iWorx by Taco Electronic Solutions

Application Guide

505-040-3

HPL1 Water Source Heat Pump Controller

Self-Contained Interoperable Controller Model UCP-1 for Software Version 3

SUPERSEDES: March 10, 2015

EFFECTIVE: October 26, 2015

Plant ID: 001-4081

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HPL1-3

The HPL1-3 heat pump controller is a stand-alone microprocessor based controller for liquid source heat pump units. The controller also provides BTU energy monitoring.

Overview

The application includes liquid source heat pump units with a two-stage compressor, reversing valve, fan, and dehumidification.

Digital inputs are provided for fan proof, fan filter, indoor air quality, and occupancy status. The indoor air quality input may be configured to receive an analog value. Analog inputs are provided for supply and return air and water temperature. A two-wire serial interface is provided for the thermostat. When the thermostat is not used, a thermistor may be connected for space temperature monitoring. An analog input is provided for applications that require power monitoring.

The HPL1-3 incorporates digital outputs in the form of triacs for fan start/stop, two compressor stages, dehumidification, reversing valve and reheat. In addition to fan start/stop, two triac outputs are provided for 3-speed digital fan operation. The controller also incorporates 0-10VDC analog outputs for compressor modulation, fan modulation, and injection circulator modulation.

The controller is based on LonWorks ® networking technology. The controller may be networked to a higher-level control system for monitoring and control applications.

Features

- Two-stage or modulated compressor heating/cooling control
- Digital reversing valve control
- 3-speed digital fan or modulated fan control with digital enable
- User-configured combination of digital and analog fan control
- Fan control energized on call for heating or cooling
- Fan proof input
- Dehumidification and reheat control
- LOFlo™ Zone Mixing Block Integration
- Local backup schedule
- Individual temperature setpoints for occupied/unoccupied heat and cool
- LonWorks interface to building automation systems
- Optional BTU energy monitoring
- Optional water flow metering
- Thermostat with space temperature, humidity, temperature and humidity setpoint adjust, fan override, occupancy override
- Automatic heat/cool changeover
- Global unit enable for main plant synchronization
- Remote sensor capabilities
- Automatic configuration with the LCI
- Supervisor control (JENE/Niagara)
- Real Time Clock
- Alarm/Event reporting
- LONWORKS® interface to building automation systems

PURPOSE OF THIS GUIDE

The *iWorx® HPL1-3 Application Guide* provides application information for the HPL1-3 Controller.

The reader should understand basic HVAC concepts, intelligent environmental control automation, and basic LONWORKS networking and communications. This Application Guide is written for:

- Users who engineer control logic
- Users who set up hardware configuration
- Users who change hardware or control logic
- Technicians and field engineers

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APPLICABLE DOCUMENTATION

Part Number	Audience	Purpose
iWorx® HPL1-3 Application Guide, Document No. 505-040-3 (this document)	– Application Engineers – Wholesalers – Contractors	Provides specific application information about the BTU series, including sequence of operation and configuration information.
iWorx® LCI Application Guide, Document No. 505-002	– Application Engineers – Installers – Service Personnel – Start-up Technicians – End user	Provides instructions for setting up and using the iWorx® Local Control Interface.
iWorx® VFTS/VTS Sensors with BTUPS Regulated Power Supply, Document No. 502-026	– Application Engineers – Installers – Service Personnel – Start-up Technicians	Provides specific installation and usage information for the sensor series that are most often used with the BTU series controllers.
http://www.iWorxWizard.com	– Application Engineers – Wholesalers – Contractors	An on-line configuration and submittal package generator based on user input. Automatically generates bill of materials, sequence of operations, flow diagrams, wiring diagrams, points and specifications.
Additional Documentation	*LonWorks FTT-10A Free Topology Transceiver User's Guide,* published by Echelon Corporation. It provides specifications and user instructions for the FTT-10A Free Topology Transceiver.	

INSTALLATION GUIDE

General

CAUTION: This symbol is intended to alert the user to the presence of important installation and maintenance (servicing) instructions in the literature accompanying the equipment.

CAUTION: Risk of explosion if battery is replaced by an incorrect type. Contains lithium type battery; dispose of properly.

WARNING: Electrical shock hazard. Disconnect **ALL** power sources when installing or servicing this equipment to prevent electrical shock or equipment damage.

Make all wiring connections in accordance with these instructions and in accordance with pertinent national and local electrical codes. Use only copper conductors that are suitable for 167 °F (75 °C).

Static Electricity

Static charges produce voltages that can damage this equipment. Follow these static electricity precautions when handling this equipment.

- Work in a static free area.
- Touch a known, securely grounded object to discharge any charge you may have accumulated.
- Use a wrist strap when handling printed circuit boards. The strap must be secured to earth ground.

FCC Compliance

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference. This equipment can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment to a power source different from that to which the receiver is connected.
- Consult the equipment supplier or an experienced radio/TV technician for help.

You are cautioned that any changes or modifications to this equipment not expressly approved in these instructions could void your authority to operate this equipment in the United States.

BEFORE INSTALLING

About this Document

The instructions in this document are for the HPL1-3 module which provides nine sensor inputs.

Inspecting the Equipment

Inspect the shipping carton for damage. If damaged, notify the carrier immediately. Inspect the equipment for damage. Return damaged equipment to the supplier.

What is Not Included with this Equipment

- A power source for the equipment electronics and peripheral devices.
- Tools necessary to install, troubleshoot and service the equipment.
- The screws or DIN rail needed to mount the device.
- Peripheral devices, such as sensors, actuators, etc.
- Cabling, cabling raceway, and fittings necessary to connect this equipment to the power source, FTT-10A network and peripheral devices.

Equipment Location

Abide by all warnings regarding equipment location provided earlier in this document.

Optimally, the equipment should be installed within a secure enclosure.

If the equipment is to be installed outside, it must be contained within a protective enclosure. The enclosure must maintain internal temperature and humidity within the ranges specified for this equipment.

The equipment must be installed within 500 feet of all input peripherals (smoke detectors, sensors, etc.) that are connected to the equipment.

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Selecting a Power Source

This equipment requires a UL recognized Class 2 external power source (not supplied) to operate. The controller power input requires a voltage of 24 Volts AC.

To calculate power source current requirements, add the power consumption of all peripheral devices to that of the controller.

The controller and sensor power supplies can use the same power source. If both are using the same power source, the loads must have EMF protection. This protection can be integral to the load, or installed in the 24 VAC wiring across the load's coil.

To provide necessary RFI and transient protection, the controller's ground (GND) pin (T40) must be connected to earth ground or the earth ground of the packaged unit's enclosure ground. Failure to properly ground the controller may cause it to exceed FCC limits. Excessive noise could also produce inaccurate sensor data. The power source must be capable of operating with this connection to ground.

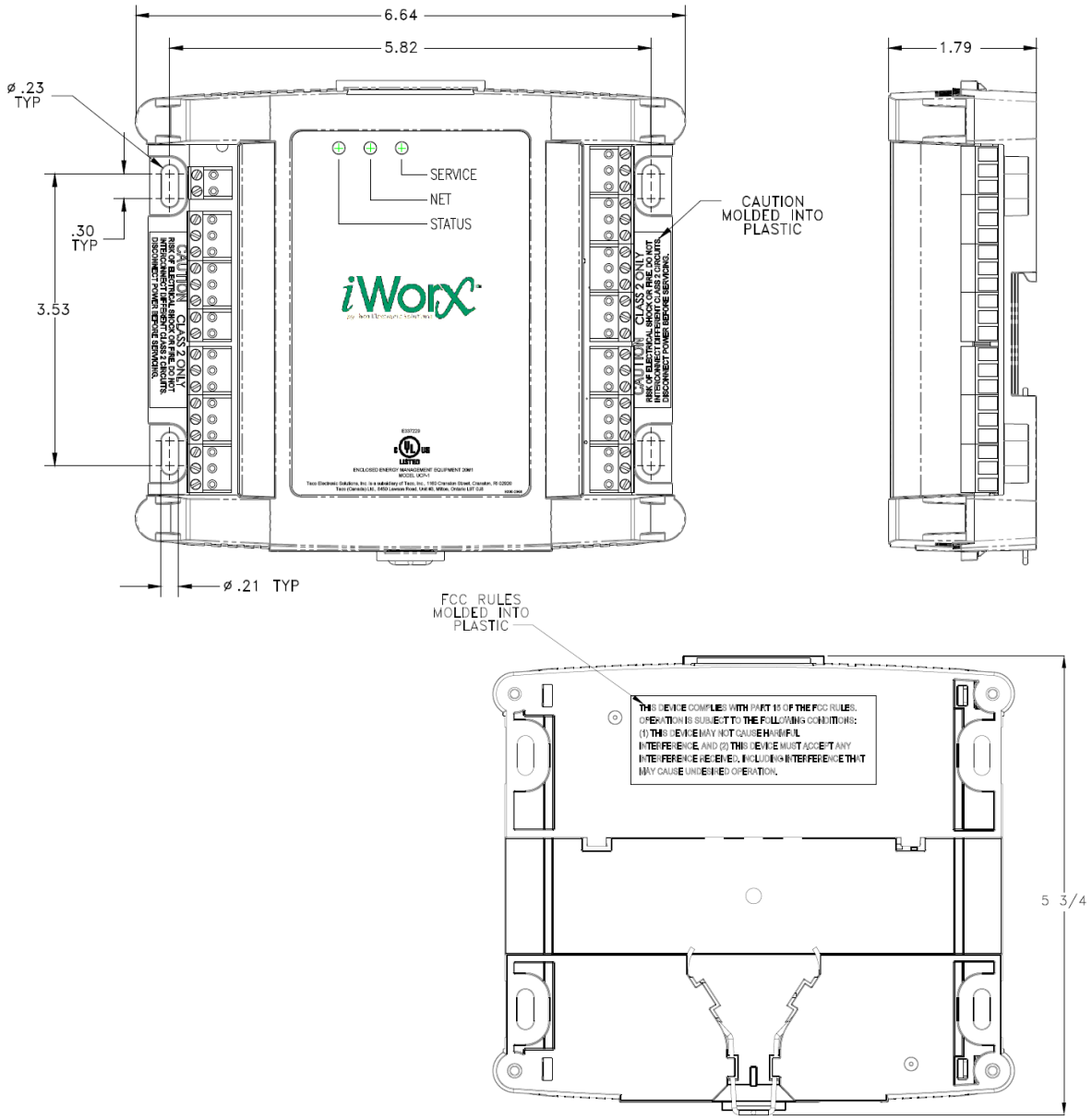
INSTALLATION

Warning: Electrical shock hazard. To prevent electrical shock or equipment damage, disconnect **ALL** power sources to controllers before installing or servicing this equipment or modifying any wiring.

Mounting the Device

1. Select a mounting location. Enclosure mounting is recommended.
2. Hold the controller on the panel you wish to mount it on. With a marker or pencil mark the mounting locations on the panel.
3. Using a small drill bit pre-drill the mounting holes.
4. Using two #6 pan head screws, mount the controller to the panel.
5. Wire the controller (See Routing Cabling to the Device).

Figure 1: Mounting Dimensions



Routing Cabling to the Device

Cabling used to connect the power source and cabling used to connect the FTT-10A network must remain separated within the control enclosure and wiring conduit.

Grounding the Device

The ground terminal (T40) must be securely connected to earth ground. Failure to properly ground this equipment will result in improper operation. Improper grounding may also increase the risk of electrical shock and may increase the possibility of interference with radio/TV reception.

For best performance, connect the power supply common terminal (T38) to the same external point as the ground terminal (T40).

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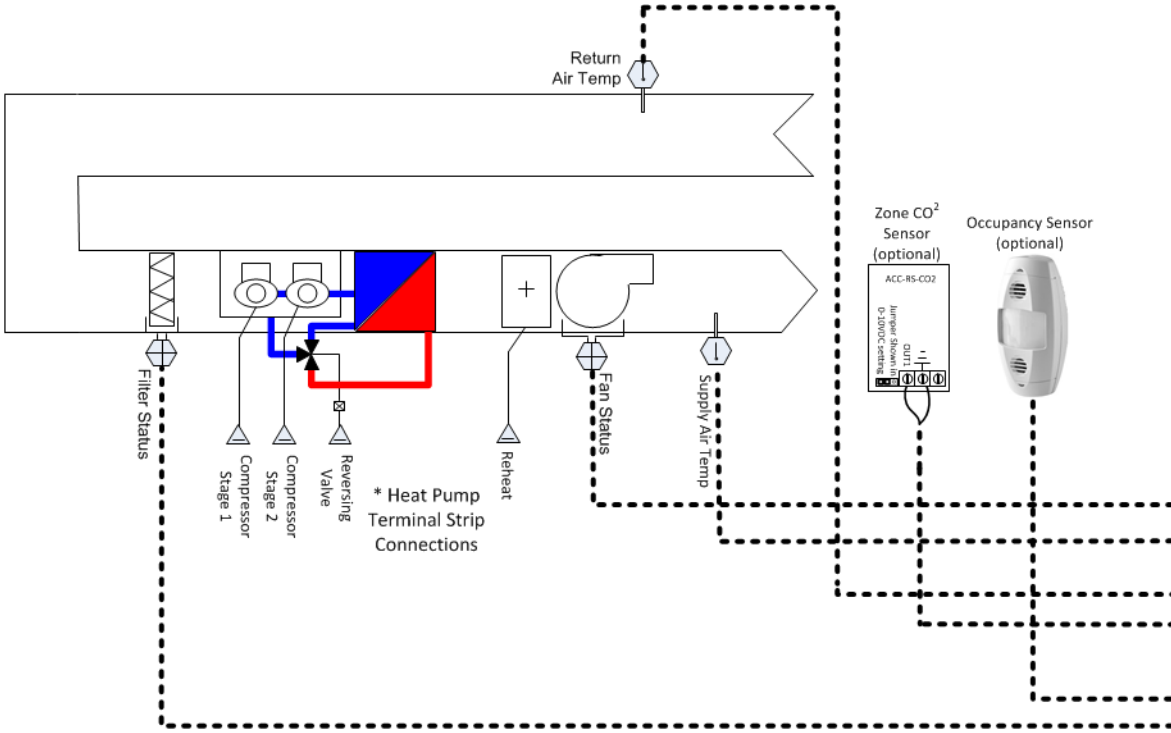
WIRING INFORMATION

WARNING: Terminals 6, 9, 12, 15, 18 and 38 are connected internally on all HPL1-3 controllers. Disconnect **ALL** power sources when installing or servicing this equipment to prevent electrical shock or equipment damage.

NOTE: Dip switches for inputs used for flow sensors or non-thermistor temperature sensors are configured for 0-10V signals. Dip switches for inputs used for thermistors or digital inputs are configured for dry contact (VTH) signals.

