

Application 2327 Electric Heating and DX Cooling, ASHRAE Cycle III

Overview

In Application 2327, the Unit Vent Controller with 2 Stages of DX controls a unit ventilator equipped with two DX coils for cooling, and an electric heating coil for ASHRAE Cycle III. Cooling only units can also be controlled with this application by overriding the point HEAT.COOL (number 5) to COOL.

Other features available in this application include morning warm-up/cool-down, night mode override, free-cooling, and auxiliary radiation in heating mode.

This application controls room temperature by directly modulating the coil control devices. This application also controls an outdoor air damper according to the schedule as defined by ASHRAE Cycle III, to maintain a given mixed air temperature set point. The free-cooling/economizer function is turned on and off by the field panel using the point FREE CLG (number 23). If free cooling is not available, then the outdoor air damper will be kept at minimum position; otherwise, the outdoor air damper will modulate to maintain the mixed air temperature set point. The unit ventilator fan is also controlled in this application. Refer to Figures 2327-1 and 2327-2.

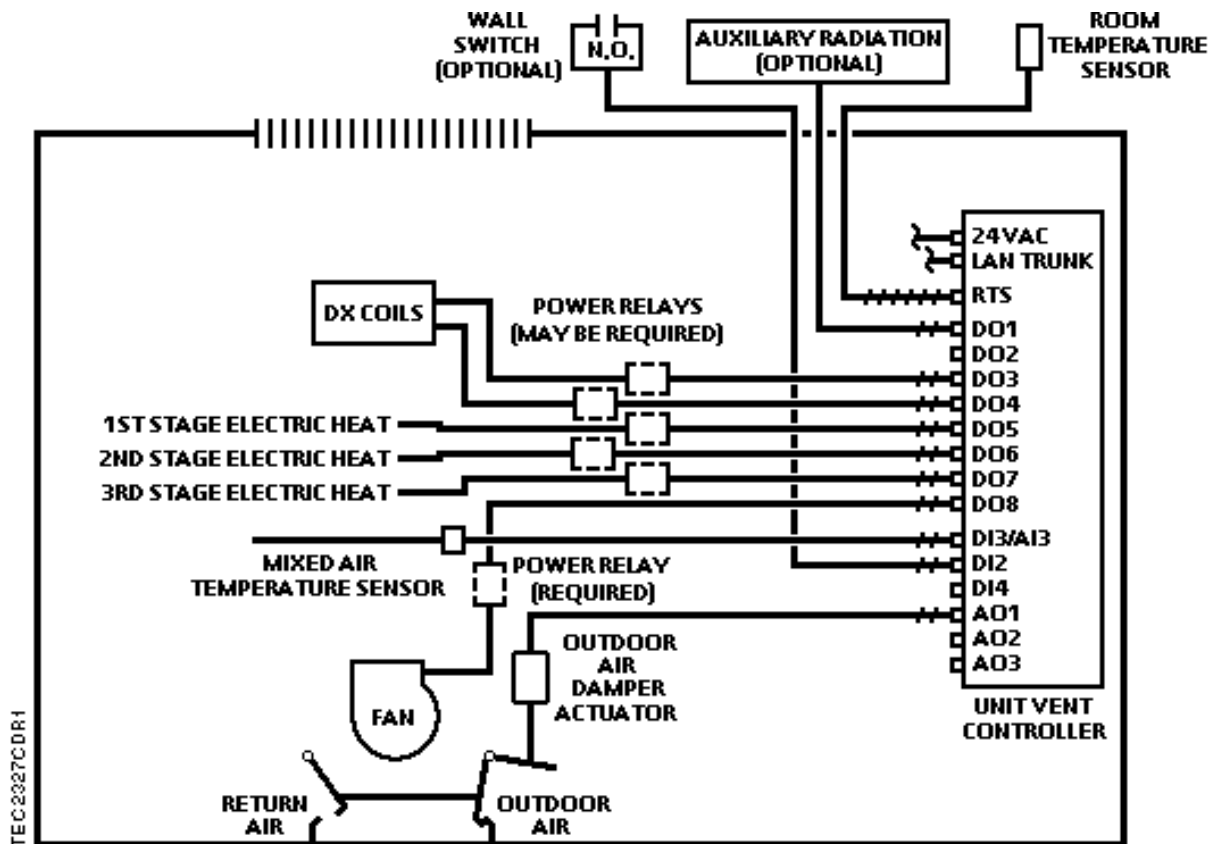


Figure 2327-1. Application 2327 Control Drawing.

