UNITED COOLAIR

# Multi-Zone Variable Air Volume

## Sequence of Operations

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MEMBER AHRI AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

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# Multi-Zone Variable Air Volume

Multi-zone variable air volume systems are designed to deliver constant temperature air flow to tenant connected VAV terminal outlet boxes. Air volume is varied based on system duct pressure caused by each zones VAV terminal outlet box opening and closing to satisfy the request for climate conditioning.

## System Start/Stop

The system is on when all enable points are set to the ON position: System ON/OFF:

System ON/OFF: The System ON/OFF selector is found in the System ON/OFF menu of the controller's Main Menu using the unit's display terminal.

Remote ON/OFF: If a Remote ON/OFF switch is field wired into the unit controller, the remote ON/OFF input requires a voltage free dry contact closure to start unit operation. Terminal blocks are provided with a jumper installed to close the input if the function is not used.

BMS ON/OFF: (optional) System must be enabled through BMS. Default position is on.

## Outdoor Air Damper (option)

Once all enabled points are on, the optional outdoor damper opens to satisfy the requirement for fresh. If the system is on and in the occupied mode, the output will open the outdoor air damper after an initial (adjustable) unit start delay. The outdoor air damper output allows the damper to drive open based on either of two methods.

1. Outdoor Air Damper Time Delay – Allows the Outdoor Air Damper to drive open for the adjustable damper time delay before starting the unit's Supply Air Blower.
2. Outdoor Air Damper End Switch (option) – Allows the Outdoor Air Damper to drive open but will not start the unit's Supply Air Blower(s) until the Outdoor Air Damper End Switch provides contact closure back to the Marvel Premium controller verifying that the Outdoor Damper is open.

## Supply Air Blower – Variable Air Volume

Once the Outdoor Air Damper is open, the output for the Supply Air Blower energizes the unit's Variable Frequency Drive(s) (VFD(s)) or optional ECM Fan Motors. The supply air blower(s) will provide a percentage of air volume based on change in system duct pressure or static pressure transducer (SPT). Duct static pressure will fall as customer supplied VAV terminal outlet boxes open to occupied spaces to provide conditioned air, the unit controller will increase the output demand to the VFD or optional ECM blower motors causing the supply air blower(s) to speed up to increase the amount of airflow to the zones being conditioned. As tenant occupied zone VAV boxes close and the tenant's climate is satisfied, this causes the duct static pressure to increase causing the unit controller to decrease the output demand to the VFD or optional ECM blower motors which slows down the speed of the supply air blower(s).

By default, the supply air blower will operate continuously during occupied and unoccupied modes of operation.

## Cooling Mode by Supply Air Temperature

Cooling is based on Cooling Demand which is calculated by the Supply Air Temperature sensor (SAT1), Supply Cool Set point, and Supply Cool Proportional Band. If the Supply Air Temperature is greater than or equal to the Supply Air Temperature Set point plus the Supply Air Temperature Proportional Band Set Point, the Cooling Demand shall be 100%. Each compressor stage is then energized and de-energized based on a Compressor Start and a Compressor Hysteresis point. Each compressor starts when the Cooling Demand is greater than or equal to the Compressor Start point plus the Compressor Hysteresis point. Each compressor stops when the Cooling Demand falls below the Compressor Start point minus the Compressor Hysteresis point. The Start and Hysteresis points are calculated based on the maximum number of compressors.

## Unoccupied Mode

During Unoccupied Mode, all outputs are de-energized. The Supply Air Blower has an option to operate continuously during the unoccupied period. The system also has the capability for setting up Unoccupied Control mode to maintain minimum conditions during unoccupied mode.

## Unoccupied Override

There are three methods of Unoccupied Override that may be utilized to override the Unoccupied Mode, to restart the unit to temporarily continue the conditioning process. These methods for Unoccupied Override are initiated 1) by User Interface, 2) by Digital Input, or 3) by BMS point interlock.