Figure 2: Typical HPL1-3 Wired as Power Sourcing



Symbols:

Duct Mount - 10K ohm Precon Type III thermistor Taco Part #ACC-DS-8-10KP3-PB, ACC-DS12-10KP3-PB

Power Transducer 0-10V

Pipe Mount Sensor – Bullet, Taco Part #TRP-1, Immersion Well w/Galvanized Box, Taco Part #ACC-WS-4-10KP3-GB, Strap On w/ Galvanized Box, Taco Part #ACC-SOS-10KP3-GB

Duct Mount – Air Differential Pressure (Flow Proof) Switch Normally Open, Dry Contact Switch, Taco Part #ACC-ADPS-12WC

Duct Mount - 10K ohm Precon Type III thermistor Taco Part #ACC-DS-8-10KP3-PB, ACC-DS12-10KP3-PB

Pipe Mount Sensor – Inline Flow, Taco Part: VFTS 1-20, VFTS 2-40, VFTS 5-100, VFTS 10-200, VFTS 20-400

Wire Types:

Line Voltage

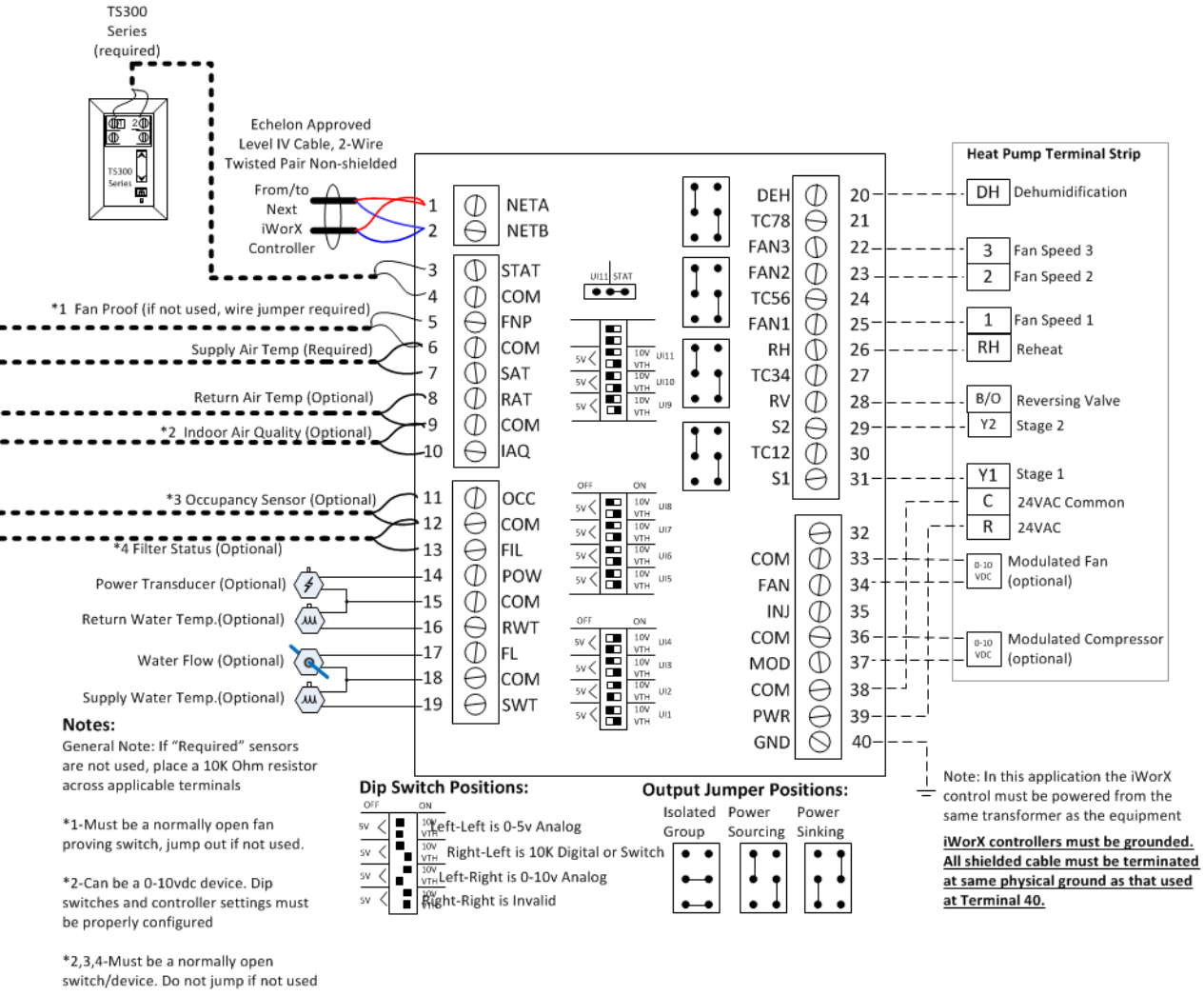
24VAC Low Voltage

Echelon Approved Level IV Cable 2-Wire, Twisted Pair, Non-shielded Taco Part #WIR-022

2-Wire Low Voltage, Shielded Cable Shield Grounded, Taco Part #WIR-018

10K Ohm ½ or ¼ Watt Resistor

Wire Jumper



Notes:

General Note: If "Required" sensors are not used, place a 10K Ohm resistor across applicable terminals

*1-Must be a normally open fan proving switch, jump out if not used.

*2-Can be a 0-10vdc device. Dip switches and controller settings must be properly configured

*2,3,4-Must be a normally open switch/device. Do not jump if not used

Connecting Input Devices

The figures below demonstrate typical sensor wiring.

Precon II or III sensors are wired as a standard thermistor. One terminal is connected to a common pin, the other to the RWT input. DIP switches for use with for Precon II or III sensors must be configured for VTH input.

Figure 3: Typical Precon III Sensor Wiring

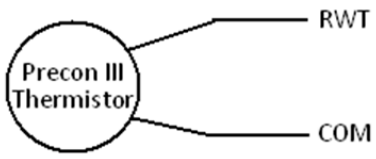
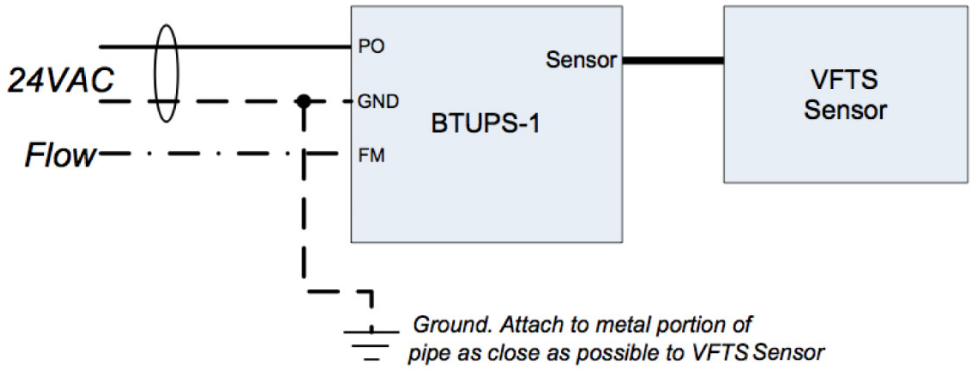


Figure 4: Typical VFTS Sensor Wiring



Thermostat (STAT)

To connect the Thermostat to the unit, attach one wire to STAT (T3) and the other wire to the adjacent common (T4).

If a humdity sensor, thermistor, or other temperature sensor is used in place of the thermostat, jumper W15 must be set to UI11 and UI11 DIP switch settings must be properly configured.

Fan Proof (FNP)

To connect the Fan Proof sensor to the unit, attach one wire from the sensor to FNP (T5) and the other wire to the adjacent common (T6). This must be a dry contact normally open switch.

NOTE: If a fan status switch is not provided, the input must be jumpered to the adjacent common.

Supply Air Temp (SAT)

This sensor measures the temperature of the supply air as it leaves the heat pump.

To connect the Supply Air Temp sensor to the unit, attach one wire from the Precon III sensor to SAT (T7) and the other wire to the adjacent common (T6).

NOTE: This sensor is required for variable fan speed outputs. This sensor must be a Precon III thermistor.

Return Air Temp (RAT)

To connect the Return Air Temp sensor to the unit, attach one wire from the Precon III sensor to RAT (T8) and the other wire to the adjacent common (T9).

NOTE: This sensor must be a Precon III thermistor.

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Indoor Air Quality (IAQ)

To connect the Indoor Air Quality sensor to the unit, attach one wire from the sensor to IAQ (T10) and the other wire to the adjacent common (T9). This must be a dry contact normally open switch.

If the Indoor Air Quality sensor is an analog device, the sensor must be connected to the terminals mentioned above, but the DIP switch settings must be changed to reflect a 0-10V input. Please refer to the Wiring Information for the corresponding DIP switch settings.

Occupancy Sensor (OCC)

To connect the external Occupancy Sensor to the unit, attach one wire from the sensor to OCC (T11) and the other wire to the adjacent common (T12). This must be a dry contact normally open switch.

When the switch is closed, controller occupancy status is overridden to "Occupied".

Filter Status (FIL)

To connect the filter switch to the digital input, attach one wire of the contact to FIL (T13) and the other wire to the adjacent common (T12). This must be a dry contact normally open switch.

When the switch is closed, a Filter Dirty Alarm is displayed on the LCI2.

Heat Pump Power Transducer (POW, optional)

To connect the power transducer to the unit, connect the positive wire from the transducer to POW (T14) and the other wire to the adjacent common (T15). The transducer must be provided and configured by Taco. It is required if the HPL1 needs to report energy usage to a GHP1 for COP calculations.

Return Water Temperature (RWT)

To connect the Return Water Temperature sensor to the unit, attach one wire from the thermistor to RWT (T16) and the other wire to the adjacent common (T15). Depending on the type of sensor, the DIP switch settings must be changed. Please refer to the Wiring Information for the sensor types and the corresponding DIP switch settings.

NOTE: This sensor is required for BTU metering.

Water Flow (FL)

To connect the Water Flow sensor to the unit, attach one wire from the VFTS flow sensor to FL (T17) and the other wire to the adjacent common (T18). The sensor must be of the 0-10 Volt type.

Supply Water Temperature (SWT)

To connect the Supply Water Temperature sensor to the unit, attach one wire from the thermistor to SWT (T19) and the other wire to the adjacent common (T18). Depending on the type of sensor, the DIP switch settings must be changed. Please refer to the Wiring Information for the sensor types and the corresponding DIP switch settings.

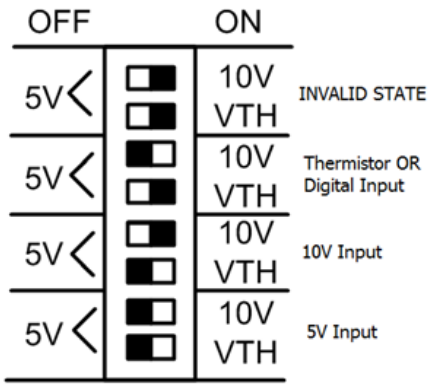
NOTE: This sensor is required for injection modulation and BTU metering.

Setting DIP Switches

Each input has a corresponding pair of DIP switches. The DIP switches are in three black cases with white switches located near the inputs. While holding the board with the inputs facing down, the pair of DIP switches furthest to the right corresponds to the right-most input (SWT). The next pair of DIP switches corresponds to the next input (FL) and so on.

DIP switch pairs must be set properly for each input to operate correctly as shown in the figure below.

Figure 5: DIP Switch Settings



NOTE: The DIP switches are black boxes with white switches. The drawing above is a negative image; the position of the switch is shown as black.

Connecting Output Devices

Modulated Compressor (MOD)

The modulated compressor output is set to 0-10 V max through the control logic. Connect the positive wire from the compressor/pump to MOD (T37) and the other wire to COM (T36).

NOTE: To enable modulated compressor outputs, the *Modulated Comp* setting *Out Min* or *Out Max* must be greater than 0V. Enabling compressor outputs disables staging. The controller ensures that staging is disabled by automatically setting *Staged Comp: Stages* to zero.

Injection Pump (INJ)

The modulated injection pump output is set to 0-10 V max through the control logic. Connect the positive wire from the pump to MOD (T35) and the other wire to COM (T36).

Note: To enable injection pump outputs, the Inj Settings setting Out Min or Out Max must be >0V.

Modulated Fan (FAN)

The modulated fan output is set to 0-10 V max through the control logic. Connect the positive wire from the fan to FAN (T34) and the other wire to COM (T33).

NOTE: To enable modulated fan outputs, the *Fan Mode* setting *Out Min* or *Out Max* must be greater than 0V and the *Fan Set: Fan OpMode* setting must be set to "Modulated" or “Configured.”

Compressor Stage 1 / Compressor Enable/ Zone Pump Enable (S1)

The compressor stage 1 output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect compressor stage 1 to S1 (T31) and TC12 (T30).

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Compressor Stage 2 (S2)

The compressor stage 2 output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect compressor stage 2 to S2 (T29) and TC12 (T30).

Reversing Valve (RV)

The reversing valve output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect the reversing valve to RV (T28) and TC34 (T27).

This output is used for controlling the heat pump's reversing valve and may be set by the user to energize on heat or energize on cool.

Reheat/Zone Pump (RH)

The reheat output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect reheat to RH (T26) and TC34 (T27).

The behavior of this output depends on the Dehumid Set: Mode setting. Please refer to the Dehumidification topic for more information.

Fan Speed 1 / Fan Enable (FAN1)

The fan output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect fan speed 1 to FAN1 (T25) and TC56 (T24).

Fan Speed 2 (FAN2)

The fan output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect fan speed 2 to FAN2 (T23) and TC56 (T24).

Fan Speed 3 (FAN3)

The fan output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect fan speed 3 to FAN3 (T22) and TC78 (T21).

Dehumidification (DEH)

The dehumidification output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. If the load is less than 1 Amp, connect dehumidifier to DEH (T20) and TC78 (T21).

This output is energized if dehumidification is configured and the controller algorithm determines that dehumidification is necessary.

Other Connections

Network (LON)

Network wiring must be twisted pair. One network wire must be connected to terminal NETA (T1) and the other network wire must be connected to terminal NETB (T2). Polarity is not an issue since an FTT-10A network is used for communications.

Power (PWR)

Connect one output wire from a 24 VAC power supply to PWR (T39) and the other output wire from the power supply to the adjacent common terminal (T38). T38 must be connected to earth ground.

Ground (GND)

Terminal GND (T40) must be connected to earth ground. Failure to properly ground this equipment will result in improper operation. Improper grounding may also increase the risk of electrical shock, and may increase the possibility of interference with radio and TV reception.

