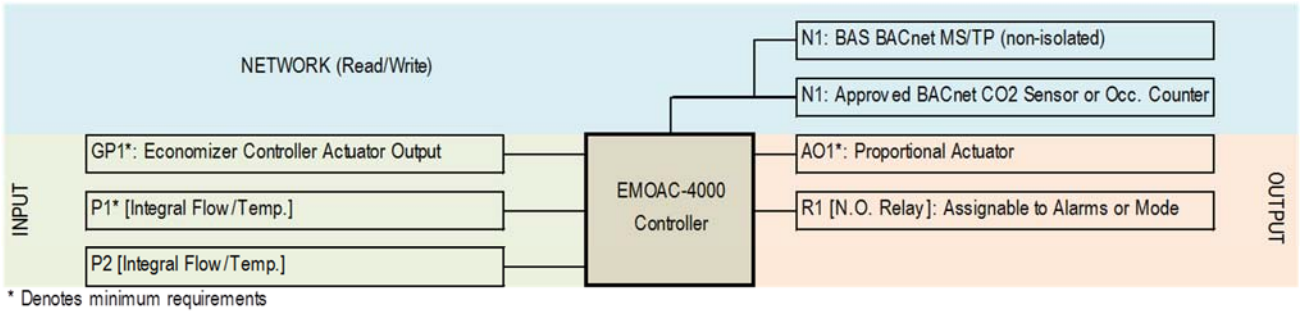
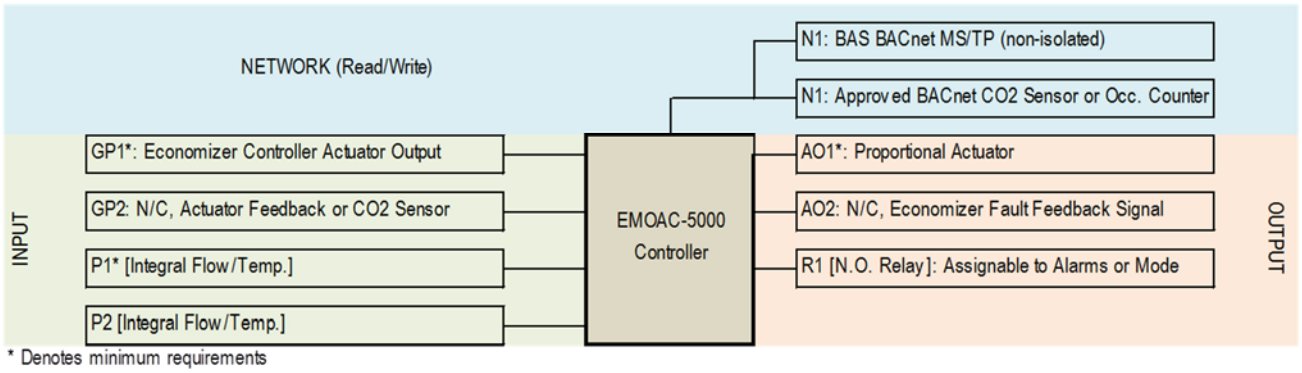
1. EMOAC HARDWARE ARCHITECTURE

EMOAC Economizer Minimum Outdoor Air Controllers are based on GreenTrol Automation's 4000 and 5000 hardware architecture. The EMOAC-4000 and EMOAC-5000 use a general purpose input factory configured as an analog input (GP1 configured as AI1) to measure the economizer controller actuator output signal and an analog output (AO1) to control a proportional actuator. The EMOAC-5000 has an additional general purpose input factory configured as an analog input (GP2 configured as AI2) and an additional analog output (AO2). The additional I/O can be used to satisfy economizer controller fault detection requirements or read an analog CO_2 sensor.

Both architectures support GreenTrol Automations integrated IAT, one or two sensor node, thermal dispersion airflow/temperature measuring devices (P1 and/or P2), have a contact closure relay (R1), and provide one non-isolated BACnet MS/TP connection (N1). The MS/TP connection can be configured for approved MS/TP airflow measurement devices in lieu of the integrated sensors, approved MS/TP DCV sensors and/or connection to a building automation system. Both controllers support full read/write privileges as a BACnet master.

