Installation, Operation, and Applications Guide for BAC-7000 Series VAV controllers

For applications version 2.2

Revision C

AN0311A

Important notices

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Disclaimer

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SECTION 1

About the controllers

This section is a description of the KMC Controls BAC-7000 series VAV controllers. It also introduces safety information. Review this material before installing or operating the controller.

The BAC-7000 series VAV controllers are native BACnet, direct digital controllers designed for VAV terminal units. An integrated actuator and the supplied programs make these ideal controllers for single duct pressure independent or pressure dependent VAV terminal units. The BAC-7000 VAV controllers include the following features.

- BACnet MS/TP compliant
- Automatically assigns the MAC address and the device instance
- On-board airflow sensor for use with a single or multi-point differential pressure measuring station or pitot tube
- Use to control single duct VAV, parallel fan, and reheat
- An internal, easy-to-use air balancing program for air balancing technicians.
- No programming required
- Configurable with any BACnet operator workstation

The embedded standard applications provide a wide range of single duct VAV terminal applications for both pressure independent and pressure dependent (bypass) terminal unit applications.

Pressure independent KMC Controls supplies the BAC-7000 series VAV controllers for the following pressure independent configurations.

- Single duct cooling
- Single duct cooling with parallel fan and on/off or modulating reheat
- Airflow balancing

Pressure dependent The BAC-7000 series VAV controllers can be set up for the following pressure dependent (bypass VAV) configurations.

- Single duct cooling
- Single duct with modulating or On/Off reheat

Specifications

BAC-7000 specifications are subject to change without notice.

Inputs and outputs

BAC-7000 series VAV controllers are supplied with three universal inputs and three output connections. The type of output is model dependent. All inputs and outputs are configured to support the standard application Control Basic programs.

Table 1-1 BAC-7000 series inputs and outputs

Model	Universal inputs	Universal outputs	Triac outputs	Relay outputs
BAC-7001	3	3		
BAC-7003	3	1	1	1
BAC-7051	3	3		
BAC-7053	3	1	1	1

Inputs	All universal inputs are configured to support supplied Control Basic programs. They are configurable as analog, binary, or accumulator objects to support custom programs.
Key features	Standard units of measure. Overvoltage input protection
Pull–up resistors	Switch selectable for none or 10 kΩ.
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

Outputs, Universal	All universal outputs are configured to support supplied Control Basic programs. They are configurable as analog or binary objects to support custom programs.
Key features	Output short protection 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

Outputs, Relay	Relay outputs are configured as binary outputs to support the supplied Control Basic programs.
Switching	Maximum switching 30 volts AC at 2 ampere
Connector	Removable screw terminal block Wire size 14–22 AWG

Outputs, triac	Triac outputs are configured as binary outputs to support the supplied Control Basic programs.
Switching	Optically isolated triac output; maximum switching 30 volts AC at 1 ampere
Connector	Removable screw terminal block Wire size 14-22 AWG
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	Standard applications compatible with model KMD-1161. Custom programming required for other models. Connects through RJ–12 connector
Programmable features	
Program objects	10 program objects, 4 for standard Control Basic programs, 6 available for custom programs
PID loop objects	4
Value objects	40 analog and 40 binary
Supported objects	See PIC statement for supported BACnet objects
Schedule objects	8 schedule objects 3 calendar objects
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 controllers with programming sequences for single-duct VAV applications: ◆ Pressure independent cooling with or without parallel fan or reheat ◆ Pressure dependent single duct cooling with or without reheat ◆ Airflow balancing

Airflow sensor	The sensor is flow through sensor with dual platinum film RTD sensors on a ceramic base. The sensor output is converted to a voltage that represents 0 to 3000 FPM (15.24 m/s) using 24-inch, 1/4 inch FR tubing and SSS-1000 series flow pickups. Airflow through the sensor is approximately 1.12 SCFH (32 liters/hour) at 0.25 inches of WC (62.5 Pa) pressure drop. The airflow sensor is available as a standard BACnet analog input object.
Actuator specifications	
Torque, minimum	50 in-lb. (5.7 N•m)
Torque, maximum	70 in-lb. (7.9 N•m)
Angular rotation	0 to 95° Adjustable end stops at 45/60/90° rotation
Motor timing: BAC-7001, BAC-7003	18°/minute at 60 Hz 15°/minute at 50 Hz
Motor timing: BAC-7051, BAC-7053	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 10 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, 8 VA minimum, 15 VA maximum load, 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	BACnet AAC for VAV, 18°/minute at 60 Hz
BAC-7051	BACnet AAC for VAV, 60°/minute at 60 Hz
BAC-7003	BACnet AAC for VAV FIU, 18°/minute at 60 Hz
BAC-7053	BACnet AAC for VAV FIU, 60°/minute at 60 Hz

Dimensions

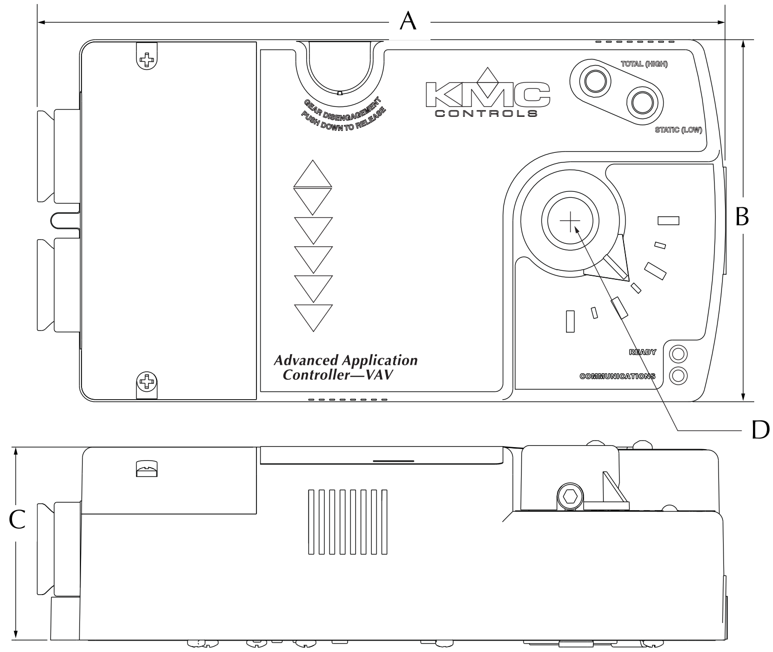

Table 1-2 Controller dimensions

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 and replacement parts

Replacement parts

HMO-4531	Non Rotation Bracket- KMD-7001
HPO-0054	Bulbs
HPO-0063	2-PIN KMD jumper (5/Pkg)

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-1012	3-5/32 in. length (80 mm) for 1/4 inch O.D. tubing
SSS-1013	5-13/32 in. length (137 mm) for 1/4 inch O.D. tubing
SSS-1014	7-21-32 in. length (195 mm) for 1/4 inch O.D. tubing
SSS-1015	9-29/32 in. length (252 mm) for 1/4 inch O.D. tubing

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 controllers

This section provides important instructions and guidelines for installing BAC-7000 series VAV controllers. Carefully review this information prior to installation.

Installing the BAC-7000 series VAV controllers includes the following topics that are included in this section.

Set the rotation limits

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

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 rotation in the either the CW or CCW direction. Refer to Illustration 2-2 for pin placement and travel. The first number represents the CCW pin and the second the CW pin.

Caution

To prevent damage to the actuator, always install both stop pins.

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.

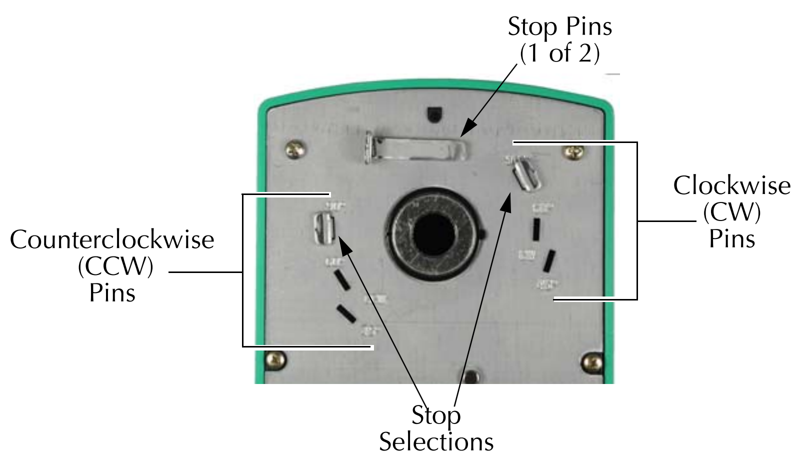

Illustration 2-1 Controller stop selections

To set the rotational limits, do the following:

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. If the stop pins are positioned as required, leave them in place.
4. Identify the limits for the VAV terminal unit damper.
5. Remove one or both pins and place them in the correct slot.

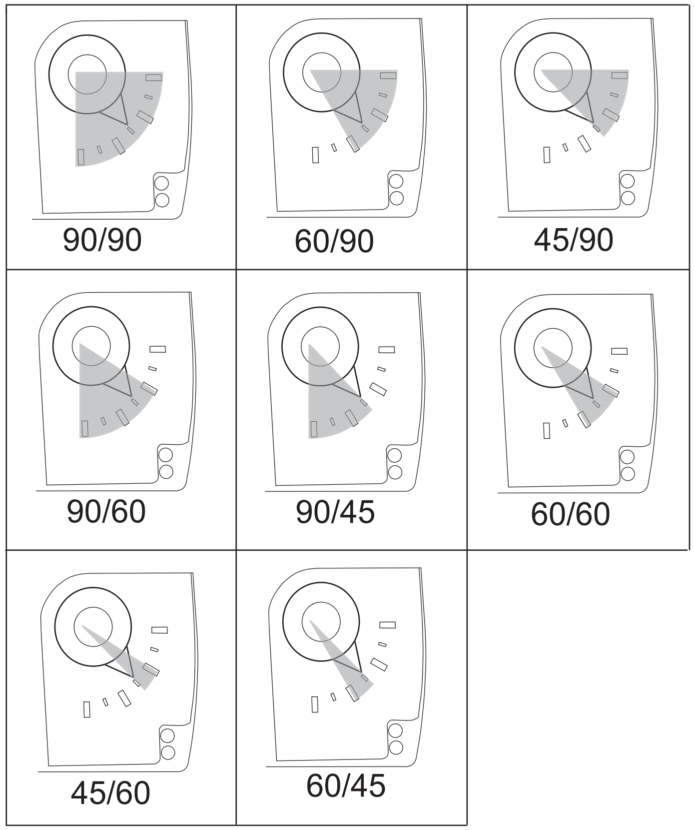

Illustration 2-2 Controller travel and stop selections

Mounting on a VAV terminal unit

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.

