism operates as previously described in this section.

Ventilation Demand Minimum

For flexible ventilation control options during occupied modes, a ventilation demand minimum (VENT DMD MIN) is provided.

VENT DMD MIN can be set above, below, or equal to the minimum airflow temp control setpoint. This provides the option of separating the ventilation minimum from the temp control minimum. During occupied cooling, minimum airflow will equal the larger of VENT DMD MIN and CLG FLOW MIN. (In application 2157, the occupied heating minimum airflow will equal VENT DMD MIN.) Note that the control maximum flow setpoints are not affected by VENT DMD MIN.

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). VENT DMD MIN can then modulate in response to CO_2 or other indoor air quality ventilation requirements to control the cooling (or heating) ventilation needs.

VENT DMD MIN is used only during occupied modes. See *Night Flow Minimum* for operation during unoccupied times.

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 a distinction between day/occupied and night/unoccupied modes for the minimum air flow setpoints. For day/occupied operation, the cooling or heating minimum flow setpoints were designed to be the air flow for minimum cooling and ventilation or for air flow across heating coils. At night/unoccupied times the associated air handling unit was typically not running and therefore no distinction was necessary.

The use of this additional flow setpoint, NGT FLOW MIN, in place of heating flow min and cooling flow min, addresses these conditions. As the flow at night/unoccupied times does not require the ventilation needs for personnel, it can be set below other minimums or at zero. The configured maximum heating and cooling flow setpoints will still be used when the zone temperature exceeds the night cooling or heating setpoints.

Control Loops

The terminal box is controlled by three Proportional, Integral, and Derivative (PID) control loops; two temperature loops and a flow loop.

The two temperature loops are a cooling loop and a heating loop. The active temperature loop maintains room temperature at the value in CTL STPT. See *Control Temperature Setpoints*.

The cooling loop generates CLG LOOPOUT which is used to calculate FLOW STPT during the cooling mode. FLOW STPT is the result of scaling the cooling loopout to the appropriate range of values as determined by CLG FLOW MAX and CTL FLOW MIN, and as shown in the following equation:

$$\frac{[\text{CLG LOOPOUT} \times (\text{CLG FLOW MAX} - \text{CTL FLOW MIN})] + \text{CTL FLOW MIN}}{\text{CLG FLOW MAX}} \times 100\% = \text{FLOW STPT}$$

CTL FLOW MIN is calculated as the larger of VENT DMD MIN and CLG FLOW MIN during occupied cooling. In occupied heating CTL FLOW MIN = VENT DMD MIN. In the unoccupied mode (or occupied and OCC STBY = YES), CTL FLOW MIN = NGT FLOW MIN. See *Ventilation Demand Minimum* for information on how VENT DMD MIN is determined.

FLOW STPT Examples

If CTL FLOW MIN = 200 cfm and CLG FLOW MAX = 1000 cfm then, when CLG LOOPOUT is 0%, FLOW STPT equals 20% flow.

$$\frac{[0\% \times (1000 - 200)] + 200}{1000} \times 100\% = 20\%$$

This ensures that the airflow out of the terminal box is no less than CLG FLOW MIN.

When CLG LOOPOUT is 50%, FLOW STPT = 60% flow.

$$\frac{[50\% \times (1000 - 200)] + 200}{1000} \times 100\% = 60\%$$

When CLG LOOPOUT is 100%, FLOW STPT = 100% flow.

$$\frac{[100\% \times (1000 - 200)] + 200}{1000} \times 100\% = 100\%$$

In addition to being used to set FLOW STPT, CLG LOOPOUT is also used to control FAN FLOW during the cooling mode (FAN FLOW is then used to control FAN AOV1). See the *Fan Operation* section for more information about FAN FLOW and FAN AOV1 control.

The Cooling Loop is operational under either of the following situations:

- The application is in the occupied mode, WARMUP is OFF, and HEAT.COOL equals COOL.
- The application is in the unoccupied mode, and
  - CTL TEMP is above TEMP HLIMIT.
  - HEAT.COOL equals COOL.
  - VAV AHU is ON. (See note 4 of Application Notes for more information on VAV AHU.)
    (Once these conditions are met, the cooling loop will remain enabled for the rest of the entire unoccupied period as long as HEAT.COOL and VAV AHU do not change status and CTL TEMP does not fall to TEMP LLIMIT.)

If the controller is in heating mode, the flow loop maintains airflow out of the terminal box equal to CTL FLOW MIN, and HTG LOOPOUT controls the electric heat and FAN FLOW in order to maintain the room temperature. (FAN FLOW is used to control FAN AOV1; see the *Fan Operation* section for more information.)

The heating loop is operational under any of the following conditions:

- The application is in the occupied mode and WARMUP is ON.
- The application is in the occupied mode, WARMUP is OFF, and HEAT.COOL equals HEAT.
- The application is in EDR (electric demand reduction) mode or in standby mode.
- The application is in the unoccupied mode, CTL TEMP is below TEMP LLIMT, and HEAT.COOL equals HEAT. (Once these conditions are met, the heating loop remains enabled for the rest of the entire unoccupied period as long as HEAT.COOL does not change status and CTL TEMP never reaches TEMP HLIMIT.)

Flow Loop – Maintains minimum airflow and maximum airflow through CTL FLOW MIN and CTL FLOW MAX. CTL FLOW MAX holds different heating and cooling flow maximums. When HEAT.COOL equals HEAT, CTL FLOW MAX equals HTG FLOW MAX. When HEAT.COOL equals COOL, CTL FLOW MAX equals CLG FLOW MAX.

Separate flow minimums for heating and cooling modes are not used — CTL FLOW MIN is used for both. CTL FLOW MIN can be set equal to, but not greater than CTL FLOW MAX. If the minimum and maximum values are set equal, the flow loop becomes a constant volume loop and loses its ability to control temperature.

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

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

FLOW is the input value for the flow loop. It is a percentage derived from the value of AIR VOLUME—that is, a value in the range of 0 cfm to CTL FLOW MAX. In the following text, this percentage is referred to as % flow.

- If AIR VOLUME = 0 CFM, FLOW is 0% flow.
- If AIR VOLUME = CTL FLOW MAX, FLOW is 100% flow.

The low limit of FLOW STPT is the percentage that corresponds to the volume given in CTL FLOW MIN. This percentage can be calculated as: (CTL FLOW MIN ÷ CTL FLOW MAX) × 100% flow. The flow loop ensures that the supply air volume will not be less than CTL FLOW MIN.

Example

If CTL FLOW MIN = 250 CFM, and CTL FLOW MAX = 1000 CFM, the low limit of FLOW STPT = (250 cfm / 1000 cfm) × 100% flow = 0.25 × 100% flow =25% flow.

Since 25% of 1000 CFM = 250 CFM, the minimum airflow out of the terminal box will be 250 CFM.

The flow loop is operational under either of the following situations:

- The application is in the occupied mode and WARMUP is OFF.
- The application is in the unoccupied mode, and
  - CTL TEMP is above TEMP HLIMIT.
  - HEAT.COOL equals COOL.
  - VAV AHU is ON. (See note 4 in the Application Notes section for more information on VAV AHU.)
    Once these conditions are met, the flow loop will remain active for the rest of the entire unoccupied period as long as HEAT.COOL and VAV AHU do not change status and CTL TEMP does not fall to TEMP LLIMIT.

