Installation and Operation Guide

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BAC-7001 and BAC-7051 Advanced Applications Controllers for VAV Applications

Important notices

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SECTION 1

About the controllers

This section provides a description of the KMC Controls BAC-7001 and BAC-7051 controllers. It also introduces safety information. Review this material before installing or operating the controller.

The BAC-7001 and BAC-7051 are native BACnet, direct digital controllers designed for VAV terminal units. An integrated actuator and the supplied programs make these ideal controllers for temperature setback, overrides, proportional reheat and other HVAC sequences. Install these versatile controllers in stand-alone environments or networked to other BACnet devices. As part of a complete facilities management system, the BAC-7001 and BAC-7051 controllers provide precise monitoring and control of connected points.

- BACnet MS/TP compliant
- Automatically assigns the MAC address and the device instance
- Standard VAV control sequences are incorporated to provide pressure independent control of a single-duct VAV unit.
- On-board airflow sensor for use with a single or multi-point differential pressure measuring station or pitot tube.
- Use to control heating, cooling, cooling with heat change-over, cooling with time proportional reheat or three-stage, sequential reheat.

Specifications

Inputs

Universal inputs	3
Air flow sensor	1
Key features	Universal inputs programmable as analog, binary or accumulator objects. Standard units of measure. Overvoltage input protection
Pull–up resistors	Switch select none or 10kΩ
Connector	Removable screw terminal block, wire size 14–22 AWG
Conversion	10–bit analog–to–digital conversion
Pulse Counting	Up to 16 Hz
Input range	0–5 volts DC
NetSensor	Compatible with models KMD-1161 and KMD-1181.

Outputs, Universal	3
Key features	Output short protection Universal outputs programmable as analog or binary objects. Standard units of measure
Connector	Removable screw terminal block Wire size 14–22 AWG
Output voltage	0–10 volts DC analog 0–12 volts DC binary
Output current	100 mA per output
Communications	
BACnet MS/TP	EIA–485 operating at rates up to 76.8 kilobaud. Automatic baud detection. Automatically assigns MAC addresses and device instance numbers Removable screw terminal block. Wire size 14–22 AWG
NetSensor	Compatible with models KMD-1161 and KMD-1181, Connects through RJ–12 connector.
Programmable features	
Control Basic	10 program areas
PID loop objects	4
Value objects	40 analog and 40 binary
Supported objects	See PIC statement for supported BACnet objects
Schedules	8 schedule objects 3 calendar object
Trend objects	8 each of which holds 256 samples
Alarms and events	
Intrinsic reporting	Supported for input, output, value, accumulator, trend and loop objects.
Notification class objects	8
Memory	Programs and program parameters are stored in nonvolatile memory. Auto restart on power failure
Applications programs	KMC Controls supplies the BAC-7001 with programming sequences for three single-duct VAV applications: ◆ Heating-cooling changeover ◆ VAV with time proportional reheat ◆ VAV with three-stage reheat.

Air sensor features	Platinum-ceramic flow-through, 0 to 3000 FPM (15.24 m/s) using 24-inch, 1/4 FR tubing and SSS-1000 series flow pickups. Range dependent upon DP pickup, tubing size/length and connections.
Actuator specifications	
Torque	50 in-lb. (5.7 N•m) minimum 70 in-lb. (7.9 N•m) maximum
Angular rotation	0 to 95° Adjustable end stops at 45/60/90° rotation
Motor timing, BAC-7001	18°/minute at 60 Hz 15°/minute at 50 Hz
Motor timing, BAC-7051	60°/minute at 60 Hz 50°/minute at 50 Hz
Shaft size	Fits 0.5 inch (13 mm) round shafts. See *Shaft adaptors* on page 7 for 0.38 inch shafts.
Regulatory	UL 916 Energy Management Equipment FCC Class B, Part 15, Subpart B BACnet Testing Laboratory listed CE compliant SASO PCP Registration KSA R-103263
Installation	
Supply voltage	24 volts AC (–15%, +20%), 50-60 Hz, 25 VA, Class 2 only, non-supervised (all circuits, including supply voltage, are power limited circuits)
Weight	2.4 lb. (1.1 kg)
Case material	Flame retardant green plastic
Environmental limits	
Operating	32 to 120° F (0 to 49° C)
Shipping	–40 to 140° F (–40 to 60° C)
Humidity	0–95% relative humidity (non-condensing)
Models	
BAC-7001	18°/Minute Actuator
BAC-7051	60°/Minute Actuator