SPECIFICATIONS

Electrical Inputs

Resolution: 10 bit

Thermostat: Slink, Precon II or III 10K Thermistor (Space Temp Only)

Supply Air Temp, Return Air Temp: Precon III 10K Thermistor

Supply Water Temperature, Return Water Temperature: 0-5 VDC VFTS/VTS, Precon Type II or III 10K Thermistor

Water Flow: 0-5 VDC VFTS

Fan Proof Sensor, Occupancy Sensor, Filter Status: Dry Contact - Normally Open - 5 Volts DC Max

IAQ Sensor: Based on configuration, may be either one of the following: Dry Contact - Normally Open - 5 Volts DC Max; 0-10 VDC

Electrical Outputs

Modulated Compressor, Injection Pump, Modulated Fan: 0-10 VDC - 2K Ohm minimum load

Compressor Stage 1, Compressor Stage 2, Reversing Valve, Reheat, Fan Speed 1, Fan Speed 2, Fan Speed 3, Dehumidification: 24 Volts AC - 1 amp at 50 °C, 0.5 amps at 60 °C, limited by Class 2 supply

Recommended Sensor Wire

Maximum Length: 500 feet (152 meters)

Cable Type	Pairs	Details	Taco Catalog No.
18AWG	1	Stranded Twisted Shielded Pair, Plenum	WIR-018

Recommended LON Bus FTT-10A Network Wire

Speed: 78KBPS

Max Volts: 42.4 Volts DC

Cabling: Maximum node-to-node distance: 1312 feet (400 meters); Maximum total distance: 1640 feet (500 meters)

Cable Type	Pairs	Details	Taco Catalog No.
Level 4 22AWG (0.65mm)	1	Unshielded, Plenum, U.L. Type CMP	WIR-022

Power

Requires: 24VAC (20VAC to 28VAC), requires an external Class 2 supply

Consumes: 7.2W with no external loads, maximum limited by the Class 2 supply rating

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Mechanical

Dimensions: 5.55” (141mm) high, 6.54” (166 mm) wide, 1.75” deep (44 mm), ABS

Controller Weight: 0.70 pounds (0.32 kilograms)

Shipping Weight: 1.0 pounds (0.46 kilograms)

Processor: 3150 Neuron 10 MHz

Flash: 48 Kilobytes

SRAM: 8 Kilobytes

Termination: 0.197” (5.0 mm) Pluggable Terminal Blocks, 14-22 AWG

Temperature: 32 °F to 140 °F (0 °C to 60 °C)

Humidity: 0 to 90%, non-condensing

UL Listed for US and Canada, Energy Management Equipment PAZX and PAZX7

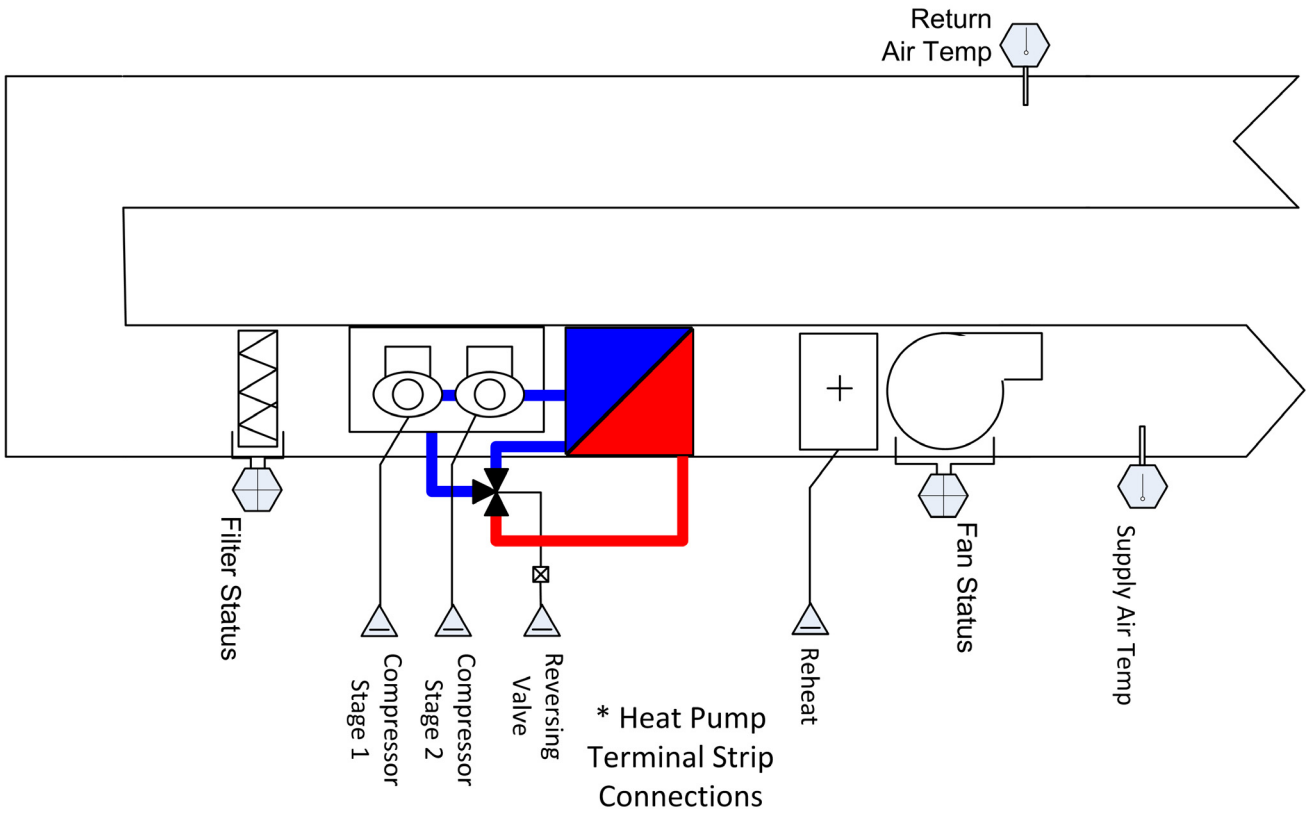
FCC Part 15 Class A compliant

APPLICATION DESCRIPTION

The controller maintains the temperature of a space to a defined setpoint and optionally supply air temperature to a defined setpoint. Injection control maintains the supply water temperature to defined heating and cooling setpoints.

The figure below illustrates a typical controller application. Space temperature control is achieved by sequencing the reversing valve and compressor stages of a liquid source heat pump based on the current space requirements.

Figure 6: Typical Staged Application



The controller operates in one of two states: occupied or unoccupied. The LCI determines the active operating mode. The operating mode may be set by a supervisor system which takes precedence over the LCI. The controller maintains the comfort level to a user-defined setpoint during the occupied period. The controller uses setup and setback values during the unoccupied period to maintain the space temperature. An optional backup schedule is provided to use when the LCI is not available.

A digital input is also provided as a physical means of signaling occupancy status to the controller. The digital input overrides any occupancy information from the LCI or supervisor system.

Each controller interfaces to a local thermostat. Depending on the model, the thermostat includes a space temperature sensor, space humidity sensor, temperature setpoint adjustment, occupancy override and a fan speed selection.

When the temperature increases above the cooling setpoint, the reversing valve is set to the cooling position. The compressor stages are sequenced on or a single compressor stage is modulated with a time proportioned control algorithm to minimize excessive cycling. As the temperature decreases below the cooling setpoint, the compressor stages are sequenced off.

When the unoccupied mode is entered, the cooling setpoint is set up to a separate cooling setpoint for unoccupied mode.

When the temperature decreases below the heating setpoint, the reversing valve is set to the heating position. The compressor stages are sequenced on or a single compressor stage is modulated with a time proportioned control algorithm to minimize excessive cycling. As the temperature increases above the heating setpoint, the compressor stages are sequenced off.

When the unoccupied mode is entered, the heating setpoint is set back to a separate heating setpoint for unoccupied mode.

When the space temperature exceeds a programmable limit, a high limit alarm is reported to the LCI. When the space temperature drops below a programmable limit, a low limit alarm is reported to the LCI. When the space temperature returns to the proper range, a return to normal alarm is reported to the LCI.

The HPL1-3 can be synchronized to the main plant water supply through its global unit enable feature. The status of the supply water flow is measured by an external device, and provided to the controller over the network.

The Injection Pump output is used in conjunction with the Supply Water Temperature sensor for controlling Supply Water Temperature to defined high and low supply water temperature setpoints. It is governed by a P+I loop with a VFTS or thermistor-based sensor to monitor the water temperature.

When the zone humidity rises above the humidity setpoint, dehumidification is enabled by activating the cooling stages and the dehumidification output. Dehumidification is disabled when zone air humidity drops below the setpoint by 3%.

When dehumidification is active and the temperature falls below the heating setpoint, the digital reheat output is activated. Reheat is disabled when dehumidification is not active or the temperature is above the cooling setpoint.

The HPL1-3 controls the starting and stopping of the supply air fan. The fan is energized when there is call for heating or cooling.

During the occupied periods, the fan may be configured to run continuously. The fan may be overridden from the local thermostat. If overridden, the fan runs continuously.

A choice of modulated analog output or 3-speed digital output is available for controlling a variable speed fan to maintain a consistent Supply Air Temperature. This output is governed by a P+I loop with a thermistor-based sensor to monitor the Supply Air Temperature.

One digital input is provided to monitor fan proof status. For more detail on response and recovery to the digital alarms, see the appropriate sections under "Sequence of Operation."

One digital input is provided for filter status. When a dirty filter status indication occurs, a maintenance alarm is sent to the LCI.

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An indoor air quality input is provided. If an indoor air quality condition is indicated, the supply air fan is energized. If the condition remains active for a configurable period of time, an alarm is generated. The indoor air quality input may be a digital input or a 0-10V analog input. If the sensor is the analog type then the level that indicates the IAQ condition is configurable. A temperature reset function is available to maintain a comfortable space temperature.

The controller monitors the runtimes of the fan, compressor and pumps. When any runtime exceeds a programmable limit, a maintenance alarm is reported to the LCI.

The controller monitors the supply and return water temperatures and the flow in the system. The values are measured every second and an average is calculated every minute. The controller calculates an energy rate value in BTU/Hr, a volume rate in GPM, a daily total heat consumption and grand total heat consumption in BTU, and a daily total volume and grand total volume in gallons for each heating and cooling. It also generates a 31 day log, which may be retrieved with the LCI2.

The controller's outputs can be manually changed through the LCI using the Commissioning configuration.

Optional Control Algorithms

- Fan Control (See topic: Fan Configuration and Operation)
- Indoor Air Quality Control (See topic: Indoor Air Quality)
- Additional Monitoring: Runtimes, Filter

SEQUENCE OF OPERATION

This section describes the sequence of operation for the controller.

Operational Mode

The HPL1-3 operates in one of 5 operational modes: fan only, heating, cooling, dehumidification, or off. The operating mode determines the state of the reversing valve, compressor stages, and modulated outputs and whether auxiliary dehumidification or reheat elements are used.

Determining Operational Mode

The controller uses the following information for determination of its mode:

- Space temperature and calculated space setpoint
- Space humidity and humidity setpoint
- Unit Enable
- Fan Proof
- Stage Timers
- Occupancy status
- Operating Mode setting and Application Mode input

Space temperature may be acquired from the TS300 thermostat (or space temperature thermistor) or over the network from the network supervisor. Humidity may be acquired from the TS300 thermostat or over the network from the network supervisor. The readings are compared to the calculated heating/cooling or humidity setpoints for the current occupancy mode.

Prior to selecting the operational mode, the controller determines whether dehumidification is needed. The dehumidification algorithm uses programmable settings to determine when to operate.

When the temperature or humidity is out of bounds, the reversing valve is set to the appropriate state and the controller turns on the fan. The fan runs for at least 30 seconds. The controller turns on compressors if the temperature or humidity stays out of bounds for at least 30 seconds. The controller shuts down the fan if the temperature or humidity returns within bounds for 30 seconds.

When compressors are on, the compressor operates for at least the amount of time specified in the setting *Staged Comp: Stage Time* (regardless of whether the controller is configured for staging or compressor modulation) provided that the temperature has not recovered substantially. After the Stage Time has expired, compressor stages may be staged or de-staged as needed. If the temperature recovers substantially, the controller turns off outputs immediately.

If plant water flow is interrupted while the controller is operating, the controller immediately switches to fan mode and runs only the fan when there is a request for heating, cooling or dehumidification.

The controller may be configured to a single operating mode by its *Operating Mode* setting. An *Operating Mode* setting of "Winter" disables cooling sequences. An *Operating Mode* setting of "Summer" disables heating sequences.

The controller may be configured to a single operating mode from a network supervisor by using the nviApplicMode network input. The setting takes precedence over the *Operating Mode* setting.

Occupancy Mode

The HPL1-3 obtains occupancy information from the LCI, from network supervisor, from an external occupancy sensor or its own occupancy backup schedule.

Space Temperature Setpoint Operation

The space setpoint for the occupied and unoccupied modes are programmable values.

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Setpoints in Occupied Mode

The heating and cooling setpoints for the occupied periods are programmable offsets from the space setpoint. The zero energy band (ZEB) is the band between the heating and cooling setpoints where there is no heating or cooling demand.

The effective setpoint is a calculated value based on the space setpoint and the thermostat setpoint offset value. The thermostat setpoint offset increases or decreases the space setpoint from the local thermostat in occupied mode only. The thermostat setpoint offset is limited to plus or minus the programmed setpoint adjustment limit. The thermostat setpoint offset affects the calculated heating and calculated cooling setpoints by an equal amount.

> **NOTE:** The actual programmed heating and cooling setpoints are not changed by the thermostat setpoint offset; the offset is simply added to the programmed setpoints to derive the calculated values. If a thermostat is not used, the thermostat offset values are zero.

CoolingSp=SpaceSp+CoolingOffset

HeatingSp=SpaceSp-HeatingOffset

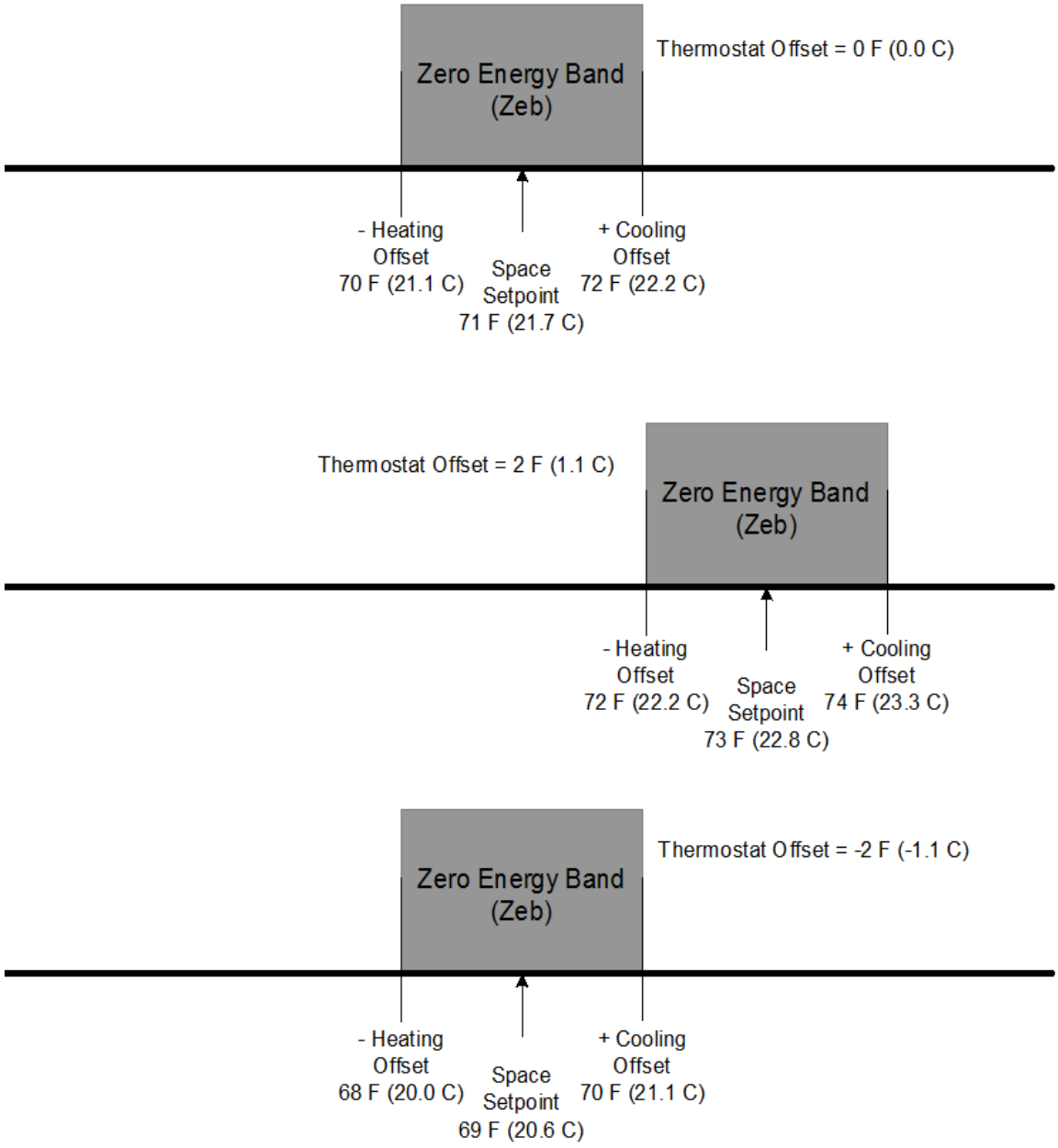
ZebOcc=CoolingSp-HeatingSp

EffectiveSetpoint=SpaceSp±ThermostatSpOffset

CalcCoolingSp=CoolingSp±ThermostatSpOffset

CalcHeatingSp=HeatingSp±ThermostatSpOffset

Figure 7: Setpoint Adjustment



Setpoint in Unoccupied mode

The heating and cooling setpoints for the unoccupied periods are directly programmable; they are not programmed as offsets. The zero energy band (ZEB) for unoccupied mode is the temperature range between the cooling setpoint and the heating setpoint. The space setpoint for unoccupied mode is calculated as the temperature that is halfway between the cooling setpoint and the heating setpoint, or midway into the zero energy band.