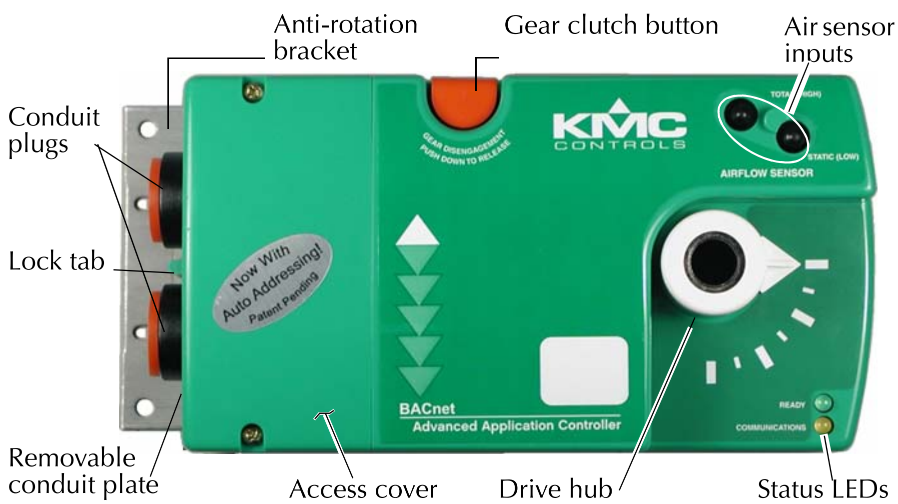

Illustration 2-3 BAC-7000 VAV series controls and indicators

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 VAV damper in the fully open position.
5. Press the gear clutch button and rotate the drive hub in the same direction that opened the damper. Turn the hub until it reaches a rotation limit.
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

All input, output, power and network connection points are located beneath the access cover. Remove the two screws that secure this cover to remove the cover.

The controller comes with a removable conduit plate. The plate provides two 0.5 inch threaded conduit couplings. If conduit connections are 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.

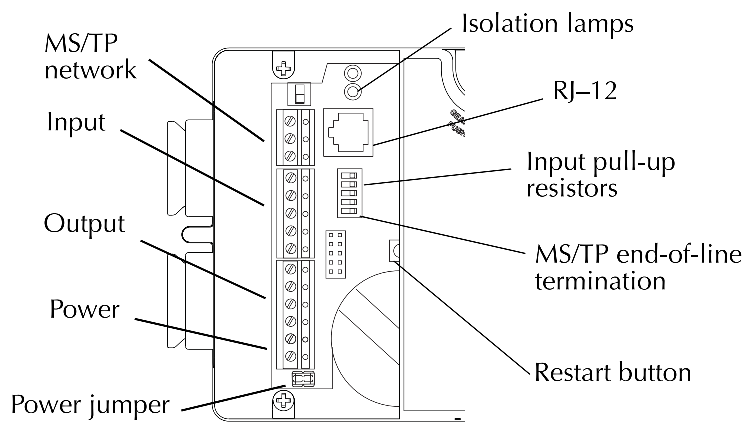

Illustration 2-4 Connection points inside wiring compartment

Connecting inputs

The BAC-7000 VAV controllers have three universal inputs. Each input is configured to support the standard application programs in the controller. By using the pull-up resistors, either passive or active devices may be connected to the inputs.

KMC supplied Control Basic programs assigns inputs to the following functions.

- Connect Input 1 to the space temperature sensor input such as the 10 kΩ thermistor in an STE-6000 series sensor.
- Connect Input 2 as a setpoint input such as a 0-10 kΩ dial on an STE-6000 series sensor.
- Input 3 is for a 10 kΩ discharge air temperature sensor.

Note

If a NetSensor is connected to the controller, the standard application programming will use the temperature and setpoint from the NetSensor and not from devices connected to Input 1 and Input 2.

Setting the pull–up resistors For passive input signals, such as thermistors or switch contacts, set the pull-up switch to the *On* position. See Illustration 2-5 for the pull-up switch location.

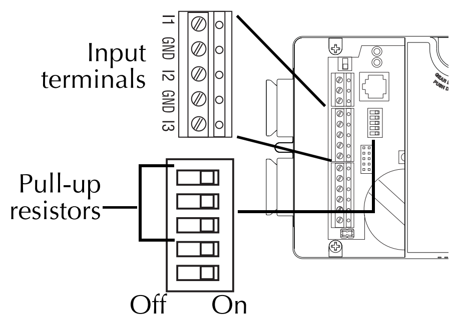

Illustration 2-5 Input terminals and pull-up resistors

Ground terminals Use the GND terminal located next to the input terminals for the input ground connection. Up to two wires, size 14–22 AWG, can be inserted into the ground terminal. If more than two wires must be joined at a common point, use an external terminal strip for the additional wires.

Connecting outputs

The output terminal configuration for a BAC-7001 and BAC-7051 controllers is different than the configuration for BAC-7003 and BAC-7053 controllers.

For a listing of the configuration of the controller output objects, see the section *Output objects* on page 62.

BAC-7001 and BAC-7051 output connections

BAC-7001 and BAC-7051 controllers provide three universal outputs. These output are rated for 0-10 volt DC loads. Returns are connected to the *GND* terminal next to output *O3* as shown in the illustration *BAC-7001 output terminals* on page 19.

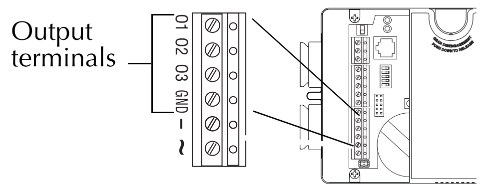

Illustration 2-6 BAC-7001 output terminals

BAC-7003 and BAC-7053 output connections

The BAC-7003 and BAC-7053 include one single-stage triac, one relay and one universal output.

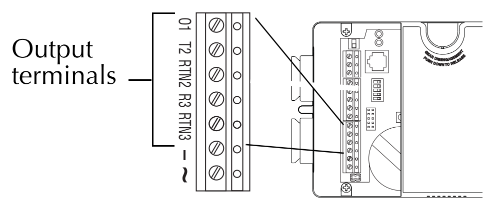

Illustration 2-7 Output terminals

Caution

When connecting loads to the triac or relay output, use only the terminal marked RTN associated with the triac or relay for the 24-volt circuit.

Output O1 This output is a universal output that can be programmed as either an analog object for modulating reheat. The universal output is rated for 0-10 volt DC loads. Use the *GND* terminal on the input connector block for the ground.

Output T2 This is a triac output programmed to switch 24-volt reheat circuits. The output is rated for 24 volt, 1 ampere loads, and switches on zero crossing. Use the *RTN2* terminal for the T2 load.

Output R3 This is a normally open relay contact programmed to control a 24-volt fan starting circuit. The relay contacts are rated for 24-volts at 2 amperes. Use *RTN3* for the R3 load.

Output 4 Output 4 is internally connected to the actuator motor.

Connecting to a NetSensor

The Network RJ-12 connector provides a connection port to a NetSensor model KMD-1161. 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.

Note

If a NetSensor is connected to the controller, the standard application programming will use the temperature and setpoint from the NetSensor and not from devices connected to Input 1 and Input 2.

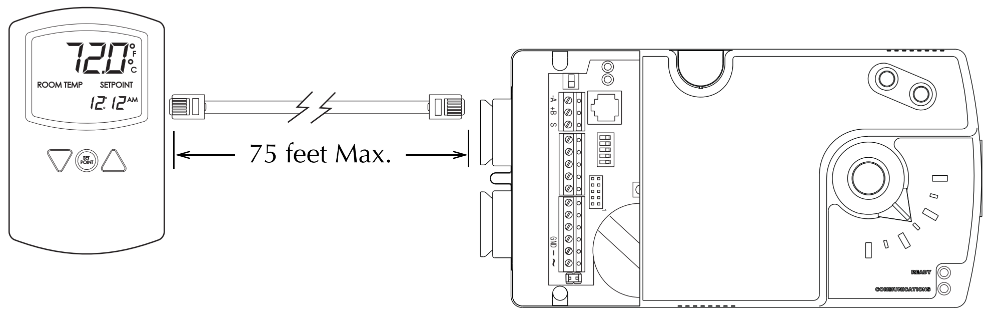

Illustration 2-8 Connecting to a NetSensor

Connecting to an MS/TP network

BAC-7000 series VAV controllers BACnet MS/TP compliant controllers. For monitoring and control by building automation system, connect them only to a BACnet MS/TP network.

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.
- Connect a KMD–5575 BACnet MS/TP repeater between every 32 MS/TP devices or if the cable length will exceed 4000 feet (1220 meters). Use no more than four repeaters per MS/TP network.
- Place a KMD–5567 surge surpressor in the cable where it exits from a building.

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

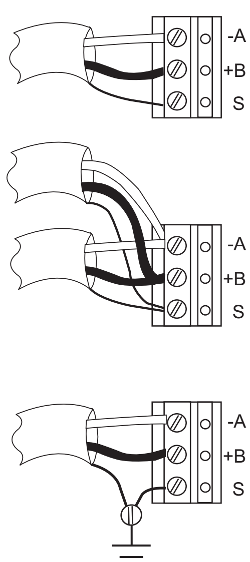

Illustration 2-9 MS/TP network wiring

Note

The BAC-7000 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.

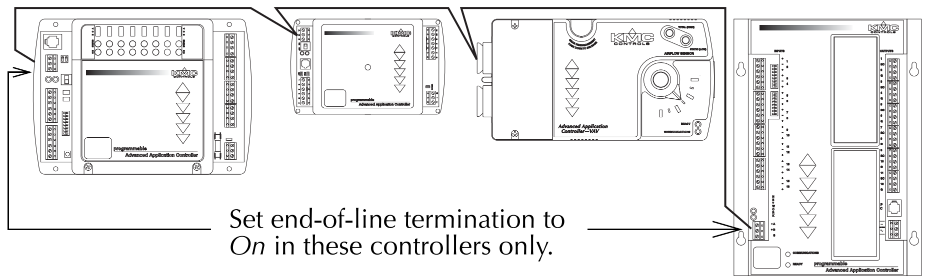

Illustration 2-10 Location for end-of-line termination

Illustration 2-5 shows the position of the controllers End-of-Line switches associated with the MS/TP connection points.

