SIEMENS

TEC Controller

Single Compressor Heat Pump with Reversing Valve Control, Application 2070

Application Note

140-1040
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Restricted

Building Technologies

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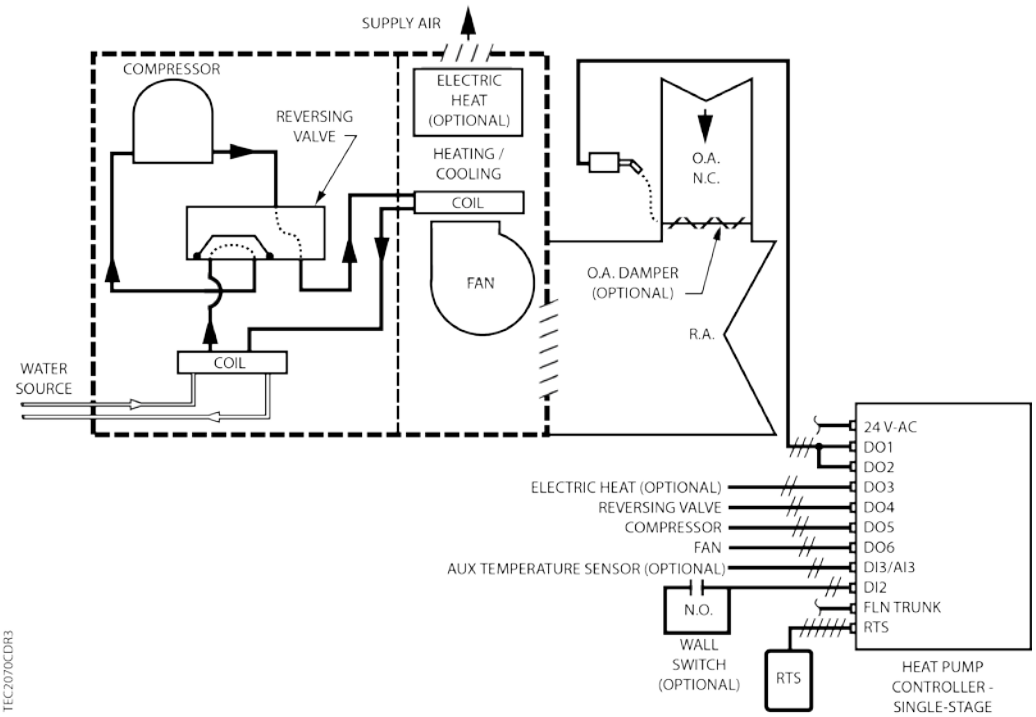
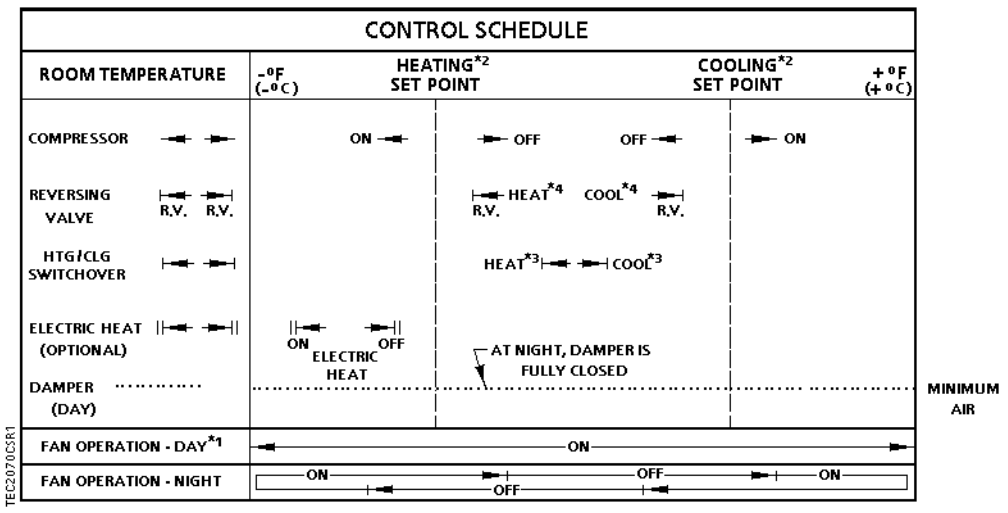
Overview

In Application 2070, the controller controls a single stage compressor heat pump with a reversing valve. In addition to a compressor, this heat pump may also be equipped with electric heat for auxiliary heat and optional outdoor air damper can be provided for ventilation air.