$$ZebUnocc=CoolingSp-HeatingSetpoint$$

$$SpaceSp=HeatingSp+ZebUnocc/2$$

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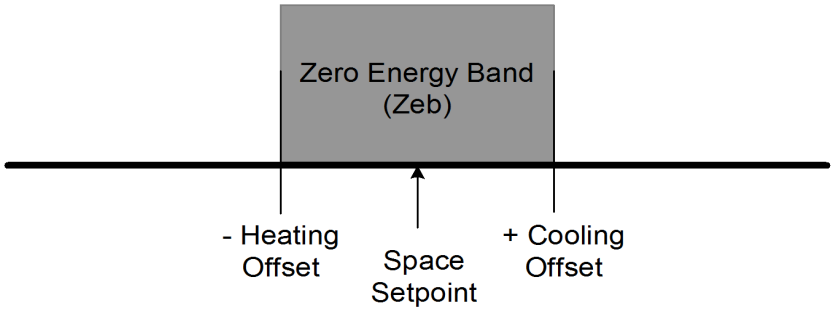
Figure 8: Space Setpoint Calculation - Unoccupied.



Heating Control

The controller provides support for up to 2 compressor stages during heating, or a single modulating 0-10V compressor. The user can select the type of heating through configuration variables.

The heating sequence is initiated when the current operating mode calls for heat.

Staged Heating

The compressor stages are sequenced based on the space temperature, the heating setpoint and the control band. When space temperature drops below its setpoint minus the control band, a stage is turned on. If space temperature remains below the control band for an additional time-period, the next available stage is turned on. This cycle continues until all available stages have been energized.

After space temperature has risen above its heating setpoint, the first available stage is turned off. If space temperature remains above the heating setpoint for an additional time-period, the next available stage is turned off. This cycle continues until all available stages have been de-energized. If space temperature rises above the heating setpoint plus control band, all of the stages cycle off immediately.

Figure 9: Staged Heat Sequence - Occupied Mode

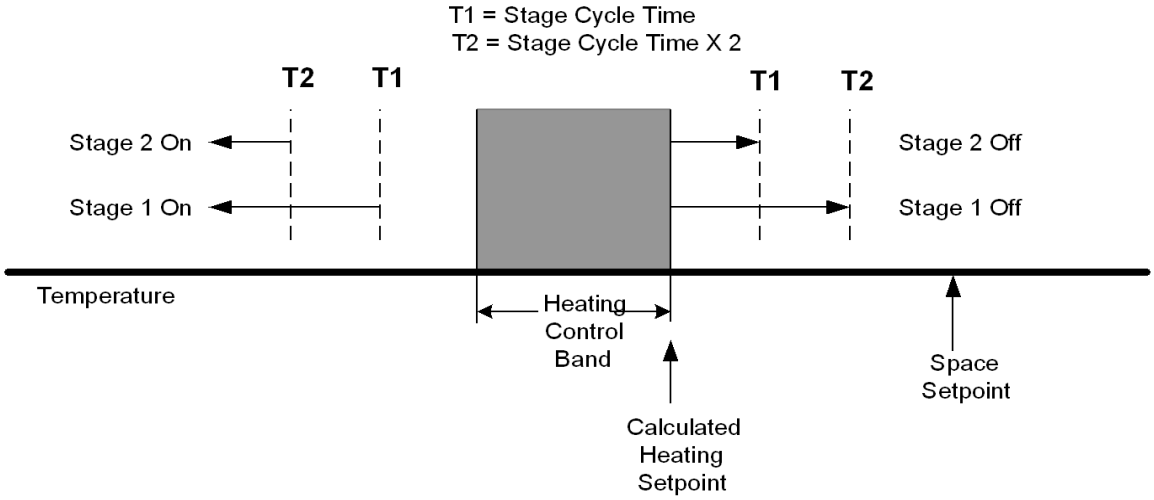
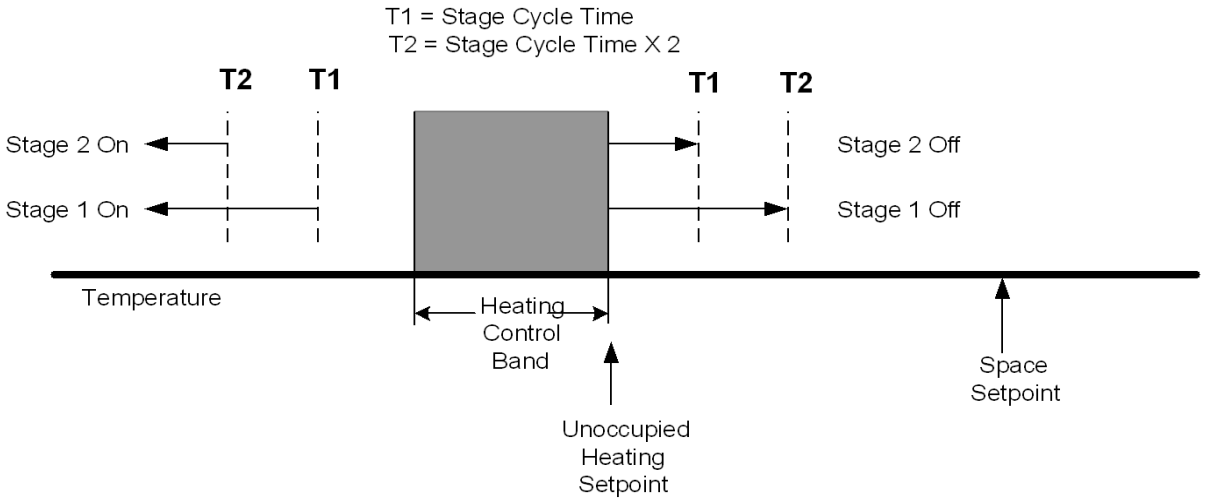


Figure 10: Staged Heat Sequence – Unoccupied Mode



Modulated Heating

The calculated heating loop setpoint is derived from the heating setpoint and the loop proportional gain:

CalcHeatingLoopSp=CalcHeatingSp-1/(2(K_p))

When heating, the analog Modulated Compressor (MOD) output is modulated by a Proportional + Integral (P+I) control loop based on the heating loop setpoint and the space temperature. The P+I control loop modulates the compressor, pump or valve to maintain a constant space temperature. As the temperature decreases below the heating loop setpoint, the output is modulated higher. As the temperature increases above the heating loop setpoint, the output is modulated lower. When unoccupied mode is entered, the heating loop setpoint is set back through a separate unoccupied heating setpoint.

To prevent the integral component from becoming too large, there is anti-wind up reset protection. This protection clamps the integral value when all of the components add up to more than 100% or less than 0%. The following equations are used for P+I control:

K_p=Proportional Gain

K_i=Integral Gain

Error=HeatingLoopSp-SpaceTemp

I=I+(K_i×Error)

HeatOutput=(K_p×(Error+I))+50.00%

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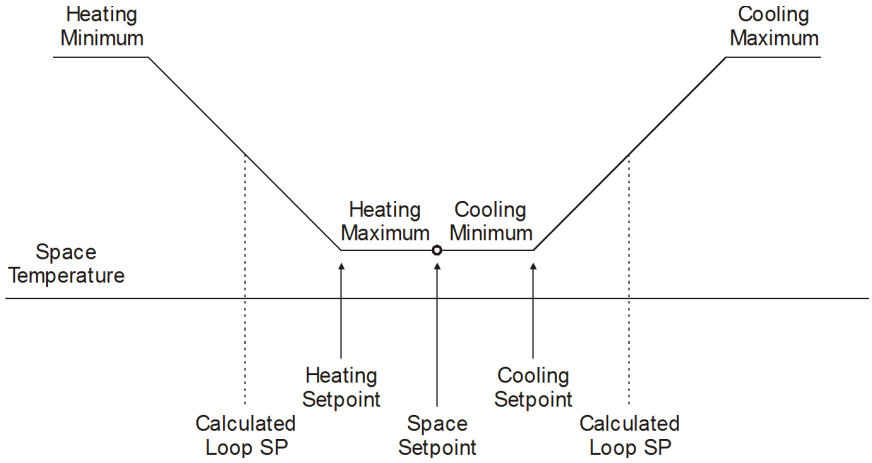
Figure 11: Modulated Heating Control



Cooling Control

The controller provides support for up to 2 compressor stages during cooling or a single modulating 0-10V compressor. The user selects the type of cooling through configuration variables.

The cooling sequence is initiated when the current operating mode calls for cooling.

Staged Cooling

The compressor stages are sequenced based on the space temperature, the cooling setpoint and the control band. When space temperature rises above the cooling setpoint plus the control band, a stage is energized. If space temperature remains above the control band for an additional time-period, the next available stage is energized. This cycle continues until all available stages have been energized.

After space temperature has dropped below the cooling setpoint, the first available stage is de-energized. If space temperature remains below the cooling setpoint for an additional time-period, the next available stage is de-energized. This cycle continues until all available stages have been de-energized. If space temperature drops below the cooling setpoint plus control band all of the stages are de-energized immediately.

Figure 12: Staged Cooling Sequence - Occupied

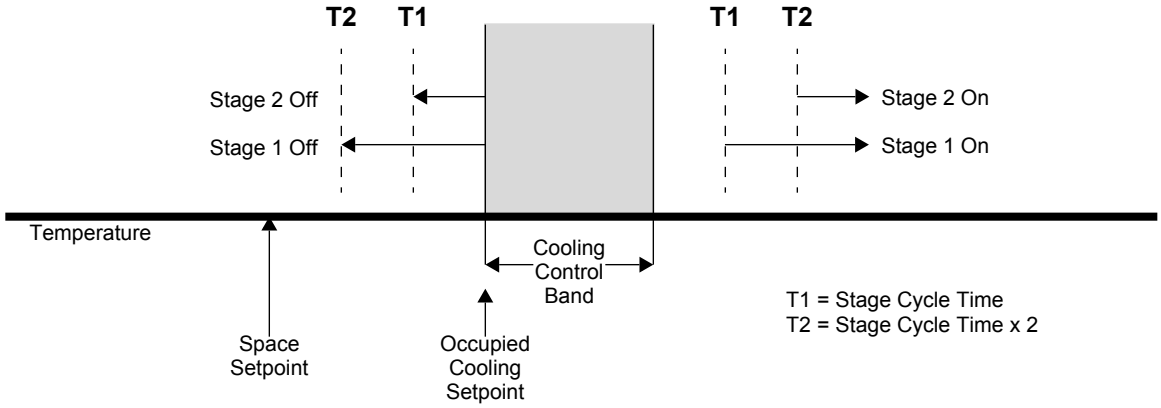
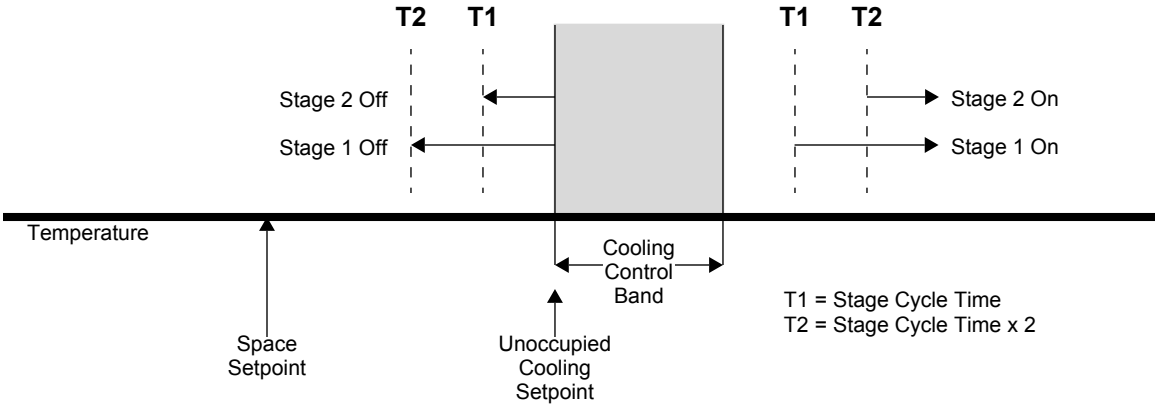


Figure 13: Staged Cooling Sequence - Unoccupied



Modulated Cooling

The calculated cooling loop setpoint is derived from the calculated cooling setpoint and the loop proportional gain:

$$CalcCoolingLoopSp=CalcCoolingSp+1/(2(K\_p))$$

When cooling, the analog Modulated Compressor (MOD) output is modulated by a Proportional + Integral (P+I) control loop based on the cooling loop setpoint and space temperature. The P+I control loop will modulate the output to maintain a constant space temperature. As the temperature increases above the cooling loop setpoint, the output is modulated higher. As the temperature decreases below the cooling loop setpoint, the output is modulated lower. When unoccupied mode is entered, the cooling setpoint is set up through a separate unoccupied cooling setpoint.

