

# Application 2287: Heating and Cooling, Nesbitt Cycle W

## Overview

In Application 2287, the Unit Vent Controller – 0 to 10V Output controls a unit ventilator equipped with a heating coil, which may be hot water or steam, for Nesbitt Cycle W. Auxiliary radiation coils are piped parallel to the heating coil and are not controlled separately by the application. A chilled water coil or a DX cooling coil may be controlled. Heating only units can also be controlled with this application by overriding HEAT.COOL (Point 5) to HEAT.

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

**NOTE:** Using a low temperature detection thermostat (LTDT) is strongly recommended for hot water and steam systems.

This application controls room temperature by directly modulating the coil control device(s) and the outdoor air damper according to the schedule defined by Nesbitt Cycle W. The free-cooling/economizer function is turned on and off by the field panel using FREE CLG (Point 23). The unit ventilator fan is also controlled in this application.

## Illustrations

Table 2287-1 lists control drawings, control schedules, and wiring diagrams that can be used in this application. Use the table to find the illustrations for your particular hardware configuration.

**Table 2287-1. Application 2287 Illustration Cross Reference Table.**

Hardware Configuration	Control Drawing	Control Schedule	Wiring Diagram
Hot water coil, valve control	Figure 2287-3, except: 1. LTDT recommended.	Figure 2287-4, except: 1. No cooling mode.	Figure 2287-7, except: 1. No DX coil. 2. LTDT recommended.
Steam coil, valve control	Figure 2287-3, except: 1. Read <u>steam coil</u> instead of heating coil. 2. LTDT recommended.	Figure 2287-4, except: 1. Read <u>steam valve</u> instead of HW valve. 2. No cooling mode.	Figure 2287-7, except: 1. No DX coil. 2. LTDT recommended.
4-pipe, hot water and chilled water coils, valve control	Figure 2287-1, except: 1. LTDT recommended.	Figure 2287-4	Figure 2287-6, except: 1. LTDT recommended.
4-pipe, steam and chilled water coils, valve control	Figure 2287-1, except: 1. Read <u>steam coil</u> instead of heating coil. 2. LTDT recommended.	Figure 2287-4, except: 1. Read <u>steam valve</u> instead of HW valve.	Figure 2287-6, except: 1. LTDT recommended.
Hot water and DX coils, valve and single step control	Figure 2287-2, except: 1. LTDT recommended.	Figure 2287-5	Figure 2287-7, except: 1. LTDT recommended.
Steam and DX coils, valve and single step control	Figure 2287-2, except: 1. Read <u>steam coil</u> instead of heating coil. 2. LTDT recommended.	Figure 2287-5, except: 1. Read <u>steam valve</u> instead of HW valve.	Figure 2287-7, except: 1. LTDT recommended.