Application 2070 Control Diagram.



Application 2070 Control Schedule.

NOTES:
1. See *Fan Operation*.
2. See *Control Temperature Setpoints*.
3. See *Heating/Cooling Switchover*.
4. See *Compressor Operation*.

Hardware Inputs

Analog

- Room temperature sensor
- Room temperature setpoint dial (optional)
- Aux temperature sensor (optional)

Digital

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

Hardware Outputs

Analog

- None

Digital

- Compressor
- Electric heat (optional)
- Reversing valve
- Outdoor Air (OA) damper actuator (floating control) (optional)
- Fan

Ordering Notes

540-105N	Siemens TEC Heat Pump Controller Single Stage

Sequence of Operation

The following paragraphs present the sequence of operation for Application 2070 - Single Compressor Heat Pump with Reversing Valve Control.

Control Temperature Setpoints

This application has a number of different room temperature setpoints (DAY HTG STPT, NGT CLG STPT, RM STPT DIAL, etc.). The application actually controls using the CTL STPT. CTL STPT is set to different values depending on its override status, the time of day, whether or not a temperature deadband (zero energy band) has been configured, and the type of RTS used.

CTL STPT is Overridden:

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

CTL STPT in Night Mode:

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

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

CTL STPT in Day Mode:

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

Without setpoint dial:

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

With setpoint dial:

When the controller is in day mode and STPT DIAL = YES. CTL STPT is set based on the value of the setpoint dial and the setpoint deadband.

The setpoint deadband exists to allow the controller to provide a separation of the heating and cooling temperature setpoints when a setpoint dial is enabled.

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

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

- *Dial value* is the value of RM STPT DIAL limited between the value of RM STPT MIN and RM STPT MAX.
- *Deadband* is the value of the difference between DAY CLG STPT and DAY HTG STPT, half of which is applied to establish the current heating and cooling setpoints.
  - *Deadband* = (DAY CLG STPT – DAY HTG STPT)

CTL STPT is calculated as follows:

With Deadband Disabled:

CTL STPT = *Dial value*

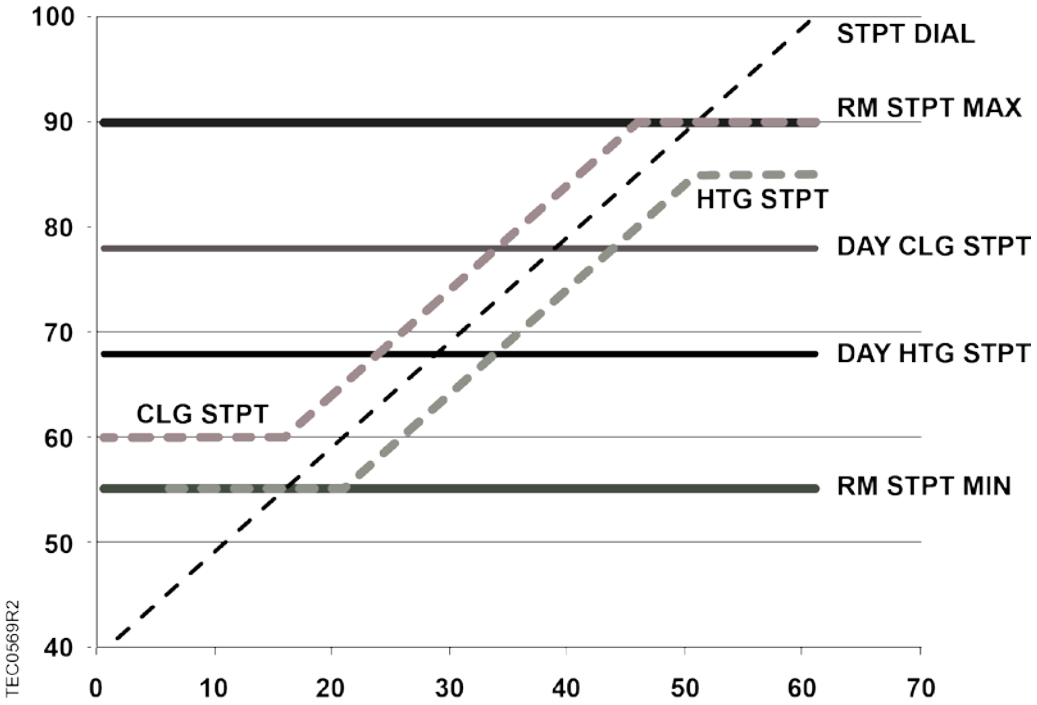
With Deadband enabled in Heat Mode:

CTL STPT = *Dial value* – 0.5 * *Deadband* (limited between the value of RM STPT MIN and RM STPT MAX)

With Deadband enabled in Cool Mode:

CTL STPT = *Dial value* + 0.5 * *Deadband* (limited between the value of RM STPT MIN and RM STPT MAX).

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



Room Temperature and CTL TEMP

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

CTL TEMP is the room temperature that is used for control purposes. In other words, what the application is trying to do is to maintain CTL TEMP at the control setpoint.

If CTL TEMP is overridden then:

- CTL TEMP equals its overridden value and ROOM TEMP has no effect on the value of CTL TEMP.

Day and Night Modes

The day/night status of the space is determined by the status of DAY.NGT. 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 DI 2 (see the Control Diagram(s), and WALL SWITCH = YES, the controller monitors the status of DI 2.) When the status of DI 2 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 = 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 DAY.NGT. See *Powers Process Control Language (PPCL) User's Manual* (125-1896) and *Field Panel User's Manual* (125-3019) or *BACnet Field Panel User's Manual* (125-3020) 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, 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 changes to DAY. After the override time elapses, the controller returns to night mode and the status of NGT OVRD changes back to NIGHT.

The override switch on the room sensor will only affect the controller when it is in night mode.

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

- HTG LOOPOUT < SWITCH LIMIT.
- CTL TEMP > CTL STPT by at least the value set in SWITCH DBAND.
- CTL TEMP > the appropriate cooling setpoint minus SWITCH DBAND.

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

- CLG LOOPOUT < SWITCH LIMIT.
- CTL TEMP < CTL STPT by at least the value set SWITCH DBAND.
- CTL TEMP < the appropriate heating setpoint plus SWITCH DBAND.

When the controller switches to heating mode, the span would be applied to the DAY HTG STPT (70°F) and you are able to adjust the heating setpoint from 68°F to 72°F.

Digital Room Units (2200/2300 Series)

The digital room unit will display a graphical bar indicating the number of steps above or below the current operating temperature setpoint. When the controller switches modes (heating to cooling) the span adjustment set will be applied to the new heating/cooling mode center value.

Analog Room Units (1000 Series)

When the controller switches to heating mode, the span is applied to the DAY HTG STPT (70°F) and you are able to adjust the heating setpoint from 68°F to 72°F.

Control Loops

The heat pump is controlled by two Proportional, Integral, and Derivative (PID) control loops; two temperature loops.

The two temperature loops are a cooling loop and a heating loop and the value of HEAT.COOL determines which is active. The active temperature loop maintains room temperature at the value in CTL STPT. The inputs to the temperature loops are CTL TEMP and CTL STPT. The outputs are CLG LOOPOUT and HTG LOOPOUT.

