

SIEMENS



BACnet PTEC Controller

VAV 0 to 10V Series Fan and 3-
Stage Electric Heat, Application
6657

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Overview

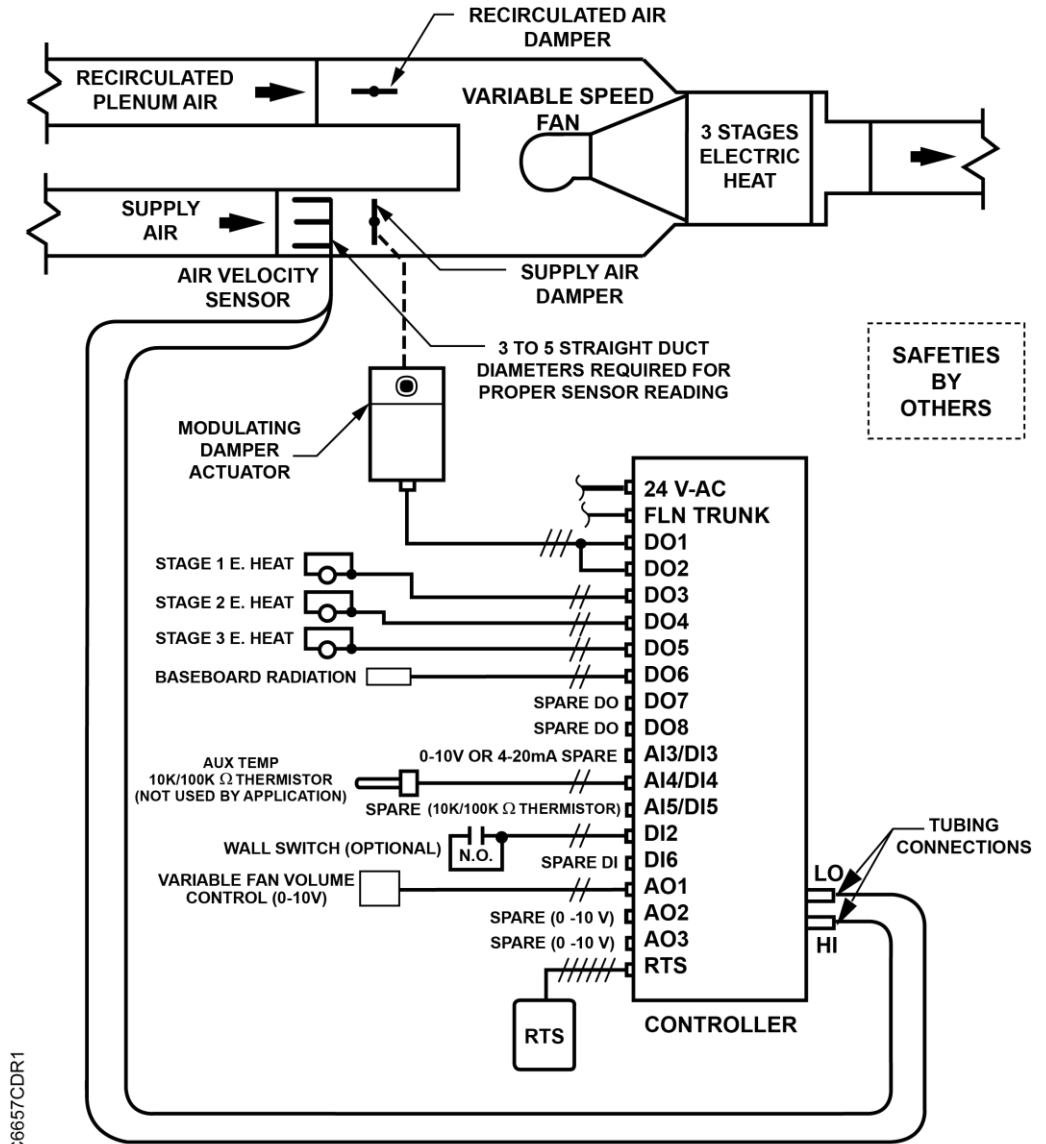
**NOTE:**

For information on applications with Firmware Revision Bx40 or earlier, see InfoLink and/or Asset Portal for documentation.

In Application 6657, 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). For the terminal box to work properly, the central air handling unit must provide supply air.

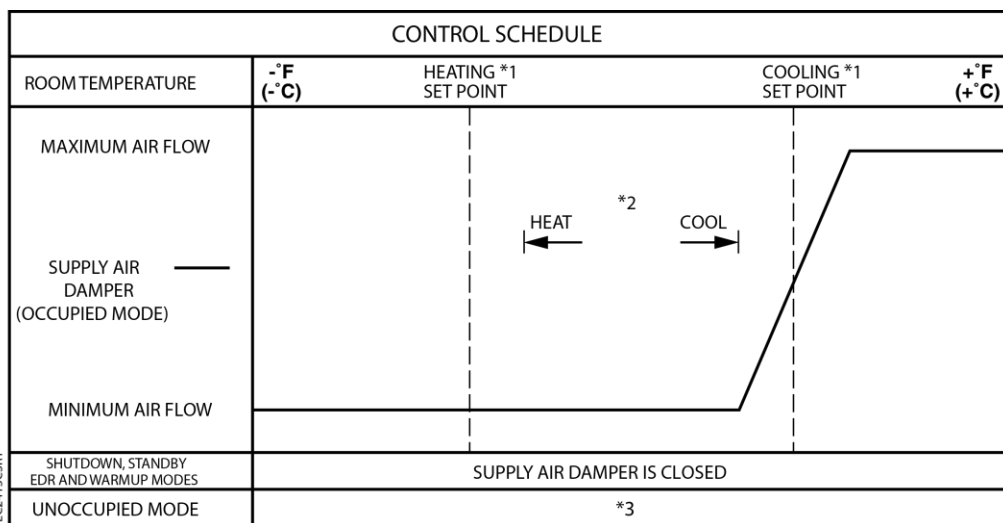
Certain control features of Application 6657 depend on whether the central air handling unit is ON or OFF. Application 6657 monitors VAV AHU for this information. Application 6657 does not command VAV AHU — it only responds to it. To command VAV AHU, it must be unbundled at the field panel and commanded by PPCL.

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.



TEC6657CDR1

Room unit can also provide monitoring for humidity and/or CO2
Application 6657 Control Diagram.

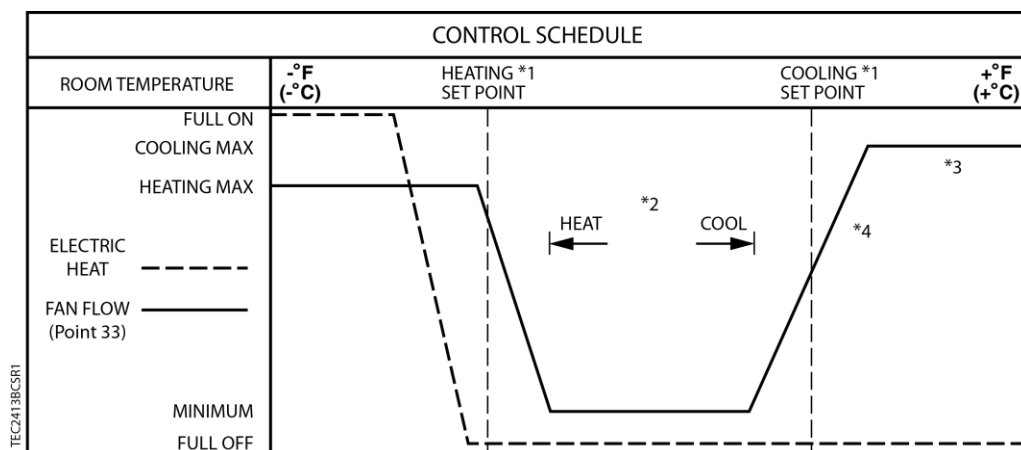


Application 6657 Supply Air Damper Control Schedule with HTG FLOW MAX = CLG FLOW MIN.



NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. The supply damper remains closed (or at NGT FLOW MIN) in the Unoccupied Mode as long as HEAT.COOL equals HEAT. The supply damper also remains closed (or at NGT FLOW MIN) in the Unoccupied mode if HEAT.COOL equals COOL and the room temperature remains less than TEMP.HLIMIT. Once the room temperature rises above TEMP.HLIMIT while VAV AHU = ON, 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.)
4. Minimum air flow (CTL FLOW MIN), during Occupied cooling modes, will be the larger of CLG FLOW MIN and VENT DMD MIN. And at Occupied heating modes, CTL FLOW MIN will be VENT DMD MIN. During unoccupied times, CTL FLOW MIN will be set to NGT FLOW MIN.



Fan and One Stage of Electric Heat in Occupied Mode.

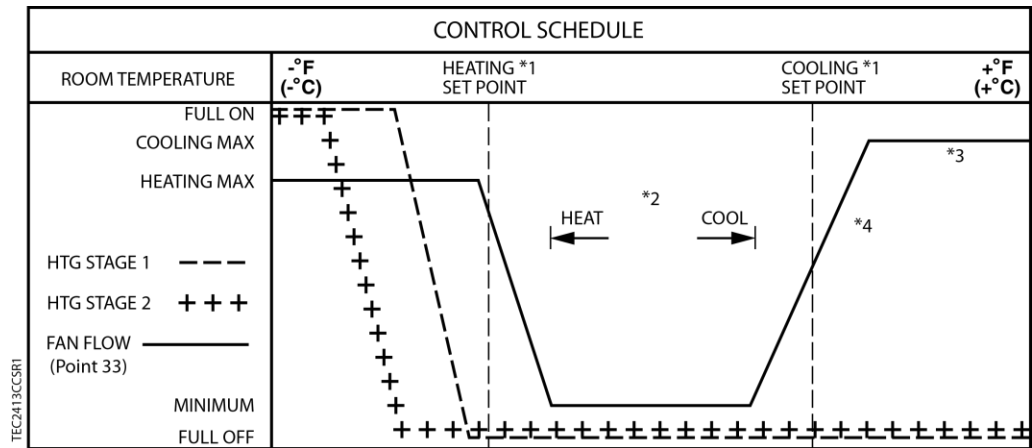


NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. The supply damper remains closed (or at NGT FLOW MIN) in the Unoccupied mode as long as HEAT.COOL equals HEAT. The supply damper also remains closed (or at NGT FLOW MIN) in the Unoccupied mode if HEAT.COOL equals COOL and the room temperature remains less than TEMP HLIMIT. Once the room temperature rises above TEMP HLIMIT while VAV AHU = ON, 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.)

2 Stages of Electric Heat

When only **two** of the three stages of electric heat are used, the supply air damper of the terminal box is modulated for cooling and up to **two** stage of electric heat controlled for heating.

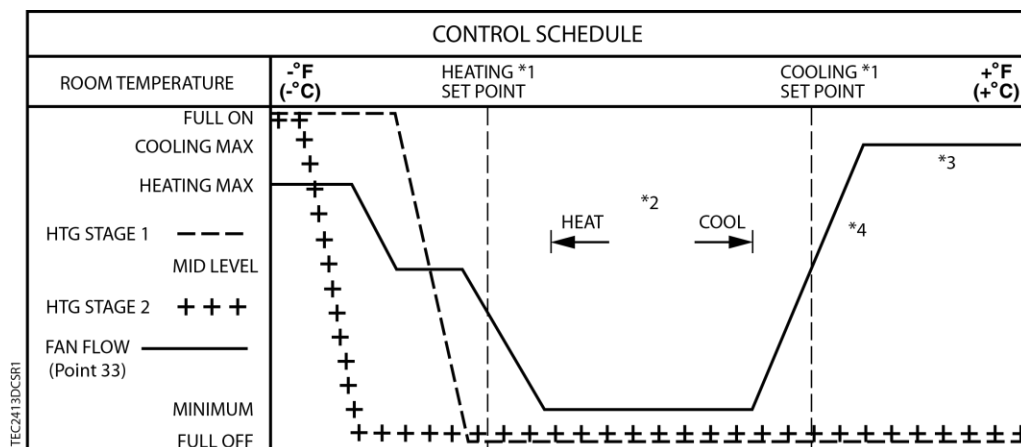


Fan and Two Stages of Electric Heat in Occupied Mode.



NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. The supply damper remains closed (or at NGT FLOW MIN) in the Unoccupied mode as long as HEAT.COOL equals HEAT. The supply damper also remains closed (or at NGT FLOW MIN) in the Unoccupied mode if HEAT.COOL equals COOL and the room temperature remains less than TEMP HLIMIT. Once the room temperature rises above TEMP HLIMIT while VAV AHU = ON, 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.)

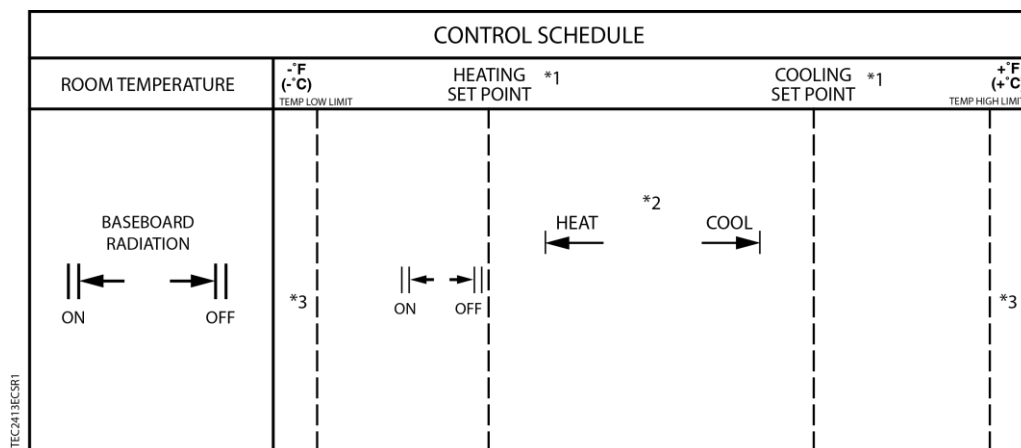


FAN MODE = VARI Control Schedule.



NOTES:

1. See *Control Temperature Setpoints*.
2. See *Heating/Cooling Switchover*.
3. The supply damper remains closed (or at NGT FLOW MIN) in the Unoccupied mode as long as HEAT.COOL equals HEAT. The supply damper also remains closed (or at NGT FLOW MIN) in the Unoccupied mode if HEAT.COOL equals COOL and the room temperature remains less than TEMP.HLIMIT. Once the room temperature rises above TEMP.HLIMIT while VAV AHU = ON, 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.)