To prevent the integral component from becoming too large, there is anti-wind up reset protection. This protection clamps the integral value when all of the components add up to more than 100% or less than 0%. The following equations are used for P+I control:

$$K\_p=Proportional\ Gain$$

$$K\_i=Integral\ Gain$$

$$Error=SpaceTemp-CoolingLoopSp$$

$$I=I+(K\_i \times Error)$$

$$CoolOutput=(K\_p \times (Error+I))+50.00\%$$

Injection Pump Control

The injection pump control is responsible for maintaining supply water to a defined set of setpoints. Injection pump control is enabled whenever the injection pump modulation settings have minimum voltage or maximum voltage set to non-zero values.

The injection pump modulated output is intended for use with an injection pump supplying a LOFlo™ mixing block (or similar configuration). The LOFlo mixing block is able to warm supply water in cooling mode and cool supply water in heating mode to create supply water temperatures suitable for the heat pump.

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Supply Water Temperature Setpoint Operation

The setpoint for the Supply Water PI Loop is configured by the user. Separate setpoints for cooling and heating mode are provided.

Heating Mode

When the injection pump is enabled and the controller is in heating mode, a Proportional + Integral (P+I) control loop modulates the injection pump speed in order to maintain supply water to the defined high supply water temperature setpoint.

As supply water temperature increases above the setpoint, the injection pump speed is reduced. The injection pump speed in increased as supply water temperature falls below the setpoint.

To prevent the integral component from becoming too large, there is anti-wind up reset protection. This protection clamps the integral value when all of the components add up to more than 100% or less than 0%. The following equations are used for P+I control:

$K\_p = Proportional\ Gain$

$K\_i = Integral\ Gain$

$Error = SupplyWaterHighLimit - SupplyWaterTemp$

$I = I + (K\_i \times Error)$

$InjectionOutput = (K\_p \times (Error + I))$

NOTE: In Heating Mode, the injection pump can only mix the supply water temperature down (by slowing the injection pump speed). In Heating Mode, the injection pump cannot correct supply water temperatures that are too cold. To prevent the controller from attempting to heat, set the controller's *Application Mode* setting to "Summer".

Cooling Mode

When the injection pump is enabled and the controller is in cooling mode, a Proportional + Integral (P+I) control loop modulates the injection pump speed in order to maintain supply water to the defined low supply water temperature setpoint.

As supply water temperature increases above the setpoint, the injection pump speed is increased. The injection pump speed in reduced as supply water temperature falls below the setpoint.

To prevent the integral component from becoming too large, there is anti-wind up reset protection. This protection clamps the integral value when all of the components add up to more than 100% or less than 0%. The following equations are used for P+I control:

$K\_p = Proportional\ Gain$

$K\_i = Integral\ Gain$

$Error = SupplyWaterTemp - SupplyWaterLowLimit$

$I = I + (K\_i \times Error)$

$InjectionOutput = (K\_p \times (Error + I))$

NOTE: In Cooling Mode, the injection pump can only mix the supply water temperature up (by slowing the injection pump speed). In Cooling Mode, the injection pump cannot correct supply water temperatures that are too hot. To prevent the controller from attempting to cool, set the controller's *Application Mode* setting to "Winter".

Global Unit Enable

The controller may be synchronized to the main plant water supply through its global unit enable feature (located on the ASM2 controller) or its network input (nviUnitEnable). The status of the supply water flow is measured by an external device, and provided to the HPL over the network.

NOTE: The controller does not energize the compressor unless the Global Unit Enable signal is active.

Reheat

A reheat output is only available when *Dehumid Set: Mode* is configured as "External" or "Internal."

If reheat output is available and the space temperature falls below the Cooling Setpoint while the controller is dehumidifying, then the reheat output is activated.

If *Dehumid Set: Mode* is set to "Heat Pumps" then this output becomes a Zone Pump/Valve output.

Dehumidification

If the Setpoint is set to zero, dehumidification is disabled. Dehumidification is configured by setting *Dehumid Set: Setpoint* greater than 0%.

When the humidity is above the Setpoint, dehumidification begins. When the humidity drops below Setpoint minus 3%, dehumidification stops.

The DEH output signal indicates that dehumidification is required. Dehumidification stops when the Space Temperature drops below the Cooling Setpoint minus Shutoff offset.

For modes other than “Heat Pumps,” reheat begins when the Space Temperature drops below the Cooling Setpoint. In “Heat Pumps” mode, a separate reheat output is not available. Instead, a zone pump output is available that is active during dehumidification, cooling, and heating.

For dehumidification configurations other than “External,” a LOFlo mixing block maintains supply water temperatures to the cooling setpoint.

Dehumidification control requires the use of a TS302 or TS304 thermostat for measuring relative humidity. Alternately, humidity may be provided to the controller over the network by a supervisor.

Dehumidification may operate during occupied periods or always depending on the *Dehumid Set: Type* setting.

The *Dehumid Set: Mode* selection governs the behavior of the controller outputs when dehumidification is required.

External Dehumidification Mode

If *Dehumid Set: Mode* is set to “External,” then the following is true during dehumidification:

- DEH output is active.
- S1, S2, FAN, RV and INJ outputs are not active.
- RH output is managed.

The Reheat/Zone Pump (RH) output acts as a reheat output. It is active during dehumidification when the space temperature falls below the cooling setpoint.

In this mode, Dehumidification outputs DEH and RH are managed for dehumidification. Other outputs are managed independently based on ventilation, heating or cooling requirements.

Heat Pumps Dehumidification Mode

If *Dehumid Set: Mode* is set to “Heat Pumps,” then the following is true during dehumidification:

- S1, S2 and FAN outputs are not active.
- DEH output is active.
- RV output is set to cooling.
- The injection pump output will manage supply water temperature to the defined cooling setpoint.

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- RH output is active.

The Reheat/Zone Pump (RH) output acts as a zone pump output. It is active during dehumidification or any time the compressor stages are active.

In this mode, Dehumidification is the responsibility of the heat pump. The controller activates DEH to signal that dehumidification is required.

In this mode, S1, S2 and FAN outputs are deliberately suppressed unless cooling is also required.

Internal Dehumidification Mode

If *Dehumid Set: Mode* is set to “Internal,” the controller manages its own compressor sequence to cool and heat the space in order to dehumidify.

- S1 and FAN outputs are active.
- RH output is managed.
- RV output is set to cooling.
- DEH output is active.
- The injection pump output manages supply water temperature to the defined cooling setpoint.

The Reheat/Zone Pump (RH) output acts as a reheat output. It is active during dehumidification when the space temperature falls below the cooling setpoint.

The following table summarizes the behavior of the control outputs during dehumidification:

	Outputs						
Mode	**RV**	**S1**	**S2**	**Fan**	**DEH**	**RH**	**LOFlo Injection**
External	On/Off to Heat/Cool Demand			On/Off to Ventilation Demand	On	Reheat: On/Off	On/Off to Heat/Cool Demand
Heat Pumps	On/Off	Off*	Off*	Off*	On	Zone Pump: On	On
Internal	On/Off	On	Off	On	On	Reheat: On/Off	On

* In Heat Pumps Mode, S1 and Fan are on when cooling is also required. S2 is on when the second stage of cooling is configured and required.

Energy Monitoring

The HPL1-3 monitors supply and return temperatures and volumetric flow rate of the water loop. From these values, energy and volumetric data is calculated and made available to the LCI to display and log.

The most common installation option is to install the VFTS flow sensor in the Supply Water position. Use Precon sensors for both supply and return.

The controller reads the temperature sensors once per second and makes the temperatures available to the LCI where they are displayed in the controller's Inputs screen.

The flow sensor inputs are scaled voltage inputs from VFTS devices. The controller reads the flow sensors once per second and makes the flow rates available to the LCI where they are displayed in the controller's Inputs screen.

The loop temperature and flow sensors are enabled by default. To limit temperature, flow or BTU monitoring, the zone's "Zone Type" must be configured in the *BTU Settings* configuration screen:

- **Temp Only:** monitors only the zone temperatures, displayed on LCI Inputs screen each second.
- **Flow Only:** monitors only the volumetric flow, displayed on LCI Inputs screen each second.
- **BTU Zone:** monitors both temperature and flow, and calculates BTU energy and volume data each minute.
- **Disabled:** disables all monitoring for this zone.

BTU energy and volume data that is calculated each minute is displayed on the LCI in the controller's *Outputs* screen. The zone has the following data:

- Daily Heating BTUs (BTU)
- Life Heating BTUs (BTU)
- Daily Cooling BTUs (BTU)
- Life Cooling BTUs (BTU)
- Daily Volume (GAL)
- Life Volume (GAL)

Daily BTU totals and Daily Volume totals are reset to zero each day at midnight, but life totals are not reset at midnight. All totals may be reset to zero by selecting **Reset Totals** from the configuration page on the LCI.

Data is logged each day at midnight before it is reset to zero. The logged data is stored on the controller until it is uploaded to the LCI (manually or automatically).

The zone has both Heating and Cooling BTUs. The meaning of each depends on the configuration of the zone's "Zone Mode":

Zone Mode	Description
Auto	If the supply temperature is greater than the return temperature (i.e. the zone is heating) then BTUs are added to the Heating BTUs. If the supply temperature is less than the return temperature (i.e. the zone is cooling), BTUs are added to the cooling BTUs.
Heat	If the supply temperature is greater than the return temperature (i.e. the zone is heating) then BTUs are added to the Heating BTUs. If the supply temperature is less than the return temperature, BTUs are subtracted from the heating BTUs.
Cool	If the supply temperature is less than the return temperature (i.e. the zone is cooling) then BTUs are added to the Cooling BTUs. If the supply temperature is greater than the return temperature, BTUs are subtracted from the cooling BTUs.

The HPL1-3 uses the following formula to calculate the rate of heat energy flow:

$$q = (8.01 \times rho \times cp) \times f \times (dT)$$

Where:

q = the rate of heat energy flow (BTU/Hr)

rho = density (lb/ft3)

cp = specific heat (Btu/lb/°F)

f = flow rate (gpm)

dT = temperature change of fluid (°F)

8.01 = units conversion factor

To retrieve saved logs, select the **Retrieve Logs** button on the controller's screen.

NOTE: If the LCI prompts for the media instead of displaying the logs, select **CF Card**, then select the controller and the **Retrieve Logs** button again. This happens the first time each day that the logs are retrieved.

A total of three logs are displayed as follows:

Log Name	Description of Log Contents
Zone 0 Cool	31 daily totals of loop COOLING BTUs in ascending order by date.
Zone 0 Heat	31 daily totals of loop HEATING BTUs in ascending order by date.
Zone 0 Volume	31 daily totals of loop volume in ascending order by date.

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The controller is able to store 31 days of logged data. If the logged data is not uploaded after 31 days, the logs are automatically uploaded and saved on the LCI.

Logged data is saved in non-volatile memory on the controller before it is uploaded to the LCI - no data is lost if power is lost to the controller or LCI. If power is lost for more than one day, data for missed days shows a zero value. If power is lost for more than 31 days, logged data that has not been uploaded to the LCI is lost.

All logs uploaded to the LCI (manually or automatically) are available on the CF card.

Compressor Power Consumption

The HPL1-3 provides an analog input to measure the amount of energy used by the compressor that it controls. It is assumed that this input receives an analog input proportional to the instantaneous power (watts) consumed by the compressor. This analog value is scaled according to a configuration value entered by the user. The instantaneous power is displayed on the LCI Inputs screen.

This value is integrated over time to calculate the watt hours of energy used. The watt hours calculation is updated twice per minute. The watt hours value is sent to an associated master controller upon request.

Fan Configuration and Operation

The operation of the fan depends on the *Occupancy Mode* as shown on the Inputs screen of the LCI2 (“Occ” or “Unocc”), the configured *Fan Type* (“Auto” or “On”) and the configured *Fan OpMode* (“Not Used”, “Fan 1”, “Fan 2”, “Fan 3”, “Auto (Fan1-3)”, “Modulated” or “Configured”).

During occupied periods, the fan can be configured to run continuously or to cycle off when the space temperature is within the zero energy band. The zero energy band is defined as the temperature range between the cooling and heating setpoints. The fan is interlocked with the cooling and heating stages. If there is a call for heating or cooling, the fan energizes immediately. During the unoccupied period, the fan always cycles off when the space temperature is within the zero energy band.

If *Fan OpMode* is set to “Configured,” then the fan operation also depends on the *Unit Status / Mode* as shown on the Outputs screen on the LCI (“heating”, “cooling”, “dehumid”), whether there is an IAQ condition, and the *Fan Config* configuration setting.

The *Fan Type* configuration setting determines when the fan runs if the *Occupancy Mode* is “Occ” (occupied):

- “On” - The fan runs continuously
- “Auto” - The fan runs only if there is a heating or cooling demand

The fan may be overridden from the local thermostat (depending on the thermostat model).

Fan operation in unoccupied mode where the fan type is ignored, is identical to the fan operation in occupied mode if *Fan Type* is set to “Auto” and there is no IAQ alarm. In both cases, the fan operation is determined by *Fan OpMode* and the heating/cooling/dehumid state of the controller.

Fan OpMode determines which of the fan outputs are used when the fan runs:

- “Off” - There is no fan output.
- “Fan1”, “Fan 2”, or “Fan 3” - Digital Output FAN1, FAN2, or FAN3 is energized.
- “Auto (Fan1-3)” - Digital Outputs FAN1, FAN2, and FAN3 are energized as needed.
- “Modulate” - Analog Output FAN is used.
- “Configured” - Digital and Analog outputs per *Fan Config*.

A complete specification of all possibilities for Normal fan operation based on *Occupancy Mode*, *Fan Type*, *Fan OpMode* and *Heating/Cooling/Dehumid Mode* is summarized in Table 1 on page 32.

In addition to the fan operation described here, fan outputs may be overridden during commissioning (see “Commissioning” on page 34) or by a LON network manager through the use of the nviOutOverride SNVT (see “Network Inputs” on page 37).

> **NOTE:** If a fan status switch is not provided, the input must be jumpered to the adjacent common. After a fan failure, the controller's status LED turns solid red. To return the controller to normal operation after the failure condition is resolved, reset the controller by removing and reapplying power or by using the controller reset feature on the LCI. (See *iWorx® LCI2 Application Guide* for details.)

Fan OpModes

Modulated / Auto (Fan1-3)

When *Fan OpMode* is set to “Modulated” or “Auto (Fan1-3),” fan modulation and auto speed are dependent on the Supply Air Temperature (external sensor required). The calculated Supply Air Temperature (SAT) Setpoint is dependent on whether the HPL1-3 is heating or cooling. When the HPL1-3 is heating , the SAT setpoint is the SAT heating setpoint. When the HPL1-3 is cooling, the SAT setpoint is the SAT cooling setpoint. If present, the modulated FAN output or one of the digital FAN1, FAN2, or FAN3 outputs is active when the heat pump fan is energized. The output is modulated by a P+I control loop based on the SAT setpoint and the SAT input. The P+I control loop modulates the output to maintain a constant SAT. When the HPL1-3 is cooling, as the SAT increases above the SAT setpoint, the SAT output is modulated higher. The SAT output is modulated lower as the temperature decreases below the SAT setpoint. When the HPL1 is in heating mode, as the SAT decreases below the SAT setpoint, the SAT output is modulated higher. The SAT output is modulated lower as the temperature increases above the SAT setpoint.