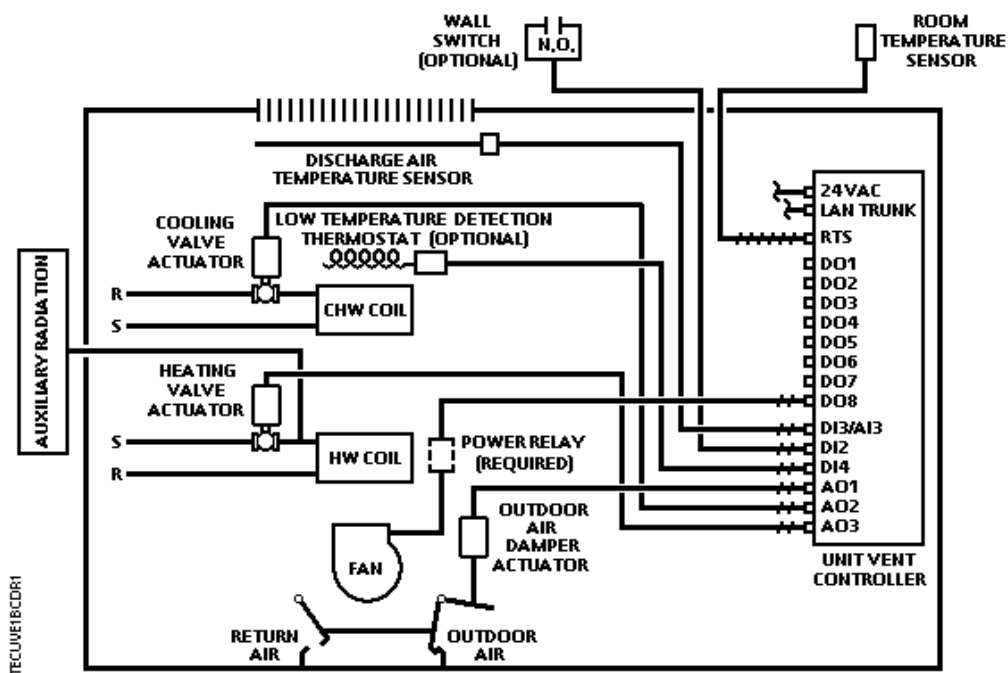


Figure 2287-1. Application 2287 Control Drawing.

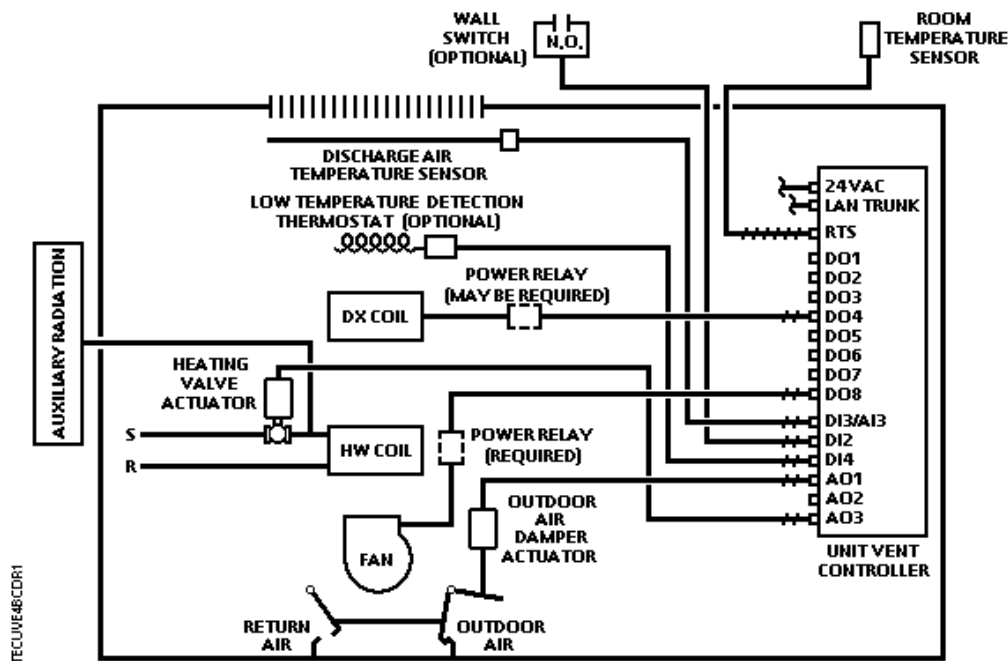


Figure 2287-2. Application 2287 Control Drawing.

