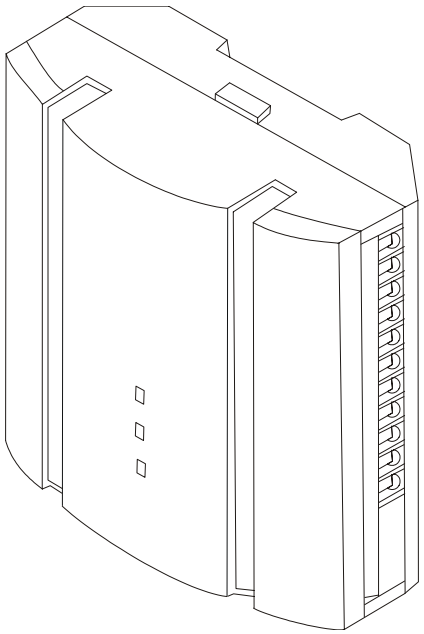
iWorX HPU-1 Application Manual

HPU-1

The HPU-1 heat pump controller is a stand-alone microprocessor based controller for liquid source heat pump units. The application would include liquid source heat pump units with two-stage compressor, reversing valve and fan.



Overview

A digital input is provided to monitor equipment status. A two wire serial interface is provided for the thermostat. The HPU-1 incorporates digital outputs in the form of triacs for fan start/stop, two compressor stages and a reversing valve.

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

Features

- Two stage compressor heating/cooling control
- Reversing valve control
- Local backup schedule
- Individual temperature setpoints for occupied/unoccupied heat and cool
- LonWorks interface to building automation systems
- Equipment status input for additional safety interlocks
- Thermostat with space temperature, setpoint adjust, fan override, occupancy override
- Fan control energized on call for heating or cooling
- Automatic heat/cool changeover
- Global unit enable for main plant synchronization
- Remote sensor capabilities
- Automatic configuration with the LCI
- Alarm/Event reporting

Purpose of This Guide

The *iWorX HPU-1 Application Manual* provides application information for the HPU-1 Controller.

The reader should understand basic HVAC concepts, intelligent environmental control automation, and basic LonWorks networking and communications. This application manual 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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iWorX-HPU1-APP-100

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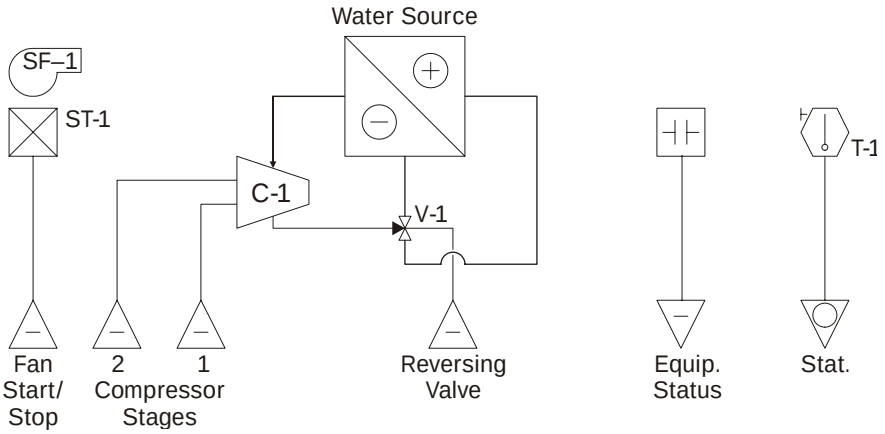
Applicable Documentation

Part Number	Description	Audience	Purpose
iWorX-HPU1-APP-100	iWorX HPU Series Installation Instructions	– Application Engineers – Installers – Service Personnel – Start-up Technicians	Provides instructions for setting up and using the iWorX HPU-1 Controller.
iWorX-LCI1-USR-100	iWorX LCI User's Guide	– Application Engineers – Installers – Service Personnel – Start-up Technicians – End user	Provides instructions for setting up and using the iWorX Local Control Interface.
iWorX-DTM-INS-100	iWorX DTM Series General Instructions	– Application Engineers – Installers – Service Personnel – Start-up Technicians	Provides step-by-step installation and checkout procedures for iWorX Digital Thermostat Modules. Also contains instructions for sensor operation.
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.		

