

### VPU-1

The VPU-1 is a microprocessor-based controller for Variable Air Volume (VAV) package units. Applications include VAV package units with up to four stages of cooling, two stages of heating, an economizer, and a variable speed fan. The VPU-1 is designed for integrated networked operation with the iWorX Local Control Interface (LCI) and up to 60 VAV-1 terminal unit controllers.

### Overview

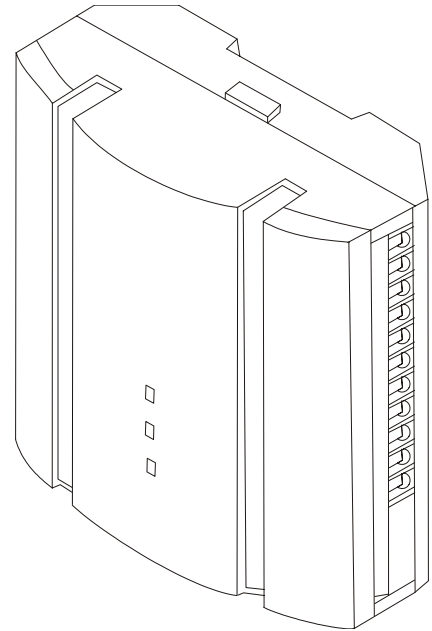
Digital inputs are provided for fan status, mixed air low limit indication, smoke detector, filter status and indoor air quality (IAQ). Analog inputs are provided for mixed air temperature, return air humidity, supply air temperature and supply duct static pressure.

The VPU-1 incorporates digital outputs in the form of triacs for fan start/stop, four cooling stages, two heating stages and a two-position economizer. In addition, two analog outputs are provided to control a modulated economizer and variable speed drive.

The controller is based on the LONWORKS<sup>®</sup> networking technology. The controller can be networked to a higher-level control system for monitoring and control applications.

### Features

- Four stages of cooling
- Two stages of heating, or floating-point valve control
- Modulated fan speed
- Digital or modulated economizer
- Economizer enabled based on enthalpy calculations or dry bulb
- Minimum cycle timers for stages
- Runtime accumulation for heating, cooling and fan
- Local backup schedule
- Maximum of 60 zones (VAV boxes)
- Supply air temperature safety limits
- Time proportioned control of the staged outputs to reduce cycling
- Proportional + Integral control of the modulated economizer
- Proportional + Integral control of static pressure
- LONWORKS interface to building automation systems
- Mixed air low limit protection
- Filter status input
- Smoke detection input
- IAQ compensation based on IAQ alarm input or zone controller alarm
- Automatic morning warm-up sequence
- Automatic configuration with the LCI
- Alarm/Event reporting



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## Purpose of This Guide

The *iWorX VPU-1 Application Manual* provides application information for the VPU-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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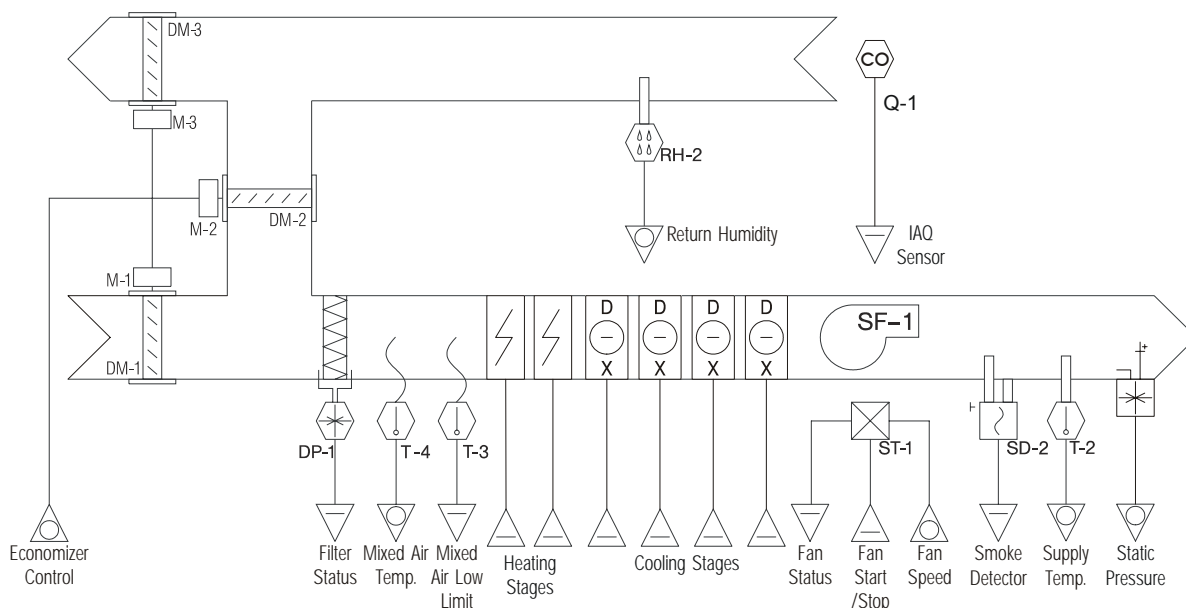
## Applicable Documentation

Part Number	Description	Audience	Purpose
iWorX-VPU-INS-100	iWorX VPU Series Installation Instructions	<ul style="list-style-type: none"> <li>– Application Engineers</li> <li>– Installers</li> <li>– Service Personnel</li> <li>– Start-up Technicians</li> </ul>	Provides instructions for setting up and using the iWorX VPU-1 Controller.
iWorX-VAV1-APP-100	iWorX VAV-1 Application Manual	<ul style="list-style-type: none"> <li>– Application Engineers</li> <li>– Wholesalers</li> <li>– Contractors</li> </ul>	Provides specific application information about the VAV-1, including sequence of operation and configuration information.
iWorX-LCI1-USR-100	iWorX LCI User's Guide	<ul style="list-style-type: none"> <li>– Application Engineers</li> <li>– Installers</li> <li>– Service Personnel</li> <li>– Start-up Technicians</li> <li>– End user</li> </ul>	Provides instructions for setting up and using the iWorX Local Control Interface.
Additional Documentation	<i>LonWorks FTT-10A Free Topology Transceiver User's Guide</i> , published by Echelon Corporation. It provides specifications and user instructions for the FTT-10A Free Topology Transceiver.		