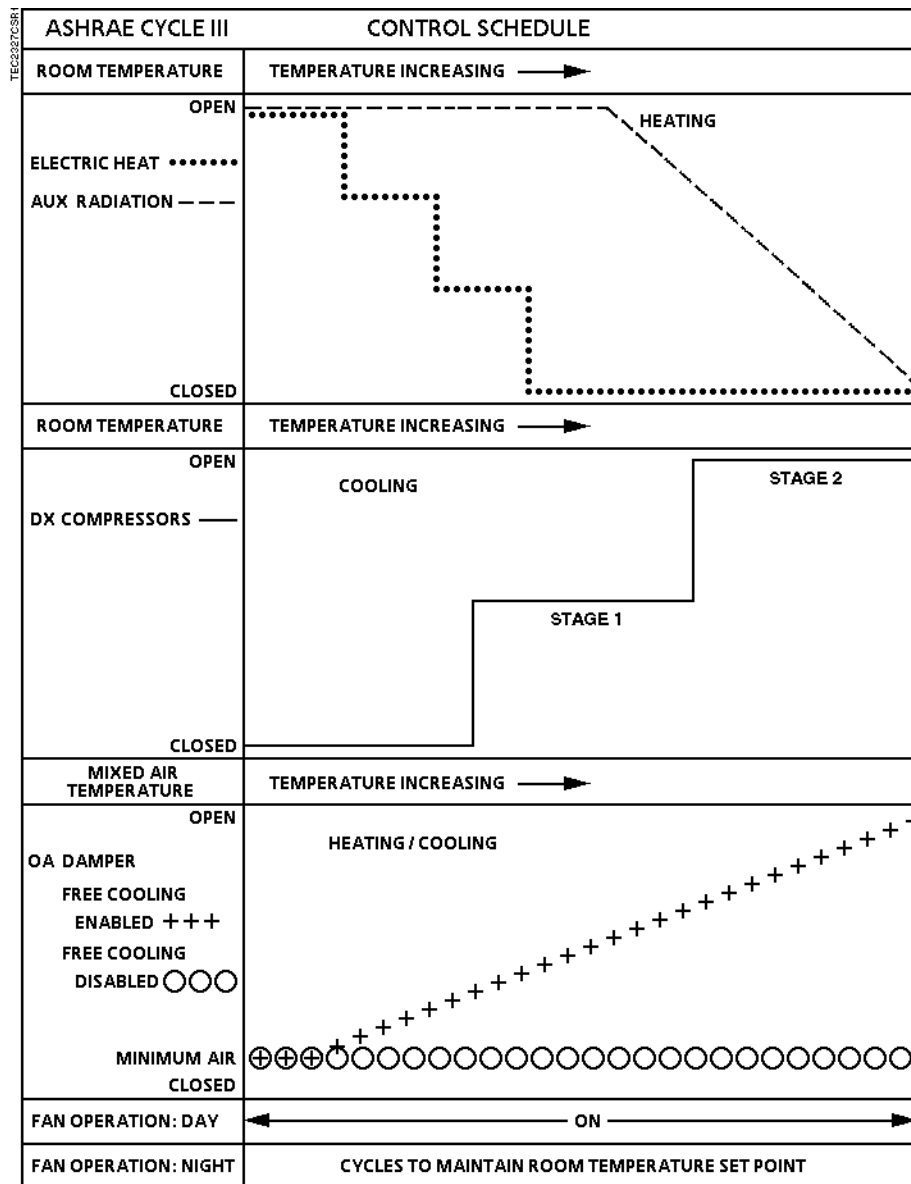


Figure 2327-2. Application 2327 Control Schedule.

*Hardware inputs***analog**

- averaging air temperature sensor
- room temperature sensor
- room temperature set point dial (optional)

digital

- night mode override (optional)
- wall switch (optional)

Hardware outputs

The following is a list of devices that can be used by this application depending on your hardware configuration. Refer to Table 2327-1.

analog (0-10V)

- outdoor air damper actuator

digital

- auxiliary radiation electric coil contact; or, auxiliary radiation 2-position valve actuator
- DX coils (2)
- unit fan
- 1st stage electric heat
- 2nd stage electric heat
- 3rd stage electric heat

Point database

Table 2327-1 presents the point database information for Application 2327.

