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The following interim Heat Pump Applications are no longer available:

- 2573 and 2574.
- 2583 and 2584.
- 2593 and 2594.

Please use Heat Pump Applications 2893 and 2894, as these applications supersede the older versions. If you have any of these older applications the information in the most recent application and start-up documents for 2893 and 2894 still applies.

SIEMENS

BACnet Heat Pump

Application Notes

Application 2893 — Multi-Compressor with Mixed Air and Reversing Valve Control

Table of Contents

Overview

In Application 2893, the controller controls a multi-stage heat pump with a reversing valve. In addition to compressors, this heat pump may also be equipped with electric heat for auxiliary heat and mixed air control for free cooling. The mixed air control can use either a spring return or a floating control damper motor.

Application 2893 is based on Application 2573 of the preceding revision of Siemens BACnet Heat Pump Controller. Application 2893 is identical to 2573 except for any differences listed in Table 1.

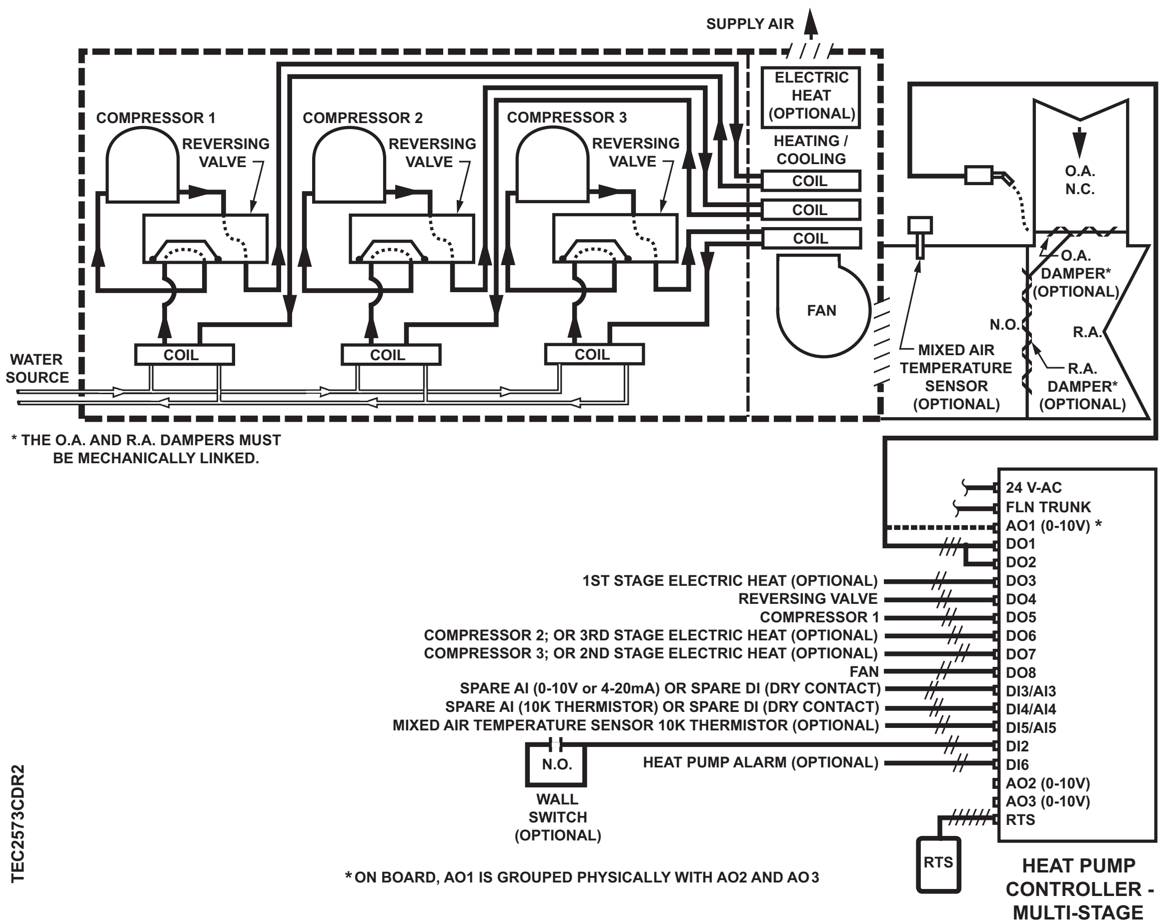


Figure 1. Application 2893 Control Drawing.

Table 1. Siemens BACnet Heat Pump Controller — New Features 2009.

	Previous	New (2009)
Application Numbers	2573 and 2574 2590 (slave)	2893 and 2894 2849 (slave)
Rev string	BM20	BK22 (September 2009)
New Feature(s)	- -	• New Points: 65, 66, 69, 70, 124, 125, 126, 127 (original points numbered 65, 66, 69, 70 are re-numbered to 102, 103, 104, 105) • Ability to Enable/Disable the commanding of critical DOs • Relative Setpoint Adjustment option • RH & T support for Series 3000 room stats • Flash/upgrade pass through using Series 1000, 2000, or 3000 stats (no need to connect directly to controller) • AI 5 OFFSET (Point 125) – calibrate aux temp at AI5 if necessary for fine tuning sensor/temp accuracy (Note: AI 4 OFFSET (Point 124) is also available)

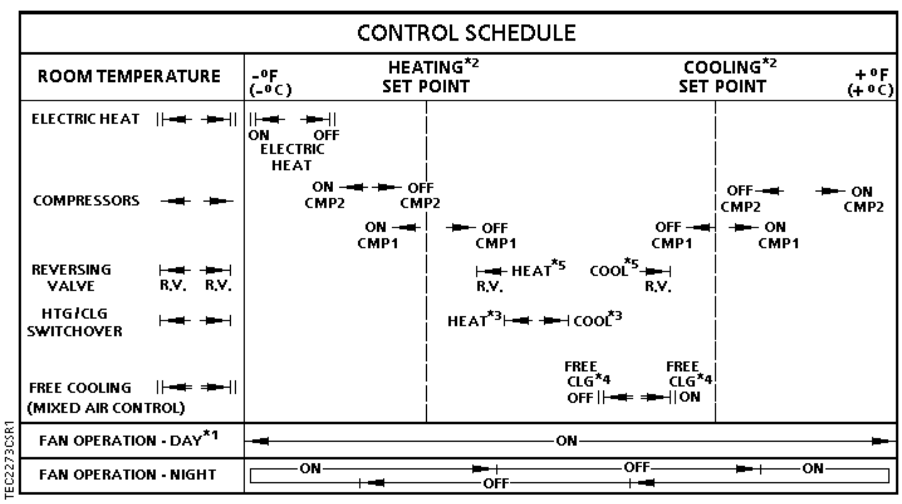


Figure 2. Application 2893 Control Schedule.