Electric Heat

CAUTION

To ensure airflow across the heating coils when they are energized, verify that others supply the equipment with safeties.

Consequences

If FAN FLOW equals 0 and/or FAN AOV1 equals 0, then this application will shut off all of the electric heating stages even if they have been overridden to ON. In other words, the application will not allow any electric heating stages to be ON when there is no airflow coming out of the fan. The rest of this section describes the operation of the electric heating stages when both FAN FLOW and FAN AOV1 are greater than 0.

Electric heat is operational when any of the following conditions occur:

- The application is in the occupied mode and WARMUP is ON.
- The application is in the occupied mode, WARMUP is OFF, and HEAT.COOL equals HEAT.
- The application is in the standby mode. (Note: When in standby, HEAT STAGE 2 and HEAT STAGE 3 are not available.)
- The application is in the unoccupied mode, CTL TEMP is below TEMP LLIMT, and HEAT.COOL equals HEAT.
  (Once CTL TEMP is less than TEMP LLIMIT, the electric heat remains under the control of HTG LOOPOUT for the remainder of the entire unoccupied period as long as HEAT.COOL does not change and CTL TEMP never reaches TEMP HLIMIT.)
  Note: The electric heat is OFF at all times during the cooling mode.

When FAN MODE equals VARI, the electric heat control depends on the amount of airflow coming from the series fan, as follows:

- The third stage of electric heat cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO HMAX.

- The second stage of electric heat cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO HMAX under the following circumstances:
  – Both FAN FLOW MID and FAN FLO MORE are greater than FAN FLO HMAX.
  – FAN FLOW MID is less than FAN FLO HMAX and FAN FLO HMAX is less than FAN FLO MORE.
- The second stage of electric heat cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO MORE under the following circumstances:
  – FAN FLO MORE is less than FAN FLOW MID and FAN FLOW MID is less than FAN FLO HMAX.
  – FAN FLO MORE is less than FAN FLO HMAX and FAN FLO HMAX is less than FAN FLOW MID.
  – FAN FLOW MID is less than FAN FLO MORE and FAN FLO MORE is less than FAN FLO HMAX.
- The 1st stage of electric heat cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO HMAX whenever both FAN FLOW MID and FAN FLO MORE are greater than FAN FLO HMAX.
- The 1st stage of electric heat cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO MORE under the following circumstances:
  – FAN FLOW MORE is less than FAN FLOW MID and FAN FLOW MID is less than FAN FLO HMAX.
  – FAN FLO MORE is less than FAN FLO HMAX and FAN FLO HMAX is less than FAN FLOW MID.
- The 1st stage of electric heat cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLOW MID under the following circumstances:
  – FAN FLOW MID is less than FAN FLO HMAX and FAN FLO HMAX is less than FAN FLO MORE.
  – FAN FLOW MID is less than FAN FLO MORE and FAN FLO MORE is less than FAN FLO HMAX.
- The first stage of electric heat (if used) cannot turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO HMAX under the following circumstances:
  – Only one stage of electric heat is being used (that is, STAGE COUNT = 1).
  – Two stages of electric heat are being used and FAN FLOW MID has been configured to be greater than or equal to FAN FLO HMAX.

When FAN MODE equals CONST, airflow from the series fan will equal FAN FLO CMAX whenever the fan is running. Since this is considered more than enough airflow for safe operation of the heating coil(s), the electric heat stage(s) can operate whenever needed without the application having to calculate and verify a minimum airflow.

NOTE:
If FAN MODE equals CONST, the electric heat will work best if FLOW END equals 0, and both FAN FLOW MID and FAN FLO MORE are set greater than FAN FLO HMAX.

2 Stages of Electric Heat

If there are two stages of electric heat (STAGE COUNT = 2), the second stage cannot turn ON until after the first stage has been ON for the length of time in STG 1 TIME. Conversely, the first stage of electric heat cannot turn OFF until after the second stage has been OFF for the length of time in STG 2 TIME.

Regardless of the heating demand and the amount of airflow from the VAV series fan, the following timing conditions hold:

- HEAT STAGE 2 cannot turn ON until HEAT STAGE 1 has been ON longer than STG 1 TIME.
- HEAT STAGE 3 cannot turn ON until HEAT STAGE 2 has been ON longer than STG 2 TIME.
- HEAT STAGE 2 cannot turn OFF until HEAT STAGE 3 has been OFF longer than STG 3 TIME.
- HEAT STAGE 1 cannot turn OFF until HEAT STAGE 2 has been OFF longer than STG 2 TIME.

HTG LOOPOUT does not control the heating stages directly. Instead, it is used to fill out an embedded Table Statement that generates an internal control signal (this was done to properly sequence the electric heat with the VAV series fan). The control signal is then used to time modulate the electric heating stages through a duty cycle, as shown in the following example.

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

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

The following paragraphs explain how control of the electric heat differs depending on the values of FAN FLOW MID, FAN FLO MORE and FAN FLO HMAX. (Regardless of these differences, Application 2157 heating stages are always controlled by an internal control signal which is generated by an embedded Table Statement that is driven by HTG LOOPOUT.)

FAN FLOW MID > FAN FLO HMAX

When FAN FLOW MID > FAN FLO HMAX, the relationship between HTG LOOPOOUT and the internal control signal is as follows:

FAN FLOW MID > FAN FLO HMAX and FAN FLO MORE > FAN FLO HMAX

When FAN FLOW MID > FAN FLO HMAX and FAN FLO MORE > FAN FLO HMAX, the relationship between HTG LOOPOOUT and the internal control signal is as follows:

- When HTG LOOPOUT is less than FLOW END, the control signal is set to 0.
- When HTG LOOPOUT equals 100, the control signal equals 100.

- When HTG LOOPOUT is between FLOW END and 100, linear interpolation is used to scale the control signal to a value between 0 and 100.

As HTG LOOPOUT goes from 0 to FLOW 1 END, FAN FLOW goes from FAN FLOW MIN to FAN FLOW MID. As HTG LOOPOUT goes from FLOW 2 START to FLOW 2 END, FAN FLOW goes from FAN FLOW MID to FAN FLO HMAX.

FAN FLOW MID < FAN FLO HMAX

When FAN FLOW MID < FAN FLO HMAX, the relationship between HTG LOOPOOUT and the internal control signal is as follows:

- When HTG LOOPOUT is less than FLOW 1 END, the control signal is set to 0.
- As HTG LOOPOUT goes from FLOW 1 END to FLOW 2 START, the control signal goes from 0 to 50.
- As HTG LOOPOUT goes from FLOW 2 START to FLOW END, the control signal remains at 50.
- When HTG LOOPOUT is between FLOW END and 100, the control signal goes from 50 to 100.