Application Description

The controller maintains the temperature of a space to a defined setpoint. Figure 1 illustrates a typical controller application. The control is achieved by sequencing the reversing valve and compressor stages of a liquid source heat pump based on the current space requirements.

Figure 1: HPU-1 Application



The controller controls the starting and stopping of the supply air fan. If the unit enable input indicates plant synchronization, the fan will be energized when there is call for heating or cooling. During the occupied periods, the fan can be configured to run continuously. The fan can be overridden from the local thermostat. If overridden, the fan will run continuously.

When the temperature increases above the cooling setpoint, the reversing valve cycles to the cooling position. The compressor stages are sequenced on 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.

When the temperature decreases below the heating setpoint, the reversing valve cycles to the heating position. The compressor stages are sequenced on 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.

Each controller interfaces to a local thermostat. The thermostat includes a space temperature sensor, temperature setpoint adjustment, occupancy override, and a fan auto/on selection (depending on the model).

The controller operates in one of two states: occupied or unoccupied. The LCI determines the active operating mode. The controller maintains the comfort level to a user-defined setpoint during the occupied period, and uses setup and setback values during the unoccupied period to maintain the space temperature. An optional backup schedule is provided for cases when the LCI is not available.

A digital input is provided to monitor the status of the equipment within the unit. An external contact may be wired to the input to provide additional equipment safety interlocks. When the contact closes, the controller shuts the unit down. An alarm will be reported to the LCI when this condition exists.

The HPU-1 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 controller monitors the runtime of the fan. When the runtime exceeds a programmable limit, a maintenance alarm will be reported to the LCI.

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

Sequence of Operation

This section describes the detailed sequence of operation for the controller control algorithms.

Setpoints

The heating and cooling setpoint for both occupied and unoccupied periods are programmable values. The *space setpoint* is a calculated value based on the programmed heating setpoint, cooling setpoint and current operating mode (i.e. occupied or unoccupied).

The space setpoint is derived by first calculating the *zero energy band (zeb)* for the current operating mode.

Occupied Mode

$$ZebOcc = OccupiedCoolSp \angle OccupiedHeatSp$$

Unoccupied Mode

$$ZeUnocc = UnoccupiedCoolSp \angle UnoccupiedHeatSp$$

The space setpoint is calculated from the zero energy band and the heating setpoint.

