Application Guide

505-029-2

MPU3 Air Control – Pressure Dependent Multi-Zone

Self-Contained Interoperable Controller Model UCP-1

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MPU3

The MPU3 is a self-contained microprocessor-based controller for multiplexed zone package units. Applications include packaged rooftop DX units with up to two stages of cooling, or a floating point control valve, or a modulated output (valve or variable speed circulator) two stages of heating, or a floating point control valve, or a modulated output (valve or variable speed circulator) economizer, and bypass damper.

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 MPU3 incorporates digital outputs in the form of triacs for fan start/stop, two cooling stages, two heating stages, floating point reheat valve, and a two-position economizer. In addition, four analog outputs are provided to control cooling and heating outputs, a modulated economizer, and bypass damper.

The MPU3 is based on the LONWORKS® networking technology. The controller can be networked to a higher-level control system for monitoring and control applications.

Features

- Two stages of cooling, or a floating point control valve, or a modulated output (valve or variable speed circulator)
- Two stages of heating, or a floating point control valve, or a modulated output (valve or variable speed circulator)
- Modulated bypass damper
- 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
- Dehumidification, dehumidification with reheat, or dehumidification with heat
- Multiplexed control of 32 zones based on zone demand
- Supply air temperature safety limits
- Supply air temperature setpoint reset based on greatest zone demand
- Time proportioned control of the staged outputs to reduce cycling
- Proportional+Integral control of the modulated economizer, modulated heating modulated cooling and static pressure
- Local backup schedule
- Filter status, fan proof, mixed air low limit, and smoke detection inputs
- Fan control energized on a call for heating, cooling or ventilation
- Automatic Heat/Cool changeover
- IAQ compensation based on the IAQ input or zone controller alarm
- Outside Air Temperature cutoffs
- Real Time Clock
- LONWORKS® interface to building automation systems
- Automatic configuration with the LCI
- Alarm/Event reporting

PURPOSE OF THIS GUIDE

The *iWorx® MPU3 Application Guide* provides application information for the MPU3 Controller.

The reader should understand basic HVAC concepts, intelligent environmental control automation, and basic LONWORKS networking and communications. This 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

REPRESENTATIONS AND WARRANTIES

This Document is subject to change from time to time at the sole discretion of Taco Electronic Solutions, Inc. All updates to the Document are available at www.taco-hvac.com. When installing this product, it is the reader's responsibility to ensure that the latest version of the Document is being used.

iWorx® products shall only be used for the applications identified in the product specifications and for no other purposes. For example, iWorx® 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 used for such purposes.

Taco Electronic Solutions, Inc. will not be responsible for any product or part not installed or operated in conformity with the Document and instructions or which has been subject to accident, disaster, neglect, misuse, misapplication, inadequate operating environment, repair, attempted repair, modification or alteration, or other abuse. For further information, please refer to the last page of this Document for the company's Limited Warranty Statement, which is also issued with the product or available at www.taco-hvac.com.

APPLICABLE DOCUMENTATION

Table 1: Applicable Documentation

Description	Audience	Purpose
iWorx® MPU3 Application Guide, Document No. 505-029-2 (this document)	– Application Engineers – Wholesalers – Contractors – Start-up Technicians – End user	Provides instructions for setting up and using the iWorx® MPU3.
iWorx® VAV Application Guide, Document No. 505-010	– Application Engineers – Installers – Service Personnel – Start-up Technicians – End user	Provides instructions for setting up and using the iWorx® VAV controller.
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.
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. See also: www.echelon.com/support/documentation/manuals/transceivers.	

INSTALLATION INSTRUCTIONS

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 manual are for the MPU3 controller, which supports one multiplexed package unit.

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.

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.

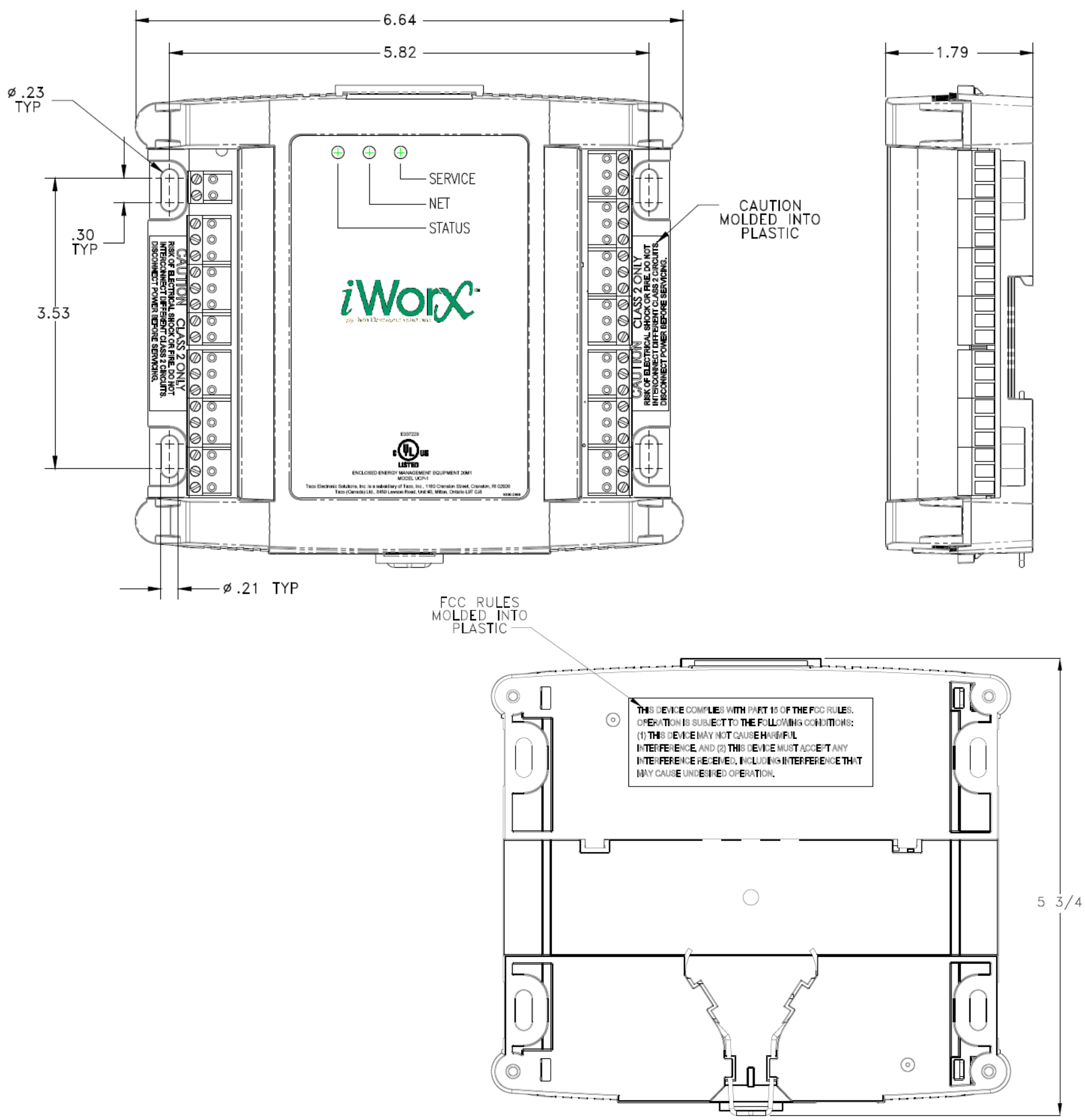
INSTALLATION

Warning: Electrical shock hazard. To prevent electrical shock or equipment damage, disconnect **ALL** power sources to controllers and loads 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).

WIRING INFORMATION

WARNING: Terminals 6, 9, 12, 15, 18, and 38 are connected internally on all MPU3 controllers. Disconnect **ALL** power sources when installing or servicing this equipment to prevent electrical shock or equipment damage.

Figure 2: Typical MPU3 Wiring - Example A

Multi Zone Unit with Staged Heating & Cooling and Modulated Economizer; Triac Outputs wired as Power Sourced