FAN FLO MORE < FAN FLOW MID < FAN FLO HMAX or FAN FLO MORE < FAN FLO HMAX < FAN FLOW MID

When FAN FLO MORE < FAN FLOW MID < FAN FLO HMAX or FAN FLO MORE < FAN FLO HMAX < FAN FLOW MID, the relationship between HTG LOOPOUT and the internal control signal is as follows:

- When HTG LOOPOUT is less than FLOW 1 END, the control signal is set to 0.
- As HTG LOOPOUT goes from FLOW 1 END to FLOW 3 START, the control signal goes from 0 to 66.
- As HTG LOOPOUT goes from FLOW 3 START to FLOW END, the control signal remains at 66.
- When HTG LOOPOUT is between FLOW END and 100, the control signal goes from 66 to 100.
- As HTG LOOPOUT goes from FLOW 1 END to FLOW 2 START, the control signal goes from 0 to 33.
- As HTG LOOPOUT goes from FLOW 2 START to FLOW 2 END, the control signal remains at 33.
- When HTG LOOPOUT is between FLOW 2 END and 100, the control signal goes from 33 to 100.

As HTG LOOPOUT goes from 0 to FLOW 1 END, FAN FLOW goes from FAN FLOW MIN to FAN FLO MORE. As HTG LOOPOUT goes from FLOW 3 START to FLOW END, FAN FLOW goes from FAN FLO MOR to FAN FLO HMAX.

FAN FLO MORE < FAN FLOW MID < FAN FLO HMAX or
FAN FLO MORE < FAN FLO HMAX < FAN FLOW MID

When FAN FLO MORE < FAN FLOW MID < FAN FLO HMAX or FAN FLO MORE < FAN FLO HMAX < FAN FLOW MID, the relationship between HTG LOOPOOUT and the internal control signal is as follows:

- When HTG LOOPOUT is less than FLOW 1 END, the control signal is set to 0.
- As HTG LOOPOUT goes from FLOW 1 END to FLOW 3 START, the control signal goes from 0 to 66.
- As HTG LOOPOUT goes from FLOW 3 START to FLOW END, the control signal remains at 66.

- When HTG LOOPOUT is between FLOW END and 100, the control signal goes from 66 to 100.

FAN FLOW MID < FAN FLO MORE < FAN FLO HMAX

When FAN FLOW MID < FAN FLO MORE < FAN FLO HMAX, the relationship between HTG LOOPOOUT and the internal control signal is as follows:

- When HTG LOOPOUT is less than FLOW 1 END, the control signal is set to 0.
- As HTG LOOPOUT goes from FLOW 1 END to FLOW 2 START, the control signal goes from 0 to 33.
- As HTG LOOPOUT goes from FLOW 2 START to FLOW 2 END, the control signal remains at 33.
- As HTG LOOPOUT goes from FLOW 2 END to FLOW 3 START, the control signal goes from 33 to 66.

As HTG LOOPOUT goes from FLOW 3 START to FLOW END, the control signal remains at 66.

When HTG LOOPOUT is between FLOW END and 100, the control signal goes from 66 to 100.

As HTG LOOPOUT goes from 0 to FLOW 1 END, FAN FLOW goes from FAN FLOW MIN to FAN FLOW MID. As HTG LOOPOUT goes from FLOW 2 START to FLOW 2 END, FAN FLOW goes from FAN FLOW MID to FAN FLO MORE. As HTG LOOPOUT goes from FLOW 3 START to FLOW END, FAN FLOW goes from FAN FLO MOR to FAN FLO HMAX.

The following paragraphs describe the relationship between the Table Statement's internal control signal and the electric heating stage(s) when STAGE COUNT equals 3.

When the internal control signal is less than 3.33, HEAT STAGE 1 is OFF throughout the entire duty cycle. When the internal control signal is greater than 30, HEAT STAGE 1 is ON throughout the entire duty cycle. When the internal control signal is between 3.33 and 30, HEAT STAGE 1 is time modulated.

When the internal control signal is less than 36.66, HEAT STAGE 2 is OFF throughout the entire duty cycle. When the internal control signal is greater than 63.333, HEAT STAGE 2 is ON throughout the entire duty cycle. When the internal control signal is between 36.66 and 63.33, HEAT STAGE 2 is time modulated.

When the internal control signal is less than 70, HEAT STAGE 3 is OFF throughout the entire duty cycle. When the internal control signal is greater than 96.66, HEAT STAGE 3 is ON throughout the entire duty cycle. When the internal control signal is between 70 and 96.66, HEAT STAGE 3 is time modulated.

Single Stage Electric Heat

When the internal control signal is less than 10, HEAT STAGE 1 is OFF. When the internal control signal is greater than 90, HEAT STAGE 1 is ON. When the control signal is between 10 and 90, HEAT STAGE 1 is time modulated.

Two Stages of Electric Heat

When the internal control signal is less than 5, HEAT STAGE 1 will be OFF throughout the entire duty cycle. When the internal control signal is greater than 45, HEAT STAGE 1 will be ON throughout the entire duty cycle. When the internal control signal is between 5 and 45, HEAT STAGE 1 will be time modulated.

When the internal control signal is less than 55, HEAT STAGE 2 will be OFF throughout the entire duty cycle. When the internal control signal is greater than 95, HEAT STAGE 2 will be ON throughout the entire duty cycle. When the internal control signal is between 55 and 95, HEAT STAGE 2 will be time modulated.

Fan Operation

CAUTION

On series fan powered terminal boxes, the terminal box fan must be controlled/interlocked to start either before or at the same time as the central air handler.

Failure to do so may cause the terminal box fan to rotate backwards and cause consequent damage at start up.

In Application 2157, the two points most directly related to the fan's operation are FAN FLOW and FAN AOV1. FAN AOV1 is the analog output that controls the fan's airflow, and FAN FLOW is the desired airflow for the fan. The rest of this section describes how these points are determined and their operation.

Fan Flow

For the fan to be OFF, FAN FLOW must = 0 and all of the stages of electric heat must be OFF for at least 30 seconds. Even after all of the electric heating stages have been OFF for at least 30 seconds, FAN FLOW is assured of equaling 0 only in 4 specific circumstances. These are:

1. The application is in the shutdown mode.
2. The application is in the unoccupied mode, CTL TEMP is below TEMP LLIMIT, and HEAT.COOL equals COOL. (FAN FLOW will remain at 0 (and the fan will be OFF) for the rest of the entire unoccupied period as long as HEAT.COOL does not change and CTL TEMP never reaches TEMP HLIMIT.
3. The application is in the unoccupied mode, and
   - CTL TEMP is above TEMP HLIMIT.
   - VAV AHU is OFF and/or HEAT.COOL equals HEAT. (See note 4 in the Application Notes section for more information on VAV AHU.)
     (Once these conditions are met, FAN FLOW will remain at 0 (and the fan will be OFF) for the rest of the unoccupied mode as long as HEAT.COOL and/or VAV AHU do not change in status and CTL TEMP does not fall to TEMP LLIMIT.)
4. The application is in the unoccupied mode and CTL TEMP has remained between TEMP LLIMIT and TEMP HLIMIT throughout the entire unoccupied mode.

In the above four cases, if all of the electric heating stages have not been OFF for at least 30 seconds, then FAN FLOW will remain where it was before that case was entered. For instance, if the application goes into the shutdown mode and all of the electric heating stages have not been OFF for at least 30 seconds, then FAN FLOW will remain where it was before the shutdown mode was entered.