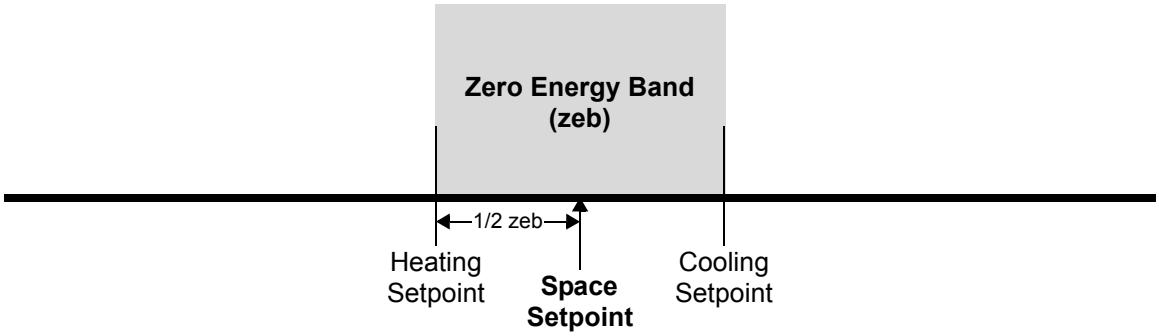
Occupied Mode

$$SpaceSP = OccupiedHeatsp + \frac{ZebOcc}{2}$$

Unoccupied Mode

$$SpaceSp = UnoccupiedHeatSp + \frac{ZebUnocc}{2}$$

Figure 2: Space Setpoint Calculation



The effective setpoint is a calculated value based on the space setpoint and the thermostat *setpoint offset* value. The setpoint offset is used to increase or decrease the space setpoint from the local thermostat. The offset value is limited to plus or minus the programmed setpoint adjustment.

The setpoint offset also affects the *calculated heating* and *calculated cooling* setpoints by an equal amount. The setpoint offset only applies in the occupied mode of operation. It has no affect in the unoccupied mode. Note that the actual programmed heating and cooling setpoints are not changed. The offset is simply added to the programmed setpoints to derive the calculated values.