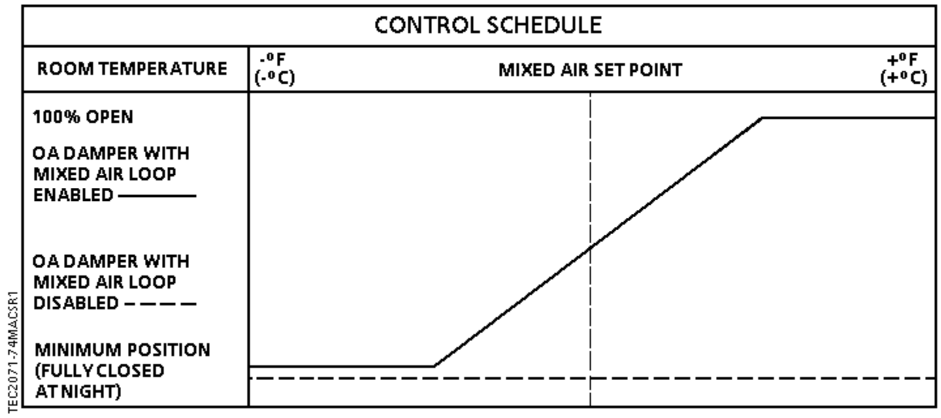


Figure 3. Application 2893 Control Schedule for Mixed Air Control.

BACnet

The Siemens BACnet Heat Pump Controller - Multi-Stage communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.

Table 2. Supported BIBBS.

Product	Supported BIBBs	BIBB Name
BTEC	DS-RP-B	Data Sharing-ReadProperty-B
	DS-RPM-B	Data Sharing-ReadPropertyMultiple-B
	DS-WP-B	Data Sharing-WriteProperty-B
	DM-DDB-B	Device Management-Dynamic Device Binding-B
	DM-DOB-B	Device Management-Dynamic Object Binding-B
	DM-DDC-B	Device Management-Device Communication Control-B

Hardware Inputs

Analog

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

Digital

- Heat pump alarm (optional)
- Night mode override (optional)
- Wall switch (optional)

Hardware Outputs

Analog

- Spring return damper actuator (optional)

Digital

- Compressor 1
- Compressor 2 (optional); or, stage 3 electric heat (optional)
- Compressor 3 (optional); or, stage 2 electric heat (optional)
- Floating control damper actuator (optional)
- Fan
- Stage 1 electric heat (optional)
- Reversing valve

Ordering Notes

Siemens BACnet Heat Pump Controller: 550-490

Related Equipment:

Damper Actuator (spring return or floating)
Mixed Air Temperature Sensor
Terminal Equipment Controller Room Temperature Sensor

Point Database

Table 3 presents the point database information for Application 2893.

Sequence of Operation

The following paragraphs present the sequence of operation for the *Siemens BACnet Heat Pump Controller - Multi-Stage Application 2893, Multi-Compressor with Mixed Air and Reversing Valve Control*.

Control Temperature Setpoints

Application 2893 has a number of different room temperature setpoints (DAY HTG STPT, NGT CLG STPT, RM STPT DIAL, etc.). The application actually controls to 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.

Selection of RTS type:
The point STAT TYPE can be set to NORMAL (default) or OFFSET. When STAT TYPE = OFFSET, an optional Relative Setpoint Adjustment feature can be used. For more information see the *Relative Setpoint Adjustment (optional)* section.

CTL STPT in Day Mode:
If the controller is in day mode and STPT DIAL = YES (and a setpoint dial is present), RM STPT DIAL will be used to determine the value of CTL STPT.

If RM STPT DIAL is Failed but has been overridden, CTL STPT will be Normal and the current value of RM STPT DIAL will be used to determine the value of CTL STPT. If RM STPT DIAL is Failed and **not** overridden, CTL STPT will be Failed and the last known good value of RM STPT DIAL will be used to determine the value of CTL STPT.

If the controller is in day mode and STPT DIAL = NO, CTL STPT will hold the value of DAY CLG STPT or DAY HTG STPT. Also, CTL STPT will have a status of Normal even if RM STPT DIAL is Failed.

CTL STPT in Night Mode:
In night mode, CTL STPT holds the value of NGT CLG STPT or NGT HTG STPT regardless of whether a setpoint dial is used. Also, CTL STPT will always have a status of Normal, even if RM STPT DIAL is Failed.

CTL STPT is Overridden:
When CTL STPT is overridden, CTL STPT will equal its overridden value and the application will have no effect on the value of CTL STPT. Also, CTL STPT will always have a status of Normal, even if RM STPT DIAL is Failed.

Setpoint Dial and Deadband:
When a setpoint dial is being used during day mode, the value of CTL STPT depends in part on whether a deadband is being used.

When DAY HTG STPT equals DAY CLG STPT, a deadband is **not** being used and the value of CTL STPT is limited to the range RM STPT MIN to RM STPT MAX, regardless of the value/position of the setpoint dial. For instance,

- CTL STPT will equal RM STPT MAX if RM STPT DIAL > RM STPT MAX.

- CTL STPT will equal RM STPT MIN if RM STPT DIAL < RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT DIAL.