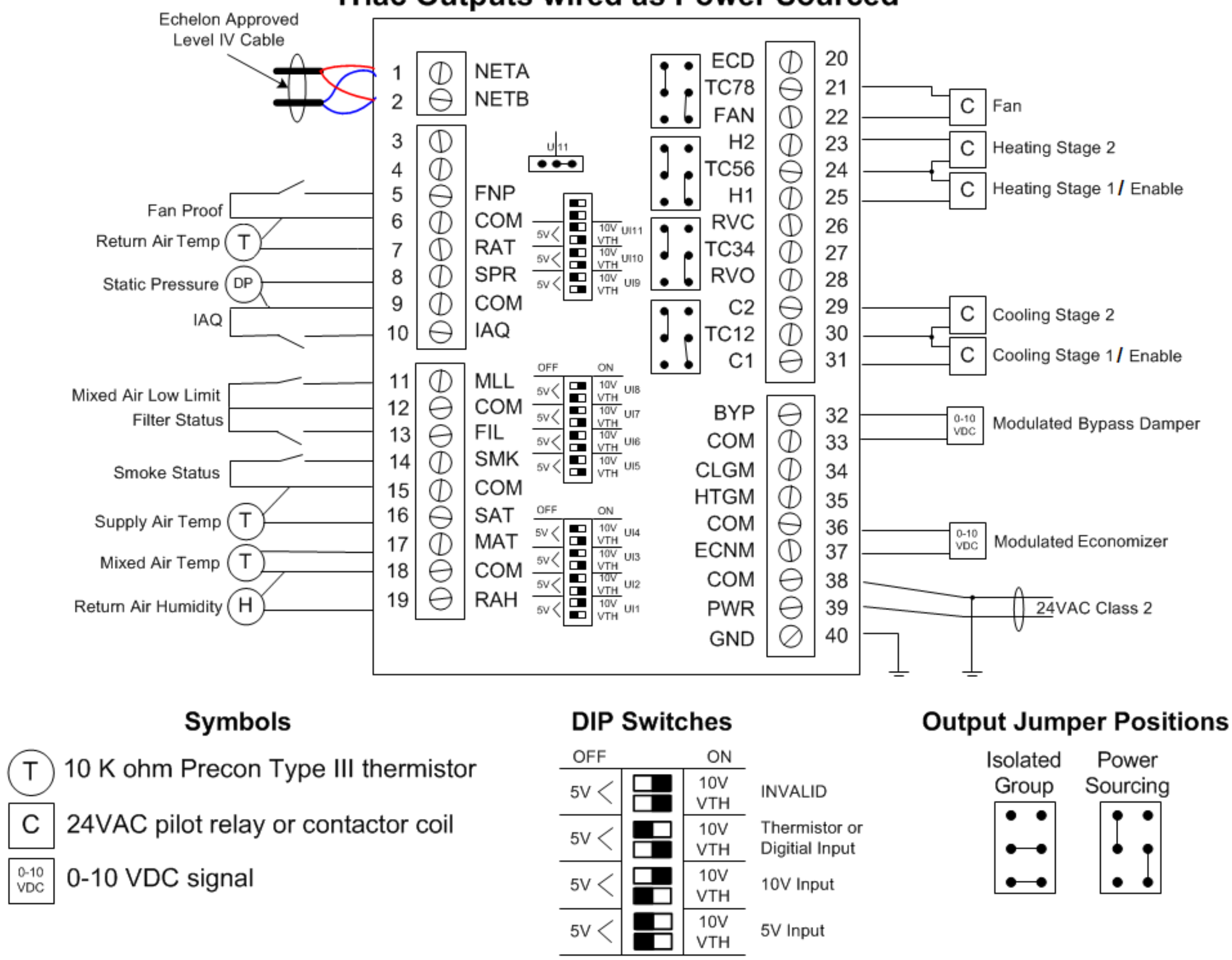


Figure 3: Typical MPU3 Wiring - Example B

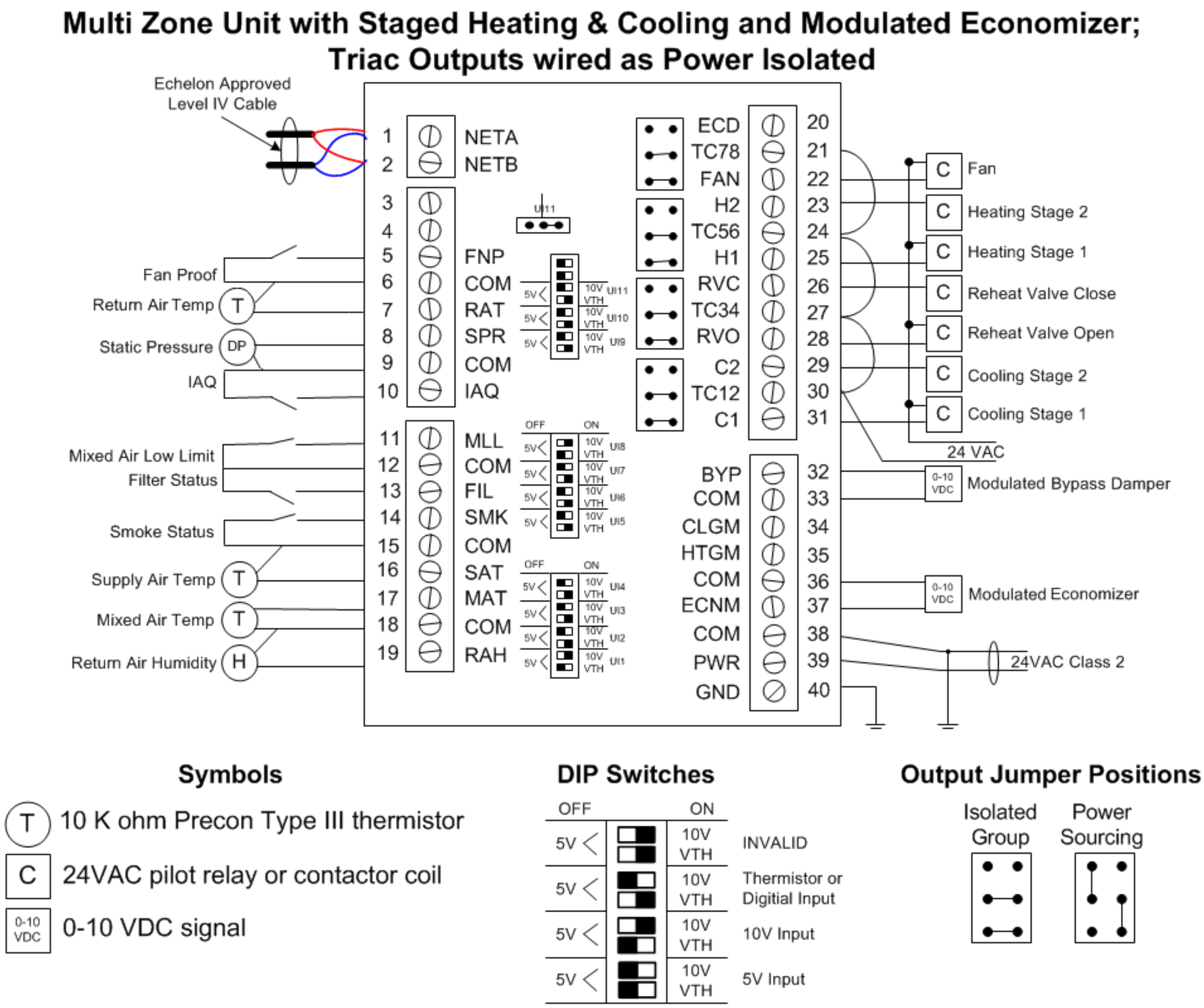
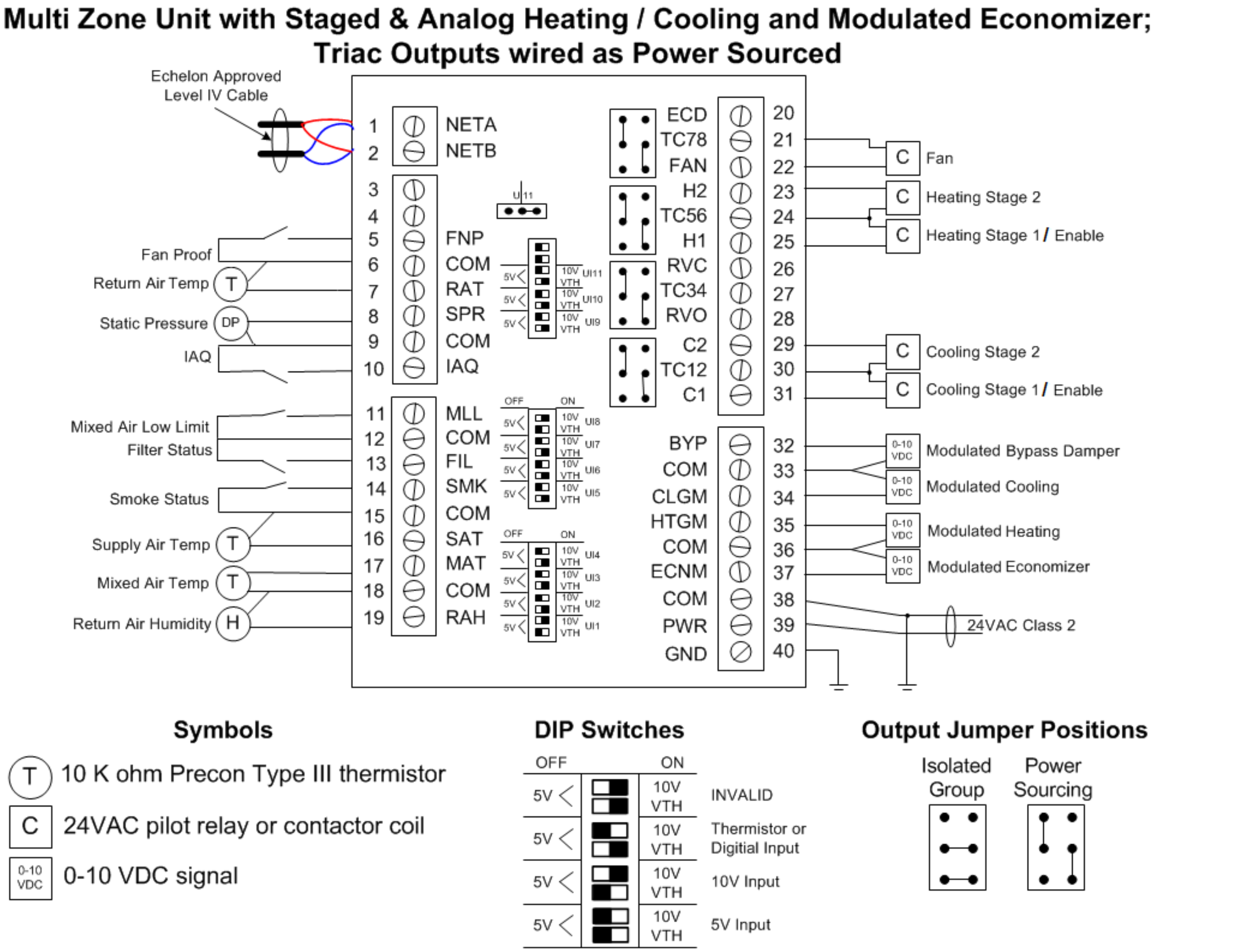


Figure 4: Typical MPU3 Wiring - Example C



Connecting Input Devices

Return Humidity (RAH)

To connect the Return Air Humidity sensor to the unit, connect the positive wire from the sensor to RAH (T19) and the other wire to the adjacent common (T18). The sensor must be of the 0-10 Volt type.

If global indoor air humidity readings are being provided over the network, it is not necessary to attach a return air humidity sensor directly to the MPU3.

Mixed Air (MAT)

To connect the Mixed Air thermistor to the unit, attach one wire from the thermistor to MAT (T17) and the other wire to the adjacent common (T18). The thermistor used must be 10K Precon Type III.

Supply Air (SAT)

To connect the Supply Air thermistor to the unit, attach one wire from the thermistor to SAT (T16) and the other wire to the adjacent common (T15). The thermistor used must be 10K Precon Type III.

Smoke Detector (SMK)

To connect the smoke detector switch to the digital input, attach one wire of the contact to SMK (T14) and the other wire to the adjacent common (T15). This must be a dry contact normally open switch. This input is for indication only. A separate smoke detector should be wired into a fire alarm system if the generation of a fire alarm is required.

Filter (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.

Mixed Air Low Limit Indication (MLL)

To connect the low limit indication switch to the digital input, attach one wire of the contact to MLL (T11) and the other wire to the adjacent common (T12). This must be a dry contact normally open switch.

Indoor Air Quality (IAQ)

To connect the digital CO_2 level sensor to the unit, attach one wire from the sensor to IAQ (T10) and the other wire to the adjacent common (T9). The sensor must provide a contact closure when the CO_2 limit is exceeded. For a digital sensor, this must be a dry contact normally open switch. For an analog sensor, it must be of the 0-10V type.

Static Pressure (SPR)

To connect the static pressure transducer to the analog input, connect the positive wire from the sensor to SPR (T8) and the other wire to the adjacent common (T9). The sensor must be of the 0 to 10 V type.

Return Air Temperature (RAT)

To connect the return air temperature thermistor to the analog input, attach one wire of the sensor to RAT (T7) and the other wire to the adjacent common (T6).

Fan Proof (FNP)

To connect the fan proof switch to the digital input, attach one wire of the contact to FNP (T5) and the other wire to the adjacent common (T6). This must be a dry contact, normally closed switch. If you are not providing a fan proof input, T5 and T6 must be shorted (jumpered) together.

Connecting Output Devices

Modulated Economizer (ECNM)

The modulated economizer output can be set to 0-10 V max through the control logic. Connect the positive wire from the damper actuator to ECNM (T37) and the other wire to the adjacent common (T36). See preceding figures for details.

Modulated Heating (HTGM)

The modulated heating output can be set to 0-10 V max through the control logic. Connect the positive wire from the heating output to ECNM (T35) and the other wire to COM (T36). See preceding figures for details.

Modulated Cooling (CLGM)

The modulated cooling output can be set to 0-10 V max through the control logic. Connect the positive wire from the cooling output to CLGM (T34) and the other wire to COM (T33). See preceding figures for details.

Bypass Damper (BYP)

The bypass damper output can be set to 0-10 VDC max through the control logic. Connect the positive wire from the damper actuator to BYP (T32) and the other wire to the adjacent common (T33). See preceding figures for details.

Cooling Stage 1 or Cooling Floating Point Valve Open (C1)

The cooling stage output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect cooling stage 1 to C1 (31) and TC12 (30). For control of a floating point valve, connect C1 as the valve open signal.

Cooling Stage 2 or Cooling Floating Point Valve Close (C2)

The cooling stage output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect cooling stage 2 to C2 (29) and TC12 (30). For control of a floating point valve, connect C2 as the valve close signal.

Reheat Valve Open (RVO)

The reheat valve open output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect to C3 (T28) and TC34 (T27).

Reheat Valve Close (RVC)

The reheat valve close output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect to C4 (T26) and TC34 (T27).

Heating Stage 1 or Heating Floating Point Valve Open (H1)

The heating stage output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect heating stage 1 to H1 (T25) and TC56 (24). For control of a floating point heating valve, connect H1 (T25) as the valve open signal. TC56 (T24) is the common.

Heating Stage 2 or Heating Floating Point Valve Close (H2)

The heating stage output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect heating stage 2 to H1 (T23) and TC56 (T24). For control of a floating point heating valve, connect H2 (T23) as the valve close signal. TC56 (T24) is the common.

Fan (FAN)

The fan output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect the fan to FAN (T22) and TC78 (T21).

Digital Economizer (ECD)

The digital economizer output must be connected to a 24 VAC pilot relay if the load is greater than 1 Amp. See preceding figures for details. If the load is less than 1 Amp, connect the economizer to ECD (T20) and TC78 (T21).