Occupied Mode

$$CalcCoolingSp = OccupiedCoolingSp \pm SpOffset$$

$$CalcHeatingSp = OccupiedHeatingSp \pm SpOffset$$

$$EffectiveSp = SpaceSp \pm SpOffset$$

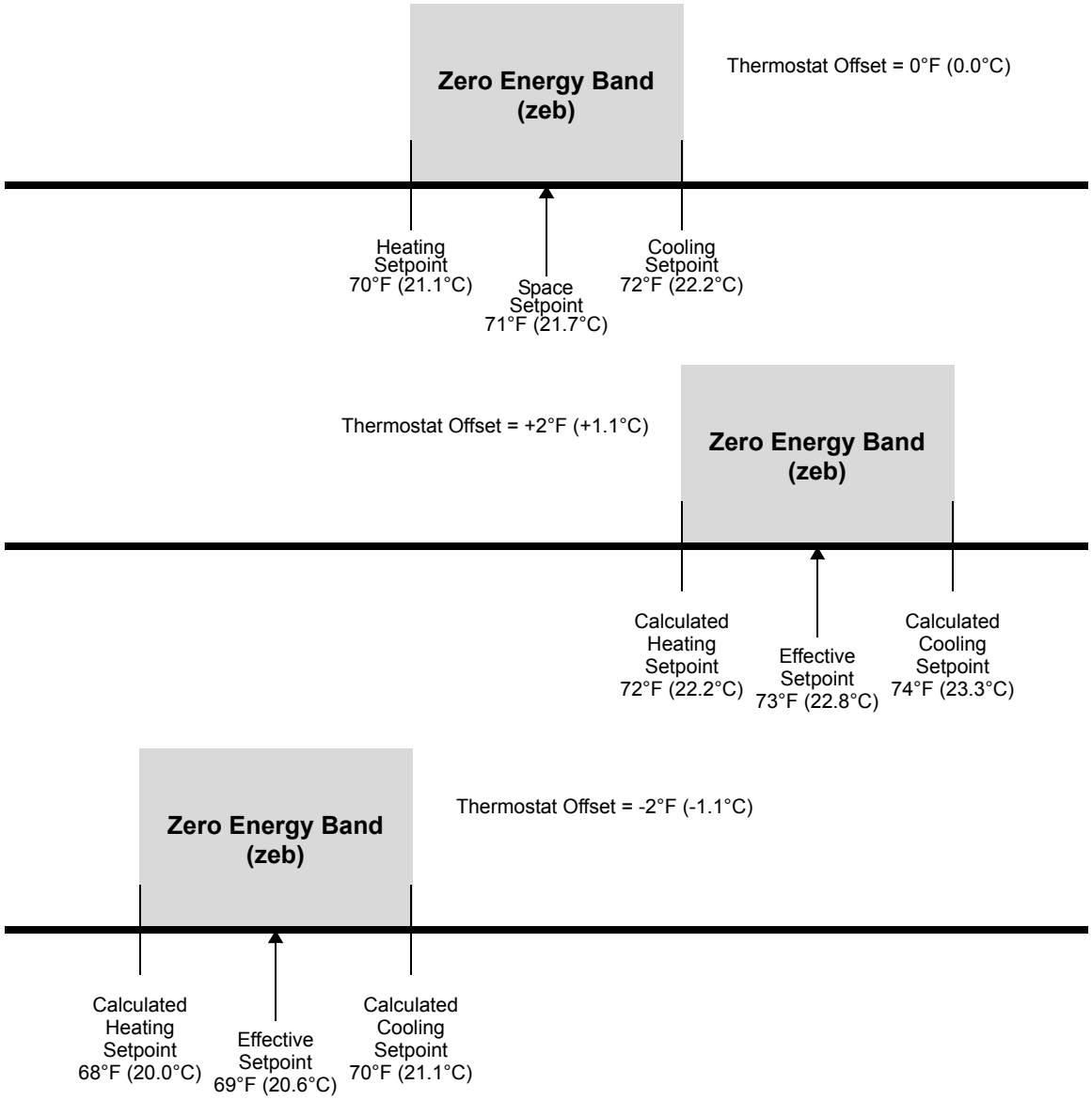
Unoccupied Mode

$$CalcCoolingSp = UnoccupiedCoolingSp$$

$$CalcHeatingSp = UnoccupiedHeatingSp$$

$$EffectiveSp = SpaceSp$$

Figure 3: Setpoint Adjustment



Heating Sequence

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

After the space temperature has risen above the heating setpoint for a predefined time-period, the last-energized stage is turned off. (Note that the last stage that was turned on will be the first one to be turned off.) If the space temperature remains above the heating setpoint for an additional time-period, the next previous stage will be turned off. This cycle continues until all stages have been de-energized.

When the space temperature rises above the space setpoint, all of the compressor stages will immediately turn off.

During unoccupied periods, the heating setpoint is adjusted downwards through a separate unoccupied heating setpoint.