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The system will accept all three methods for Unoccupied Override mode so if connected to either a digital input or a BMS system, Unoccupied Override can be initiated by either of these methods or directly by the User Interface.

## Unoccupied Override by User Interface

The User Interface has an Unoccupied Override trigger built in on the last page of the main System Status screens. Simply press the Up one time and the Unoccupied Override screen appears. Set the Duration (Override Time) and Override position (on), to start the override process. Once the Elapsed time equals the Duration, the unit will return to unoccupied mode.

## Unoccupied Override by Digital Input

**(Requires available digital input and a voltage free dry contact closure momentary push button)**

A digital input can be set up to receive a momentary push-button contact closure to initiate the start period of the Unoccupied Override function. The Unoccupied Time period will follow the existing Duration (Override Time) that is set into the wall display just as it would by initiating it at the wall controller.

## Unoccupied Override by BMS

**(Requires the BMS Communications option)**

A BMS Point is available and requires the BMS Option to initiate the Unoccupied Override function. The Duration (Override Time) for Unoccupied Override mode is also adjustable through BMS. Simply set the unoccupied override time period in minutes. Then Enable/Disable the Unoccupied Override point to start the Unoccupied Override process. If terminating Unoccupied Override before time expiration is desired then a reset point is also available.

## Airside Economizer Mode (option)

Airside Economizer is an optional feature for free cooling that requires a factory-provided duct mount type, field-installed, Outdoor Air Temperature and Humidity sensor, a factory provided wall or duct mountable Return Air Temperature and Humidity sensor, and a factory supplied duct mount Supply Air or Mixed Air Temperature sensor. With the Airside Economizer Option, there is a minimum damper position set point to maintain a minimum amount of fresh outdoor air based on regional code requirements. Also with the Airside Economizer Option, there is a maximum damper position set point to maintain a maximum amount of outdoor air based on maximum outdoor air and airflow limits required. The minimum and maximum outdoor air damper set points are field adjustable under the Technician Menu - Economizer Setup.

If the Cooling Demand rises above minimum damper position set point, and the Outdoor Air Enthalpy is less than the Return Air Enthalpy, and the Outdoor Air Temperature is below the Outdoor Air Temperature Set Point minus the Outdoor Air Temperature Band Set Point, the unit will perform Airside Economizer mode of operation. The amount of demand for Airside Economizer can be viewed by looking at the System Demands screen for Air Side Economizer x%. When operating in airside economizer mode, the outdoor air dampers are modulated to the position that the Economizer demand is calling for. If the outdoor air temperature is less than the Mixed/Supply Air Temperature Set point, the system will regulate the Outdoor and Return Air Dampers to maintain the Mixed Air/Supply Air Temperature Set point.

## Waterside Economizer (option)

Waterside Economizer Mode is an option available for a more energy efficient method of cooling when customers have cooling towers available that can periodically supply water at a temperature of 55.0°F or lower. The Waterside Economizer option requires a factory-provided, factory-installed, water temperature sensor to monitor the inlet water temperature to the unit. If the entering water temperature is below the Water Temperature Set Point minus the Water Temperature Band Set Point, the controller regulates the water valve position in an effort to maintain the cooling set point.

Waterside Economizer Mode will stop when the Cooling Demand is 0% or the entering water temperature rises above the Water Temperature Set Point plus the Water Temperature Band Set Point. When the Water Temperature rises above the Water Temperature Set Point plus the Water Temperature Band Set Point and there is still a demand for cooling, the unit will revert back to mechanical cooling with compressors to provide the required cooling to meet the cooling demand.

## Waterside Economizer plus Mechanical Cooling Assist (option)

The Mechanical Cooling plus Waterside Economizer Assist option follows the same sequence of operation as the Waterside Economizer option. If the customer selects the Waterside Economizer plus Mechanical Cooling Assist Option, the water piping shall be piped internally so that mechanical cooling will be able to assist the waterside econ-

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omizer operation. The controller shall be enabled for the mechanical cooling assist option. The Compressors will be staged when the Waterside Economizer Demand is equal to 100% for greater than the Economizer Assist (field adjustable) time delay. The amount of compressors shall be limited based on the water temperature.