Figure 1-1 EMOAC Application Specific Hardware Architecture





2. MINIMUM OUTDOOR AIR CONTROL (OAC) METHODS

2.1. Methods Supported

EMOAC controllers support four modulating outdoor air control methods and two non-modulating methods during minimum outdoor air (MOA) mode. The outdoor air control (OAC) method is selected during firmware configuration.

2.2. Modulating Control Methods

Modulating control continuously modifies the signal, AO1, to the outdoor air/return air actuator using one or more PID control loops and sensor inputs to maintain setpoint within a user defined deadband when minimum outdoor air mode is detected. EMOAC controllers support fixed and variable setpoint control.

2.2.1 FIXED SETPOINT CONTROL METHODS

Fixed setpoint control maintains a user defined airflow or CO_2 setpoint. EMOAC controllers support the following fixed setpoint modulating control methods:

- FLOW: maintains a user defined fixed airflow setpoint
- CO2: maintains a user defined fixed CO_2 setpoint bound by optional upper and lower airflow limits

2.2.1.1. Airflow Setpoint Control [OAC=FLOW, default]

Modulates AO1 to maintain a user defined airflow setpoint. The setpoint can be entered during firmware configuration or during normal operation by pressing either the ↑ or ↓ pushbuttons on the main circuit board.

2.2.1.2. Improved CO_2 Demand Control Ventilation (CO_2-DCV) [OAC=CO2]

Modulates AO1 to maintain a user defined CO_2 setpoint. The setpoint can be entered during firmware configuration or during normal operation by pressing either the ↑ or ↓ pushbuttons on the main circuit board.

EMOAC controllers reset the outdoor airflow setpoint to maintain the desired CO_2 level. As a result, minimum and maximum ventilation airflow limits can be set by the user. Setting airflow limits significantly improves traditional CO_2-DCV that relies on fixed damper positions which are affected by damper hysteresis, fan speed changes and wind/stack pressure variations.

2.2.2 VARIABLE SETPOINT CONTROL METHODS

Variable airflow setpoint control, or population based-DCV, satisfies the ventilation requirements of ASHRAE Standard 62.1 at all population levels and is an improvement over CO_2-DCV.

The population of the ventilation zone is used to calculate the required breathing zone outdoor airflow rate. There is no user defined airflow setpoint. The breathing zone outdoor airflow rate, Vbz, is determined using the estimated population and values for the ventilation rate required per person, Rp, the ventilation rate required per floor area, Ra, and the ventilation zone floor area, Az. Values for Rp, Ra and Az should be modified for the specific space type during firmware configuration.

Vbz can be corrected for the zone ventilation effectiveness and the total outdoor air can be corrected for the worst-case expected ventilation efficiency on multi-zone systems during firmware configuration when the total population of the ventilation zone is estimated. The resulting airflow setpoint is Voz.

Variable setpoint control modulates AO1 to maintain the calculated value for Voz. EMOAC controllers support the following variable setpoint modulating control methods:

- CO2/OAF: maintains a calculated airflow setpoint using the calculated population bound by optional upper and lower airflow limits
- COUNT: maintains a calculated airflow setpoint using the counted population bound by optional upper and lower airflow limits

2.2.2.1. CO2/OAF Population Estimation-DCV [OAC=CO2/OAF]

The CO2/OAF method uses a steady-state algorithm that estimates the population of the ventilation zone using indoor/outdoor CO_2 levels, metabolic activity and the measured outdoor airflow rate. The outdoor CO_2 level and metabolic activity can be modified during firmware configuration.

2.2.2.2. Direct Count-DCV [OAC=COUNT]

The COUNT method uses one to four door mounted occupancy counters to determine the occupancy of the ventilation zone.