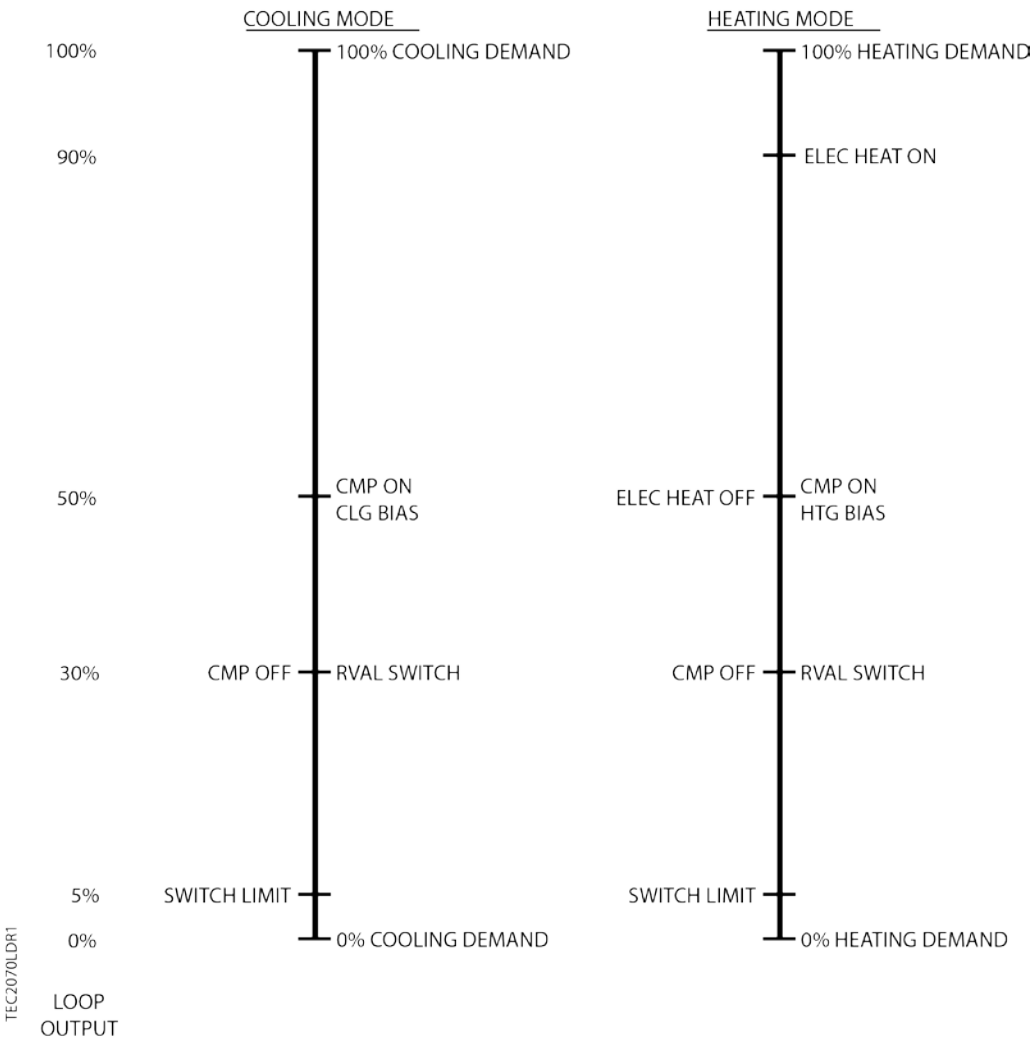
The two temperature loops perform the overall sequencing of the heat pump equipment; they determine when to turn the compressors, fan, and stages of electric heat ON and OFF.

In heating mode, as the room temperature drops below the heating setpoint, the heating loop calls for more heating (the heating loop output rises). In cooling mode, if the room temperature rises above the cooling setpoint, the cooling loop calls for more cooling (the cooling loop output rises). The output of the inactive loop will remain at zero.

The ladder diagram shows the heating and cooling loop sequencing of single compressor with one stage of electric heat. The diagrams show the outputs of the heating and cooling loops as vertical bars from 0 to 100%. The right side of each ladder diagram reflects a rising loop output. The left side of each ladder diagram reflects a falling loop output.

No action occurs when the loop output rises above or drops below the values of CLG BIAS and HTG BIAS. The purpose of these points is to provide a starting place for the loops at startup.

NOTE:
The values used in this diagram are for example purposes only. They may be set to different values to suit your specific needs.



Application 2070 Heating and Cooling Loops.

Cooling Loop – CLG LOOPOUT must be greater than the value stored in RVAL SWITCH before the reversing valve will switch from heating to cooling. When the reversing valve is in cooling mode, the compressor operates as a cooling compressor.

COMPRESSOR will not be allowed to turn ON until CLG LOOPOUT becomes greater than CMP ON. COMPRESSOR will not be allowed to turn OFF until CLG LOOPOUT drops below CMP OFF.

When CLG LOOPOUT drops below the value of SWITCH LIMIT, the controller will be allowed to change to heating mode if all other criteria for the change have been met.

Heating Loop – HTG LOOPOUT must be greater than the value stored in RVAL SWITCH before the reversing valve will switch from cooling to heating. When the reversing valve is in heating mode, the compressor operates as a heating compressor.

COMPRESSOR will not be allowed to turn ON until HTG LOOPOUT becomes greater than CMP ON. COMPRESSOR will not be allowed to turn OFF until HTG LOOPOUT drops below CMP OFF.