## Morning Warm-Up

Morning Warm-Up is a function typically found in Variable Air Volume applications. There are numerous methods of enabling the Morning Warm-Up function. The three basic methods available through the controller are:

1. By Time
2. By Digital Input (Requires available Digital Input)
3. By BMS Communications (Building Management System)

## Morning Warm-Up by Time

When selected to Morning Warm-Up by Time, the Warm-Up Schedule is located and setup under the Schedule menu. The Morning Warm-Up Set Points are adjusted through the Set Points menu. Warm-Up should be scheduled to operate during the Unoccupied Mode just prior to the start of the occupied day. Morning Warm-Up shall start the heating cycle and heaters until either the Return Air Temperature rises above the Morning Warm-Up Set point or the Morning Warm-Up Time period expires. Once this occurs, the start of the occupied day becomes active and the controller switches to occupied mode.

## Morning Warm-Up by Digital Input

**(Requires available Digital Input)**

Should the controller have additional Digital Inputs available, Morning Warm-Up by Digital Input can be enabled on one of the Open Digital Inputs. If Morning Warm-Up by Digital Input is preferred, it is best to request this upon ordering the equipment that way the factory can ensure there will be enough Digital Inputs available to add this function.

Morning Warm-Up by Digital Input simply enables the Morning Warm-Up Mode when a dry contact closure is provided to the Morning Warm-Up Digital Input. Once active, the Morning Warm-Up Mode will start the heating process based on the Morning Warm-Up Set points located under the Set Points menu.

## Morning Warm-up by BMS

**(Requires BMS Communications option)**

Should the controller have the BMS option, Morning Warm-Up by BMS can be enabled. Morning Warm-Up by BMS simply enables the Morning Warm-Up Mode when the BMS point for Morning Warm-Up is enabled ON. Once active, the Morning Warm-Up Mode will start the heating process based on the Morning Warm-Up Set points located under the Set Points menu. These set points are also adjustable via BMS points.

## Morning Warm-up - Control of Heaters

Morning Warm-up heating is based on the Return Air Temperature (RAT). If the system has staged heaters, there will be a Morning Warm-Up ON Temperature Set point and a Morning Warm-Up OFF Temperature Set point. If the system has modulating type heaters, the amount of modulation is based the Morning Warm-Up Return Air Temperature Set point and Morning Warm-Up Return Air Temperature Proportional Band Set point.

## Morning Cool-Down

Morning Cool-Down is a function typically found in Variable Air Volume applications. There are numerous methods of enabling the Morning Cool-Down function. The three basic methods available through the controller are:

1. By Time
2. By Digital Input (Requires available Digital Input)
3. By BMS Communications (Building Management System)

## Morning Cool-Down by Time

When selected to Morning Cool-Down by Time, the Cool-Down Schedule is located and setup under the Schedule menu. The Morning Cool-Down Set Points are adjusted through the Set Points menu. Cool-Down should be scheduled to operate during the Unoccupied Mode just before the start of the occupied day. Morning Cool-Down shall start the cooling cycle and cool until either the Return Air Temperature falls below the Morning Cool-Down Set point or the Morning Cool-Down Time period expires. Once this occurs, the start of the occupied day becomes active.

## Morning Cool-Down by Digital Input

**(Requires available Digital Input)**

Should the controller have additional Digital Inputs available, Morning Warm-Up by Digital Input can be enabled on one of the Open Digital Inputs. If Morning Warm-Up by Digital Input is preferred, it is best to request this upon ordering the equipment that way the factory can ensure there will be enough Digital Inputs available to add this function.

Morning Cool-Down by Digital Inputs simply enables the Morning Cool-Down Mode when a dry contact closure is provided to the Morning Cool-Down Digital Input. Once active, the Morning Cool-Down Mode will start the cooling process based on the Morning Cool-Down Set points located under the Set Points menu.