When DAY HTG STPT **does not** equal DAY CLG STPT, a deadband (or zero energy band) is being used. In this case, the controller operates as follows:

When HEAT.COOL equals HEAT

1. If RM STPT DIAL > than RM STPT MAX, then:

   - If [RM STPT MAX – 0.5 * (DAY CLG STPT – DAY HTG STPT)] > RM STPT MAX, then CTL STPT will equal RM STPT MAX.
   - If [RM STPT MAX – 0.5 * (DAY CLG STPT – DAY HTG STPT)] < RM STPT MIN, then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT MAX – 0.5 * (DAY CLG STPT – DAY HTG STPT).

2. If RM STPT DIAL < than RM STPT MIN, then:

   - If [RM STPT MIN – 0.5 * (DAY CLG STPT – DAY HTG STPT)] > RM STPT MAX, then CTL STPT will equal RM STPT MAX.
   - If [RM STPT MIN – 0.5 * (DAY CLG STPT – DAY HTG STPT)] < RM STPT MIN, then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT MIN – 0.5 * (DAY CLG STPT – DAY HTG STPT).

3. If RM STPT MAX > RM STPT DIAL > RM STPT MIN, then:

   - If [RM STPT DIAL – 0.5 * (DAY CLG STPT – DAY HTG STPT)] > RM STPT MAX, then CTL STPT will equal RM STPT MAX.
   - If [RM STPT DIAL – 0.5 * (DAY CLG STPT – DAY HTG STPT)] < RM STPT MIN, then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT DIAL – 0.5 * (DAY CLG STPT – DAY HTG STPT).

When HEAT.COOL equals COOL

1. If RM STPT DIAL > than RM STPT MAX, then:

   - If [RM STPT MAX + 0.5 * (DAY CLG STPT – DAY HTG STPT)] > RM STPT MAX, then CTL STPT will equal RM STPT MAX.
   - If [RM STPT MAX + 0.5 * (DAY CLG STPT – DAY HTG STPT)] < RM STPT MIN, then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT MAX + 0.5 * (DAY CLG STPT – DAY HTG STPT).

2. If RM STPT DIAL < than RM STPT MIN, then:

   - If [RM STPT MIN + 0.5 * (DAY CLG STPT – DAY HTG STPT)] > RM STPT MAX, then CTL STPT will equal RM STPT MAX.
   - If [RM STPT MIN + 0.5 * (DAY CLG STPT – DAY HTG STPT)] < RM STPT MIN, then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT MIN + 0.5 * (DAY CLG STPT – DAY HTG STPT).

3. If RM STPT MAX > RM STPT DIAL > RM STPT MIN, then:

   - If [RM STPT DIAL + 0.5 * (DAY CLG STPT – DAY HTG STPT)] > RM STPT MAX, then CTL STPT will equal RM STPT MAX.
   - If [RM STPT DIAL + 0.5 * (DAY CLG STPT – DAY HTG STPT)] < RM STPT MIN, then CTL STPT will equal RM STPT MIN.

..otherwise, CTL STPT will equal RM STPT DIAL + 0.5 * (DAY CLG STPT – DAY HTG STPT).

Relative Setpoint Adjustment (optional)

When STAT TYPE = OFFSET, the point STPT SPAN can be used to keep the temperature range that is available to the user of a setpoint dial constrained to a narrow range. Room sensor part number SB1-0916 or SB1-1072 should be used for this option (SB1-1072 has a display; SB1-0916 does not). These room sensors have a slider with red and blue colored bands indicating warmer/cooler, instead of a preprinted 55 to 95 degree temperature scale. When STAT TYPE = OFFSET, moving the slider up/down adjusts the room temperature a few degrees above/below the day heating or cooling setpoint. The maximum amount of adjustment is configured in STPT SPAN. For example, if STPT SPAN is set to 2.0, then moving the slider all the way up would add only 2 degrees to the day heating (or cooling) setpoint. Similarly, 2 degrees would be subtracted if the slider were moved all the way down. Between these extremes the offset is proportionately scaled.

Stat Supervision

Point 126, STAT SUPV is an enumerated point that can be configured to tell the controller how to respond to a loss of communication between a Series 3000 room stat and the controller. The default value for STAT SUPV is zero, no response (good also for Series 1000/2000 stats). A value of 1 means that if communication is lost for at least one minute, CTL TEMP will have a status of Fail. A value of 2 means that if communication is lost for at least one minute, Point 127, RM RH (humidity monitoring) will be Fail. A value of 3 means that both CTL TEMP and RM RH will be Fail after a loss of communications of at least one minute.

Room Temperature Offset

The Room Temperature Offset feature is optional.

RMTMP OFFSET is a user-adjustable offset that will compensate for deviations between the value of ROOM TEMP and the actual room temperature. This corrected value is displayed in CTL TEMP.

CTL TEMP = ROOM TEMP + RMTMP OFFSET.

EXAMPLE: If the actual room temperature is 72.0°F, and the value of ROOM TEMP is 73.0°F, then the value entered into RMTMP OFFSET is –1.0. In this case, the value of ROOM TEMP would read 73.0°F, but the value of CTL TEMP would read 72.0°F.

AI5 / AI4 OFFSET (optional)

AI 5 OFFSET (Point 125) works like RMTMP OFFSET. It can be used to calibrate AI5 aux temp sensor input if necessary. The *actual* temperature plus AI 5 OFFSET will equal AI5 display temperature.

AI 4 OFFSET (Point 124) works exactly like AI 5 OFFSET.

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 at DI 2 and WALL SWITCH = YES, the controller monitors the status of DI 2. When DI 2 is ON (the switch is closed), DAY.NGT will be set to DAY indicating that the controller is in day mode. When 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 = NO, the controller does not monitor the status of the wall switch, even if one is connected to it. In this case, the controller is operating stand-alone, it stays in day mode all the time. If the controller is operating with centralized control, connected to a field panel, the field panel can send an operator or PPCL command to override the status of DAY.NGT.

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 mode for the time period set in OVRD TIME. The status of NGT OVRD changes to DAY. After the override time elapses, the controller returns to night mode and NGT OVRD changes back to NIGHT.