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

- Cabling: twisted shielded pair, 18 AWG recommended—500 feet max. (152 meters)
- Resolution: 10 bit

Mixed Air Low Limit, Filter Status, Smoke Detect, Local IAQ Alarm

- Dry Contact
- Normally Open
- 5 Volts DC Max

Fan Proof

- Dry Contact
- Normally Closed

Return Air Humidity, Static Pressure

- 0 - 10 Volts DC

Mixed Air Temperature, Supply Air Temperature, Return Air Temperature

- Precon Type III 10K thermistor

Outputs

Fan Start/Stop, Heating Stage 1, Heating Stage 2, Cooling Stage 1, Cooling Stage 2, Reheat Valve Open, Reheat Valve Close, Digital Economizer

- 24 Volts AC
- 1A @ 50C, 0.5A @ 60C, limited by the Class 2 supply rating

Modulated Economizer, Bypass Damper

- 0-10 Volts DC
- 2K Ohm minimum load
- 8 bit resolution

Power

Power Requirements

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

Power Consumption

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

Recommended Sensor Wire

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

FTT-10A Network

- Speed: 78KBPS
- 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

For detailed specifications, refer to the *FTT-10A Free-Topology Transceiver User's Guide* published by Echelon Corporation (www.echelon.com/support/documentation/manuals/transceivers).

Mechanical

Housing

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

Weight

- Controller Weight: 0.70 pounds (0.32 kilograms)
- Shipping Weight: 1.0 pounds (0.46 kilograms)

Electronics

- Processor: 3150 Neuron 10 MHz
- Flash: 48 Kilobytes
- SRAM: 8 Kilobytes
- Termination: 0.197" (5.0 mm) Pluggable Terminal Blocks, 14-22 AWG

Environmental

- Temperature: 32 °F to 140 °F (0 °C to 60 °C)
- Humidity: 0 to 90%, non-condensing

Agency Listings

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

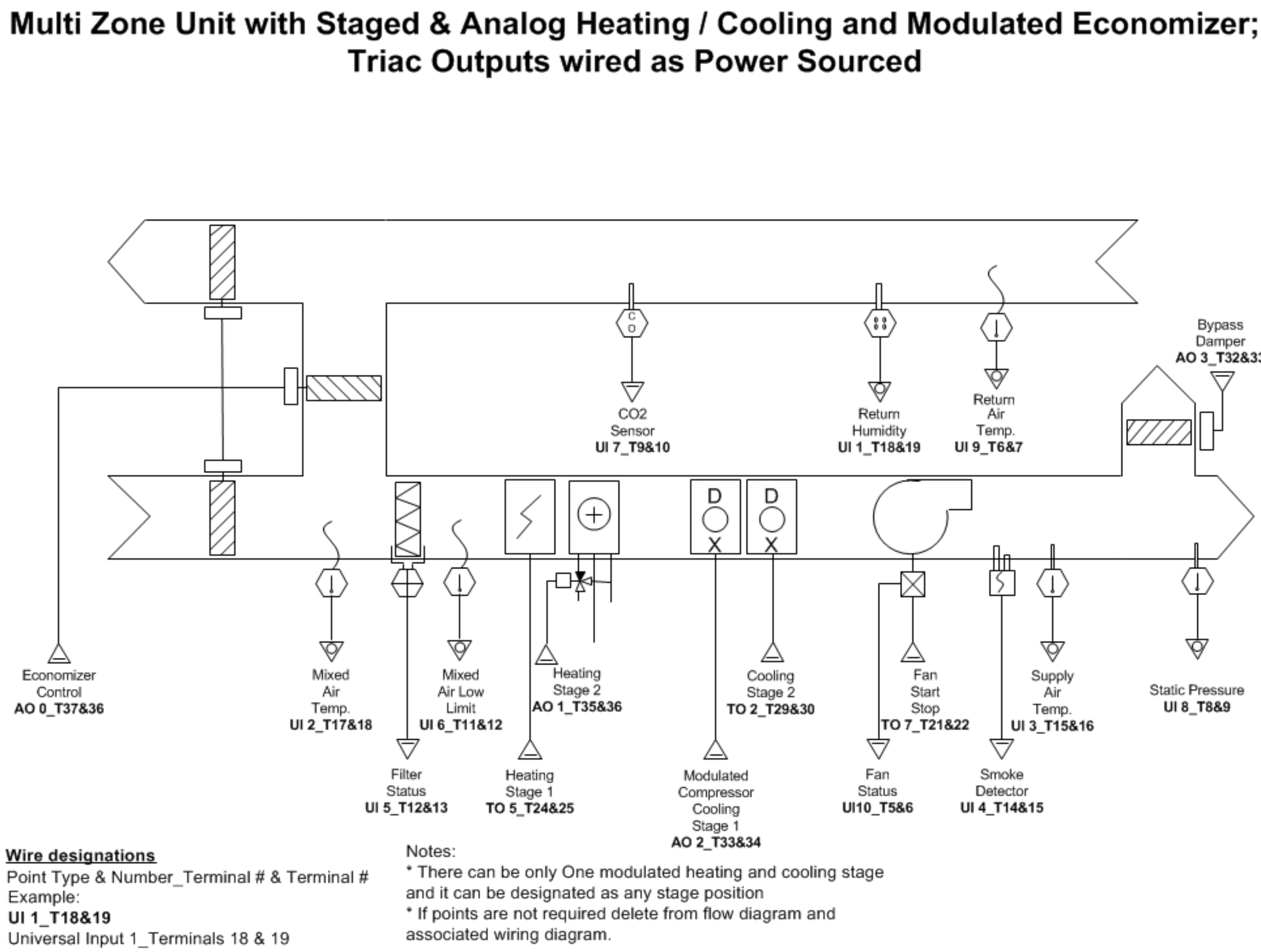
Agency Compliances

- FCC Part 15 Class A

APPLICATION DESCRIPTION

The MPU3 is a multiplexed package unit controller that permits a single zone package unit to operate multiple zones. Figure 5 and Figure 6 illustrate typical MPU3 applications. The MPU3 operates in conjunction with up to 32 multiplexed zone controllers. The control is achieved by multiplexing the primary supply air between cooling and heating based on the various demands from the Zone Controllers. In addition to multiplexing, the MPU3 controls an economizer and bypass damper.

Figure 5: Multiplexed Package Unit - Staged Heating & Cooling, Modulated Economizer



The starting and stopping of the supply air fan is controlled by the MPU3. The fan is energized when the there is a call for heating or cooling from the Zone Controllers. During the occupied periods, the fan can be configured to run continuously.

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 temperature.

The economizer can be configured as two-position (digital) or modulated (analog). If enabled, the two 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 two-position economizer output is off when the economizer is disabled.

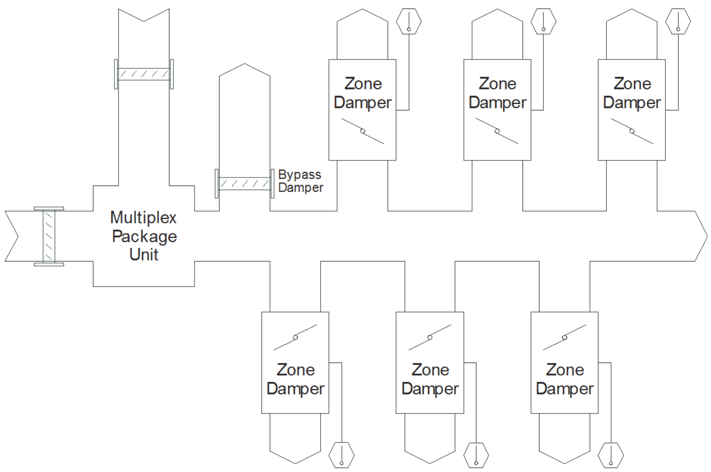
When “free cooling” is available, the modulated economizer position is calculated by a Proportional + Integral (P+I) control loop based on the mixed air temperature and setpoint. As the temperature increases above the mixed air setpoint, the economizer damper is modulated open. The economizer is modulated 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 optionally be disabled during unoccupied periods.

The bypass damper operates to maintain a configurable system static pressure setpoint. The bypass damper position 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 bypass damper is modulated open. The bypass damper is modulated closed as the pressure decreases below the pressure setpoint.

Heating and cooling changeover setpoints are provided to prevent zone thermal shock during mode changes.

The bypass damper operates to maintain a configurable system static pressure setpoint. The bypass damper position 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 bypass damper is modulated open. The bypass damper is modulated closed as the pressure decreases below the pressure setpoint. Heating and cooling changeover setpoints are provided to prevent zone thermal shock during mode changes.

Figure 6: Multiplexed Zone Control System



An indoor air quality input is provided to monitor the Indoor Air Quality (IAQ). It can accept a digital CO2 sensor providing a contact closure, or an analog CO2 sensor. In addition, an alarm condition can be signaled by one of the Zone Controllers. When an alarm condition exists, the MPU3 energizes the supply air fan and override the static pressure setpoint to the IAQ alarm setpoint. The controller attempts to clear the IAQ condition by allowing the economizer to open more than usual. If the condition has not been cleared after a programmable delay, an alarm is sent to the LCI.

The MPU3 scans all associated Zone Controllers to collect system demand data. The total heating and cooling demands are accumulated. The greatest demand determines the control mode.

When the system cooling demand is greater than the system heating demand, the system enters the cooling mode.

When the system heating demand is greater than the system cooling demand, the system enters the heating mode.

Heating is accomplished through control of up to two stages of electric heating, or control of one floating point heating valve or control of one analog output (valve or variable speed circulator). Cooling is accomplished through control of up to two stages of cooling, or one floating point cooling valve or control of one analog cooling output (valve or variable speed circulator).

The cooling stages are sequenced with a timed-proportioned control algorithm to minimize excessive cycling. The sequencing is based on the measured supply air temperature, and the cooling setpoint. The cooling and heating demands are continually re-evaluated during the cooling mode of operation. The controller is capable of switching to the heating mode when the temperature demand is greater for heating. The cooling stages are interlocked with the economizer control. If the two-position economizer is employed, the stages sequence on after the economizer.

The heating stages are sequenced with a timed-proportioned control algorithm to minimize excessive cycling. The sequencing is based on the measured supply air temperature, and the heating setpoint. The cooling and heating demands are continually re-evaluated during the heating mode of operation. The controller is capable of switching to the cooling mode when the temperature demand is greater for cooling.

If configured for modulated analog output (valve or variable speed circulator) the cooling output position is calculated by a P + I control loop based on the supply temperature and the cooling setpoint. As the temperature increases above the cooling setpoint, the cooling output will be modulated open. The cooling output will be modulated closed as the temperature decreases below the cooling setpoint.

The heating output (valve or variable speed circulator) position is calculated by a P +I control loop based on the supply temperature and the heating setpoint. As the temperature decreases below the heating setpoint, the heating output will be modulated open. The heating output will be modulated closed as the temperature increases above the heating setpoint.

If configured for a floating point valve control, the cooling valve is calculated by a P + I control loop based on the supply temperature and cooling setpoint. As the temperature increases above the cooling setpoint, the valve will be modulated open. The valve will be modulated closed as the temperature decreases below the cooling setpoint.

If configured for a floating point valve control, the heating valve is calculated by a P + I control loop based on the supply temperature and cooling setpoint. As the temperature decreases below the heating setpoint, the valve will be modulated open. The valve will be modulated closed as the temperature increases above the heating setpoint.

In both the heating and cooling modes, the supply air temperature setpoint may be reset by the greatest zone temperature.

The controller optionally has the capability of monitoring 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, the cooling stages shut down and 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, the heating stages shut down and a heating failed alarm is reported to the LCI.

As a safety device, the controller can optionally monitor the supply air temperature to determine if the heating stages have failed on. If the supply air temperature rises above the heating high limit setpoint, the fan energizes. If the supply air temperature does not drop below the setpoint after a pre-programmed time delay, the bypass damper is overridden closed. A heating high limit exceeded alarm is reported to the LCI and all of the zone controllers.

The controller operates in one of two states: occupied or unoccupied. The LCI determines the active operating mode. An optional backup schedule is provided for cases when the LCI is not available.

A digital input is provided to monitor the fan proof. If the fan is energized and no air flow is detected after 30 seconds, the controller turns off all stages of heating and cooling along with the supply air fan. The controller returns to normal operation after it is reset. An alarm is reported to the LCI when this condition exists.

A digital input is provided on the controller 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.

Mixed air low limit protection is provided through a digital input. If a low limit condition exists, the controller turns off all stages of heating and cooling along with the supply air fan. An alarm is reported to the LCI when this condition exists. If configured for either analog or floating point valve, the output will open 100% to prevent freezing of the coils. The controller returns to normal operation after it is reset. Following the reset there is a 10 minute delay before the mixed air low limit is checked again.