In any condition other than the four above, FAN FLOW will not equal 0 and the series fan will be running. In this case, the value of FAN MODE makes a big difference in the fan's operation. FAN MODE can equal VARI or CONST (variable or constant). If FAN MODE = CONST, FAN FLOW runs steadily at the rate indicated by FAN FLO CMAX. If

FAN MODE = VARI, FAN FLOW is controlled by either the cooling loop or the heating loop as described in the following paragraphs.

FAN FLOW Controlled by CLG LOOPOUT – When FAN MODE = VARI, CLG LOOPUT controls FAN FLOW under either of the following conditions:

1. The application is in the occupied mode, WARMUP equals OFF, and HEAT.COOL is set to COOL.
2. The application is in the unoccupied mode, and
   – CTL TEMP is above TEMP HLIMIT.
   – HEAT.COOL equals COOL.
   – VAV AHU is ON. (See note 4 in the Application Notes section for more information on VAV AHU.)
   (Once these conditions are met, FAN FLOW will remain under the control of CLG LOOPOUT for the rest of the entire unoccupied period as long as HEAT.COOL and VAV AHU do not change status and CTL TEMP does not fall to TEMP LLIMIT.)

CLG LOOPOUT controls FAN FLOW via an embedded Table Statement as follows:

- When CLG LOOPOUT is zero, FAN FLOW is set to FAN FLOW MIN.
- When CLG LOOPOUT is 100, FAN FLOW is set to FAN FLO CMAX.
- When CLG LOOPOUT is between 0 and 100, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN and FAN FLO CMAX.

FAN FLOW Controlled by HTG LOOPOUT – When FAN MODE = VARI, HTG LOOPUT controls FAN FLOW under any of the following conditions:

- The application is in occupied mode and WARMUP is ON.
- The application is in occupied mode, WARMUP is OFF, and HEAT.COOL equals HEAT.
- The application is in the unoccupied mode, CTL TEMP is below TEMP LLIMT, and HEAT.COOL equals HEAT.
  (Once these conditions are met, FAN FLOW will remain under the control of HTG LOOPOUT for the rest of the entire unoccupied period as long as HEAT.COOL does not change and CTL TEMP never reaches TEMP HLIMIT.)
- The application is in the EDR (electric demand reduction) mode or in standby mode.

Because the operation of the series fan must be coordinated with the electric heating stage(s), controlling FAN FLOW with HTG LOOPOUT is more complicated than controlling it with CLG LOOPOUT. Whereas CLG LOOPOUT uses only one embedded Table Statement to adjust the value of FAN FLOW, HTG LOOPOUT will use one of several embedded Table Statements to control FAN FLOW depending on the circumstances. (Keep in mind that in all of the following circumstances the application is also controlling three stages of electric heat; that is STAGE COUNT equals 3.) Refer to the following:

FAN FLOW Control when both FAN FLOW MID and FAN FLO MORE are greater than or equal to FAN FLO HMAX – When both FAN FLOW MID and FAN FLO MORE are greater than or equal to FAN FLO HMAX and HEAT STAGE 1 is ON, FAN FLOW will be set to FAN FLO HMAX. Once this occurs, FAN FLOW cannot change in value until HEAT STAGE 1 turns OFF and remains OFF for longer than the amount of time set in STAGE TIME.

Whenever HEAT STAGE 1 remains OFF for longer than STAGE TIME, a “speed limit”—in addition to the Table Statement’s control signal—is used to control FAN

FLOW. However, for the speed limit to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT is 0, FAN FLOW is set equal to FAN FLOW MIN.
- When HTG LOOPOUT is equal to or greater than FLOW END, FAN FLOW is set equal to FAN FLO HMAX.
- When HTG LOOPOUT is between 0 and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN and FAN FLO HMAX.

NOTE:
When HTG LOOPOUT is greater than FLOW END, the electric heat will time modulate.

When HTG LOOPOUT changes rapidly, the speed limit works as follows:

Regardless of how rapidly HTG LOOPOUT changes, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × FLOW END. Even if HTG LOOPOUT changes suddenly from 0 to 100, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MIN to FAN FLO HMAX. (If FAN TIME is less than LOOP TIME, the speed limit is disabled and FAN FLOW can change as fast as HTG LOOPOUT changes.)

FAN FLOW Control when FAN FLOW MID < FAN FLO HMAX < FAN FLO MORE – If FAN FLOW MID is less than or equal to FAN FLO HMAX and FAN FLO HMAX is less than FAN FLO MORE, FAN FLOW will be set to FAN FLO HMAX when HEAT STAGE 2 is ON or has been OFF for less than STAGE TIME. When HEAT STAGE 2 has been OFF for longer than STAGE TIME, but HEAT STAGE 1 has not been OFF for longer than STAGE TIME, FAN FLOW is controlled by a Table Statement and a speed limit.

Whenever HEAT STAGE 2 has been OFF for longer than STAGE TIME, but HEAT STAGE 1 has not, a “speed limit” — in addition to the Table Statement’s control signal — is used to control FAN FLOW. However, for the speed limit to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT is equal to or less than FLOW 2 START, FAN FLOW is set equal to FAN FLOW MID.
- When HTG LOOPOUT is equal to or greater than FLOW2 END, FAN FLOW is set equal to FAN FLO HMAX.
- When HTG LOOPOUT is between FLOW 2 START and FLOW2 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MID and FAN FLO HMAX.

When HTG LOOPOUT changes rapidly, the speed limit works as follows:

Regardless of how rapidly HTG LOOPOUT changes, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW2 END – FLOW 2 START). Even if HTG LOOPOUT changes suddenly from FLOW 2 START to FLOW2 END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MID to FAN FLO HMAX. (If FAN TIME is less than LOOP TIME, the speed limit is disabled and FAN FLOW can change as fast as HTG LOOPOUT changes.)

When all three heating stages have been OFF for longer than STAGE TIME, FAN FLOW is controlled by two speed limits and the Table Statement’s control signal.

However, for the speed limits to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT equals 0, FAN FLOW is set equal to FAN FLOW MIN.
- When HTG LOOPOUT is between 0 and FLOW 1 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN and FAN FLOW MID.
- When HTG LOOPOUT equals FLOW 1 END, FAN FLOW is set equal to FAN FLOW MID. (If HTG LOOPOUT rises above FLOW 1 END but stays below FLOW 2 START, FAN FLOW remains equal to FAN FLOW MID while HEAT STAGE 1 time modulates.)
- When HTG LOOPOUT is between FLOW 2 START and FLOW2 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MID and FAN FLO HMAX.
- When HTG LOOPOUT is equal to or greater than FLOW2 END, FAN FLOW is set equal to FAN FLO HMAX. (Note: when HTG LOOPOUT is greater than FLOW2 END, HEAT STAGE 2 and HEAT STAGE 3 will time modulate.)

When HTG LOOPOUT changes rapidly, the speed limits work as follows:

If HTG LOOPOUT is less than or equal to FLOW 2 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × FLOW 1 END, no matter how quickly HTG LOOPOUT changes. Therefore, even if HTG LOOPOUT changes suddenly from 0 to FLOW 2 START, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MIN to FAN FLOW MID. If HTG LOOPOUT is greater than FLOW 2 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW2 END – FLOW 2 START). Therefore, even if HTG LOOPOUT changes suddenly from FLOW 2 START to FLOW2 END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MID to FAN FLO HMAX.