Figure 4: Heat Sequence - Occupied Mode

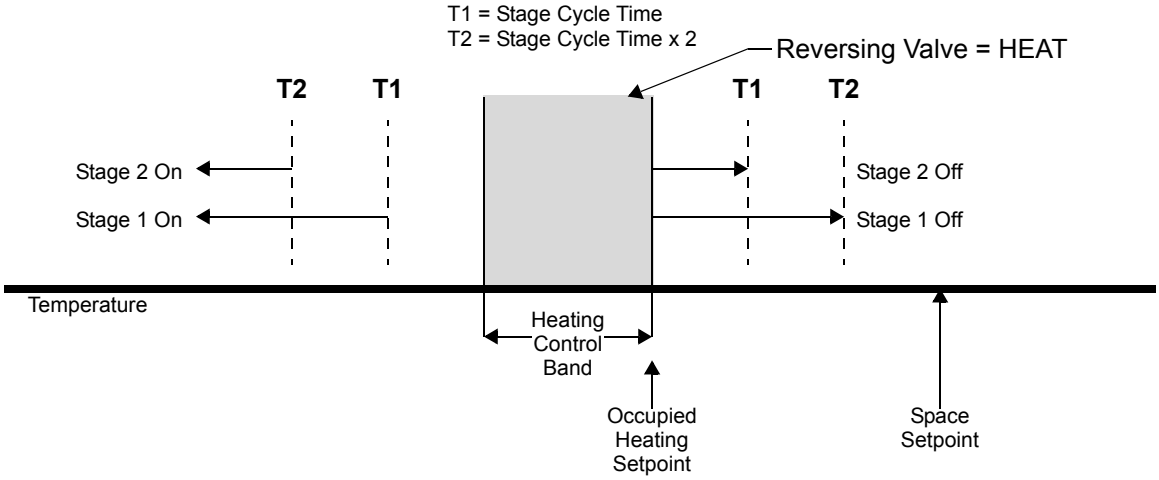
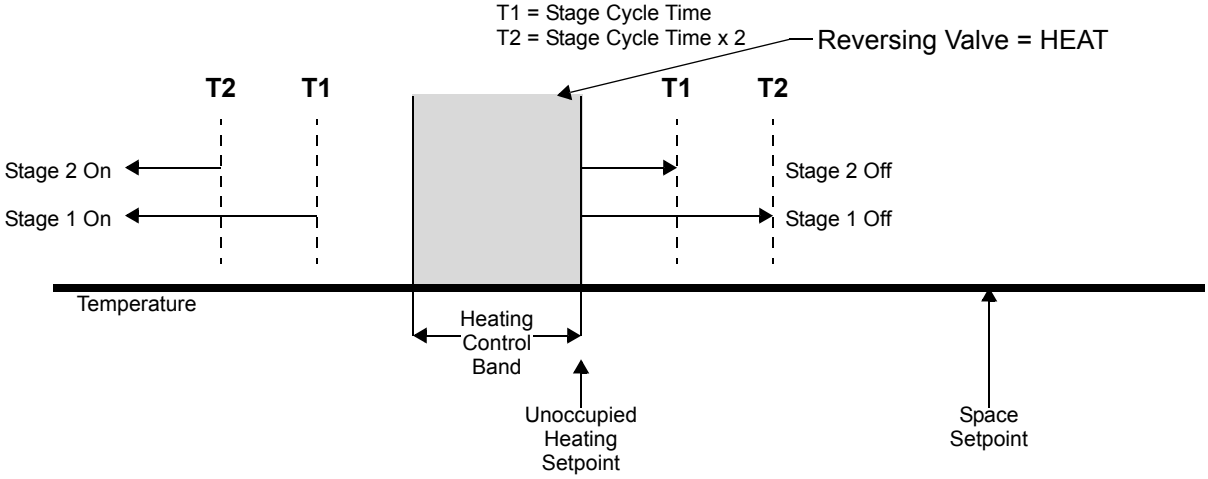


Figure 5: Heat Sequences – Unoccupied Mode



Cooling Sequence

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

After the space temperature has dropped below the cooling setpoint for a predefined time-period, the last-energized stage is turned off. (Note that the last stage that was turned on will be the first one to be turned off.) If the space temperature remains below the cooling setpoint for an additional time-period, the next previous stage will be turned off. This cycle continues until all stages have been de-energized.

When the space temperature drops below the space setpoint, all of the compressor stages will immediately turn off.

During unoccupied periods, the cooling setpoint is adjusted upwards through a separate unoccupied cooling setpoint.