HTG LOOPOUT must be greater than ELEC HEAT ON before ELEC HEAT is turned ON. When HTG LOOPOUT drops below CMP ON, ELEC HEAT will be shut OFF.

When HTG LOOPOUT drops below the value of SWITCH LIMIT, the controller will be allowed to change to cooling mode if all other criteria for the change have been met.

Reversing Valve Operation

NOTE:
To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of the reversing valve. See Overriding Critical Heat Pump DOs section for more information.

The status of REV VALVE determines the operation of the heat pump's compressors (heating or cooling). The reversing valve changes from heating to cooling when the following conditions have been met:

- HEAT.COOL = COOL.
- Compressor stage 1 has been OFF longer than the time stored in RVAL SW TIME.
- CLG LOOPOUT > the value set in RVAL SWITCH.

The reversing valve changes from cooling to heating when the following conditions have been met:

- HEAT.COOL = HEAT.
- Compressor stage 1 has been OFF longer than the time stored in RVAL SW TIME.
- HTG LOOPOUT > the value set in RVAL SWITCH.

Compressor Operation

NOTE:
To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of compressors. See the *Overriding Critical Heat Pump DOs* section for more information.

When HEAT.COOL and REV VALVE are both in cooling mode, the output of the cooling loop controls the compressor.

When HEAT.COOL and REV VALVE are both in heating mode, the output of the heating loop controls the compressor.

When HEAT.COOL and REV VALVE are in opposite states, the compressors are turned OFF. If a compressor has been ON it will not shut OFF until its minimum ON timer has expired. The following paragraphs explain the compressor staging.

If the loop that is currently active (either CLG LOOPOUT or HTG LOOPOUT), > CMP ON and the compressor has been OFF for at least the time set in CMP MIN OFF, COMPRESSOR is turned ON.

COMPRESSOR is turned OFF when the loop currently under control is less than CMP OFF provided the following conditions have been met:

- The compressor has been ON for at least the time set in CMP MIN ON.
- ELEC HEAT is OFF for more than 30 seconds.

Electric Heat (Optional)

NOTE:
To prevent damage to the heat pump, ELEC HEAT you cannot send commands to the pump at the portable operator's terminal or the field panel.

If the reversing valve is in cooling mode, ELEC HEAT is OFF.

If the reversing valve is in heating mode, ELEC HEAT turns ON when the output of the heating loop > the value of ELEC HEAT ON. The electric heat turns OFF when the output of the heating loop is less than COMP ON.

Fan Operation

NOTE:
To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of the fan. See the *Overriding Critical Heat Pump DOs* section for more information.

Day Mode – FAN is ON when CYCLE FAN = NO. If CYCLE FAN = YES, the fan control in day mode is the same as it is in night mode.

Night Mode –The fan is controlled as follows:

The fan will turn ON when the following condition has been met:

- The compressor or stage of electric heat is ON.

The fan will turn OFF only after the following condition has been met:

- The compressor and stages of electric heat have been OFF for at least 30 seconds.

Damper Operation

If the heat pump has a damper, it is set at the value of DMPR MIN POS during day mode and is fully closed during night mode.

Power Failure Recovery

Upon return from a power failure, the heating and cooling compressors are kept OFF, the optional electric heat (if used), is kept OFF, however the fan turns ON. In addition to the equipment being OFF, both CLG LOOPOUT and HTG LOOPOUT are set to 0. This situation will remain in effect until the power failure recovery period is over for this controller.

The controller returns to normal control when its power failure recovery period is over. The power failure recovery time for a heat pump is based on the following formula:

RETURN DELAY + (CTLR ADDRESS × 10 seconds)

RETURN DELAY is useful for water to air heat pumps because it allows the central equipment to be running before the heat pumps start coming back on-line. This gives the water loop a chance to stabilize its temperature before the compressors start using it and therefore minimizes the chance that the heat pumps will trip the high temperature/pressure alarms.

CTLR ADDRESS is used so the power failure recovery time of the controllers will be different from each other even if they all have the same value for RETURN DELAY. This lessens the demand of having all the electrical equipment starting at once.

Overriding DOs

This application is designed to prevent you from directly commanding critical DOs ON or OFF. Specifically, the fan, reversing valve, electric heat and compressor cannot be directly commanded ON or OFF. Commanding these DOs can only be done indirectly by overriding the output of the loop currently under control (either CLG LOOPOUT or HTG LOOPOUT). This is done to protect the equipment.