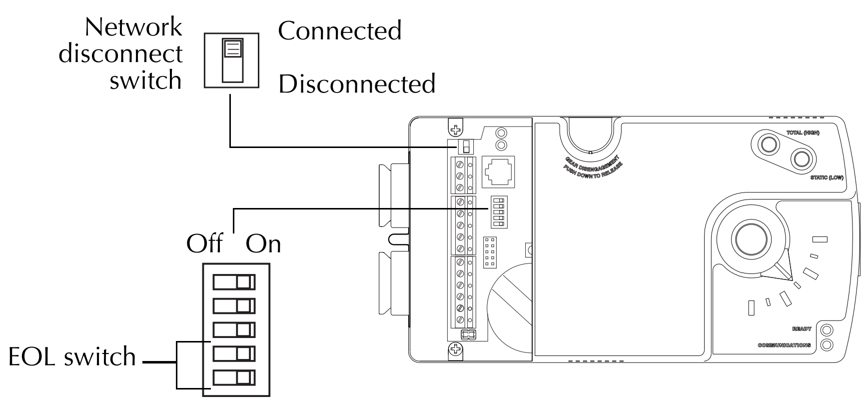

Illustration 2-11 Location of EOL switch

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.

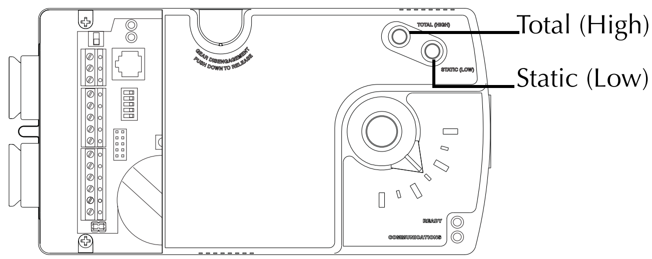

Illustration 2-12 Airflow sensor inputs

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.
- 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 **–** terminal and the AC phase to the ~ (phase) terminal. Power is applied to the controller when the transformer powered and the power jumper is in place.

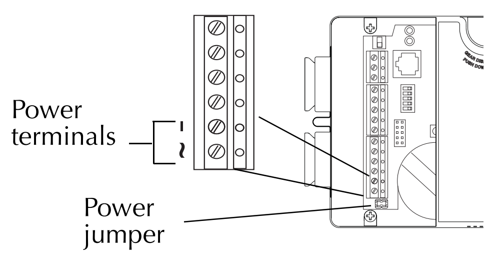

Illustration 2-13 Power terminals and jumper

SECTION 3

Operation

This section provides a brief overview of the BAC-7000 series VAV controllers. Review this material before installing the controllers.

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 disconnect switch is located near the RJ-12 connector. Use this switch to enable or disable the MS/TP 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.

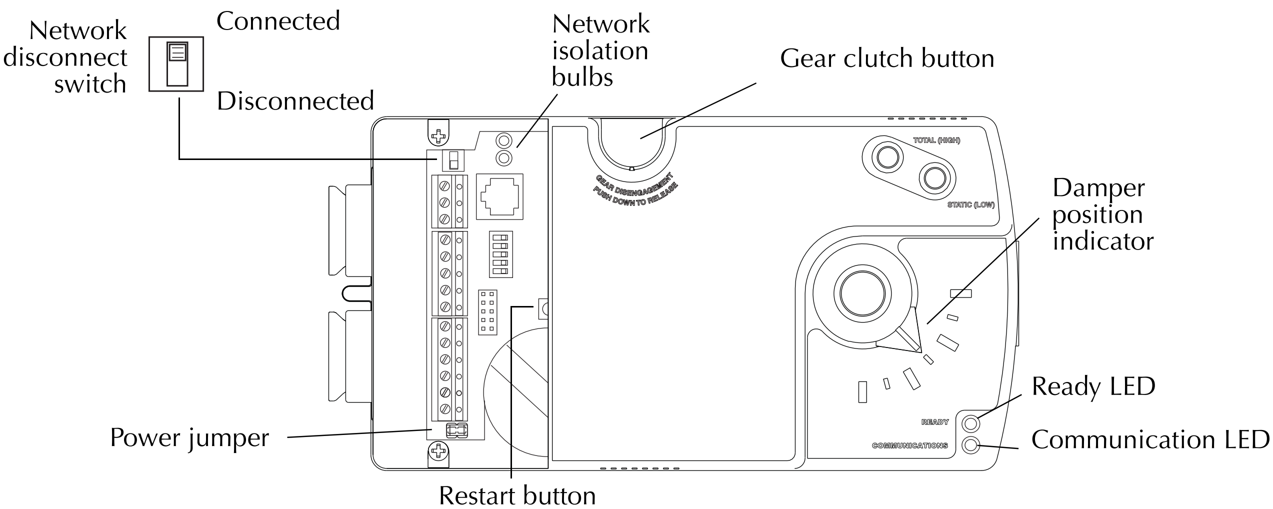

Illustration 3-1 Controls and indicators

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

Error conditions are indicated with a combination of the Ready and Com LEDs.

- If the Ready LED and Com LED are both unlit, check the fuse, power, and connections to the controller.
- If the Ready LED alternates with the Com LED at a one-half-second rate, there is an error in the controller's memory. Restoring the controller to factory default settings will typically resolve the problem.

Isolation bulbs

The two network isolation bulbs, 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 clutch button

To manually position the damper, press the gear clutch button and rotate the drive hub.

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.

Maintenance

BAC-7000 series VAV controllers require no routine maintenance. If necessary, clean with a damp cloth and mild soap.

SECTION 4

Configuration and set up

The topics in this section are advanced topics for control technicians and engineers. Carefully review this information before installing or operating a controller.

Configuration of a BAC-7000 series VAV controller sets all of the values and settings required to control a VAV terminal unit. Typically, these settings do not change after the installation and commissioning process.

To set up the configuration functions, you will need the following items and information.

- Details about the VAV terminal unit including the configuration for fans and reheat.
- A BACnet operator workstation such as BACstage or TotalControl.
- The building automation system plans for controllers connected to a network.

Assigning network addresses

Every controller on a BACnet MS/TP network must have a unique device instance and MAC address. Assigning the MAC address and device instance to a controller can be done by using either the automatic or manual method.

Automatic addressing

If the controller is part of a KMC Controls network that uses automatic addressing, follow the directions in the guide *MS/TP Automatic MAC Addressing Installation Instructions* that is available from the KMC Controls web site.

Manual addressing

To manually address a new controller it must first be changed to an anchor controller by doing the following:

1. Set the network switch to Off (disconnected).
2. Press and hold the restart button for 10 seconds. The Ready LED will start flashing rapidly. The Com LED will remain dark.
3. Release the restart button.
4. Turn off controller power.
5. Set the anchor network switch to On (connected).
6. Turn on controller power. The Ready LED will blink slowly and the Com LED will flash rapidly. This controller is now an anchor with a MAC address of 3.

Once a controller is converted to an anchor controller, connect it to a BACnet operator workstation and set the following properties.

- MAC address
- Device instance number
- Baud rate

Configuring for pressure independent VAV

The BAC-7000 VAV controllers are supplied with programming and object configuration for single-duct VAV cooling. The following value objects must be set or verified with a BACnet operator workstation such as BACstage or TotalControl for correct operation.

Note

When changing any of the value objects in this procedure, make the changes to the Relinquish Default property. If the change is added to the Priority Array property at any other level, the change will be deleted when the controller restarts.

Configure the damper direction to close

The CW_CLOSE value object sets the direction the controller will rotate the damper to the closed position.

- Set this property to Yes (Active or 1) to set the controller to close the damper in the clockwise direction.
- Set the property to No (Inactive or 0) to set the controller to close the damper in the counter clockwise direction.

Change this value in the Relinquish Default property of Binary Value object 4.

Enter the volume correction factor

The volume correction factor is used to calculate airflow based on the primary air inlet size of the VAV terminal unit. For round ducts, choose the correction factor from the following table. Enter the factor in the Relinquish Default property of Analog Value object 22, VOLFACTR.

Table 4-1 Volume factor for round ducts (inches)

Diameter	Circumference	Volume factor
4	12 5/8	0.087
5	15 3/4	0.136
6	18 7/8	0.196
7	22	0.267
8	25 1/8	0.349
9	28 1/4	0.442
10	31 3/8	0.545
12	37 3/8	0.785
14	44	1.068
16	50 1/4	1.396

For other sizes of round ducts, use the following formula. Diameter is in inches.

$$\text{Volume factor} = \frac{0.785 \text{ x Diameter}^2}{144}$$

For rectangular ducts, use the following formula. Width and Height are in inches.

$$\text{Volume factor} = \frac{\text{Width x Height}}{144}$$

Enable or disable reheat

The BAC-7000 VAV controllers are supplied with reheat enabled. To disable reheat, set the Relinquish Default property of REHEAT, Binary Value object 5, to Inactive (0).

Configure auxiliary airflow (optional)

Auxiliary airflow sets the airflow when reheat is active and is not used if reheat is disabled. Enter the value for the auxiliary airflow in the Relinquish Default property of Analog Value object 28, AUX_FLOW.

Set the airflow limits

VAV airflow limits can be set with either a KMD-1161 NetSensor or with a BACnet operator workstation. Enter the values in the Relinquish Default properties of Analog Value objects 20 and 21, MIN_FLOW, and MAX_FLOW.

To set the values with a NetSensor, follow the procedures in the section *Balancing with a NetSensor* on page 35.

Set the temperature setpoint limits

The temperature setpoint limits place limits on the highest heating setpoint and the lowest cooling setpoint a user can enter. Enter the values in the Relinquish Default properties of Analog Value objects 11 and 12, STPT_MIN and STPT_MAX.

Configuring for pressure dependent VAV

To operate a BAC-7000 series VAV controller as a pressure dependent controller, use a BACnet operator workstation to make the following changes.

- Halt Program object 1 and enable Program object 2 to run. If available, set the program object to automatically run on a coldstart.
- *Configure the damper direction to close* on page 32
- *Enable or disable reheat* on page 33
- *Set the temperature setpoint limits* on page 33

SECTION 5

Balancing with a NetSensor

Topics in this section are for control technicians or engineers who will be balancing the airflow in the controllers.