## Morning Cool-Down by BMS

**(Requires BMS Communications option)**

Should the controller have the BMS option, Morning Cool-Down by BMS can be enabled. Morning Cool-Down by BMS simply enables the Morning Cool-Down Mode when the BMS point for Morning Cool-Down is enabled ON. Once active, the Morning Cool-Down Mode will start the cooling process based on the Morning Cool-Down Set points located under the Set Points menu. These set points are also adjustable via BMS points.

## Morning Cool-Down - Control of Compressors

Morning Cool-Down cooling is based on the Return Air Temperature (RAT). If the system has staged compressors, there will be a Morning Cool-Down ON Temperature Set point and a Morning Cool-Down OFF Temperature Set point. If the system has modulating type compressors (Digital Scrolls or Variable Compressors), the amount of modulation is based the Morning Cool-Down Return Air Temperature Set point and Morning Cool-Down Return Air Temperature Band Set point.

## Sensors

OAT: A duct mount temperature sensor factory supplied field installed in the outdoor air stream when the Airside Economizer option is ordered. Outdoor Air Temperature is used with the Airside Economizer to calculate and compare outdoor air enthalpy to return air enthalpy.

OAH: A duct mount humidity sensor factory supplied field installed in the outdoor air stream when the Airside Economizer option is ordered. The Outdoor Air Humidity is used to calculate the Outdoor Air Enthalpy to compare outdoor air enthalpy with return air enthalpy for air economizer

RAT: A duct mount temperature sensor factory supplied field installed in the return air stream for Morning Warm-up and providing supply temperature set point reset based on return air temperature. Return Air Temperature is also used with the Airside Economizer to calculate and compare return air enthalpy to outdoor air enthalpy.

RAH: A duct mount humidity sensor factory supplied field installed in the return air stream when the Airside Economizer option is ordered. The Return Air Humidity is used to calculate the Return Air Enthalpy to compare return air enthalpy with outdoor air enthalpy for air economizer operation. The return air temperature and humidity are a combination sensor (1 sensor for installation).

RPT: A refrigerant pressure transducer is factory installed in each compressors circuit to on water cooled packaged units to maintain compressor head pressure during colder entering tower water conditions.

SAT1: A duct mount temperature sensor factory supplied field installed in the supply air ducting for controlling the compressors.

WTS: A water temperature sensor is factory installed when the Water Economizer option is ordered. It is used to determine if the entering water temperature is less than the water temperature set point to allow Water Economizer Mode of operation.

## Global Alarm

As a standard, Interlock Terminal Blocks are provided for field connection to the Global Alarm dry contact closure output. Should the unit go into an alarm condition on any of the following items listed below, a relay will be energized to provide a dry contact closure to control a field provided alarm buzzer or indicator light to alert the customer of the alarm condition with the unit. The power required to drive the field provided device shall be 24VAC powering a device of less than 3 amps maximum through the factory provided relay.

Loss of Airflow

Drain Pan Overflow

Dirty Air Filter

Heater High Limit

Damper Failed to Open

Fan Motor Overload

High Duct Pressure

Water Flow

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Fire/Smoke Detected

Freeze Stat Alarm (with Freeze Stat option)

Preheat Coil Freeze Protection (with Preheat Coil option)

Compressor High and Low Pressure

Sensor Failure

Temperature High or Low Alarms

Humidity High or Low Alarms

# STANDARD SYSTEM SAFETIES

## Proof of Airflow (Air Flow Switch)

Each system has a switch to monitor for loss of airflow. The output for the Supply Air Blower must be energized for a minimum 60 seconds (field adjustable) before any modes of operation are enabled. Should the airflow switch remain open after the time delay expires or the airflow switch opens while any system modes are in operation, the system shuts down the modes of operation and the supply air blower and provides a loss of airflow alarm.