## Application Description

The VPU-1 is a VAV package unit controller for controlling supply air temperature and supply air duct static pressure. Figure 1 and Figure 2 illustrate typical VPU-1 applications. The VPU-1 operates in conjunction with up to 60 VAV-1 zone controllers. Control is achieved by modulating the economizer position and sequencing the heating and cooling stages based on the current supply air temperature requirements. In addition, the VPU-1 controls the supply fan speed to maintain a supply duct static pressure setpoint.

**Figure 1: VPU-1 Application with Modulated Economizer**



The starting and stopping of the supply air fan is controlled by the VPU-1. During the occupied and warm-up periods, the fan runs continuously. The fan cycles on during the unoccupied periods when a zone is in extended occupancy or when there is a call for emergency heating.

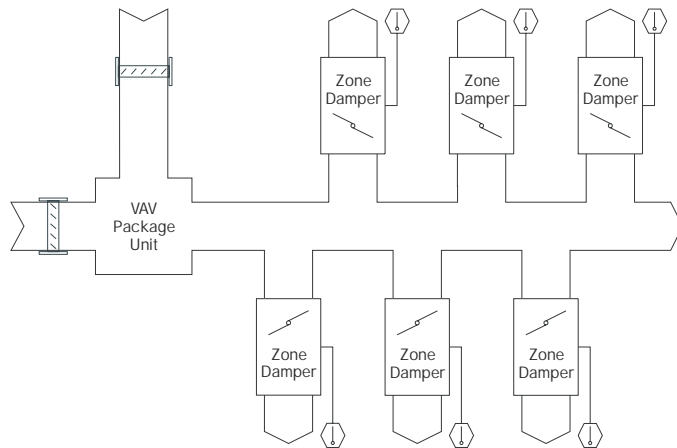
The fan speed control operates to maintain a configurable system static pressure setpoint. The fan speed is calculated by a Proportional + Integral (P+I) control loop based on the measured static pressure and setpoint. As the pressure increases above the pressure setpoint, the fan speed output is throttled back. As the pressure decreases below the pressure setpoint, the output is increased.

The enthalpies of the outside and inside air are calculated periodically. A comparison is performed to determine if “free cooling” is available. If “free cooling” is available, the economizer is enabled. Optionally, free cooling can be determined by a dry bulb comparison of the outside air temperature and average zone temperatures from the zone controllers.

The economizer can be configured as 2-position or modulated. If enabled, the 2-position economizer output is energized when there is a call for cooling. It is used as the first stage of cooling to take advantage of the energy savings. The 2-position economizer output is off when the economizer is disabled.

If enabled, the modulated economizer position is calculated by a P+I control loop based on the mixed air temperature and setpoint. As the temperature increases above the mixed air setpoint, the economizer is modulated open. The economizer is modulated closed as the temperature decreases below the mixed air setpoint. The economizer is modulated to its minimum position when the economizer is disabled. The economizer can be disabled during unoccupied periods.

The VPU-1 operates in one of four states: morning warm-up/cool-down, occupied, unoccupied, or shutdown. A host device on the network determines the active operating mode. An optional backup schedule is provided for cases when the host device is not available. The operating state determines if the VPU-1 is in heating mode or cooling mode.

**Figure 2: VAV Zone Control System**

When the operating mode is cooling (occupied and extended occupancy), the cooling stages are sequenced on and off with a time-proportioned control algorithm to minimize excessive cycling. The sequencing is based on the supply air temperature and cooling setpoint. The cooling stages are interlocked with the economizer control. If the economizer is enabled, the cooling stages do not sequence on until the economizer has reached its open position.

When the operating mode is heating (morning warm-up), the heating stages are sequenced on and off with a time-proportioned control algorithm to minimize excessive cycling. The sequencing is based on the supply air temperature and heating setpoint. Heating can also be controlled with floating-point control of a valve.

The VPU-1 can also monitor the supply air temperature to determine if the heating and cooling are operating properly. During the cooling mode, if the supply air temperature fails to drop below the cooling operational limit after a pre-determined time period, a cooling failed alarm is reported to the LCI. During the heating mode, if the supply air temperature fails to rise above the heating operational limit after a pre-determined time period, a heating failed alarm is reported to the LCI.

A digital input is provided to monitor the indoor air quality. A CO<sub>2</sub> sensor that provides a contact closure can be connected directly to the VPU-1. Additionally, an alarm condition can be signaled by any of the zone controllers. When an alarm condition exists, the VPU-1 energizes the supply air fan and overrides the static pressure setpoint to the IAQ alarm setpoint. The economizer is overridden to the minimum ventilation position. After a programmable time delay, the economizer is overridden open to supply fresh air to the zones. Optional heating and cooling outside air temperature lockouts are provided for the economizer. If the IAQ sensor is connected directly to the VPU-1, an IAQ alarm is reported to the LCI and all of the zone controllers in the VPU-1's group.

The VPU-1 monitors a digital input to determine the presence of smoke. When the input indicates smoke, the controller immediately turns off the fan and all stages of heating and cooling. An alarm is reported to the LCI when this condition exists. The VPU-1 remains in the shutdown alarm state until it is reset.

A digital input is provided on the VPU-1 to monitor the status of the air filter. An external pressure switch is wired to the input to determine when the filter becomes dirty. An alarm is reported to the LCI when this condition exists. The VPU-1 remains in the shutdown alarm state until it is reset.

Mixed air low limit protection is provided through a digital input. If a low limit condition exists, the VPU-1 turns off all stages of heating and cooling along with the supply air fan. If heating is controlled by a floating-point valve, the valve is opened fully to prevent equipment damage. An alarm is reported to the LCI when this condition exists. The VPU-1 remains in the shutdown alarm state until it is reset.

The VPU-1 monitors an input to determine if the fan is operating properly. When the input indicates a fan failure, the controller immediately turns off the fan and all stages of heating and cooling. An alarm is reported to the LCI when this condition exists.

The VPU-1 monitors the runtime of the cooling stages, heating stages and fan. When any one of the runtimes exceeds a programmable limit, a maintenance alarm is reported to the LCI.

## Sequence of Operation

This section describes the detailed sequence of operation for the VPU-1 control algorithms.

### Occupancy State

The VPU-1 operates in one of three occupancy states: extended occupancy, occupied, or unoccupied. A host device on the network determines the active operating mode. An optional backup schedule is provided for cases when the host device is not available.