The airflow balancing procedure described in this section requires the following items.

- An airflow hood or other accurate method to measure airflow.
- An KMD-1161 NetSensor. If the system does not include one of these sensors, temporarily disconnect the installed sensor and connect a KMD-1161 as a service tool.
- The engineering design specifications for the minimum and maximum airflow setpoints.

Note

The procedures in this section are for pressure independent systems only.

The airflow setpoints can be entered either in the balancing routines or they can be entered through the use of a BACnet operator workstation. This is described in the section *Configuration and set up* on page 31. Regardless of how these setpoints are entered, they must be entered before balancing.

Balancing overview

Balancing airflow is the process of calibrating the internal airflow sensor to a known standard. In the field, airflow is measured with an airflow hood or other measuring instrument and then compared to the airflow measurements from the sensor in the controller. The balancing process uses a KMD-1161 NetSensor as the technicians service tool for initiating the balancing sequence and entering actual flow measurements.

When the balancing sequence starts, all other functions of the controller are locked out.

The balancing procedure

This balancing procedure requires a KMD-1161 NetSensor as a service tool. If other sensors are permanently installed, temporarily connect a KMD-1161 to the controller, perform airflow balancing, and then return the original sensors to the installation.

In the following procedures, the NetSensor buttons are referenced as they are labeled on a standard KMD-1161. If the NetSensor has custom labeling, refer to the button diagram included with each step or the illustration *Standard NetSensor button assignments* on page 36.

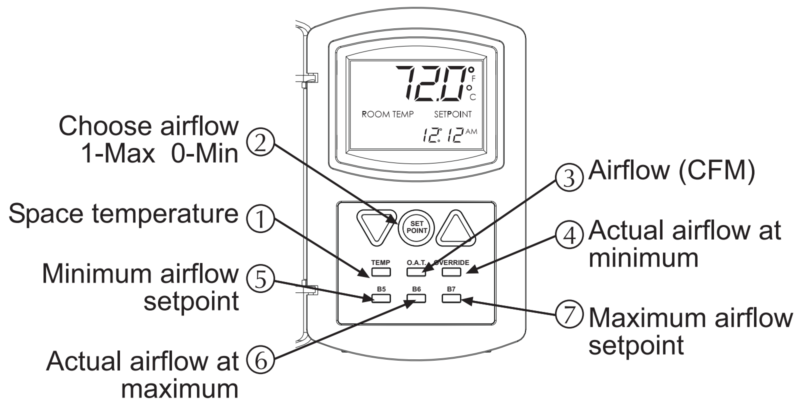

Illustration 5-1 Standard NetSensor button assignments

Start the balancing routine To start balancing or to set the airflow setpoints, do the following.

1. Start the balancing routine by pushing together and then releasing B5 and B7. The display changes to AUX and then to OFF when the buttons are released.
2. Push the Up button △. The display changes to ON. The controller is now in the balancing mode.
3. Wait approximately 15 seconds.
4. Continue with the procedure *Enter airflow setpoints* or *Balance the airflow*.

Enter airflow setpoints If required, enter the airflow setpoints from the NetSensor. This is not necessary if these setpoints are entered from a BACnet operator workstation during controller configuration.

1. Start balancing as described in the previous procedure.
2. Push B7 and use the Up and Down buttons ▽△ to enter the maximum airflow setpoint.
3. Push B5 and use the Up and Down buttons ▽△ to enter the minimum airflow setpoint.
4. Continue with the procedure *Balance the airflow* on page 36 or follow the procedure *End balancing* on page 37.

Balance the airflow The following procedure balances airflow at the minimum and maximum airflow setpoints.

1. If not in balancing, see the procedure *Start the balancing routine* on page 36.
2. Press the Setpoint button. The NetSensor should display "01". This is the indication that the controller is rotating the damper to the maximum airflow setpoint.

- If the NetSensor is still displaying the temperature setpoint, wait approximately 15 seconds.
- If the value is “00” press the Up button △ to change the display to”01”.

3. Monitor the actual airflow by pushing O.A.T. .
4. Once the actual airflow stabilizes, measure the airflow at the VAV outlet and note the measurement.
5. Push B6 and use the Up and Down buttons ▽△ to enter the measured maximum airflow.
6. Press the Setpoint button and press the Down ▽ button. The display changes to “00”. This is the indication that the controller is driving the damper to the minimum airflow setpoint.
7. Monitor the actual airflow by pushing O.A.T .
8. Once the actual airflow stabilizes, measure the airflow at the VAV outlet and note the measurement.
9. Push OVERRIDE and use the Up and Down buttons ▽△ to enter the measured minimum airflow.

End balancing End balancing by performing the following procedure. Balancing will automatically end after two hours from the time the last button is pushed.

1. End balancing by pushing together and then releasing B5 and B7 . The display changes to AUX and then to ON when the buttons are released.
2. Push the Down button ▽. The display changes to OFF. The controller is now in the normal operating mode.

SECTION 6

Sequences of operation

Topics in the section cover the sequences of operation for the BAC-7000 series VAV controllers. These are advanced topics for control technicians and engineers.

These sequences of operation are descriptions of each major components of the BAC-7000 VAV programming. They are provided as an aid to understanding on how the controllers operate.

This section covers the following sequences of operation.

Input sources

The BAC-7000 series VAV controllers require specific sensors for room temperature, room setpoint, and airflow through the VAV terminal unit.

The controllers are set up for KMD-1161 NetSensors. When a NetSensor is connected to a controller, the programming automatically detects the sensor and updates Analog Value objects AV1, SPACESTP, and AV2, SPACESSTPT, from the values passed from the NetSensor.

If a NetSensor is not detected, the values from Analog Inputs objects AI1 and AI2, ROOMTEMP and STESETPOINT, are passed to Analog Value objects AV1 and AV2. Input AI1 is configured for a Type-II, 10 kΩ thermistor and input AI2 is configured for a 10 kΩ potentiometer.

A third input is configured as Analog Input object AI3 for a Type-III, 10 kΩ, discharge air temperature sensor. This input is not required for any of the programming sequences but may be installed for monitoring by a BACnet operator workstation or another controller on the building management system network.

The airflow sensor is an internal, flow-through sensor that is connected to airflow pickup tubes on the VAV terminal unit inlet. The input is represented by Analog Input object AI4 and is configured to represent airflow in feet-per-minute.

Space setpoints

The BAC-7000 VAV controllers use the following setpoints based on the user-entered setpoint or the state of occupancy and standby. See the topic *Occupancy and standby* on page 40 for a description of these modes.

Active setpoint—The active setpoint is the current setpoint the controller uses to maintain temperature in the space. It is the Controlled Input property for Loop 1. Controller programming sets this value to either the Cooling Setpoint or Heating setpoint based on the state of Heating/Cooling value object. The active setpoint is stored in Analog Value object AV26, ACTIVESP.

Table 6-1 Active setpoint calculations

	Cooling setpoint	Heating setpoint
Occupied	Space setpoint + 1/2 deadband	Space setpoint – 1/2 deadband
Standby	Space setpoint + offset	Space setpoint – offset
Unoccupied	Unoccupied cooling setpoint	Unoccupied heating setpoint

Space setpoint—This is the setpoint entered or selected by the user and is stored in Analog Value object AV2, SPACESSTPT. The value is either the value set from the NetSensor or Analog Input object AI1. The Active and Standby setpoints are calculated from this setpoint. See the topic *Input sources* on page 39.

Setpoint limits—The setpoint limits are entered by the controls technician during controller setup and system commissioning. Analog Value object AV11, STPT_MIN, limits the lowest cooling setpoint and Analog Value object AV12, STPT_MAX, limits the highest heating setpoint allowed regardless of the setting or entry of the user space setpoint.

Unoccupied setpoints—These setpoints are entered by the controls technician during controller setup and system commissioning. Analog Value objects AV39 and AV40, UNOCC_HTG_SP and UNOCC_CLG_SP, are the setpoints used when the system is unoccupied.

Standby setpoint—Standby setpoints are used when the controller is in the standby state. It is a value calculated from the current active setpoint and the value of Analog Value object AV3, OFFSET. The standby offset value is entered by the controls technician during controller setup and system commissioning. See the topic *Occupancy and standby* on page 40.

Occupancy and standby

The BAC-7000 VAV controllers have no internal programming to enable a change to the occupancy or standby modes.

Occupancy—Binary Value object BV2, UNOCC, sets the state controller occupancy. When the controller is in the occupied state, the active setpoint is calculated as described in the topic *Space setpoints* on page 40. When the controller is in the unoccupied state, either the cooling or heating unoccupied setpoint is used as the active setpoint. The state of this object can be controlled by a schedule object, custom Control Basic programming, or from another device on the building management network.

Standby—The Binary Value object BV1, STANDBY, sets the state of standby or occupied. When the controller is in the occupied standby state, the standby setpoint is used as the active setpoint. The state of this object can be controlled by a schedule object, custom Control Basic programming, or from another device on the building management network.

PID control loops

A PID control loop calculates an error value from the difference between a measured input value and a setpoint value. The error value is expressed as a percentage and is typically used in a BAS controller to control the state of an output. When the difference between the setpoint and measured input is large, the error is large. As the system reduces the difference between the setpoint and measured input, the error becomes smaller.

The BAC-7000 series VAV controllers use three PID loops.

- The active setpoint loop, Loop object 1—This is a direct-acting loop. It compares the room temperature to the active setpoint to determine the VAV flow requirement. The output of the loop is a percentage passed to Analog Value object AV16, LP1.
- The flow request loop, Loop object 2—This is a direct-acting loop. It compares actual airflow in Analog Value object AV27, VOLUME1 to the requested flow in Analog Value object AV25, RQSTFLOW. The output of the loop is passed to Analog Value object AV17, LP2, and is used to calculate the movement of the damper to control airflow.
- The heating loop, Loop object 3—This reverse acting loop compares room temperature to Analog Value object AV29, HEAT_SP. The output of the loop is passed to Analog Value object AV18, LP3, to calculate the call for reheat. See the topic *Reheat sequence* on page 42 for a description of the reheat sequence.

The PID loops in the controllers are standard BACnet objects and are listed in the topic *Loop objects* on page 63.

Pressure independent airflow sequence

For pressure independent VAV installations, the airflow through the VAV terminal unit is determined by Loop 1 and Loop 2 both of which are direct acting loops.