Since FLOW 1 END and the value of FLOW2 END – FLOW 2 START are likely to be different, two different speed limits will be used even though the value of FAN TIME remains the same. The speed limit being used at any given time will depend on the value of HTG LOOPOUT (as explained in the previous paragraph). If FAN TIME is less than LOOP TIME, the speed limits are disabled and FAN FLOW can change as quickly as HTG LOOPOUT changes.

FAN FLOW Control when FAN FLO MORE < FAN FLOW MID < FAN FLO HMAX or FAN FLO MORE < FAN FLO HMAX < FAN FLOW MID – If FAN FLO MORE is less than FAN FLO HMAX and FANFLO HMAX is less than FAN FLOW MID or if FAN FLO MORE is less than FAN FLOW MID and FAN FLOW MID is less than FAN FLO HMAX, FAN FLOW will be set to FAN FLO HMAX when HEAT STAGE 3 is ON or has been OFF for less than STAGE TIME. When HEAT STAGE 3 has been OFF for longer than STAGE TIME, but HEAT STAGE 2 has not been OFF for longer than STAGE TIME, FAN FLOW is controlled by a Table Statement and a speed limit.

Whenever HEAT STAGE 3 has been OFF for longer than STAGE TIME, but HEAT STAGE 2 has not, a “speed limit” — in addition to the Table Statement’s control signal — is used to control FAN FLOW. However, for the speed limit to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT is equal to or less than FLOW 3 START, FAN FLOW is set equal to FAN FLO MORE.
- When HTG LOOPOUT is equal to or greater than FLOW END, FAN FLOW is set equal to FAN FLO HMAX.

- When HTG LOOPOUT is between FLOW 3 START and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLO MORE and FAN FLO HMAX.

When HTG LOOPOUT changes rapidly, the speed limit works as follows:

Regardless of how rapidly HTG LOOPOUT changes, FAN FLOW cannot change faster than (LOOP TIME÷FAN TIME) × (FLOW END – FLOW 3 START). Even if HTG LOOPOUT changes suddenly from FLOW 3 START to FLOW END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLO MORE to FAN FLO HMAX. (If FAN TIME is less than LOOP TIME, the speed limit is disabled and FAN FLOW can change as fast as HTG LOOPOUT changes.)

When all three heating stages have been OFF for longer than STAGE TIME, FAN FLOW is controlled by two speed limits and the Table Statement's control signal. However, for the speed limits to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT equals 0, FAN FLOW is set equal to FAN FLOW MIN.
- When HTG LOOPOUT is between 0 and FLOW 1 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN and FAN FLO MORE.
- When HTG LOOPOUT equals FLOW 1 END, FAN FLOW is set equal to FAN FLO MORE. (If HTG LOOPOUT rises above FLOW 1 END but stays below FLOW 3 START, FAN FLOW remains equal to FAN FLO MORE while HEAT STAGE 1 and HEAT STAGE 2 time modulate.)
- When HTG LOOPOUT is between FLOW 3 START and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLO MORE and FAN FLO HMAX.
- When HTG LOOPOUT is equal to or greater than FLOW END, FAN FLOW is set equal to FAN FLO HMAX.

When HTG LOOPOUT changes rapidly, the speed limits work as follows:

If HTG LOOPOUT is less than or equal to FLOW 3START,FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × FLOW 1 END, no matter how quickly HTG LOOPOUT changes. Therefore, even if HTG LOOPOUT changes suddenly from 0 to FLOW 3 START, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MIN to FAN FLO MORE. If HTG LOOPOUT is greater than FLOW 3 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW END – FLOW 3 START). Therefore, even if HTG LOOPOUT changes suddenly from FLOW 3 START to FLOW END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLO MORE to FAN FLO HMAX.

Since FLOW 1 END and the value of FLOW END – FLOW 3 START are likely to be different, 2 different speed limits will be used even though the value of FAN TIME remains the same. The speed limit being used at any given time will depend on the value of HTG LOOPOUT (as explained in the previous paragraph). If FAN TIME is less than LOOP TIME, the speed limits are disabled and FAN FLOW can change as quickly as HTG LOOPOUT changes.

FAN FLOW Control when FAN FLOW MID < FAN FLO MORE < FAN FLO HMAX – If FAN FLOW MID is less than FAN FLO MORE and FAN FLO MORE is less than FAN FLO HMAX, FAN FLOW will be set to FAN FLO HMAX when HEAT STAGE 3 is ON or has been OFF for less than STAGE TIME. When HEAT STAGE 3 has been OFF for longer than STAGE TIME, but HEAT STAGE 2 has not been OFF for longer than STAGE TIME, FAN FLOW is controlled by a Table Statement and a speed limit.

Whenever HEAT STAGE 3 has been OFF for longer than STAGE TIME, but HEAT STAGE 2 has not, a “speed limit” — in addition to the Table Statement’s control signal — is used to control FAN FLOW. However, for the speed limit to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT is equal to or less than FLOW 3 START, FAN FLOW is set equal to FAN FLO MORE.
- When HTG LOOPOUT is equal to or greater than FLOW END, FAN FLOW is set equal to FAN FLO HMAX.
- When HTG LOOPOUT is between FLOW 3 START and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLO MORE and FAN FLO HMAX.

When HTG LOOPOUT changes rapidly, the speed limit works as follows:

Regardless of how rapidly HTG LOOPOUT changes, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW END – FLOW 3 START). Even if HTG LOOPOUT changes suddenly from FLOW 3 START to FLOW END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLO MORE to FAN FLO HMAX. (If FAN TIME is less than LOOP TIME, the speed limit is disabled and FAN FLOW can change as fast as HTG LOOPOUT changes.)

When HEAT STAGE 3 and HEAT STAGE 2 have both been OFF for longer than STAGE TIME but HEAT SATGE 1 has not, FAN FLOW is controlled by two speed limits and the Table Statement’s control signal. However, for the speed limits to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT is equal to or less than FLOW 2 START, FAN FLOW is set equal to FAN FLOW MID.
- When HTG LOOPOUT is between FLOW 2 START and FLOW 2 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MID and FAN FLO MORE.
- When HTG LOOPOUT equals FLOW 2 END, FAN FLOW is set equal to FAN FLO MORE. (If HTG LOOPOUT rises above FLOW 2 END but stays below FLOW 3 START, FAN FLOW remains equal to FAN FLO MORE while HEAT STAGE 1 and HEAT STAGE 2 time modulate.)
- When HTG LOOPOUT is between FLOW 3 START and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLO MORE and FAN FLO HMAX.
- When HTG LOOPOUT is equal to or greater than FLOW END, FAN FLOW is set equal to FAN FLO HMAX.

When HTG LOOPOUT changes rapidly, the speed limits work as follows:

If HTG LOOPOUT is less than or equal to FLOW 3 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW 2 END – FLOW 2 START), no matter how quickly HTG LOOPOUT changes. Therefore, even if HTG LOOPOUT changes suddenly from FLOW 2 START to FLOW 3 START, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MID to FAN FLO MORE. If HTG LOOPOUT is greater than FLOW 3 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW END – FLOW 3 START). Therefore, even if HTG LOOPOUT changes suddenly from FLOW 3 START to FLOW END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLO MORE to FAN FLO HMAX.