2.3. Non-modulating Control Methods

EMOAC controllers support the following non-modulating methods when minimum outdoor air mode is detected:

- FIXED: maintains a user defined fixed damper position
- PASS: passes the economizer controller damper output signal

3. EMOAC OUTPUT

3.1. Mode Detection

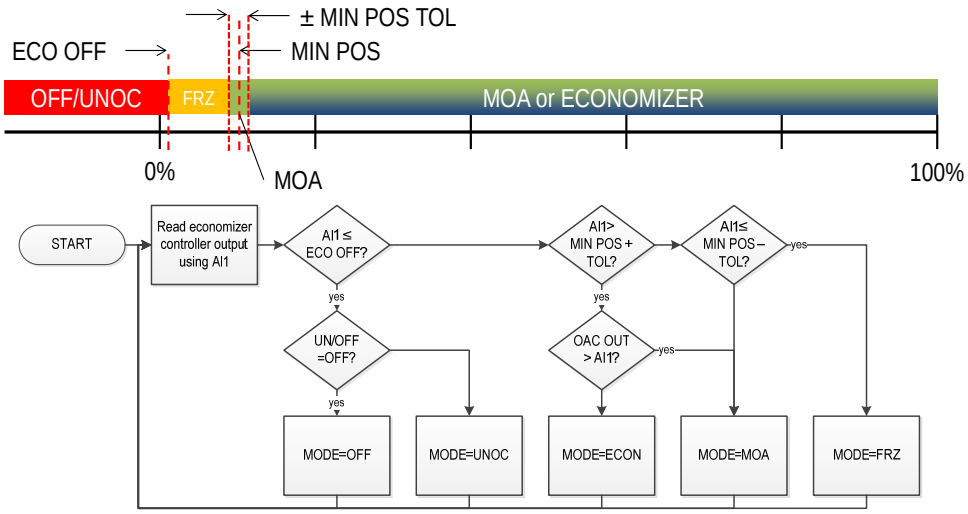
EMOAC controllers use the proportional analog control output signal of the economizer controller (by others), connected to AI1 and scaled between 0 and 100%, to detect the active control mode (Figure 3-1).

EMOAC controllers detect the following modes of operation:

- Off Mode
- Unoccupied Mode
- Minimum Outdoor Air Mode
- Economizer Mode
- Freeze Mode

Three parameters, ECO OFF, MIN POS and MIN POS TOL are used to determine mode. The minimum fixed damper position, MIN POS, typically 10%, can be modified during firmware configuration and must match minimum position output set in the host economizer controller. ECO OFF and MIN POS TOL parameters can be modified using advanced setup, if required.

Figure 3-1 Mode Detection Logic



3.2. EMOAC Actuator and Fault Signal Outputs

The EMOAC actuator control output signal is provided on AO1 and is dependent on active mode, OAC method, control status and sensor status. An optional economizer fault signal (EMOAC-5000 only) can be provided to the host economizer controller on AO2. EMOAC Actuator and Fault Signal Combinations are shown in Figures 3-2 and 3-3.

Figure 3-2 EMOAC Control

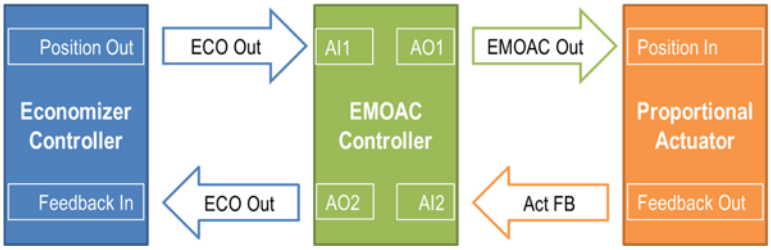
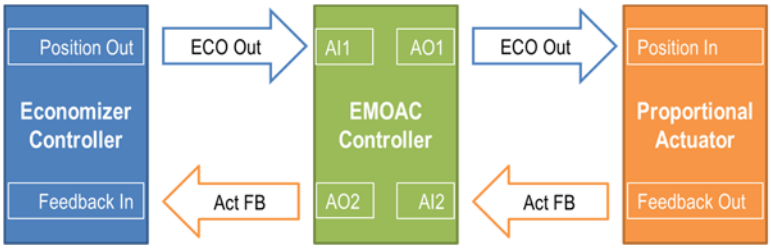


Figure 3-3 Economizer Controller Control



Note: All references regarding AI2 and AO2 for fault detection are only valid on EMOAC-5000 controllers. The EMOAC-5000 must be configured to provide an economizer fault output signal (ECO OUT=ON) and have AI2 connected to the actuator feedback output.