Loop object 1, a direct acting loop, compares the room temperature to the active setpoint to determine a required change in temperature which is passed to Analog Value object AV16, LP1. The value of LP1 is inverted if in heating mode and not inverted for cooling and then passed to Analog Value object 25, RQSTFLOW, as the setpoint reference property for Loop object 2. This is compared to the actual airflow. The result is passed to Analog Value object AV17, LP2. LP2 is then used by the damper routine to open or close the damper.

See also the topic, *Damper operation* on page 42.

Pressure dependent temperature control

For pressure dependent (bypass) control, only Loop object 1 is used to control damper position.

Loop object 1, a direct acting loop, compares the room temperature to the active setpoint to determine a required change in temperature. The temperature change is stored in Analog Value object AV16, LP1. LP1 is then used by the damper routine to open or close the damper.

Changeover

The BAC-7000 VAV controllers are configured as cooling only controllers. The controller can be commanded to heating from another controller connected to the building management system network or by adding custom Control Basic programming. Changeover from cooling to heating is controlled by the Binary Value object BV3, HEATING.

Damper operation

The damper position is calculated and then commanded to move through Analog Output object AO4, MOTOR. When the output is commanded to 0 volts the motor drives the damper counterclockwise, 10 volts drives the damper clockwise, and 5 volts stops the damper. Controller programming limits the motor run-time in either direction to no longer than 6 minutes. See *Pressure independent airflow sequence* on page 41 or *Pressure dependent temperature control* on page 41 for a description of how damper position is determined.

Damper position is indicated by Analog Value object 32, DMPR_POS. It is calculated with programming by measuring the time the damper has been commanded open or closed and comparing it to the time required for 90° rotation. It is not used as feedback in the control sequence.

Fan operation

(Pressure Independent only) If the controller is configured for fan operation, the controller will start the fan when there is a call for reheat. The fan starts when the Reheat Setpoint loop is above 5% and stops 30 seconds after the reheat output is turned off. See the topic *Reheat sequence* on page 42.

Reheat sequence

BAC-7000 VAV controllers simultaneously control modulating and On/Off reheat outputs. All reheat is controlled by Loop object 3 which is described in the topic *PID control loops* on page 41.

Binary Value object BV5, REHEAT, enables both modulating and On/Off reheat.

Modulating reheat The controller controls for modulating reheat with 0-10 volts DC at Analog Output object AO1, ANALOG_HEAT. On a call for reheat, the reheat output is modulated over the span of the Heating Setpoint loop. If the loop is less than 5%, the reheat output remains at zero.

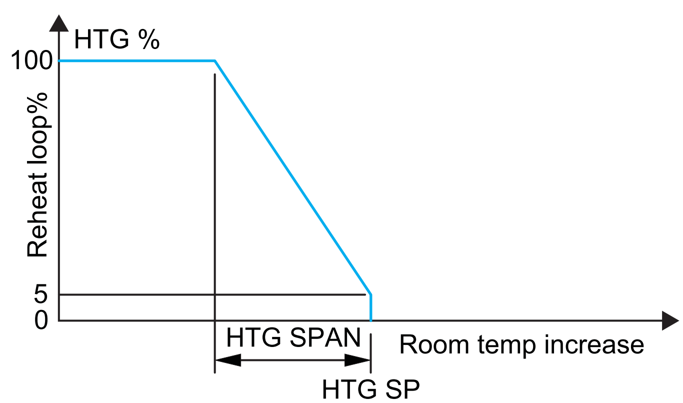

Illustration 6-1 Modulating reheat operation

On/Off reheat When reheat is enabled, the controller turns on the Binary Output 2 when the output of Loop object 3 reaches 50%. The output will remain on until the output of the loop falls below 5%.

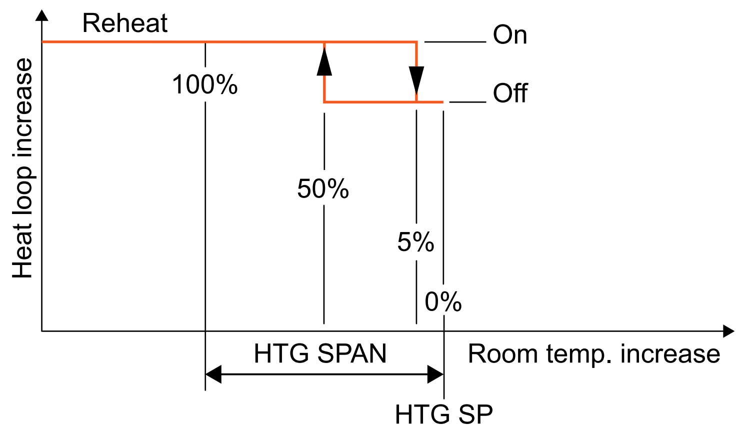

Illustration 6-2

Staged reheat options The BAC-7000 controllers do not directly support staged reheat. Staged reheat can be added by connecting an external staging relay to the modulating reheat analog output. See the section *Applications for BAC-7000 series VAV controllers* on page 45 for adding the staging relay.

Balancing sequence

Balancing airflow is the process of calibrating the internal airflow sensor to a known standard. In the field, airflow is measured with an airflow hood or other measuring instrument and then compared to the airflow measurements from the sensor in the controller. The balancing process uses a KMD-1161 NetSensor as the technicians service tool for initiating the balancing sequence and entering actual flow measurements.

When the balancing sequence starts, all other functions of the controller are locked out.

At the start of the sequence, the technician uses the NetSensor to drive the damper open until the airflow reaches the maximum airflow setpoint. An airflow measurement is made with an airflow hood and the actual airflow value is entered into the controller. Once the actual airflow is entered, the technician commands the controller to drive the damper closed to the minimum airflow setpoint. Another measurement is made with the flow hood and that measurement is entered into the controller.

After both measurements are entered, the programming in the controller calculates airflow correction factors which are used to adjust measurements from the internal airflow sensor. Balancing is complete and the controller is returned to normal operation.

Balancing automatically ends two hours after the last button is pushed.

For the procedure to use the balancing routine, see the section *Balancing with a NetSensor* on page 35.

SECTION 7

Applications for BAC-7000 series VAV controllers

This section covers the drawings, materials, and instructions for specific VAV applications.

Each BAC-7000 VAV model is designed for a specific set of applications. The following topics are for control technicians and engineers that will design installations and install the controllers

The application drawings in this section are supported by the programming supplied in the BAC-7000 series VAV controllers. Both pressure independent and pressure dependent (bypass) applications are supported.

- *Pressure independent applications* on page 46
- *Pressure dependent applications* on page 54

Pressure independent applications

The following pressure independent applications and configurations are supported by BAC-7000 series VAV controllers.

- *BAC-7001 or BAC-7051 with reheat and parallel fan* on page 46
- *BAC-7001 or BAC-7051 with staged reheat and parallel fan* on page 48
- *BAC-7003 or BAC-7053 with reheat and parallel fan* on page 50
- *BAC-7003 or BAC-7053 staged reheat and parallel fan* on page 52

For pressure dependent applications, see the topic *Pressure dependent applications* on page 54.

BAC-7001 or BAC-7051 with reheat and parallel fan

The standard programming in a BAC-7001 or BAC-7051 controller supports parallel fan operation and On/Off reheat or modulating reheat. External relays are required to switch the fan and On/Off reheat AC circuits.

- The fan output switches a relay for 24 volt AC pilot duty.
- The modulating option for reheat can control either an electric reheat unit with an analog input or a modulating hot water valve. The analog reheat output at output terminal AO1 varies between 0 and 10 volts DC.
- The On/Off reheat output switches a relay for 24 volt AC pilot duty.

For installation details, see the diagram *Pressure independent BAC-7001 or BAC-7051 with reheat and parallel fan* on page 47.

To configure the controller, see the topic *Configuring for pressure independent VAV* on page 32.

***Table 7-1 Bill of material for B*AC-70x1 with reheat and parallel fan**

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X1	BACNET AAC FOR VAV, 3UI
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
NS1	KMD-1161	NETSENSOR
FAN	REE-3112	12VDC Control Relay
HT1	REE-3112	12VDC Control Relay
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

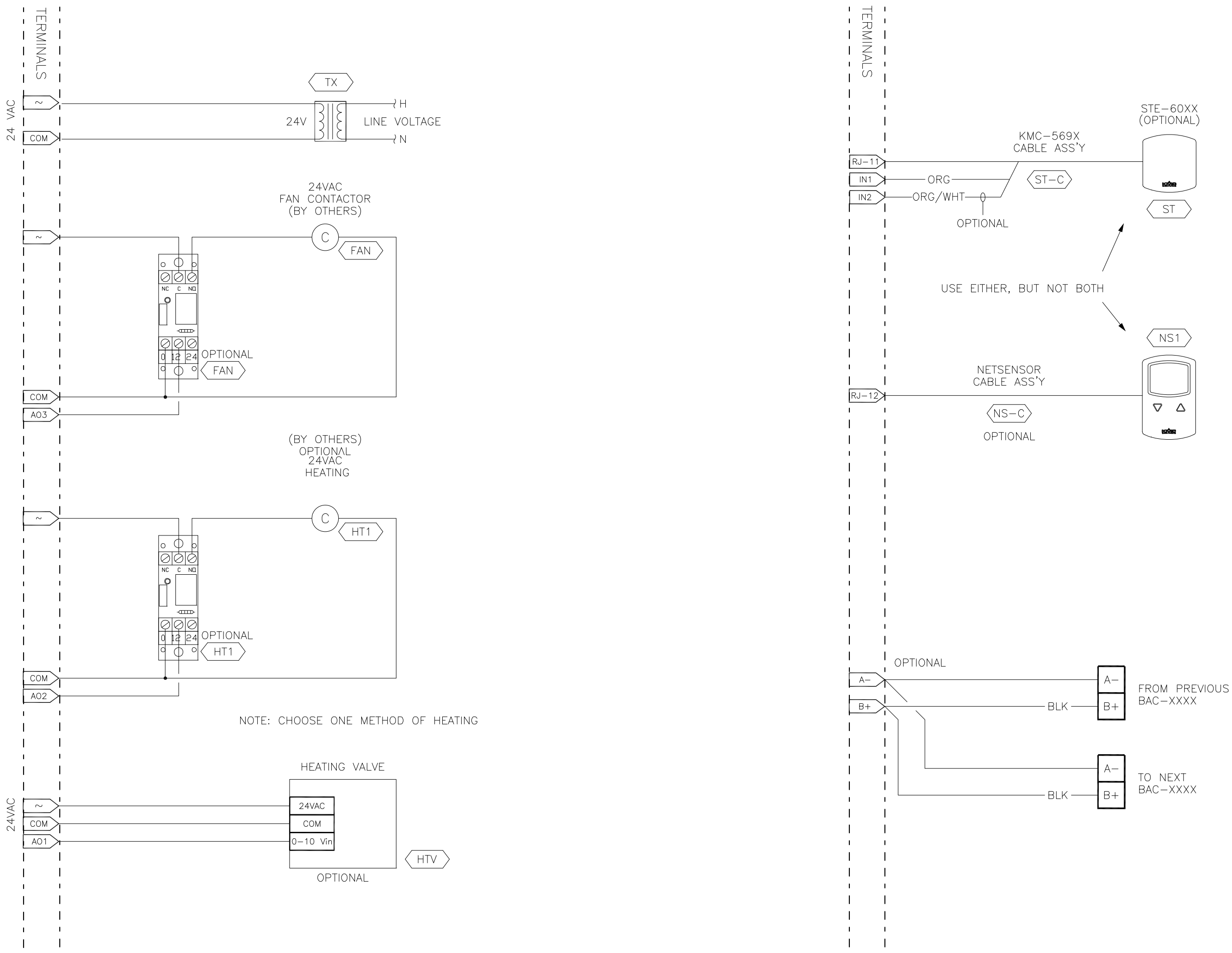

Illustration 7-1 Pressure independent BAC-7001 or BAC-7051 with reheat and parallel fan