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2327, "Electric Heating and DX Cooling, ASHRAE Cycle III".

Control temperature set points

Depending on the controller's current operational mode (day or night), the control temperature set point, CTL STPT (number 92) holds the value of one of the following set points:

Day Mode – In day mode, CTL STPT holds the value of the point DAY CLG STPT (number 6) or the point DAY HTG STPT (number 7). If the room temperature sensor has a set point dial and the point STPT DIAL (number 14) is set to YES, then CTL STPT holds the value of the point RM STPT DIAL (number 13).

If the set point dial is used and the value of RM STPT DIAL is less than the value of the point RM STPT MIN (number 11), then CTL STPT holds the value of RM STPT MIN. If the value of RM STPT DIAL is greater than the value of the point RM STPT MAX (number 12), then CTL STPT holds the value of RM STPT MAX.

Night Mode – In night mode, CTL STPT holds the value of the point NGT CLG STPT (number 8) or the point NGT HTG STPT (number 9).

Note: The value of the point CTL TEMP (number 78) is the same as the value of the point ROOM TEMP (number 4), unless CTL TEMP is overridden.

Day and night modes

The day/night status of the space is determined by the status of the point DAY.NGT (number 29). The control of this point differs depending on whether the controller is monitoring the status of a wall switch or if the controller is connected to a field panel.

When a wall switch is physically connected to the termination strip on the controller at DI 2 (Figures 2327-1 through 2327-3 and 2327-7 through 2327-9), and the point WALL SWITCH (number 18) equals YES, the controller monitors the status of DI 2. When the status of the point DI 2 (number 24) is ON (the switch is closed), then DAY.NGT will be set to DAY indicating that the controller is in day mode. When the status of DI 2 is OFF (the switch is open), then DAY.NGT will be set to NIGHT indicating that the controller is in night mode.

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

*Night mode
override switch*

If an override switch is present on the room temperature sensor and a value (in hours) other than zero has been entered into the point OVRD TIME (number 20), then by pressing the override switch a room occupant can reset the controller to day operational mode of the time period that is set in OVRD TIME. The status of the point NGT OVRD (number 21) changes to DAY. After the override time elapses, the controller returns to night mode and the status of NGT OVRD changes back to NIGHT.

It is only when the controller is in night mode that the override switch on the room sensor will have any effect on the controller.

*Day heating
operation*

In day heating operation, the controller maintains the room temperature at the value stored in the point CTL STPT (number 92) by doing the following:

- Modulating the electric stages based on the difference between the control temperature point, CTL TEMP (number 78), and CTL STPT. If CTL TEMP goes below CTL STPT, then the stages of electric heat energize. If CTL TEMP goes above CTL STPT, then the reverse occurs.
- Controlling auxiliary radiation (if provided) using a pulse-width modulation algorithm. The auxiliary radiation will be on for a percentage of the time held in the point AUX HTG TIME (number 57). The on-time is modulated in sequence with the coil control device. Auxiliary radiation is first ON and last OFF.

Note: If AUX.NOAUX is set to AUX, the auxiliary radiation will go fully on before the electric heating will start to turn on.

- Positioning the outdoor air damper as follows:
 - ▶ For ASHRAE Cycle III, when the point FREE CLG (number 23) is enabled, the position of the outdoor air damper is based on the difference between the mixed air temperature point, MA TEMP (number 15), and the mixed air temperature set point, MA STPT (number 93). If the value of MA TEMP is below the value of MA STPT, then the damper closes. The damper cannot close beyond the value of the point OADPR MINPOS (number 10). When FREE CLG is disabled, the damper is held at the value of OADPR MINPOS.

*Day cooling
operation*

In day cooling operation, the controller maintains the room temperature at the value stored in the point CTL STPT (number 92) by doing the following:

- Cycling the DX coil based on the difference between the control temperature point, CTL TEMP (number 78), and CTL STPT.
- Positioning the outdoor air damper as follows:

- ▶ For ASHRAE Cycle III, when the point FREE CLG (number 23) is enabled, the position of the outdoor air damper is based on the difference between the mixed air temperature point, MA TEMP (number 15), and the mixed air temperature set point, MA STPT (number 93). If the value of MA TEMP is below the value of MA STPT, then the damper closes. The damper cannot close beyond the value of the point OADPR MINPOS (number 10). When FREE CLG is disabled, the damper is held at the value of OADPR MINPOS.