## Fire/Smoke Detection

The Fire/Smoke Detection shut down is a factory standard feature with electrical termination points only. The digital input for Fire/Smoke alarm requires a voltage free normally closed dry contact (opens on alarm). If the Fire Stat/Smoke Detector goes into alarm, the normally closed contact opens and all functions of the system will be shut down, and the controller will provide a Fire/Smoke Alarm. The system will reset based on the setup for reset of the Fire/Smoke Alarm. There are two types of reset for a Fire/Smoke Alarm “Automatic or Manual”.

Automatic reset will automatically reset and restart the system when the Fire/Smoke alarm system is reset without resetting the audible or visual alarm so the customer knows when the unit tripped on a Fire/Smoke Detector Alarm. Manual reset requires the customer to manually reset the Fire Stat/Smoke Alarm condition before the unit will restart the functions of the system. The default setup for Fire/Smoke Alarm is to lock the system out from operation requiring a manual reset/restart at the unit’s Interface Controller. The field has the ability to set the unit to auto-reset/auto-restart once the Fire/Smoke Alarm resets.

## Compressor High Pressure Switch

Each Compressor is protected with a high pressure cutout switch. The switch may vary in pressure range based on the type of refrigerant within the refrigerant circuit. For ON/OFF Type Compressors, the high pressure switch is wired in series with the digital output that controls the ON/OFF function of the corresponding compressor.

For instance Compressor 1 High Pressure switch connected to Digital Output 2 will start and stop Compressor 1 by whether the switch is open or closed. The High pressure switch will open if the refrigerant pressure is greater than the refrigerant pressure set point. The open Compressor 1 High Pressure Switch will de-energize the relay that energizes and de-energizes the Compressor 1 Contactor. One contact energizes and de-energizes the compressor contactor and the other relay contact sends the alarm signal back to the controller to let the controller know that Compressor 1 High Pressure switch tripped. The high pressure switch will take the compressor offline as it is wired to the relay that controls the contactor for the compressor but it will also allow the relay to provide the alarm signal.

Once the High Pressure Trip occurs, the compressor must be re-enabled under the System Enables menu in the controller.

**NOTE: R410A Refrigerant Systems also require a manual reset of the switch due to higher operating pressures within the system.**

## Compressor Low Pressure Switch

Each Compressor is protected by a Low Pressure cutout switch. The switch may vary in pressure range based on the type of refrigerant within the refrigerant circuit. Unlike the high pressure switch, the low pressure switch is connected directly to a digital input on the controller. Should the Low Pressure Switch open during a compressor run cycle, the corresponding compressor will trip on low pressure safety. If this occurs, the controller will de-energize the corresponding digital output to the compressor contactor.

Once the Low Pressure Trip occurs, the compressor must be manually re-enabled under the System Enables menu in the controller. The low pressure switches automatically reset once the pressure at switch rises above the switches reset point.

## Heater High Temperature Cutout

Factory provided heating banks are supplied with a heater high temperature cutout switch that trips as the surrounding air temperature at the switch causes the temperature on the switch to rise above the cutout point. The switch is bimetallic auto reset type. Should the switch trip, an alarm will be displayed on the controller alerting the customer to Heater High Temperature Cutout. If a heater high temperature cutout occurs, the heaters automatically restart once the surround-

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ing air temperature cools the surface of the switch enough to allow the switch to reset.

## Sensor Failure

There are two methods for sensor failure. One method is when the reading is above or below minimum and maximum range of the sensor. With this method, the sensor should be displaying a value on the display of the controller. The other method is a mis-wired or sensor that simply was not installed during installation. This method will display a ###.# output for the failed sensor on the wall controller along with the label of the sensor.