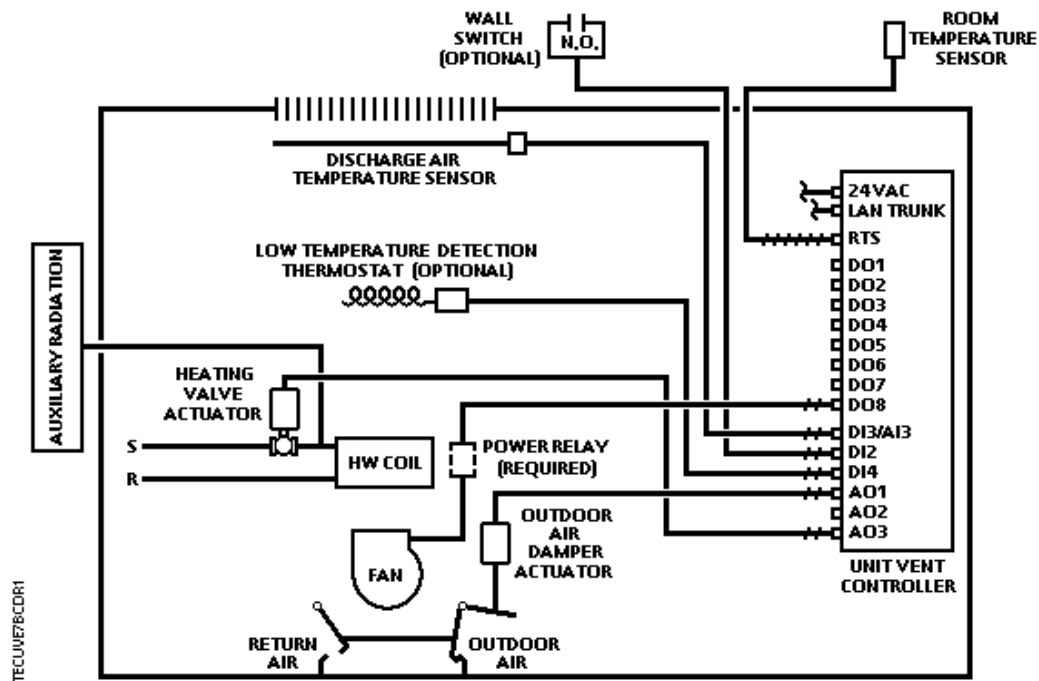


Figure 2287-3. Application 2287 Control Drawing.

**NOTE:** The outdoor air damper may close to maintain a low-limit discharge air temperature.

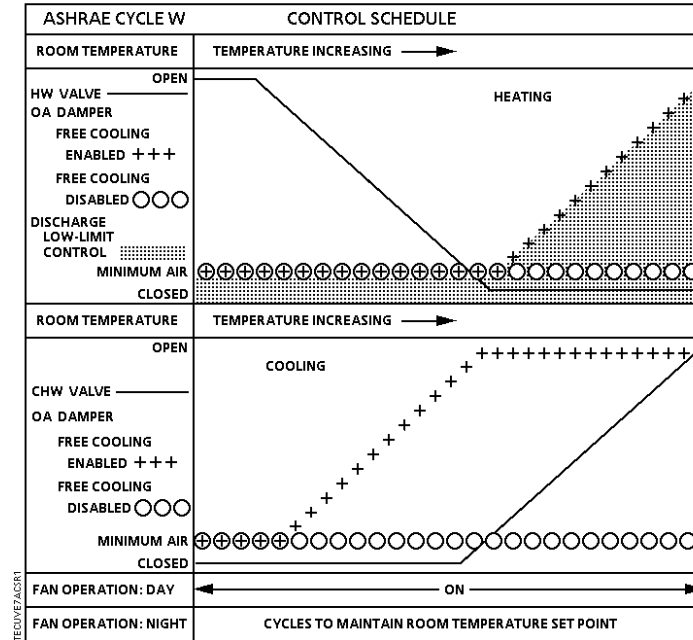


Figure 2287-4. Application 2287 Control Schedule.

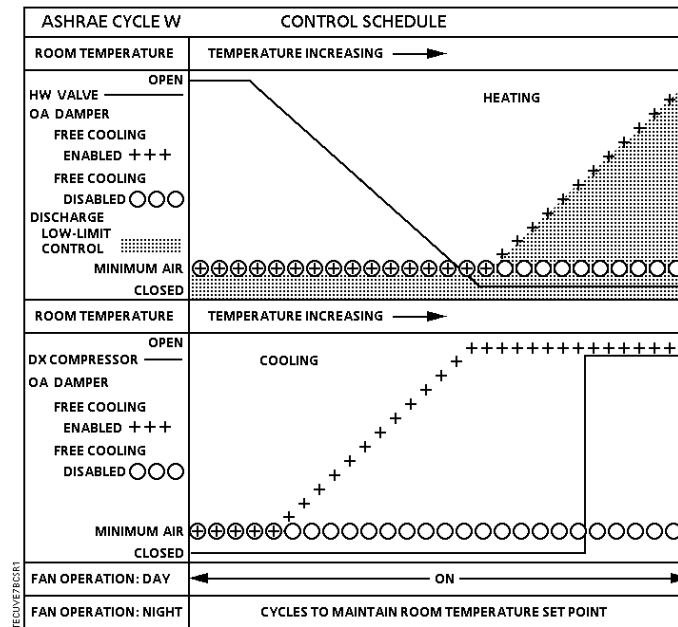


Figure 2287-5. Application 2287 Control Schedule.

