

## Custom Solutions Application 2413

### VAV with 0-10V Series-Fan Speed Output and Electric Heat

TEC-0155.08

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This document contains the following topics:

- Overview
  - Hardware Inputs
  - Hardware Outputs
  - Ordering Notes
- Sequence Of Operation
  - Definition of MODE Point
  - Occupied and Unoccupied Modes
  - Unoccupied Mode Override Switch
  - Control Temperature Set Points
  - Heating/Cooling Switchover
  - Control Loops
  - Electric Heat
  - Fan Operation
  - Warm-up
  - Baseboard Radiation
  - Flow-Temperature Alarm
  - Fail-Safe Operation
  - Calibration
- Application Notes
- Wiring Diagrams
- Point Database
- Slave Mode Point Database

## Overview

**NOTE:** For the latest on Custom Solution Applications and Controllers, visit the [Custom Solutions website](http://iknow.us.abatos.com/automate/customsolutions/custom_solutions.htm).  
([http://iknow.us.abatos.com/automate/customsolutions/custom\\_solutions.htm](http://iknow.us.abatos.com/automate/customsolutions/custom_solutions.htm))

In Application 2413, the supply air damper of the terminal box is modulated for cooling, and up to two stages of electric heat are controlled for heating. When in heating, the terminal box maintains minimum airflow out of the supply air duct. The terminal box also has a variable air volume series fan for air circulation (an option exists to run this series fan at constant volume). In order for the terminal box to work properly, the central air handling unit must provide supply air. Refer to Figures 2413-1 through 2413-6.

Certain control features of application 2413 depend on whether the central air handling unit is ON or OFF. Application 2413 monitors VAV AHU (Point 61) for this information. Application 2413 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.

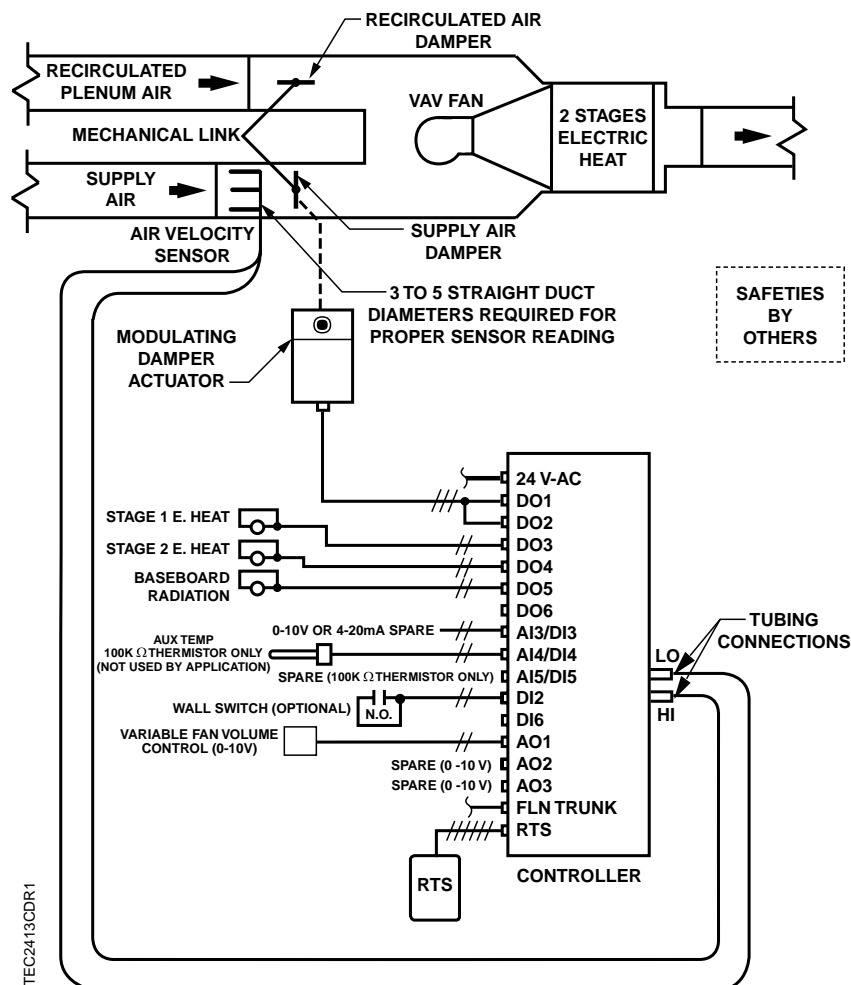
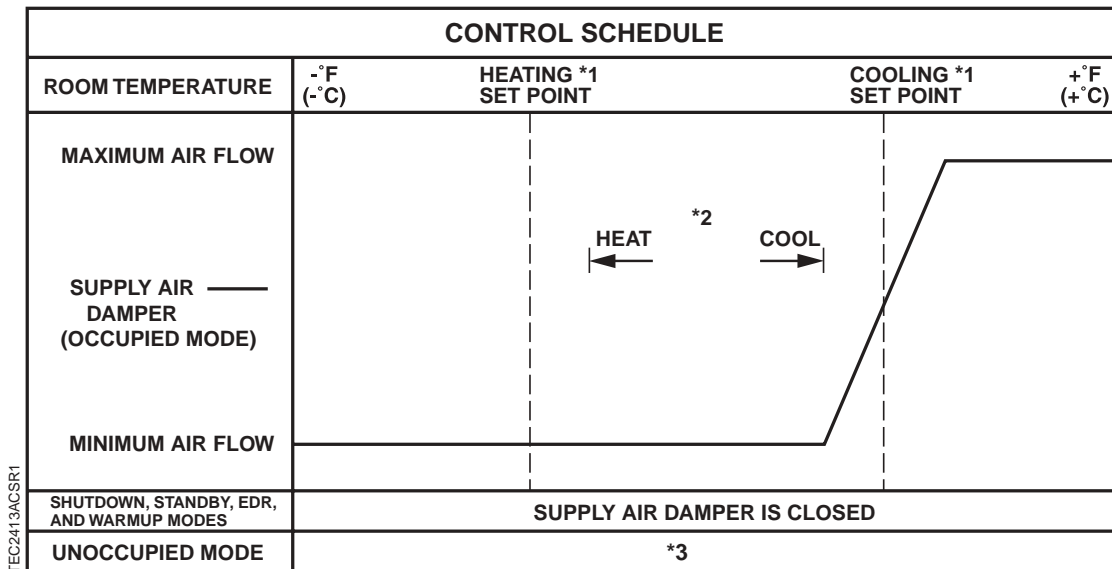
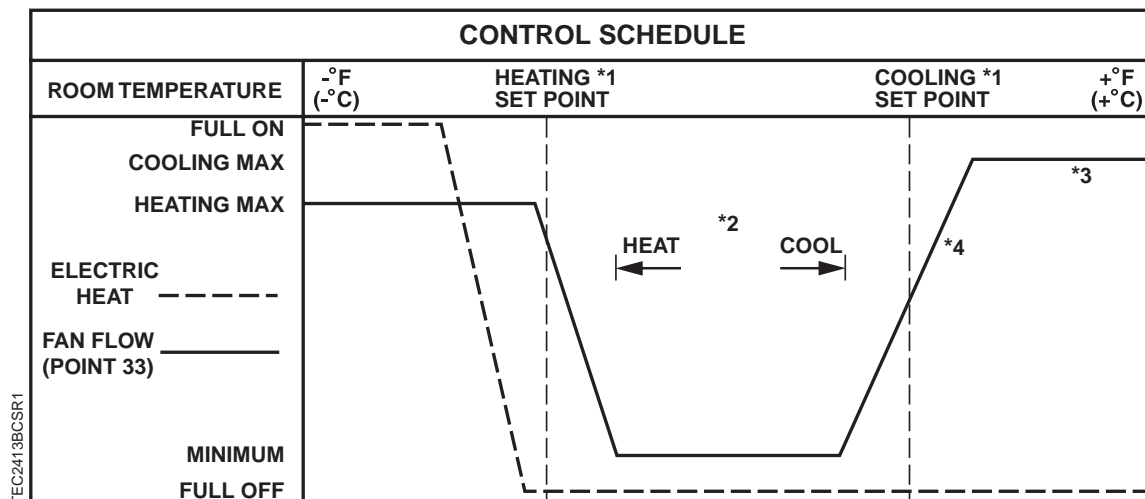


Figure 2413-1. Application 2413 Control Drawing.