## High and Low Limit Alarms

Each controller has adjustability for High and Low set point alarms for the following sensors. The High and Low Limit Set Points are available under the Alarm Set Points menu. The sensors must be enabled for the High and Low Alarm Set Point display screens to appear. The following sensors have high and low alarm set point capability:

Return Air Temperature

Supply Air Temperature

Duct Pressure

Refrigerant Pressure

## High Duct Pressure

A factory provided high duct pressure switch *(may require field installation on non-EZ-Fit/Renovator units)* opens when the duct pressure rises above the field adjustable trip point. If this occurs, all modes of operation are de-energized and the supply air blower is de-energized. A manual reset of the High Duct Pressure Switch as well as a manual reset of the Alarm on the controller is required.

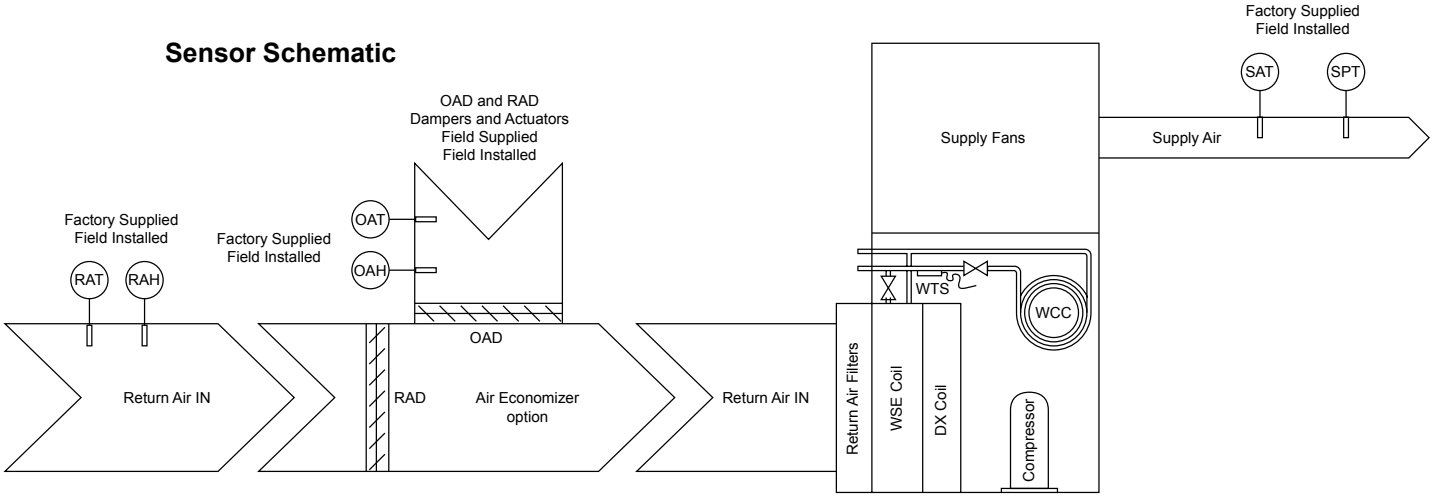
## Drain Pan Overflow Switch

The drain pan overflow switch is a water level detection switch that opens when the water level is too high in the unit's condensate drain pan. If there is a blockage in the condensate line, the rising water level in the condensate drain pan will open the drain pan switch creating an alarm at the controller. The drain pan overflow switch shuts down cooling preventing the condensate from overflowing the drain pan. The alarm will notify the customer of the drain pan overflow condition. Once the blockage is removed from the condensate drain line, the system must be manually reset at the controller's user interface.

## Dirty Filter Switch

When the air filter(s) become clogged with dirt and debris, the contacts on the filter switch will open causing a Dirty Filter Alarm at the controller. The alarm will be in the form of a notification recommending that the air filter(s) be changed for preventive maintenance. No modes of operation are locked out during the Dirty Filter Alarm and the unit will continue operation in the presently operating mode. The alarm notification can be reset through the units user interface once the filter(s) are replaced.

**Sensor Schematic**




491 East Princess Street, York, PA 17403 Phone: 717-843-4311 Fax: 717-854-4462
web: www.unitedcoolair.com