UNITED COOLAIR

Single-Zone Variable Air Volume

Sequence of Operations

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MEMBER AHRI AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

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Single-Zone Variable Air Volume

Single-zone variable air volume systems are designed to deliver constant temperature air at varied air flow rates to maintain air temperature within a single zone / space being conditioned. In order to maintain constant air temperature due to the variance in air flow rate, there must be a method to modulate the cooling and/or heating components to maintain the constant temperature air being supplied to the space being conditioned. Air flow is increased/decreased based on Return Air Temperature to the zone being conditioned.

System Start/Stop

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.

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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 air. If the system is on and in the occupied mode, a relay 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 – Single Zone Variable Air Volume

Once the optional 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 remains at minimum fan speed as long as the Return Air Temperature remains at the Return Air Temperature Set point. The supply air blower(s) changes the percentage of air volume based on deviation of the Return Air Temperature from the Return Air Temperature Set point. If the Return Air Temperature is within the Return Air Temperature Dead Band, there will be no output adjustment to increase fan speed.

Supply Blower – Cooling Mode

As the Return Air Temperature rises above the Return Air Temperature Set Point plus ½ the Return Air Temperature Dead Band, the Supply Blower speed will start to increase. The Supply Blower shall be at full speed when the Return Air Temperature is greater than or equal to the Return Air Temperature Set Point plus the Return Air Temperature Proportional Band.

Supply Blower – Heating Mode

As the Return Air Temperature falls below the Return Air Temperature Set Point minus ½ the Return Air Temperature Dead Band, the Supply Blower speed will start to increase. The Supply Blower shall be at full speed when the Return Air Temperature less than or equal to the Return Air Temperature Set Point minus the Return Air Temperature Proportional Band.

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%. A digital or variable compressor starts when the demand for the compressor is greater than 30%. Each additional stage of fixed speed compressor is then energized

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when the demand for the digital or variable compressor is equal to 100% plus 25% (this is the minimum allowable for the digital or variable compressor) for start of the next stage. Once the next stage of compressor starts, the digital or variable compressor falls back to the 25% minimum demand and then slowly starts to ramp upward based on further demand for the compressor. Should the total cooling demand start to fall, the staged compressor shall de-energize if the cooling demand for the staged compressor falls below 75%. At that point, the variable compressor shall return to 100% full capacity and then modulates downward if the total cooling demand continues to fall.

Heating Mode by Supply Air Temperature

Heating is based on Heating Demand which is calculated by the Supply Air Temperature sensor (SAT1), Supply Heat Set point, and Supply Heat Proportional Band. If the Supply Air Temperature is less than or equal to the Supply Air Temperature Set point minus the Supply Air Temperature Proportional Band Set Point, the Heating Demand shall be brought back to 100% full capacity. If the heating demand continues to fall, the output to the modulating heat device will decrease.

The output to the heating device starts immediately as the heating demand rises above 0% heating demand. When the demand for the modulating heater is 100%, if there are additional staged heaters within the system the next stage of heating is brought on and the modulating device is dropped to 0% demand and starts to modulate upward again if the heating demand continues to rise. If the heating demand starts to fall and the demand for the staged heater reaches 0%, the staged heater de-energizes. At that point, the modulating heating device is brought back to 100% full capacity and then modulates downward if the total heating demand continues to fall.

Dehumidification Mode (option)

Dehumidification is based on the Dehumidification Set Point and Dehumidification Proportional Band (both adjustable). If the Return Air Humidity rises above the Return Air Humidity Set Point plus ½ the Proportional Band Set Point, the modulated compressor is brought on for dehumidification mode following the Supply Cooling Mode strategy previously listed for sequencing of compressors. The Supply Air Blower shall modulate from minimum to maximum which is the Return Air Humidity Set Point plus the full Proportional Band.

Hot Gas Reheat (option)

The Hot Gas Reheat coil is modulated to maintain the supply air temperature at the Reheat Set Point only when the unit is dehumidification mode. This option also requires an Air Leaving Evaporator Temperature sensor (DXT) so that the temperature of the air leaving the evaporator is cold enough to dehumidify but also use the Supply Air Temperature Sensor to reheat the supply air back to the Reheat Set Point.

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 can be used to override the Unoccupied Mode. This will restart the unit in Occupied Mode to temporarily continue the conditioning process. These methods for Unoccupied Override are initiated 1) by User Interface (unit display and keypad), 2) by Digital Input, or 3) by BMS point interlock.

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 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 economizer 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.

Sensors

OAT: Outdoor Air Temperature is used with the Airside Economizer option to calculate and compare outdoor air enthalpy to return air enthalpy. The OAT is a combination OAT/OAH sensor that is factory- supplied, field-installed duct mount type that is to be installed in the outdoor air stream.

OAH: Outdoor Air Humidity is used with the Airside Economizer option to calculate and compare outdoor air enthalpy to return air enthalpy. The OAH is a combination OAT/OAH sensor that is factory-supplied, field- installed duct mount type that is to be installed in the outdoor air stream.

RAT: Return Air Temperature is used to determine the cooling or heating mode of operation and calculate the required supply air blower speed. When the Airside Economizer option is ordered, it is also used to calculate the Return Air Enthalpy to compare to the Outdoor Air Enthalpy and determine if Airside Economizer is available to satisfy the cooling requirement.