Since the value of FLOW 2 END – FLOW 2 START and the value of FLOW END – FLOW 3 START are likely to be different, two different speed limits will be used even though the value of FAN TIME remains the same. The speed limit being used at any given time will depend on the value of HTG LOOPOUT (as explained in the previous paragraph). If FAN TIME is less than LOOP TIME, the speed limits are disabled and FAN FLOW can change as quickly as HTG LOOPOUT changes.

When all three heating stages have been OFF for longer than STAGE TIME, FAN FLOW is controlled by three speed limits and the Table Statement's control signal. However, for the speed limits to be used, HTG LOOPOUT must be changing rapidly. If HTG LOOPOUT is constant or changing slowly, the Table Statement works as follows:

- When HTG LOOPOUT equals 0, FAN FLOW is set equal to FAN FLOW MIN.
- When HTG LOOPOUT is between 0 and FLOW 1 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN and FAN FLOW MID.
- When HTG LOOPOUT equals FLOW 1 END, FAN FLOW is set equal to FAN FLOW MID. (If HTG LOOPOUT rises above FLOW 1 END but stays below FLOW 2 START, FAN FLOW remains equal to FAN FLOW MID while HEAT STAGE 1 time modulates.)
- When HTG LOOPOUT is between FLOW 2 START and FLOW 2 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MID and FAN FLO MORE.
- When HTG LOOPOUT equals FLOW 2 END, FAN FLOW is set equal to FAN FLO MORE. (If HTG LOOPOUT rises above FLOW 2 END, but stays below FLOW 3 START, FAN FLOW remains equal to FAN FLO MORE while HEAT STAGE 2 time modulates.)
- When HTG LOOPOUT is between FLOW 3 START and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLO MORE and FAN FLO HMAX.
- When HTG LOOPOUT is equal to or greater than FLOW END, FAN FLOW is set equal to FAN FLO HMAX.

When HTG LOOPOUT changes rapidly, the speed limits work as follows:

If HTG LOOPOUT is less than or equal to FLOW 2 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × FLOW 1 END, no matter how quickly HTG LOOPOUT changes. Therefore, even if HTG LOOPOUT changes suddenly from 0 to FLOW 2 START, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MIN to FAN FLOW MID. If HTG LOOPOUT is greater than FLOW 2 START and less than or equal to FLOW 3 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW 2 END – FLOW 2 START), no matter how quickly HTG LOOPOUT changes. Therefore, even if HTG LOOPOUT changes suddenly from FLOW 2 START to FLOW 3 START, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MID to FAN FLO MORE. If HTG LOOPOUT is greater than FLOW 3 START, FAN FLOW cannot change faster than (LOOP TIME ÷ FAN TIME) × (FLOW END – FLOW 3 START). Therefore, even if HTG LOOPOUT changes suddenly from FLOW 3 START to FLOW END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLO MORE to FAN FLO HMAX.

Since FLOW 1 END, FLOW 2 END –FLOW 2 START and FLOW END–FLOW 3 START are all likely to be different, three different speed limits are used even though the value of FAN TIME remains the same. The speed limit being used at any given time depends on the value of HTG LOOPOUT (as explained in the previous paragraph). If FAN TIME is less than LOOP TIME, the speed limits are disabled and FAN FLOW can change as quickly as HTG LOOPOUT changes.

FAN AOV1

Once a value for FAN FLOW (the fan's desired airflow) has been determined, a Table Statement in the firmware calculates the proper value for FAN AOV1 (FAN AOV1 is the analog output that controls the fan's airflow). Application 2157 actually contains 4 such Table Statements, but only one will be used. Which one gets used depends on the value of BOX SIZE. Refer to the following:

BOX SIZE = 3, 5 or 7 – When BOX SIZE is set to 3, 5 or 7, the application uses 1 of 3 pre-coded Table Statements with pre-determined FAN AOV1 voltage levels. The voltage values are fixed and cannot be changed by the user.

NOTE:
BOX SIZE should be set to 3, 5, or 7 only if you have a Nailor box of size 3, 5, or 7.

BOX SIZE = 0 – When BOX SIZE is set to 0, the application uses a general purpose Table Statement to adjust the value of FAN AOV1.

NOTE:
BOX SIZE should be set to 0 if the box being used is either a Nailor box with a size other than 3, 5, or 7, or any box made by a manufacturer other than Nailor.

The flow and voltage values of the general purpose table statement are not pre-coded and must be entered by the user as follows:

- FLO LO – The lowest flow the fan can produce. (FLO LO must be less than or equal to FAN FLOW MIN, and may be set to 0 cfm, if desired.)
- FLO LO VOLTS – The voltage used by FAN AOV1 that tells the fan to produce an airflow equal to FLO LO.
- FLO HI – The highest flow that the fan can produce. (FLO HI must be greater than or equal to both FAN FLO HMAX and FAN FLO CMAX.).
- FLO HI VOLTS – The voltage used by FAN AOV1 that tells the fan to produce an airflow equal to FLO HI.

Once properly set up, the Table Statement works as follows:

- When FAN FLOW is less than or equal to FLO LO, FAN AOV1 will be set to FAN LO VOLTS.
- When FAN FLOW is greater than or equal to FAN HI, FAN AOV1 will be set to FAN HI VOLTS.
- When FAN FLOW is between FLO LO and FLO HI, linear interpolation is used to scale FAN AOV1 to a value that is between FAN LO VOLTS and FAN HI VOLTS.

Once FAN AOV1 is set to a particular voltage, the signal is sent to an intelligent motor controller that controls the fan. This intelligent motor controller is provided by others. It must be set up to know what the fan's airflow should be for a given value of FAN AOV1 voltage. Consult the operating instructions provided by the manufacturer for information on how to do this.

NOTES:
1. FAN FLOW is a calculated value, not a measured value. The application does not measure the airflow coming out of the fan.

2. This application does not have a DO that turns the fan ON and OFF. To turn the fan OFF, FAN FLOW must be set equal to 0.

Warm-Up Mode

Warm-up mode is only allowed to operate during occupied heating. At no other time may the application enter warm-up mode.

WARMUP is turned ON only if all of the following circumstances are true:

- MODE has just changed from Unoccupied to Occupied (MODE currently equals occupied but equaled unoccupied one LOOP TIME ago).
- HEAT.COOL equals HEAT.
- The room temperature is not warm enough. CTL TEMP < (CTL STPT – MORN DBAND).

The warm-up mode remains in effect until CTL TEMP becomes equal to or greater than (CTL STPT – MORN DBAND). Once this occurs, WARMUP is set to OFF. Once OFF, WARMUP cannot be turned back ON for the rest of the Occupied period.

Baseboard Radiation

For baseboard radiation (BASE DO6) to turn ON, the application must be in unoccupied heating (MODE = UNOCC, UNOCC OVRD = UNOCC, and HEAT.COOL = HEAT), and both of the following must be true:

- CTL TEMP is between TEMP LLIMIT and TEMP HLIMIT.
- The room temperature is not warm enough: CTL TEMP < (CTL STPT – HTG DBAND).