Night heating operation

The controller maintains the room temperature at the value stored in the point CTL STPT (number 92) by doing the following:

- If the point CTL TEMP (number 78) drops below the value of the point NGT HTG STPT (number 9) minus the value of the point NGT DBAND (number 88), then:
 - the fan turns ON
 - heating turns ON
- If CTL TEMP rises above NGT HTG STPT, then:
 - the fan turns OFF
 - heating turns OFF

When the fan turns ON, the electric stages and auxiliary radiation are turned on. When the fan turns OFF, all electric stages and auxiliary radiation are turned off. The fan will remain ON for 30 seconds after the last stage of electric heat is turned OFF. If NGT HW HTG is set to YES, then the electric stages are kept on at all times during the night (make sure to set this point to NO).

In night heating operation, the controller operates as follows:

- For units with steam or electric coils, NGT HW HTG must be set to NO, so that the coils can be cycled.
- The controller may switch to cooling mode when appropriate if the point NGT CLG MODE (number 54) is set to YES.
- Heating only is provided when NGT CLG MODE is set to NO.

Night cooling operation

In night cooling operation, the controller maintains the room temperature at the value stored in the point CTL STPT (number 92) by doing the following:

- For units with electric coils, NGT HW HTG must be set to NO, so that the heating coils can be kept OFF.

In night cooling operation, the controller operates as follows:

- If the point CTL TEMP (number 78) rises above the sum of the points NGT CLG STPT (number 8) and NGT DBAND (number 88), then:
 - the fan turns ON
 - DX cooling turns ON
- If CTL TEMP drops below NGT CLG STPT, then:
 - the fan turns OFF
 - DX cooling turns OFF
- When the point NGT CLG MODE (number 54) is set to NO, the unit will operate in night heating mode only.

Heating/cooling switchover

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

- The point HTG LOOPOUT (number 80) is below 50% if auxiliary radiation is not available, (the point AUX.NOAUX (number 22) is set to NOAUX), or below SWITCH LIMIT if auxiliary radiation is available.
- The point CTL TEMP (number 78) is greater than the sum of the points CTL STPT (number 92) plus SWITCH DBAND (number 90).
- CTL TEMP is greater than the appropriate cooling set point minus SWITCH DBAND.

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

- The point CLG LOOPOUT (number 79) is below SWITCH LIMIT.
- CTL TEMP is less than CTL STPT minus SWITCH DBAND.
- CTL TEMP is less than the appropriate heating set point plus SWITCH DBAND.

If night cooling is not available, as indicated by the point NGT CLG MODE (number 54), then the controller remains in heating mode during the night.

Control loops

The unit ventilator is controlled by three Proportional, Integral, and Derivative (PID) control loops; a heating loop, a DX loop, and a mixed air loop.

Heating Loop – The heating loop uses the value of the point CTL STPT (number 92) and the point CTL TEMP (number 78) to modulate the value of the point HTG LOOPOUT (number 80).

DX Loop – The DX loop uses the value of CTL STPT and CTL TEMP to modulate the value of the point CLG LOOPOUT (number 79).

Mixed Air Loop – The mixed air loop uses the values of the points MA STPT (number 93) and MA TEMP (number 15) to modulate the value of the point MA LOOPOUT (number 77).

*Morning warm-up/
cool-down*

Morning warm-up or cool-down occurs after the controller switches from night mode to day mode, upon power-up, or if the controller is reset. During morning warm-up or cool-down, the controller provides maximum heating or cooling with the outdoor air damper closed until the temperature of the space reaches the value of the point CTL STPT (number 92) plus or minus the value of the point MORN DBAND (number 89). In morning cool-down, if the point FREE CLG (number 23) is set to ENABLE, then the outdoor air damper is opened.

In heating mode, normal day heating operation begins when the temperature of the room reaches the value of CTL STPT minus MORN DBAND.

In cooling mode, normal day cooling operation begins when the temperature of the room reaches the value of CTL STPT plus MORN DBAND.

For example, in day heating mode, if CTL STPT is 72°F (22.2°C) and MORN DBAND is 3°F (1.6°C), then normal day heating operation begins when the temperature of the room reaches 69°F (20.6°C).