1. Refer to the *Control Temperature Set Points* section.
2. Refer to the *Heating/Cooling Switchover* section.
3. The supply damper remains closed in the unoccupied mode as long as HEAT.COOL (Point 5) equals HEAT. The supply damper also remains closed in the unoccupied mode if HEAT.COOL equals COOL **and** the room temperature remains less than TEMP HLIMIT (Point 69). Once the room temperature rises above TEMP HLIMIT while VAV AHU (Point 61) = 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.)

**Figure 2413-2. Supply Air Damper Control Schedule.**



**FAN MODE = VARI.**

FAN MODE (Point 16) 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.

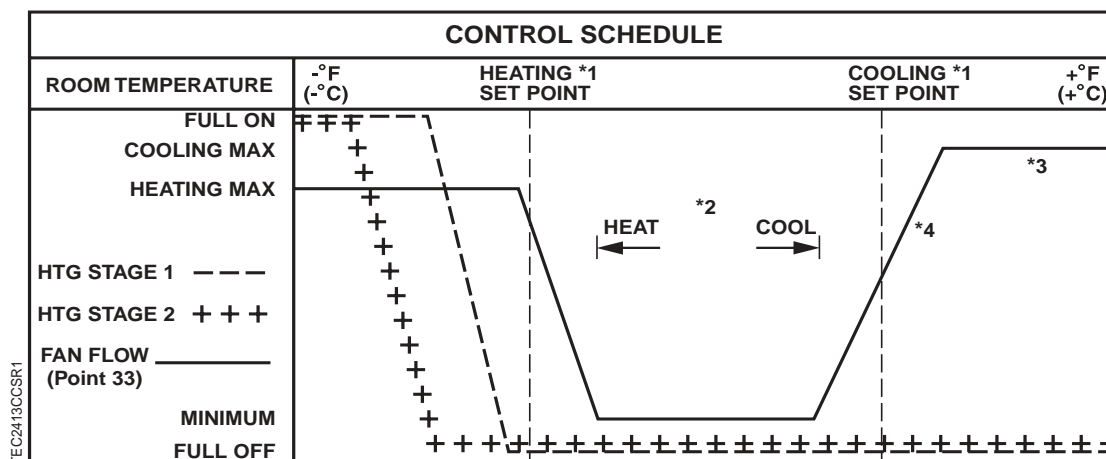
1. Refer to the *Control Temperature Set Points* section.
2. Refer to the *Heating/Cooling Switchover* section.
3. NOTE: If FAN MODE (Point 16) = CONST, FAN FLOW (Point 33) remains at the highest possible maximum flow (FAN FLO CMAX, Point 85) throughout the entire occupied mode.
4. To regulate fan speed, application 2413 uses FAN FLOW (Point 33) and embedded table statements to modulate the voltage of FAN AOV1 (Point 66). The particular table statement used depends on the box size.

**Figure 2413-3. Operation of the Fan and One Stage of Electric Heat in Occupied Mode.**

The following describes the operation of the fan and one stage of electric heat during the controller's other modes:

<b>Shutdown Mode</b>	The fan (see note 5) and electric heat are both OFF.
<b>Unoccupied Mode</b>	See note 6 for fan operation. See note 7 for heat stage operation.
<b>Electrical Demand Reduction (EDR) Mode</b>	The fan is controlled as in the occupied heating mode. The heating stage is OFF.
<b>Standby Mode</b>	During standby and warm-up, the single electric heating stage and the fan are controlled the same as in the occupied heating mode.
<b>Warm-up Mode</b>	

5. FAN FLOW (Point 33) is set to 0 in shutdown mode. 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 (Point 65) and TEMP HLIMIT (Point 69). If the room temperature drops below TEMP LLIMIT while the fan is OFF, the fan will be controlled like it is during occupied heating for the remainder of the unoccupied mode. If the room temperature rises above TEMP HLIMIT while the fan is OFF—and VAV AHU is ON—the fan will be 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 single stage of electric heat stays OFF unless the room temperature drops below TEMP LLIMIT. If this occurs, the heating stage is controlled like it is during occupied heating for the remainder of the unoccupied mode.



FAN MODE (Point 16) 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.

**Note:** In this figure, the application has been set up so that neither stage of electric heat can turn ON until the airflow out of the fan is at “HEATING MAX” (see figure).

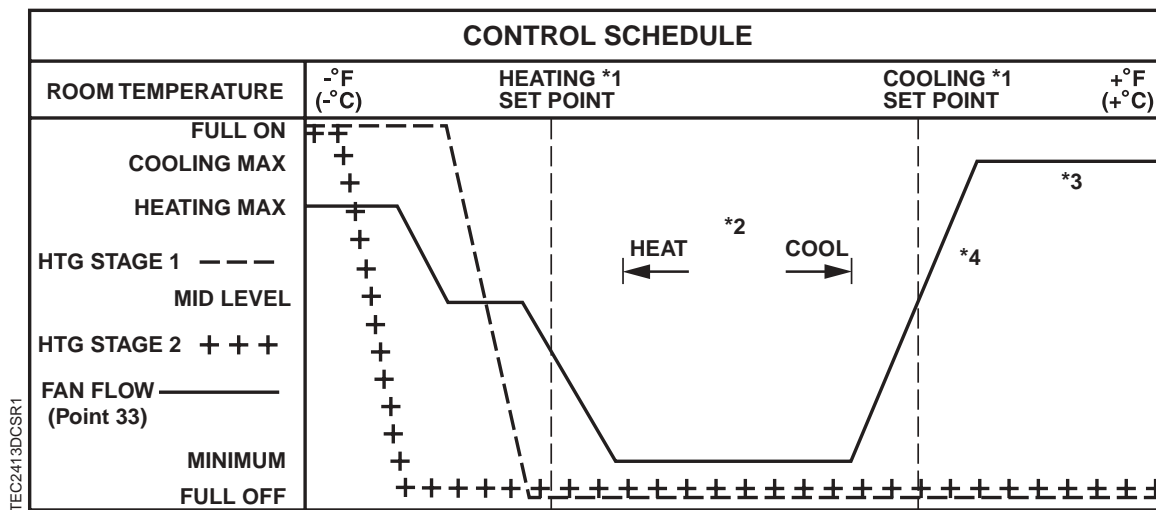
1. Refer to the Control Temperature Set Points section.
2. Refer to the Heating/Cooling Switchover section.
3. NOTE: If FAN MODE (Point 16) = CONST, FAN FLOW (Point 33) remains at the highest possible maximum flow (FAN FLO CMAX, Point 85) throughout the entire occupied mode.
4. To regulate fan speed, application 2413 uses FAN FLOW (Point 33) and embedded table statements to modulate the voltage of FAN AOV1 (Point 66). The particular table statement used depends on the box size.