In addition, the VPU-1 polls each zone controller (VAV-1) to determine if extended occupancy (bypass) has been requested. During unoccupied periods when extended occupancy has been requested, the VPU-1 enters the occupied mode of operation. At least once every 5 seconds a different zone controller is polled.

### Operational Mode

The VPU-1 operates in one of three operating modes: primary heating, primary cooling, and primary off. The operating mode determines whether warm or cool air is supplied to the zone controllers. The VPU-1 determines the operating mode based on its internal schedule state, which is determined based on the occupancy state and internal configuration variables. The VPU-1 can be in one of the following operational states: morning warm-up, occupied, extended occupancy, emergency heating, shutdown, and emergency.

#### Morning Warm-up

The purpose of morning warm-up is to heat up the unoccupied zones to a comfortable level before the zones are occupied. During morning warm-up, the VPU-1 is in heating mode: the fan is energized, the static pressure is controlled, the economizer is disabled, and the heating stages are controlled. The VPU-1 enters the morning warm-up state from shutdown, bypass, or emergency heating states.

The VPU-1 must be configured at the LCI to perform morning warm-up; a reference VAV zone must be selected, and the optimum start time for heating must be configured. If the reference zone requires heating, and morning warm-up is configured, the LCI advances the occupancy start time of the VPU-1 and passes the number of minutes the occupancy has been advanced. The VPU-1 remains in morning warm-up until the reference zone temperature is within 1 °F of the heating setpoint, or until the optimum start time has expired.

The VPU-1 informs all of its associated VAV-1 controllers, regardless of their occupancy state, that morning warm-up is being performed, to allow all associated VAV-1s to take advantage of the heating mode. During morning warm-up, all VAV-1 controllers control to their occupied setpoints, regardless of their occupancy state. After morning warm-up, the VPU-1 enters the occupied state and delays the staging of cooling for one stage time.

#### Morning Cool Down

Similarly to morning warm-up, the VPU-1 can perform morning cool-down, cooling the soon-to-be-occupied zones to a comfortable level before occupancy. Morning cool-down is exactly like the occupied state, but the occupancy time has been advanced.

The VPU-1 must be configured at the LCI to perform morning cool-down: a reference VAV zone must be selected and the optimum start time for cooling must be configured. If the reference zone requires cooling, the VPU-1 enters the occupied state.

Unlike morning warm-up, the VPU-1 does not inform its associated zone controllers that it is in morning cool-down. Only the VAV-1 controllers that are in the same group take advantage of the cooling, and control to their occupied setpoints.

## Occupied

The VPU-1 is in the occupied state if the VPU-1 is scheduled for occupancy or an associated VAV-1 zone controller is occupied. The VPU-1 periodically polls a zone controller for its occupancy status, and if a zone is occupied the VPU-1 enters the occupied state.

During the occupied state, the VPU-1 is normally in cooling mode. If the mixed air temperature is 7 °F colder than the supply temperature (as can happen during cold winter weather), the VPU-1 enters heating mode, and heats the air to the cooling setpoint. Also, the fan is energized, the static pressure is controlled, and the economizer is enabled. In heating mode, the VPU-1 compensates for the colder air being brought in by setting the economizer to its minimum position.

The VPU-1 enters the occupied state from shutdown, extended occupied, morning warm-up, and emergency heating stages. The VPU-1 remains in the occupied state until the VPU-1 goes into the unoccupied state and no associated zone controllers are occupied.

## Shutdown

When the space being controlled by the VPU-1 is unoccupied, the controller operates in the shutdown state. The air handler package unit is off, and there is no control of the static pressure or duct temperature. The VPU-1 is in the shutdown state when the occupancy status is “unoccupied”, and no associated controllers are occupied or in extended occupancy. The VPU-1 enters the shutdown state from occupied, extended occupied, and emergency heating stages.

## Extended Occupancy

When the VPU-1 is in shutdown and a VAV-1 zone controller has indicated extended occupancy, the controller enters the extended occupancy state. Extended occupancy acts identically to the occupied state. The VPU-1 remains in the extended occupancy state until the VAV-1 controller's extended occupancy is over, the VPU-1 enters morning warm-up or cool-down, the VPU-1 enters the occupied state, or the VPU-1 enters the shutdown state.

## Emergency Heating

The VPU-1 enters the emergency heating state from shutdown when an associated VAV-1 zone controller's space temperature is 10 °F colder than its unoccupied heating setpoint. During the emergency heating state, the VPU-1 is in heating mode: the fan is energized, the static pressure is controlled, the economizer is disabled, and the heating stages are controlled. The VPU-1 remains in the emergency heating state for thirty minutes, after which the VPU-1 reverts to the shutdown state.

## Emergency

The VPU-1 enters the emergency state (from any state) when there is an emergency condition. Emergency conditions are:

- Mixed air low limit (freeze)
- Heat stuck on
- Fan failure
- Smoke alarm

During the emergency state, the air handler package unit is off and there is no control of the static pressure or duct temperature. The VPU-1 remains in the emergency state until the controller is reset.

## Setpoint Calculations

The supply air heating and cooling setpoints are programmable values. The effective setpoint is a calculated value based on the current operating mode. The effective setpoint is set to the heating setpoint when the operational mode is heating. It is set to the cooling setpoint when the operational mode is cooling.

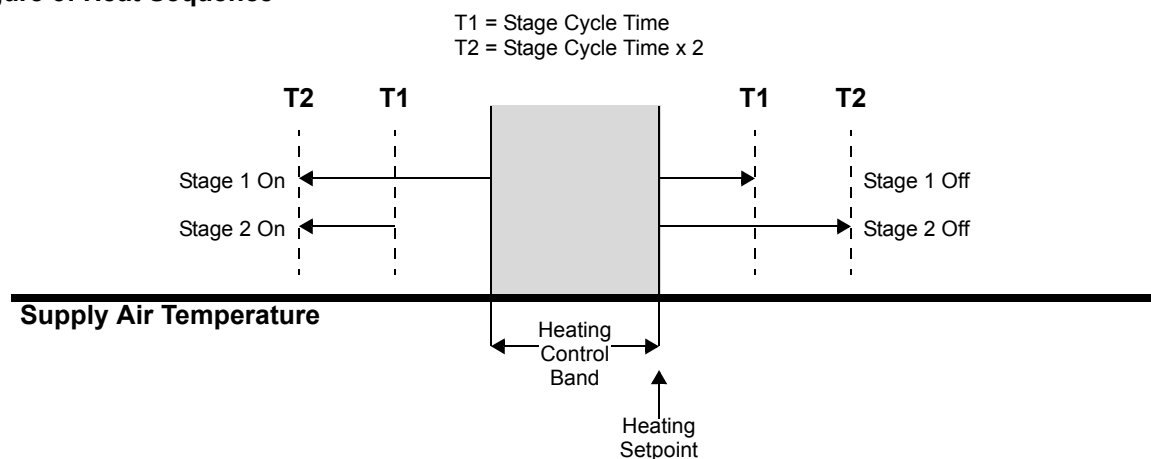
## Heating Stage Sequence

The VPU-1 supports staged heating or modulated heat through floating point control (See “Heating with Floating Point Control” on page 11.). Staged heating is enabled when the number of heating stages is non-zero.