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

When the Return Air Humidity rises above the humidity setpoint, dehumidification is enabled by activating the cooling stages. If modulated cooling is enabled, the cooling output goes to 100%. Dehumidification is disabled when return air humidity drops below the setpoint by 3%. Dehumidification with floating point reheat or heat is also available.

SEQUENCE OF OPERATION

This section describes the detailed sequence of operation for the MPU3 control algorithms.

Operational Mode

The MPU3 operates in one of four operating modes: primary heating, primary cooling, primary fan only, and primary off. The operating mode determines whether warm or cool air is supplied to the zone controllers. The MPU3 determines the operational mode based on the zone demand information supplied by each of the associated zone controllers. At least once every 5 seconds, a different zone controller is polled. Each zone controller transfers its zone demand information to the MPU3 over the communications network. The following information is transferred to the MPU3 controller:

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

A zone heating demand is recognized when the zone temperature of a zone is at least 1.0 ° F below the calculated heating setpoint. The total heating demand is the sum of all zones requiring heating.

A zone cooling demand is recognized when the zone temperature of a zone is at least 1.0 ° F above the calculated cooling setpoint. The total cooling demand is the sum of all zones requiring cooling.

The system operational mode is determined by the greatest total demand value. When there is demand for both heating and cooling, the system switches between heating and cooling based on a configurable changeover time. Note that minimum cycle times for the heating and cooling stages are enforced before an operational mode change can take place. Also, a minimum 5-minute off-cycle is enforced before switching modes and following controller startup or reset.

When all zone demands have been satisfied (zone demand = 0), the operational mode is set to primary off indicating no heating or cooling is being provided. When there is neither heating nor cooling, but the supply fan is on, the operational mode is set to primary fan only.

The heating mode can be disabled during warm weather by setting the outdoor air temperature heating lockout *Max OAT Heat*. If the OAT is above the heating lockout temperature, the primary heating mode is disabled and the MPU3 can only be in the primary off or primary cooling modes. This feature requires that a controller that broadcasts the OAT, such as an iWorx® ASM2, be installed on the network.

The cooling mode can be disabled during cold weather by setting the outdoor air temperature cooling lockout *Min OAT Cool*. If the OAT is below the cooling lockout temperature, the primary cooling mode is disabled and the controller can only be in the primary off or primary heating modes. This feature requires that a controller that broadcasts the OAT, such as an ASM2 be installed on the network.

The economizer can be disabled during warm or cold weather by setting the outdoor air temperature economizer *Max* and *Min OAT Econ* settings. If the OAT is above the Max lockout temperature or below the Min OAT temperature, the economizer is disabled and forced to its minimum fresh air position. The controller can only be in the primary off, primary heating or primary cooling modes. This feature requires that a controller that broadcasts the OAT, such as an ASM2 be installed on the network.

The MPU3 can also be configured to only enter primary cooling or primary heating mode when a minimum number of zones require cooling or heating. Setting the *Zone Limit* to a higher number prevents a small number of zones from affecting the desired operating mode of the whole space by instructing the MPU3 to not change operating modes until at least that number of zones require heating or cooling.

The current operational mode information is periodically transferred to the VAVD over the communications network. The following information is transferred to the VAVD from the primary air source controller:

- Operational Mode (primary cool, primary heat, primary fan only, primary off)

- Alarm Conditions (IAQ Mode, Heat Failed On)
- Supply Air Temperature

Occupancy Mode

A remote device on the network (such as an LCI) provides the current occupancy mode. There are two modes of occupancy: occupied and unoccupied.

In addition, the current occupancy mode is periodically retrieved from each of the zone controllers. If at least one zone controller is currently in occupancy extension mode the occupancy mode is overridden to the occupied state.

The current occupancy mode can affect the operation of the economizer, fan and bypass damper.

Additionally the heating and cooling setpoints may be reset based on the greatest zone demand.

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.

Supply Air Setpoint Reset Curve

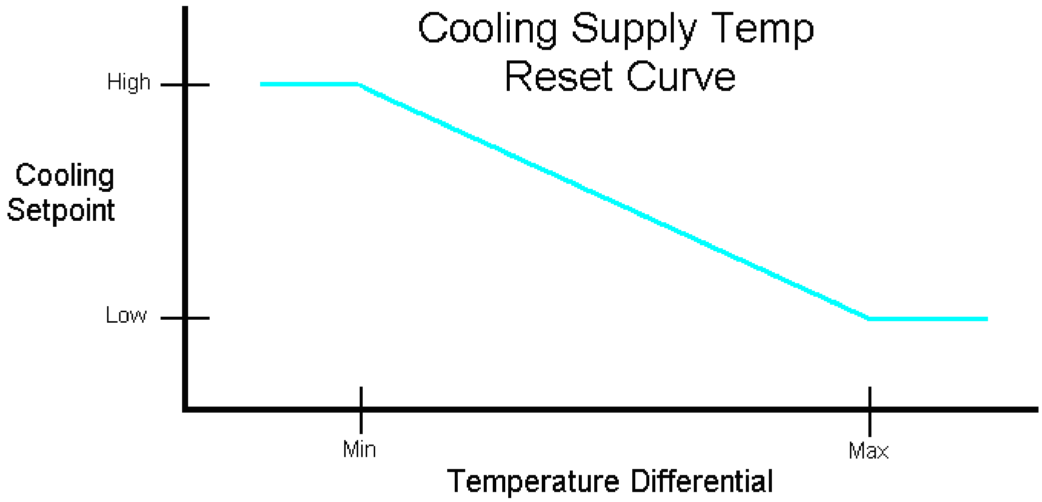
If the *Supply Temperature Setpoint Reset Curve* is enabled, the MPU3 keeps track of the differential between each zone's space temperature and its temperature setpoint. The MPU3 selects the zone with the greatest differential and uses that *Temperature Differential* to adjust the *Supply Temperature Setpoint*.

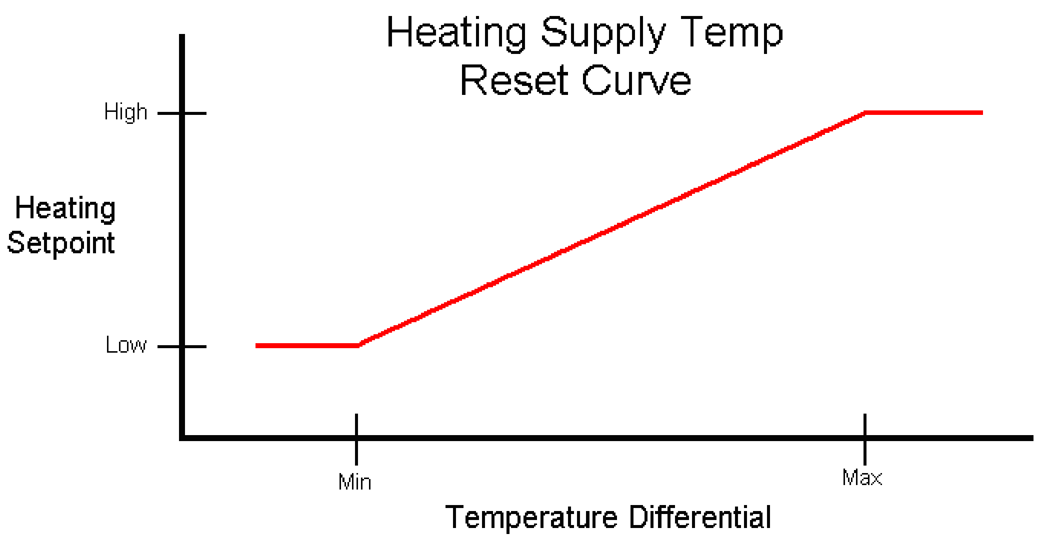
If the *Temperature Differential* is less than the *Temperature Differential Minimum*, then the *Supply Temperature Setpoint Low* will be used. If the *Temperature Differential* is greater than the *Temperature Differential Maximum*, then the *Supply Temperature Setpoint High* is used.

When the *Temperature Differential* is between the *Temperature Differential Maximum* and *Temperature Differential Minimum*, the *Supply Temperature Setpoint* is linearly interpolated between the *Supply Setpoint High* and *Supply Setpoint Low*.

When the *Temperature Differential Maximum* is set to 0, the *Supply Temperature Setpoint Reset Curve* is disabled and the MPU3 operates with the usual heating and cooling supply air temperature setpoints.

Figure 7: Supply Air Setpoint Reset Curves





Heating Sequence

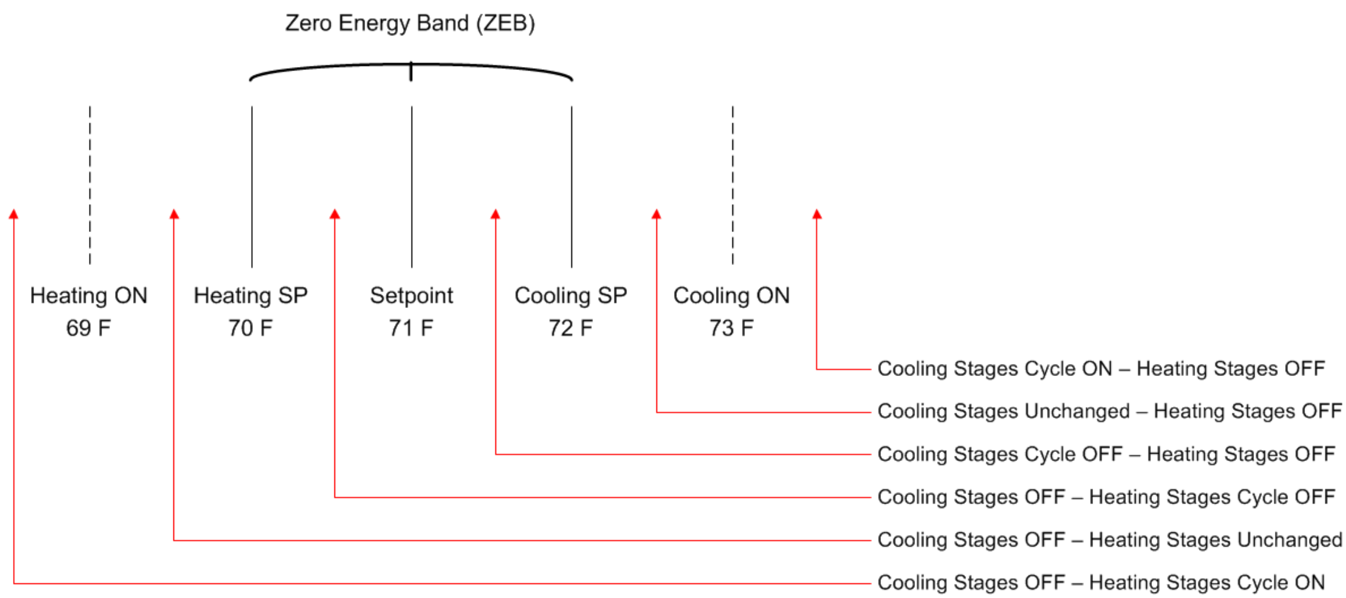
The controller provides support for either two stages of electric heating or one floating point or 0-10V modulating heating output (valve or variable speed circulator). You can specify which type of heat you are using through configuration parameters.

Heating Stages

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, 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. If all zone temperature readings are within 0.5 °F of their setpoints, the next stage does not cycle on. This cycle continues until all available stages have been energized.

As the supply air temperature rises above the heating setpoint, 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 8: Staged Heating and Cooling



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 heating stages are set to zero and the *Heating Valve Travel Time* is non-zero. The heating stage 1 output is the valve open signal and the heating stage 2 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. This ensures that the valve is fully closed. When the valve is at its calculated 0% or 100% position, the valve is overdriven for 30 seconds to ensure that the valve is fully closed or open.

The floating point control is similar to the heating modulated algorithm. If the supply temperature is below the heating setpoint, the valve is driven open. When the supply temperature is above the heating setpoint, the vale is driven close. There is a +-1.0 °F (0.55 °C) deadband around the setpoint to prevent the valve from dithering. During mixed air low limit alarms, the heating valve is driven to 100%.