**Figure 2413-4. Operation of the Fan and 2 Stages of Electric Heat in Occupied Mode.**

The following describes the operation of the fan and electric heat during the controller’s other modes:

<b>Shutdown Mode</b>	The fan (see note 5) and electric heating stages are OFF.
<b>Unoccupied Mode</b>	See note 6 for fan operation. See note 7 for operation of heating stages.
<b>Electrical Demand Reduction (EDR) Mode</b>	The fan is controlled as in the occupied heating mode. The heating stages are OFF.
<b>Standby Mode</b>	Both the fan and first heating stage are controlled as in the occupied heating mode. The second heating stage remains OFF.
<b>Warm-up Mode</b>	Both the fan and the heating stages are controlled as in the occupied heating mode.

5. FAN FLOW (Point 33) is set to 0 in shutdown mode. 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 (Point 65) and TEMP HLIMIT (Point 69). If the room temperature drops below TEMP LLIMIT while the fan is OFF, the fan will be controlled like it is during occupied heating for the remainder of the unoccupied mode. If the room temperature rises above TEMP HLIMIT while the fan is OFF—and VAV AHU is ON—the fan will be 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.



**FAN MODE = VARI.**

FAN MODE (Point 16) 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.

**Note:** In this figure, the application has been set up so that the first stage of electric heat can turn ON when the fan is producing a “MID LEVEL” airflow (see figure).

1. Refer to the *Control Temperature Set Points* section.
2. Refer to the *Heating/Cooling Switchover* section.
3. NOTE: If FAN MODE (Point 16) = CONST, FAN FLOW (Point 33) remains at the highest possible maximum flow (FAN FLO CMAX, Point 85) throughout the entire occupied mode.
4. To regulate fan speed, application 2413 uses FAN FLOW (Point 33) and embedded table statements to modulate the voltage of FAN AOV1 (Point 66). The particular table statement used depends on the box size.

**Figure 2413-5. Operation of the Fan and 2 Stages of Electric Heat in Occupied Mode.**

The following describes the operation of the fan electric heat during the controller's other modes:

<b>Shutdown Mode</b>	The fan (see note 5) and electric heating stages are OFF.
<b>Unoccupied Mode</b>	See note 6 for fan operation. See note 7 for operation of heating stages.
<b>Electrical Demand Reduction (EDR) Mode</b>	The fan is controlled as in the occupied heating mode. The heating stages are OFF.
<b>Standby Mode</b>	Both the fan and first heating stage are controlled as in the occupied heating mode. The second heating stage remains OFF.
<b>Warm-up Mode</b>	Both the fan and the heating stages are controlled as in the occupied heating mode.

5. FAN FLOW (Point 33) is set to 0 in shutdown mode. 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 (Point 65) and TEMP HLIMIT (Point 69). If the room temperature drops below TEMP LLIMIT while the fan is OFF, the fan will be controlled like it is during occupied heating for the remainder of the unoccupied mode. If the room temperature rises above TEMP HLIMIT while the fan is OFF—and VAV AHU is ON—the fan will be 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.

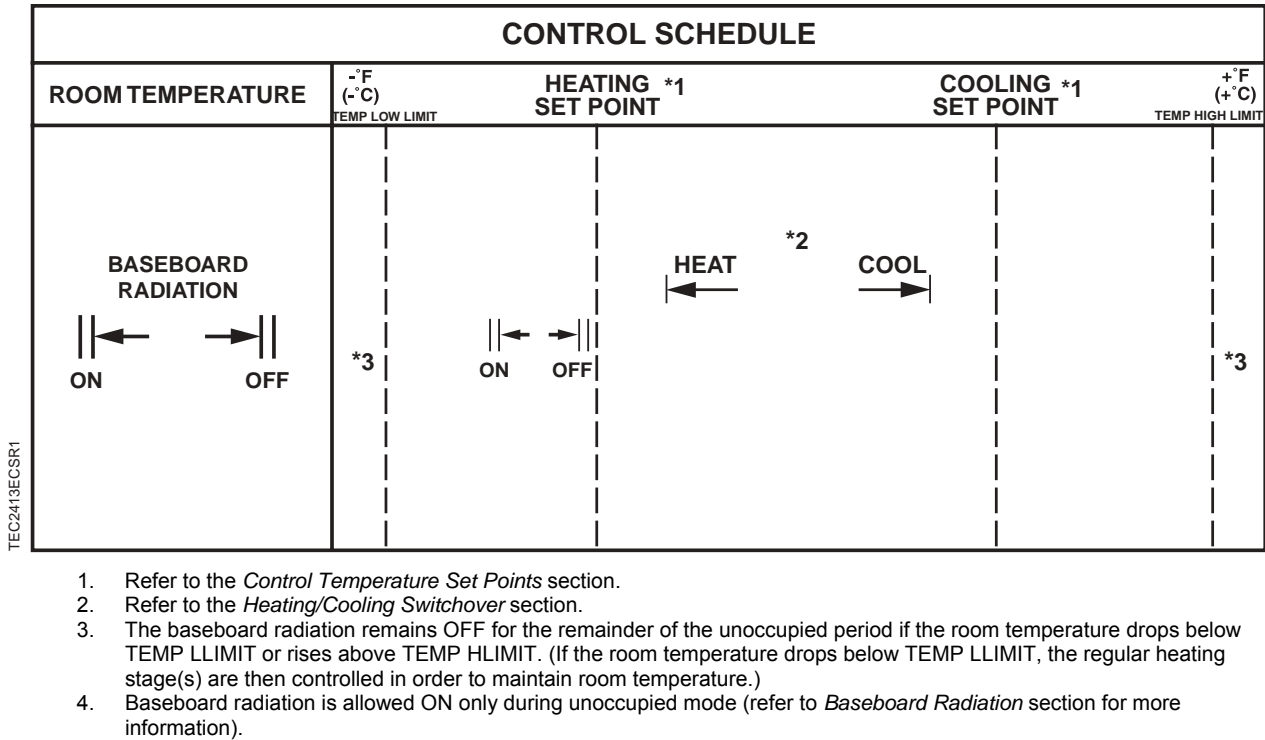


Figure 2413-6. Control Schedule for Baseboard Radiation During Unoccupied Mode.

## Hardware Inputs

### Analog

- Air velocity sensor
- Room temperature sensor
- Room temperature set point dial (optional)

### Digital

- Unoccupied mode override (optional)
- Wall switch (optional)

## Hardware Outputs

### Analog

- Fan AOV

### Digital

- Damper actuator
- Stage 1 electric heat
- Stage 2 electric heat (optional)
- Baseboard radiation (optional)

## Ordering Notes

P/N 540-865A

You can also order this controller as Custom Solution number 262.

**NOTE:** Order online from the [Custom Solutions website](http://iknow.us.abatos.com/customsolutions/custom_solutions.htm).  
([http://iknow.us.abatos.com/customsolutions/custom\\_solutions.htm](http://iknow.us.abatos.com/customsolutions/custom_solutions.htm))



## Sequence of Operation

The following paragraphs present the sequence of operation for Application 2413, *VAV with 0-10V Series-Fan Speed Output and Electric Heat*.

## Definition of MODE Point

In application 2413, the DAY.NGT point is not used. A virtual AO point (MODE, Point 3) is used instead. The following table shows the values that MODE can have, as well as the names of the modes that correspond to these different values.