## Hardware Inputs

### Analog

- Averaging air temperature sensor
- Room temperature sensor
- Room temperature setpoint dial (optional)

### Digital

- Low Temperature Detection Thermostat (LTDT)
- 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. See Table 2287-1.

### Analog (0 to 10V)

- Cooling valve actuator
- Heating valve actuator
- Outdoor air damper actuator

### Digital

- DX coil
- Unit fan

## Ordering Notes

Unit Vent Controller – 0 to 10V Output (540-509)

See *APOGEE Automation Configuration and Sizing Guidelines* on InfoLink for product numbers.

Powers Averaging Air Temperature Sensor

Terminal Equipment Controller Room Temperature Sensor

## Point Database

Table 2287-2 presents the point database information for Application 2287.

## Sequence of Operation

The following paragraphs present the sequence of operation for Application 2287, "Heating and Cooling, Nesbitt Cycle W".

### Control Temperature Setpoints

Depending on the controller's current operational mode (day or night), the control temperature setpoint, CTL STPT (Point 92) holds the value of one of the following setpoints:

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

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

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

**NOTE:** The value of CTL TEMP (Point 78) is the same as the value of ROOM TEMP (Point 4), unless CTL TEMP is overridden.

### Day and Night Modes

The day/night status of the space is determined by the status of DAY.NGT (Point 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 (Figure 2287-1 through Figure 2287-3 and Figure 2287-6 through Figure 2287-7), and WALL SWITCH (Point 18) equals YES, the controller monitors the status of DI 2. When the status of DI 2 (Point 24) is ON (the switch is closed), 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), 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, 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), the field panel can send an operator or PPCL command to override the status of DAY.NGT. See *Powers Process Control Language (PPCL) User's Manual* (125-1896) and *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 OVRD TIME (Point 20), pressing the override switch will reset the controller to day operational mode for the time period that is set in OVRD TIME. The status of NGT OVRD (Point 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 has any effect on the controller.

## Day Heating Operation

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

- Modulating the heating coil control device based on the difference between the control temperature point, CTL TEMP (Point 78), and CTL STPT. If CTL TEMP goes below CTL STPT, the heating valve actuator opens. If CTL TEMP goes above CTL STPT, the reverse occurs.
- Positioning the outdoor air damper as follows:
  - When the coil is providing heat, the damper is positioned at its minimum setting. When the coil is not providing heat and FREE CLG (Point 23) is set to ENABLE, the damper is positioned from minimum to maximum open to provide ventilation cooling. If DISCH TEMP (Point 15) drops below DISCH STPT (Point 93), the damper closes to maintain a low limit on the discharge temperature. If FREE CLG is set to DISABL, the damper is kept at minimum at all times.

## Day Cooling Operation

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

- Modulating the available coil control device based on the difference between the control temperature point, CTL TEMP (Point 78), and CTL STPT.
- Positioning the outdoor air damper as follows:
  - When the coil is providing cooling and FREE CLG (Point 23) is set to ENABLE, the damper is kept open. When the coil is not providing cooling and FREE CLG is set to ENABLE, the damper is modulated between minimum and maximum. If FREE CLG is set to DISABL, the damper is kept at minimum at all times.

If DX COOLING (Point 27) is set to YES, DX cooling is controlled as follows:

- If CLG OUTPUT (Point 61) is greater than 75%, the DX turns ON.
- If CLG OUTPUT is less than 75%, the DX turns OFF.
- The DX may not turn ON or OFF until the number of minutes held in CMP MIN ON (Point 76) or CMP MIN OFF (Point 75) have expired.



## Night Heating Operation

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

- If CTL TEMP (Point 78) drops below the value of NGT HTG STPT (Point 9) minus the value of NGT DBAND (Point 88):
  - The fan turns ON
  - Heating turns ON
- If CTL TEMP rises above NGT HTG STPT:
  - The fan turns OFF
  - Heating turns OFF

When the fan turns ON, the heating actuator is opened. When the fan turns OFF, all heating is closed. If NGT HW HTG is set to YES, (for hot water coils), the heating actuator is kept open at all times during the night.