Dimensions

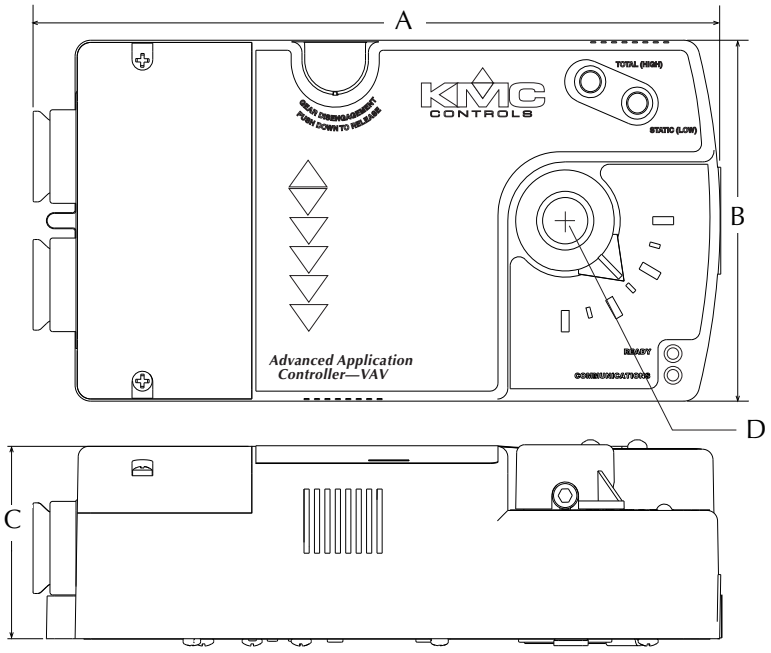

Table 1-1 BAC-7001 dimensions

A	B	C	D
8.23 in.	4.22 in.	2.25 in.	0.510 in.
209 mm	107 mm	57 mm	13 mm

Accessories

Shaft adaptors	
HFO-0011	3/8 inch (9.5 mm) shaft adaptor
Airflow sensors	Order one of the following for installation on VAV units without airflow sensor pickup tubes.
SSS-1002	3-5/32 in. length (80 mm)
SSS-1003	5-13/32 in. length (137 mm)
SSS-1004	7-21-32 in. length (195 mm)
SSS-1005	9-29/32 in. length (252 mm)
Power transformer	
XEE-6111-40	Single-hub 120 volt transformer
XEE-6112-40	Dual-hub 120 volt transformer

Safety considerations

KMC Controls assumes the responsibility for providing you a safe product and safety guidelines during its use. Safety means protection to all individuals who install, operate, and service the equipment as well as protection of the equipment itself. To promote safety, we use hazard alert labeling in this manual. Follow the associated guidelines to avoid hazards.

Danger

Danger represents the most severe hazard alert. Bodily harm or death will occur if danger guidelines are not followed.

Warning

Warning represents hazards that could result in severe injury or death.

Caution

Caution indicates potential personal injury or equipment or property damage if instructions are not followed.

Note

Notes provide additional information that is important.

Detail

Provides programing tips and shortcuts that may save time.

SECTION 2

Installing the controller

This section provides important instructions and guidelines for installing the BAC-7001 controller. Carefully review this information prior to attempting installation.

Set the rotation limits

Note

Before mounting the controller, set the rotational limits with two supplied stop pins. These settings limit the shaft rotation in the clockwise (CW) and counterclockwise (CCW) directions. (See Illustration 2-1.)

Caution

Before setting the rotation limits on the controller, refer to the damper position specifications in the VAV control box to which the controller will be attached. Setting rotation limits that do not match the VAV damper may result in improper operation or equipment damage.

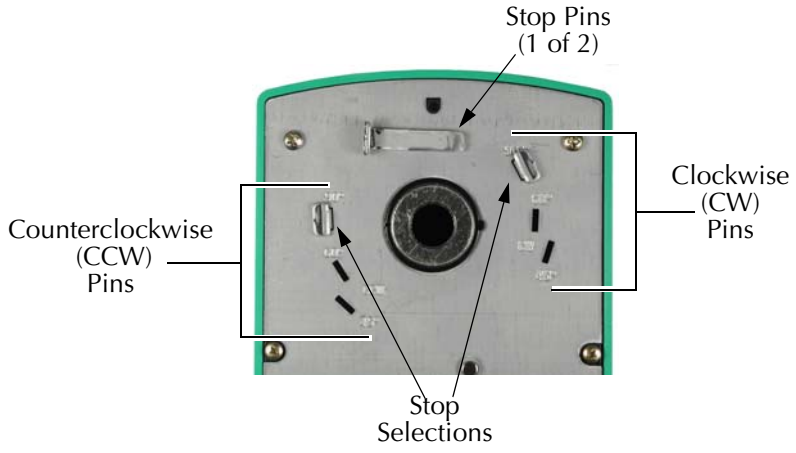

Illustration 2-1 Controller stop selections

To set the rotational limits:

1. Turn the controller over so you have access to the back.
2. Locate the two stop pins installed in the back of the unit. (You will find one pin in a CCW setting and one in a CW setting.)
3. Identify the limits for the VAV damper.