The override switch on the room sensor will only affect the controller when 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.

Control Loops

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

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 and when to enable or disable mixed air control.

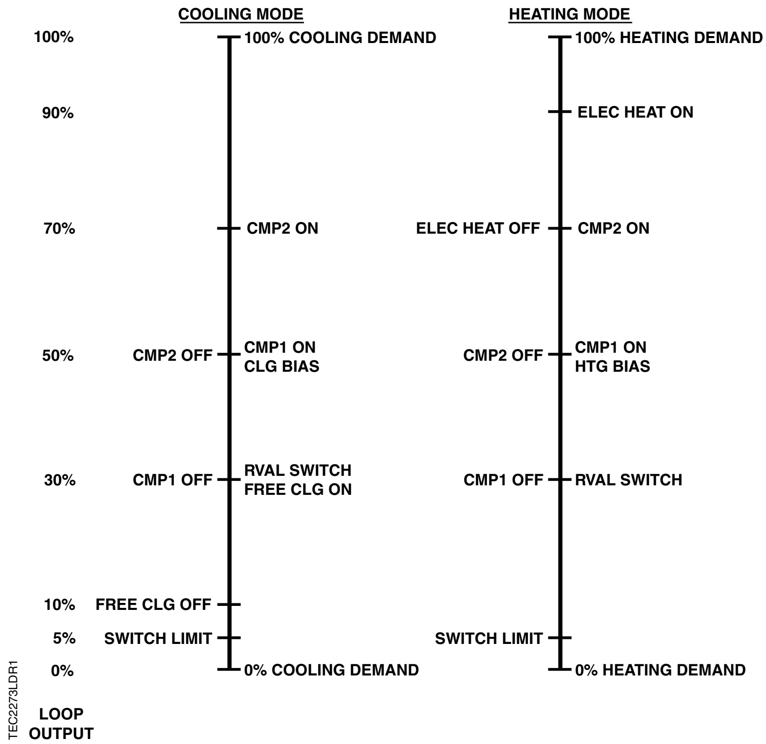


Figure 4. Heating and Cooling Loops.

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

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 (Figure 4).

The ladder diagrams (Figure 4) show the heating and cooling loop sequencing of multiple compressors 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 outputs rise above or drop 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.

Cooling Loop – CLG LOOPOUT must be greater than RVAL SWITCH before the reversing valve will switch from heating to cooling. When the reversing valve is in cooling mode, the compressors operate as cooling compressors. Before turning on any compressors, the controller will try to use free cooling if it is enabled by the field panel.

CLG LOOPOUT must be greater than FREE CLG ON before free cooling will be used. The controller accomplishes free cooling by enabling the mixed air loop to modulate the mixed air damper. COMPRESSOR 1 will not be allowed to turn ON until CLG LOOPOUT becomes greater than CMP1 ON. COMPRESSOR 1 will not be allowed to turn OFF until CLG LOOPOUT drops below CMP1 OFF.

When a second compressor is available, EHEAT3.CMP2 will not be allowed to turn ON until CLG LOOPOUT becomes greater than CMP2 ON. EHEAT3.CMP2 will not be allowed to turn OFF until CLG LOOPOUT drops below CMP2 OFF.

When a third compressor is available, EHEAT2.CMP3 will not be allowed to turn ON until CLG LOOPOUT becomes greater than CMP3 ON. EHEAT2.CMP3 will not be allowed to turn OFF unless CLG LOOPOUT drops below CMP3 OFF.

CLG LOOPOUT must be less than FREE CLG OFF before free cooling will be turned OFF. The controller turns OFF free cooling by disabling the mixed air loop. When the loop is disabled, the mixed air damper will be set to either minimum position for day mode or to 0% open for night mode.

When CLG LOOPOUT becomes less than 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 of RVAL SWITCH before the reversing valve will switch from cooling to heating. When the reversing valve is in heating mode, the compressors operate as heating compressors. COMPRESSOR 1 will not be allowed to turn ON until HTG LOOPOUT becomes greater than CMP1 ON. COMPRESSOR 1 will not be allowed to turn OFF until HTG LOOPOUT drops below CMP1 OFF.

When a second compressor is available, EHEAT3.CMP2 will not be allowed to turn ON until HTG LOOPOUT becomes greater than CMP2 ON. EHEAT3.CMP2 will not be allowed to turn OFF until HTG LOOPOUT drops below CMP2 OFF. HTG LOOPOUT must be greater than EHEAT 1 ON before ELEC HEAT 1 is turned ON.

When a third compressor is available, EHEAT 2.CMP3 will not be allowed to turn ON until HTG LOOPOUT becomes greater than CMP3 ON. EHEAT2.CMP3 will not be allowed to turn OFF until HTG LOOPOUT drops below CMP3 OFF.

When HTG LOOPOUT drops below CMP2 ON, ELEC HEAT 1will shut OFF. EHEAT3.CMP2 will not be allowed to turn OFF until HTG LOOPOUT drops below CMP2 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.

Mixed Air Loop – The heat pump is controlled by two Proportional, Integral, and Derivative (PID) control loops: a cooling loop and a heating loop. This section describes the mixed air control loop.

The mixed air loop controls only the mixed air portion of the application. The inputs to the mixed air loop are MA TEMP and MA STPT. The output is DMPR COMD.

Mixed Air Control

Day Mode – If the fan is ON, the mixed air damper, DMPR COMD, will be set to minimum position (as stored in DMPR MIN POS) when at least one of the following conditions occurs:

- HEAT.COOL = HEAT. Free cooling is not needed in the heating season.
- MA TEMP is failed. When this point is failed, mixed air control is not possible.
- FREE CLG = DISABL. The outside air temperature is too warm to be used for free cooling. During day mode, the damper is at its minimum position. During night mode, the damper is at its closed position.
- CLG LOOPOUT < FREE CLG OFF. The cooling load is so small that no cooling is required.

If the fan is OFF, DMPR COMD will be set to 0%.