Figure 6: Cooling Sequence - Occupied Mode

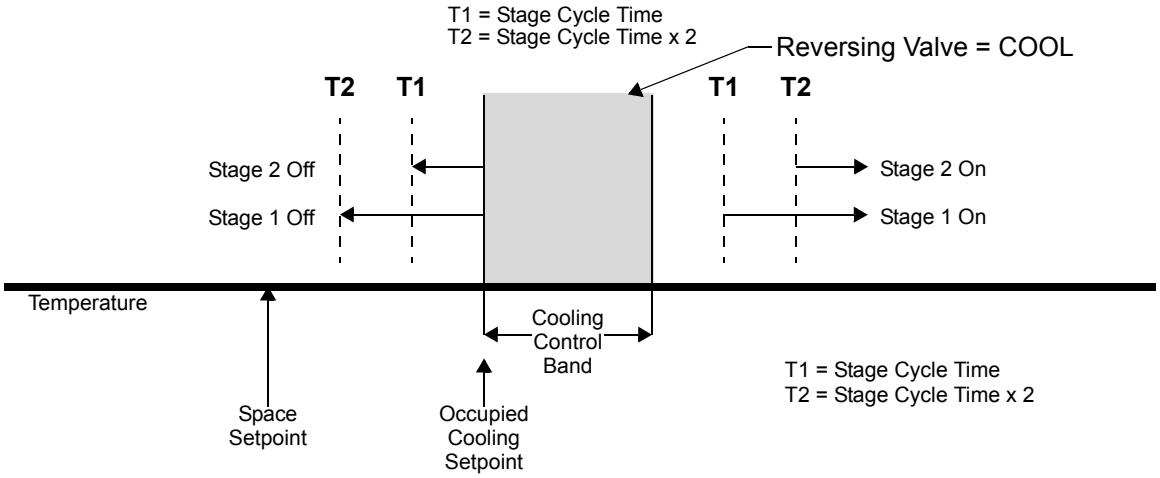
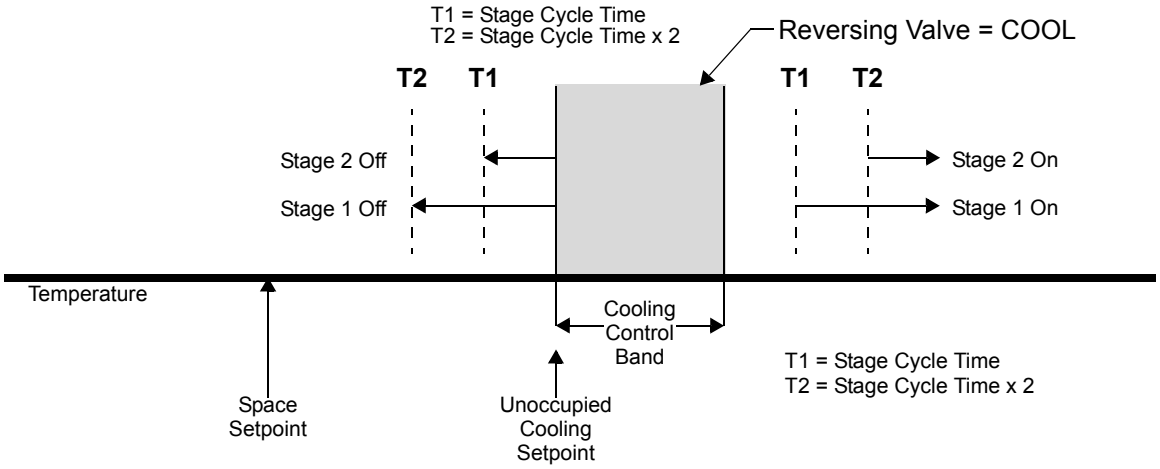


Figure 7: Cooling Sequence – Unoccupied Mode



Fan Operation

During occupied periods, you can set the fan to always run 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 will immediately energize. During the unoccupied period, the fan will always cycle off when the space temperature is within the zero energy band.

You can override the fan from the local thermostat (depending on the model). When the fan selection is set to *Auto*, the fan operates as described above. If the fan selection is set to *On*, the fan will be constantly on.

Equipment Status

An equipment status input is monitored to determine if the fan coil equipment is operating properly. When the fan is initially turned on, there is a 30 second delay before the equipment status is checked. If the contact closes after the delay, indicating equipment failure, the compressor stages will turn off and the fan will turn off. The status LED on the controller will turn solid red. The controller must be reset to clear this condition.

Global Unit Enable

The controller 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 HPU-1 over the network. The controller waits in shutdown mode until water flow is detected.

Thermostat

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

The controller will automatically detect a failure of the thermostat. When the thermostat fails, the compressor stages will turn off, the fan will turn off, and control will be disabled.

Note: The thermostat must be connected. The status LED on the controller will turn solid red if the thermostat is not connected. Once the thermostat is connected, the status LED will turn green indicating normal operation.

Local Backup Schedule

The LCI normally determines the operating mode. You can define a local backup schedule 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 schedule that you have configured. If the local backup schedule is disabled, the controller defaults to occupied mode.