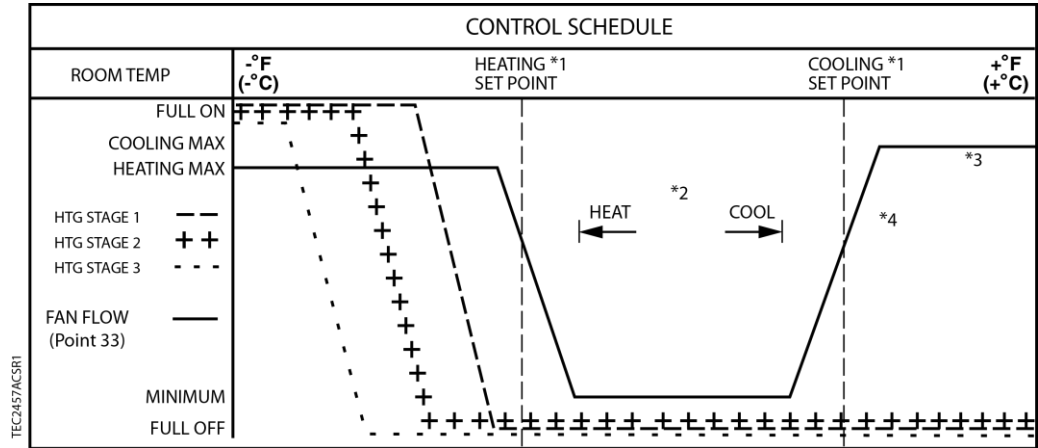
Application 6657 Baseboard Radiation Operation in Unoccupied Mode Control Schedule.



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* for more information.)

3 Stages of Electric Heat

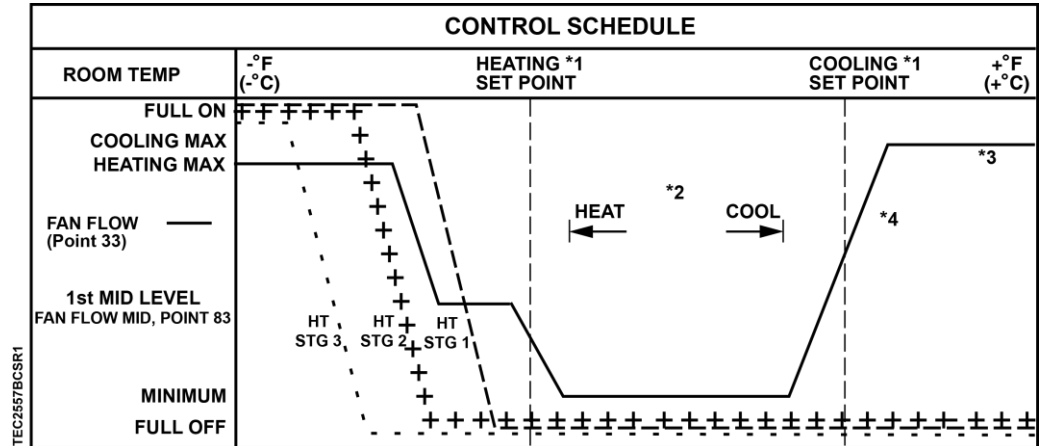


Application 6657 FAN FLOW control and up to Three Stages of Electric Heat Operation in Occupied Mode.

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

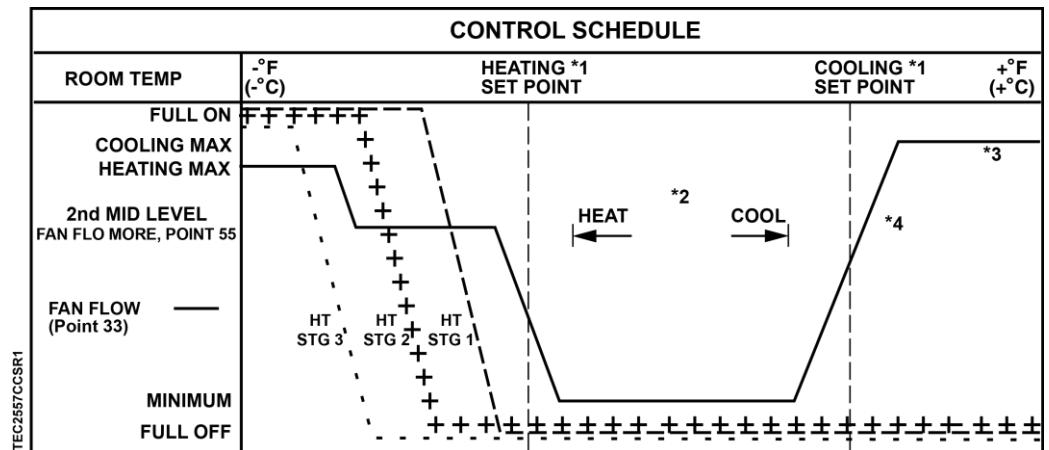
**NOTES:**

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 6657 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 (see *Definition of MODE Point*):
 - Shutdown Mode** — The fan (see *Note 5*) and electric heating stages are OFF.
 - Unoccupied Mode** — See *Note 6* for fan operation. See *Note 7* 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. 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.
6. During unoccupied mode the fan stays OFF 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.)
7. 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.
8. 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.
9. During unoccupied modes if NGT FLOW MIN is set to non-zero, and measured air flow is greater than 50 percent of NGT FLOW MIN, the fan will turn on.



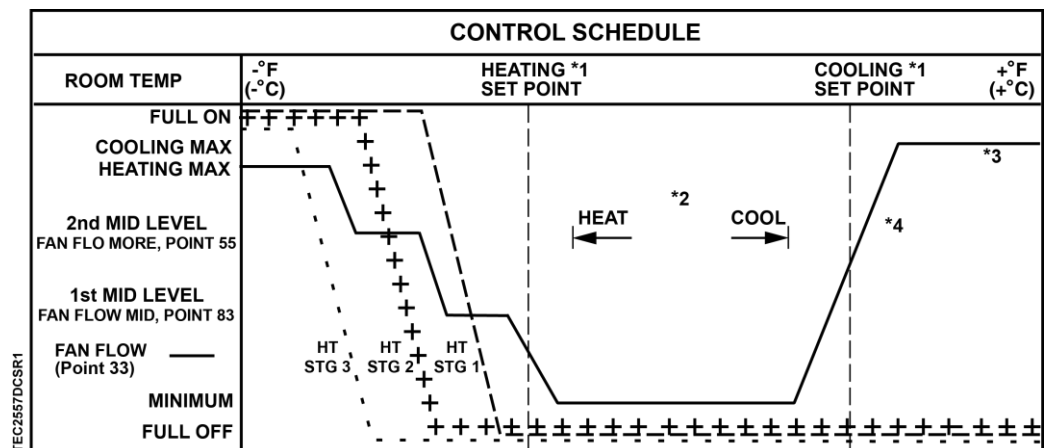
Application 6657 Fan and up to Three Stages of Electric Heat Operation in Occupied Mode.

Heating Option 2: The application has been set up so that neither heating valve can modulate open until the airflow out of the fan is at FAN FLO HMAX.



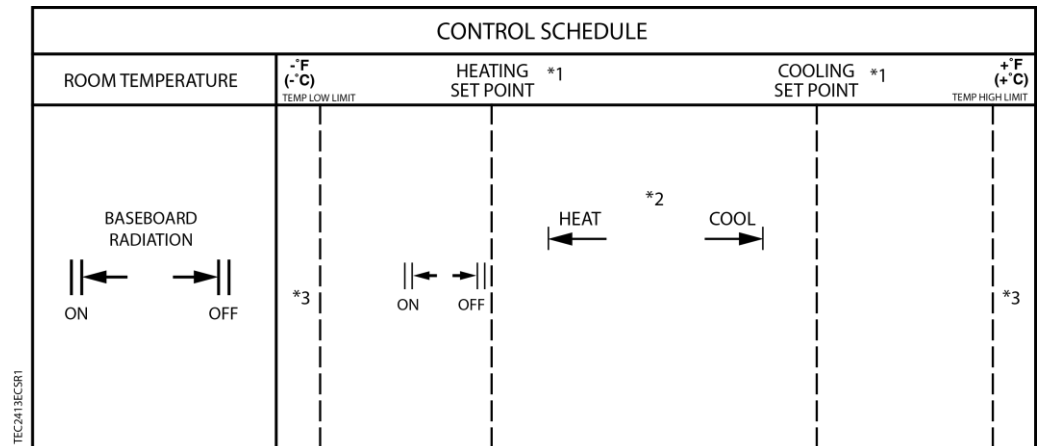
Application 6657 Fan and Three Stages of Electric Heat Operation in Occupied Mode.

