REQUIRED CONTROL SETUP

Jumper Settings

The jumper settings on the new control board must be set at the time of installation to insure proper system operation. It is easiest to set the jumpers before actual installation of the control board, but it is also possible after the control board is installed in the control box.

1. If hot heat pump configuration is desired, change HOT HEAT PUMP jumper to ON position. This is described in more detail under the Heating Operation section.
2. If installation includes a fossil fuel furnace, change FFUEL jumper to ON position. This is described in more detail under the Fossil Fuel Jumper section.
3. Set low temperature cutout (LTCO) and balance point (BP) jumpers as desired. This is described in more detail under the LTCO and BP paragraph.
4. Set defrost curve jumper, as shown below and in Table 1. Defrost curves are described in more detail under the Defrost Operation section.

Jumper Inputs

The control uses seven jumpers to determine how the heat pump should operate. These jumpers are shown in Figures 1 & 3. The jumpers that affect this heat pump are the following. The effects of these jumper settings on the operation of the heat pump are described in other sections of this document.

- LTCO – Low Temperature Cutout
- BP – Balance Point
- Defrost Curve
- FFUEL – Specifies fossil fuel furnace application
- HOT HEAT PUMP – Enables indoor airflow control for hot heat pump application

The two jumpers that do not affect the operation of this heat pump are Y2 LOCK and SWITCH POINT. Both of these jumpers apply only to two-stage compressor units.

The control only reads the jumper inputs when the Y1, Y2, and W thermostat inputs are de-energized. If a jumper position is changed while any of these inputs are energized, the control will not act upon the jumper changes until all three of these thermostat calls are de-energized or power (24 VAC) to the control is cycled.

IMPORTANT: Changes to the jumper inputs do not take affect until Y1, Y2, and W thermostat signals are de-energized.

Defrost Curves

The control uses a set of defrost curve parameters that are selected using the defrost curve selection jumper. The location of the defrost curve selection jumper is shown in Figures 1 & 3. Table 1 shows the jumper position that is appropriate for each heat pump model. Jumper positions 4, 5, and 6 are not used and the control will not allow the compressor to operate when the jumper is in any of these positions.

Defrost Curve Selection

The control will also not energize the compressor if the defrost curve selection jumper is in a numbered position that is not described in Table 1 or if the defrost curve selection jumper is missing. The control will display the proper fault code when a defrost curve jumper error is present.

IMPORTANT: The control will lock out the compressor if the defrost curve selection jumper is not properly set.

TABLE 1: Defrost Initiate Curves

<table>
<thead>
<tr>
<th>Defrost Curve Selection Jumper Position</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump Model</td>
<td>2-ton</td>
<td>4-ton</td>
<td>3-ton</td>
</tr>
<tr>
<td></td>
<td>2.5-ton</td>
<td>5-ton</td>
<td>3.5 ton</td>
</tr>
</tbody>
</table>
**INSTALLATION**

1. Disconnect power to the unit.
2. Remove control access panel.
3. Remove the old control board.
4. Locate the correct position of the control board, part number 031-01996-000, as shown in Figure 2.
5. Attach the control board to the control box with the existing screws, after appropriate jumpers are set.
6. Wire control board as shown in Figures 6 & 7.
7. Verify proper system functionality. Confirm room thermostat operation including fault code display capability.
8. Upon completion of installation, verify that no fault codes are stored in memory. Clear the fault code memory if necessary, as described later in this document.

**ANTI-SHORT CYCLE DELAY**

The control includes a five-minute anti-short cycle delay (ASCD) timer to prevent the compressor from short cycling after a power or thermostat signal interruption. The ASCD timer is applied when the control is first powered from the indoor unit thermostat and immediately following the completion of a compressor run cycle. The compressor and the outdoor fan will not operate during the five minutes that the timer is active.

The ASCD timer can be bypassed by connecting the TEST terminals for three seconds while the thermostat is calling for compressor operation (Y1 input signal energized).

**LOW VOLTAGE DETECTION**

The control monitors the transformer secondary (24 VAC) voltage and provides low voltage protection for the heat pump and its components. In particular, the control prevents contactor chatter during low voltage conditions. If the voltage drops below approximately 19 VAC, the control will continue to energize any relays that are already energized but will not energize any additional relays until the voltage level increases. If the voltage drops below approximately 16 VAC, the control will immediately de-energize the relay outputs and will not energize any relays until the voltage level increases. The control will store and display the appropriate fault codes when low voltage conditions occur.

**CRANKCASE HEATER**

The control energizes the crankcase heater terminal (CCH) whenever line voltage is applied to the control and the outdoor fan is not on. If the compressor is equipped with a crankcase heater, it will be energized from the CCH terminal of the control.

**TEST INPUT**

The control includes a TEST input connector that can be used for various testing functions during installation and service. The TEST input connector is shown in Figures 1 & 3. The following table summarizes the behavior of the control when the two TEST pins are connected.
LED DIAGNOSTIC INDICATORS

The control includes two LED’s that display various types of diagnostic information. LED1 is red and LED2 is green. The location of the LED’s is shown in Figures 1 & 3. These LED’s are used to display operational mode, status, and fault information.

OPERATIONAL MODE DETECTION

The control can be used in a variety of applications including heat pumps and air conditioners with modulating compressors. The control uses various inputs to determine the proper mode of operation.