**Table 2413-1. Mode Point Explanation.**

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 2413 controls several pieces of equipment throughout its different operational modes. For an overview of what each piece of equipment does in each mode, refer to Table 2413-2. (For brevity and clarity, Table 2413-2 provides only summaries of equipment actions. Full descriptions of detailed interactions between equipment pieces are provided in the related sections of the text.)

## Occupied and Unoccupied Modes

The operational mode status of the space is determined by the status of MODE (Point 3). Control of this point differs depending on whether it is being controlled by a wall switch or by a field panel. If a wall switch is controlling this point, it should not also be controlled by a field panel.

When a wall switch is physically connected to the termination strip on the controller at DI 2 (Figures 2413-1 and 2413-7), and WALL SWITCH (Point 18) equals YES, the controller monitors the status of DI 2 (Point 24). When the status of DI 2 is ON (the switch is closed), MODE is set to occupied mode. When the status of DI 2 is OFF (the switch is open), MODE is set to unoccupied mode.

When WALL SWITCH equals NO, the controller does not monitor the status of the wall switch, even if one is connected to it. In this case, and if the controller is operating stand-alone, then the controller stays in occupied mode all the time. If the controller is operating with centralized control (that is, it is connected to a field panel), then the field panel can send an operator or PPCL command to override the status of MODE. Refer to *Powers Process Control Language (PPCL) User's Manual* (125-1896) and *Field Panel User's Manual* (125-1895) for more information.

**Table 2413-2. Summary of Equipment Action During Different Operational Modes.**

<b>Operational Modes</b>	<b>Fan</b> constant volume configuration	<b>Fan</b> variable volume configuration	<b>Supply Damper</b>	<b>Electric Heat</b>	<b>Baseboard Radiation</b>
<b>Shutdown</b>	OFF	OFF	Closed	OFF	OFF
<b>Unoccupied</b> (See Note 1) Room temp stays between TEMP LLIMIT (Point 65) and TEMP HLIMIT (Point 69)	OFF	OFF	Closed	OFF	See Note 4
<b>Unoccupied Heating</b> (See Note 2) Room temp has dropped below TEMP LLIMIT	Maximum flow at FAN FLO CMAX (Point 85)	Modulates from min to max flow based on heating demand	Closed	See Note 5	OFF
<b>Unoccupied Cooling</b> (See Note 3) Room temp has risen above TEMP HLIMIT	At max flow if VAV AHU (Point 61) is ON. (OFF if VAV AHU is OFF)	Note 6	Note 7	OFF	OFF
<b>Electrical Demand Reduction (EDR)</b>	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on heating demand	Closed	OFF	OFF
<b>Standby</b>	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 stage (if used) remains OFF.	OFF
<b>Warm-up</b> 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	Note 5	OFF
<b>Occupied Heating</b>	Maximum flow at FAN FLO CMAX	Modulates from min to max flow based on <b>heating</b> demand	Provides minimum airflow for ventilation	Note 5	OFF
<b>Occupied Cooling</b>		Modulates from min to max flow based on <b>cooling</b> demand	Modulates from min to max flow based on cooling demand	OFF	

1. The unoccupied mode is more complex than the other modes, so 3 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 and 3 (for Unoccupied Heating and Cooling, respectively) summarize what happens if it does leave this range.
2. Once the room temperature drops below TEMP LLIMIT (Point 65), this sequence of operation will remain in effect **for the remainder of the entire unoccupied period** so long as the room temperature never rises as high as TEMP HLIMIT (Point 69).
3. Once the room temperature rises above TEMP HLIMIT (Point 69), this sequence of operation will remain 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 (Point 65).
4. Baseboard radiation is OFF in the unoccupied mode if HEAT.COOL (Point 5) equals COOL. If HEAT.COOL equals HEAT, the baseboard radiation cycles to maintain the room temperature at CTL STPT (Point 92).
5. During all heating modes (warm-up, occupied heating, and unoccupied heating), the 1st stage of electric heat is time modulated based on heating demand. The 2nd stage (if used) is also time modulated based on heating demand.
6. If VAV AHU (Point 61) 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.
7. If VAV AHU (Point 61) 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 (Point 20), 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 (Point 21) 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 Set Points

Depending on certain conditions, CTL STPT (Point 92) holds the value of one of the occupied or unoccupied cooling/heating set points, or it holds the value of the room set point dial. Refer to the following:

**Occupied CLG/HTG Set Points** – When STPT DIAL equals NO (default), CTL STPT holds the value of OCC CLG STPT (Point 6) or OCC HTG STPT (Point 7) if:

- MODE (Point 3) equals Occupied, EDR, or Standby.
- MODE equals Unoccupied but UNOCC OVRD (Point 21) equals OCC.

**Unoccupied CLG/HTG Set Points** – CTL STPT holds the value of UOC CLG STPT (Point 8) or UOC HTG STPT (Point 9) if:

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

**Room Set Point Dial** – When STPT DIAL is set to YES, CTL STPT holds the value of RM STPT DIAL (Point 13) 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 (Point 11) and RM STPT MAX (Point 12) or CTL STPT will use those values instead.

## Heating/Cooling Switchover

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

If all of the following conditions are met for the length of time set in SWITCH TIME (Point 86), the controller switches from heating to cooling by setting HEAT.COOL (Point 5) to COOL:

- HTG LOOPOUT (Point 80) is less than 5%.

- CTL TEMP (Point 78) is above CTL STPT (Point 92) by at least the value set in SWITCH DBAND (Point 90).
- CTL TEMP is greater than the appropriate cooling set point minus SWITCH DBAND.

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

- CLG LOOPOUT (Point 79) is less than 5%.
- CTL TEMP is below CTL STPT by at least the value set SWITCH DBAND.
- CTL TEMP is less than the appropriate heating set point plus SWITCH DBAND.



**CAUTION:**

This heating/cooling switchover mechanism is not affected by the air temperature in the supply duct. To change the value of HEAT.COOL based on the supply air temperature, you must command it through PPCL. (This is required if the flow loop is used as a source of cooling in cooling mode and as a source of heating in heating mode.)

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

## Control Loops

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

**Temperature Loops** – 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 (Point 92). Refer to *Control Temperature Set Points* for more information.

The cooling loop generates CLG LOOPOUT (Point 79) which is used to calculate FLOW STPT (Point 93) 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 (Point 32) and CTL FLOW MIN (Point 76), and as shown in the following equation:

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

For example:

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 not less than CTL FLOW MIN.)

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

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

When CLG LOOPOUT is 100%, FLOW STPT equals 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 (Point 33) 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 (Point 60) is OFF, and HEAT.COOL (Point 5) equals COOL.
- The application is in the unoccupied mode, and
  - CTL TEMP is above TEMP HLIMIT
  - HEAT.COOL equals COOL
  - VAV AHU (Point 61) 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 (Point 76), and HTG LOOPOUT (Point 80) controls the electric heat and FAN FLOW (Point 33) 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 (Point 60) is ON.
- The application is in the occupied mode, WARMUP is OFF, and HEAT.COOL (Point 5) equals HEAT.
- The application is in the EDR (electric demand reduction) mode or in the 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** – The flow loop maintains minimum and maximum airflow through CTL FLOW MIN (Point 76) and CTL FLOW MAX (Point 77), respectively. CTL FLOW MAX holds different heating and cooling flow maximums. When HEAT.COOL equals HEAT, CTL FLOW MAX equals HTG FLOW MAX. When HEAT.COOL equals COOL, CTL FLOW MAX equals CLG FLOW MAX.