*DX cooling
operation*

DX cooling is controlled as follows:

- If the point CLG OUTPUT (number 61) is greater than 33%, then the first stage of DX turns ON.
- If CLG OUTPUT is less than 33%, then the first stage of DX turns OFF.
- If the point CLG OUTPUT is greater than 67%, then the second stage of DX turns ON.
- If CLG OUTPUT is less than 67%, then the second stage of DX turns OFF.
- The DX stages may not turn ON or OFF until the number of minutes held in the point CMP MIN ON (number 76) or the point CMP MIN OFF (number 75) have expired.
- Once one stage of DX changes state (ON or OFF) the other stage can not change state until the time in DX STG DELAY (number 56) expires.

Electric heat

If electric heat is used, then it is controlled as follows:

HTG OUTPUT (number 60)	Stage 1	Stage 2	Stage 3
0% - 33%	ON	OFF	OFF
34% - 66%	ON	ON	OFF
67% - 100%	ON	ON	ON

In addition, no stage may turn ON or OFF until the number of seconds held in the point EHT STG DELY (number 58) have elapsed since the last time any stage turned ON or OFF. Stage one will always be the first stage to turn ON and the last stage to turn OFF.

Fan operation

In day mode, the point FAN (number 50), is ON all of the time.

In night mode, the fan only operates when required for heating or cooling.

In night heating, the fan turns ON when the temperature drops below the value of the points CTL STPT (number 92) minus NGT DBAND (number 88). When the temperature rises above CTL STPT, the fan turns OFF. If any stage of electric heat is ON, then the fan will be ON. The fan will remain ON for 30 seconds after the last stage of electric heat is turned OFF.

In night cooling, the fan turns ON when the temperature rises above the value of CTL STPT plus NGT DBAND. When the temperature drops below CTL STPT, the fan turns OFF. If the DX coils are ON, then the fan will be ON. The fan will remain ON for 30 seconds after the DX coils are turned OFF.

Fail-safe operation

The Unit Vent Controller has a fail-safe operation that can be triggered by several occurrences.

A normally-closed low temperature detection thermostat (LTDT) (connected to DI4) can be used to signal the controller when the temperature, sensed by the LTDT, is below the low temperature limit.

NOTE: If an LTDT is not wired to DI4, a hard-wired jumper should be wired across ports 21 and 22 in place of the LTDT to prevent the LTDT failure mode.

If the room temperature sensor input to the Unit Vent Controller fails or the LTDT equals ON, then the controller goes through the following shutdown sequence:

- Outdoor air damper is closed.
- Electric heating is OFF.
- DX cooling is full OFF.
- Fan is OFF.
- Auxiliary radiation is OFF.

Note: DO 2 will not be commanded by the fail-safe mode, all other DOs can be affected.

If the mixed air temperature sensor fails, then the outdoor air damper is closed and the heating and cooling loops continue to control room temperature.

If a failed sensor returns or if the LTDT turns OFF, then normal control resumes.

Analog and digital outputs cannot be commanded when the controller is in fail-safe mode, however, failed points may be overridden, allowing the controller to return from fail-safe mode. In this instance, room temperature control is not possible.

Application notes

1. If the unit ventilator cycles excessively, if the temperature swings in the room are excessive or if there is trouble in maintaining the set point, then either the cooling loop, the heating loop or both need to be tuned.
2. The Unit Vent Controller with 2 Stages of DX, as shipped from the factory, keeps all associated equipment OFF. Refer to the Startup document for this controller for information on how to release the controller and its equipment to application control.
3. When the fan is manually switched OFF at the unit fan speed switch, the actuators should be wired so they return to their normal state.

Wiring diagrams

The point wiring for Application 2327 is shown in Figure 2327-3.

**CAUTION:**

The Unit Vent Controller's Digital Outputs (DOs) controls 24 Vac loads only. The maximum rating is 12 VA for each DO. For higher VA requirements, 110 or 220 Vac requirements, separate requirements used to power the load, or DC power requirements, use an interposing 220 V 4-relay module (P/N 540-147).