The maximum amount of shaft rotation is 90°. Placing a stop pin in both 90° slots allows the actuator the full 90° of travel. Placing a stop pin in any other slot restricts actuator motion in the indicated direction (CW or CCW). Refer to Illustration 2-2 for pin placement and travel. The first number represents the CCW pin and the second the CW pin (CCW/CW).

Caution

Both stop pins must be installed to prevent actuator damage.

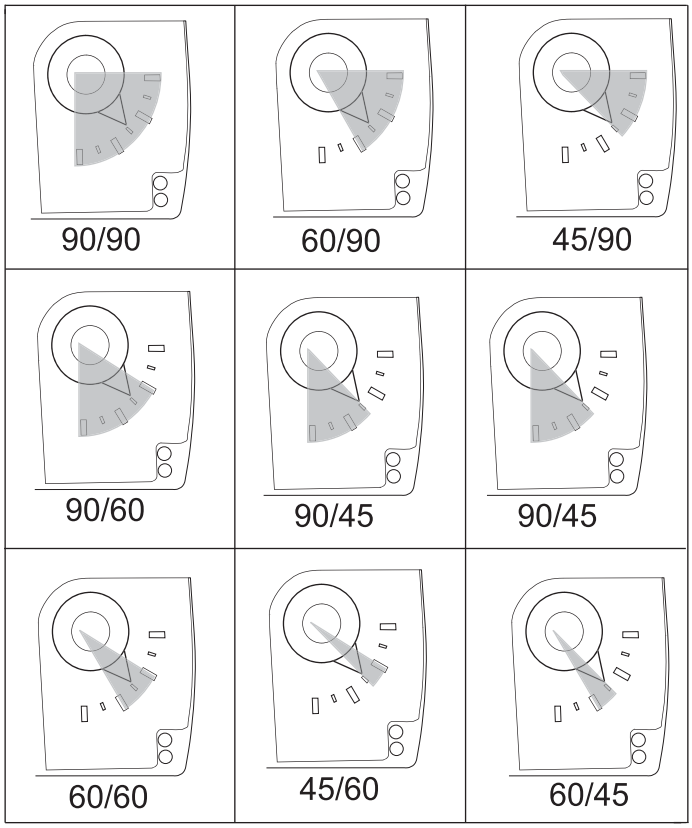

Illustration 2-2 Controller travel and stop selections

4. If the stop pins are positioned as required, you may leave them in place. If not, remove the appropriate pin(s) and place it in the correct slot.

Mounting

Mount the controller inside of a metal enclosure. To maintain RF emissions specifications, use either shielded connecting cables or enclose all cables in conduit.

Mount the controller directly over the damper shaft. A minimum shaft length of 1.75 inch (45 mm) is required. The base of the controller must contact the mounting surface to allow installation of a bracket to prevent the controller from rotating.

Note

KMC Controls designed the controller for use with either 1/2 inch round or 3/8 inch square damper shafts. For installations with a 3/8 inch round shaft, use an HFO–0011 shaft adaptor.

Note

Mount the controller close enough to the pitot tubes to keep the tubing length to be less than 24 inches between the controller's inputs and the tubes.

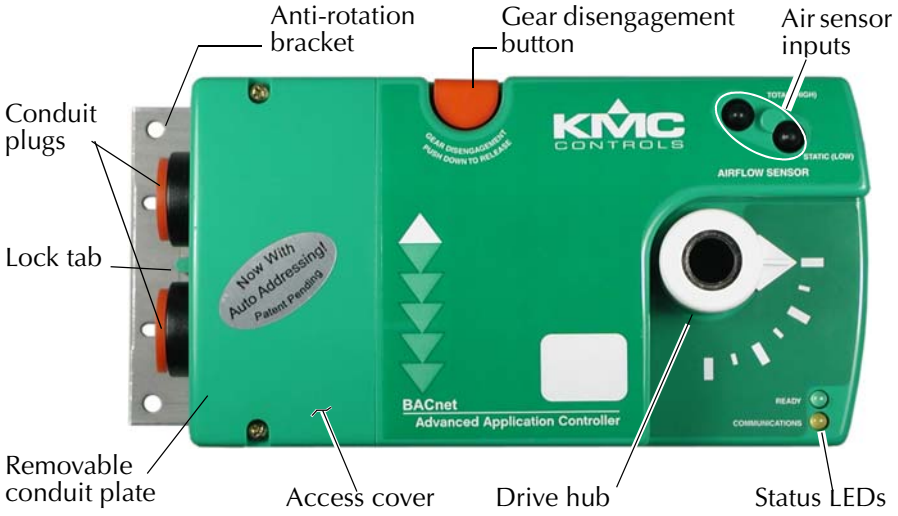

Illustration 2-3 BAC-7001 controls and indicators

Mount the controller as follows:

1. Back the set screws out of the drive hub until the shaft can fit through the collar.
2. Place the controller on the damper shaft in the approximate final position.
3. Position the anti-rotation bracket and secure it using #8 or #10 self-tapping screws. Verify the notch in the bracket securely engages the lock tab on the controller. (Refer to Illustration 2-3.)
4. Manually position the damper in the full open position.
5. Adjust the drive hub as follows:
   a. If the damper rotates counter clockwise to close, depress the gear disengagement button and rotate the drive hub to the full clockwise position then release the button.
   b. If the damper rotates clockwise to close, depress the gear disengagement button and rotate the drive hub to the full counter clockwise position then release the button.

6. Tighten the two set screws in the drive hub to approximately 50–inch pounds (5.65 N•m) to lock the hub to the shaft.

Wiring compartment

The controller comes with a removable conduit plate. The plate provides two 0.5 inch female threaded conduit couplings. If conduit is to be used, note the following:

- The conduit plate may be removed by removing the two screws that secure the access cover and removing the cover. Connect the required conduit and replace the plate in the controller housing.
- The plugs may also be sliced to allow wiring to enter the controller with a minimum of outside contaminates.

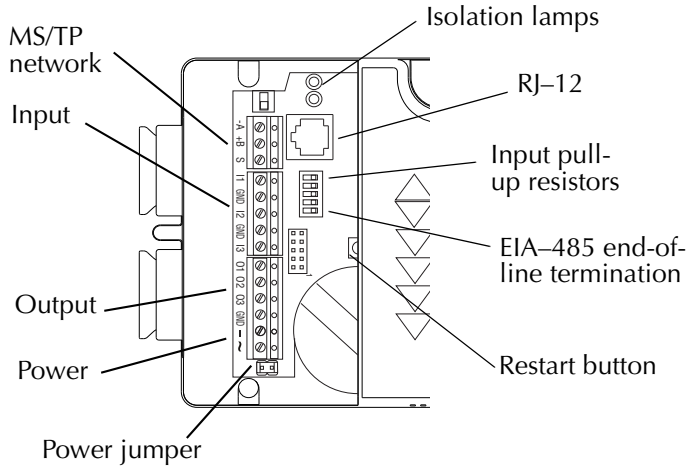

Illustration 2-4 Connection points inside wiring compartment

All input, output, power and network connections are made using the connectors beneath the access cover. Remove the two screws that secure this cover to remove the cover.

Connecting inputs

The BAC-7001 controller has three universal inputs. Each input can be configured to receive either analog or digital signals. By using the pull-up resistors, either passive or active devices may be connected to the inputs.

Note

KMC supplied Control Basic programs assigns input 1 (I1) to the space temperature sensor input. If the KMC programs are not used or are modified, input 1 is available for other use. Inputs 2 and 3 are not assigned by KMC programs and are available as needed.

Pull–up resistors

For passive input signals, such as thermistors or switch contacts, use a pull-up resistor. For KMC thermistors and most other applications set the switch to the *On* position. See Illustration 2-5 for the pull-up switch location.

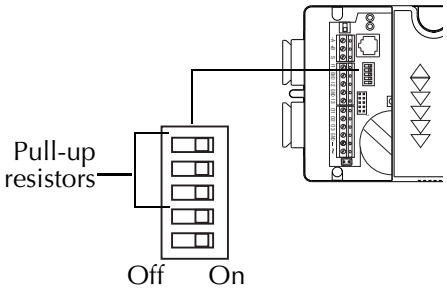

Illustration 2-5 Pull-up resistors

4–20 mA inputs

To use a 4–20 current loop input, connect a 250 ohm resistor from an input to ground. The resistor will convert the current input to a voltage which can be read by the controller analog-to-digital converter. Set the pull-up switch to the *Off* position.

Ground terminals

Input ground terminals are located next to the input terminals. Up to two wires, size 14–22 AWG, can be clamped into each ground terminal. If more than two wires must be joined at a common point, use an external terminal strip to accommodate the additional wires.

Pulse inputs

Connect pulse inputs under the following conditions:

- If the pulse input is a passive input such as switch contacts, then place the input pull-up in the *On* position.
- If the pulse is an active voltage (up to a maximum of +5 volts DC), then place the input pull-up switch in the *Off* position.