DMPR COMD will be modulated by the mixed air temperature control loop when all of the following conditions have been met:

- HEAT.COOL = COOL.
- MA TEMP is normal. (Not failed.)
- FREE CLG = ENABLE. The outside air is cool enough to be used for free cooling.
- CLG LOOPOUT > FREE CLG ON. The cooling load is large enough to require cooling.
- DMPR COMD > DMPR MIN POS.

DMPR COMD will not be set below minimum position (DMPR COMD = DMPR MIN POS). This is done to make sure that the ventilation requirements are being met.

Night Mode – DMPR COMD = 0% OPEN if at least one of the following conditions occurs:

- HEAT.COOL = HEAT. Free cooling is not needed in the heating season.
- MA TEMP is failed. When this point is failed, mixed air control is not possible.
- NGT MA CTL = NO. Mixed air control is not being used during the night mode.
- FREE CLG = DISABL. The outside air is too warm to be used for free cooling.
- CLG LOOPOUT < FREE CLG OFF. The cooling load is so small that no cooling is required.

DMPR COMD will be modulated by the mixed air temperature control loop when all of the following conditions have been met:

- HEAT.COOL = COOL.
- MA TEMP is normal. (Not failed)

- NGT MA CTL = YES. (See *Application Notes*.)
- FREE CLG = ENABLE. The outside air is cool enough to be used for free cooling.
- CLG LOOPOUT > FREE CLG ON. The cooling load is large enough to require cooling.

If CLG LOOPOUT is between FREE CLG ON and FREE CLG OFF and all other conditions have been met for enabling the mixed air loop, the action taken will depend on the following:

- If CLG LOOPOUT was previously above FREE CLG ON, the mixed air loop will remain enabled.
- If CLG LOOPOUT was previously below FREE CLG OFF, the mixed air loop will remain disabled.

This will happen whether or not the heat pump is in day or night mode.

The mixed air damper motor can be either a spring return damper motor or a floating control damper motor.

- For a spring return damper, set DAMPER TYPE = SPRING. The mixed air loop will control the damper through its 0 – 10 volt analog output, AOV1, and DO 1 and DO 2 will be spare DOs.
- For a floating control damper, set DAMPER TYPE = FLOAT. The mixed air loop will control the damper through DO 1 and DO 2, and AOV1 will be a spare analog output.

CAUTION:

This application does not have built in low temperature detection for the mixed air dampers. The low temperature detection is handled differently depending on the type of damper used (spring return or floating control).

Spring Return Damper – Stand-alone low temperature detection can be accomplished with an external low limit thermostat. In order to do this, the damper should be set up to be normally closed and the external low temperature thermostat should cut power to the damper actuator upon reaching a low limit condition. When this happens, the spring will drive the damper shut.

Floating Control Damper – Stand-alone low temperature detection is not possible. A PPCL program can be written to close the damper when a low temperature situation occurs. In order to do this, an outside air temperature sensor needs to be connected to the field panel and DMPR COMD needs to be unbundled. Even though this is possible, make sure that the customer will allow it before attempting it.

Reversing Valve Operation

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

To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of compressors. See *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 staging of the compressors.

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

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 CMP TOTL = 0, the application does not control COMPRESSOR 1.

If CMP TOTL ≥ 1, the application controls COMPRESSOR 1 as follows:

- If the loop that is currently active (either CLG LOOPOUT or HTG LOOPOUT), is greater than CMP1 ON and the first compressor has been OFF for at least the time set in CMP1 MIN OFF, COMPRESSOR 1 is turned ON.
- COMPRESSOR 1 is turned OFF when the loop that is currently active is less than CMP1 OFF provided the following conditions have been met:
  - The first compressor has been ON for at least the time set in CMP1 MIN ON.
  - EHEAT3.CMP2 is OFF for more than 30 seconds. If the heat pump is not equipped with the second compressor, this is not applicable.

  - EHEAT2.CMP3 is OFF. If the heat pump is not equipped with the third compressor, this is not applicable.

If CMP TOTL = 1, the application does not control EHEAT3.CMP2.

If CMP TOTL = 2, the application controls EHEAT3.CMP2 as follows:

- EHEAT3.CMP2 is turned ON when the loop that is currently active is greater than CMP2 ON provided that the following conditions have been met:
  - The second compressor has been OFF for at least the time set in CMP2 MIN OFF.
  - The first compressor has been ON for at least 30 seconds to lessen the demand of having more than one compressor start at once.
- EHEAT3.CMP2 is turned OFF when the loop that is currently active is less than CMP2 OFF provided that the following conditions have been met:
  - The second compressor has been ON for at least the time set in CMP2 MIN ON.
  - EHEAT2.CMP3 is OFF for more than 30 seconds. If the heat pump is not equipped with the third compressor, this is not applicable.

If CMP TOTL = 2, the application does not control EHEAT2.CMP3.

If CMP TOTL = 3, the application controls EHEAT2.CMP3 as follows:

- EHEAT2.CMP3 is turned ON when the loop that is currently active is greater than CMP3 ON provided that the following conditions have been met:
  - The third compressor has been OFF for at least the time set in CMP3 MIN OFF.
  - The first compressor has been ON for at least 30 seconds to lessen the demand of having more than one compressor start at once.
  - The second compressor has been ON for at least 30 seconds to lessen the demand of having more than one compressor start at once.
- EHEAT2.CMP3 is turned OFF when the loop that is currently active is less than CMP3 OFF provided that the following conditions have been met:
  - The third compressor has been ON for at least the time set in CMP3 MIN ON.

Electric Heat (optional)

If no stages of electric heat are being used (EHTG STG CNT = 0), this control is omitted.

In this section, EHEAT3.CMP2 and EHEAT2.CMP3 refer to the stages of electric heat.

If at least one stage of electric heat is being used (EHTG STG CNT > 0), and either HEAT.COOL or REV VALVE = COOL, all stages of electric heat are OFF.