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

The flow loop maintains FLOW STPT by modulating the supply air damper point, DMPR COMD (Point 48) to keep airflow between CTL FLOW MIN and CTL FLOW MAX.

FLOW (Point 75) is the input value for the flow loop. It is a percentage derived from the value of AIR VOLUME (Point 35)—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 equals 0 CFM, FLOW is 0% flow.
- If AIR VOLUME equals 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 equals 250 CFM, and if CTL FLOW MAX equals 1000 CFM,

then,

$$\begin{aligned}\text{the low limit of FLOW STPT} &= (250 \text{ CFM} \div 1000 \text{ CFM}) \times 100\% \text{ flow} \\ &= 0.25 \times 100\% \text{ flow} \\ &= 25\% \text{ flow}\end{aligned}$$

Since 25% of 1000 CFM equals 250 CFM, the minimum airflow out of the terminal box is 250 CFM.

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

- The application is in the occupied mode and WARMUP (Point 60) is OFF.
- The application is in the unoccupied mode, **and**
  - CTL TEMP is above TEMP HLIMIT
  - HEAT.COOL equals COOL
  - VAV AHU (Point 61) 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:**

Verify that the equipment is supplied with safeties by others to ensure airflow across the heating coils when they are energized.

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

- The application is in the occupied mode and WARMUP (Point 60) is ON
- The application is in the occupied mode, WARMUP is OFF, and HEAT.COOL (Point 5) equals HEAT.
- The application is in the EDR (electric demand reduction) mode or in the standby mode. (Note: When in standby, HEAT STAGE 2 (if it exists) is not available.)
- The application is in the unoccupied mode, CTL TEMP is below TEMP LLIMIT, and HEAT.COOL equals HEAT. (Note: 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 (Point 16) equals VARI, the electric heat control depends on the amount of airflow coming from the series fan, as follows:

- The second stage of electric heat (if used) will not be allowed to turn ON until FAN FLOW (Point 33) is equal to or greater than 98% of FAN FLO HMAX (Point 84).
- The first stage of electric heat (if used) will not be allowed to turn ON until FAN FLOW (Point 33) 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 (Point 88) = 1).
  - Two stages of electric heat are being used and FAN FLO MID (Point 83) has been configured to be greater than or equal to FAN FLO HMAX.
- If STAGE COUNT (Point 88) equals 2, and FAN FLO MID has been configured to be less than FAN FLO HMAX, the first stage of heat turns ON when FAN FLOW (Point 33) becomes equal to or greater than 98% of FAN FLO MID.

When FAN MODE equals CONST, airflow from the series fan will equal FAN FLO CMAX (Point 85) 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 (Point 17) equals 0 and FAN FLO MID is set equal to or greater than FAN FLO HMAX.

If there are two stages of electric heat (STAGE COUNT (Point 88) = 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 (Point 27). 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 (Point 28).

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 stage(s) through a duty cycle, as shown in the following example.

**Example:** If the duty cycle is 10 minutes (STAGE TIME (Point 89) equals 10 minutes) and the internal control signal is calling for 60% of heating, then for every 10-minute period, the stages of electric heat cycle as follows:

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

As the following paragraphs explain, control of the electric heat differs depending on whether one or two stages are operational and whether the first stage is allowed to modulate at a lower FAN FLOW value than the second stage, as when FAN FLOW MID is less than FAN FLO HMAX. (Regardless of these differences, application 2413's heating stage(s) 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 $\geq$ FAN FLO HMAX**

When FAN FLOW MID  $\geq$  FAN FLO HMAX, the relationship between HTG LOOPOUT and the internal control signal is as follows:

- When HTG LOOPOUT is less than FLOW END (Point 17), 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.

**NOTE:** As HTG LOOPOUT goes from 0 to FLOW END, FAN FLOW (Point 33) goes from FAN FLOW MIN (Point 82) to FAN FLO HMAX (Point 84).

#### **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 (Point 23), the control signal is set to 0.
- As HTG LOOPOUT goes from FLOW 1 END to FLOW 2 START (Point 22), the control signal goes from 0 to 50.



- As HTG LOOPOUT goes from FLOW 2 START to FLOW END (Point 17), the control signal remains at 50.
- When HTG LOOPOUT is between FLOW END and 100, the control signal goes from 50 to 100.

**NOTE:** As HTG LOOPOUT goes from 0 to FLOW 1 END, FAN FLOW goes from FAN FLOW MIN to FAN FLOW MID (Point 83). As HTG LOOPOUT goes from FLOW 2 START to FLOW END, FAN FLOW goes from FAN FLOW MID to FAN FLO HMAX.

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

### Single Stage Electric Heat

When the internal control signal is less than 10, HEAT STAGE 1 (Point 43) 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 (Point 44) 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 2413, the two points most directly related to the fan's operation are FAN FLOW (Point 33) and FAN AOV1 (Point 66). 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 (Point 33)

For the fan to be OFF, FAN FLOW must = 0. 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 (Point 78) is below TEMP LLIMIT (Point 65), 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 (Point 69).
3. The application is in the unoccupied mode, **and**
  - CTL TEMP is above TEMP HLIMIT
  - VAV AHU (Point 61) 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 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 (Point 16) 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 (Point 85). 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 LOOPUT (Point 79)** – 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, Point 61.)  
(Once these conditions are met, FAN FLOW will remain under the control of CLG LOOPUT 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 LOOPUT controls FAN FLOW via an embedded Table Statement as follows:

- When CLG LOOPUT is zero, FAN FLOW is set to FAN FLOW MIN (Point 82).
- When CLG LOOPUT 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 LOOPUT (Point 80)** – When FAN MODE = VARI, HTG LOOPUT controls FAN FLOW under any of the following conditions:

1. The application is in occupied mode and WARMUP (Point 60) is ON.
2. The application is in occupied mode, WARMUP is OFF, and HEAT.COOL equals HEAT.
3. 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.)
4. 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 1 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. Refer to the following:

**FAN FLOW Control and 1 Stage of Electric Heat** – When STAGE COUNT (Point 88) equals 1 and HEAT STAGE 1 (Point 43) is ON, FAN FLOW will be set to FAN FLO HMAX (Point 84). Once this occurs, FAN FLOW is not allowed to change in value until HEAT STAGE 1 turns OFF *and remains OFF* for longer than the amount of time set in STAGE TIME (Point 89).

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 (Point 17), FAN FLOW is set equal to FAN FLO HMAX. (Note: when HTG LOOPOUT is greater than FLOW END, the electric heat will time modulate.)
- When HTG LOOPOUT is between 0 and FLOW END, linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN (Point 82) and FAN FLO HMAX.

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

Regardless of how rapidly HTG LOOPOUT changes, FAN FLOW is not allowed to change faster than  $(\text{LOOP TIME (Point 98)} \div \text{FAN TIME (Point 71)}) \times \text{FLOW END (Point 17)}$ . 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 2 Stages of Electric Heat are Used and  
FAN FLOW MID  $\geq$  FAN FLOW HMAX**

If FAN FLOW MID (Point 83) is equal to or greater than FAN FLO HMAX (Point 84), and STAGE COUNT (Point 88) equals 2, FAN FLOW will be set to FAN FLO HMAX when HEAT STAGE 2 (Point 44) is either ON, or has been OFF for less than STAGE TIME. Other than this, the control of FAN FLOW is identical to when STAGE COUNT equals 1.