At all other times, BASE DO6 will be OFF.

Once ON, baseboard radiation remains ON until CTL TEMP becomes equal to or greater than CTL STPT. When CTL TEMP is between CTL STPT and (CTL STPT – HTG DBAND), the baseboard radiation remains in its last commanded state: If ON, it remains ON; if OFF, it remains OFF.

If CTL TEMP becomes less than TEMP LLIMIT or greater than TEMP HLIMIT, BASE DO6 is shut OFF and not allowed to turn back ON for the remainder of the unoccupied heating mode.

Flow Temperature Alarm

The status of FLOW TEMP indicates whether the supply airflow is properly cooling down the control temperature (CTL TEMP) during cooling. Basically, this feature checks whether the supply airflow is both great enough and cool enough to cool down the space.

FLOW TEMP is sent to ALARM only when all of the following are true:

- HEAT.COOL equals COOL.
- MODE equals occupied, or UNOCC OVRD equals OCC while MODE equals unoccupied.
- FLOW < FLOW STPT, and CTL TEMP > CTL STPT, both of these being true for at least the amount of time stored in ALARM TIME.

At all other times FLOW TEMP = NORMAL.

NOTE:
During occupied cooling, FLOW TEMP equals NORMAL when: FLOW > (FLOW STPT – LOW FLOW) and/or CTL TEMP < CTL STPT.

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.

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%.

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

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.

Application Notes

1. 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 FLOW is oscillating while FLOW STPT is constant, then the flow loop requires tuning.
2. Unless overridden, the value of CTL TEMP equals ROOM TEMP plus RMTMP OFFSET.
3. 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.
4. Certain control features depend on whether the central air handling unit is ON or OFF. Application 2157 monitors VAV AHU for this information. The application does not command VAV AHU — it only reacts to it. To command VAV AHU, it must be unbundled at the field panel and PPCL must be written for it.
5. Since Application 2157 has no fan DO, the only way to manually shut the fan OFF is to set FAN FLOW to 0.
6. In Application 2157, DOs 3 and 4 cannot be used as auxiliary floating-control motor points, even if the application is not using them. The same is true for DOs 5 and 6 and also DOs 7 and 8. Floating control logic is not present in the firmware for these DOs. However, these DOs can otherwise be used as spare points if the application is not using them for other purposes (DOs 7 and 8 are always spare).
7. If FAN FLOW equals 0 and/or FAN AOV1 equals 0, the application will shut off all stages of electric heating even if they have been overridden to ON. Thereafter, if both FAN FLOW and FAN AOV1 become greater than 0, the application will not automatically turn the electric heat stages back on due to the previous user command. Instead, the application will control them normally.

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:

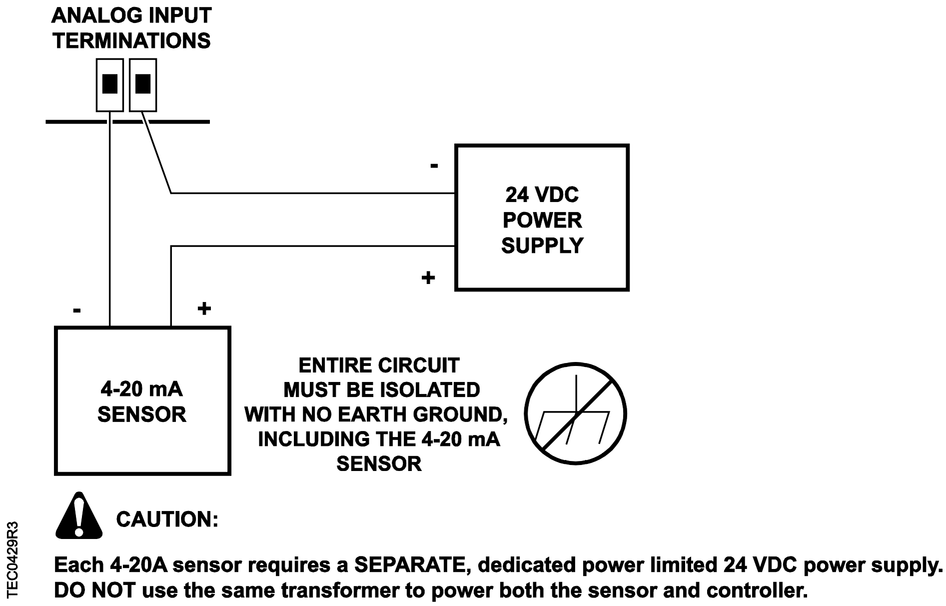
• VA requirements higher than the maximum

• 110 or 220 Vac requirements

• DC power requirements

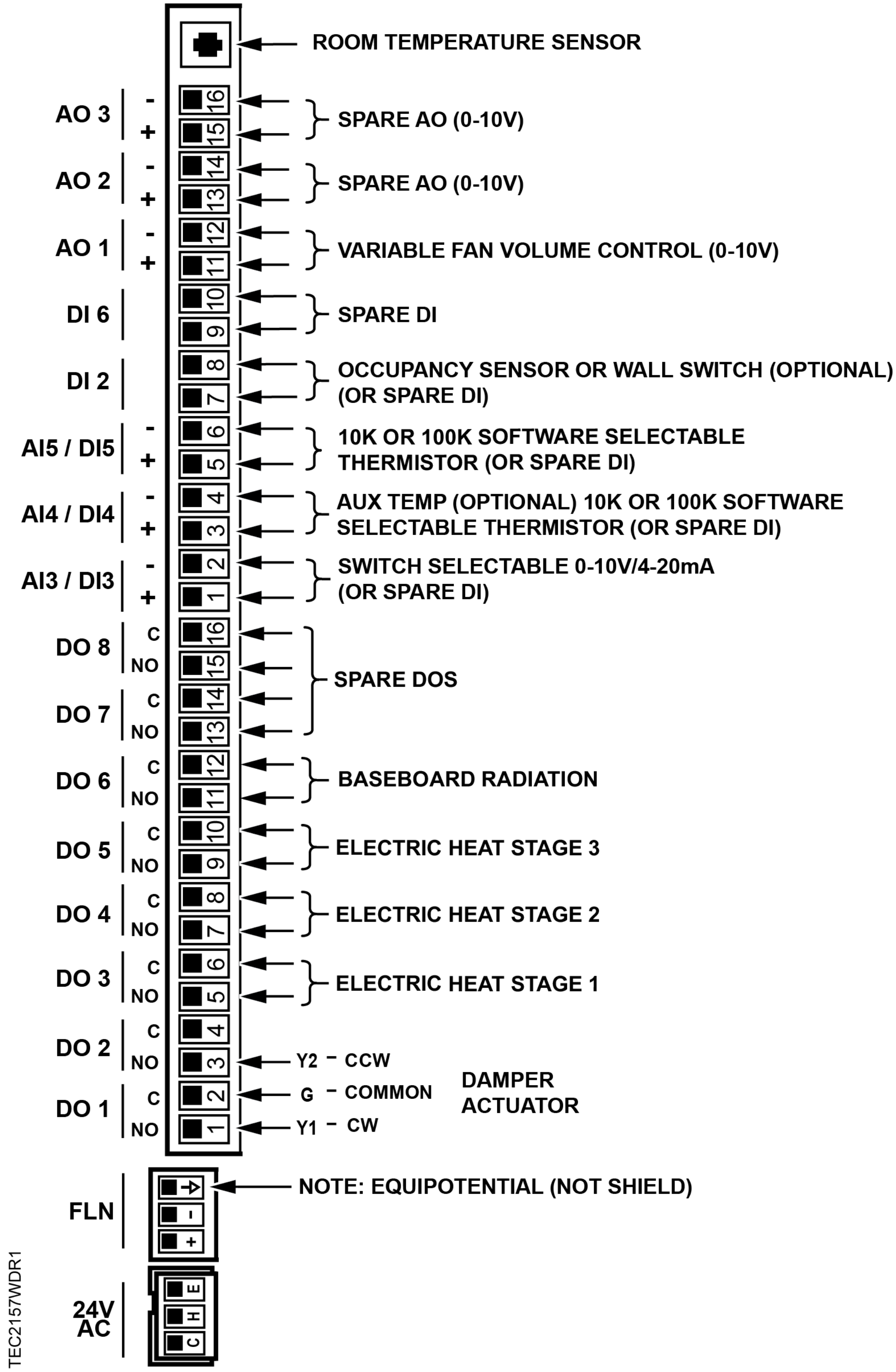
• Separate transformers used to power the load
(for example part number 540-147, Terminal Equipment Controller Relay Module)