The heating sequence is initiated when the current operating mode calls for heat. The electric heating stages are sequenced based on the supply air temperature, heating setpoint, and control band. When the supply air temperature drops below the heating setpoint minus the control band for a predefined time-period, a stage is turned on. If the supply air 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.

As the supply air temperature rises above the heating setpoint for a predefined time period the first available stage is turned off. If the supply air 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 the supply air temperature rises above the heating setpoint plus control band all of the stages immediately cycle off.

**Figure 3: Heat Sequence**



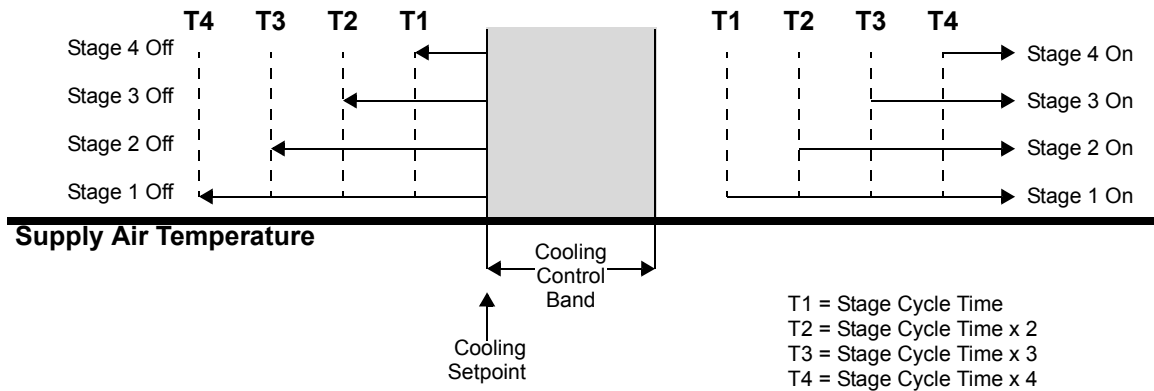
## Cooling Sequence

The cooling sequence is initiated when the current operating mode calls for cooling. The cooling compressor stages are sequenced based on the supply air temperature, cooling setpoint and control band. When the supply air temperature rises above the cooling setpoint plus the control band for a pre-defined time-period, a stage is turned on. If the supply air temperature remains above the cooling control band for an additional time-period, the next available stage is turned on. This cycle continues until all available stages have been energized.

In order to provide maximum energy savings, the cooling stages are interlocked with the economizer. When the economizer is enabled, the cooling stages are prevented from energizing before the economizer has reached its maximum position.

As the supply temperature drops below the cooling setpoint for a predefined time-period, the first available stage is turned off. If the supply air temperature remains below the cooling setpoint for an additional time-period, the next available stage is turned off. This cycle continues until all available stages have been de-energized.

**Figure 4: Cooling Sequence**



## Economizer Operation

The VPU-1 provides support for either two-position or modulated economizer types. A configuration parameter is provided to allow selection of the economizer type. Both economizer types are enabled based on the availability of “free cooling” from the outside air. Free cooling can be determined by enthalpy comparisons or dry bulb comparison.

### Dry Bulb Comparison

Free cooling can be determined based on the outside air temperature and average zone temperature. When the outside air temperature is below the average zone temperature by a programmable amount, free cooling is enabled. When the outside air temperature rises above the average zone temperature, free cooling is disabled.

### Enthalpy Calculation

An enthalpy calculation is performed periodically to determine if “free cooling” is available. The outside enthalpy is calculated based on the outside air temperature and humidity. The outside temperature and humidity are measured by an external device (such as an ASM-1 or ASM-2) on the network and sent to the VPU-1. The same calculation is performed on the inside air based on the space temperature and return air humidity. The inside enthalpy minus the outside enthalpy must be greater than the *Free Cooling Setpoint* in order for the economizer to be used for free cooling.

Optionally, an external device can measure the indoor air humidity globally. In this case, a return air humidity sensor would not be required at each VPU-1.

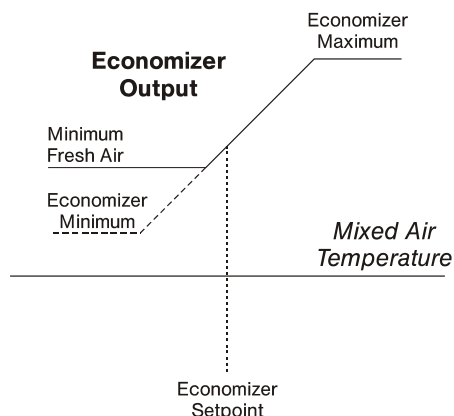
## Two-position Economizer Control

If present, the two-position economizer is enabled when there is “free cooling” available as determined by the enthalpy calculations. When the economizer is enabled, the economizer digital output is energized. When the economizer is disabled, the economizer output is de-energized. During IAQ alarm conditions the economizer is enabled to provide fresh air to the zones.

## Modulated Economizer Control

If present, the modulated economizer is enabled when there is “free cooling” available as determined by the enthalpy calculations.

**Figure 5: Economizer Control**



When the economizer is enabled, a P+I control loop modulates the economizer output. The P+I control loop modulates the economizer position to maintain a constant mixed air temperature

The economizer is modulated by P+I control loop based on the mixed air temperature setpoint and mixed air temperature. The P+I control loop modulates the economizer to maintain a constant mixed air temperature. As the temperature increases above the economizer setpoint, the economizer is modulated open. The economizer is modulated closed as the temperature decreases below the economizer setpoint.

When the economizer is disabled, it modulates to the minimum position. A configuration parameter is available to optionally disable the economizer during unoccupied periods. During IAQ alarm conditions the economizer is enabled to provide fresh air to the zones.