**FAN FLOW Control when 2 Stages of Electric Heat are Used and  
FAN FLOW MID < FAN FLOW HMAX**

If FAN FLOW MID is less than FAN FLO HMAX, and STAGE COUNT equals 2, 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. (This is the difference between having FAN FLOW MID be **less than** FAN FLO HMAX, and having it be **equal to or greater than** FAN FLO HMAX (FAN FLOW MID is configurable during controller start-up): If FAN FLOW MID is equal or greater than FAN FLO HMAX, both heating stages are alike in terms of how their ON/OFF status influences the control of FAN FLOW (see Figure 2413-4). But if FAN FLOW MID is *less than* FAN FLO HMAX, then FAN FLOW's relationship to the heating stages — specifically, the values FAN FLOW gets set to — differs for each heating stage. See Figure 2413-5.)

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 (Point 22), FAN FLOW is set equal to FAN FLOW MID.
- When HTG LOOPOUT is equal to or greater than FLOW END (Point 17), FAN FLOW is set equal to FAN FLO HMAX.
- When HTG LOOPOUT is between FLOW 2 START and FLOW 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 is not allowed to change faster than  $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW END} - \text{FLOW 2 START})$ . Even if HTG LOOPOUT changes suddenly from FLOW 2 START to FLOW 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 **both** 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 (Point 82).
- When HTG LOOPOUT is between 0 and FLOW 1 END (Point 23), linear interpolation is used to scale FAN FLOW to a value between FAN FLOW MIN and FAN FLO 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 FLO MID while HEAT STAGE 1 time modulates.)
- When HTG LOOPOUT is between FLOW 2 START and FLOW 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 FLOW END, FAN FLOW is set equal to FAN FLO HMAX. (Note: when HTG LOOPOUT is greater than FLOW END, HEAT STAGE 2 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 will not be allowed to change faster than  $(\text{LOOP TIME} \div \text{FAN TIME}) \times \text{FLOW 1 END}$ , no matter how quickly HTG LOOPOUT changes. If HTG LOOPOUT is greater than FLOW 2 START, FAN FLOW cannot change faster than  $(\text{LOOP TIME} \div \text{FAN TIME}) \times (\text{FLOW END} - \text{FLOW 2 START})$ .

Since FLOW 1 END and the value of FLOW END – FLOW 2 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 AOV1 (Point 66)

Once a value for FAN FLOW (the fan's desired airflow) has been determined, a Table Statement in the firmware calculates the proper value for FAN AOV1 (FAN AOV1 is the analog output that controls the fan's airflow). Application 2413 actually contains 4 such Table Statements, but only one will be used. Which one gets used depends on the value of BOX SIZE (Point 31). Refer to the following:

**BOX SIZE (Point 31) = 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. These pre-coded Table Statements are similar to PPCL Table Statements, except that they have more x,y pairs. This was done to increase the accuracy of the fan's output over a wide CFM range.

**NOTE:** BOX SIZE (Point 31) should be set to 3, 5, or 7 **only** if you have a Nailor box of size 3, 5, or 7.

**BOX SIZE (Point 31) = 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 (Point 31) 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 (Point 39) – The lowest flow the fan can produce. (FLO LO must be less than or equal to FAN FLOW MIN (Point 82), and may be set to 0 CFM, if desired.)

- FLO LO VOLTS (Point 37) – The voltage used by FAN AOV1 that tells the fan to produce an airflow equal to FLO LO.
- FLO HI (Point 87) – 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 (Point 38) – 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 (Point 33) 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

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

WARMUP (Point 60) is turned ON only if **all** of the following circumstances are true:

- MODE (Point 3) has just changed from Unoccupied to Occupied (MODE currently equals occupied but equaled unoccupied one LOOP TIME (Point 98) ago).
- HEAT.COOL (Point 5) equals HEAT.
- The room temperature is not warm enough.  
 $\text{CTL TEMP (Point 78)} < (\text{CTL STPT (Point 92)} - \text{MORN DBAND (Point 74)})$

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 DO5, Point 45) 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 (Point 78) is between TEMP LLIMIT (Point 65) and TEMP HLIMIT (Point 69).
- The room temperature is not warm enough:  
 $\text{CTL TEMP} < (\text{CTL STPT (Point 92)} - \text{HTG DBAND (Point 73)})$

At all other times, BASE DO5 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  $(\text{CTL STPT} - \text{HTG DBAND})$ , 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 DO5 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 (Point 62) indicates whether the supply airflow is properly cooling down the control temperature (CTL TEMP, Point 78) during cooling. Basically, this feature checks whether the supply airflow is both great enough and cool enough to cool down the room.

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

- HEAT.COOL (Point 5) equals COOL.
- MODE (Point 3) equals occupied, or UNOCC OVRD (Point 21) equals OCC while MODE equals unoccupied.
- $\text{FLOW (Point 75)} < \text{FLOW STPT (Point 93)}$ , and  $\text{CTL TEMP} > \text{CTL STPT (Point 92)}$ , both of these being true for at least the amount of time stored in ALARM TIME (Point 26).

At all other times FLOW TEMP = NORMAL.

**NOTE:** During occupied cooling, FLOW TEMP equals NORMAL when:  
 $\text{FLOW} \geq (\text{FLOW STPT} - \text{LOW FLOW, Point 30})$  and/or  $\text{CTL TEMP} \leq \text{CTL STPT}$ .

## Fail-Safe Operation

If the air velocity sensor fails, the controller uses pressure dependent control with the temperature loop controlling the damper's position. If the room temperature sensor fails, the controller operates using the last known temperature value.

## Calibration

The controller's air velocity transducer requires periodic calibration to maintain accurate air velocity readings. CAL SETUP (Point 95) is configured during controller startup to allow calibration to take place either automatically or manually. The status of CAL AIR (Point 94) indicates whether calibration is in progress. During calibration CAL AIR = YES. Note that the damper is commanded closed to get a zero airflow reading during calibration. At the end of a calibration sequence, CAL AIR returns to NO automatically and the damper returns to normal control.

## Application Notes

1. If the temperature swings in the room are excessive or there is trouble maintaining the set point, then either the cooling loop, the heating loop, or both need to be tuned. If FLOW (Point 75) is oscillating while FLOW STPT (Point 93) is constant, then the flow loop requires tuning. Refer to *APOGEE Automation Service Procedures* on InfoLink for more information.
2. Unless overridden, the value of CTL TEMP (Point 78) equals ROOM TEMP (Point 4).
3. The controller as shipped from the factory keeps all associated equipment OFF. Refer to the *APOGEE Automation Start-up Procedures* on InfoLink for information on how to release the controller and its equipment to application control.
4. Certain control features of application 2413 depend on whether the central air handling unit is ON or OFF. Application 2413 monitors VAV AHU (Point 61) for this information. Application 2413 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 2413 has no fan DO, the only way to manually shut the fan OFF is to set FAN FLOW to 0.
6. In application 2413, DOs 3 and 4 cannot be used as auxiliary motor points, even if the application is not using them (the same is true for DOs 5 and 6). This is because there are not enough database points in the application to support their use as auxiliary floating-control motor points. Of course, if the application is not using these points, they can be used as spare DOs.