Heating Option 3: 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). 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 and the remaining stages cannot start until the fan flow is at FAN FLO HMAX.



Application 6657 Fan and Three Stages of Electric Heat Operation in Occupied Mode.

Heating Option 4: The application has been set up so that the first heating valve can modulate open when the fan is producing a MID LEVEL airflow.



Application 6657 Baseboard Radiation Operation in Unoccupied Mode Control Schedule.



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* for more information.)

BACnet

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

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

Hardware Inputs

Analog

- Air velocity sensor
- Room temperature sensor
- *(Optional)* Room temperature setpoint dial
- *(Optional)* Auxiliary temperature sensor (100K or 10K Ω selectable thermistor)
- *(Optional)* Spare temperature sensor (100K or 10K Ω selectable thermistor)

Digital

- *(Optional)* Unoccupied mode override
- *(Optional)* Night/Unoccupied mode override
- *(Optional)* Wall switch



NOTE:

Digital Room Units (Firmware Revision 26 and later) will update their controlled inputs without putting them Out Of Service. However, a command from an external source through the digital room unit will put the associated BACnet Input point Out Of Service.

Room Unit Identification

- For Analog Room Units (Series 1000) – The revision number is visually identified by its case.

- For Digital Room Units (Series 200/2300 Firmware Revision 25 or earlier) – The revision number displays for 5 seconds when the room unit is first powered up. These room units will display `laptop` when a laptop is connected and will no longer update room temperature sensor values.
- For Digital Room Units (Series 2200/2300 Firmware Revision 26 and later) – The revision number displays for 5 seconds when the room unit is first powered up or when a laptop is disconnected. These room units will continue to display and update the room temperature sensor values when a laptop is connected.

Hardware Outputs

Analog

- Fan AOV
- Spare Analog Output (two) 0-10 Vdc

Digital

- Damper actuator (DO 1/DO 2)
- *(Optional)* Stage 1 electric heat
- *(Optional)* Stage 2 electric heat
- *(Optional)* Stage 3 electric heat
- *(Optional)* Baseboard radiation
- Spare Digital Output (two)

Ordering Notes

550-492PA BACnet PTEC VAV with Series Fan and 3-Stage Electric Heat

Sequence of Operation

The following paragraphs present the sequence of operation for Application 6657, BACnet PTEC VAV with Series Fan and 3-Stage Electric Heat.

Definition of MODE Point

The DAY.NGT point is not used. A virtual AO point (MODE) 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.

Summary of Equipment Actions

Application 6657 controls several pieces of equipment throughout its different operational modes. For an overview of what each piece of equipment does in each mode and for brevity and clarity, see Summary of Equipment Actions During Different Operational Modes [→ 16] and the table which provides only summaries of equipment actions. (Full descriptions of detailed interactions between equipment pieces are provided in the related sections of the text.)

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 and minimum airflow for ventilation	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.

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

CTL STPT is Overridden

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

Depending on certain conditions, CTL STPT holds either the value of one of the occupied or unoccupied cooling/heating setpoints, or the value of the room setpoint dial. See the following:

Occupied CLG/HTG Setpoints – When STPT DIAL equals NO (default), CTL STPT holds the value of OCC CLG STPT or OCC HTG STPT if:

- MODE equals Occupied, EDR, or Standby.
- MODE equals Unoccupied, but UNOCC OVRD equals OCC.

Unoccupied CLG/HTG Setpoints – CTL STPT holds the value of UOC CLG STPT or UOC HTG STPT if:

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

Room Setpoint Dial –When STPT DIAL is 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.



NOTE:

RM STPT DIAL must stay between the values of RM STPT MIN and RM STPT MAX; otherwise, CTL STPT will use those values instead.

CTL STPT in Night Mode

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

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

CTL STPT in Day Mode

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

Without setpoint dial:

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

With setpoint dial:

When the controller is in Day mode and STPT DIAL = YES, CTL STPT holds a value based on RM STPT DIAL depending on your room unit model/revision.

The following sections describe the value of CTL STPT based on room unit type and configuration:

- CTL STPT using Standard/Absolute Mode (Digital Room Unit, Revision 26 and later)
- CTL STPT using Warmer/Cooler Mode (Digital Room Unit, Revision 26 and later)
- CTL STPT using Standard/Absolute Mode (Analog or Digital Room Unit)
- CTL STPT using Warmer/Cooler Mode (Analog Room Unit Only)



NOTE:

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

CTL STPT Using Standard/Absolute Mode (Digital Room Unit, Revision 26 and later)

Digital Room Unit (2200/2300 Series Firmware Revision 26 and later)

For all new digital room units, the value displayed and reported by the room unit is linked to the current heat/cool mode. When the mode changes, the value is automatically updated based on the new heat/cool mode.

When STPT SPAN is set to 0, the room setpoint adjustment on the digital room unit functions in a standard mode. The range of the adjustment is based on RM STPT MIN and RM STPT MAX.

CTL STPT is set equal to RM STPT DIAL. The values for RM STPT MIN and RM STPT MAX are applied to limit RM STPT DIAL before it is copied into CTL STPT.

CTL STPT Using Warmer/Cooler Mode (Digital Room Unit, Revision 26 and later)

Digital Room Unit (2200/2300 Series Firmware Revision 26 and later)



NOTE:

The warmer-cooler function is only available with BACnet PTEC controllers (standard 66xx apps).

When STPT SPAN is set to a value > 0 , the room setpoint adjustment on the digital room unit functions in a warmer/cooler mode. The range of the adjustment is calculated based on the current DAY CLG STPT or DAY HGT STPT and the STPT SPAN value. This will allow the Room Setpoint Dial to be incremented up or down from these setpoints by STPT SPAN.

CTL STPT is set equal to RM STPT DIAL. The values for RM STPT MIN and RM STPT MAX is applied to limit RM STPT DIAL before it is copied into CTL STPT.

When SPTP SPAN > 0 , the minimum and maximum values for RM STPT DIAL are calculated as follows:

- Minimum lowest adjusted setpoint value is equal to DAY CLG STPT or DAY HTG STPT - STPT SPAN
- Maximum highest adjusted setpoint value is equal to DAY CLG STPT or DAY HTG STPT + STPT SPAN

Example in Cooling Mode

If the STPT SPAN is set to 2.0 degrees, and the DAY CLG STPT is 76°F, you can move the room unit setting up or down to adjust the RM STPT DIAL from 74°F to 78°F.

CTL STPT Using Standard/Absolute Mode (Analog or Digital Room Unit)

Analog (Series 1000) or Digital Room Units (Firmware Revision 25 or earlier)



NOTE:

2200/2300 digital room units with Firmware Revision 25 or earlier are only compatible with standard room unit functionality (no warmer/cooler).

When STPT SPAN is set to 0, CLT STPT is set based on the value of the setpoint dial and the setpoint deadband.

The setpoint deadband is the difference between the cooling and heating day setpoints (DAY CLG STPT DAY – HTG STPT). The setpoint deadband can be disabled by setting DAY HTG STPT equal to DAY CLG STPT. When DAY HTG STPT does not equal DAY CLG STPT, a setpoint deadband (or zero energy band) is used.