When at least one stage of electric heat is being used and both HEAT.COOL and REV VALVE = HEAT, the electric heat is controlled as follows:

- If EHTG STG CNT ≥ 1 and HTG LOOPOUT > EHEAT 1 ON, the first stage of electric heat, ELEC HEAT 1, is turned ON.
- If EHTG STG CNT ≥ 2 and HTG LOOPOUT > EHEAT 2 ON, the second stage of electric heat, EHEAT2.CMP3, is turned ON.
- If EHTG STG CNT ≥ 2 and HTG LOOPOUT < EHEAT 1 ON, EHEAT2.CMP3 is turned OFF.
- If EHTG STG CNT = 3 and HTG LOOPOUT > EHEAT 3 ON, the third stage of electric heat, EHEAT3.CMP2 is turned ON.
- If EHTG STG CNT = 3 and HTG LOOPOUT < EHEAT 2 ON, EHEAT3.CMP2 is turned OFF.
- The first stage of electric heat will turn OFF differently depending on the number of compressors being used:
  - If HTG LOOPOUT < CMP1 ON and CMP TOTL = 0 or 1, ELEC HEAT 1 is turned OFF.
  - If HTG LOOPOUT < CMP2 ON and CMP TOTL = 2, ELEC HEAT 1 is turned OFF.
  - If HTG LOOPOUT < CMP3 ON and CMP TOTL = 3, ELEC HEAT 1 is turned OFF.

Fan Operation

To prevent damage to the heat pump, the default setting of HP DO OVRD does not allow operator command of the fan. See *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 at least one of the following two conditions has been met:

1. Free cooling is being provided by the mixed air control loop.
2. At least one compressor or stage of electric heat is ON.

The fan will turn OFF only after the following two conditions have been met:

1. Free cooling is not being provided by the mixed air control loop.
2. All compressors and stages of electric heat have been OFF for at least 30 seconds.

Damper Status Operation (optional)

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 and the fan is kept OFF. 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.

Centralized Alarm Monitoring

DI 6 can be used to monitor an input that changes state when the heat pump is in alarm. DI 6 can be unbundled to send alarm information to the field panel for centralized alarm monitoring.

Overriding Critical Heat Pump DOs

This application includes a setup point that enables or disables ON and OFF commands to critical DOs. Specifically, the fan, reversing valve, and compressor(s) cannot be directly commanded ON or OFF unless the point HP DO OVRD is set to ENABLE. When HP DO OVRD is set to DISABL, commands to the fan, reversing valve and compressor DO points are ignored regardless of BACnet command priority. Commands to electric heat DOs and any spare DOs are always allowed. Physical points DO1 and DO2 can never be overridden when configured for motor control. However, the position of the attached motor is always commandable via the DMPR COMD point.

CAUTION:

HP DO OVRD should be set to ENABLE only when there is a complete understanding of the consequences. Since the direct control will override the applications minimum on and off time safeties, improper use of the DO commands can cause permanent equipment damage. Also, during normal daily operation, the override of critical DOs should only be done via a BACnet command. If a digital output is overridden via the MMI port, the point may be left in an incorrect internal state upon release. If during commissioning an override command must be issued via the MMI port, it is critical that the point be manually commanded off before the point is released.

Fail-safe Operation

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

Application Notes

1. If the heat pump cycles excessively, 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.

2. Running the mixed air loop during night mode can increase energy savings by taking advantage of free cooling at night to pre-cool the building in time for day mode. This can lessen the need to use mechanical cooling during day mode. Pre-cooling the building this way can also improve the indoor air quality because this type of cooling is accomplished with fresh air.

   Some field panel involvement is necessary to pre-cool the building with this application. For instance, the field panel needs to adjust the night cooling setpoint downward whenever the outside can be used for free cooling at night. This would require unbundling FREE CLG and CTL STPT.

3. In this application the maximum configurations are as follows:

   - The maximum of CMP TOTL = 3.
   - The maximum of EHTG STG CNT = 3.
   - The maximum of CMP TOTL + EHTG STG CNT = 4.

   If these limits are exceeded, CMP TOTL will be set to 0 and EHTG STG CNT will be set to 0. These points will remain at 0 until they are set correctly. (This prevents the application from trying to use the same DO as both a compressor and a stage of electric heat.)

4. Rev string BK22 makes it possible to upgrade/flash the controller using Series 1000, 2000, or 3000 stats as a pass through to the controller. In other words you do not have to connect to the controller directly.

Wiring Diagram

The point wiring for Application 2893 is shown in Figure 5.

CAUTION:

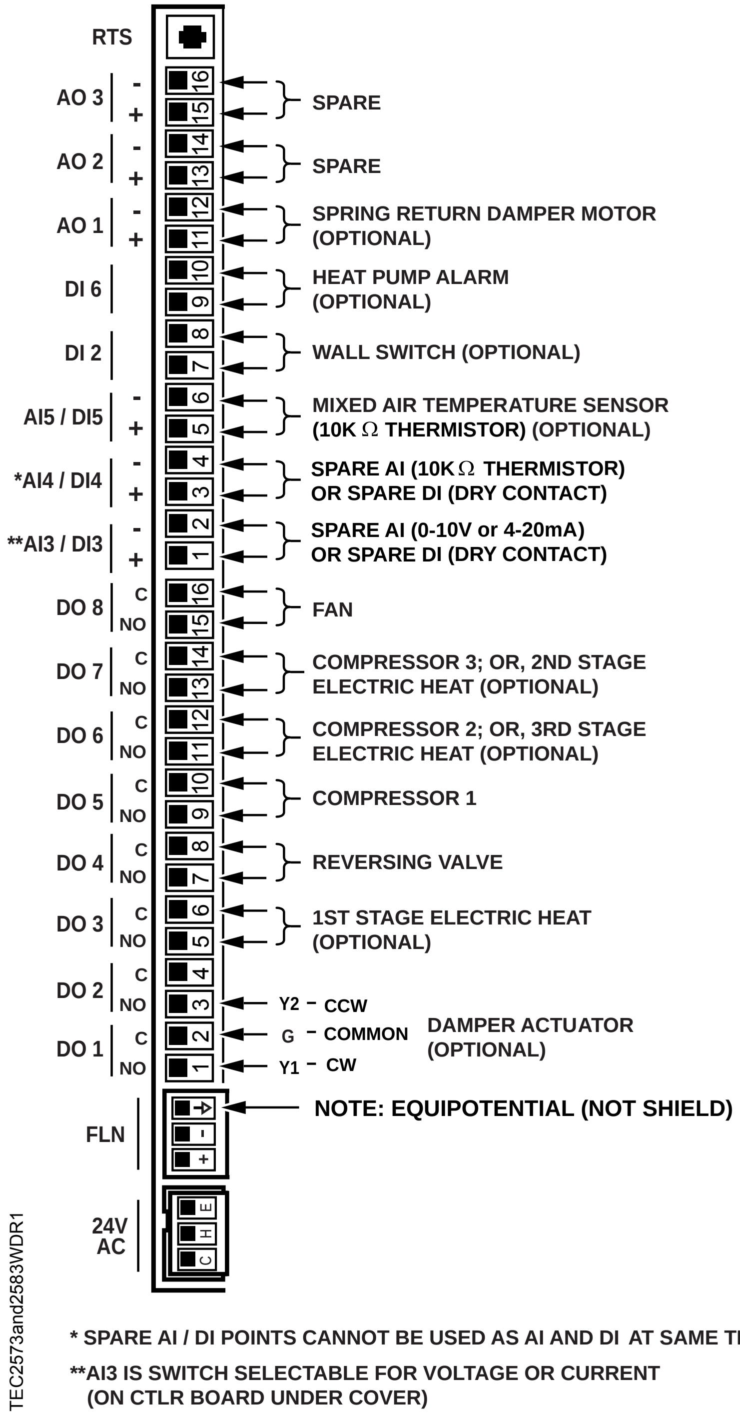
The controller’s DOs control 24 Vac loads only. The maximum rating is 12 VA for each DO. Use an interposing 220V 4-relay module for any of the following:

• VA requirements higher than the maximum

• 110 or 220 Vac requirements

• DC power requirements

• Separate transformers used to power the load.



* SPARE AI / DI POINTS CANNOT BE USED AS AI AND DI AT SAME TIME

**AI3 IS SWITCH SELECTABLE FOR VOLTAGE OR CURRENT (ON CTLR BOARD UNDER COVER)

Figure 5. Application 2893.

Table 3. Point Database for Application 2893.

Object Type[a]	Object Instance (Point Number)[b]	Object Name and Description	Factory Default (SI Units)[c]	Eng Units (SI Units)[c]	Range	Active Text	Inactive Text
AO	1	CTLR ADDRESS	99	–	0 - 254	–	–
AO	2	APPLICATION	2849	–	2849, 2893 and 2894	–	–
AO	3	RETURN DELAY	10	MIN	0 to 255	–	–
AI	{04}[d]	ROOM TEMP	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
BO	{05}	HEAT.COOL	COOL	–	Binary	HEAT	COOL
AO	6	DAY CLG STPT	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	7	DAY HTG STPT	70.0 (21.21)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	8	NGT CLG STPT	82.0 (27.93)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	9	NGT HTG STPT	65.0 (18.41)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	10	DMPR MIN POS	14.8	PCT	0.0 to 102.0	–	–
AO	11	RM STPT MIN	55.0 (12.81)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	12	RM STPT MAX	90.0 (32.41)	DEG F (DEG C)	48.0 to 111.75	–	–
AI	{13}	RM STPT DIAL	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
BO	14	STPT DIAL	NO	–	Binary	YES	NO
AI	{15}	MA TEMP	74.0 (23.496)	DEG F (DEG C)	37.5 to 165.0	–	–
AO	16	CMP2 ON	70	PCT	0.0 to 102.0	–	–
AO	17	CMP2 OFF	50	PCT	0.0 to 102.0	–	–
BO	18	WALL SWITCH	NO	–	Binary	YES	NO
BI	{19}	DI OVRD SW	OFF	–	Binary	ON	OFF
AO	20	OVRD TIME	0	HRS	0 to 255	–	–
BO	{21}	NGT OVRD	NIGHT	–	Binary	NIGHT	DAY
AO	22	RMTMP OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75 to 32.0	–	–

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Table 3. Point Database for Application 2893. *(continued)*

Object Type[a]	Object Instance (Point Number)[b]	Object Name and Description	Factory Default (SI Units)[c]	Eng Units (SI Units)[c]	Range	Active Text	Inactive Text
BO	{23}	FREE CLG	DISABL	–	Binary	ENABLE	DISABL
BI	{24}	DI 2	OFF	–	Binary	ON	OFF
BI	{25}	DI 5	OFF	–	Binary	ON	OFF
BI	{26}	DI 6	OFF	–	Binary	ON	OFF
AO	27	CMP2 MIN OFF	3	MIN	0 to 255	–	–
AO	28	CMP2 MIN ON	3	MIN	0 to 255	–	–
BO	{29}	DAY.NGT	DAY	–	Binary	NIGHT	DAY
AO	34	CMP3 ON	90	PCT	0.0 to 102.0	–	–
AO	35	CMP3 OFF	70	PCT	0.0 to 102.0	–	–
AO	36	CMP3 MIN OFF	3	MIN	0 to 255	–	–
AO	37	CMP3 MIN ON	3	MIN	0 to 255	–	–
BO	38	DAMPER TYPE	FLOAT	–	Binary	SPRING	FLOAT
AO	39	AO DIR.REV	0	–	0 to 255	–	–
AO	{40}	AOV1	0	VOLTS	0.0 to 10.23	–	–
BO	{41}	DO 1	OFF	–	Binary	ON	OFF
BO	{42}	DO 2	OFF	–	Binary	ON	OFF
BO	{43}	ELEC HEAT 1	OFF	–	Binary	ON	OFF
BO	{44}	REV VALVE	COOL	–	Binary	HEAT	COOL
BO	{45}	COMPRESSOR 1	OFF	–	Binary	ON	OFF
BO	{46}	EHEAT3.CMP2	OFF	–	Binary	ON	OFF
BO	{47}	EHEAT2.CMP3	OFF	–	Binary	ON	OFF
AO	{48}	DMPR COMD	0	PCT	0.0 to 102.0	–	–
AO	{49}	DMPR POS	0	PCT	0.0 to 102.0	–	–
BO	{50}	FAN	OFF	–	Binary	ON	OFF
AO	51	MTR TIMING	130	SEC	0 to 511	–	–
AI	{52}	AI 3	0.0	PCT.	0.0 to 102.0	–	–
AI	{53}	AI 4	74.0 (23.496)	DEG F (DEG C)	37.5 to 165.0	–	–
AO	{54}	AOV2	0	VOLTS	0.0 to 10.23	–	–