4. NORMAL OPERATION (NO FAULTS)

4.1. Off Mode (MODE=OFF)

The EMOAC controller passes the economizer controller output measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2 (see Figure 3-3).

4.2. Unoccupied Mode (MODE=UNOC)

The EMOAC controller modulates the output of AO1 to maintain a user defined unoccupied airflow setpoint, UNOC SET whenever UNOC SET is greater than zero. The actuator control signal from the economizer controller measured on AI1 passes to economizer fault signal output on AO2 to avoid a false fault condition (see Figure 3-2).

Note: Unoccupied airflow control is only available when a modulating minimum outdoor air control method is selected.

4.3. Minimum Outdoor Air Mode (MODE=MOA)

The EMOAC controller sets AO1 based on the minimum outdoor air control (OAC) method selected in SECTION 2. The actuator control signal from the economizer controller measured on AI1 passes to economizer fault signal output on AO2 to avoid a false fault condition (see Figure 3-2).

4.4. Economizer Mode (MODE=ECON)

The EMOAC controller passes the economizer controller output measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2, thus preserving full economizer functionality (see Figure 3-3).

4.5. Freeze Mode (MODE=FRZ)

The EMOAC controller passes the economizer controller output measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2, thus returning freeze protection operation to the economizer controller (see Figure 3-2).

5. CONTROL FAULT HANDLING

5.1. Control States

During modulating control, EMOAC controllers monitor the active control state (Figure 5-1). Control states are categorized as follows:

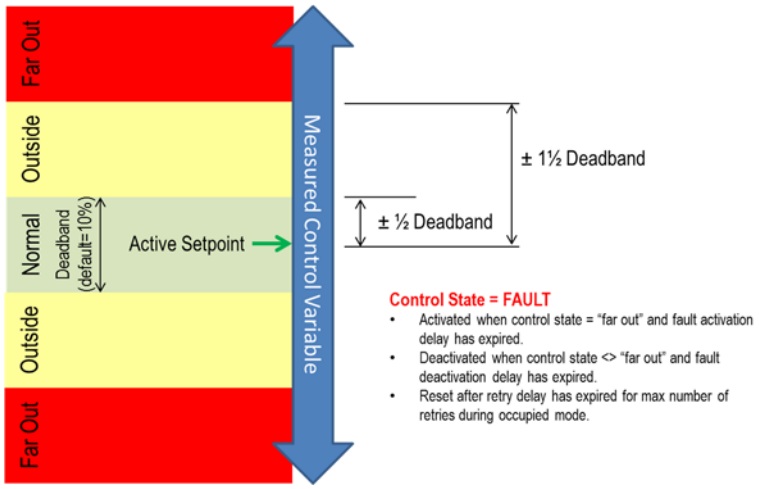
- Inactive (not in a modulating control mode)
- Normal (within/equal to active setpoint ± 0.5 deadband)
- Outside (outside active setpoint ± 0.5 deadband)
- Far Out (outside active setpoint ± 1.5 deadband)
- Control Fault (Far Out for greater than specified fault activation delay period)

Active control faults are indicated on the LCD as follows:

- Outside High, + indicated after measured output
- Outside Low, - indicated after measured output
- Far Out High, ++ indicated after measured output
- Far Out Low, -- indicated after measured output

- Control Fault High, flashing ++ after measured output
- Control Fault Low, flashing -- after measured output

Figure 5-1 Control States



5.2. Mode Dependent Control Fault Operation

Note: All references regarding AI2 and AO2 for fault detection are only valid on EMOAC-5000 controllers. The EMOAC-5000 must be configured to provide an economizer fault output signal on AO2 (ECO OUT=ON) and have AI2 connected to the actuator feedback output.

5.2.1. UNOCCUPIED AIRFLOW MODE CONTROL FAULTS

5.2.1.1. Unoccupied Airflow Control Fault

An active unoccupied airflow control fault passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2. EMOAC modulating control is disabled (Figure 3-3).