Heating with Modulated Output (Valve or Variable Speed Circulator)

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

$$CalcHeatingLoopSp = CalcHeatingSp - \frac{1}{2}(Kp)$$

The heating output is modulated by a P+I control loop based on the heating loop setpoint and the supply temperature. The P+I control loop will modulate the output to maintain a constant supply temperature. As the temperature decreases below the heating loop setpoint, the heating output will be modulated open. The heating output will be modulated closed as the temperature increases above the heating loop 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:

$Kp = Proportional\ Gain$

$Ki = Integral\ Gain$

$Error = HeatingLoopSp - SpaceTemp$

Heating with Stages and Modulation

The controller can combine its staged and modulated modes. In the combined mode of operation, the modulated output is considered to be one of the stages. The stage to be associated with modulation is selected in the *Staged Heating* configuration page.

Modulation starts when the selected stage would normally start (i.e., if stage 2 is selected as the modulating stage, it starts if stage 1 has been active for the staging interval and the temperature is still below the heating control band).

If the modulating stage is not the last stage, subsequent stages are activated once the *Stage Threshold* percentage has been met by the modulating output and has remained there for the duration of the *Staging Interval*.

In order to maintain a smooth total heating output, the modulating output responds to subsequent stages activating or deactivating. It does so by clearing its interval output when a subsequent stage is activated:

$I = 0$

$Modulating\ Output = K_p \times Error$

It forces its interval output to the *Staging Interval* whenever a subsequent stage is deactivated. This feature prevents large jumps in overall heating output.

$I = Staging\ Threshold$

$Modulating\ Output = (K_p \times Error) + I$

Figure 9: Modulated Staging with 2 Stages; 2nd Stage Modulating

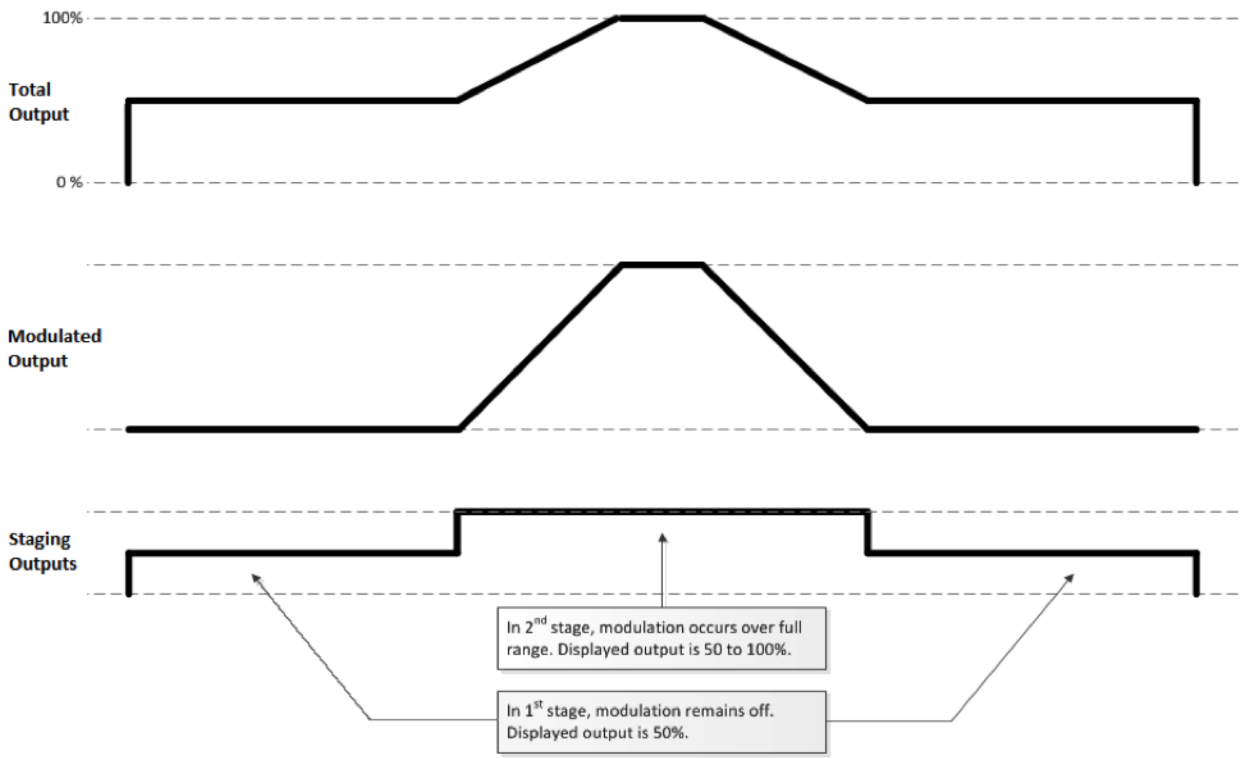
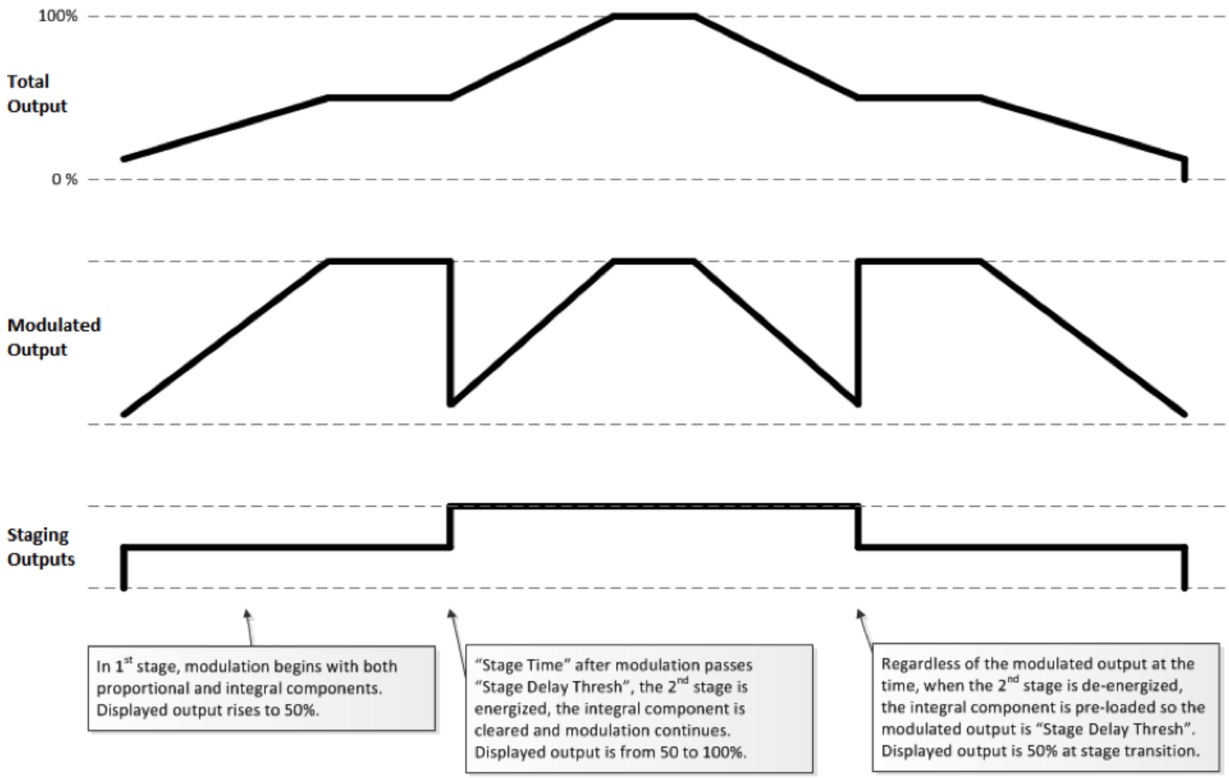


Figure 10: Modulated Staging with 2 Stages; 1st Stage Modulating



Cooling Sequence

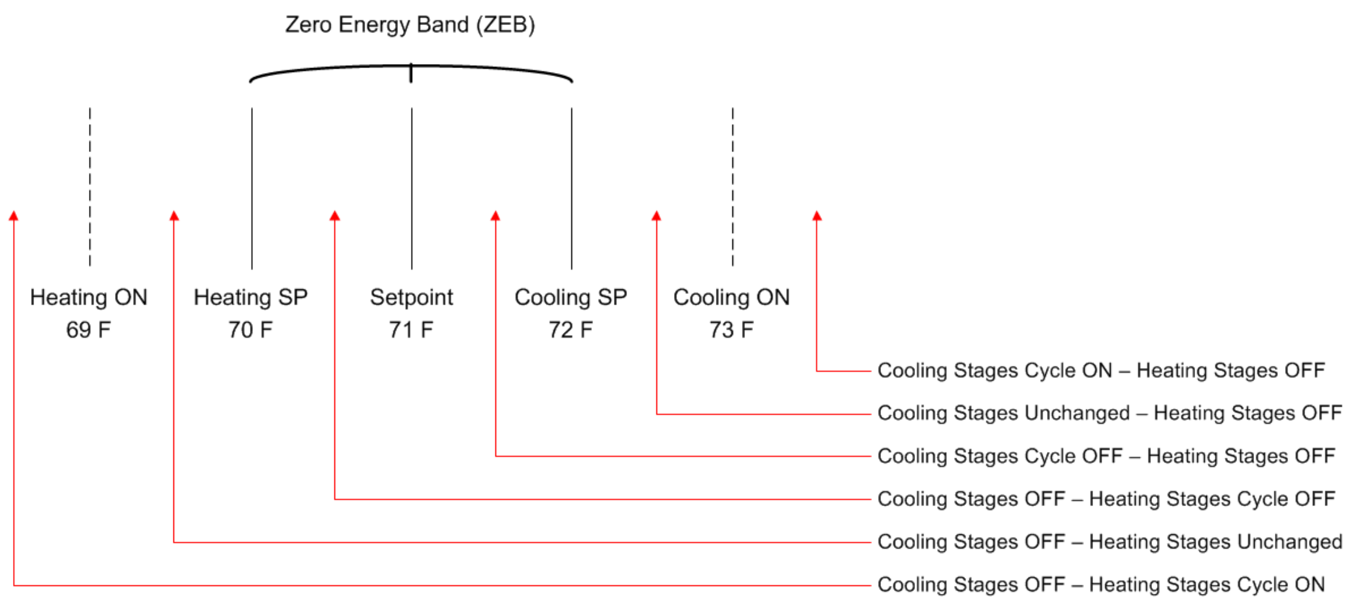
The controller provides support for either two compressor stages of cooling or one floating point or 0-10V modulating cooling valve. You can specify which type of cooling you are using through configuration parameters.

Cooling Stages

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 the control band. When the supply air temperature rises above the cooling setpoint plus the control band, 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. If all zone temperature readings are within 0.5 °F of their setpoints, the next stage does not cycle on. This cycle continues until all available stages have been energized.

As the supply temperature drops below the cooling setpoint, 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. If the supply air temperature drops below the cooling setpoint minus control band all of the stages immediately cycle off.

Figure 11: Staged Heating and Cooling



Cooling with Floating Point Control

The cooling outputs can be configured for floating point control of a cooling valve. Floating point control is enabled when *Cooling Stages* are set to zero and the *Cooling Valve Travel Time* is non-zero. The *Cooling Stage 1* output is the valve open signal and the *Cooling Stage 2* 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. This ensures that the valve is fully closed. When the valve is at its calculated 0% or 100% position, the valve is overdriven for 30 seconds to ensure that the valve is fully closed or open.

The floating point control is similar to the cooling modulated algorithm. If the space temperature is above the cooling setpoint, the valve is driven open. When the space temperature is below the cooling setpoint, the valve is driven closed. There is a +/- 1 °F (0.55 °C) deadband around the setpoint to prevent the valve from dithering. During mixed air low limit alarms, the cooling valve is driven to 100%.

Cooling with Modulated Output (Valve or Variable Speed Circulator)

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

$$CalcCoolingLoopSp = CalcCoolingSp - \frac{1}{2}(Kp)$$

The cooling output is modulated by a P+I control loop based on the cooling loop setpoint and the 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 cooling output will be modulated open. The cooling output will be modulated closed as the temperature decreases below the cooling loop setpoint. When unoccupied mode is entered, the cooling loop 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:

Kp = Proportional Gain

Ki = Integral Gain

Error = CoolingLoopSp - SpaceTemp

Cooling with Stages and Modulation

The controller can combine its staged and modulated modes. In the combined mode of operation, the modulated output is considered to be one of the stages. The stage to be associated with modulation is selected in the *Staged Cooling* configuration page.