It looks for the presence of a reversing valve connected to the RV and RVG terminals to determine if it should operate as a heat pump or an air conditioner. If the reversing valve is not connected, the control will not operate in the heat pump mode. The control senses the reversing valve loads and determines the operational mode each time power to the control is cycled.

The control also senses the connections that are made to the M, M1, and M2 terminals and determines the correct operational mode for the control. This is done each time power to the control is cycled. Therefore, it is important that no loads be attached to the M1 or M2 terminals of the control. Incorrect system behavior could result.

IMPORTANT: Do not connect any loads to the M1 or M2 terminals of the control. Incorrect system behavior could result.

OPERATIONAL MODE DISPLAY

The control will display its active operational mode using the onboard LED’s when the TEST pins are connected while no thermostat signals are energized. See Table 3. The control will display the operational mode as long as the TEST pins are shorted and no thermostat signals are energized. When the TEST pin short is removed, the control will return to normal LED displays. The X/L output will not be energized while the operational mode is displayed.

<table>
<thead>
<tr>
<th>Duration of connection (seconds)</th>
<th>Control behavior with no thermostat signals present</th>
<th>Control behavior with thermostat signals present</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>No response</td>
<td>No response</td>
</tr>
<tr>
<td>2-6</td>
<td>Display operational mode</td>
<td>Bypass ASCD. If Y1 is present and high-pressure switch is closed, contactors will be energized.</td>
</tr>
<tr>
<td></td>
<td>Clear soft lockout</td>
<td>Clear soft lockout</td>
</tr>
<tr>
<td></td>
<td>Clear hard lockout</td>
<td>Clear hard lockout</td>
</tr>
<tr>
<td>&gt; 6</td>
<td>Display operational mode</td>
<td>Initiate defrost cycle ignoring the liquid line and outdoor ambient temp.</td>
</tr>
<tr>
<td>Connection removed</td>
<td>Resume normal LED display</td>
<td>Terminate defrost as normal or until O signal is energized.</td>
</tr>
<tr>
<td>Connection not removed</td>
<td>Display operational mode</td>
<td>Continue defrost cycle until TEST connection removed.</td>
</tr>
</tbody>
</table>

TABLE 3: Operational Mode Display

<table>
<thead>
<tr>
<th>Operational Mode</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Pump</td>
<td>---</td>
<td>ON</td>
</tr>
<tr>
<td>Air Conditioner</td>
<td>---</td>
<td>OFF</td>
</tr>
<tr>
<td>Single-Stage Compressor</td>
<td>1</td>
<td>---</td>
</tr>
<tr>
<td>Reciprocating Two-Stage Compressor</td>
<td>2</td>
<td>---</td>
</tr>
<tr>
<td>Scroll Two-Stage Compressor</td>
<td>3</td>
<td>---</td>
</tr>
</tbody>
</table>

If the control displays an operational mode other than LED2 (Green) ON and LED1 (Red) 1 flash indicating a heat pump with a single stage compressor, an error condition exists. Check all wiring of the reversing valve (RV and RVG terminals) and compressor outputs (M, M1, and M2 terminals). Cycle 24 VAC power to the control and check the operational mode again.

STATUS MODE DISPLAY

The control also provides status codes using the LED’s. Status codes indicate the state of operation of the unit but do not represent a fault. During the following conditions, the control will not energize the X/L output. Table 4 describes the LED displays during status codes. Status codes will not be displayed when a fault code is present.

During the following conditions, the control will not energize the X/L output.

<table>
<thead>
<tr>
<th>Description</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No power to control</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>First-stage compressor operation – not applicable to single stage compressor</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>Second-stage or full capacity compressor operation</td>
<td>ON</td>
<td>ON</td>
</tr>
<tr>
<td>Control normal operation – no call for compressor</td>
<td>OFF</td>
<td>2s ON 2s OFF</td>
</tr>
<tr>
<td>No fault codes in memory – Initiated by LAST ERROR pushbutton</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Fault code memory cleared – Initiated by LAST ERROR pushbutton</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

TABLE 4: Status Code Display
FAULT CODE DISPLAY
X/L Output
The X/L terminal of the heat pump control is typically connected to the X/L input of the room thermostat. The thermostat uses this signal to notify the homeowner of a problem with the heat pump using an LED or LCD display. When the control energizes the X/L terminal, the thermostat displays the flash code so the homeowner can see it.

The heat pump control informs the homeowner of the type of condition that is present using flash codes. Table 5 shows the condition categories and the corresponding X/L flash codes.

The control will continue to energize the X/L output for fault codes having an X/L code of 4 flashes even after the thermostat calls are removed. The control does this to notify the installer or homeowner that a significant problem with the wiring or system configuration is present and needs to be corrected.

The control will continue to energize the X/L output until the condition that caused the fault condition no longer exists.

<table>
<thead>
<tr>
<th>Condition Category</th>
<th>X/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Lockout – Reset with interruption of thermostat call following correction of fault condition</td>
<td>2 flashes</td>
</tr>
<tr>
<td>Hard Lockout – Reset by cycling power to system</td>
<td>3 flashes</td>
</tr>
<tr>
<td>Wiring, sensor or control setting related error</td>
<td>4 flashes</td>
</tr>
</tbody>
</table>

LED Display
The control will display any fault code that is currently active using the LED's. The control will display the fault code, pause two seconds, and display the fault again. The control will continue the fault code display until the condition that caused the fault code no longer exists. If multiple fault codes are present at the same time, the control will display only the most recent fault. The other active errors may be accessed from memory using the LAST ERROR pushbutton.