You will be able to directly turn any spare DOs ON or OFF. Also, you will always be able to command the damper via DMPR COMD.

Fail Mode Operation

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

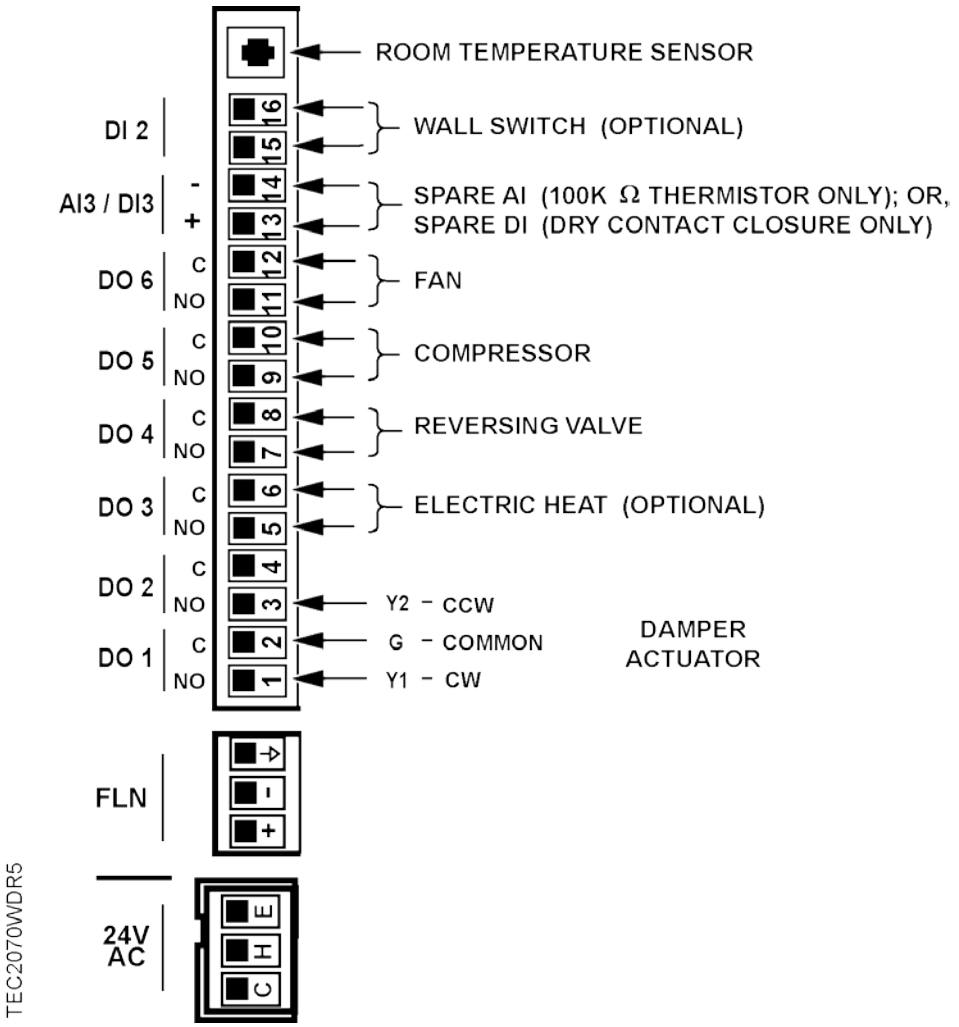
Application Notes

- If the heat pump cycles excessively, the temperature swings in the room are excessive, or there is trouble maintaining the setpoint, the cooling loop, the heating loop or both need to be tuned.
- The controller, as shipped from the factory, keeps all associated equipment OFF. See the *Start-up* document for how to release the controller and its equipment to application control.

For more information, contact your nearest Siemens Industry, Inc. representative.

Wiring Diagrams

	⚠ CAUTION
	The controller's DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. An external interposing relay is required for any of the following: • VA requirements higher than the maximum • 110 or 220 Vac requirements • DC power requirements • Separate transformers used to power the load (for example part number 540-147, Terminal Equipment Controller Relay Module)



Application 2070 – Single Compressor Heat Pump with Reversing Valve Control.