Modulation starts when the selected stage would normally start (i.e., if stage 2 is selected as the modulating stage, it starts if stage 1 has been active for the *Staging Interval* and the temperature is still above the cooling control band).

If the modulating stage is not the last stage, subsequent stages are activated once the *Stage Threshold* percentage has been met by the modulating output and has remained there for the duration of the *Staging Interval*.

In order to maintain a smooth total cooling output, the modulating output responds to subsequent stages activating or deactivating. It does so by clearing its interval output when a subsequent stage is activated:

$I = 0$

$\text{Modulating Output} = K_p \times \text{Error}$

It forces its interval output to the *Staging Interval* whenever a subsequent stage is deactivated. This feature prevents large jumps in overall cooling output.

$I = \text{Staging Threshold}$

$\text{Modulating Output} = (K_p \times \text{Error}) + I$

Figure 12: Modulated Staging with 2 Stages; 2nd Stage Modulating

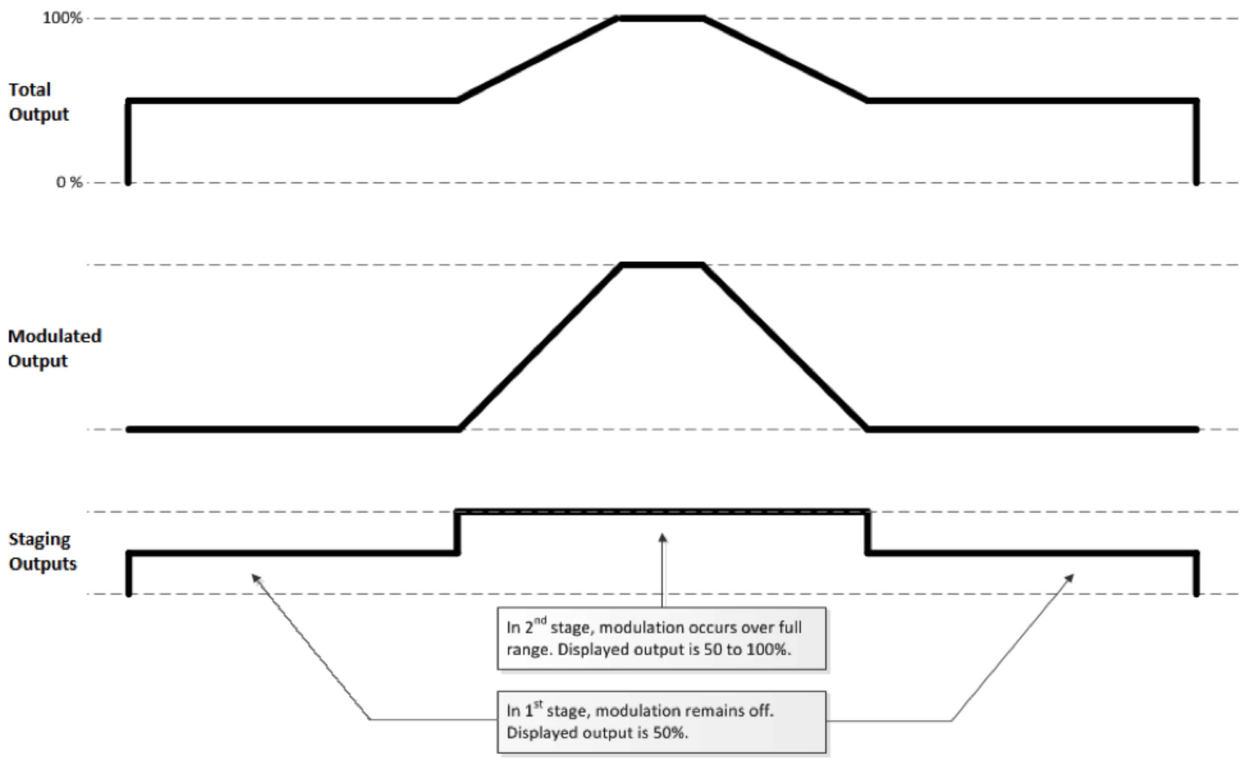
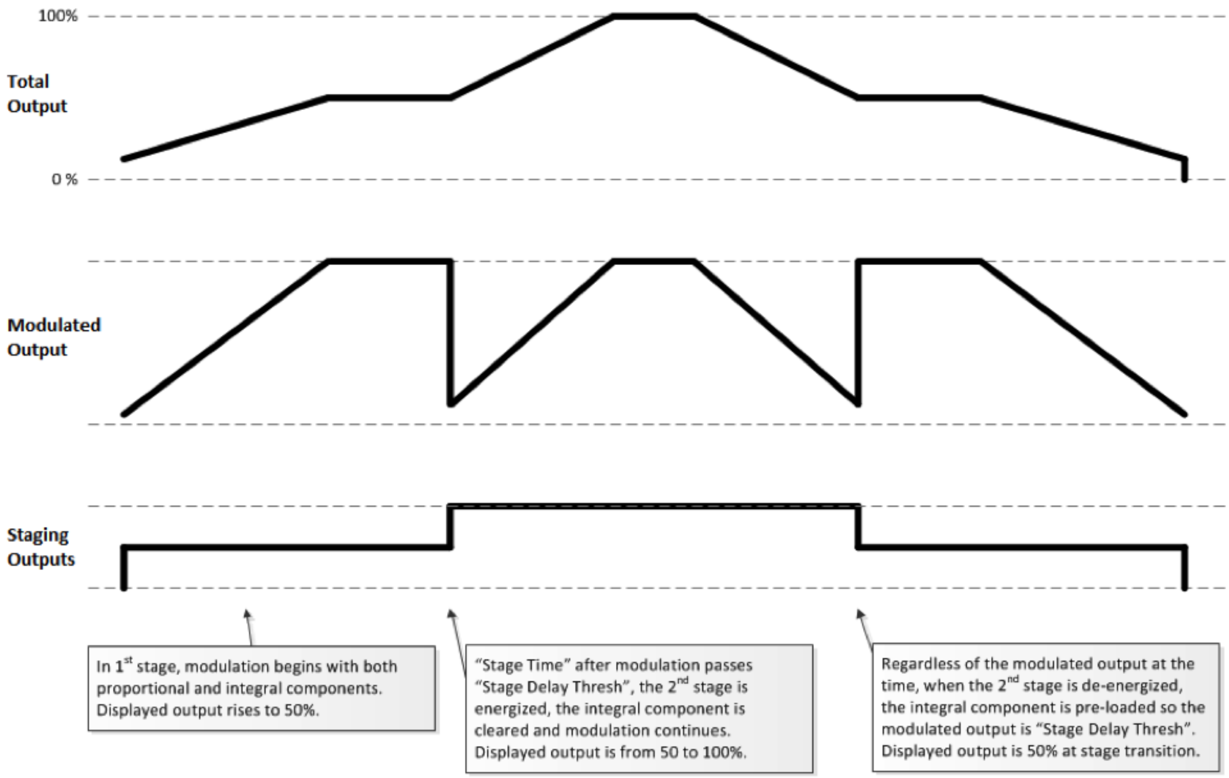


Figure 13: Modulated Staging with 2 Stages; 1st Stage Modulating



Economizer Operation

The controller may be configured for either a two-position or a modulated economizer. The economizer is enabled based on the availability of "free cooling" from the outdoor air. Free cooling is determined by dry bulb or enthalpy comparisons. To provide maximum energy savings, the cooling stages are delayed for three minutes to allow free cooling to cool the space.

Dry Bulb Comparisons

Free cooling is determined based on a comparison of outdoor air temperature and indoor air temperature. When the outdoor air temperature is a programmable amount below the indoor air temperature, free cooling is enabled. When the outdoor air temperature rises above the indoor temperature, free cooling is disabled.

Enthalpy Comparison

An enthalpy calculation is performed periodically to determine if "free cooling" is available from the outside air. 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) on the network and sent to the controller. 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 ASM can measure the indoor air humidity globally. In this case, a return air humidity sensor would not be required at each MPU3.

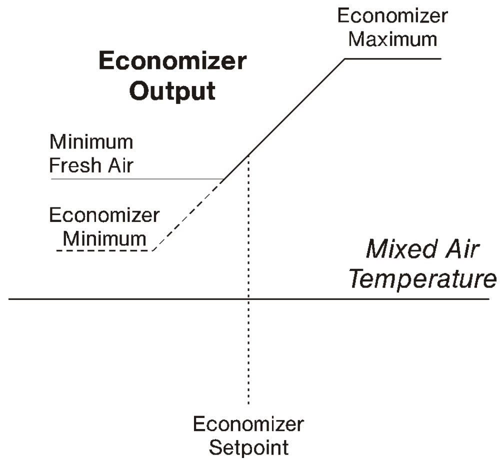
Two-position Economizer Control

When configured, the two-position economizer is enabled when free cooling is available as determined by the enthalpy or dry bulb calculations. When the economizer is enabled, the economizer triac output is energized. When the economizer is disabled, the economizer output is de-energized. A configuration parameter is available to optionally disable the economizer during unoccupied periods.

Modulated Economizer Control

The modulated economizer is enabled when there is “free cooling” available as determined by the enthalpy or dry bulb calculations. A configuration parameter is available to optionally disable the economizer during unoccupied periods.

Figure 14: Economizer Control.



When the economizer is enabled, a control loop modulates the economizer output position to maintain a constant mixed air temperature. During this free cooling state, cooling stages do not run. If free cooling cannot bring the mixed air temperature down to setpoint, then cooling stages are allowed to run after three minutes of the economizer output reaching 100%.

If an IAQ condition occurs, the economizer modulates open to 100% to allow fresh air into the space. This occurs immediately when an IAQ condition is first detected and may clear the condition before an alarm is sent to the LCI.

When the IAQ condition clears, the economizer returns to the operation it was in prior to the IAQ state - if it was free cooling before the IAQ occurred, it returns to free cooling. If it was mechanical cooling before the IAQ occurred, it returns to mechanical cooling.

When the economizer is disabled, it closes completely. A configuration parameter is available to optionally disable the economizer during unoccupied periods.

Cutoff Temperatures

The cutoff temperatures can be set for heating, cooling and for the economizer to suppress mechanical equipment from activating if the outside air temperature is above or below a cutoff setpoint.

Heating will be suspended when the outside air temperature rises above *Max OAT Heat*. It resumes when the OAT falls 5 °F below the setting. Cooling is suspended when the OAT fails below *Min OAT Cool*. It resumes when OAT rises 5 °F above the setting. The economizer will close the dampers to the Minimum fresh air position when the OAT is outside the *Max OAT* and *Min OAT Economizer* temperature limits.

Dehumidification

If the Setpoint is set to zero, dehumidification is disabled. When the humidity is above the Setpoint, dehumidification begins, and it stops when the humidity drops below Setpoint minus 3%.

During dehumidification, the operating mode will be displayed as “Dehumid,” the cooling outputs will stage on, and the stage timer is enforced; or, modulating output or floating point valve will be set to 100%.

Normal mode

Dehumidification may activate when the MPU3 is in cooling mode or when heating and cooling are inactive. Dehumidification is disabled when the unit is in Heating mode.

With Reheat

Dehumidification with Reheat means that a floating point valve is modulated to drive an external reheat element. Cooling and reheating can occur at the same time. The floating point reheat valve uses triac outputs Reheat Valve Open (RVO) and Reheat Valve Close (RVC) to modulate the valve. RVO opens the valve and RVC closes the valve.

With Heat

Dehumidification with Heat **expects the heating coil to be placed downstream from the cooling coil in the duct.** Cooling and heating can then operate at the same time. The heating coil can then heat air which was previously cooled for dehumidification.

Bypass Damper

Static pressure control is achieved by modulating a bypass damper between the fully open and fully closed positions 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 bypass damper 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 damper 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 bypass damper is modulated closed. The bypass damper modulates open as the supply static pressure increases to 0.025" W.C. above the static pressure loop setpoint. When the static pressure is within ±0.025” W.C. of the static pressure setpoint, the damper remains at its current position.

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:

$$Kp = Proportional\ Gain$$
$$Ki = Integral\ Gain$$
$$Error = SupplyStaticPressure - LoopSetpoint$$

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

The bypass damper modulates to the full open (bypass) position prior to the fan energizing. During operational mode changes the bypass damper remains open until the supply air temperature has reached the programmable cooling and heating setpoints. This prevents thermal shock in the zones.