Operational Fault Codes
Table 6 shows the operational faults that the control can detect. The control displays this type of error by flashing LED1 (Red) only. LED1 (Green) is not energized. These faults typically occur when the heat pump has been operating and a problem occurs.

<table>
<thead>
<tr>
<th>Description</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
<th>X/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Faults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control Failure that still allows fault code output</td>
<td>ON</td>
<td>OFF</td>
<td>4 if possible</td>
</tr>
<tr>
<td>High-pressure switch fault (not in lockout yet)</td>
<td>1</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>High-pressure switch lockout (last mode of operation was heat pump)</td>
<td>2</td>
<td>OFF</td>
<td>2 (soft) 3 (hard)</td>
</tr>
<tr>
<td>High-pressure switch lockout (last mode of operation was defrost)</td>
<td>3</td>
<td>OFF</td>
<td>2 (soft) 3 (hard)</td>
</tr>
<tr>
<td>Low-pressure switch lockout</td>
<td>4</td>
<td>OFF</td>
<td>2 (soft) 3 (hard)</td>
</tr>
<tr>
<td>Low Voltage (&lt; 19 VAC) preventing further relay outputs</td>
<td>5</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Low Voltage (&lt; 16 VAC) stopped current relay outputs</td>
<td>6</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>Pipe Freeze Protection Timer expiration</td>
<td>7</td>
<td>OFF</td>
<td>4</td>
</tr>
</tbody>
</table>

Sensor or Switch Fault Codes
Table 7 shows the faults that the control can detect when a problem is present with a sensor or switch. The control displays this type of error by energizing LED1 (Red) constantly and flashing LED2 (Green). These faults typically occur when the heat pump has been operating and a problem occurs with a sensor or its wiring. These faults could also occur during installation as the heat pump is configured.

<table>
<thead>
<tr>
<th>Description</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
<th>X/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Required Sensor or Switch Faults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor ambient sensor failure (short)</td>
<td>ON</td>
<td>1</td>
<td>2 (soft)</td>
</tr>
<tr>
<td>Outdoor ambient sensor failure (open)</td>
<td>ON</td>
<td>2</td>
<td>2 (soft)</td>
</tr>
<tr>
<td>Liquid line sensor failure (short)</td>
<td>ON</td>
<td>3</td>
<td>2 (soft)</td>
</tr>
<tr>
<td>Liquid line sensor failure (open)</td>
<td>ON</td>
<td>4</td>
<td>2 (soft)</td>
</tr>
</tbody>
</table>

Optional Discharge Line Sensor Faults

<table>
<thead>
<tr>
<th>Description</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
<th>X/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>High discharge line temperature</td>
<td>ON</td>
<td>5</td>
<td>2 (soft) 3 (hard)</td>
</tr>
<tr>
<td>Low discharge line temperature</td>
<td>ON</td>
<td>6</td>
<td>2 (soft) 3 (hard)</td>
</tr>
</tbody>
</table>

Optional Bonnet Sensor Faults

<table>
<thead>
<tr>
<th>Description</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
<th>X/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonnet sensor failure (short)</td>
<td>ON</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Fossil Fuel Mode setting error (FFUEL jumper in OFF position but bonnet sensor present)</td>
<td>ON</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
Wiring Related Fault Codes
Table 8 shows the faults that the control can detect when a problem is present with the system wiring or jumper configurations. The control displays this type of error by flashing LED1 (Red) and energizing LED2 (Green) constantly. These faults typically occur when the heat pump is first installed or when a system component such as the room thermostat or indoor unit is replaced or rewired.

**TABLE 8: Wiring Related Fault Codes**

<table>
<thead>
<tr>
<th>Description</th>
<th>LED1 (Red)</th>
<th>LED2 (Green)</th>
<th>X/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiring Related Faults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressor Contactor Miswire</td>
<td>1</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>Y2 present without Y1</td>
<td>2</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>Y1 and W present without Y2 in two stage mode</td>
<td>3</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>O signal received in AC mode</td>
<td>4</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>W signal received in AC mode</td>
<td>5</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>W and O signal received in AC mode</td>
<td>6</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>W and O signal received in HP mode</td>
<td>7</td>
<td>ON</td>
<td>4</td>
</tr>
<tr>
<td>Defrost Curve Jumper Error (Invalid jumper setting preventing compressor operation)</td>
<td>8</td>
<td>ON</td>
<td>4</td>
</tr>
</tbody>
</table>

**FAULT CODE MEMORY**

Displaying Stored Fault Codes
The control will store up to five fault codes in memory. If more than five faults occur, the five most recent fault codes will remain in memory. The stored faults can be displayed by depressing the LAST ERROR pushbutton for one to five seconds while no thermostat inputs to the control are energized. See Figures 1 & 3 for the location of the pushbutton. Since some room thermostats energize the O signal even when not calling for compressor operation, turn the room thermostat to the SYSTEM OFF setting when displaying fault codes.

When the LAST ERROR pushbutton is depressed and released, the control will display the stored fault codes beginning with the most recent. The control will display the most recent fault code, pause two seconds, and display the next fault code. The control will display the stored error codes and then return to the normal LED status display mode. The stored fault codes can be displayed again by depressing the pushbutton again. When the control displays the fault codes with the onboard LED's, it will also energize the X/L output with the corresponding flash code. The X/L output signal can be observed at the room thermostat or at the control using a 24VAC LED test device connected to the X/L terminal.