BAC-7001 or BAC-7051 with staged reheat and parallel fan

The standard programming in a BAC-7001 or BAC-7051 controller supports parallel fan operation and staged reheat with the addition of a staging relay. An external relay is also required for an AC fan circuit.

- The fan out relay switches a 24 volt AC pilot duty output.
- The analog reheat output at terminal AO1 varies between 0 and 10 volts DC to control the staging relay.

For installation details, see the diagram *Pressure independent BAC-7001 or BAC-7051 with staged reheat and parallel fan* on page 49.

To configure the controller, see the topic *Configuring for pressure independent VAV* on page 32.

Table 7-2 **Bill of material for BAC-70x1 with staged reheat and parallel fan**

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X1	BACNET AAC FOR VAV, 3UI
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
NS1	KMD-1161	NETSENSOR
FAN	REE-3112	12VDC Control Relay
HT3	REE-5001	3-STAGE RELAY CONTROLLER
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

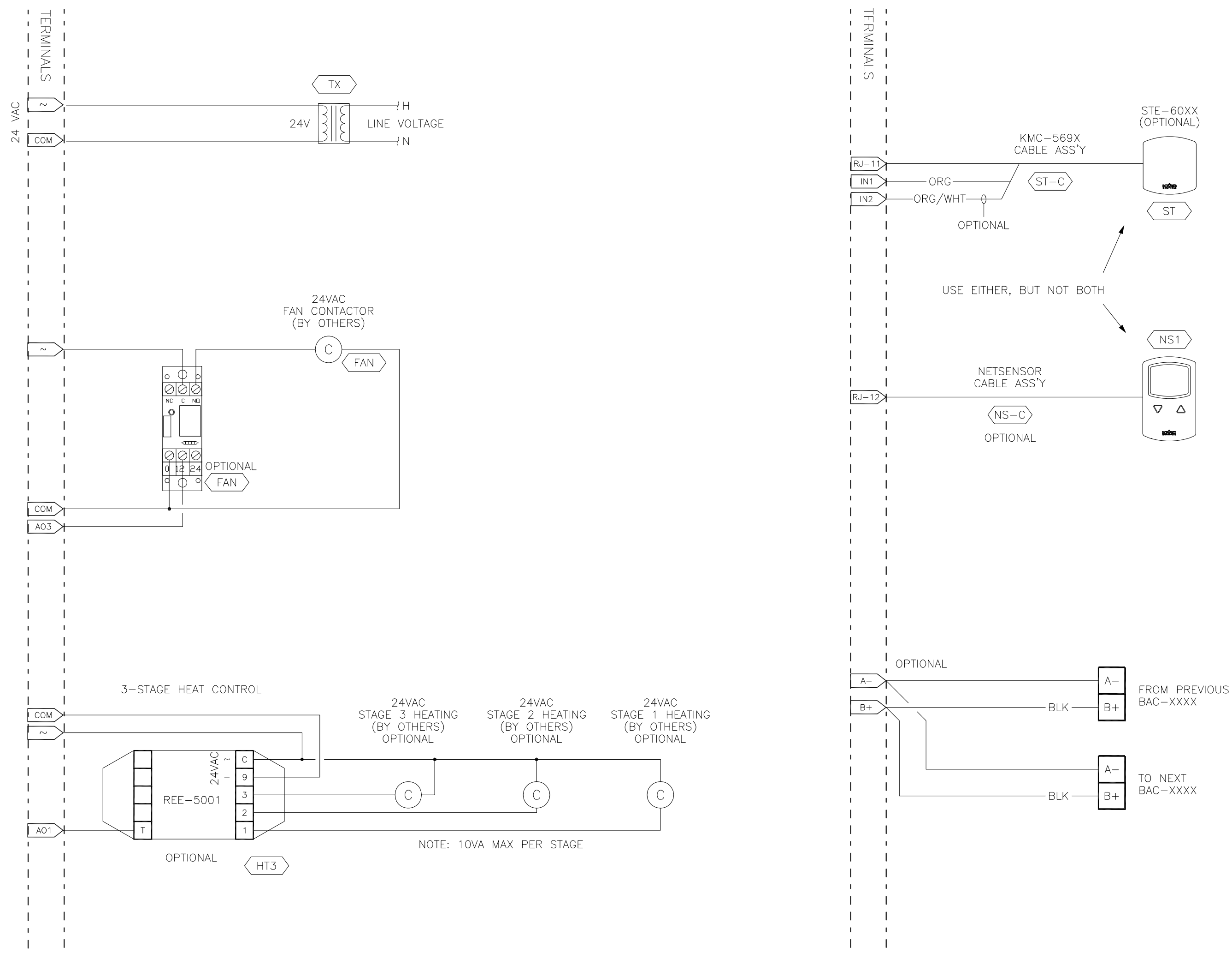

Illustration 7-2 Pressure independent BAC-7001 or BAC-7051 with staged reheat and parallel fan

BAC-7003 or BAC-7053 with reheat and parallel fan

The standard programming in a BAC-7003 or BAC-7053 controller supports parallel fan operation and On/Off reheat or modulating reheat. The BAC-7003 and BAC-7053 controllers can directly control pilot duty switching for the fan and On/Off reheat.

- The fan circuit is a 24 volt AC pilot duty output.
- The modulating option for reheat can control either an electric reheat unit with an analog input or a modulating hot water valve. The analog reheat output at output terminal AO1 varies between 0 and 10 volts DC.
- The On/Off reheat output is a 24-volt AC pilot duty output.

For connection details, see the diagram *Pressure independent BAC-7003 or BAC-7053 with reheat and parallel fan* on page 51.

To configure the controller, see the topic *Configuring for pressure independent VAV* on page 32.

***Table 7-3 Bill of materials for* 70x3 with reheat and parallel fan**

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X3	BACNET AAC FOR VAV, 1UI, 1 TRIAC, 1 N.O. RELAY
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
NS1	KMD-1161	NETSENSOR
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

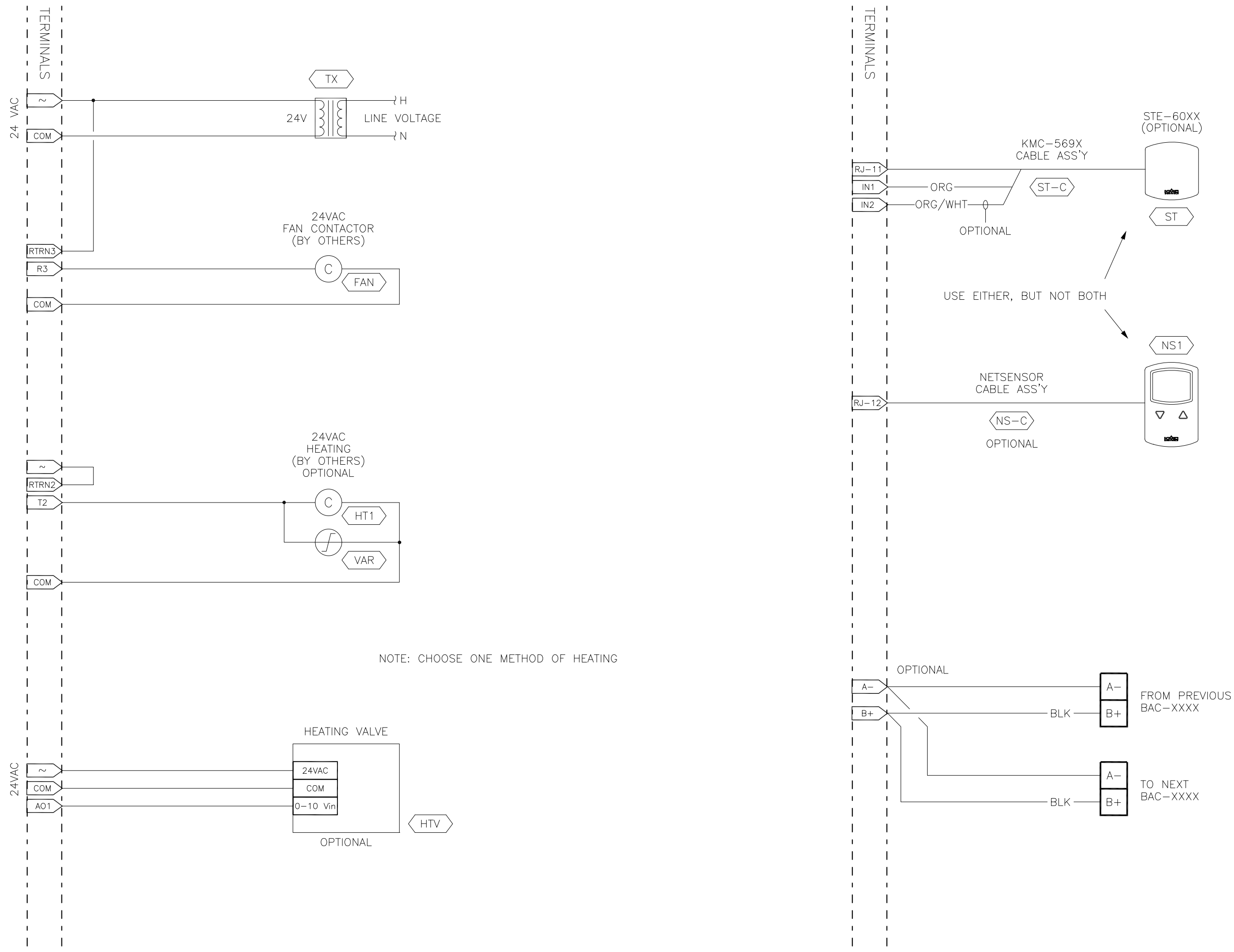

Illustration 7-3 Pressure independent BAC-7003 or BAC-7053 with reheat and parallel fan

BAC-7003 or BAC-7053 staged reheat and parallel fan

The standard programming in a BAC-7003 or BAC-7053 controller supports parallel fan operation and staged reheat with the addition of a staging relay. The BAC-7003 and BAC-7053 controllers can directly control pilot duty switching for the fan.