There are two exceptions that override the output of the P+I control loop:

- While dehumidifying, the fan speed selection is fixed to the value specified by *Fan Config: Fan Dehumidification* or *Fan Config: Motor Speed Dehum*.
- When Air Quality is poor, the fan speed output is fixed at 100%.

Configured

When *Fan OpMode* is set to “Configured,” the application requires an additional configuration parameter (*Fan Config*) to define both the digital output (“FAN1”, “FAN2”, or “FAN3”) and the analog output (0 to 100%) used for cooling, heating, dehumidification, and maximum (or IAQ) conditions.

If the application requires configured analog outputs with a shared fan enable, the digital outputs must be set to the same fan (FAN1, FAN2, or FAN3).

Table 1: Normal Fan Operation

Occupancy Mode	Fan Set / Fan Type	Fan Set / Fan Op Mode	Mode	Fan Operation
Unocc	-	Off	-	All fan outputs are off
		1, 2, 3		Fan is digital output: FAN 1, FAN 2, or FAN 3 - the selection is configured in *Fan Speed*
		Auto Speed	-	Fan is digital output: speed based on SAT demand
			Dehumid	Digital outputs set to configured values for Dehumid
		Modulated	-	Fan is analog output: speed based on SAT demand
			Dehumid	Analog output set to configured values for Dehumid
		Configured	Heating	Analog / digital outputs set to configured values for Heating
			Cooling	Analog / digital outputs set to configured values for Cooling
			Dehumid	Analog / digital outputs set to configured values for Dehumid

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Occupancy Mode	Fan Set / Fan Type	Fan Set / Fan Op Mode	Mode	Fan Operation
Occ	Auto	Off	-	All fan outputs are off
		1, 2 3		Fan is digital output: FAN 1, FAN 2, or FAN 3 - the selection is configured in *Fan Speed*
		Auto Speed	-	Fan is digital output - speed based on SAT demand
			Dehumid	Digital outputs set to configured values for Dehumid
		Modulated	-	Fan is analog output: speed based on SAT demand
			Dehumid	Analog outputs set to configured values for Dehumid
		Configured	Heating	Analog / digital outputs set to configured values for Heating
			Cooling	Analog / digital outputs set to configured values for Cooling
			Dehumid	Analog / digital outputs set to configured values for Dehumid
		Off	An IAQ Condition Exists	All fan outputs are off (subject to minimum ON time)
		1, 2, 3		Fan is digital output: FAN 1, FAN 2, or FAN 3 - the selection is configured in *Fan Speed*
		Auto Speed		Fan is digital output: FAN 3
		Modulated		Fan is analog output: speed is 100%
		Configured		Analog / digital outputs set to the configured values for Max
	On	Off	-	All fan outputs are off
		1, 2, 3		Fan is digital output: FAN 1, FAN 2, or FAN 3 - the selection is configured in *Fan Speed*
		Auto Speed		Fan is digital output: FAN 1
		Modulated		Fan is analog output: 33%
		Configured		Analog / digital outputs set to Minimum of configured settings

Indoor Air Quality

An indoor air quality (IAQ) input is provided. The IAQ sensor can be a digital sensor providing an on/off signal or a configurable analog sensor.

The digital sensor requires only the *Delay* and *Temperature Reset* settings to be configured. An IAQ condition is said to exist if the digital IAQ input is energized.

The analog sensor requires the settings *Deadband*, *Temperature Reset*, *Delay*, *Min*, *Max*, *Setpoint*, and *Offset* to be configured. An IAQ condition is said to exist if the analog IAQ sensor input exceeds the configured setpoint.

When an IAQ condition exists, the supply air fan is energized to supply fresh air to the space. The *Delay* setting determines the time delay to wait before signaling an IAQ Alarm. This delay affects the Alarm only; the fan operates without delay.

Thermostat

The space temperature value, setpoint adjustment, fan auto/on status and speed (depending on the thermostat model), and occupancy override request are monitored by the thermostat and sent to the controller.

When the thermostat fails, the compressor stages turn off, the fan turns off, and control is disabled.

A thermistor may be used in place of the thermostat for applications that require a more basic means of monitoring space temperature without local control capabilities. Without the TS302 or TS304 thermostat, dehumidification control by the controller is only available if humidity values are supplied by the network.

> **NOTE:** When configured for a thermostat, the thermostat must be connected to the controller. The status LED on the controller blinks red if the thermostat is not connected. Once the controller begins receiving temperature data, the status LED turns green indicating normal operation.
>
> **NOTE:** The Space Temperature can also be acquired by a Precon II or III sensor. The *Thermostat: Type* setting must be set to “Precon II” or “Precon III.”

When the thermostat is put into occupied mode for the purpose of changing the temperature setpoint settings, the amount of extended occupancy is accumulated. The extended occupancy time is accumulated in minutes and may be viewed from the LCI under *Thermostat Settings*. The extended occupancy time is backed up to non-volatile memory at 11:00 pm. The user may clear the accumulated extended occupancy from the LCI.

Local Backup Schedule

Normally, the LCI determines the operating mode. Local weekday and weekend backup schedules may be configured for situations when the LCI is not available. When the controller detects that the LCI is not available (after 10 minutes without communication), it resorts to the local backup schedules. If the local backup schedules are disabled, the controller defaults to the occupied mode. Occupied and Unoccupied times determine the operating mode of the controller when it is running a backup schedule. By default, both the unoccupied and occupied times are set to zero, which disables the local backup schedule which causes the controller to default to the occupied mode of operation if it cannot communicate with the LCI.

Runtime Accumulations

The total runtime is accumulated for the compressor, fan, and injection pump. The runtimes can be used to indicate that maintenance is required on the equipment controlled by these outputs. The runtimes can be reset by an operator or maintenance personnel once service has been performed.

Commissioning

The HPL1-3 provides the ability to override normal operation through the LCI using the Commissioning mode. The Commissioning mode is accessed using the Commissioning Mode configuration structure. When Commissioning mode is enabled, values in the Commissioning structure are used for outputs.

Commissioning Outputs

The HPL1-3 has a commissioning SNVT that allows the user to override the operation of the outputs. When leaving commissioning mode, the power-on delay is enforced.

Alarms

The controller detects alarm conditions and sends them to the LCI. Before this can occur, the controller must be communicating on the LCI’s LON network. If the controller is in any alarm situation, its status LED turns red. Otherwise, the status LED is green.

Fan Failed Alarm

The controller monitors the status of the fan proof digital input and generates a Fan Failed Alarm if detected. When the fan is initially turned on, there is a 30 second delay before the fan status is checked. If the contact is still open after the delay, indicating equipment failure, the compressor stages turn off and the fan turns off. The status LED on the controller turns solid red. The controller must be reset to clear this condition.

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Thermostat Failure Alarm

The controller automatically detects the presence of the local thermostat and monitors its status. If the thermostat fails to communicate with the controller, a Thermostat Failed Alarm is generated and the controller's status LED turns red.

Supply Water Temperature High/Low Alarm

This alarm is generated when the supply water is above or below user-defined thresholds. The controller sends a return to normal message to the LCI when the condition is resolved.

Return Water Temperature High/Low Alarm

This alarm is generated when the supply water is above or below user-defined thresholds. The controller sends a return to normal message to the LCI when the condition is resolved.

Space Temperature Alarms

The controller generates high and low limit alarms for the space temperature. The user can configure a programmable space temperature alarm limit offset. The temperature limits are calculated based on the control setpoints and alarm limit offset. When the measured space temperature exceeds the high limit, a high limit alarm (Space Temperature High Limit Alarm) is generated. When the space temperature drops below the low limit, a low limit alarm is generated (Space Temperature Low Limit Alarm). A return to normal alarm is generated when the space temperature is between the high and low limit (Space Temperature Return to Normal). To help eliminate nuisance alarms when the controller switches between the unoccupied and occupied modes of operation, space temperature alarms are not reported for 30 minutes following the switch.

Runtime Maintenance Alarm

The controller provides programmable run limits for generating runtime Maintenance alarms. When the compressor, fan, or injection limits are exceeded, a Maintenance alarm is sent to the LCI.

Filter Status

The filter status input is monitored to determine if the filter is operating properly. The input is used to indicate that maintenance is required on the filter. The controller application is not shutdown due to a filter alarm.

Indoor Air Quality Alarm

When indoor air quality issues are signaled for a configurable period of time, the controller sends an Indoor Air Quality alarm to the LCI. The controller sends an IAQ back to normal message to the LCI when the condition is resolved.

Automatic Configuration

The HPL1-3 and Local Control Interface (LCI) use a self-configuring network management scheme requiring no external tools, binding, or LonWorks knowledge. The LCI recognizes and configures the controller when the controller's service pin is pressed. The controller's status light flashes green until the controller is configured and is solid green after the controller is configured. Once the service pin has been pressed, no further action is required by the user; the controller is fully accessible to the LCI.

The LCI also provides network supervision of the controller. The LCI periodically sends a "ping" message to the controller which elicits a response. If the response fails, an alarm is displayed on the LCI. The LCI also uses the "ping" message to refresh the occupancy mode and other system wide data.

Power-On Delay

During Power-On Delay, the controller outputs are turned off for 30 seconds. Digital outputs are not energized. Modulated outputs supply minimum voltage as configured by the "Out Min" setting for the modulated output. The Power-On Delay occurs when power is cycled, when the controller is reset from the LCI2, when compressor-related configuration parameters are changed, and when leaving Commissioning Mode.

Communications

The HPL1-3 communicates demand and operational info to and from its associated master controller and the LCI.

Master Controllers

The following master controllers can associate with the HPL1-3:

- CCU2 - Chiller Controller
- GHP - Geothermal Heat Pump Controller (Heat/Cool)
- LHP - Geothermal Heat Pump Controller (Heat/Cool)
- HPM - Heat Pump Master Controller (Heat/Cool)
- BLMC - Boiler Control Module
- ASM2/CSM1 - Auxiliary Sensor Module

Communication between HPM, CCU2, GHP, LHP2 and the HPL1-3

The HPL1-3 automatically reports demand and alarm status to the HPM, CCU2, GHP, LHP2.

Communication between ASM2/CSM1 and the HPL1-3

The ASM2 or CSM1 is able to collect zone humidity from the HPL1-3 and other controllers then report an averaged value back to the network.

Communication between GHP and HPL1-3

The HPL1-3 responds to periodic power usage data requests from a GHP.

Communication between BLMC and HPL1-3

The HPL1-3 responds to periodic demand requests from a BLMC.

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CONTROLLER IDENTIFICATION

Once the HPL1-3 is properly installed and recognized by the LCI, the LCI is used to configure the settings of the controller. This section describes the commands available on the LCI for configuration of the HPL1-3, and the meanings and default values for controller parameters. For more information on using the LCI, see the *iWorx® LCI Application Guide*.

Network Inputs

The HPL1-3 allows a network manager to write to Network Input Variables for the purpose of overriding the configuration, operation and outputs of the HPL1-3. The variables are listed below and in “Network Variable Inputs (NVIs)” on page 37. Values written to NVIs have absolute priority over any other controller operation.

- *nviSpaceTemp* overrides the space temperature as obtained from the thermostat, sensor, or ASM module and is used by the controller for temperature control. Writing to this variable is also reflected in the controller's output of the space temperature as displayed on the LCI.
- *nviSpaceHumidity* overrides the space humidity as obtained from the thermostat, sensor, or ASM module and is used by the controller for dehumidification control. Writing to this variable is also reflected in the controller's output of the space temperature as displayed on the LCI.
- *nviSetpoint* overrides the setpoint as obtained from the thermostat, the LCI or from a pre-configured schedule. Writing to this variable is also reflected in the controller's output of the effective setpoint as displayed on the LCI.
- *nviOccCmd* overrides the occupancy as obtained from the thermostat. Writing to this variable is also reflected in the controller's output of the occupancy mode. Note that this is NOT the occupancy sensor. The occupancy sensor hardware input (OCC) is still displayed on the LCI based on its configuration.
- *nviResetRuntime* is a command to reset the fan, compressor and pump runtimes. If the value sent is 0, then no reset occurs; if the value sent is 1, then the runtimes are reset.
- *nviSysTime* is a time stamp to set the date and time. Writing to this variable will change the time on the device and will affect all time-related functions such as schedules.
- *nviUnitEnable* may be used by a network supervisor to enable the controller.
- *nviOutOverride* is a structure defined in Table 4 that overrides the hardware digital and analog outputs on the HPL1-3. These values allow the network controller to directly control the analog and digital outputs of the board. Additionally, the two floating setpoint outputs may be set directly.
- *nviApplicMode* is the Application Mode set by a supervisor. The Application recognizes only the values listed below and disregards any other supervisor setting.

Table 2: Network Variable Inputs (NVIs)

Internal Variable Name	Format	Range	Description
nviSpaceTemp	SNVT_temp_p	-29 to 230°F (-34 to 110°C)	Space temperature override
nviSpaceHumidity	SNVT_lev_percent	0 to 100 percent	Space humidity override
nviSetpoint	SNVT_temp_p	-29 to 230°F (-33 to 210°C)	Setpoint override
nviOccCmd	SNVT_occupancy	0=Occupied 1=Unoccupied 2=Bypass 3-Standby	Occupancy Command
nviResetRuntime	SNVT_lev_disc	0=no reset 1=reset runtimes	Resets fan, compressor, and injection pump runtimes
nviSysTime	SNVT_time_stamp	Date/Time	System time

Internal Variable Name	Format	Range	Description
nviUnitEnable	Unsigned Byte	0=Off 4=On	Global unit enable override
nviOutOverride	Structure	Structure	Output override - see below
nviApplicMode	Non-standard enumeration	0=Auto 1=Heat 3=Cool 9=FanOnly 12*=Dehumid	Application Mode override

Table 3: Output Override Structure (NVI)

Name	Type/Range	Default	Description
digOut[8]	Unsigned Byte: 0=OFF 1=ON 0xFF=no override	0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF 0xFF	digOut[0] = TO1 (pin 31) S1 digOut[1] = TO2 (pin 29) S2 digOut[2] = TO3 (pin 28) RV digOut[3] = TO4 (pin 26) RH digOut[4] = TO5 (pin 25) FAN1 digOut[5] = TO6 (pin 23) FAN2 digOut[6] = TO7 (pin 22) FAN3 digOut[7] = TO8 (pin 20) DEH
aOut[4]	SNVT_lev_percent: 0% to 100% 32767=no override	32767 32767 32767	aOut[0] = AO 0 (pin 37) MOD aOut[1] = AO 1 (pin 35) INJ aOut[2] = AO 2 (pin 34) FAN
fpOut[4]	SNVT_lev_percent: 0% to 100% 32767=no override	32767 32767 32767 32767	fpOut[0] = unassigned fpOut[1] = unassigned fpOut[2] = unassigned fpOut[3] = unassigned

Inputs

Network Variable Outputs (NVOs) are parameters set by the controller to pass data to another device or network controller. The "output" nature of these variables refers to the fact that the data is sent out from the controller. Data represents controller inputs or derived (calculated) values in the LCI.