If the control has no fault codes stored in memory, it will flash both LED's twice simultaneously. If a thermostat signal is energized while the control is displaying the stored error codes, the control will stop displaying the stored error codes and resume normal operation.

Clearing Fault Code Memory
Once the stored fault codes have been displayed and recorded, the installer should clear the stored fault codes from the control's memory. This practice will enable better troubleshooting and diagnosis of system problems. If the stored fault codes are not cleared after the cause of the problem has been resolved, a service technician doing a later service call may not know that the fault codes in the memory were caused by a problem that has already been fixed. The technician may waste time trying to fix a condition that no longer exists. Therefore, it is very important to always clear the fault code memory after the unit is installed and running properly following a service call.

**IMPORTANT:** Always clear the fault code memory after resolving the condition that caused the fault code.

To clear the fault code memory, depress the LAST ERROR pushbutton for longer than 5 seconds. The control will flash both LED's three times to indicate that the memory has been cleared. To confirm that the memory has been cleared, depress the LAST ERROR pushbutton for one to five seconds. The control will flash both LED's twice to indicate that no faults are stored in memory.

**LOCKOUT MODES**

Soft Lockout
The control will cause a soft lockout during the following conditions. Detailed descriptions of the conditions required for the control to enter the soft lockout mode are contained in other sections of this document.

1. High-pressure switch
   a. Two openings within six hours
2. Low-pressure switch
   a. One opening of the switch for more than five seconds except under certain conditions.
3. High discharge temperature (with optional discharge sensor)
   a. Temperature reading exceeds 263F
4. Low discharge temperature (with optional discharge sensor)
   a. Temperature reading does not reach 90F following timer expiration under certain conditions.

During the soft lockout mode, the control will do the following.

1. De-energize the compressor
2. If in heating mode, the control will energize auxiliary heat as if the outdoor ambient temperature was below the LTCO setting.
3. Energize the LED and X/L outputs with the appropriate flash codes
4. Store the appropriate fault code in memory.

The control will reset the soft lockout condition when any of the following occur following removal of the fault condition.

1. Power is cycled to the R or Y1 inputs of the control. This will cause the soft lockout condition to be reset when the thermostat is satisfied or when the thermostat is set to SYSTEM OFF and back to HEAT or COOL mode.
2. The TEST terminals are shorted for more than two seconds.
When the soft lockout condition is reset, the control will stop displaying the fault code and will respond to thermostat inputs normally.

**Hard Lockout**
If four soft lockouts occur within a twelve-hour period, the control shall cause a hard lockout condition. These soft lockouts can be caused by the same or different conditions. The control will function in the same way during soft and hard lockout conditions. The difference is in the requirements for resetting the lockout condition. The control will reset the hard lockout condition when any of the following occur following removal of the fault condition.
1. Power is removed from the R input of the control.
2. The TEST terminals are shorted for more than two seconds.
A hard lockout condition will not be reset when the thermostat is satisfied or when the thermostat is set to SYSTEM OFF and back to HEAT or COOL mode. Power (24 VAC) to the control must be removed and reapplied.
When the hard lockout condition is reset, the control will de-energize the LED and X/L outputs and respond to thermostat inputs normally.

**Wiring or Setting Related Lockouts**
The control will not operate the compressor when the following faults occur. These faults can be reset using the same methods used to reset a soft lockout. However, two occurrences of these faults will not cause a hard lockout condition.
1. Presence of Y2 thermostat signal without Y1.
2. Shorted discharge sensor input
3. Shorted bonnet sensor
4. Shorted or open liquid line or outdoor ambient sensor
5. Defrost curve jumper error
If a compressor wiring error is detected, the control will not operate the compressor. Once the compressor wiring error has been detected, power (24 VAC) must be cycled to the control for the control to sense the wiring change and clear the lockout condition.

**DEFROST OPERATION**

**General**
The control maintains proper airflow through the outdoor coil during heating operation by melting frost and ice that may form on the coil. Frost may accumulate unevenly in different sections of the coil because of the arrangement of the refrigeration circuit within the coil. The control may initiate a defrost cycle even when the coil is not completely covered with frost. This is normal operation.
The control regulates the defrost operation of the heat pump based on accumulated compressor run time, outdoor coil temperature, and outdoor ambient temperature. The control will cause the unit to operate in the normal heating mode until it determines that a defrost cycle is needed.
All defrost timings are based on accumulated compressor run time.

**Operation**
The defrost mode is equivalent to the cooling mode except that the outdoor fan motor is de-energized. The control shall do the following to initiate a defrost cycle.
- De-energize the outdoor fan
- Energize the crankcase heater
- Energize the reversing valve
- Energize the auxiliary heat outputs based on the system configuration
- Energize Y2 Out terminal if not already energized
- Begin the maximum defrost cycle length timer

If the call for heating (Y1) is removed from the control during the defrost cycle, it will terminate the defrost cycle and de-energize the compressor. The control will also stop the defrost cycle length timer but not reset it. When the control receives another call for heating, it will restart the defrost cycle and the timer at the point at which the call for heating was removed. This will happen only if the liquid line temperature conditions allow defrost to occur.