You configure the *occupied* and *unoccupied* times that are used in determining the current operating mode of the controller when it is running the backup schedule. By default, both the unoccupied and occupied time will be set to zero, which disables the local backup schedule. This causes the controller to default to the occupied mode of operation if it cannot communicate with the LCI.

Runtime Accumulation

The total runtime is accumulated for the heating, cooling, and fan outputs. The runtimes can be used to indicate that maintenance is required on the equipment controlled by these outputs. The runtime can be reset by an operator or maintenance person once servicing has been performed.

Alarms and Events

The controller will detect certain alarm conditions and send them to the LCI. Before this can occur, you must use the LCI to configure the controller.

Digital Input Alarms

The controller monitors the status of the equipment status digital input and generates an Equipment Status Alarm if detected.

Thermostat Failure

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 will be generated and the controller's status LED will turn red.

Maintenance Alarm

The controller provides programmable run limits for generating a runtime Maintenance Alarm. When any of the cooling, heating, or fan runtime limits are exceeded, a maintenance alarm is sent to the LCI.

Space Temperature Alarms

The controller generates high and low limit alarms for the space temperature. You can configure a programmable space temperature alarm limit offset. The temperature limits are calculated based on the control setpoints, alarm limit offset, and control band.

$$HighLimit = CalcCoolingSp + AlarmLimitOffset + CoolBand$$

$$LowLimit = CalcHeatingSp \angle AlarmLimitOffset \angle HeatBand$$

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).

When the controller switches between the unoccupied and occupied modes of operation, no space temperature alarms are reported for 30 minutes following the switch. This helps eliminate nuisance alarms.

Controller Identification

You need to press the controller's service pin to allow the LCI to identify it. The controller's status light will be flashing green until it is configured, and will be solid green after it is configured. The controller must be configured by the LCI to allow you to use the LCI to set the controller's schedules, change its setpoints, etc. You need to press the service pin after the controller is installed and the LCI is active on the network.

Troubleshooting

Diagnostic LEDs

The controllers have 3 LED indicators. These indicators can aid in troubleshooting equipment operation problems. The following table lists the function of each LED in the order it appears from top to bottom on the unit.

Figure 8: Diagnostic LEDs

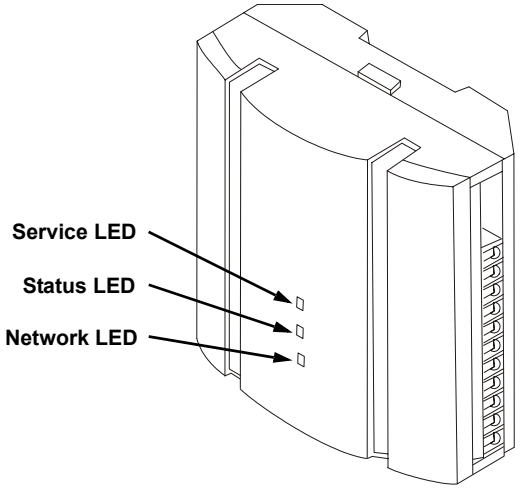


Table 1: Diagnostic LEDs

LED	Indication
Service	Illuminated when the service pin is pushed
Status	Solid green when running and configured by an LCI Flashing green when running and NOT configured by an LCI Solid red when a fault condition exists
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

Troubleshooting Tips

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 fan will not cycle on.

There are several reasons the fan may not cycle on and all should be checked.

1. Is the controller in an occupied mode?
2. Has the controller been overridden by the LCI?
3. Is the thermostat connected?
4. Does the unit have no alarms, and is the Status LED solid green?

The fan and valve pilot relays will not come on.

1. Ensure that the controller has been powered with 24 VAC and the output has been correctly wired to the coils of the pilot relays. Also ensure that the pilot relays have a 24 VAC coil.
2. Ensure that the global unit enable indicates that there is water flow in the main plant.