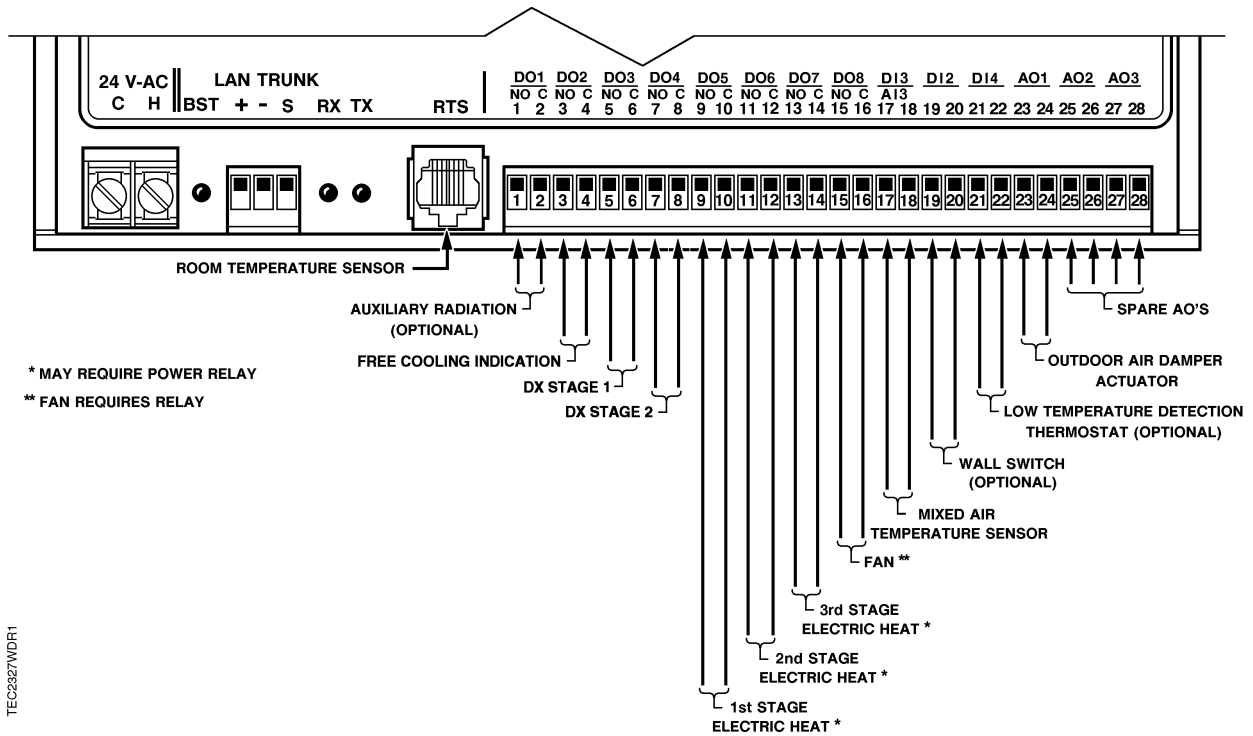


Figure 2327-3. Application 2327 Wiring Diagram.

Table 2327-2. Point Database for Application 2327.

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	2299	--	1	0	--	--
{04}	ROOM TEMP	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{05}	HEAT.COOL	COOL	--	1	0	HEAT	COOL
06	DAY CLG STPT	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
07	DAY HTG STPT	70.00 (21.21)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
08	NGT CLG STPT	82.00 (27.93)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
09	NGT HTG STPT	65.00 (18.41)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
10	OADPR MINPOS	14.8	PCT	0.4	0	--	--
11	RM STPT MIN	55.00 (12.81)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
12	RM STPT MAX	90.00 (32.41)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{13}	RM STPT DIAL	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
14	STPT DIAL	NO	--	1	0	YES	NO
{15}	MA TEMP	74.00 (23.5)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.06)	--	--
18	WALL SWITCH	NO	--	1	0	YES	NO
{19}	DI OVRD SW	OFF	--	1	0	ON	OFF
20	OVRD TIME	1	HRS	1	0	--	--
{21}	NGT OVRD	DAY	--	1	0	NIGHT	DAY
22	AUX.NOAUX	NOAUX	--	1	0	AUX	NOAUX
{23}	FREE CLG	DISABL	--	1	0	ENABLE	DISABL
{24}	DI 2	OFF	--	1	0	ON	OFF
{25}	DI 3	OFF	--	1	0	ON	OFF
{26}	LOW TEMP DET	ON	--	1	0	OFF	ON
{29}	DAY.NGT	DAY	--	1	0	NIGHT	DAY
{30}	WRMUP.COOLDN	ON	--	1	0	ON	OFF
31	AOV1 SPAN	10	VOLTS	0.01	0	--	--
32	AOV1 START	0	VOLTS	0.01	0	--	--
33	AOV2 SPAN	10	VOLTS	0.01	0	--	--
34	AOV2 START	0	VOLTS	0.01	0	--	--
35	AOV3 SPAN	10	VOLTS	0.01	0	--	--
36	AOV3 START	0	VOLTS	0.01	0	--	--

Notes:

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.