**Defrost Cycle Initiation**
The control will allow the heat pump to operate in the heating mode until the combination of outdoor ambient and outdoor coil temperatures indicate that a defrost cycle is necessary.
The control will initiate a defrost cycle when the liquid line temperature is below the initiate point for the measured ambient temperature (See Figure 4) continuously for 4-1/2 minutes. This delay eliminates unnecessary defrost cycles caused by refrigeration surges such as those that occur at the start of a heating cycle.
The control will initiate a defrost cycle every 6 hours (accumulated compressor run time) to recirculate refrigerant lubricants. This forced defrost timer will be reset and restarted following the completion or termination of a defrost cycle.
The control will also initiate a defrost cycle when the TEST terminals are shorted. This feature allows an installer or service technician to start a defrost cycle immediately as required. When the TEST terminals are shorted for more than six seconds with a Y1 input energized and the high-pressure switch closed, the ASCD will be bypassed and the compressor will be energized. If an O signal is present, the control will not initiate a defrost cycle. If the defrost cycle is initiated using the TEST terminals, the control will bypass the normal auxiliary heat timings and will energize the W1 Out and W2 Out terminals immediately when it begins the defrost cycle.

When the TEST inputs are used to force a defrost cycle, the control will ignore the state of the liquid line temperature and outdoor ambient temperature inputs. The coil does not have to be cold and the outdoor temperature does not have to be within a certain range for the heat pump to be forced into a defrost cycle. After the TEST input jumper is removed, the defrost mode will be terminated as normal. The defrost cycle length timer will not be started until the TEST input is removed. If the TEST terminals remain shorted, the control will keep the unit in defrost mode.
**Defrost Inhibition**

The control will not initiate a defrost cycle if the liquid line temperature is above 40°F unless the defrost cycle is forced using the TEST input.

The control will not initiate a defrost cycle when the outdoor ambient temperature is below −25°F or above 55°F unless the defrost cycle is forced using the TEST input.

The control will also prevent a defrost cycle from being initiated too soon after the initiation of the previous defrost cycle. When power is applied to the control and after the completion or termination of each defrost cycle, the control will start a 40-minute timer. When this timer expires, the control will allow another defrost cycle when needed. The timer is based on accumulated compressor run time.

**Defrost Termination**

The control will terminate the defrost cycle immediately after the liquid line temperature reaches 80°F or after eight minutes of defrost operation.

The control will also terminate a defrost cycle that has been forced using the TEST input when the O input is energized. The control will not terminate a normal defrost cycle when it receives an O input.

The control will do the following to terminate a defrost cycle.
- Energize the outdoor fan
- De-energize the crankcase heater
- De-energize the reversing valve
- De-energize the auxiliary heat outputs
- Control the Y2 Out terminal based on operating conditions
- Reset and restart the 40-minute defrost inhibit timer

---

**FIGURE 4: Defrost Operation Curves**

**COOLING OPERATION**

During cooling operation, the control will receive thermostat signals at the Y1 and O input terminals. The control will energize the M compressor output terminal. This signal energizes the coil of the compressor contactor causing the compressor to run. The control also closes the outdoor fan relay delivering power to the ODF terminal causing the outdoor fan to operate. The control energizes the RV terminal with 24VAC to switch the reversing valve. Additionally, the Y2 Out terminal is energized with 24 VAC. This signal can be used to signal the indoor unit to deliver high airflow.

**HEATING OPERATION**

During normal heating mode, the control will receive a thermostat signal at the Y1 input terminal. The control will energize the M compressor output terminal. This signal energizes the coil of the compressor contactor causing the compressor to run. The control also closes the outdoor fan relay delivering power to the ODF terminal causing the outdoor fan to operate. The reversing valve is not energized in heating mode. If the Y2 terminal of the control is energized when the Y1 terminal is not energized, the control will display and store a fault code and will not energize the compressor.
### Conventional Heat Pump Mode

The factory setting of the HOT HEAT PUMP jumper on the control is the OFF position. In this configuration the heat pump operates in conventional heat pump mode. If the jumper is not in place, the control will act as if the jumper is in the OFF position.

If the HOT HEAT PUMP jumper is in the OFF position, the control will energize the Y2 Out terminal whenever the compressor is running.

The location of the hot heat pump jumper is shown in Figures 1 & 3.

#### Hot Heat Pump Mode

The control will operate in Hot Heat Pump Mode only if the HOT HEAT PUMP jumper on the control is placed in the ON position. The Y2 Out signal must also be connected to the indoor unit.

The SWITCH POINT jumper on the control has no effect on the operation of the heat pump.

The control implements the Hot Heat Pump Mode by controlling the indoor airflow level during heating operation only. Cooling operation is not affected. By reducing the indoor airflow level, the heat pump system will operate with increased indoor discharge air temperatures. The control changes the indoor airflow level using the Y2 Out signal. This terminal is connected to the high speed cooling input of a variable speed indoor unit. When the heat pump control energizes the Y2 Out terminal, the indoor blower runs at high speed delivering high airflow. When the control de-energizes the Y2 Out terminal, the indoor blower runs at a lower speed delivering lower airflow.

If the HOT HP jumper is in the ON position and the control receives a call for heating (Y1), the control will energize the compressor and measure the outdoor ambient temperature.

If the outdoor ambient temperature is equal to or greater than 50F, the control will energize Y2 Out and keep it energized until the thermostat is satisfied (Y1 signal removed). The higher airflow is required to keep the operating pressures low when the outdoor ambient temperature is 50F or greater.

If the outdoor ambient temperature is less than 50F, the control will start a ten-minute timer and keep Y2 Out de-energized. Therefore, the compressor will be operating and the indoor unit will be operating with reduced airflow. If the HOT HP jumper is in the ON position and if the outdoor ambient temperature is less than 50F, the indoor airflow at the beginning of a heating cycle will always be low.