Connecting outputs

BAC-7001 provides three universal outputs. Returns are connected to the *GND* terminal next to output *O3*. (Refer to Illustration 2-6)

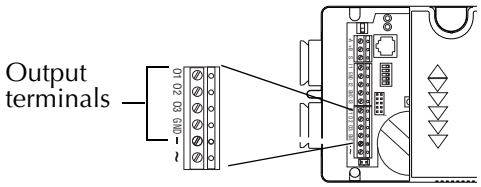

Illustration 2-6 Output terminals

Connecting to a NetSensor

The Network RJ–12 connector provides a connection port to a NetSensor model KMD-1161 or KMD-1181. Link the controller to a NetSensor with a KMC Controls approved cable up to 75 feet long. See the installation guide supplied with the NetSensor for complete NetSensor installation instructions.

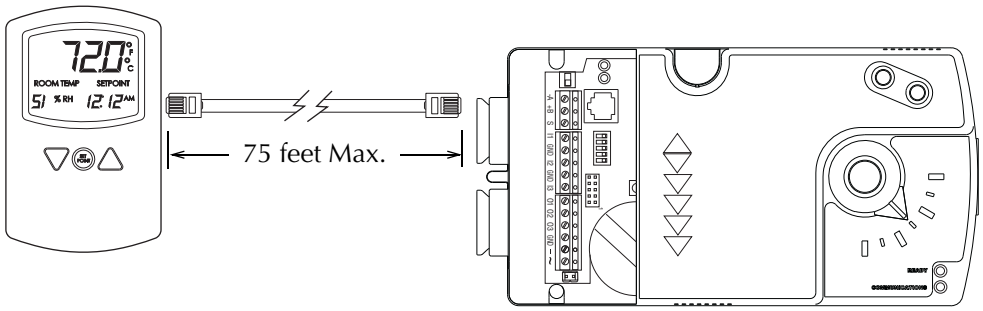

Illustration 2-7 BAC-7001 Connecting to a NetSensor

Connecting to an MS/TP network

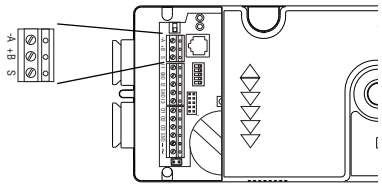

Illustration 2-8 MS/TP network connection

Connections and wiring

Use the following principles when connecting a controller to an MS/TP network:

- Connect no more than 128 addressable BACnet devices to one MS/TP network. The devices can be any mix of controllers or routers.
- To prevent network traffic bottlenecks, limit the MS/TP network size to 60 controllers.
- Use 18 gauge, twisted pair, shielded cable with capacitance of no more than 50 picofarads per foot for all network wiring. Belden cable model #82760 meets the cable requirements.
- Connect the -*A* terminal in parallel with all other - terminals.
- Connect the +*B* terminal in parallel with all other + terminals.
- Connect the shields of the cable together at each controller. For KMC BACnet controllers use the *S* terminal.
- Connect the shield to an earth ground at one end only.
- Use a KMD–5575 repeater between every 32 MS/TP devices or if the cable length will exceed 4000 feet (1220 meters). Use no more than seven repeaters per MS/TP network.
- Place a KMD–5567 surge surpressor in the cable where it exits a building.

See Application Note AN0404A, *Planning BACnet Networks* for addional information about installing controllers.

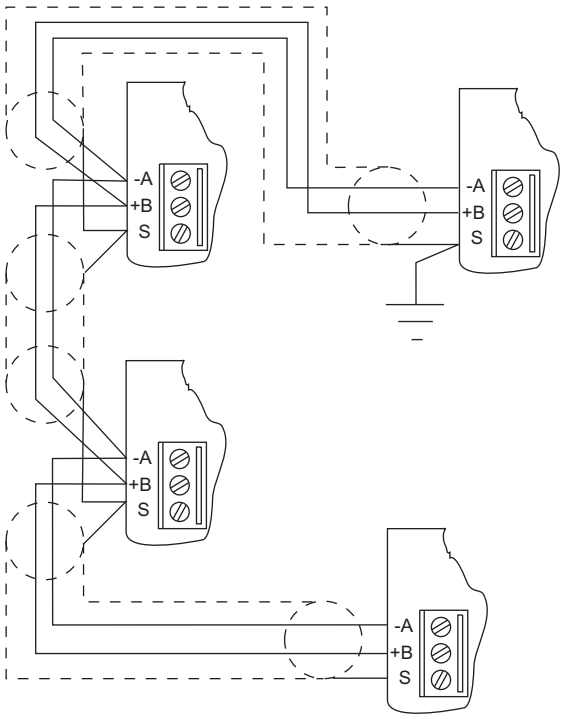

Illustration 2-9 MS/TP network wiring

Note

The BAC-7001 MS/TP terminals are labeled *-A*, *+B* and *S*. The *S* terminal is provided as a connecting point for the shield. The terminal is not connected to the ground of the controller. When connecting to controllers from other manufacturers, verify the shield connection is not connected to ground.