In night heating operation, the controller operates as follows:

- For units with hot water coils, NGT HW HTG (Point 53) must be set to YES, so that the valve will be positioned to full open.
- For units with steam coils, NGT HW HTG must be set to NO, so that the coils can be controlled.
- The controller may switch to cooling mode when appropriate if NGT CLG MODE (Point 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 CTL STPT (Point 92) by doing the following:

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

In night cooling operation, the controller operates as follows:

- For units with hot water coils, NGT HW HTG (Point 53) must be set to YES, so that the valve will be positioned to full open.
- For units with steam coils, NGT HW HTG must be set to NO, so that the heating coils can be kept OFF.

## Heating/Cooling Switchover

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

- HTG LOOPOUT (Point 80) is below SWITCH LIMIT.
- CTL TEMP (Point 78) is greater than the sum of CTL STPT (Point 92) plus SWITCH DBAND (Point 90).
- CTL TEMP is greater than 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 (Point 79) is below SWITCH LIMIT.
- CTL TEMP is less than CTL STPT minus SWITCH DBAND.
- CTL TEMP is less than the appropriate heating setpoint plus SWITCH DBAND.

If night cooling is not available, as indicated by NGT CLG MODE (Point 54), 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 cooling loop, and an outdoor air loop.

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

**Cooling Loop** – The cooling loop uses the value of CTL STPT and CTL TEMP to modulate the value of CLG LOOPOUT (Point 79).

**Outdoor Air Loop** – The outdoor air loop uses the values of DISCH STPT (Point 93) and DISCH TEMP (Point 15) to modulate the value of OA LOOPOUT (Point 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 CTL STPT (Point 92) plus or minus the value of MORN DBAND (Point 89). In morning cool-down, if FREE CLG (Point 23) is set to ENABLE, 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), normal day heating operation begins when the temperature of the room reaches 69°F (20.6°C).

## Fan Operation

In day mode, FAN (Point 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 CTL STPT (Point 92) minus NGT DBAND (Point 88). When the temperature rises above CTL STPT, the fan turns 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 DX cooling is available, the fan is ON when the DX coil is ON. The fan will remain ON for 30 seconds after the DX coil is turned OFF.

## Fail-safe Operation

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

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

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

- Outdoor air damper is closed.
- Heating is full ON.
- Cooling is full OFF.
- Fan is OFF.

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

If the discharge air temperature sensor fails, the following conditions occur:

- If the last valid discharge air temperature is greater than 150 degrees, the outdoor air damper is set to minimum position.
- If the last valid discharge air temperature is less than 150 degrees, the outdoor air damper is closed.

The heating and cooling loops continue to control the room temperature.

If a failed sensor returns or if the LTDT turns OFF, 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 setpoint, either the cooling loop, the heating loop or both need to be tuned. See *APOGEE Automation Service Procedures* on InfoLink for more information.
2. The Unit Vent Controller – 0 to 10V Output, as shipped from the factory, keeps all associated equipment OFF. See the “Equipment Controllers” tab in the *APOGEE Automation Start-up Procedures* on InfoLink 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 2287 is shown in Figure 2287-6 through Figure 2287-7.

**CAUTION:**

The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220V 4-relay module 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