When the ten-minute timer expires, the control will compare the liquid line temperature to the indoor airflow control curve for the measured outdoor ambient temperature. If the point is within region A (See Figure 5), the control shall maintain Y2 OUT in the de-energized state until the liquid line temperature rises so that region B is entered. While in region A, the indoor unit will continue to run at low airflow. When the liquid line temperature point enters region B, the control will start a 30 second timer. When the timer expires, the control will immediately energize Y2 OUT. If the liquid line temperature drops back into region A before the timer expires, the control will reset the timer and restart it when the liquid line temperature again enters region B. When the liquid line temperature is in region B continually for thirty seconds, the Y2 Out signal will be delivered to the indoor unit and cause high airflow.

During defrost operation, the control will ignore the HOT HP jumper setting and energize the Y2 Out signal to create high indoor airflow. Additionally, if at any point the conditions require a defrost cycle, the control will override the reduced indoor airflow feature and function based on the defrost requirements and conditions.
EMERGENCY HEAT
When the thermostat calls for emergency heat operation (W signal without a Y signal), the control will de-energize the compressor and energize the W1 Out and W2 Out terminals immediately. The balance point setting is ignored during a call for emergency heat. Therefore, W1 Out and W2 Out will be energized regardless of the outdoor ambient temperature.

LOW TEMPERATURE CUTOUT (LTCO) AND BALANCE POINT (BP)
The control includes a low temperature cutout (LTCO) feature that prevents compressor operation below a specified temperature during heat pump heating operation only. The LTCO setting does not apply to compressor operation during cooling or defrost operation.

The control also includes a balance point feature that prevents the operation of auxiliary heat above a specified temperature.

Setting
The LTCO and BP jumpers on the control are shown in Figures 1 & 3. Both jumpers are placed on the same connector. The control will consider the lowest jumper pin setting to be the LTCO and the highest jumper pin setting to be the BP. The use of the same connector forces the BP and the LTCO to always be separated by at least 10 degrees.

The temperatures shown on the side of the connector labeled LTCO are the LTCO temperature options. The values shown are in degrees F. The control allows the LTCO to be set to any of the following temperatures: -10, 0, 10, 15, 20, 25, 30, 35 degrees F or ON. Placing the jumper in the ON position will allow the control to operate the compressor at any temperature during heating operation.

The factory places the LTCO jumper in the ON position. The jumper must be changed in the field to implement the LTCO feature. If the jumper is removed, the control will behave as if the jumper is in the ON position.

The temperatures shown on the side of the connector labeled BP are the BP temperature options. The values are shown in degrees F. The control allows the balance point to be set to any of the following temperatures: 0, 10, 15, 20, 25, 30, 35, 40, or 45 degrees F.

The factory places the BP jumper in the 35 F position. The jumper may be changed in the field as desired. If the jumper is removed, the control will behave as if the jumper is in the 35 position.

If only one jumper is in place, the control will set the balance point based on the jumper position and will set the LTCO to ON. If only one jumper is in place and it is below the valid BP settings (in the –10 or ON position), the control will set the BP to the default value for no jumper in place (35F) and set the LTCO based on the jumper position (-10 or ON).
Low Temperature Cutout (LTCO) Operation
The control will not operate the compressor in heating mode when the outdoor ambient temperature is below the selected LTCO. The LTCO applies only to air handler mode operation. In fossil fuel mode the balance point (BP) restricts the operation of the compressor so the LTCO setting has no effect.

Balance Point (BP) Operation
If the measured outdoor ambient temperature is greater than the balance point setting, the control will not energize the auxiliary heat outputs. However, the control shall ignore the balance point setting and energize auxiliary heat under some conditions as described in the auxiliary heat sections of this document.

FOSSIL FUEL JUMPER (FFUEL) Setting
The control includes a FFUEL jumper to specify whether the control is installed with a fossil fuel furnace or an air handler (electric heat). This jumper is shown in Figures 1 & 3. The factory places the FFUEL jumper in the OFF position which is the correct position for an air handler installation. The jumper must be changed to the ON position in the field if the heat pump is installed with a fossil fuel furnace. If the jumper is removed, the control will behave as if the jumper is in the OFF position.

IMPORTANT: If the heat pump is installed with a fossil fuel furnace, the FFUEL jumper must be placed in the ON position during installation for proper system operation.

Operation
The control operates the auxiliary heat outputs, W1 Out and W2 Out, based on the position of the FFUEL jumper. If the FFUEL jumper is in the ON position, the control will function in fossil fuel mode. If the jumper is in the OFF position, the control will function in air handler mode. The FFUEL jumper has no effect on cooling operation.

AUXILIARY HEAT - AIR HANDLER MODE
The heat pump control energizes the auxiliary electric heat in air handler mode using the W1 Out and W2 Out signals. The control receives the room thermostat call for auxiliary heat at the W input terminal.

Standard Operation
If the outdoor ambient temperature is less than ten degrees F below the balance point setting and a W input is received with a Y1 input, the control will energize the M compressor contactor output based on the Y1 input and will energize the W1 Out immediately when the W input is received. When the W input is received, the control will start a fifteen-minute timer. If the call for Y1 + W is still present after the fifteen-minute timer expires, the control will then energize W2 Out along with W1 Out. If the W input is removed but the Y1 signal remains, the control will de-energize W1 Out and W2 Out (if energized) and reset and restart the timer. If the W input is received again without a loss of the Y1, the same functionality will be repeated.