NOTE:
Thermistor inputs are 10K (default) or 100K software selectable.



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 2157, Siemens VAV with 0-10V Series-Fan Speed Output, Occupancy Sensor and 3-Stage Electric Heat.

Application 2157 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	2158	--	1	0	--	--
{03} [3]	MODE	0	--	1	0	--	--
{04}	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	OCC CLG STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
07	OCC HTG STPT	70.0 (21.20888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
08	UOC CLG STPT	82.0 (27.92888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
09	UOC HTG STPT	65.0 (18.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{10}	DI 5	OFF	--	--	--	ON	OFF
11	RM STPT MIN	52.5 (11.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
12	RM STPT MAX	74.25 (23.58888)	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}	AI 3	0.0	PCT	0.4	0.0	--	--
{16}	FAN MODE	VARI	--	--	--	CONST	VARI
17	FLOW END	75.2	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}	UNOCC OVRD	UNOCC	--	--	--	UNOCC	OCC
22	FLOW 2 START	30.0	PCT	0.4	0.0	--	--
23	FLOW 1 END	15.2	PCT	0.4	0.0	--	--
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
26	ALARM TIME	5	MIN	1	0	--	--
27	STG 1 TIME	120	SEC	1	0	--	--
28	STG 2 TIME	120	SEC	1	0	--	--
30	LOW FLOW	5.0	PCT	0.25	0.0	--	--
31	BOX SIZE	3	--	1	0	--	--
32	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{33}	FAN FLOW	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
34	HTG FLOW MAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1.0	--	0.01	0.0	--	--
{37}	FLO LO VOLTS	0.0	VOLTS	0.01	0.0	--	--
{38}	FLO HI VOLTS	10.0	VOLTS	0.01	0.0	--	--
{39}	FLO LO	0 (0.0)	CFM (LPS)	4 (1.8876)	0	--	--
{40}	DI 4	OFF	--	--	--	ON	OFF
{41}	DO 1	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
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	HEAT STAGE 1	OFF	--	--	--	ON	OFF
{44}	HEAT STAGE 2	OFF	--	--	--	ON	OFF
{45}	HEAT STAGE 3	OFF	--	--	--	ON	OFF
{46}	BASE DO6	OFF	--	--	--	ON	OFF
{47}	DI 6	OFF	--	--	--	ON	OFF
{48}	DMPR COMD	0.0	PCT	0.4	0.0	--	--
{49}	DMPR POS	0.0	PCT	0.4	0.0	--	--
{50}	AUX TEMP	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
51	MTR1 TIMING	95	SEC	1	0	--	--
52	FLOW 2 END	45.2	PCT	0.4	0.0	--	--
53	FLOW 3 START	60.0	PCT	0.4	0.0	--	--
{54}	AI 5	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
55	FAN FLO MORE	2500 (1179.75)	CFM (LPS)	4 (1.8876)	0	--	--
56	DMPR ROT ANG	90	--	1	0	--	--
57	STG 3 TIME	120	SEC	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR. REV	0	--	1	0	--	--
{60}	WARMUP	OFF	--	--	--	ON	OFF
{61}	VAV AHU	OFF	--	--	--	ON	OFF
{62}	FLOW TEMP	NORMAL	--	--	--	ALARM	NORMAL
63	CLG P GAIN	20.0 (36.0)	--	0.25 (0.45)	0.0	--	--
64	CLG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0.0	--	--
65	TEMP LLIMIT	55.0 (12.80888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{66}	FAN AOV1	0.0	VOLTS	0.01	0.0	--	--
67	HTG P GAIN	10.0 (18.0)	--	0.25 (0.45)	0.0	--	--
68	HTG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0.0	--	--
69	TEMP HLIMIT	85.0 (29.60888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{70}	AOV 2	0.0	VOLTS	0.01	0.0	--	--
71	FAN TIME	60	SEC	1	0	--	--
72	FLOW I GAIN	0.02	--	0.001	0.0	--	--
73	HTG DBAND	2.0 (1.12)	DEG F (DEG C)	0.25 (0.14)	0.5(0.28)	--	--
74	MORN DBAND	2.0 (1.12)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
{75}	FLOW	0.0	PCT	0.25	0.0	--	--
{76}	CTL FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
{77}	CTL FLOW MAX	2200 (1038.18)	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	0.0	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	FAN FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
83	FAN FLOW MID	2500 (1179.75)	CFM (LPS)	4 (1.8876)	0	--	--

Point Number [1]	Descriptor	Factory Default (SI Units)[2]	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
84	FAN FLO HMAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
85	FAN FLO CMAX	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
86	SWITCH TIME	10	MIN	1	0	--	--
{87}	FLO HI	2200 (1038.18)	CFM (LPS)	4 (1.8876)	0	--	--
88	STAGE COUNT	2	--	1	0	--	--
89	STAGE TIME	10	MIN	1	1	--	--
90	SWITCH DBAND	1.0 (0.56)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
{91}	AOV 3	0.0	VOLTS	0.01	0.0	--	--
{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{93}	FLOW 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	DUCT 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	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	0.25 (0.14)	-31.75(-17.78)	--	--
{103}	DO 7	OFF	--	--	--	ON	OFF
{104}	DO 8	OFF	--	--	--	ON	OFF
106	NGT FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
107	VENT DMD MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
109	CLG FLOW MIN	220 (103.818)	CFM (LPS)	4 (1.8876)	0	--	--
110	OCC SWITCH	NO	--	--	--	YES	NO
{111}	OCC STBY	NO	--	--	--	YES	NO
112	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.

Issued by
Siemens Industry, Inc.
Building Technologies Division
1000 Deerfield Pkwy
Buffalo Grove IL 60089
Tel. +1 847-215-1000