End of line termination switches

The controllers on the physical ends of the EIA-485 wiring segment must have end-of-line termination installed for proper network operation. Set the end-of-line termination to *On* using the *EOL* switches.

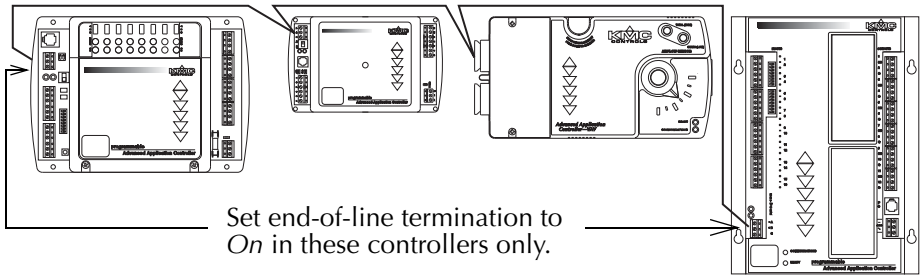

Illustration 2-10 End of line termination

Illustration 2-11 shows the position of the BAC-7001 End-of-Line switches associated with the MS/TP inputs.

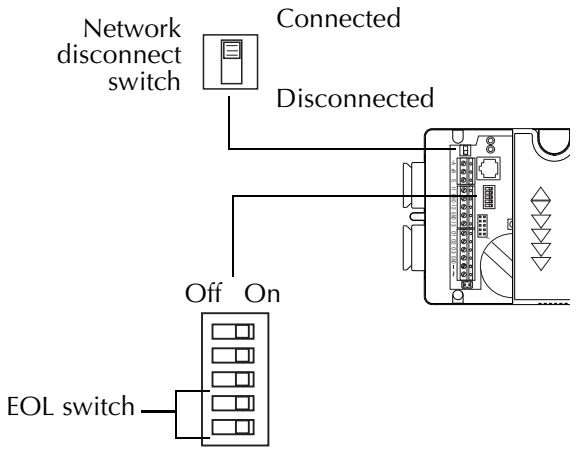

Illustration 2-11 Location of EOL switch

Connecting an airflow sensor

An airflow sensor is incorporated as one of the inputs to the controller. Remove the plugs and connect the tubing from the pitot assembly to the airflow sensor inputs above the drive hub. (See Illustration 2-12.). The airflow sensor is programmed as input 4.

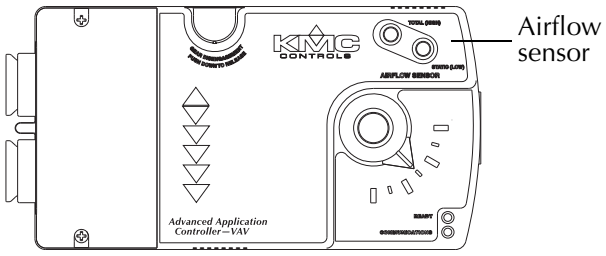

Illustration 2-12 Airflow sensor inputs

Note

Mount the controller close enough to the pitot tubes to keep the tubing length to be less than 24 inches between the controller's inputs and the tubes.

Connecting power

The controllers require an external, 24 volt, AC power source. Use the following guidelines when choosing and wiring transformers.

- Use a KMC Controls Class–2 transformer of the appropriate size to supply power to the controllers. KMC Controls recommends powering only one controller from each transformer.
- When installing a controller in a system with other controllers, you may power multiple controllers with a single transformer as long as the total power drawn from the transformer does not exceed its rating and phasing is correct.
- If several controllers are mounted in the same cabinet, you can share a transformer between them provided the transformer *does not exceed* 100 VA or other regulatory requirements.
- Do not run 24 volt, AC power from within an enclosure to external controllers.

Connect the 24 volt AC power supply to the power terminal block on the lower right side of the controller near the power jumper. Connect the ground side of the transformer to the **–** or GND terminal and the AC phase to the **~** (phase) terminal. Power is applied to the controller when the transformer is plugged in and the power jumper is in place.

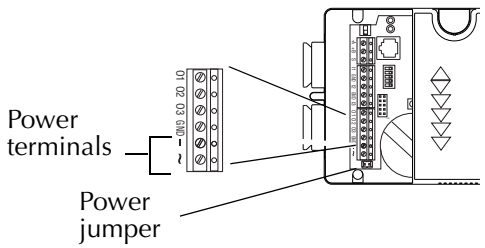

Illustration 2-13 Power terminals and jumper

Note

Typical Application Diagrams may be obtained by contacting KMC Controls Technical Support or from the KMC Controls web site.