If the outdoor ambient temperature is ten degrees F or more below the balance point setting and a W input is received with a Y1 input, the control will energize W1 Out and W2 Out immediately.

If the outdoor ambient temperature is below the low temperature cutout (LTCO) setting, the control will de-energize the compressor and energize W1 Out immediately when a Y1 input is received. If the outdoor ambient temperature rises above the LTCO setting before the thermostat is satisfied, the control will continue to keep the compressor outputs de-energized until the thermostat is satisfied. In other words, the control will use auxiliary heat to satisfy the thermostat demand and not turn the compressor back on even if the outdoor ambient temperature rises above the LTCO setting during a call for heating.

Table 9 describes the auxiliary heat operation for air handler mode.

<table>
<thead>
<tr>
<th>Outdoor Ambient Temp</th>
<th>Y1</th>
<th>Y1 + W</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amb. &gt; BP</td>
<td>Heat Pump Operation</td>
<td>Heat Pump Operation (then + W1 Out + W2 Out after pipe freeze protection timer expires)</td>
<td>W1 Out + W2 Out</td>
</tr>
<tr>
<td>LTCO &gt; Amb.</td>
<td>W1 Out</td>
<td>W1 Out + W2 Out</td>
<td>W1 Out + W2 Out</td>
</tr>
</tbody>
</table>
Auxiliary Heat Defrost Operation – Air Handler Mode

The control will energize W1 Out and W2 Out 45 seconds prior to and during defrost operation. If a call for heating (Y1) is still present after the defrost cycle has terminated, the control will continue to energize W1 Out and W2 Out for 180 seconds after the defrost cycle has been terminated. The control will begin normal heat pump heating mode operation upon termination of the defrost cycle.

Pipe Freeze Protection Timer – Air Handler Mode Operation

The control starts a sixty-minute timer when a call for compressor operation and auxiliary heat (Y1 + W) is received. If the call for compressor operation and auxiliary heat is still present after the timer expires, the control will energize W1 Out and W2 Out in addition to the compressor output regardless of the balance point setting. If the call for auxiliary heat (W) is removed but the call for compressor operation (Y1) remains, the control will de-energize auxiliary heat (W1 Out and W2 Out) and reset and restart the timer. If the timer expires again, the same functionality will be repeated indefinitely. The purpose of this feature is to prevent the pipes in a home from freezing if the balance point is set too low and the heat pump cannot heat the home using compressor operation only. This will be a benefit if a home is not occupied and a compressor problem occurs. The control shall also store and display a fault flash code when the pipe freeze timer has expired.

TABLE 10: Fossil Fuel Furnace Auxiliary Heat Functionality

<table>
<thead>
<tr>
<th>Outdoor Ambient Temp</th>
<th>CONTROL INPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y1</td>
</tr>
<tr>
<td>Amb. &gt; BP</td>
<td>Heat Pump Operation</td>
</tr>
<tr>
<td>Amb. &lt; BP</td>
<td>W1 Out</td>
</tr>
</tbody>
</table>

Bonnet Sensor – Fossil Fuel Mode

The heat pump may be equipped in the field with an optional indoor air discharge temperature or bonnet sensor. The control does not allow the heat pump and the furnace to operate simultaneously even with a bonnet sensor installed except surrounding a defrost cycle. The control cycles the fossil fuel furnace differently surrounding a defrost cycle depending on whether a bonnet sensor is installed.

The bonnet sensor is installed in the indoor unit and is mounted so that it measures the indoor air temperature after the air exits the furnace. The bonnet sensor is connected to the heat pump control using the BS and BSG terminals. Refer to the bonnet sensor accessory kit for complete installation instructions.

AUXILIARY HEAT - FOSSIL FUEL MODE Standard Operation

The LTCO does not have any impact on the operation of auxiliary heat when the control is in fossil fuel mode. Since the compressor is not allowed to come on below the balance point and the balance point is always above the LTCO, the balance point setting effectively becomes the LTCO setting. This is done intentionally to allow the balance point to function as an economic balance point based on the cost of heating with electricity (above the balance point) versus heating with fossil fuel (below the balance point).

If the measured outdoor ambient temperature is below the balance point setting, the control will de-energize compressor outputs and energize W1 Out immediately when the Y1 input is received. If the outdoor ambient temperature rises above the balance point setting before the thermostat is satisfied, the control will continue to keep the compressor outputs de-energized until the thermostat is satisfied. In other words, the control will use furnace to satisfy the thermostat demand and not turn the compressor back on even if the outdoor ambient temperature rises above the LTCO setting during the call for heating.

If a W input is received with or without a Y1 input, the control will de-energize the compressor outputs and energize W1 Out and W2 Out immediately.

Table 10 describes the auxiliary heat operation for fossil fuel mode.

The bonnet sensor only applies to fossil fuel furnace applications and should not be installed with air handlers. If the bonnet sensor is present and the control is set to air handler mode, the indoor unit might be a furnace and the operation mode is incorrectly specified. The control will operate in fossil fuel mode instead of air handler mode so that the furnace and heat pump are not operated simultaneously.

Since the bonnet sensor is an optional accessory, the control cannot detect a bonnet sensor that fails in the open position. If the control senses that the bonnet sensor thermistor is open, it will assume that a bonnet sensor thermistor is not connected and will function without implementing the optional bonnet sensor features. If the control senses that the bonnet sensor thermistor is shorted, it will cause a lockout condition and store and display the appropriate error code.
If the control is in air handler mode and detects that a bonnet sensor input is present, it will control W1 Out and W2 Out as required by the fossil fuel mode. It will also cause a fault code to be displayed on the thermostat via the X/L output to notify the homeowner that there is a problem even though the system is operating.