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

- *Deadband* is the value of the difference between DAY CLG STPT and DAY HTG STPT and is used to establish the current heating and cooling setpoints.
- $Deadband = (DAY\ CLG\ STPT - DAY\ HTG\ STPT)$

CTL STPT is calculated as follows:

With Deadband disabled:

$CTL\ STPT = RM\ STPT\ DIAL$

With Deadband enabled in Heat Mode:

$CTL\ STPT = RM\ STPT\ DIAL - 0.5 * Deadband$

With Deadband enabled in Cool Mode:

$CTL\ STPT = RM\ STPT\ DIAL + 0.5 * Deadband$

CTL STPT is limited between the value of RM STPT MIN and RM STPT MAX

CTL STPT Using Warmer/Cooler Mode (Analog Room Unit Only)

Analog Room Unit (Series 1000)



NOTE:

The warmer-cooler function for analog room units (Series 1000) use the warmer/cooler scale of units with a warmer/cooler housing.

When SPTP SPAN > 0, the minimum and maximum values for RM STPT DIAL are calculated as follows:

- Minimum lowest adjusted setpoint value is equal to DAY CLG STPT or DAY HTG STPT - STPT SPAN
- Maximum highest adjusted setpoint value is equal to DAY CLG STPT or DAY HTG STPT + STPT SPAN

The full range of the analog room unit slider are mapped to a range of minimum setpoint value to maximum setpoint value.

CTL STPT is set equal to RM STPT DIAL. The values for RM STPT MIN and RM STPT MAX are applied to limit RM STPT DIAL before it is copied into CTL STPT.

Example in Cooling Mode

If the STPT SPAN is set to 2.0 degrees, and the DAY CLG STPT is 76°F, the room unit slider will adjust the cooling setpoint from 74°F to 78°F.

Heating/Cooling Switchover

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% (internal setpoint)
- CTL TEMP > CTL STPT by at least the value set in SWITCH DBAND
- CTL TEMP > the appropriate cooling setpoint minus SWITCH DBAND

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

- CLG LOOPOUT < 5.2% (internal setpoint)
- CTL TEMP < CTL STPT by at least the value set in SWITCH DBAND
- CTL TEMP < the appropriate heating setpoint minus SWITCH DBAND

When the STPT DIAL = NO, the heating/cooling switchover values are determined by DAY HTG STPT and DAY CLG STPT.

When the STPT DIAL = YES, the following sections describe the values used for the heating/cooling switchover points based on room unit type and configuration.

See the appropriate sections:

- Heating/Cooling Switchover Using Standard/Absolute Mode (Digital Room Unit, Revision 26 and later) [→ 22]
- Heating/Cooling Switchover Using Warmer/Cooler Mode (Digital Room Unit, Revision 26 and later) [→ 23]
- Heating/Cooling Switchover Using Standard/Absolute Mode (Analog Room Unit) [→ 23]
- Heating/Cooling Switchover Using Warmer/Cooler Mode (Analog Room Unit) [→ 24]

Heating/Cooling Switchover using Standard/Absolute Mode (Digital Room Unit, Revision 26 and later)

Recommended Configuration: Digital Room Units (2200/2300 Series Firmware Revision 26 and later)

For new digital room units, the graphic or actual value displayed and reported by the room unit is linked to the current heat/cool mode. When the mode changes, the value is automatically updated based on the new heat/cool mode.

- When the controller is in cooling mode, the heating switchover setpoint is as follows:
Heating switchover point is equal to $RM\ STPT\ DIAL - DAY\ CLG\ STPT + DAY\ HTG\ STPT$
- When the controller is in heating mode, the cooling switchover setpoint is as follows:
Cooling switchover point is equal to $RM\ STPT\ DIAL - DAY\ HTG\ STPT + DAY\ CLG\ STPT$

Example

DAY CLG STPT = 74 and DAY HTG STPT = 70

In Cooling mode, when you adjust the setpoint value on the room unit to 76, the heating switchover point will equal $72 - \text{SWITCH DBAND}$.

Heating switchover point: $76 - 74 + 70 = 72 - \text{SWITCH DBAND}$

When the room temperature drops below heating switchover point and the switchover conditions are met, the controller switches to heating mode, the new value for the setpoint displays and RM STPT DIAL is 72 degrees.

Heating/Cooling Switchover Using Warmer/Cooler Mode (Digital Room Unit, Revision 26 and later)

Digital Room Unit (2200/2300 Series Firmware Revision 26 and later)

For new digital room units, the graphic or actual value displayed and reported by the room unit is linked to the current heat/cool mode. When the mode changes, the value is automatically updated based on the new heat/cool mode.

The RM STPT DIAL displays the current temperature setpoint based on a plus or minus position or increment that you enter at the room unit.

When SPTP SPAN > 0, the minimum and maximum values for RM STPT DIAL are calculated as follows:

- Minimum lowest adjusted setpoint value is equal to $\text{DAY CLG STPT or DAY HTG STPT} - \text{STPT SPAN}$
- Maximum highest adjusted setpoint value is equal to $\text{DAY CLG STPT or DAY HTG STPT} + \text{STPT SPAN}$

The heat/cool switchover mechanism is the same as in standard/absolute mode.

- When the controller is cooling mode, the heating switchover setpoint is as follows:
Heating switchover point is equal to $\text{RM STPT DIAL} - \text{DAY CLG STPT} + \text{DAY HTG STPT}$
- When the controller is heating mode, the cooling switchover setpoint is as follows:
Cooling switchover point is equal to $\text{RM STPT DIAL} - \text{DAY HTG STPT} + \text{DAY CLG STPT}$

Heating/Cooling Switchover Using Standard/Absolute Mode (Analog Room Unit)

Analog (Series 1000) or Digital Room Units (Firmware Revision 25 or earlier)

The difference between day heating and day cooling setpoint establishes the separation for heat/cool switchover points (deadband = $\text{DAY CLG STPT} - \text{DAY HTG STPT}$).

- When the controller is in Cooling mode, the heating switchover setpoint is as follows:
Heating switchover point is equal to $\text{RM STPT DIAL} - 0.5 * \text{the deadband}$
- When the controller is in Heating mode, the cooling switchover setpoint is as follows:
Cooling switchover point is equal to $\text{RM STPT DIAL} + 0.5 * \text{the deadband}$

Heating/Cooling Switchover Using Warmer/Cooler Mode (Analog Room Unit)

Analog Room Unit (Series 1000)

The RM STPT DIAL displays the current temperature setpoint based on a plus or minus position or increment that you enter at the room unit.

The amount of offset that can be entered with the analog room unit is limited to a value of minus STPT SPAN to plus STPT SPAN.

- When the controller is in Cooling mode, the heating switchover setpoint is as follows:
Heating switchover point is equal to DAY CLG STPT, plus the amount of offset entered
- When the controller is in Heating mode, the cooling switchover setpoint is as follows:
Cooling switchover point is equal to DAY HTG STPT, plus the amount of offset entered

Room Temperature, Room Temperature Offset and CTL TEMP

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

RMTMP OFFSET (or TEMP OFFSET) is a user-adjustable offset that compensates 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, the application is trying to maintain CTL TEMP at the control setpoint.

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

$$\text{CTL TEMP} = \text{ROOM TEMP} + \text{RMTMP OFFSET (or TEMP OFFSET)}$$

If CTL TEMP is not overridden then,

- The current value of ROOM TEMP (normal or overridden) determines the value of CTL TEMP.
- If ROOM TEMP has a status of Failed, then the last known good value of ROOM TEMP determines the value of CTL TEMP.

Ventilation Demand Minimum

The additional flow setpoint (VENT DMD MIN) is provided to allow setting and adjustment of the ventilation air required during occupied modes. VENT DMD MIN flow setpoint is used in conjunction with the existing cooling and heating flow minimum setpoints but only during the occupied modes.