Programmable minimum and maximum outputs are provided for the fan speed output. Reversing the minimum and maximum values configures the economizer output for reverse operation. Overrides are provided to assist in system air balancing during commissioning.

## Fan Operation

During warm-up, occupied, extended occupied, and emergency heating states, the fan runs continuously. During the shutdown state, the fan is off.

The fan can be overridden from the LCI or another host controller. When the fan is overridden, the static pressure P+I loop control is disabled and the integral sum is cleared to prevent anti-windup reset. The fan's modulated output can be overridden between 0 and 100%. If the desired speed is greater than the current speed, the speed is ramped up to the desired speed based on the *Soft Start Ramp* setting. See “Soft Start Ramping” on page 10.

## Static Pressure Control

Static pressure control is achieved by modulating a variable speed drive based on the measured static pressure in the supply duct. The static pressure sensor input has maximum range of 5.000" W.C. with a minimum resolution of 0.005" W.C.

The fan speed output is modulated by a P+I control loop based on the static pressure loop setpoint and the supply static pressure measurement. The P+I control loop modulates the output to maintain a constant static pressure within the supply air duct. As the supply static pressure decreases 0.025" W.C. below the static pressure loop setpoint, the output is modulated towards its maximum value. The output is modulated towards its minimum value as the supply static pressure increases to 0.025" W.C. above the static pressure loop setpoint. When the static pressure is within  $\pm 0.025$ " W.C. of the static pressure setpoint, the output remains at its current level.

A separate static pressure setpoint is provided to increase the supply static pressure when an IAQ alarm condition exists. The fan speed control maintains the IAQ alarm pressure setpoint as long as an IAQ alarm condition exists.

Programmable minimum and maximum outputs are provided for the fan speed output. Reversing the minimum and maximum values configures the fan output for reverse operation. Overrides are provided to assist in system air balancing during commissioning.

## Soft Start Ramping

The VPU-1 can be configured to soft start ramp to prevent damage to the ducts and equipment when the fan is first energized. Setting the soft start ramp rate to 0% per second or 100% per second disables soft start ramping. The soft start ramping clamps the P+I output to the current ramp rate. Soft start ramping ends when the static pressure is within the deadband, greater than the pressure setpoint, or when the soft start ramp reaches 100%. Once soft start ramping ends, the P+I loop's integral sum is backwards calculated to create a bumpless transfer to the static pressure P+I loop control.

## VPU-1 and VAV-1 Communications

The VPU-1 and its associated VAV-1 controllers transfer information, depending on the number of VAV-1 controllers configured. The VPU-1 polls a VAV-1 controller every 5 seconds to transfer information necessary for control. The following information is transferred from the VPU-1 to the VAV-1 controller:

- Operational Mode: primary cool, primary heat, and primary off
- Occupancy Mode: occupied, unoccupied, and bypass (denotes morning warm-up)
- Alarm Conditions: IAQ Mode and Heat Failed On

The following information is transferred from the VAV-1 to the VPU-1 controller:

- Zone temperature
- Calculated Heating Setpoint
- Calculated Cooling Setpoint
- IAQ Sensor Status (safe, alarm)
- Local Alarm (VAV-1 shutdown)
- Occupancy Mode: occupied, unoccupied, and occupied extension)
- Supplemental heat status: on, off

## Power On/Reset Delay

The VPU-1 imposes a thirty second delay after being powered on or after a reset. No control takes place until after the thirty second delay has expired.

## Heating with Floating Point Control

The heating stage outputs can be configured for floating point control of a heating valve. Floating point control is enabled when the number of heating stages is set to zero, and the heating valve travel time is non-zero. The H1 output is the valve open signal, and the H2 output is the valve close signal.

After a reset, the floating point valve is calibrated by closing the valve for a period of the travel time plus an extra 30 seconds. This ensures that the valve is fully closed. When the valve is at its calculated 0% of 100% position, the valve is overdriven for 30 seconds to ensure that the valve is fully closed or open.

Temperature control only occurs when the operational mode is heating or morning warm-up, or when heating is required to heat the mixed air temperature to reach the supply air setpoint. During unoccupied and cooling periods, the heating valve is driven to 0%. During mixed air low limit alarms, the heating valve is driven to 100%.

The floating point control is similar to the heating staging algorithm. If the supply air temperature is below the supply air setpoint, the valve is driven open. When the supply air temperature is above the supply air setpoint, the valve is driven closed. There is a +/- 2 °F deadband around the setpoint to prevent the valve from dithering.

## Cooling-Only Support

The VPU-1 supports roof top units that do not provide central heating. The VAV terminal units perform local reheat to maintain the zone temperature setpoint, but the package unit only provides cool air. The VPU-1 operates in cooling mode even though heating is the operational mode. By indicating to the VAV-1s that it is in cooling mode, they take advantage of the central fan for airflow, and perform local reheat.

## Supply Air Temperature Monitoring

The VPU-1 monitors the supply air temperature to determine if the heating and cooling stages are operating properly. During heating mode, if the supply air temperature does not rise above the heat mode alarm setpoint after a 10 minute delay a heating failed alarm is generated. During cooling mode, if the supply air temperature does not drop below the cooling failed alarm setpoint after a 10 minute delay, a cooling failed alarm is generated.

## Fan Proof

A fan status input is provided for monitoring the operation of the fan. A 30 second delay is imposed when the fan is initially turned on. If at any time after the delay, the fan proof indicates the fan is not running, a fan failure condition is generated. The heating, cooling, fan speed, and economizer are interlocked with the fan. When a fan failure condition exists, the heating stages, cooling stages and the fan immediately turn off. In addition, the economizer closes and fan speed is dropped to 0%. The VPU-1 must be reset to clear this condition.

## Indoor Air Quality Compensation

The VPU-1 is capable of performing two modes of indoor air quality compensation. The first is to read an IAQ sensor placed in the return air duct and connected to a discrete input on the VPU-1. The second is to receive an IAQ alarm from one of the zone controllers.

### Return Air IAQ

The VPU-1 can read the status of an IAQ sensor placed in the return air duct. When the IAQ sensor indicates that contaminants are above a preset limit, the VPU-1 energizes the fan. After a preset time delay, the economizer is enabled to supply fresh air to the zones. All of the zones are made aware of the IAQ alarm condition. Any zone configured to participate in return air IAQ modulates its damper open. Heating and cooling operate as normal.