Programming

Network configuration

For more information on installing, configuring, and programming HVAC system controllers, see the following documents available on the KMC Controls web site:

- *BACstage User's Guide to Installation and Getting Started* (902-019-62)
- *BAC-5000 Reference Guide* (902019-63)
- *TotalControl Reference Guide*
- Application Note AN0404A *Planning BACnet Networks*.
- *MS/TP Automatic MAC Addressing Installation Instructions*

Supplied applications programming

Refer to the KMC Digital Applications Manual for information on using the applications programs included with the controller.

- Inputs 1-3 are programmed as universal inputs.
- If using the KMC Controls supplied applications program, input 1 is assigned as the space temperature input.
- Input 4 is the dedicated to the airflow sensor.
- Outputs 1-3 may be programmed as universal outputs.
- Output 4 is dedicated to the actuator motor.

Programming drive time

When programming the controller to open and close a damper, use the data in Table 2-1 to calculate drive time.

Table 2-1 Drive time in seconds

Rotation in degrees	BAC-7001	BAC-7051
90	300	90
60	200	60
45	150	45

SECTION 3

Operation

This section provides a brief overview of the BAC-7001 and the BAC-7051 Direct Digital Controllers. Review this material before you attempt to install the controller.

Operation

Once configured, programmed and powered, the controller requires very little user intervention.

Controls and Indicators

The following topics describe the controls and indicators found on the controller. Additional information for automatic addressing functions are described in the guide *MS/TP Automatic MAC Addressing Installation Instructions* that is available from the KMC Controls web site.

Network disconnect switch

The network ON/OFF switch is located near the RJ–12 connector. Use this switch to enable or disable the EIA–485 network connection. When the switch is ON the controller can communicate on the network; when it is OFF, the controller is isolated from the network.

Alternately, you may remove the isolation bulbs to isolate the controller from the network.

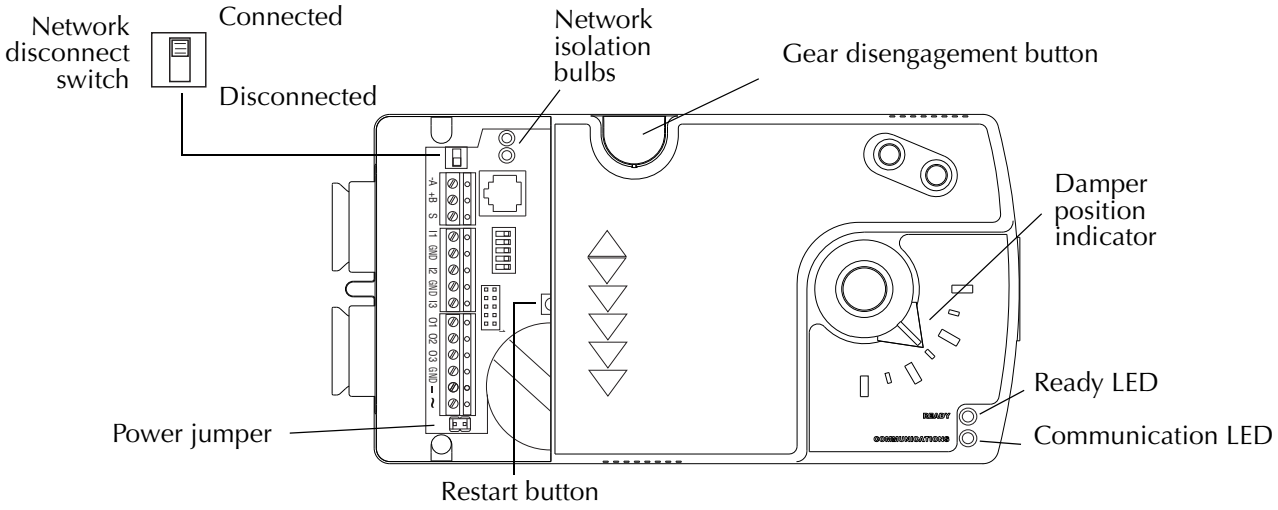

Illustration 3-1 Controls and indicators

Ready LED

The green Ready LED indicates the state of the controller. This includes automatic addressing functions that are fully described in the guide *MS/TP Addressing For BACnet Controllers.*

Power up During controller initialization, the Ready LED is continuously illuminated for 5 to 20 seconds. Once initialization is complete, the Ready LED begins flashing to indicate normal operation.

Normal operation During normal operation, the Ready LED flashes a repeating pattern of one second on and then one second off.