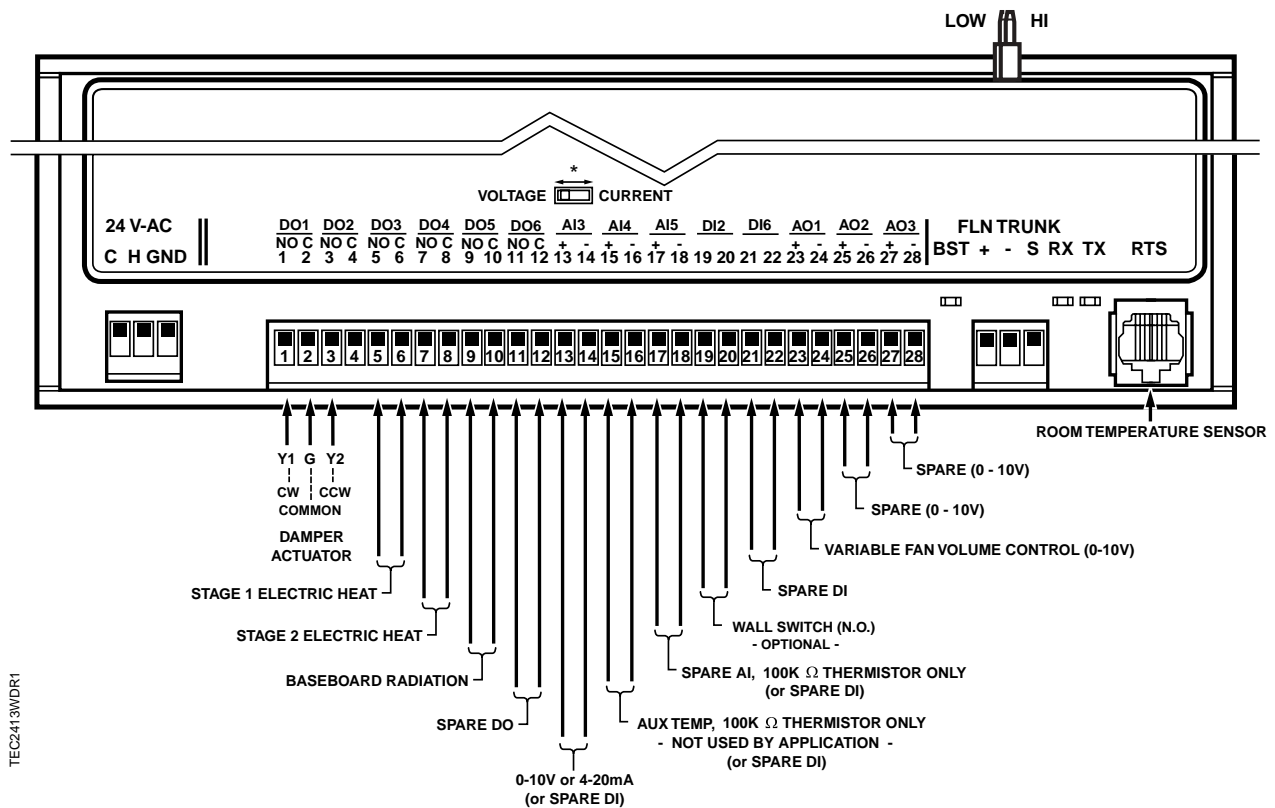
## Wiring Diagrams



### CAUTION:

The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220V relay module (550-052) for any of the following:

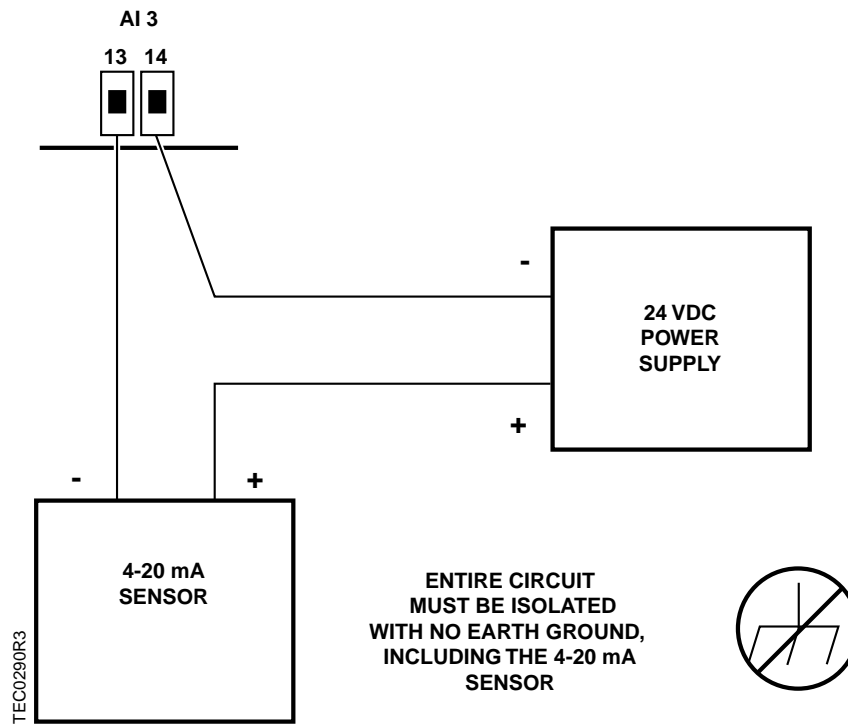
- VA requirements higher than the maximum
- 110 or 220 Vac requirements
- DC power requirements
- Separate transformers used to power the load



\*Using AI 3 as a spare 0-10V or 4-20 mA sensor input requires setting the dipswitch on the controller's circuit board (under the controller's cover) to the appropriate setting, either voltage (V) or current (I).

**IMPORTANT:** If a 4-20 mA sensor is used at AI 3, special wiring requirements must be followed. Refer to Figure 2413-8.

**Figure 2413-7. Application 2413 Wiring Diagram.**



**NOTE:** You can NOT use the same transformer to power the controller and a 4-20 mA sensor. The 4-20 mA sensor requires a SEPARATE dedicated power supply.

**Figure 2413-8. Special Wiring Requirements if 4-20 mA Sensor is Used at AI 3.**



**CAUTION:**

Equipment damage or loss of data may occur if the user does not follow procedure as specified.

## Point Database

Note: the slave mode point database follows this database.

**Point Database for Application 2413.**

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	--	1	0	--	--
02	APPLICATION	2484	--	1	0	--	--
{03}	MODE	0	--	1	0	--	--
{04}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
06	OCC CLG STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
07	OCC HTG STPT	70.0 (21.20888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
08	UOC CLG STPT	82.0 (27.92888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
09	UOC HTG STPT	65.0 (18.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{10}	DI 5	OFF	--	--	--	ON	OFF
11	RM STPT MIN	52.5 (11.40888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
12	RM STPT MAX	74.25 (23.58888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
14	STPT DIAL	NO	--	--	--	YES	NO
{15}	AI 3	0.0	PCT	0.4	0.0	--	--
{16}	FAN MODE	VARI	--	--	--	CONST	VARI
17	FLOW END	75.2	PCT	0.4	0.0	--	--
18	WALL SWITCH	NO	--	--	--	YES	NO
{19}	DI OVRD SW	OFF	--	--	--	ON	OFF
20	OVRD TIME	0	HRS	1	0	--	--
{21}	UNOCC OVRD	UNOCC	--	--	--	UNOCC	OCC
22	FLOW 2 START	50.0	PCT	0.4	0.0	--	--
23	FLOW 1 END	25.2	PCT	0.4	0.0	--	--
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
26	ALARM TIME	5	MIN	1	0	--	--
27	STG 1 TIME	120	SEC	1	0	--	--
28	STG 2 TIME	120	SEC	1	0	--	--
30	LOW FLOW	5.0	PCT	0.25	0.0	--	--
31	BOX SIZE	3	--	1	0	--	--
32	CLG FLOW MAX	2200 (1038.18)	CFM ( LPS)	4 (1.8876)	0	--	--

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets { } may be unbundled at the field panel.