## Local Zone IAQ

The VPU-1 can receive the status of local IAQ sensors connected to discrete inputs on each zone controller. When the local zone IAQ sensor indicates that contaminants are above a preset limit, the VPU-1 energizes the fan. After a preset time delay, the economizer is enabled to supply fresh air to the zones. Only the VPU-1 and local zone controller participate in local zone IAQ. Heating and cooling operate as normal.

## Smoke Detection

A smoke detector input is provided. If the smoke detector indicates smoke is present then all of the stages and the fan turn off. Once the situation has been corrected, reset the controller to clear this condition.

## Mixed Air Low Limit Detection

An input is provided for a mixed air low limit detection device. If a low limit condition is detected, all of the stages and the fan turn off. Once the low limit is corrected, reset the controller to clear this condition.

## 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 unit is not shut down due to a filter alarm.

## Local Backup Schedule

A remote device on the network normally provides the current operating mode. A local backup schedule is provided for cases when the remote device is not available. When the controller detects that the remote device is not available for a 10 minute period, it resorts to the local backup schedule.

The schedule defines an occupied and unoccupied period within the day. The user configures the occupied and unoccupied times that are used in determining the current operating mode of the controller.

## 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. An operator or maintenance personnel can reset the runtime once servicing has been performed. The runtimes are accumulated in volatile memory (RAM). Once a day they are backed up to non-volatile memory (NVRAM). When the VPU-1 is reset, the runtimes are copied from NVRAM to RAM.

## Alarms and Events

The VPU-1 detects certain alarm conditions and sends them to LCI. Before this can occur, the VPU-1 must have been configured by the LCI.

### Digital Input Alarms

The VPU-1 monitors the status of the digital inputs and generates alarms for the following events:

- Fan Failure
- Smoke Detect
- Mixed Air Low Limit Condition
- Dirty Filter
- CO<sub>2</sub> Alarm (IAQ alarms are only generated when the space is occupied.)

### Supply Air Temperature Alarms

The following alarms can be generated based on supply air monitoring.

- Cooling Failed
- Heating Failed

## Maintenance Alarm

A VPU-1 provides programmable run limits for generating runtime maintenance alarms. When the cooling runtime, heating runtime, or fan runtime exceeds these limits, a maintenance alarm is sent to the LCI.

## Automatic Configuration

The VPU-1 and iWorX 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 VPU-1 when the controller's service pin is pressed. The controller's status light flashes green until the controller is configured, and will be 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. Users may bind to SNVTs on the VPU-1 with LNS or other LONWORKS tools if they wish.

The LCI also provides network supervision of the VPU-1. The LCI periodically sends a "ping" message to the VPU-1, 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.

## VPU-1 Configuration

Once the VPU-1 is properly installed and recognized by the Local Control Interface (LCI), the LCI can be used to configure the settings of the controller. This section describes the commands available on the LCI for configuration of the VPU-1, and the meanings and default values for controller parameters. For more information on using the LCI, see the *iWorX LCI User's Guide*.

## Setup

### Heating/Cooling Settings

This screen displays the heating and cooling setpoints used by the VPU-1 controller. Use the up and down arrow keys to select a value to change, then use **-** or **+** to increase or decrease the value (or utilize **USE KEYS** to directly enter the desired value). Press **Save** to save your changes or **Back** to return to the Setup screen.

**Table 1: VPU-1 Heating/Cooling Settings**

Setpoint	Range	Default	Description
Occupied Heating Setpoint	80.00 to 130.00 °F (26.67 to 54.44 °C)	90.00 °F (32.22 °C)	Temperature below which heating should be enabled.
Occupied Cooling Setpoint	45.0 to 65 °F (7.22 to 18.33 °C)	55.00 °F (12.78 °C)	Temperature above which cooling should be enabled.
Stage Control Band	0.00 to 10.00 °F (0.00 to 5.56 °C)	1.00 °F (0.56 °C)	Value added to cooling setpoint or subtracted from the heating setpoint to indicate when the second stage of heating or cooling should be enabled.
Stage Timer	0 to 255 minutes	5 minutes	The amount of time between stage cycles.
Heating Stages	0 to 2	2	Number of heating stages that are available.
Cooling Stages	0 to 4	4	Number of cooling stages that are available.

## Pressure Setup

Displays VPU-1 setpoints that specifically relate to static pressure.

**Table 2: VPU-1 Pressure Setup**

Setting	Range	Default	Description
Static Pressure Setpoint	0.00 to 5.00" W.C. (0 to 1246 Pa)	1.50" W.C. (374 Pa)	Setpoint for supply air static pressure.
VFD Minimum Output	0.0 to 10.0 Volts	0.0 Volts	Minimum output voltage for the bypass damper.
VFD Maximum Output	0.0 to 10.0 Volts	10.0 Volts	Maximum output voltage for the bypass damper.
Pressure Proportional Gain	0 to 100% per 0.1" W.C.	25.00%	Proportional gain of the static pressure P+I control loop.
Pressure Integral Gain	0.00 to 100.00%	0.05%	Integral gain of the static pressure P+I control loop.
Static Pressure Minimum	-2.50 to 5.00" W.C. (0.722 to 1246 Pa)	0.00" W.C. (0 Pa)	Static pressure to report when the analog input receives 0 volts.
Static Pressure Maximum	0.00 to 5.00" W.C. (0 to 1246 Pa)	2.00" W.C. (498 Pa)	Static pressure to report when the analog input receives 10 volts.
IAQ Alarm Pressure Setpoint	0.00 to 5.00" W.C. (0 to 1246 Pa)	2.00" W.C. (498 Pa)	Static pressure setpoint used when an IAQ alarm is present.

## Economizer Settings

Displays VPU-1 setpoints that specifically relate to economizer operation.