- The fan circuit is a 24 volt AC pilot duty output.
- The analog reheat output at terminal AO1 varies between 0 and 10 volts DC to control the staging relay.

For connection details, see the diagram *Pressure independent BAC-7003 or BAC-7053 with staged reheat and parallel fan* on page 53.

To configure the controller, see the topic *Configuring for pressure independent VAV* on page 32.

Table 7-4 **Bill of material for BAC-70x1 with staged reheat and parallel fan**

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X3	BACNET AAC FOR VAV, 1UI, 1 TRIAC, 1 N.O. RELAY
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
NS1	KMD-1161	NETSENSOR
HT3	REE-5001	3-STAGE RELAY CONTROLLER
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

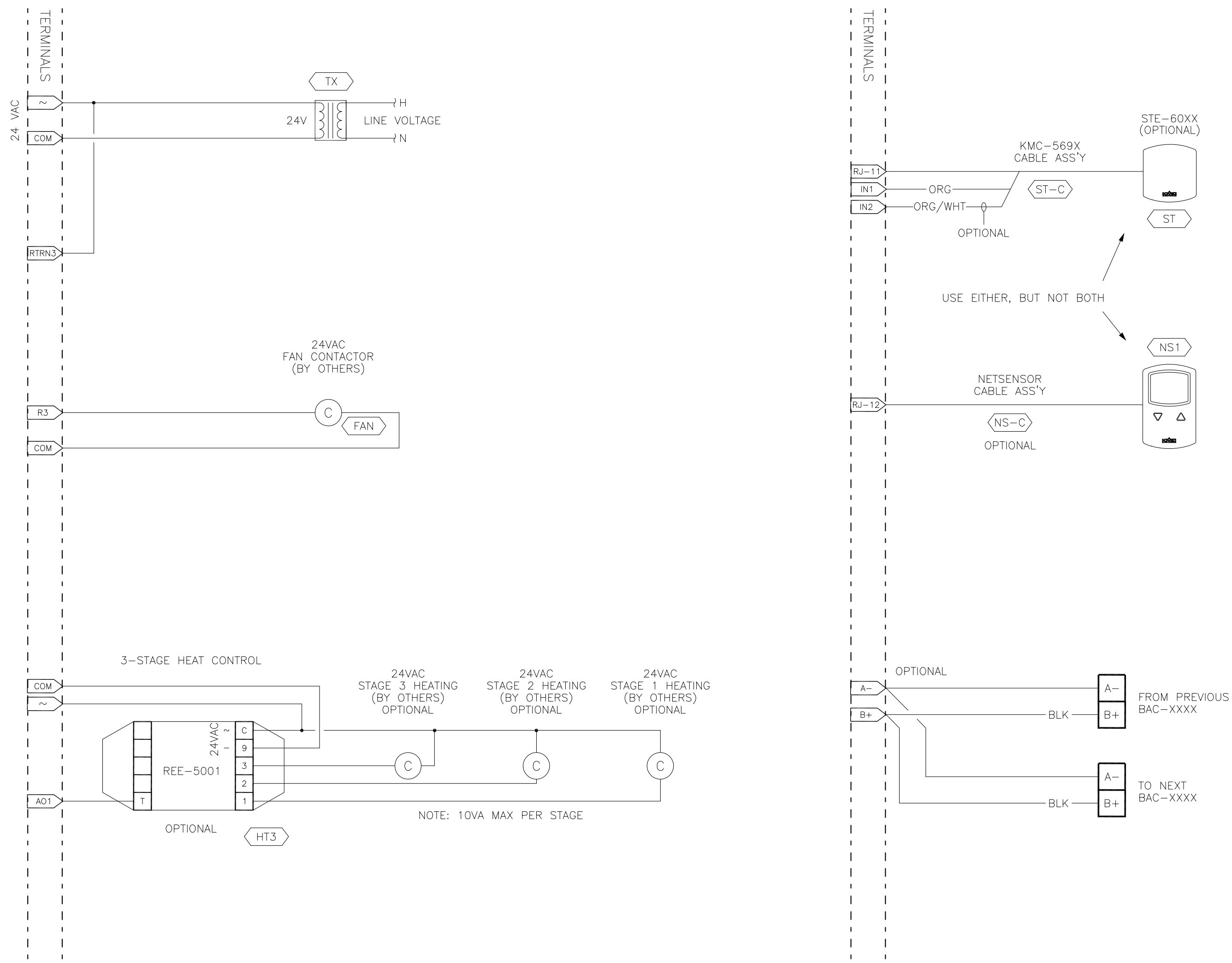

Illustration 7-4 Pressure independent BAC-7003 or BAC-7053 with staged reheat and parallel fan

Pressure dependent applications

The standard applications in a BAC-7000 series VAV controller support the following pressure dependent VAV applications.

- *BAC-7001 or BAC-7051 pressure dependent with single reheat* on page 54
- *BAC-7003 or BAC-7053 pressure dependent with single reheat* on page 56
- *Pressure dependent with staged reheat* on page 58

For pressure independent applications, see the topic *Pressure independent applications* on page 46.

BAC-7001 or BAC-7051 pressure dependent with single reheat

The standard programming in a BAC-7001 or BAC-7051 controller supports On/Off reheat or modulating reheat. An external relay is required for the On/Off reheat AC circuit.

- The modulating option for reheat can control either an electric reheat unit with an analog input or a modulating hot water valve. The analog reheat output at terminal AO1 varies between 0 and 10 volts DC.
- The the On/Off reheat output switches a relay for 24 volt AC pilot duty.

To enable pressure dependent programming, see the procedure in the topic, *Configuring for pressure dependent VAV* on page 33.

Table 7-5 Bill of material for BAC-70x1 with single reheat

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X1	BACNET AAC FOR VAV, 3UI
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
NS1	KMD-1161	NETSENSOR
HT1	REE-3112	12VDC Control Relay
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

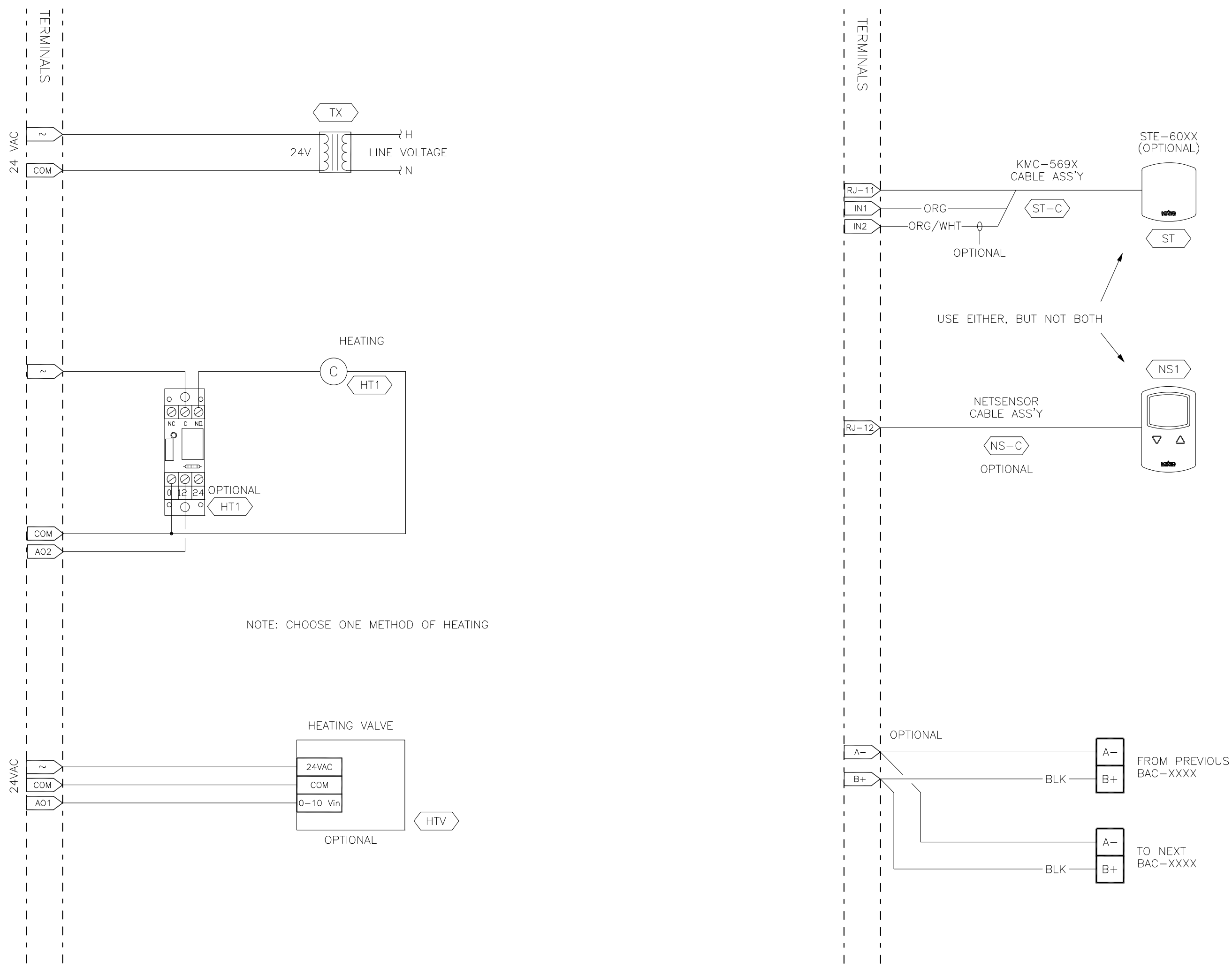

Illustration 7-5 Pressure dependent BAC-7001 or BAC-7051 with single reheat

BAC-7003 or BAC-7053 pressure dependent with single reheat

The standard programming in a BAC-7003 or BAC-7053 controller On/Off or modulating reheat. An external relay is not required to switch 24-volt AC devices.