5.2.2. MINIMUM OUTDOOR AIRFLOW MODE CONTROL FAULTS

5.2.2.1. Minimum Airflow Control Fault

An active minimum airflow control fault passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2. EMOAC modulating control is disabled (Figure 3-3).

5.2.2.2. CO_2 Control Fault

A CO_2 control fault only affects operation when OAC is set to CO2.

If DCVMAX is set to NONE, an active CO_2 control fault passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2. EMOAC modulating control is disabled (Figure 3-3).

If DCVMAX is not set to NONE, an active CO_2 control fault maintains DCV MAX. The actuator control signal from the economizer controller measured on AI1 passes to AO2 to avoid a false fault condition (Figure 3-2).

If DCVMAX is not set to NONE and an active airflow control fault is active, an active CO_2 control fault passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2. EMOAC modulating control is disabled (Figure 3-3).

5.3. Control Fault Recovery

Control is restored when the active fault is not present for the specified fault deactivation delay period.

Since control is disabled when an active control fault is present, it is not likely that the fault will be cleared. The EMOAC controller allows for a user specified number of retries after a specified retry delay. The control fault is also reset whenever the mode of operation changes.

EMOAC controllers log the cumulative time the controller is in each control state in non-volatile memory. Times can be viewed by navigating through the system diagnostics menus.

Press the {ESC} and ↑ buttons simultaneously during normal operation to enter the advanced setup, tools and diagnostics menus.

6. SENSOR FAULT HANDLING

6.1. Sensor Fault Detection

The EMOAC controller has a built-in sensor diagnostic system that detects full or partial airflow sensor, CO_2 sensor or occupancy counter failure.

6.2. Sensor Fault Operation

Note: All references regarding AI2 and AO2 for fault detection are only valid on EMOAC-5000 controllers. The EMOAC-5000 must configured to provide an economizer fault output signal (ECO OUT=ON) and have AI2 connected to the actuator feedback output.

6.2.1. AIRFLOW SENSOR FAILURE

A partial airflow sensor failure averages functioning airflow sensor nodes and does not disrupt control operation. A complete airflow sensor failure passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2. EMOAC modulating control is disabled (Figure 3-3).

6.2.2. DCV SENSOR FAILURE

A DCV sensor is either a CO_2 sensor or an occupancy counter. A CO_2 sensor failure only affects operation when OAC is set to CO2 or CO2/OAF. An occupancy counter failure only affects operation when OAC is set to COUNT.

If DCVMAX is set to NONE, a DCV sensor failure passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO2. EMOAC modulating control is disabled (Figure 3-3).

If DCVMAX is not set to NONE, a DCV sensor failure maintains DCV MAX. The actuator control signal from the economizer controller measured on AI1 passes to AO2 to avoid a false fault condition (Figure 3-2).

If DCVMAX is not set to NONE and an active airflow control fault is active, a DCV sensor failure passes the economizer controller's output signal measured on AI1 to AO1 and the actuator feedback signal measured on AI2 to AO1. EMOAC modulating control is disabled (Figure 3-3).

6.3. Sensor Fault Recovery

Control is restored when the sensor fault is no longer present.

EMOAC controllers maintain active trouble codes and trouble history in non-volatile memory. Trouble codes and history and can be viewed by navigating through the system diagnostics menus.

Press the {ESC} and ↑ buttons simultaneously during normal operation to enter the advanced setup, tools and diagnostics menus.

7. CONTACT CLOSURE RELAY

The contact closure relay, R1, may be assigned to one or more notification alarms or the active control mode.

7.1. Notification Alarm Assignment [R1 ASGN=ALRMS, default]

The contact closure relay, R1, closes when a bound notification alarm is active. To assign the contact closure relay to notification alarms, set R1 ASNG to ALRMS (default) during hardware configuration.

Note: Individual alarms must be bound to R1 during firmware configuration for an active alarm to close the relay.