VENT DMD MIN can be set above, equal to, or below CLG FLOW MIN or HTG FLOW MIN setpoints and the controlling minimum is the greater of the two. This allows you to set the cooling flow minimum to be set to zero and use the vent demand to control cooling and heating ventilation requirements.

VENT DMD MIN can be controlled (reset) externally, or by PPCL in the controller, for ventilation demands as based on CO2 or other indoor air quality requirements. Minimum airflow is the greater of cooling flow minimum or heating flow minimum

setpoints and the current ventilation demand flow setpoint. The control maximum flow setpoints are not affected by VENT DMD MIN.

Night Flow Minimum

Some applications do not provide a distinction between day/occupied and night/unoccupied modes for the minimum airflow setpoints. For day/occupied operation, the cooling minimum flow setpoint is designed to be the airflow for minimum cooling and ventilation. For night/unoccupied times, the associated air handling unit was typically not running and therefore no distinction was necessary.

Using the additional flow setpoint, NGT FLOW MIN, in place of cooling flow minimum, addresses this condition. Since 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 cooling flow setpoint is still used when the zone temperature exceeds the night cooling setpoint.

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:

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

During occupied cooling mode:

CLT FLOW MIN is the larger of CLG FLOW MIN and VENT DMD MIN

During occupied heating mode:

CLT FLOW MIN is equal to VENT DMD MIN

During unoccupied mode, CLT FLOW MIN = NGT FLOW MIN

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 about FAN FLOW and FAN AOV1.)

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 the EDR (electric demand reduction) mode or in standby mode.
- The application is in the unoccupied mode, CTL TEMP is below TEMP LLIMIT, 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. In the cooling mode, CTL FLOW MIN is the larger of CLG FLOW MIN and VENT DMD MIN. Either 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: $(\text{CTL FLOW MIN} \div \text{CTL FLOW MAX}) \times 100\%$ 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 = $(250 \text{ cfm} / 1000 \text{ cfm}) \times 100\% \text{ flow} = 0.25 \times 100\% \text{ flow} = 25\% \text{ flow}$.

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.

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 LLIMIT, 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 will not be allowed to turn ON until FAN FLOW is equal to or greater than 98% of FAN FLO HMAX.
- The second stage of electric heat will not be allowed to 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 will not be allowed to 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 will not be allowed to 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 will not be allowed to 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 will not be allowed to 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) will not be allowed to 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 is not allowed to 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 is not allowed to 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 will not be allowed to turn ON until HEAT STAGE 1 has been ON longer than STG 1 TIME.
- HEAT STAGE 3 will not be allowed to turn ON until HEAT STAGE 2 has been ON longer than STG 2 TIME.
- HEAT STAGE 2 will not be allowed to turn OFF until HEAT STAGE 3 has been OFF longer than STG 3 TIME.
- HEAT STAGE 1 will not be allowed to 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 6657 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 LOOPOUT 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 LOOPOUT 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 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 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 FLO 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 FLO 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.

FAN FLOW MID < FAN FLO MORE < FAN FLO HMAX

When FAN FLOW MID < FAN FLO MORE < FAN FLO HMAX, 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 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 6657, 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 LLIMIT, 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.)

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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times \text{FLOW END}$. 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW2 END} - \text{FLOW 2 START})$. 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times \text{FLOW 1 END}$, 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW2 END} - \text{FLOW 2 START})$. 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 FAN FLO 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW END} - \text{FLOW 3 START})$. 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 3 START, FAN FLOW cannot change faster than $(\text{LOOP TIME} \div \text{FAN TIME}) \times \text{FLOW 1 END}$, 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW END} - \text{FLOW 3 START})$. 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW END} - \text{FLOW 3 START})$. 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 STAGE 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 FLOW MORE.
- When HTG LOOPOUT equals FLOW 2 END, FAN FLOW is set equal to FAN FLOW MORE. (If HTG LOOPOUT rises above FLOW 2 END but stays below FLOW 3 START, FAN FLOW remains equal to FAN FLOW MORE while HEAT STAGE 1 and HEAT STAGE 2 time modulate.)
- When HTG LOOPOUT is between FLOW 3 START and FLOW 3 END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MORE and FAN FLOW HMAX.
- When HTG LOOPOUT is equal to or greater than FLOW 3 END, FAN FLOW is set equal to FAN FLOW 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW 2 END} - \text{FLOW 2 START})$, 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 FLOW MORE. If HTG LOOPOUT is greater than FLOW 3 START, FAN FLOW cannot change faster than $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW 3 END} - \text{FLOW 3 START})$. Therefore, even if HTG LOOPOUT changes suddenly from FLOW 3 START to FLOW 3 END, the amount of time stored in FAN TIME must still elapse before FAN FLOW may change from FAN FLOW MORE to FAN FLOW HMAX.

Since the value of FLOW 2 END – FLOW 2 START and the value of FLOW 3 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 FLOW MORE.
- When HTG LOOPOUT equals FLOW 2 END, FAN FLOW is set equal to FAN FLOW MORE. (If HTG LOOPOUT rises above FLOW 2 END, but stays below FLOW 3 START, FAN FLOW remains equal to FAN FLOW MORE while HEAT STAGE 1 and HEAT STAGE 2 time modulate.)

- 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times \text{FLOW 1 END}$, 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW 2 END} - \text{FLOW 2 START})$, 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 $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW END} - \text{FLOW 3 START})$. 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). This application 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). 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.



NOTE:

The first time after startup or initialization, the controller will calibrate the dampers as if not using Autozero Modules, although the Autozero Modules will be activated. All subsequent calibrations will use the Autozero Modules only.

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%.

Room Unit Operation

Sensor Select

SENSOR SEL is a configurable, enumerated point (values are additive). This point tells the controller what type of room unit is being used and how to handle loss of communication, for more information see Fail Mode Operation. It also provides the ability to enable the optional RH and CO2 sensors and indicates which thermistor type is connected.

Room Temperature, Setpoint, RH and CO2

- When the digital room unit (Series 2200/2300) is used, SENSOR SEL selects the source for temperature and setpoint and enables a loss of communications indication:
 - 1 = enables supervision (from the room unit) for fail communications for temperature and setpoint.
 - 2 = enables supervision (from the room unit) for fail communications for relative humidity.
 - 4 = enables supervision (from the room unit) for fail communications for CO2.
- When the analog room unit (Series 1000/2000) is used, SENSOR SEL values for temperature/setpoint, relative humidity and CO2 should be left at their default values (0).

Thermistor Inputs

- Default for either input is 10K.
- To enable 100K Ω thermistor on input, see the following table for additive values.

SENSOR SEL Value * (additive)	Description (include values to enable feature)
1	Select Digital Room Unit (for temperature sensing and setpoint dial)
2	Relative Humidity (RH) sensing
4	CO ₂ sensing
8	If short board: 100K Ω thermistor on AI 3 (or input is 10K Ω) If long board: 100K Ω thermistor on AI 5 (or input is 10K Ω)
16	Long board only: 100K Ω thermistor on AI 4 (or input is 10K Ω)

Example 1: Digital Room Unit with temperature, RH, CO2 and 10K thermistor.
1+2+4+0 = 7

Example 2: Analog Room unit with 100K thermistor. 0+0+0+8 = 8

Room CO2

RM CO2 displays the CO₂ value in units of parts-per-million (PPM). RM CO2 (from the digital 2200/2300 room units) can be used with PPCL in the PTEC/ATEC controller or unbundled for control or monitoring purposes.

Room RH

RM RH displays the relative humidity value in percent. RM RH can be used for PPCL in the PTEC or unbundled for control or monitoring purposes.

RM RH displays the relative humidity value in percent.