Application 2070 Point Database

Point Number	Descriptor	Factory Default (SI Units)	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
1	CTLR ADDRESS	99	--	1	0	--	--
2	APPLICATION	2090	--	1	0	--	--
3	RETURN DELAY	10	MIN	1	0	--	--
{04}	ROOM TEMP	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
{05}	HEAT.COOL	COOL	--	--	--	HEAT	COOL
6	DAY CLG STPT	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
7	DAY HTG STPT	70.0 (21.21)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
8	NGT CLG STPT	82.0 (27.93)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
9	NGT HTG STPT	65.0 (18.41)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
10	DMPR MIN POS	14.8	PCT	0.4	0	--	--
11	RM STPT MIN	55.0 (12.81)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
12	RM STPT MAX	90.0 (32.41)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
{13}	RM STPT DIAL	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
14	STPT DIAL	NO	--	--	--	YES	NO
{15}	AUX TEMP	74.0 (23.496)	DEG F (DEG C)	0.5 (0.28)	37.5(3.056)	--	--
18	WALL SWITCH	NO	--	--	--	YES	NO
{19}	DI OVRD SW	OFF	--	--	--	ON	OFF
20	OVRD TIME	0	HRS	1	0	--	--
{21}	NGT OVRD	NIGHT	--	--	--	NIGHT	DAY
{24}	DI 2	OFF	--	--	--	ON	OFF
{25}	DI 3	OFF	--	--	--	ON	OFF
{29}	DAY.NGT	DAY	--	--	--	NIGHT	DAY
{41}	DO 1	OFF	--	--	--	ON	OFF
{42}	DO 2	OFF	--	--	--	ON	OFF
{43}	ELEC HEAT	OFF	--	--	--	ON	OFF
{44}	REV VALVE	COOL	--	--	--	HEAT	COOL
{45}	COMPRESSOR	OFF	--	--	--	ON	OFF
{46}	FAN	OFF	--	--	--	ON	OFF

Point Number	Descriptor	Factory Default (SI Units)	Eng Units (SI Units)	Slope (SI Units)	Intercept (SI Units)	On Text	Off Text
{48}	DMPR COMD	0	PCT	0.4	0	--	--
{49}	DMPR POS	0	PCT	0.4	0	--	--
51	MTR TIMING	130	SEC	1	0	--	--
56	DMPR ROT ANG	90	--	1	0	--	--
58	MTR SETUP	0	--	1	0	--	--
59	DO DIR.REV	0	--	1	0	--	--
60	CYCLE FAN	NO	--	--	--	YES	NO
63	CLG P GAIN	10.0 (18.0)	--	0.25 (0.45)	0	--	--
64	CLG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0	--	--
65	CLG D GAIN	24 (43.2)	--	2 (3.6)	0	--	--
66	CLG BIAS	50	PCT	0.4	0	--	--
67	HTG P GAIN	10.0 (18.0)	--	0.25 (0.45)	0	--	--
68	HTG I GAIN	0.01 (0.018)	--	0.001 (0.0018)	0	--	--
69	HTG D GAIN	24 (43.2)	--	2 (3.6)	0	--	--
70	HTG BIAS	50	PCT	0.4	0	--	--
{78}	CTL TEMP	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
{79}	CLG LOOPOUT	0	PCT	0.4	0	--	--
{80}	HTG LOOPOUT	0	PCT	0.4	0	--	--
81	ELEC HEAT ON	90	PCT	0.4	0	--	--
82	CMP ON	50	PCT	0.4	0	--	--
83	CMP OFF	30	PCT	0.4	0	--	--
84	RVAL SWITCH	30	PCT	0.4	0	--	--
85	SWITCH LIMIT	4.8	PCT	0.4	0	--	--
86	SWITCH TIME	10	MIN	1	0	--	--
87	CMP MIN OFF	3	MIN	1	0	--	--
88	CMP MIN ON	3	MIN	1	0	--	--
89	RVAL SW TIME	30	SEC	1	0	--	--
90	SWITCH DBAND	2.0 (1.12)	DEG F (DEG C)	0.25 (0.14)	0	--	--
{92}	CTL STPT	74.0 (23.45)	DEG F (DEG C)	0.25 (0.14)	48.0(8.89)	--	--
96	CAL TIMER	12	HRS	1	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.

* This point may be unbundled at the field panel as an input for monitoring purposes only.

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

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