7.2. Mode Assignment [R1 ASGN=MODE]

The contact closure relay, R1, closes and can enable an external device, such as a start relay for a booster fan or exhaust fan, when the specified mode is active. To assign the contact closure relay to the active control mode, set R1 ASNG to MODE during hardware configuration. Select the desired active control mode, minimum outdoor air mode (R1 ACTMOD=MOA), economizer mode (R1 ACTMOD=ECO) or both MOA and economizer modes (R1 ACTMOD=MOAECO), that enables the contact closure relay.

8. NOTIFICATION ALARMS

EMOAC controllers have built-in notification alarms. Notification alarms are automatically displayed at position 11 on the LCD and can be individually bound to the contact closure relay, R1, when R1 ASGN is set to ALRMS. Notification alarms are also available via BACnet.

8.1. System Status Alarms

8.1.1. SYSTEM TROUBLE ALARM [TRBL ALARM]

The alarm can become active during any mode. The system trouble alarm is active when any malfunction of the controller module, airflow measuring device or installed DCV sensor is detected. The alarm is enabled by default and configured for automatic reset. Active trouble codes and trouble code history are viewed using built-in diagnostic tools.

8.2. Mode Dependent Setpoint Alarms

The following mode dependent setpoint alarms are available:

- Unoccupied Airflow Alarm
- Minimum Outdoor Airflow Alarm
- CO_2 Alarm

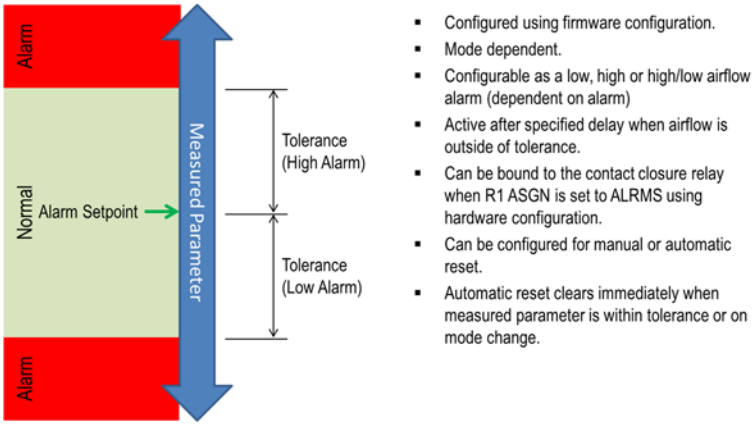
Notification alarms are disabled by default and must be enabled during firmware configuration to become active.

Notification alarms can be configured to reset automatically when the mode changes and/or alarm status is no longer active, or require manual reset. Active, manually reset, notification alarms are cleared by pressing the {ESC} button or via BACnet.

Each notification alarm has unique type (high, low or high/low), tolerance and delay parameters. Alarm history is maintained in non-volatile memory.

Notification alarm parameters can be modified during firmware configuration.

Figure 8-1 Setpoint Notification Alarms



8.2.1. UNOCCUPIED AIRFLOW ALARM [UNOC ALARM]

The alarm can only become active during unoccupied mode when the unoccupied airflow setpoint (UNOC SET) is greater than zero. The alarm uses the unoccupied airflow setpoint as the default alarm setpoint. The alarm can be set as a high, low or high/low airflow alarm.

8.2.2. MINIMUM OUTDOOR AIRFLOW ALARM [MOA ALARM]

The alarm can only become active during MOA mode and any OAC method except when the OAC method is set to CO2. The alarm uses the active MOA airflow setpoint (MOA SET) when the OAC method is set to FLOW, CO2/OAF or COUNT. The alarm uses a user defined airflow setpoint when the OAC method is set to FIXED or PASS. The alarm can be set as a high, low or high/low airflow alarm.

8.2.3 CO_2 ALARM [CO2 ALARM]

The alarm can become active during any mode and with any OAC method. A CO_2 sensor must be installed and configured for the alarm to be available. The alarm uses the CO_2 setpoint (CO2 SET) when the OAC method is set to CO_2 or a user defined CO_2 setpoint for all other methods. The alarm is only available as a high CO_2 alarm.