Restart button acknowledge The restart button includes several functions for automatic addressing that are acknowledged with the Ready LED. When the restart button is pressed, the Ready LED illuminates continuously until either of the following take place:

- The restart button is released.
- The restart button time-out period is reached and a restart operation is complete. Restart button operations are listed in the following table.

Table 3-1 Ready LED patterns for restart button operations

Controller state	LED pattern
The controller is set as an automatic addressing anchor. The MAC in the controller is set to 3	A rapid repeating pattern of a short flash followed by a short pause.
The controller has sent the automatic addressing lock command to the network	Two short flashes followed by a long pause. The pattern repeats until the restart button is released.
No restart operation	Ready LED remains unlit until the restart button is released.

Communications (Com) LED

The yellow Communications LED indicates how the controller is communicating with other controllers on the network.

Sole master Repeating pattern of a long flash and a short pause that repeats once a second. It indicates that the controller has either generated the token or is a sole MS/TP master and has yet to establish communications with other MS/TP devices.

Token passing A short flash each time the token is passed. The frequency of the flash is an indication of how often the device receives the token.

Nomad patterns There are three Com LED patterns that indicate that the controller is an automatic addressing nomad controller that is receiving valid MS/TP traffic.

Table 3-2 Automatic addressing nomad patterns

Controller state	LED pattern
Lost nomad	A long flash
Wandering nomad	A long flash followed by three short flashes
Assigned nomad	Three short flashes followed by a long pause.

Error conditions for the LEDs

The two network isolation bulbs (KMC P/N HPO-0054), located next to the network switch, serve three functions:

- Removing the bulbs opens the EIA-485 circuit and isolates the controller from the network.
- If one or both bulbs are lit, it indicates the network is improperly phased. This means that the ground potential of the controller is not the same as other controllers on the network.
- If the voltage or current on the network exceeds safe levels, the bulbs operate as fuses and may protect the controller from damage.

Isolation bulbs

The two network isolation bulbs (KMC P/N HPO-0054), located next to the network switch, serve three functions:

- Removing the bulbs opens the EIA-485 circuit and isolates the controller from the network.
- If one or both bulbs are lit, it indicates the network is improperly phased. This means that the ground potential of the controller is not the same as other controllers on the network.
- If the voltage or current on the network exceeds safe levels, the bulbs operate as fuses and may protect the controller from damage.

Gear disengagement button

Depress the gear disengagement button to manually position the damper.

Restoring factory settings

If the controller appears to be operating incorrectly, or is not responding to commands, you may need to reset the controller. Remove the cover and locate the red restart button.

To perform a reset or restart, locate the red restart push-button and then—in order—use one of the following procedures.

1. A warm start is the option least disruptive to the network and should be tried first.
2. If problems persist, then try a cold start.
3. If the problems continues, restoring the controller to factory settings may be required.

Caution

Read all of the information in this section before proceeding!

Note

Momentarily pushing the red reset button while the controller remains powered will have no effect on the controller.

Performing a warm start

A warm start changes the controller as follows:

- Restarts the controller's Control Basic programs.
- Leaves object values, configuration, and programming intact.

Caution

In the unlikely event that the checksum test in RAM fails during the warm start, the controller will automatically perform a cold start. During a cold start, controller outputs may abruptly turn connected equipment on and off. To prevent equipment damage, turn connected equipment off or temporarily remove the output terminal blocks from the controller before performing a warm start.

Do either of the following to perform a warm start:

- Reinitialize the controller with either BACstage or TotalControl Design Studio.
- Remove the power jumper for a few seconds and then replace it.

Performing a cold start

Performing a cold start changes the controller as follows:

- Restarts the controller programs.
- Returns all object states to their initial factory settings until the controller programs update them.
- Leaves configuration and programming intact.

Caution

Returning object values to their relinquished defaults during a cold start may abruptly turn connected equipment on or off. To prevent equipment damage, turn connected equipment off or temporarily remove the output terminal blocks from the controller before performing a warm start.

To perform a cold start:

1. While the controller is powered, press and hold the restart button.
2. Remove the power jumper.
3. Release the red button *before* replacing the power jumper.

Note

A cold start performed by this method is the same as performing a cold start with BACstage or from TotalControl Design Studio.

Restoring to factory settings

Restoring a controller to factory settings changes the controller as follows:

- Removes all programming.
- Removes all configuration settings.
- Restores the controller to factory default settings.

Caution

Resetting the controller erases all configuration and programming. After resetting to factory settings, you must configure and program the controller to establish normal communications and operation.

To reset the controller to factory settings.

1. If possible, use BACstage or TotalControl Design Studio to backup the controller.
2. Remove the power jumper.
3. Press and hold the red restart button.
4. Replace the power jumper while continuing to hold the restart button.
5. Restore configuration and programming with BACstage or TotalControl Design Studio.