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RAH: The Return Air Humidity option is used to determine if dehumidification mode is required. When the Airside Economizer option is ordered, it is also used to calculate the Return Air Enthalpy to compare to the Outdoor Air Enthalpy and determine if Airside Economizer is available to satisfy the cooling requirement. If the return air humidity sensor is ordered, the return air temperature and humidity are a combination sensor.

DXT: On units with the dehumidification and reheat options, a bulb mount temperature sensor shall be installed between the evaporator and hot gas reheat coils. This senses the air temperature leaving the evaporator coil.

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

SAT1: Supply Air Temperature sensor is factory-supplied field-installed in the supply air ducting for controlling the compressors when no humidity control is required. If the Return Air Humidity Sensor is ordered for dehumidification mode, then this sensor is used monitor the Supply Air Temperature for Reheat.

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 Temperature Limit
- Damper Failed to Open
- Fan Motor Overload
- High Duct Pressure
- Water Flow Switch
- 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

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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 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 switch will automatically reset the pressure on the switch rises above the switches reset value but the compressor is required to be re- enabled as explained previously to prevent continuous low pressure trips.

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 surrounding 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
- Return Air Humidity
- Supply Air Temperature
- Refrigerant Pressure

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.

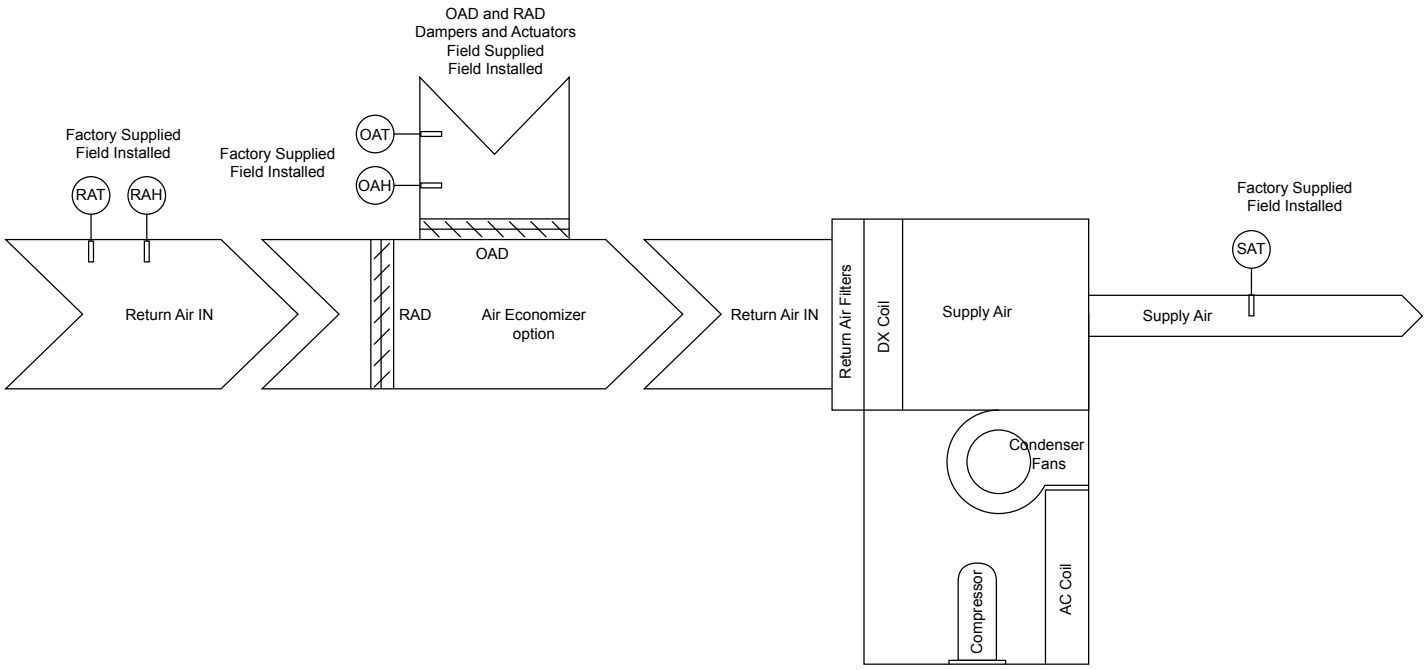
Dirty Filter Switch

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.

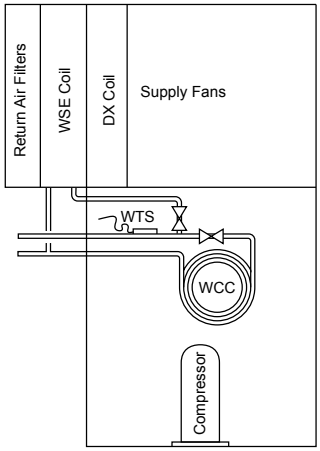
Single-Zone Variable Air Volume

Sequence of Operations

Sensor Schematic



Alternate View:
Water Cooled
Condenser and
Optional Water
Economizer



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