**Auxiliary Heat Defrost Operation – Fossil Fuel Mode with Bonnet Sensor**

With a bonnet sensor present the control will energize W1 Out and W2 Out 45 seconds prior to the initiation of the defrost cycle.

During defrost operation, if the bonnet sensor input reaches 109F, the control will de-energize W1Out and W2Out. The control will re-energize W1Out and W2Out when the bonnet sensor input drops below 90F again and the defrost cycle is still in process.

If a call for heating (Y1) is still present after the defrost cycle has terminated, the control will continue to energize W1 Out and W2 Out after the defrost cycle has been terminated until the bonnet sensor reaches 109F. When the bonnet sensor reaches 109F after the defrost cycle has terminated, the control will de-energize W1 Out and W2 Out and will not re-energize them during this call for heat. That is, once the defrost cycle has terminated, the control will not cycle W1 Out and W2 Out with the bonnet sensor.

The control will begin normal heat pump heating mode operation upon termination of the defrost cycle.

**Auxiliary Heat Defrost Operation – Fossil Fuel Mode without Bonnet Sensor**

If the control is in fossil fuel mode and senses that no bonnet sensor is present, it will energize W1 Out and W2 Out immediately when the defrost cycle is initiated. If a call for heating (Y1) is still present after the defrost cycle has terminated, the control will de-energize W1 Out and W2 Out immediately and return to normal heat pump mode operation.

In this mode the control will energize the fossil fuel furnace only during defrost and not provide any comfort enhancements during the transition. The heat pump and furnace will not operate at the same time if the bonnet sensor is not in place.

**Pipe Freeze Protection Timer – Fossil Fuel Mode Operation**

The control starts a sixty-minute timer when a call for compressor operation and auxiliary heat (Y1 + W) is received. If the outdoor temperature is above the balance point, the control will energize the compressor instead of the auxiliary heat outputs. If the call for compressor operation and auxiliary heat is still present after the timer expires, the control will energize W1 Out and W2 Out and de-energize the compressor regardless of the balance point setting. The control will keep the W1 Out and W2 Out signals energized until the Y1 signal is removed. That is, the control will lock into auxiliary heat furnace operation until the room thermostat is satisfied.

The purpose of this feature is to prevent the pipes in a home from freezing if the balance point is set too low and the heat pump cannot heat the home using compressor operation only. This will be a benefit if a home is not occupied and a compressor problem occurs. The control will also store and display a fault flash code when the pipe freeze timer has expired.

**HIGH-PRESSURE SWITCH FAULT**

The heat pump is equipped with a high-pressure switch that is connected to the control at the HPS terminals. If the high-pressure switch opens for more than 40 milliseconds, the control will de-energize the compressor and store and display the appropriate fault code. If the pressure switch closes and a thermostat call for compressor operation is present, the control will apply the five-minute anti-short cycle delay timer and start the compressor when the timer expires.

When the compressor is started following a high-pressure switch fault, the control will start a six-hour timer based on accumulated compressor run time. If the control senses another opening of the high-pressure switch before the timer expires, it will cause a soft lockout condition. The second opening of the high-pressure switch must be greater than 160 milliseconds for the lockout to occur. If the second opening is between 40 and 160 milliseconds, the control will de-energize the compressor but not cause a soft lockout condition. If the control does not sense a second high-pressure switch opening before the six-hour timer expires, the timer and counter will be reset.

**LOW-PRESSURE SWITCH**

The heat pump is equipped with a low-pressure switch which is connected to the control at the LPS terminals. If the low-pressure switch opens for more than five seconds, the control will cause a soft lockout condition and display the appropriate fault codes. However, the control will ignore the low pressure switch input and not cause a soft lockout condition if it opens during the following conditions.

- Defrost operation
- First thirty seconds of compressor operation
- Two minutes following the completion of a defrost cycle
- TEST input shorted with Y1 input energized

**DISCHARGE LINE TEMPERATURE SENSOR (OPTIONAL)**

The heat pump may be equipped with an optional discharge line temperature sensor. If a discharge sensor is present, the control will provide the following features.

**High Discharge Line Temperature**

If the control senses a discharge line temperature reading of 263F for 30 seconds continually, it will cause a soft lockout condition. If the discharge line temperature drops below 263F during the 30-second timer, the control will reset the 30-second timer and restart the timer if the discharge line temperature again exceeds 263F.
Low Discharge Line Temperature

The control will begin a sixty-minute timer when either of the following conditions are met.

• The discharge line temperature has not reached 90°F after eight minutes of accumulated compressor run time.
• The discharge temperature has not reached 90°F after fifteen minutes of accumulated compressor run time following the exit of a defrost cycle.

If the discharge line temperature has not reached 90°F after the sixty-minute timer has expired, the control will cause a soft lockout condition. The control will reset the sixty-minute timer upon expiration and when the compressor starts. The timer is reset when the compressor starts and is only restarted if one of the two conditions shown above are met. The low discharge temperature fault indicates that the outdoor coil is too cold during heating operation. The lockout is intended to prevent refrigerant flooding back to the compressor.

IMPORTANT: The discharge sensor must be well insulated and installed properly to prevent nuisance lockouts from occurring.

FIGURE 6: Wiring Diagram
FIGURE 7: Wiring Diagram