**Table 3: VPU-1 Economizer Settings**

Setting	Range	Default	Description
Economizer Setpoint	40.00 to 70.00 °F (4.44 to 21.11 °C)	55.00 °F (12.78 °C)	Setpoint used for controlling the modulated economizer.
Economizer Minimum Output	0.0 to 10.0 Volts	0.0 Volts	Minimum output voltage for the modulated economizer.
Economizer Maximum Output	0.0 to 10.0 Volts	10.0 Volts	Maximum output voltage for the modulated economizer.
Economizer Type	Disabled, 2 State Unoccupied On, 2 State Unoccupied Off, Modulated Unocc. On, Modulated Unocc. Off,	Disabled	If using an economizer, set this field to a value that describes the type of economizer and whether it should be enabled during unoccupied periods.
Economizer Proportional Gain	0.00 to 100.00% per °F	25.00%	Proportional gain of the economizer's P+I control loop.
Economizer Integral Gain	0.00 to 100.00%	0.05%	Integral gain of the economizer's P+I control loop.
Minimum Fresh Air	0.00 to 100.00%	0.00%	Minimum fresh air position for the modulated economizer.
Free Cool Setpoint	0.0 to 60.0 BTU/lb. (0.0 to 139.6 kjoule/kg)	5.0 BTU/lb. (11.6 kjoule/kg)	Difference between inside enthalpy and outside enthalpy that enables or disables the economizer. <sup>a</sup>

a. This value is only used for "Return Air Humidity Sensor" and "Global Indoor Humidity Sensor" free cooling types.

## Grouping Buttons

These three buttons enable you to configure which zone controllers on the network are being supplied with air by the current VPU-1. These devices control sub-zones of the VPU-1's overall system.

Press **Add New Device** to see a list of available zone controllers. Use the up and down arrow keys to select a controller (use **Page Up** and **Page Down** if the list is longer than one screen), then press **Select** to move it to the list of devices in the VPU-1's group.

Press **Devices in Group** to see a list of devices that are currently in the VPU-1's group. If you wish to remove a device from this list, use the up and down arrow keys to select a controller (use **Page Up** and **Page Down** if the list is longer than one screen), then press **Delete**.

Press **Send Grouping** to inform the VPU-1 which zone controllers are associated with it.

## Heating and Cooling Factors

These buttons enable you to configure the LCI's non-adaptive optimum start (OS) feature to enable morning warm-up and cool down. The OS feature modifies the scheduling of the controller to account for the heating and cooling factor of the system. Set these values to the number of degrees per minute that your system is capable of modifying the indoor air temperature. To disable this feature, set these values to zero. To utilize this feature, you must also set one zone controller as the "reference zone".

## List All Settings

Displays all of the VPU-1's setpoints and editable settings and provides access to edit all VPU-1 parameters from a single screen.

**Table 4: All VPU-1 Settings**

Setting	Range	Default	Description
Fan Override			
– Override Mode	Off, Position, Minimum, Maximum	Off	Set to any value besides "Off" to place the fan into that override mode.
– Fan VFD Percentage	0.00% to 100.00%	0.00%	Fan setting to use when the controller is placed in "Position" override mode.
Supply Air Cooling Setpoint	45.00 to 65.00 °F (7.22 to 18.33 °C)	55.00 °F (12.77 °C)	Temperature setpoint for cooling mode.
Supply Air Heating Setpoint	80.00 to 130.00 °F (26.66 to 54.44 °C)	90.00 °F (32.22 °C)	Temperature setpoint for heating mode.
Supply Air Cooling Limit	0.00 to 30.00 °F (0.00 to 16.66 °C)	10.00 °F (5.55 °C)	Minimum temperature change from cooling setpoint in 10 minutes to avoid a cooling failed alarm.
Supply Air Heating Limit	0.00 to 30.00 °F (0.00 to 16.66 °C)	10.00 °F (5.55 °C)	Minimum temperature change from heating setpoint in 10 min. to avoid a heating failed alarm.
Heating Stages	0 to 2	2	Number of heating stages that are available.
Cooling Stages	0 to 4	4	Number of cooling stages that are available.
Stage Control Band	0.00 to 10.00 °F (0.00 to 5.56 °C)	1.00 °F (0.56 °C)	Value added to cooling setpoint or subtracted from the heating setpoint to indicate when the second stage of heating or cooling should be enabled.
Stage Time	0 to 255 minutes	5 minutes	The amount of time between stage cycles.

**Table 4: All VPU-1 Settings (Continued)**

<b>Setting</b>	<b>Range</b>	<b>Default</b>	<b>Description</b>
Economizer Type	Disabled, 2 State Unoccupied On, 2 State Unoccupied Off, Modulated Unocc. On, Modulated Unocc. Off,	Disabled	If using an economizer, set this field to a value that describes the type of economizer and whether it should be enabled during unoccupied periods.
Economizer Setpoint	40.00 to 70.00 °F (4.44 to 21.11 °C)	55.00 °F (12.78 °C)	Setpoint used for controlling the modulated economizer.
Economizer Proportional Gain	0.00 to 100.00% per °F	25.00%	Proportional gain of the economizer's P+I control loop.
Economizer Integral Gain	0.00 to 100.00%	0.05%	Integral gain of the economizer's P+I control loop.
Minimum Fresh Air	0.00 to 100.00%	0.00%	Minimum fresh air position for the modulated economizer.
Economizer Minimum Output	0.0 to 10.0 Volts	0.0 Volts	Minimum output voltage for the modulated economizer.
Economizer Maximum Output	0.0 to 10.0 Volts	10.0 Volts	Maximum output voltage for the modulated economizer.
Free Cool Type	Return Air Humidity Sensor, Global Indoor Humidity Sensor, Dry Bulb Temperature Comparison	Return Air Humidity Sensor	Type of free cooling comparison to perform.
Free Cool Setpoint	0.0 to 60.0 BTU/lb. (0.0 to 139.6 kjoule/kg)	5.0 BTU/lb. (11.6 kjoule/kg)	Difference between inside enthalpy and outside enthalpy that enables or disables the economizer. <sup>a</sup>
Economizer Drybulb Setpoint	0.0 to 20.0 °F (0.0 to 11.1 °C)	5 °F (2.78 °C)	Difference between zone temperature and outside temperature that enables or disables the economizer. <sup>b</sup>
Static Pressure Minimum	-1.25 to 5.00" W.C. (311 to 1246 Pa)	0.00" W.C. (0 Pa)	Static pressure to report when the analog input receives 0 volts.
Static Pressure Maximum	0.00 to 5.00" W.C. (0 to 1246 Pa)	2.00" W.C. (498 Pa)	Static pressure to report when the analog input receives 10 volts.
Static Pressure Setpoint	0.00 to 5.00" W.C. (0 to 1246 Pa)	1.50" W.C. (374 Pa)	Setpoint for supply air static pressure.
IAQ Alarm Pressure Setpoint	0.00 to 5.00" W.C. (0 to 1246 Pa)	2.00" W.C. (498 Pa)	Static pressure setpoint used when an IAQ alarm is present.
Pressure Proportional Gain	0 to 100% per 0.1" W.C.	25.00%	Proportional gain of the static pressure P+I control loop.
Pressure Integral Gain	0.00 to 100.00%	0.05%	Integral gain of the static pressure P+I control loop.
Fan Minimum Output	0.0 to 10.0 Volts	0.0 Volts	Minimum voltage for the fan output.
Fan Maximum Output	0.0 to 10.0 Volts	10.0 Volts	Maximum voltage for the fan output.
IAQ Delay Time	0 to 255 minutes	10 minutes	Delay before reporting a global IAQ alarm.
Fan Runtime Limit	0 to 65535 hours	1000 hours	Runtime limit for fan after which a maintenance alarm is generated.
Cooling Runtime Limit	0 to 65535 hours	1000 hours	Runtime limit for cooling after which a maintenance alarm is generated.