Name	Range	Description
Occupancy mode	Occ, Unocc, Bypass, Invalid	Current occupancy mode
Space Temperature	-22 °F to 122 °F (-30 °C to 50 °C)	Space temperature reading
IAQ	0 to 4000 ppm	Reading of the indoor air quality sensor when configured for analog input. This is a hardware input.
Heating-Cooling	Structure	Sensor readings for the Heating/Cooling loop
Supply Air Temp	-22 °F to 122 °F (-30 °C to 50 °C)	Supply Air Temperature
Return Air Temp	-22 °F to 122 °F (-30 °C to 50 °C)	Return air temperature

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Input Status	Structure	Lists all digital inputs
Inst Power	0.0 to 3.4e38 Watts	Power Usage Reading from the heat pump power transducer (Watts)
Space Humidity	0.0 to 100.0 %	Relative Humidify

Heating-Cooling

Setting	Range	Description
Mode	Auto, Heat, Cool	Current Mode of the Loop
Supply Temp	-29 to 230°F (-34 to 110°C)	Supply Temp of the Loop
Return Temp	-29 to 230°F (-34 to 110°C)	Return Temp of the Loop
Flow Rate	0-3.4e38 GPM	Current Flow Rate
Energy Rate	0-3.4e35 KBTU/hr	Current Energy Rate

Input Status

This structure displays information related to the HPL's input pins.

Name	Range	Description
Outside Temp	-60 to 230 °F (-51.1 to 110 °C)	Outside air temperature as reported by the ASM controller
Fan Proof	Off, On	Status of the Fan Proof (FNP) input
Indoor Air Quality	Normal, Alarm	Status of the Indoor Air Quality Alarm (IAQ) input
ExtOccupancy Sensor	Off, On	Status of the Occupancy Sensor (OCC) input
Filter Alarm	Normal, Alarm	Status of the Filter Alarm (FIL) input
Heat Stage Enabled	Off, On	Value is "On" if at least one heat stage is active.
Heat Mod Enabled	Off, On	Value is "On" if heat modulation is active.
Heat Inj Enabled	Off, On	Value is "On" if heat injection is active.
Cool Stage Enabled	Off, On	Value is "On" if at least one cool stage is active.
Cool Mod Enabled	Off, On	Value is "On" if cool modulation is active.
Cool Inj Enabled	Off, On	Value is "On" if cool injection is active.

Outputs

Network Variable Outputs (NVOs) are parameters set by the controller to pass data to another device or network controller. The "output" nature of these variables refers to the fact that the data is sent out from the controller. Data represents controller outputs or derived (calculated) values in the LCI.

Name	Range	Description
Application Mode	Off, Auto, Heat, Cool, Fan, Dehumid	Application mode where Heat is "Winter Season" and Cool is "Summer Season."
Unit Status	Structure	Digital Input State
Output Status	Structure	Status of the outputs

Runtimes	Structure	Runtimes for the compressor, fan and injection pump.
BTU Data	Structure	BTU Meter Values for heating/cooling. These are calculated values.
Voltage Levels	Structure	Voltage levels for analog outputs.
Day of Week	Sun to Sat	Current day of week.

Unit Status

This structure displays information related to unit status.

Name	Range	Description
Mode	Heat, Cool, Dehumid, Fan, Off	HVAC mode of operation. This parameter provides real-time status of what the controller is actually doing.
Heat Output	0 to 100%	Current compressor heat output (PI loop output when modulated or stage#/total stages)
Heat Inj Output	0 to 100%	Injection heating PI output.
Cool Output	0 to 100%	Current compressor cool output (PI loop output when modulated or stage#/total stages)
Cool Inj Output	0 to 100%	Injection cooling PI output.
Fan Output	0 to 100%	Current Fan Output (modulated value or converted fan speed: Fan 1 = 33%, Fan 2 = 66%, Fan 3 = 100%)
In Alarm?	No, Yes	Is the unit in an alarm state?

Output Status

This structure displays digital HPL output status.

Name	Range	Description
Stage 1	Off, On	Status of Stage 1 (S1) output
Stage 2	Off, On	Status of Stage 2 (S2) output
Reversing Vlv	Off, On	Status of the Reversing Valve (RV) output
Reheat/Zone	Off, On	Status of the Reheat/Zone Pump (RH) output. See Dehumidification topic for further details.
Reheat/Zone Src	Reheat, Zone	Describes the function of the RH output pin. This field is directly related to the *Dehumid Set: Mode* selection. When *Dehumid Set: Mode* is “Heat Pumps,” RH is a Zone Pump output. When *Dehumid Set: Mode* is “Internal” or “External,” RH is a Reheat output.
FAN1	Off, On	Status of the Fan 1 (FAN1) output
FAN2	Off, On	Status of the Fan 2 (FAN2) output
FAN3	Off, On	Status of the Fan 3 (FAN3) output
Dehumid	Off, On	Status of the Dehumid (DEH) output

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Runtimes

This structure displays information related to runtimes.

Name	Range	Description
Compressor	0 to 65535 hours	Compressor runtime
Injection	0 to 65535 hours	Injection pump runtime
Fan	0 to 65535 hours	Fan runtime

BTU Data

Output	Range	Description
Daily Heating BTUs	-3.4e38 to +3.4e35 KBTU	Reports BTUs used for Heating for the current day up to this minute
Life Heating BTUs	-3.4e38 to +3.4e35 KBTU	Reports the BTUS for Heating since last reset
Daily Cooling BTUs	-3.4e38 to +3.4e35 KBTU	Reports BTUs used for Cooling for the current day up to this minute
Life Cooling BTUs	-3.4e38 to +3.4e35 KBTU	Reports the BTUS for Cooling since last reset
Daily Volume	-3.4e38 to +3.4e38 G	Reports the Volume used for the current day up to this minute
Life Volume	-3.4e38 to +3.4e38 G	Reports the Volume used since last reset

Voltage Levels

This structure displays voltages at the 0-10V analog output pins.

Name	Range	Description
Fan	0 to 10 V	Voltage applied to the analog FAN output pin.
Inj	0 to 10 V	Voltage applied to the analog INJ output pin.
Mod	0 to 10 V	Voltage applied to the analog MOD output pin.

Configuration

Once the HPL1-3 is properly installed and recognized by the Local Control Interface (LCI2), the LCI2 can be used to configure the settings of the controller. This section describes the commands available on the LCI2 for configuration of the HPL1-3, and the meanings and suggested values for controller configuration parameters. For more information on using the LCI2, see the *iWorx® LCI Application Guide*.

All Settings

Displays all of the HPL1-3‘s setpoints and editable settings and provides access to edit all HPL1-3 parameters from a single screen. Some of the parameters are structures and are described in individual tables below this table.

Setting	Range	Default	Description
Thermostat	Structure	N/A	Thermostat Settings
Setpoints	Structure	N/A	Setpoint Settings
Operating Mode	Auto, Summer, Winter,	Auto	Application mode where Heat is “Winter” and Cool is “Summer.”
Staged Comp	Structure	N/A	Compressor Stage Settings
Modulated Comp	Structure	N/A	Modulated Compressor/Zone Settings
Rev Vlv Action	Energize on Heat, Energize on Cool	Energize on Cool	Reverse Valve Action Settings Energize on Cool; Cool=1, Heat=0 Energize on Heat; Cool=0; Heat=1

Setting	Range	Default	Description
Anti Cycle Timer	Structure	N/A	Settings for compressor min off and min on time
SAT Setpoints	Structure	N/A	Settings related to supply air temperature setpoints
Fan Set	Structure	N/A	Fan configuration
Fan Mod	Structure	N/A	Settings related to modulated fan control
Fan Config	Structure	N/A	Fan Speed and Digital Output Choice Configuration
Supply Water Setpt	Structure	N/A	Supply water temperature setpoints for heating or cooling mode.
Inj Settings	Structure	N/A	Settings for the heat injection loop for the LOFlo heating circulator
Dehumid Set	Structure	N/A	Dehumidification Settings
IAQ Mode	Digital, Analog	Digital	Type of IAQ Sensor
IAQ Settings	Structure	N/A	IAQ settings for Setpoint, Deadband, and Temperature limits
IAQ Sensor	Structure	N/A	Settings for the IAQ analog Sensor
Runtime Limits	Structure	N/A	Runtime limits for the compressor, fan and injection pump.
BTU Settings	Structure	N/A	BTU meter settings
Power Scale	100-10000 Watts	1000 Watts	Power Tran
Supply Water Alarm	Structure	N/A	Supply Water Temperature Alarm Settings
Return Water Alarm	Structure	N/A	Supply and Return Water Temperature Alarm Settings
WDay Occ. Time	Structure	N/A	Hour and minute to begin the occupied period for the weekday local backup schedule.
WDay Unocc. Time	Structure	N/A	Hour and minute to begin the unoccupied period for the weekday local backup schedule.
WEnd Occ. Time	Structure	N/A	Hour and minute to begin the occupied period for the weekend local backup schedule.
WEnd Unocc. Time	Structure	N/A	Hour and minute to begin the unoccupied period for the weekend local backup schedule.
Commissioning	Structure	N/A	Commissioning overrides of the controller outputs
Day of Week	Not Set, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday	Not Set	Adjusts the controller day of week. *Day of Week* is used for selecting the weekly or weekend occupancy schedule. Use "Not Set" unless *Outputs: Day of Week* does not match the current day.
Use Global Unit Enable?	No, Yes	Yes	Specifies whether the controller observes and follows the Global Unit Enable signal.

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Thermostat

This screen displays settings related to the thermostat and allows access to all of these settings from a single screen.

Setting	Range	Default	Description
Type	SLink, Precon-III, Used for RH, Not Used	SLink	Type of Thermostat or sensor
Occupancy Extension	0 to 1000 minutes	60 min	Allowable occupancy extension time.
Alarm Temp Offset	0 to 10.0 °F (0 to 5.56 °C)	5 °F (2.8 °C)	Degrees below the heating setpoint or above the cooling setpoint to trigger a low limit or high limit alarm. Zero disables the alarm.
Temperature Offset	-10.0 to 10.0 °F (-5.56 to +5.56 °C)	0 °F (0 °C)	The amount of offset applied to a Precon Type II or Type III sensor.
Accumulated Ext Occ	0 to 1000 min	0 min	Number of minutes the controller has been overridden from the thermostat.

Setpoints

This screen displays settings related to space temperature setpoints and allows access to all of these settings from a single screen.

Setting	Range	Default	Description
Setpoint	50 to 95 °F (10 to 35 °C)	71 °F (21.2 °C)	Setpoint for occupied time periods
Cooling Offset	0 to 10.0 °F (0 to 5.56 °C)	1 °F (0.6 °C)	This value is added to Setpoint to calculate the cooling setpoint
Heating Offset	0 to 10.0 °F (0 to 5.56 °C)	1 °F (0.6 °C)	This value is subtracted from Set-point to calculate the heating setpoint
SP Adjust Limit	0 to 10.0 °F (0 to 5.56 °C)	2 °F (1.2 °C)	Maximum setpoint adjustment allowed during occupied periods
Unocc Cooling	50 to 95 °F (10 to 35 °C)	82 °F (27.7 °C)	Cooling setpoint for unoccupied time periods
Unocc Heating	50 to 95 °F (10 to 35 °C)	60 °F (15.5 °C)	Heating setpoint for unoccupied time periods

Staged Comp

This screen displays settings related to compressor staging and allows access to all of these settings from a single screen.

Setting	Range	Default	Description
Stages	0 to 2	2	Number of compressor stages.
Control Band	0 to 10.0 °F (0 to 5.56 °C)	1 °F (0.6 °C)	Heating and cooling stage control band.
Stage Time	0 to 255 minutes	5 minutes	Compressor control cycle timer.

Modulated Comp

This screen displays settings related to the modulated compressor and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Gain	-4 to +5	0	Gain, index into array of Kp and Ki control
On	0.00 to 100.00%	50.0 %	Minimum output to turn on
Ramp up	0.00 to 20.00%	1.0 %	Ramp up percent per second
Ramp down	0.00 to 20.00%	0.5 %	Ramp down percent per second
Out min	0.0 to 10.0 Volts	0.0 Volts	Maximum output voltage for modulation
Out max	0.0 to 10.0 Volts	0.0 Volts	Maximum output voltage for modulation. If set to 0, Modulation is disabled.

Anti Cycle Timer

This screen displays settings related to the anti cycle limits.

Setting	Range	Default	Description
Min On Time	0 to 100 minutes	2 minutes	Minimum amount of time the compressor must stay on upon turning on.
Min Off Time	0 to 100 minutes	2 minutes	Minimum amount of time the compressor must stay off upon turning off.

SAT Setpoints

This screen displays settings related to the supply air temperature setpoint and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
SAT Cool SetPt	40 to 80°F (4.4 to 26.7°C)	55 °F (12.8°C)	Specifies the target temperature for cool air supply
SAT Heat SetPt	60 to 100°F (15.5 to 37.8°C)	85 °F (29.4 °C)	Specifies the target temperature for heated air supply

Fan Set

This screen displays settings related to fan operation.

Setting	Range	Default	Description
Fan Type	Auto,On	Auto	Auto, or On when occupied
Fan OpMode	Not Used, Fan 1, Fan 2, Fan 3, Auto (Fan1-3), Modulated, Configured	Fan 1	- Fan 1, 2, 3 - User sets fan choice directly - Auto (Fan 1-3) - Digital speed selection based on SAT - Modulated - Modulation based on SAT - Configured - User sets digital and analog outputs to user configured values

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Fan Mod

This screen displays settings related to the modulated fan and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Kp	0.00 to 100.00%	5 %	Ramp up percent per second
Ki	0.00 to 100.00%	0.05 %	Ramp down percent per second
Out min	0.0 to 10.0 Volts	0.0 Volts	Maximum output voltage for modulation
Out max	0.0 to 10.0 Volts	10.0 Volts	Maximum output voltage for modulation. If set to 0, Modulation is disabled.

Fan Config

This screen displays settings related to fan speed while Fan Set: Fan OpMode is set to "Configured"

Setting	Range	Default	Description
Fan Dehumidification	Not Used, Fan 1, Fan 2, Fan 3	Fan 1	Fan choice used for dehumidification
Motor Speed Dehum	0.0 to 100.0 %	33.34 %	Fan output used for dehumidification
Fan Cooling	Not Used, Fan 1, Fan 2, Fan 3	Fan 1	Fan choice used for cooling
Motor Speed Cooling	0.0 to 100.0 %	0.0 %	Fan output used for cooling
Fan Heating	Not Used, Fan 1, Fan 2, Fan 3	Fan 1	Fan choice used for heating
Motor Speed Heating	0.0 to 100.0 %	0.0 %	Fan output used for heating
Fan Max	Not Used, Fan 1, Fan 2, Fan 3	Fan 1	Fan choice used for IAQ/Max
Motor Speed Max	0.0 to 100.0 %	0.0 %	Fan output used for IAQ/Max

Supply Water Setpt

This screen displays supply water temperature setpoints required for injection control and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Heating	0 to 160 °F (-18 to 71 °C)	80.0 °F (26.7 °C)	Heat pump supply water temperature high limit. In heating mode, the injection pump slows to mix cool zone return water when the supply temperature is above the limit.
Cooling	0 to 160 °F (-18 to 71 °C)	70.0 °F (21.1 °C)	Heat pump supply water temperature low limit. In cooling mode, the injection pump slows to mix warm zone return water when the supply temperature is below the limit.