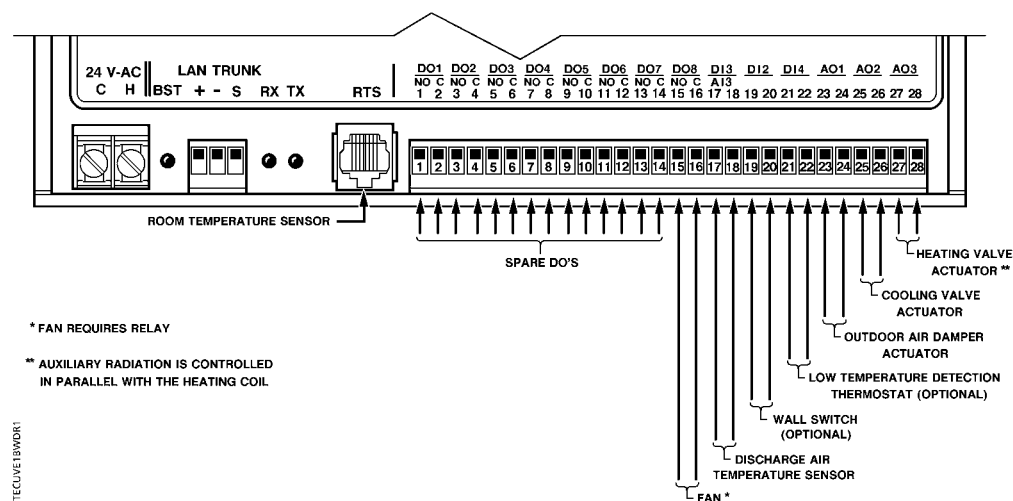


Figure 2287-6. Application 2287 Wiring Diagram.

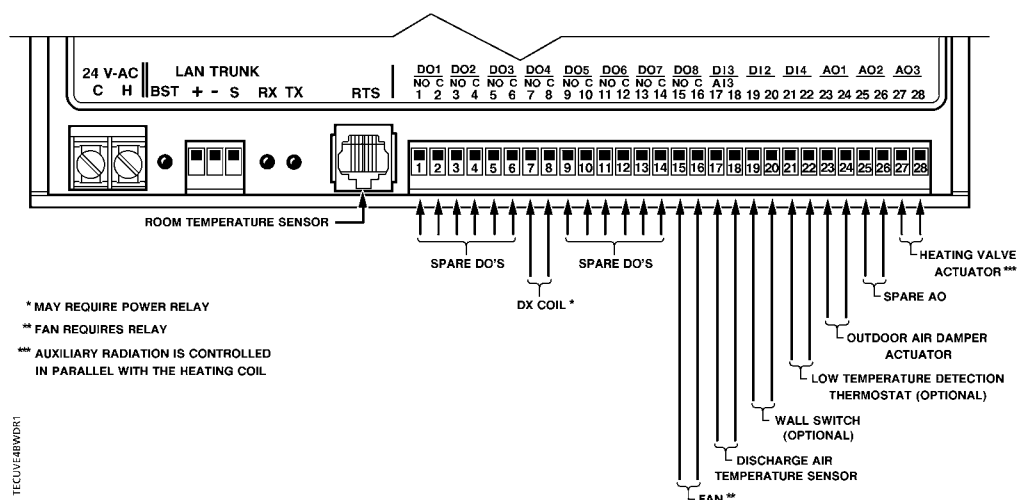


Figure 2287-7. Application 2287 Wiring Diagram.

Table 2287-2. Point Database for Application 2287.

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}	DISCH 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	NIGHT	–	1	0	NIGHT	DAY
{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
27	DX COOLING	NO	–	1	0	YES	NO
{29}	DAY.NGT	DAY	–	1	0	NIGHT	DAY

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

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

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

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Table 2287-2. Point Database for Application 2287.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{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	–	–
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}	DO 1	OFF	–	1	0	ON	OFF
{42}	DO 2	OFF	–	1	0	ON	OFF
{43}	DO 3	OFF	–	1	0	ON	OFF
{44}	DX	OFF	–	1	0	ON	OFF
{45}	DO 5	OFF	–	1	0	ON	OFF
{46}	DO 6	OFF	–	1	0	ON	OFF
{47}	DO 7	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
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	–	–

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 2287-2. Point Database for Application 2287.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
<i>continued on next page...</i>							
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	–	–
75	CMP MIN OFF	5	MIN	1	0	–	–
76	CMP MIN ON	5	MIN	1	0	–	–
{77}	OA 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}	OA P GAIN	0.2 (0.36)	–	0.2 (0.036)	0	–	–
{82}	OA I GAIN	0.00054 (0.000972)	–	0.00009 (0.000162)	0	–	–
{83}	OA D GAIN	24 (43.2)	–	1 (1.8)	0	–	–
{84}	OA 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}	DISCH STPT	74.00 (23.5)	DEG F (DEG C)	0.5 (0.28)	37.5 (3.06)	–	–

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 2287-2. Point Database for Application 2287.

Point Number	Descriptor	Factory Default (SI Units)	Engr. Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
<i>continued on next page...</i>							
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.