**Table 4: All VPU-1 Settings (Continued)**

Setting	Range	Default	Description
Heating Runtime Limit	0 to 65535 hours	1000 hours	Runtime limit for heating after which a maintenance alarm is generated.
Occupied Time			
– Hours	0 to 23	0	Time to begin occupied period for the local backup schedule.
– Minutes	0 to 59	0	
Unoccupied Time			
– Hours	0 to 23	0	Time to end occupied period for the local backup schedule.
– Minutes	0 to 59	0	
Heat Travel Time	0 to 600 seconds	0 seconds	Travel time of floating point heating valve.
Soft Start Ramp	0.00 to 100.00%	0.00%	Percentage of fan output increase per second.

- a. This value is only used for “Return Air Humidity Sensor” and “Global Indoor Humidity Sensor” free cooling types.
- b. This value is only used for “Dry Bulb Temperature Comparison” free cooling.

## Inputs

The Inputs screen displays the current values of the VPU-1’s inputs. These values cannot be changed.

**Table 5: VPU-1 Inputs**

Input	Range	Description
Supply Air Temperature	-22 to 122 °F (-30 to 50 °C)	Temperature reported by the SAT sensor.
Return Air Humidity	0.00 to 100.00%	Humidity reported by the RAH sensor.
Mixed Air Temperature	-22 to 122 °F (-30 to 50 °C)	Temperature reported by the MAT sensor.
Fan Status	Off, On	Status of the fan proof switch (FNP)
Low Limit	Normal, Freeze	Status of the mixed air low limit indication switch (MLL).
Filter Status	Normal, Dirty	Status of the filter switch (FIL).
Smoke Detector	Normal, Smoke	Status of the smoke detector (SMK).
Indoor Air Quality	Normal, Alarm	Status of the IAQ alarm sensor.
Inside Enthalpy	0.0 to 60.0 BTU/lb. (0.0 to 139.6 kjoule/kg)	Calculated inside air enthalpy.
Outside Enthalpy	0.0 to 60.0 BTU/lb. (0.0 to 139.6 kjoule/kg)	Calculated outside air enthalpy.
Supply Air Static Pressure	-2.50 to 5.00” W.C. (0.722 to 1246 Pa)	Static pressure reported by the static pressure sensor (SPR).
Optimum Start Minutes	0 to 65535 minutes	Number of minutes remaining in optimum start.

## Outputs

This screen displays the current values of the VPU-1's outputs. These values cannot be changed.

**Table 6: VPU-1 Outputs**

Output	Range	Description
Heating Output	0.00% to 100.00%	Heat output currently being supplied to the space.
Cooling Output	0.00% to 100.00%	Current status of the cooling outputs.
Fan Output	0.00% or 100.00%	Current status of the fan output.
Economizer Output	0.00% to 100.00%	Current status of the economizer output.
Mode	Off, Heat, Cool, Fan Only	Current mode of the VPU-1.

This screen also displays the current status of each device in the VPU-1's group. Each device is displayed on its own line, and is identified as being off, in heating mode, or in cooling mode.

## Runtimes/Limits

This screen shows all runtime totals and runtime limits for the VPU-1. To reset a runtime total to zero, use the up and down arrows to highlight the value, and then press **Reset**. To change a limit value, highlight it and press **Select**.

**Table 7: VPU-1 Runtimes/Limits**

Setting	Range	Default	Description
Fan Runtime	0 to 65535 Hours	0 Hours	Current fan runtime.
Fan Runtime Limit	0 to 65535 Hours	1000 Hours	Runtime limit for fan after which a maintenance alarm is generated.
Cooling Runtime	0 to 65535 Hours	0 Hours	Current cooling runtime.
Cooling Runtime Limit	0 to 65535 Hours	1000 Hours	Runtime limit for cooling after which a maintenance alarm is generated.
Heating Runtime	0 to 65535 Hours	0 Hours	Current heating runtime.
Heating Runtime Limit	0 to 65535 Hours	1000 Hours	Runtime limit for heating after which a maintenance alarm is generated.

## Troubleshooting

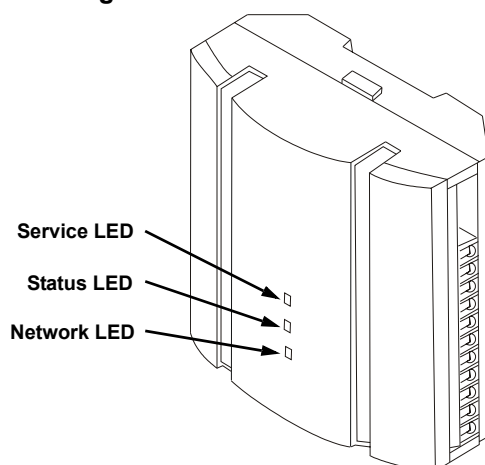
### Diagnostic LEDs

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 top to bottom on the unit.

**Table 8: VPU-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

**Figure 6: Diagnostic LEDs**



### 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.

#### **Can my iWorX system contain multiple VPU-1 controllers?**

Yes, provided that you do not exceed the maximum number of controllers that can be handled by the Local Control Interface (LCI).

#### **Thermistor readings fluctuate rapidly, sometimes by several degrees.**

The controller is not properly grounded. The controller's ground (GND) pin (T28) 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.

#### **How do I associate my VAV-1 controllers with the VPU-1?**

Use the VPU-1's grouping mechanism, specifically **Add New Device** on the VPU-1 Setup screen of the LCI.

### **What is Send Grouping for, and when do I press it?**

This button stores network information into the VPU-1 about the VAV-1s in its group. Press this button when there has been any change in the grouping arrangement.