Programmable minimum and maximum outputs are provided for the bypass damper. These settings can be reversed for reverse-action. Overrides are provided to assist in system air balancing during commissioning.

Analog Outputs

The modulated Economizer and Bypass Damper analog outputs support normal and reverse actuation. Making the analog output's minimum voltage scaling parameter less than the maximum enables normal actuation. Making the analog output's maximum scaling parameter less than the minimum enables reverse actuation.

Fan Operation

During occupied periods, the fan may either always run or cycle off when there is no demand for heating or cooling. The fan is interlocked with the cooling and heating stages. If there is a call for heating or cooling the fan immediately energizes. During unoccupied period, the fan always cycles off when there is no demand for heating or cooling. During IAQ alarm conditions the fan energizes to provide fresh air to the zones.

Fan Proof

When there is a call for heating or cooling, the fan output is energized. A fan status input is provided for monitoring the operation of the fan. When the fan is initially turned on, there is a 30 second delay before the fan status is checked. If at any time after the delay, the fan status indicates the fan is not running, a fan failure condition is generated. The heating and cooling stages are interlocked with the fan. When a fan failure condition exists, the heating stages, cooling stages and the fan immediately turn off. The controller must be reset to clear this condition.

NOTE: If not providing a fan proof switch, the dip switch for the fan proof input must be configured with the (0-10V) switch set to “on” and the “Vth” set to off. After a fan failure, the controller's status LED changes from green to solid red. To return the controller to normal operation after the failure condition is resolved, you must reset the controller by removing and reapplying power or by using the controller reset feature on the LCI.

MPU3 and VAVD Communications

The MPU3 and its associated VAVD controllers transfer information, depending on the number of VAVD controllers configured. The MPU3 polls a VAVD controller every 5 seconds to transfer information necessary for control. The following information is transferred from the MPU3 to the VAVD controller:

- Operational Mode: primary cool, primary heat, and primary off
- Occupancy Mode: occupied, unoccupied, and bypass
- Alarm Conditions: IAQ Mode and Heat Failed On

The following information is transferred from the VAVD to the MPU3 controller:

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

Associating VAVDs

In order for the MPU3 and VAVDs to share information, the controllers need to be associated. To associate the VAVDs to the MPU3, you first need to select the MPU3 from the LCI's list of controllers. Once the MPU3 has been selected, depress the **`HVAC Setup`** button followed by the **`Zone Members`** button. You will see a list of all VAVDs on the network, with the designation “Included” or “Excluded” showing on each line. To include a VAVD, simply depress the desired VAVD in the list and it will show “Included” and the color will change to Red. After all the desired associations are complete, depress the **`Save`** button so the information will be sent to all associated controllers.

Supply Air Temperature Monitoring

The MPU3 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 heat mode alarm is generated. During cooling mode, if the supply air temperature does not drop below the cool mode alarm setpoint after a 10-minute delay, a cool mode alarm is generated.

The MPU3 has provisions for detecting a gas valve that has been become stuck in the open position. The stuck gas valve sequence helps to prevent overheating the HVAC unit.

During periods when the operational mode is primary off or primary fan only, if the supply air temperature rises above 175 °F, the system fan is started. If the supply air temperature does not drop below 150 °F after 5 minutes, the bypass damper closes and an alarm is sent to the zone controllers and LCI. The zone controllers react to the alarm by positioning their dampers to the maximum position.

During periods when the operational mode is primary cooling, if the supply air temperature does not drop below 100 °F after 15 minutes, the cooling mode is terminated and the MPU3 enters the primary off operational mode. The primary off logic then checks for the stuck gas valve condition.

Indoor Air Quality

An indoor air quality input is provided. If an indoor air quality alarm is indicated while the space is occupied, the supply air fan is energized and the economizer is overridden to supply fresh air to the space. The source of an indoor air quality signal can be a digital sensor providing an on/off signal or a configurable analog sensor.

Setup of the analog sensor requires the IAQ sensor settings to be populated. A Min, Max, Setpoint, and Offset can be specified.

When an indoor air quality condition is sensed by the controller, the economizer is opened to 100%. If the mixed air temperature drops too low, the economizer modulates in an attempt to maintain the IAQ MAT setpoint while still allowing fresh air into the system.

The controller has a temperature reset function for IAQ alarm operation. The temperature reset function allows the space temperature to rise above or drop below the calculated control setpoints by a configurable amount. During IAQ Alarm operation, if the space temperature rises above or drops below the temperature reset limit, the controller resumes normal economizer control to maintain a comfort space temperature. Once the space temperature is brought within the calculated setpoints and an IAQ Alarm condition still exists, the controller resumes the IAQ mode of operation.

The controller has a configurable alarm delay function. This function allows the controller to attempt to clear the IAQ condition with the economizer before triggering an alarm. If the IAQ condition is still present after the IAQ Alarm Delay, the alarm message is sent to the LCI.

Return Air IAQ

The controller 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 MPU3 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 MPU3 can receive the status of local IAQ sensors connected to discrete inputs of each zone controller. When the local zone IAQ sensor indicates that contaminants are above a preset limit, the MPU3 energizes the fan. After a preset time delay, the economizer is enabled to supply fresh air to the zones. Only the MPU3 and local zone controller participates 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 turns off. The controller returns to normal operation after a reset. After the controller switches from unoccupied mode to occupied mode, there is a ten minute delay before it reports Mixed air Low Limit alarms. If heating and cooling are configured as modulated or floating point, the heating valves open to 100%.

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.

Real Time Clock (RTC)

The RTC will be set or synced by the LCI each day at midnight. The controller will utilize the RTC in conjunction with its local backup schedule during periods when the LCI is not available.

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 communications), it resorts to the local backup schedule that has been configured. If the local backup schedule is disabled, the controller defaults to the 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 times are set to zero, which disables the local backup schedule. This causes the controller to default to the occupied mode of operation when communications are lost to the LCI for 10 minutes or longer.

Runtime Accumulations

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.

Alarms and Events

The MPU3 detects certain alarm conditions and sends them to the LCI. Before this can occur, the MPU3 must have been configured by the LCI.

Digital Input Alarms

The MPU3 monitors the status of the digital inputs and generates alarms for the following events:

- Fan Failure
- Smoke Detect
- Mixed Air Low Limit
- Dirty Filter
- CO_2 Alarm

Supply Air Temperature Alarms

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

- Cooling Failed
- Heating Failed
- Heat Stuck On

Maintenance Alarm

A MPU3 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 MPU3 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 MPU3 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. Users may bind to SNVTs on the MPU3 with LNS or other LONWORKS tools if they wish.

The LCI also provides network supervision of the MPU3. The LCI periodically sends a "ping" message to the MPU3, 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.

CONTROLLER IDENTIFICATION

Once the MPU3 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 MPU3, and the meanings and default values for controller parameters. For more information on using the LCI, see the *iWorX LCI Application Guide.*

Inputs

The Inputs screen displays the current values of the MPU3's inputs. These values cannot be changed.

Input	Range	Description
Outside Temp	-29 to 230 °F (-33.9 to 110 °C)	The outside air temperature communicated through the LCI from the ASM controller.
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.
Smoke Detector	Normal, Smoke	Status of the smoke detector (SMK).
Fan Status	Off, On	Status of the fan proof switch (FNP)
Low Limit	Normal, Low Limit	Status of the mixed air low limit indication switch (MLL).
Filter Status	Normal, Dirty	Status of the filter switch (FIL).
Indoor Air Quality	Normal, Alarm	Status of the IAQ alarm sensor.
Occupancy Mode	Occupied, Unoccupied, Bypass	Occupancy mode of controller
Supply Air Temp	-29 to 230 °F (-33.9 to 110 °C	Temperature of the supply air duct.
Mixed Air Temp	-29 to 230 °F (-33.9 to 110 °C)	Temperature of the mixed air plenum.
Return Air Temp	-29 to 230 °F (-33.9 to 110 °C)	Temperature of the return air duct.
Return Air Humidity	0.00 to 100.00%	Humidity reported by the RAH sensor.
Static Pressure	0.00 to 5.00" W.C. (0 to 1246 Pa)	Static pressure in the supply air duct.
IAQ	0-4000ppm	Reading of the indoor air quality sensor when defined as Analog.

Outputs

This screen displays the current values of the MPU3's outputs. These values cannot be changed.

Output	Range	Description
Mode	Heat, Cool, Off, Fan, Free Cooling, Dehumidification, Shut Down	Current operating mode.
Heat Output	0.00% to 100.00%	Current state of the heating output.
Reheat Output	0.00% to 100.00%	Current state of the reheat output.
Cool Output	0.00% to 100.00%	Current state of the cooling output.
Economizer Output	0.00% to 100.00%	Current state of the economizer output.
Fan Output	0.00% or 100.00%	Current state of the fan output.
Bypass Damper Pos	0.00% or 100.00%	Current state of the bypass output.
In Alarm?	On, Off	Alarm indication

Configuration

All Settings

Displays all of the MPU3's setpoints and editable settings and provides access to edit all MPU3 parameters from a single screen.

Setting	Range	Default	Description
Commissioning	Structure	N/A	Commissioning Settings
Setpoints	Structure	N/A	Setpoint Settings
Supply Temp Reset Curve	Structure	N/A	Reset Settings
Pressure Settings	Structure	N/A	Static Pressure Settings
MPU Settings	Structure	N/A	MPU Settings
Staged Cooling	Structure	N/A	Staged Cooling Settings
Modulated Cooling	Structure	N/A	Modulated Cooling Settings
Floating SP Cooling	Structure	N/A	Floating Point Valve Cooling Settings
Staged Heating	Structure	N/A	Staged Heating Settings
Modulated Heating	Structure	N/A	Modulated Heating Settings
Floating SP Heating	Structure	N/A	Floating Point Valve Heating Settings
Fan Type	Auto, On	Auto	Set to "On" to enable continuous operation during occupied mode. Otherwise, fan switches on and off automatically according to the control algorithm,
Economizer	Structure	N/A	Economizer Settings
Free Cooling	Structure	N/A	Free Cooling Settings
Dehumidification	Structure	N/A	Dehumidification Settings
Floating Setpoint Dehum	Structure	N/A	Floating setpoint dehumidification settings

Setting	Range	Default	Description
Dehumidification Type	Normal, Dehumid, Dehumid w/Reheat, Dehumid w/Heat	Normal	Type of dehumidification
Runtime Limits	Structure	N/A	Runtime Limit Settings
Backup Occ Time	Structure	N/A	Backup schedule settings for Occupied mode.
Backup Unocc Time	Structure	N/A	Backup schedule settings for Unoccupied mode.
IAQ Mode	Digital, Analog	Digital	Type of IAQ Sensor.
IAQ Settings	Structure	N/A	Setting for the IAQ Alarm.
IAQ Sensor	Structure	N/A	Settings for the IAQ analog Sensor.
OAT Cutoff	Structure	N/A	Provides entries for cutoff temperatures for heating, cooling, and economizer functions.

Commissioning

Displays all of the commissioning settings and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Override Mode	Off, Reposition Damp, Dmp Fully Open, Dmp Fully Closed	Off	Set to any value besides “off” to place the controller into that override mode.
Damper Percentage	0.00% to 100.00%	0.00%	Damper setting to use when the controller is placed in “Damper Percentage” override mode.

Setpoints

Displays all of the setpoints and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Cooling Setpoint	45.0 to 65.0 °F (7.2 to 18.3 °C)	55.0 °F (12.2 °C)	Temperature setpoint for the cooling mode.
Heating Setpoint	55.0 to 130.0 °F (12.8 to 54.4 °C)	90 °F (32.2 °C)	Temperature setpoint for the heating mode.
Supply Cool Limit	0.0 to 30.0 °F (0.0 to 16.7 °C)	10 °F (5.6 °C)	Minimum temperature change from cooling setpoint in 10 minutes to avoid a cooling failed alarm.
Supply Heat Limit	0.0 to 30.0 °F (0.0 to 16.7 °C)	10 °F (5.6 °C)	Minimum temperature change from heating setpoint in 10 minutes to avoid a heating failed alarm.