Room DEW POINT

The controller provides a calculation for DEW POINT temperature in Fahrenheit degrees (or Celsius degrees) using room temperature (using CLT TEMP) and room humidity (using RM RH). This calculation is valid for ranges of 55°F (12.8°C) to 95°F (35°C) and 20 to 100% relative humidity.

Auto Discovery

Auto Discovery allows you to automatically discover and identify PTEC/ATEC controllers on the BACnet MS/TP Network. There are two basic configurations:

- Devices not configured with an address. (Devices are discovered by their unique serial number.)
- Devices configured with an address and available for modification.

Auto Addressing

Auto Addressing allows you to automatically assign device addresses to a PTEC/ATEC controller on the BACnet MS/TP Network. If a controller is not configured with a MAC address, you have the option to auto-address or manually address the controller. During this time the baud rate is automatically detected by the controller. Controller(s) must be connected on the BACnet/IP network in order for automatic addressing to occur.

PPCL STATUS

PPCL STATUS displays LOADED or EMPTY.

- LOADED = PPCL - programming is present in the controller. A new application number must be assigned (12000 through 12999).
- EMPTY = NO PPCL - programming is present.

The maximum number of PPCL dynamic points is 15.

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.

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.
4. Certain control features depend on whether the central air handling unit is ON or OFF. Application 6657 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 6657 has no fan DO, the only way to manually shut the fan OFF is to set FAN FLOW to 0.
6. In Application 6657, 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.

For more information, contact your local Siemens Industry representative.

Wiring Diagram



NOTE:

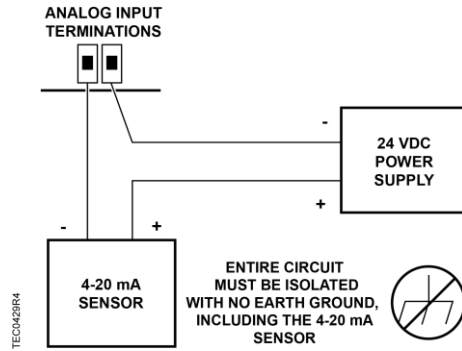
The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. An external interposing relay is required for any of the following:

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



NOTE:

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



Wiring for AI with a 4 to 20 mA Sensor.



CAUTION

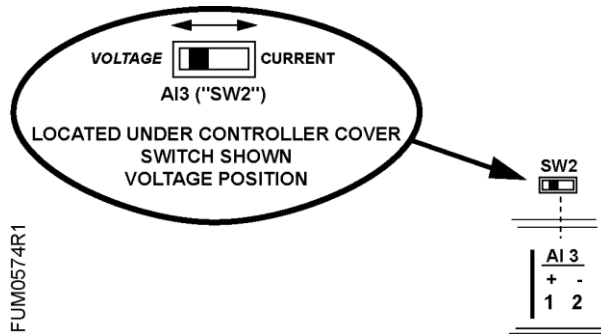
Each 4-20 mA sensor requires a **SEPARATE** dedicated power limited 24 Vdc power supply.

DO NOT use the same transformer to power both the sensor and the controller.



NOTE:

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

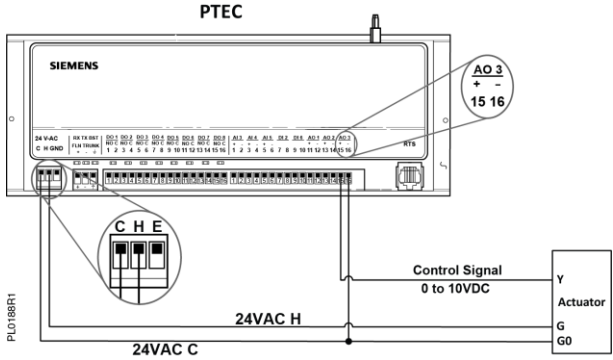


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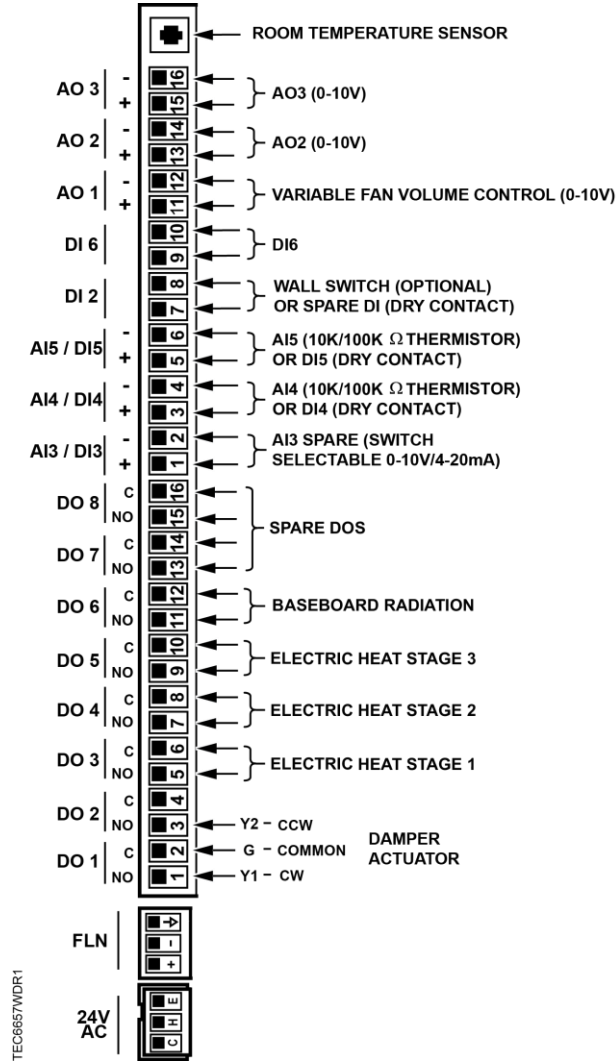
NOTE:

When wiring any actuator that uses a 0 to 10V control signal and ties AC neutral to DC common, an additional wire **must** connect the actuator AC neutral to the DC common of the PTEC/TEC AO being used to control the actuator.



24 Vac Modulating Control.

Actuator Symbol	TEC Connection	Function	Terminal Connection	Standard Color
1	H	Supply (SP)	G	Red
2	C	Neutral (SN)	G0	Black
8	AO3 – 15 (+)	0 to 10V input signal	Y	Gray
--	C to AO3 –16 (-)	Common jumper	--	--



Application 6657 - 0 to 10 V Series Fan and 3-Stage Electric Heat Controller.

Application 6657 Point Database

Object Type ¹	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ²	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	1	CTLR ADDRESS	255	--	0-255	--	--
AO	2	APPLICATION	6699	--	0-32767	--	--
AO	{03}	MODE	0	--	0-255	--	--
AI	{04}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
BO	{05}	HEAT.COOL	COOL	--	Binary	HEAT	COOL
AO	6	OCC CLG STPT	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	7	OCC HTG STPT	70.0 (21.20888)	DEG F (DEG C)	48-111.75	--	--
AO	8	UOC CLG STPT	82.0 (27.92888)	DEG F (DEG C)	48-111.75	--	--
AO	9	UOC HTG STPT	65.0 (18.40888)	DEG F (DEG C)	48-111.75	--	--
BI	{10}	DI 5	OFF	--	Binary	ON	OFF
AO	11	RM STPT MIN	52.5 (11.40888)	DEG F (DEG C)	48-111.75	--	--
AO	12	RM STPT MAX	74.25 (23.58888)	DEG F (DEG C)	48-111.75	--	--
AI	{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
BO	14	STPT DIAL	NO	--	Binary	YES	NO
AI	{15}	AI 3	0	PCT	0-102	--	--
BO	{16}	FAN MODE	VARI	--	Binary	CONST	VARI
AO	17	FLOW END	75.2	PCT	0-102	--	--
BO	18	WALL SWITCH	NO	--	Binary	YES	NO
BI	{19}	DI OVRD SW	OFF	--	Binary	ON	OFF
AO	20	OVRD TIME	0	HRS	0-255	--	--
BO	{21}	UNOCC OVRD	UNOCC	--	Binary	UNOCC	OCC
AO	22	FLOW 2 START	30	PCT	0-102	--	--
AO	23	FLOW 1 END	15.2	PCT	0-102	--	--
BI	{24}	DI 2	OFF	--	Binary	ON	OFF
BI	{25}	DI 3	OFF	--	Binary	ON	OFF
AO	26	ALARM TIME	5	MIN	0-255	--	--
AO	27	STG 1 TIME	120	SEC	0-255	--	--
AO	28	STG 2 TIME	120	SEC	0-255	--	--