Network Variables and Configuration Variables

This section describes all of the Network and Configuration Variables used in the controller.

Table 2: HPU-1 Inputs.

LCI Variable Name	Range	Default Value	Description
Space Temperature	-22 °F to 122 °F (-30 °C to 50 °C), or Auto	Auto	Network override of the actual space temperature provided by the local thermostat
Temp Setpoint	50 °F to 95 °F (10 °C to 35 °C), or Auto	Auto	Network override for effective set-point (when not in Auto, value over-rides thermostat)
Occupancy Cmd	Occ, Unocc, Bypass, Auto	Auto	Network override for occupancy command (set when schedule runs)
Reset Runtimes	Off, On	Off	Resets the runtime hours for heat-ing, cooling and fan (can be set through LCI interface)
System Time	00:00 to 23:59	00:00	System clock value (not used by LCI)
Unit Enable	Off, On, Null	Null	Current value of the unit enable contact

The following output variables are read only and cannot be changed.

Table 3: HPU-1 Outputs.

LCI Variable Name	Range	Description
Space Temperature	-22 °F to 122 °F (-30 °C to 50 °C)	Measured space temperature
Mode	Auto, Heat, Cool, Off, Fan	Operating mode
Heat Output	0-100%	Capacity of heating used
Cool Output	0-100%	Capacity of cooling used
Fan Output	0-100%	Off=0, ON=100%
In Alarm?	No, Yes	Alarm indication
Effective Setpt	50 °F to 95 °F (10 °C to 35 °C)	Effective temperature setpoint
Occ. Ext. Time Rem.	0 to 1000 minutes	Occupancy override time remaining
Equipment Status	Normal, Failed	Current state of the fan proof input
Occupancy Mode	Occ, Unocc, Bypass	Current occupancy mode
Comp. Runtime	0 to 65535 hours	Runtime hours for the compressor stages
Fan Runtime	0 to 65,535 hours	Runtime hours for the fan

Table 4: HPU-1 Setpoints.

LCI Variable Name	Range	Default Value	Description
Occupied Cool	50 °F to 95 °F (10 °C to 35 °C)	72°F (22.2 °C)	Occupied cooling setpoint
Unoccupied Cool	50 °F to 95 °F (10 °C to 35 °C)	82°F (27.8 °C)	Unoccupied cooling setpoint
Occupied Heat	50 °F to 95 °F (10 °C to 35 °C)	70°F (21.1 °C)	Occupied heating setpoint
Unoccupied Heat	50 °F to 95 °F (10 °C to 35 °C)	60°F (15.6 °C)	Unoccupied heating setpoint
Space Temp Limit	0 °F to 15 °F (0 °C to 8.3 °C)	5 °F (2.8 °C)	Space temperature limit offset for alarming purposes
Comp. Stages	0 to 2	2	Number of compressor stages
Stage Ctl. Band	0 °F to 10 °F (0 °C to 5.6 °C)	1 °F (0.6 °C)	Heating and cooling stage control band
Stage Time	0 to 255 minutes	5 minutes	Compressor control cycle timer
Fan Type	Auto, On	Auto	Type of fan operation
Setpoint Adjust	0 °F to 10 °F (0 °C to 5.6 °C)	5 °F (2.8 °C)	Allowed range of the setpoint adjustment
Occ. Extend Time	0 to 1000 minutes	60 minutes	Allowable occupancy extension time
Fan Runtime Limit	0 to 65,535 hours	1000 hours	Runtime limit for heating
Comp. Runtime Limit	0 to 65,535 hours	1000 hours	Runtime limit for the compressor
Occupied Time	00:00 to 23:59	00:00	Occupied time for local backup schedule (if both Occupied Time and Unoccupied Time are zero, the local backup schedule is disabled)
Unoccupied Time	00:00 to 23:59	00:00	Unoccupied time for local backup schedule