Supply Temp Reset Curve

Displays all of the Supply Temp Reset settings and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Min Differential	0.0 to 30.0 °F (0.0 to 16.7 °C)	0.0 °F (0.0 °C)	Differential at or below which the supply air is at its coolest.
Max Differential	0.0 to 30.0 °F (0.0 to 16.7 °C)	0.0 °F (0.0 °C)	Differential at or above which the supply air is at its warmest.
Cool Setp Low	45.0 to 65.0 °F (7.2 to 18.3 °C)	45.0 °F (7.2 °C)	Lowest cooling SP when the zone is at its warmest.
Cool Setp High	45.0 to 65.0 °F (7.2 to 18.3 °C)	65.0 °F (18.3 °C)	Highest cooling SP when the zone is at its coolest.
Heat Setp Low	55.0 to 130.0 °F (12.8 to 54.4 °C)	80 °F (26.7 °C)	Lowest heating SP when the zone is at its warmest.
Heat Setp High	55.0 to 130.0 °F (12.8 to 54.4 °C)	130 °F (54.4 °C)	Highest heating SP when the zone is at its coolest.

Pressure Settings

Displays all of the Static Pressure settings and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Press Min	-2.5 to 5.0"W.C.	0.0"W.C.	Static pressure to report when the analog input receives 0 volts.
Press Max	-2.5 to 5.0"W.C.	2.00"W.C.	Static pressure to report when the analog input receives 10 volts.
Setpoint	-2.5 to 5.0"W.C.	1.0”W.C.	Setpoint for supply air static pressure.
IAQ Setpoint	-2.5 to 5.0"W.C.	1.5”W.C.	Setpoint for supply air static pressure used when an IAQ alarm is present.
Kp	0 to 100%	5.0%	Proportional gain of the economizers P+I control loop.
Ki	0 to 100%	0.05%	Integral gain of the economizer's P+I control loop.
Minimum Output	0 to 10 V	0.0 V	Minimum output voltage for the output.
Maximum Output	0 to 10 V	10 V	Maximum output voltage for the output.

MPU Settings

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Changeover Time	0 to 255 min	5 min	Minimum amount of time between heating and cooling.
Zone Limit	0 to 32	1	Minimum number of zone demands required before heating or cooling is enabled.

Staged Heating/Cooling

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setpoint	Range	Default	Description
Stages	0 to 4 (cooling) 0 to 2 (heating)	4 2	Number of stages controlled. Set to zero to disable heating or cooling.
Control Band	0 to 10 °F (0 to 5.6 °C)	1.0 ° F (0.6 °C)	Value used to modify the calculated heating and cooling setpoints to form the temperature range in which local heating or cooling is enabled.
Stage Time	0 to 255 min	5 min	The rate at which stages are sequenced.
Stage Delay Thresh	0 to 100%	99%	Modulated threshold that must be surpassed before the next stage may be turned on.
Modulating Stage	No Mod Stage, Stage 1 Mod, Stage 2 Mod	No Mod Stage	Stage with modulated output

Modulated Heating/Cooling

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Kp	0.00 to 100.00% (per °F)	5.00%	Proportional gain of the cooling P+I control loop.
Ki	0.00 to 100.00%	0.05%	Integral gain of the cooling P+I control loop.
Out Min	0.0 to 10.0 V	0.0 V	Minimum output voltage for modulated heating or cooling.
Out Max	0.0 to 10.0 V	0.0 V	Maximum output voltage for modulated heating or cooling. If set to 0, Modulation is disabled.

Floating SP Heating/Cooling

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Kp	0.00 to 100.00% per °F	5.00%	Proportional gain of the P+I control loop.
Ki	0.00 to 100.00%	0.05%	Integral gain of the P+I control loop.
Travel Time	0.0 to 600 seconds	0 seconds	Total time it takes for the valve to travel from fully closed to fully open. If set to 0 floating point is disabled.
Deadband	0.0 to 100.00%	10%	The desired setpoint must be this far or greater from the actual position before modulating the actuator.

Economizer

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Type	Disabled, 2 St Unocc On, 2 St Unocc Off, Mod Unocc. On, Mod Unocc. Off	Disabled	Type of Economizer: Disabled, Two State and ON when unoccupied, Two State and OFF when unoccupied, Modulated and ON when unoccupied or Modulated and OFF when unoccupied.
Setpoint	40.00 to 70.00 °F (4.44 to 21.11 °C)	55.00 °F (12.78 °C)	Setpoint used for controlling the economizer.
Min Fresh Air	0.00 to 100.00%	10.0%	Minimum fresh air position for the modulated economizer.
Kp	0.00 to 100.00% (per °F)	5.00%	Proportional gain of the economizer's P+I control loop.
Ki	0.00 to 100.00%	0.05%	Integral gain of the economizer's P+I control loop.
Min AO Voltage	0.0 to 10.0 V	0.0 V	Minimum output voltage for the modulated economizer.
Max AO Voltage	0.0 to 10.0 V	10.0 V	Maximum output voltage for the modulated economizer.

Free Cooling

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Type	Rtn Air Humidity, Global Humidity, Dry Bulb Temp	Rtn Air Humidity	Type of free cooling comparison to be performed.
Enthalpy Offset	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.
Dry Bulb Offset	0.0 to 20.0 °F (0.0 to 11.1 °C)	5.0 °F (2.78 °C)	Difference between return temperature and outside temperature that enables or disables the economizer.

Dehumidification

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Type	Occupied, Always enabled	Occupied	Defines when dehumidification is enforced.
Setpoint	0.00 to 100.00%	0%	Humidity Setpoint
Shutoff Offset	N/A	N/A	N/A

Floating SP Dehumid

Displays all of the floating point valve settings for dehumidification and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Kp	0.00 to 100.00% (per °F)	5.00%	Proportional gain of the floating point valve's P+I control loop.
Ki	0.00 to 100.00%	0.05%	Integral gain of the floating point valve's P+I control loop.
Travel Time	0 to 600 sec	0 sec	Total time it takes for the floating point heating valve to travel from fully closed to fully open. If set to 0, floating point valve is disabled.
Deadband	0.00 to 100.00%	10%	The desired setpoint must be this far or greater from the actual position before modulating the actuator.

Runtime Limits

Displays all of the settings for this category and provides access to edit these parameters from a single screen.

Setting	Range	Default	Description
Cooling	0 to 65,535 hours	1000 hours	Runtime limit for cooling after which a maintenance alarm is generated.
Heating	0 to 65,535 hours	1000 hours	Runtime limit for heating after which a maintenance alarm is generated.
Fan	0 to 65,535 hours	1000 hours	Runtime limit for fan after which a maintenance alarm is generated.

Backup Occ Time/ Backup Unocc Time

The Backup time for Unoccupied and occupied mode is stored in the controller.

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

IAQ Settings

This parameter structure shows the settings for the IAQ Alarm, settings include IAQ Alarm Delay time, Temp Reset Limit and Deadband.

Setting	Range	Default	Description
IAQ Delay Time	0 to 1000 Min	5 Min	Time the Alarm will be delayed.
Temp Reset Limit	0 to 15 °F (0 to 8.3 °C)	5 °F (2.8 °C)	Temperature Reset Limit to ensure comfort temperature during IAQ Alarm conditions.
Deadband	0 to 400 ppm	0 ppm	Deadband to allow the IAQ to recover from Alarm condition.

IAQ Sensor

If the IAQ Mode is set to Analog, this parameter structure needs to be configured.

Setting	Range	Default	Description
Min	0 to 4000 ppm	0 ppm	Minimum ppm sensor setting
Max	0 to 4000 ppm	0 ppm	Maximum ppm sensor setting
Setpoint	0 to 4000 ppm	0 ppm	Setpoint
Offset	0 to 4000 ppm	0 ppm	Offset to the sensor reading

OAT Cutoff

The OAT cutoff temperatures are temperatures above or below heating or cooling function is disabled and the economizer is reduced to the MinAir position.

Setting	Range	Default	Description
Max OAT Heat	-7.6 to 122 °F (-22 to 50 °C)	-4 °F (-20 °C)	Outside Air Temperature above which heating is disabled. See Note below.
Min OAT Cool	-7.6 to 122 °F (-22 to 50 °C)	-4 °F (-20 °C)	Outside Air Temperature below which cooling is disabled. See Note below.
Max OAT Econ	-7.6 to 122 °F (-22 to 50 °C)	-4 °F (-20 °C)	Outside Air Temperature above which economizer is disabled. See Note below.
Min OAT Econ	-7.6 to 122 °F (-22 to 50 °C)	-4 °F (-20 °C)	Outside Air Temperature below which economizer is disabled. See Note below.
SAT Cooling Limit	45 to 75 °F (7.2 to 23.9 °C)	55 °F (12.8 °C)	Supply air temperature below which additional cooling will not be enabled. See Note below.

Note: A value of -4 °F disables this cutoff temperature setting. All other values within the range are valid cutoff temperatures.

Alarms

The table below describes the alarms you may encounter and how they are reset.

Alarm	Range	Alarm Trigger	Alarm Reset
Fan Failure	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 and the controller must be reset.
Smoke	Normal, Alarm	Occurs when the smoke alarm input detects the presence of smoke.	The cause of the emergency condition must be resolved and the controller must be reset.
Mixed Air Low Limit	Normal, Alarm	Occurs when the mixed air temperature drops below the Low Limit that has been set, indicating a freeze condition.	The cause of the emergency condition must be resolved and the controller must be reset.
Filter	Normal, Alarm	Occurs when the Filter Alarm input detects that the filter needs to be replaced.	Automatic when the dirty filter is replaced.
Indoor Air Quality	Normal, Alarm	Occurs when the IAQ sensor detects inadequate indoor air quality.	Automatic when air quality returns within normal parameters.

Alarm	Range	Alarm Trigger	Alarm Reset
Heating Failure	Normal, Alarm	Occurs when Supply Air temperature is *Supply Heat Limit* degrees from the setpoint 10 minutes after entering heating mode.	The cause of the emergency condition must be resolved.
Cooling Failure	Normal, Alarm	Occurs when Supply Air temperature is *Supply Cool Limit* degrees from the setpoint 10 minutes after entering cooling mode.	The cause of the emergency condition must be resolved.
Heat Stuck On	Normal, Alarm	Occurs when the mode is primary off or primary fan only if the supply air temperature does not drop below 150 °F after five minutes.	The cause of the emergency condition must be resolved.
Maintenance	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 times to zero.

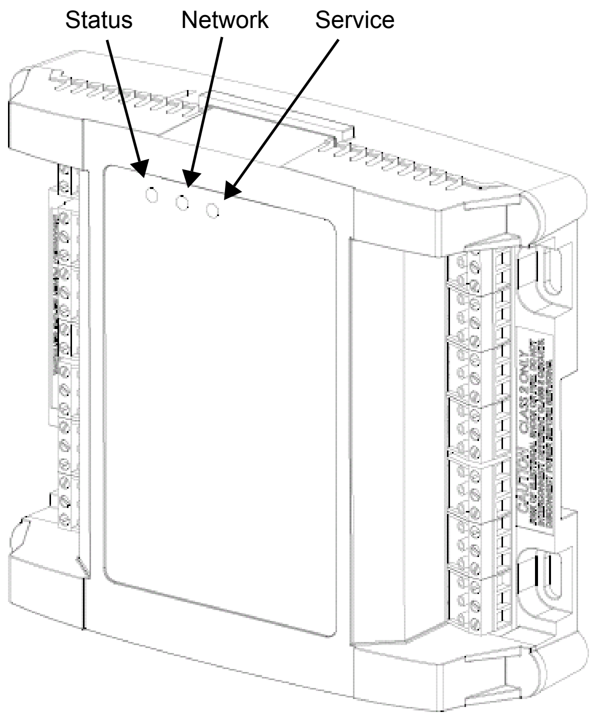
TROUBLESHOOTING

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.

Figure 15: MPU3 Controller LEDs



Troubleshooting Tips

This section provides remedies for common problems.

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.
Can my iWorx® system contain multiple MPU3 controllers?	Yes, provided that you do not exceed the maximum number of controllers that can be handled by the Local Control Interface (LCI).
Can I reverse the minimum and maximum values for the bypass damper?	Yes. This will result in reverse damper action.
Can I use the bypass damper outputs to control a VFD instead?	Yes.
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.

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 applications software.

   Controller firmware version number.

   A complete description of difficulties encountered.

Notes:

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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