Inj Settings

This screen displays settings related to the LOFlo injection pump modulation and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Gain	-4 to +5	-2	Gain, index into array of Kp and Ki control
On	0.00 to 100.00%	38.0 %	Minimum output to turn on
Ramp up	0.00 to 20.00%	1.0 %	Ramp up percent per second
Ramp down	0.00 to 20.00%	0.5 %	Ramp down percent per second
Out min	0.0 to 10.0 Volts	0.0 Volts	Maximum output voltage for modulation
Out max	0.0 to 10.0 Volts	10.0 Volts	Maximum output voltage for modulation. If set to 0, Modulation is disabled.

Dehumid Set

This screen displays settings related to dehumidification and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Type	Occupied, Always Enabled	Occupied	Type of dehumidification.
Setpoint	0.0 to 100.0 %	0.0 %	Dehumidification setpoint. A value of 0.0 disables dehumidification.
Shutoff Offset	0 to 10.0 °F (0 to 5.6 °C)	2 °F (1.2 °C)	Dehumidification shutoff offset
Mode	External, Heat Pumps, Internal	External	Configures reheat/zone pump output and controls sequencing of the dehumidification output, compressor outputs and reheat/zone pump output. See Dehumidification topic for details.

IAQ Settings

This screen displays settings related to indoor air quality and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
IAQ Delay Time	0 to 1000 minutes	5 minutes	Delay after IAQ condition occurs before sending an alarm
Temp Reset Limit	0 to 15.0 °F (0 to 8.3 °C)	0 °F (-17.8 °C)	To insure comfort temperature during IAQ alarm conditions
Deadband	0 to 400 ppm	100 ppm	Deadband around setpoint for hysteresis

IAQ Sensor

This screen displays settings related to the indoor air quality sensor and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Min	0 to 4,000 ppm	0 ppm	Minimum of range

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Setting	Range	Default	Description
Max	0 to 4,000 ppm	2,000 ppm	Maximum of range
Setpoint	0 to 4,000 ppm	1,200 ppm	Setpoint
Offset	0 to 4,000 ppm	0 ppm	Offset

Runtime Limits

This screen displays settings related to the runtime limits and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Compressor	0 to 65535 hours	1,000 hours	Compressor runtime limit
Injection	0 to 65535 hours	1,000 hours	Injection pump runtime limit
Fan	0 to 65535 hours	1,000 hours	Fan runtime limit

BTU Meter Settings

This screen displays settings related to the BTU meter and provides access to edit these parameters from a single screen.

Settings	Range	Default	Description
Zone Type	BTU Zone, Flow only, Temp only, Disabled	BTU Zone	Determines, what Sensor readings are taken and what calculations are performed.
Zone Mode	Auto, Heat, Cool	Auto	HVAC mode can be set to Heat or Cool only. When set to Auto, the loop detects what mode it is currently in.
Meter Type	ACC-VFTS 4-1 (DN8) ACC-VFTS 10-1 (DN10) ACC-VFTS 20-1 (DN20) ACC-VFTS 40-1 (DN25) VFTS 1-20, VFTS 2-40, VFTS 5-100, VFTS 10-200, VFTS 20-400, DISABLED	1-20	Flow Meter Type. If “DISABLED” is chosen, BTU metering is disabled and supply and return temps are both read as indicated in the *Temp type* setting.
Meter Ratio	100% WATER, EG-10 to EG-50 (in steps of 10%), PG-10 to PG-50 (in steps of 10%), TYCOFO_HTL	100% WATER	Water, or alcohol ratio.
Supply Sensor	Not Used, Precon III, Precon II	2=Precon III	Temperature sensor used in the supply position.
Return Sensor	Not Used, Precon III, Precon II	2=Precon III	Temperature sensor used in the return position.
Enable Logging	Off, On	Off	Determines if Logging is enabled
Reset	No, Yes	No	When Reset is set to yes, the log is cleared and the momentary values are set to 0. The setting is then automatically set back to "No.”

Supply Water Alarm

This screen displays settings related to SWT alarms and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Cooling High	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	SWT high temperature alarm limit while cooling.
Cooling Low	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	SWT low temperature alarm limit while cooling.
Heating High	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	SWT high temperature alarm limit while heating.
Heating Low	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	SWT low temperature alarm limit while heating.

Return Water Alarm

This screen displays settings related to RWT alarms and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Cooling High	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	RWT high temperature alarm limit while cooling.
Cooling Low	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	RWT low temperature alarm limit while cooling.
Heating High	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	RWT high temperature alarm limit while heating.
Heating Low	32 to 140 °F (0 to 60 °C)	32.0 °F (0.0 °C)	RWT low temperature alarm limit while heating.

WDay Occ. Time

This screen displays all the weekday occupied backup schedule settings and provides access to edit these parameters from a single screen. Backup times are based on a 24 hour clock.

Setting	Range	Default	Description
Hours	0 to 23	0	Hour to start occupied times.
Minutes	0 to 59	0	Minute to start occupied times.

WDay Unocc. Time

This screen displays all the weekday unoccupied backup schedule settings and provides access to edit these parameters from a single screen. Backup times are based on a 24 hour clock.

Setting	Range	Default	Description
Hours	0 to 23	0	Hour to start unoccupied times.
Minutes	0 to 59	0	Minute to start unoccupied times.

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WEnd Occ. Time

This screen displays all the weekend occupied backup schedule settings and provides access to edit these parameters from a single screen. Backup times are based on a 24 hour clock.

Setting	Range	Default	Description
Hours	0 to 23	0	Hour to start occupied times.
Minutes	0 to 59	0	Minute to start occupied times.

WEnd Unocc. Time

This screen displays all the weekend unoccupied backup schedule settings and provides access to edit these parameters from a single screen. Backup times are based on a 24 hour clock.

Setting	Range	Default	Description
Hours	0 to 23	0	Hour to start unoccupied times.
Minutes	0 to 59	0	Minute to start unoccupied times.

Commissioning

This screen displays settings that can be used during commissioning to override values from the system.

Setting	Range	Default	Description
Enabled	No, Yes	No	Enable Commissioning
Fan	Not Used, Fan 1, Fan 2, Fan 3, User Defined	Not Used	Fan used when commissioning. Fan 1, Fan 2, Fan 3 are chosen fan outputs.User Defined activates Fan 1 and Modulated Fan output (see Fan Percent below)
Fan Percent	0.0 to 100.0 %	0.00%	Modulated Fan (FAN) output level used when Fan State is set to "User Defined."
Compressor	Off, S1, S1 & S2, User Defined	Off	Activate compressor Stage 1 (S1) and optionally Stage 2 (S2). User Defined activates S1 and Modulated Compressor output (see Mod Percent setting). S1, S2, S1 & S2, or User Defined may activate Reversing Valve (see Reversing Valve setting below).
Comp Mod Percent	0.0 to 100.0 %	0.0 %	Modulated Compressor (MOD) output level when Compressor is set to "User Defined."
Reversing Valve	Off, On	Off	Setting for Reversing Valve (RV) output. Active when Compressor is set to S1, S2, S1 & S2, or User Defined
Ext. Dehumid	Off, On	Off	Setting for External Dehumidification (DEH) output.
Reheat	Off, On	Off	Setting for Reheat (RH) output.
Injection Percent	0.0 to 100.0 %	0.0 %	Analog Injection Pump (INJ) output level used when Injection Pump is set to "On".

Alarms

The table below shows the alarms that may be reported by the HPL1-3 and how they can be reset.

Alarm	Range	Alarm Trigger	Alarm Reset
Thermostat Failure Alarm	Normal, Alarm	Occurs when the fan input detects that the fan is not running after a 30-second grace period after the fan has been activated.	The cause of the emergency condition must be resolved.
Maintenance Alarm	Normal, Alarm	Occurs when the fan, heating, or cooling operating hours have exceeded their Runtime limit.	To clear the alarm, a user must enter a new value for the alarm limit or reset the accumulated runtimes to zero.
Space Temperature High Limit Alarm	Normal, Alarm	SpaceTemp > (CalcCoolingSp + Cool-Band + AlarmLimitOffset)	Space temperature returns back below the high limit
Space Temperature Low Limit Alarm	Normal, Alarm	SpaceTemp < (CalcHeatingSp - Heat-Band - AlarmLimitOffset)	Space temperature returns back above the low limit
Fan Status	Normal, Alarm	The fan is on but air flow is not detected	Equipment failure must be resolved and the controller must be reset.
Filter Dirty	Normal, Alarm	Occurs when the Filter Alarm input detects that the filter needs to be replaced.	Automatic when the dirty filter is replaced.
Heat Pump Supply Water Temp High	Normal, Alarm	Supply Temp > Water Temp Alm: High Limit	Supply Temp < Water Temp Alm: High Limit - 1°F
Heat Pump Supply Water Temp Low	Normal, Alarm	Supply Temp < Water Temp Alm: Low Limit	Supply Temp > Water Temp Alm: Low Limit + 1°F
Heat Pump Return Water Temp High	Normal, Alarm	Return Temp > Water Temp Alm: High Limit	Return Temp < Water Temp Alm: High Limit - 1°F
Heat Pump Return Water Temp Low	Normal, Alarm	Return Temp < Water Temp Alm: Low Limit	Return Temp > Water Temp Alm: Low Limit + 1°F
Indoor Air Quality	Normal, Alarm	IAQ condition has existed configurable period of time.	The IAQ condition has cleared.

TROUBLESHOOTING

Diagnostic LEDs

The controller has 3 LED indicators. These indicators can aid in troubleshooting equipment operation problems. The following table lists the functions of the controller's LEDs in the order they appear from left to right on the unit.

LED	Indication
Status	– Solid green when running and configured by an LCI (networking) – Flashing green when running and NOT configured by an LCI (stand-alone) – Solid red when a fault condition exists (control shut down) – Blinking Red - the controller has a device failure – Solid Amber - The controller has not received a LCI ping message in over 10 minutes and is part of a network.
Network	– Yellow while the controller is transmitting data onto the FTT-10A network – Green when there is network activity – Off when there is no network activity
Service	– Illuminated when the service pin is depressed or when a controller gets configured by the LCI.

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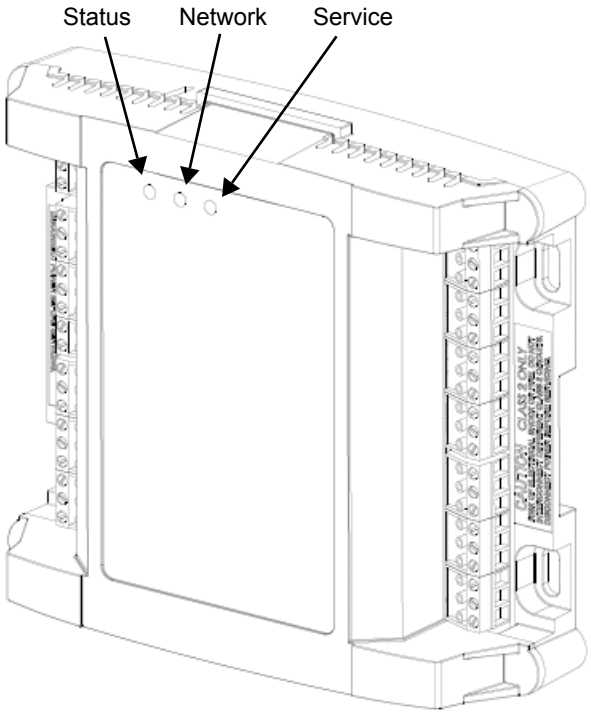
Figure 14: HPL1-3 Controller LEDs



Troubleshooting Tips

This section describes common problems and how to resolve them.

Problem	Solution
Controller is not running and Status LED is not illuminated.	No power to controller. Verify the voltage on the controller's power connector (24 VAC).
How do I reset the controller?	The controller can be reset by the LCI, or you can cycle power to the controller. Refer to the LCI documentation for more information on resetting the controller using the LCI.
The RWT or SWT reading is out of range, at minimum, or maximum.	The input is either shorted or open.
The compressor stages fail to activate.	Is the ASM/CSM Unit Enable signal On? The controller does not operate the compressor without the unit enable signal.
The Flow Sensor is not reading values.	- Has the proper sensor been selected in the "All Settings" section? - Is the cable from the VFTS plugged into the BTUPS? - Are the FM and WT wires connected to the proper inputs? - Are the DIP switches for the FM inputs set for 10V? - Is 24VAC power connected to the BTUPS? (Its LED should be on). - Is the VFTS properly connected to a pipe ground?

Thermistor readings fluctuate rapidly, sometimes by several degrees.	The controller is not properly grounded. The controller's ground (GND) pin (T40) must be connected to earth ground. Also ensure that the controller's digital inputs are dry contacts and that no voltage is being applied or switched to the inputs.
The Flow Sensor is registering a flow even when there can be no flow in the system.	The VFTS is not properly grounded. If the pipe in which the VFTS is installed is metal, strap one end of a ground wire to the pipe as close as possible to the VFTS. If the pipe is NOT metal, find the nearest metal fitting to the VFTS and strap the ground wire to it. Make sure there is good electrical contact between the metal and the ground wire. The other end of the ground wire should be connected to the GND terminal of the BTUPS.

Getting Help

Components within an iWorx® controller, sensor, or power supply cannot be field repaired. If there is a problem with a unit, follow the steps below before contacting your local TES representative or TES technical service.

1. Make sure controllers, sensors, and power supplies are connected and communicating to desired devices.
2. Record precise hardware setup indicating the following:

   Version numbers of application software.

   Device and/or firmware version number.

   A complete description of difficulties encountered.

Notes:

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LIMITED WARRANTY STATEMENT

Taco Electronic Solutions, Inc. (TES) will repair or replace without charge (at the company's option) any product or part which is proven defective under normal use within one (1) year from the date of start-up or one (1) year and six (6) months from date of shipment (whichever occurs first).

In order to obtain service under this warranty, it is the responsibility of the purchaser to promptly notify the local TES stocking distributor or TES in writing and promptly deliver the subject product or part, delivery prepaid, to the stocking distributor. For assistance on warranty returns, the purchaser may either contact the local TES stocking distributor or TES. If the subject product or part contains no defect as covered in this warranty, the purchaser will be billed for parts and labor charges in effect at time of factory examination and repair.

Any TES product or part not installed or operated in conformity with TES instructions or which has been subject to accident, disaster, neglect, misuse, misapplication, inadequate operating environment, repair, attempted repair, modification or alteration, or other abuse, will not be covered by this warranty.

TES products are not intended for use to support fire suppression systems, life support systems, critical care applications, commercial aviation, nuclear facilities or any other applications where product failure could lead to injury to person, loss of life, or catastrophic property damage and should not be sold for such purposes.

If in doubt as to whether a particular product is suitable for use with a TES product or part, or for any application restrictions, consult the applicable TES instruction sheets or in the U.S. contact TES at 401-942-8000 and in Canada contact Taco (Canada) Limited at 905-564-9422.

TES reserves the right to provide replacement products and parts which are substantially similar in design and functionally equivalent to the defective product or part. TES reserves the right to make changes in details of design, construction, or arrangement of materials of its products without notification.

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