Object Type ¹	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ²	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	30	LOW FLOW	5	PCT	0-127.75	--	--
AO	31	BOX SIZE	3	--	0-255	--	--
AO	32	CLG FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	{33}	FAN FLOW	0 (0.0)	CFM (LPS)	0-4092	--	--
AO	34	HTG FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AI	{35}	AIR VOLUME	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	36	FLOW COEFF	1	--	0-2.55	--	--
AO	{37}	FLO LO VOLTS	0	VOLTS	0-10.23	--	--
AO	{38}	FLO HI VOLTS	10	VOLTS	0-10.23	--	--
AO	{39}	FLO LO	0 (0.0)	CFM (LPS)	0-4092	--	--
BI	{40}	DI 4	OFF	--	Binary	ON	OFF
BO	{41}	DO 1	OFF	--	Binary	ON	OFF
BO	{42}	DO 2	OFF	--	Binary	ON	OFF
BO	{43}	HEAT STAGE 1	OFF	--	Binary	ON	OFF
BO	{44}	HEAT STAGE 2	OFF	--	Binary	ON	OFF
BO	{45}	HEAT STAGE 3	OFF	--	Binary	ON	OFF
BO	{46}	BASE DO6	OFF	--	Binary	ON	OFF
BI	{47}	DI 6	OFF	--	Binary	ON	OFF
AO	{48}	DMPR COMD	0	PCT	0-102	--	--
AO	{49}	DMPR POS	0	PCT	0-102	--	--
AI	{50}	AUX TEMP	74.0 (23.495556)	DEG F (DEG C)	37.5-165	--	--
AO	51	MTR1 TIMING	95	SEC	0-511	--	--
AO	52	FLOW 2 END	45.2	PCT	0-102	--	--
AO	53	FLOW 3 START	60	PCT	0-102	--	--
AI	{54}	AI 5	74.0 (23.495556)	DEG F (DEG C)	37.5-165	--	--
AO	55	FAN FLO MORE	2500 (1179.75)	CFM (LPS)	0-4092	--	--
AO	56	DMPR ROT ANG	90	--	0-255	--	--
AO	57	STG 3 TIME	120	SEC	0-255	--	--
AO	58	MTR SETUP	0	--	0-255	--	--
AO	59	DO DIR. REV	0	--	0-255	--	--
BO	{60}	WARMUP	OFF	--	Binary	ON	OFF

Object Type ¹	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ²	Eng Units (SI Units)	Range	Active Text	Inactive Text
BO	{61}	VAV AHU	OFF	--	Binary	ON	OFF
BO	{62}	FLOW TEMP	NORMAL	--	Binary	ALARM	NORMAL
AO	63	CLG P GAIN	20.0 (36.0)	--	0-63.75	--	--
AO	64	CLG I GAIN	0.01 (0.018)	--	0-1.023	--	--
AO	65	TEMP LLIMIT	55.0 (12.80888)	DEG F (DEG C)	48-111.75	--	--
AO	{66}	FAN AOV1	0	VOLTS	0-10.23	--	--
AO	67	HTG P GAIN	10.0 (18.0)	--	0-63.75	--	--
AO	68	HTG I GAIN	0.01 (0.018)	--	0-1.023	--	--
AO	69	TEMP HLIMIT	85.0 (29.60888)	DEG F (DEG C)	48-111.75	--	--
AO	{70}	AOV 2	0	VOLTS	0-10.23	--	--
AO	71	FAN TIME	60	SEC	0-255	--	--
AO	72	FLOW I GAIN	0.02	--	0-1.023	--	--
AO	73	HTG DBAND	2.0 (1.12)	DEG F (DEG C)	0.5-64.25	--	--
AO	74	MORN DBAND	2.0 (1.12)	DEG F (DEG C)	0-63.75	--	--
AO	{75}	FLOW	0	PCT	0-1023.75	--	--
AO	{76}	CTL FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	{77}	CTL FLOW MAX	2200 (1038.18)	CFM (LPS)	0-131068	--	--
AO	{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	{79}	CLG LOOPOUT	0	PCT	0-102	--	--
AO	{80}	HTG LOOPOUT	0	PCT	0-102	--	--
AO	{81}	AVG HEAT OUT	0	PCT	0-409.2	--	--
AO	82	FAN FLOW MIN	220 (103.818)	CFM (LPS)	0-4092	--	--
AO	83	FAN FLOW MID	2500 (1179.75)	CFM (LPS)	0-4092	--	--
AO	84	FAN FLO HMAX	2200 (1038.18)	CFM (LPS)	0-4092	--	--
AO	85	FAN FLO CMAX	2200 (1038.18)	CFM (LPS)	0-4092	--	--
AO	86	SWITCH TIME	10	MIN	0-255	--	--
AO	{87}	FLO HI	2200 (1038.18)	CFM (LPS)	0-4092	--	--
AO	88	STAGE COUNT	2	--	0-255	--	--

Object Type ¹	Object Instance (Point Number)	Object Name (Descriptor)	Factory Default (SI Units) ²	Eng Units (SI Units)	Range	Active Text	Inactive Text
AO	89	STAGE TIME	10	MIN	1-256	--	--
AO	90	SWITCH DBAND	1.0 (0.56)	DEG F (DEG C)	0-63.75	--	--
AO	{91}	AOV 3	0	VOLTS	0-10.23	--	--
AO	{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	48-111.75	--	--
AO	{93}	FLOW STPT	0	PCT	0-255.75	--	--
BO	{94}	CAL AIR	NO	--	Binary	YES	NO
AO	95	CAL SETUP	4	--	0-255	--	--
AO	96	CAL TIMER	12	HRS	0-255	--	--
AO	97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0-6.375	--	--
AO	98	LOOP TIME	5	SEC	0-255	--	--
AO	{99}	ERROR STATUS	0	--	0-255	--	--
AO	102	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75-32	--	--
BO	{103}	DO 7	OFF	--	Binary	ON	OFF
BO	{104}	DO 8	OFF	--	Binary	ON	OFF
AO	106	NGT FLOW MIN	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	{107}	VENT DMD MIN	0 (0.0)	CFM (LPS)	0-131068	--	--
AO	109	CLG FLOW MIN	220 (103.818)	CFM (LPS)	0-131068	--	--
AO	110	STPT SPAN	0.0 (0.0)	DEG F (DEG C)	0-63.75	--	--
AO	{121}	DEW POINT	-40.0 (-40.0)	DEG F (DEG C)	-40-1598.35	--	--
AO	124	SENSOR SEL	0	--	0-255	--	--
AI	{125}	RM CO2	1000	PPM	0-8191	--	--
AI	{126}	RM RH	50	PCT	0-102	--	--
BO	{127}	PPCL STATE	EMPTY	--	Binary	LOADED	EMPTY

- 1) Object Types are: Analog Input (AI), Analog Output (AO), Binary Input (BI) and Binary Output (BO).
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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