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Table 3. Point Database for Application 2893. *(continued)*

Object Type[a]	Object Instance (Point Number)[b]	Object Name and Description	Factory Default (SI Units)[c]	Eng Units (SI Units)[c]	Range	Active Text	Inactive Text
BI	{55}	DI 3	OFF	–	Binary	ON	OFF
AO	56	DMPR ROT ANG	90	–	0 to 255	–	–
BI	{57}	DI 4	OFF	–	Binary	ON	OFF
AO	58	MTR SETUP	0	–	0 to 255	–	–
AO	59	DO DIR.REV	0	–	0 to 255	–	–
BO	60	CYCLE FAN	NO	–	Binary	YES	NO
AO	61	FREE CLG ON	30	PCT	0.0 to 102.0	–	–
AO	62	FREE CLG OFF	10	PCT	0.0 to 102.0	–	–
AO	63	CLG P GAIN	10.0 (18.0)	–	0.0 to 63.75	–	–
AO	64	CLG I GAIN	0.01 (0.018)	–	0.0 to 1.023	–	–
AO	65	STPT SPAN	4.0	DEG F	0 to 63.75	–	–
BO	66	STAT TYPE	NORMAL	–	Binary	OFFSET	NORMAL
AO	67	HTG P GAIN	10.0 (18.0)	–	0.0 to 63.75	–	–
AO	68	HTG I GAIN	0.01 (0.018)	–	0.0 to 1.023	–	–
BO	69	HP DO OVRD	DISABL	–	Binary	ENABLE	DISABL
AO	{70}	STPT OFFSET	0	DEG F	-31.75 to +32.0	–	–
AO	{71}	MA P GAIN	5.0 (9.0)	–	0.0 to 63.75	–	–
AO	{72}	MA I GAIN	0.024 (0.0432)	–	0.0 to 1.023	–	–
AO	{73}	MA D GAIN	0 (0.0)	–	0 to 510	–	–
AO	{74}	MA BIAS	0	PCT	0.0 to 102.0	–	–
AO	75	CMP TOTL	1	–	0 to 255	–	–
AO	76	EHTG STG CNT	1	–	0 to 255	–	–
AI	{78}	CTL TEMP	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	{79}	CLG LOOPOUT	0	PCT	0.0 to 102.0	–	–
AO	{80}	HTG LOOPOUT	0	PCT	0.0 to 102.0	–	–
AO	81	EHEAT 1 ON	90	PCT	0.0 to 102.0	–	–
AO	82	CMP1 ON	50	PCT	0.0 to 102.0	–	–

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Table 3. Point Database for Application 2893. ***(continued)***

Object Type[a]	Object Instance (Point Number)[b]	Object Name and Description	Factory Default (SI Units)[c]	Eng Units (SI Units)[c]	Range	Active Text	Inactive Text
AO	83	CMP1 OFF	30	PCT	0.0 to 102.0	–	–
AO	84	RVAL SWITCH	30	PCT	0.0 to 102.0	–	–
AO	85	SWITCH LIMIT	4.8	PCT	0.0 to 102.0	–	–
AO	86	SWITCH TIME	10	MIN	0 to 255	–	–
AO	87	CMP1 MIN OFF	3	MIN	0 to 255	–	–
AO	88	CMP1 MIN ON	3	MIN	0 to 255	–	–
AO	89	RVAL SW TIME	30	SEC	0 to 255	–	–
AO	90	SWITCH DBAND	2.0 (1.12)	DEG F (DEG C)	0.0 to 63.75	–	–
BO	{91}	NGT MA CTL	NO	–	Binary	YES	NO
AI	{92}	CTL STPT	74.0 (23.45)	DEG F (DEG C)	48.0 to 111.75	–	–
AO	{93}	MA SETPT	55.0 (12.856)	DEG F (DEG C)	37.5 to 165.0	–	–
AO	94	EHEAT 2 ON	94.8	PCT	0.0 to 102.0	–	–
AO	95	EHEAT 3 ON	98	PCT	0.0 to 102.0	–	–
AO	96	CAL TIMER	12	HRS	0 to 255	–	–
AO	{97}	AOV3	0	VOLTS	0.0 to 10.23	–	–
AO	98	LOOP TIME	5	SEC	0 to 255	–	–
AO	{99}	ERROR STATUS	0	–	0 to 255	–	–
AO	102	CLG D GAIN	24 (43.2)	–	0 to 510	–	–
AO	103	CLG BIAS	50	PCT	0.0 to 102.0	–	–
AO	104	HTG D GAIN	24 (43.2)	–	0 to 510	–	–
AO	105	HTG BIAS	50	PCT	0.0 to 102.0	–	–
AO	124	AI 4 OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75- 32	–	–

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Table 3. Point Database for Application 2893. ***(continued)***

Object Type[a]	Object Instance (Point Number)[b]	Object Name and Description	Factory Default (SI Units)[c]	Eng Units (SI Units)[c]	Range	Active Text	Inactive Text
AO	125	AI 5 OFFSET	0.0 (0.0)	DEG F (DEG C)	-31.75- 32	–	–
AO	126	STAT SUPV	0	–	0- 255	–	–
AI	{127}	RM RH	50	PCT	0- 102	–	–

[a] Object Types are; Analog Input (AI), Analog Output (AO), Binary Input (BI) and Binary Output (BO).

[b] Points not listed are not used in this application.

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

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