Table 2327-2. Point Database for Application 2327.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
37	AO DIR.REV	0	--	1	0	--	--
{38}	AOV1	0	VOLTS	0.01	0	--	--
{39}	AOV2	0	VOLTS	0.01	0	--	--
{40}	AOV3	0	VOLTS	0.01	0	--	--
{41}	AUX RAD	OFF	--	1	0	ON	OFF
{42}	FREE CLG DO2	OFF	--	1	0	ON	OFF
{43}	DX STG1 DO3	OFF	--	1	0	ON	OFF
{44}	DX STG1 DO4	OFF	--	1	0	ON	OFF
{45}	EHEAT 1 DO5	OFF	--	1	0	ON	OFF
{46}	EHEAT 2 DO6	OFF	--	1	0	ON	OFF
{47}	EHEAT 3 DO7	OFF	--	1	0	ON	OFF
{50}	FAN	OFF	--	1	0	ON	OFF
53	NGT HW HTG	YES	--	1	0	YES	NO
54	NGT CLG MODE	NO	--	1	0	YES	NO
{55}	AUX OUTPUT	0	PCT	0.4	0	--	--
56	DX STG DELAY	30	SEC	1	0	--	--
57	AUX HTG TIME	10	MIN	1	0	--	--
58	EHT STG DELY	30	SEC	1	0	--	--
59	DO DIR.REV	0	--	1	0	--	--
{60}	HTG OUTPUT	0	PCT	0.4	0	--	--
{61}	CLG OUTPUT	0	PCT	0.4	0	--	--
{62}	OA DMPR POS	0	PCT	0.4	0	--	--
63	CLG P GAIN	1.6 (2.88)	--	0.2 (0.36)	0	--	--
64	CLG I GAIN	0.05 (0.09)	--	0.0005 (0.0009)	0	--	--
65	CLG D GAIN	10 (18)	--	2 (3.6)	0	--	--
66	CLG BIAS	50.00	PCT	0.2	0	--	--
67	HTG P GAIN	0.4 (0.72)	--	0.05 (0.09)	0	--	--
68	HTG I GAIN	0.015 (0.027)	--	0.0002 (0.00036)	0	--	--
69	HTG D GAIN	5 (9)	--	1 (1.8)	0	--	--
70	HTG BIAS	50.00	PCT	0.2	0	--	--

Notes:

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.

Table 2327-2. Point Database for Application 2327.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
75	CMP MIN OFF	5	MIN	1	0	--	--
76	CMP MIN ON	5	MIN	1	0	--	--
{77}	MA LOOPOUT	0	PCT	0.2	0	--	--
{78}	CTL TEMP	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{79}	CLG LOOPOUT	0.00	PCT	0.2	0	--	--
{80}	HTG LOOPOUT	0.00	PCT	0.2	0	--	--
{81}	MA P GAIN	0.2 (0.36)	--	0.02 (0.036)	0	--	--
{82}	MA I GAIN	0.00054 (0.000972)	--	0.00009 (0.000162)	0	--	--
{83}	MA D GAIN	24 (43.2)	--	1 (1.8)	0	--	--
{84}	MA BIAS	0	PCT	0.2	0	--	--
85	SWITCH LIMIT	4.8	PCT	0.4	0	--	--
86	SWITCH TIME	10	MIN	1	0	--	--
88	NGT DBAND	3 (1.68)	DEG F (DEG C)	0.25 (0.14)	0	--	--
89	MORN DBAND	2 (1.12)	DEG F (DEG C)	0.25 (0.14)	0	--	--
90	SWITCH DBAND	2 (1.12)	DEG F (DEG C)	0.25 (0.14)	0	--	--
{92}	CTL STPT	74.00 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.00 (8.89)	--	--
{93}	MA STPT	74.00 (23.5)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.06)	--	--
98	LOOP TIME	5	SEC	1	0	--	--
{99}	ERROR STATUS	0	--	1	0	--	--

Notes:

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.