*continued on the next page...*

Point Database for Application 2413.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{33}	FAN FLOW	0 (0.0)	CFM ( LPS)	4 (1.8876)	0	--	--
34	HTG FLOW MAX	2200 (1038.18)	CFM ( LPS)	4 (1.8876)	0	--	--
{35}	AIR VOLUME	0 (0.0)	CFM ( LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1.0	--	0.01	0.0	--	--
{37}	FLO LO VOLTS	0.0	VOLTS	0.01	0.0	--	--
{38}	FLO HI VOLTS	10.0	VOLTS	0.01	0.0	--	--
{39}	FLO LO	0 (0.0)	CFM ( LPS)	4 (1.8876)	0	--	--
{40}	DI 4	OFF	--	--	--	ON	OFF
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	HEAT STAGE 1	OFF	--	--	--	ON	OFF
{44}	HEAT STAGE 2	OFF	--	--	--	ON	OFF
{45}	BASE DO5	OFF	--	--	--	ON	OFF
{46}	DO 6	OFF	--	--	--	ON	OFF
{47}	DI 6	OFF	--	--	--	ON	OFF
{48}	DMPR COMD	0.0	PCT	0.4	0.0	--	--
{49}	DMPR POS	0.0	PCT	0.4	0.0	--	--
{50}	AUX TEMP	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
51	MTR1 TIMING	95	SEC	1	0	--	--
{52}	VLV COMD	0.0	PCT	0.4	0.0	--	--
{53}	VLV POS	0.0	PCT	0.4	0.0	--	--
{54}	AI 5	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5(3.055556)	--	--
56	DMPR ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR. REV	0	--	1	0	--	--
{60}	WARMUP	OFF	--	--	--	ON	OFF
{61}	VAV AHU	OFF	--	--	--	ON	OFF
{62}	FLOW TEMP	NORMAL	--	--	--	ALARM	NORMAL
63	CLG P GAIN	20.0 (36.0)	--	0.25 (0.45)	0.0	--	--
64	CLG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0.0	--	--
65	TEMP LLIMIT	55.0 (12.80888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{66}	FAN AOV1	0.0	VOLTS	0.01	0.0	--	--
67	HTG P GAIN	10.0 (18.0)	--	0.25 (0.45)	0.0	--	--

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets { } may be unbundled at the field panel.

*continued on the next page...*

Point Database for Application 2413.

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
68	HTG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0.0	--	--
69	TEMP HLIMIT	85.0 (29.60888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{70}	AOV 2	0.0	VOLTS	0.01	0.0	--	--
71	FAN TIME	60	SEC	1	0	--	--
72	FLOW I GAIN	0.02	--	0.001	0.0	--	--
73	HTG DBAND	2.0 (1.12)	DEG F (DEG C)	0.25 (0.14)	0.5(0.28)	--	--
74	MORN DBAND	2.0 (1.12)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
{75}	FLOW	0.0	PCT	0.25	0.0	--	--
{76}	CTL FLOW MIN	220 (103.818)	CFM ( LPS)	4 (1.8876)	0	--	--
{77}	CTL FLOW MAX	2200 (1038.18)	CFM ( LPS)	4 (1.8876)	0	--	--
{78}	CTL TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{79}	CLG LOOPOUT	0.0	PCT	0.4	0.0	--	--
{80}	HTG LOOPOUT	0.0	PCT	0.4	0.0	--	--
{81}	AVG HEAT OUT	0.0	PCT	0.4	0.0	--	--
82	FAN FLOW MIN	220 (103.818)	CFM ( LPS)	4 (1.8876)	0	--	--
83	FAN FLOW MID	2500 (1179.75)	CFM ( LPS)	4 (1.8876)	0	--	--
84	FAN FLO HMAX	2200 (1038.18)	CFM ( LPS)	4 (1.8876)	0	--	--
85	FAN FLO CMAX	2200 (1038.18)	CFM ( LPS)	4 (1.8876)	0	--	--
86	SWITCH TIME	10	MIN	1	0	--	--
{87}	FLO HI	2200 (1038.18)	CFM ( LPS)	4 (1.8876)	0	--	--
88	STAGE COUNT	2	--	1	0	--	--
89	STAGE TIME	10	MIN	1	1	--	--
90	SWITCH DBAND	1.0 (0.56)	DEG F (DEG C)	0.25 (0.14)	0.0	--	--
{91}	AOV 3	0.0	VOLTS	0.01	0.0	--	--
{92}	CTL STPT	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0(8.88888)	--	--
{93}	FLOW STPT	0.0	PCT	0.25	0.0	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
95	CAL SETUP	4	--	1	0	--	--
96	CAL TIMER	12	HRS	1	0	--	--
97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0.025 (0.002323)	0.0	--	--
98	LOOP TIME	5	SEC	1	0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

1. Points not listed are not used in this application.
2. A single value in a column means that the value is the same in English units and in SI units.
3. Point numbers that appear in brackets { } may be unbundled at the field panel.

## Slave Mode Point Database, Application 2484

Point Number	Descriptor	Factory Default (SI Units)	Engr Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
01	CTLR ADDRESS	99	--	1	0	--	--
02	APPLICATION	2484	--	1	0	--	--
{04}	ROOM TEMP	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
{10}	DI 5	OFF	--	--	--	ON	OFF
{13}	RM STPT DIAL	74.0 (23.44888)	DEG F (DEG C)	0.25 (0.14)	48.0 (8.88888)	--	--
{15}	AI 3	0.0	PCT	0.4	0.0	--	--
18	WALL SWITCH	NO	--	--	--	YES	NO
{19}	DI OVRD SW	OFF	--	--	--	ON	OFF
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
{35}	AIR VOLUME	0 (0.0)	CFM ( LPS)	4 (1.8876)	0	--	--
36	FLOW COEFF	1.0	--	0.01	0.0	--	--
{40}	DI 4	OFF	--	--	--	ON	OFF
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	DO 3	OFF	--	--	--	ON	OFF
{44}	DO 4	OFF	--	--	--	ON	OFF
{45}	DO 5	OFF	--	--	--	ON	OFF
{46}	DO 6	OFF	--	--	--	ON	OFF
{47}	DI 6	OFF	--	--	--	ON	OFF
{48}	MTR1 COMD	0.0	PCT	0.4	0.0	--	--
{49}	MTR1 POS	0.0	PCT	0.4	0.0	--	--
{50}	AI 4	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.055556)	--	--
51	MTR1 TIMING	95	SEC	1	0	--	--
{52}	MTR2 COMD	0.0	PCT	0.4	0.0	--	--
{53}	MTR2 POS	0.0	PCT	0.4	0.0	--	--
{54}	AI 5	74.0 (23.495556)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.055556)	--	--
55	MTR2 TIMING	130	SEC	1	0	--	--
56	DPR1 ROT ANG	90	--	1	0	--	--
57	DPR2 ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR. REV	0	--	1	0	--	--
{66}	AOV 1	0.0	VOLTS	0.01	0.0	--	--
{70}	AOV 2	0.0	VOLTS	0.01	0.0	--	--
88	VALVE COUNT	2	--	1	0	--	--
{91}	AOV 3	0.0	VOLTS	0.01	0.0	--	--
{94}	CAL AIR	NO	--	--	--	YES	NO
95	CAL SETUP	4	--	1	0	--	--
96	CAL TIMER	12	HRS	1	0	--	--
97	DUCT AREA	1.0 (0.09292)	SQ. FT (SQ M)	0.025 (0.002323)	0.0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--