- The modulating option for reheat can control either an electric reheat unit with an analog input or a modulating hot water valve. The analog reheat output at output terminal AO1 varies between 0 and 10 volts DC.
- The On/Off reheat output is a 24-volt AC pilot duty output.

To enable pressure dependent programming, see the procedure in the topic, *Configuring for pressure dependent VAV* on page 33.

***Table 7-6 Bill of materials for* 70x3 with reheat**

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X3	BACNET AAC FOR VAV, 1UI, 1 TRIAC, 1 N.O. RELAY
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
NS1	KMD-1161	NETSENSOR
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

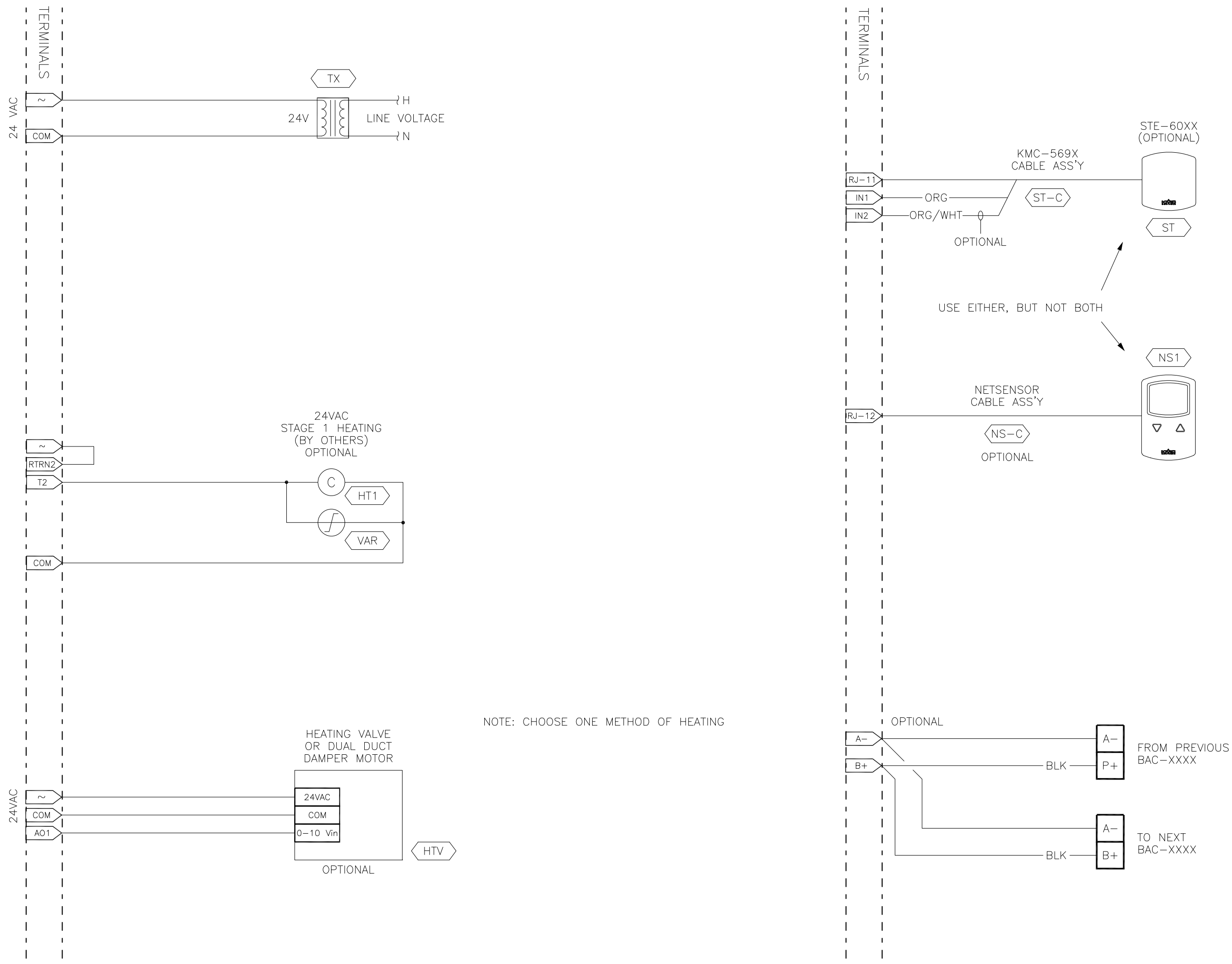

Illustration 7-6 Pressure dependent BAC-70x3 with reheat

Pressure dependent with staged reheat

The standard programming in a BAC-7003 or BAC-7053 controller supports staged reheat with the addition of a staging relay. The analog reheat output at terminal AO1 varies between 0 and 10 volts DC to control the staging relay.

To enable pressure dependent programming, see the procedure in the topic, *Configuring for pressure dependent VAV* on page 33.

Table 7-7 **Bill of material for BAC-70x1 with staged reheat and parallel fan**

REFERENCE	PART #	PART DESCRIPTION
DDC	BAC-70X1	BACNET AAC FOR VAV, 3UI
DDC	BAC-70X3	BACNET AAC FOR VAV, 1UI, 1 TRIAC, 1 N.O. RELAY
ST	STE-60XX-10	CHOOSE 6011 OR 6014 SPACE TEMP SENSOR MODEL
ST-C	KMD-569X	TEMP SENSOR PLENUM CABLE W/CONN. CHOOSE LENGTH
AF	SSS-100X	AIRFLOW SENSOR, CHOOSE SIZE 'X' FROM DATA SHEET
NS1	KMD-1161	NETSENSOR
HT3	REE-5001	3-STAGE RELAY CONTROLLER
TX	XEE-6311-50	Control Transformer, 120/240/277/480VAC-24VAC, 50VA

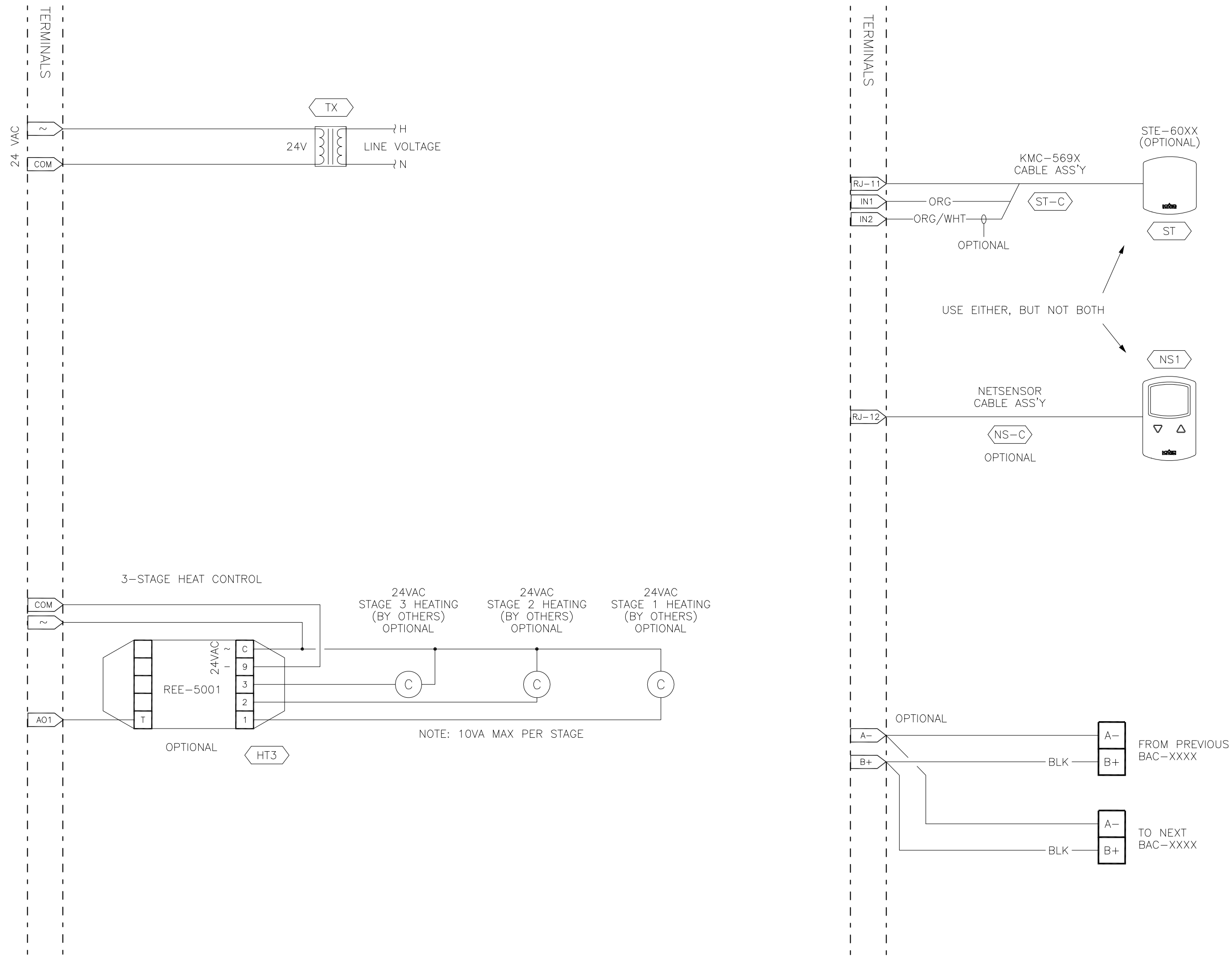

Illustration 7-7 Pressure dependent BAC-7000 series VAV controller pressure dependent staged reheat

SECTION 8

Reference to objects and programs

The following topics list the BACnet objects and Control Basic programs are supplied with the controllers. These are advanced reference topics for control technicians and engineers.

The BAC-7000 VAV controllers are BACnet Advanced Application Controlles (AAC) and are composed of standard BACnet objects. This section lists the objects that are likely to be monitored by a standard BACnet operator workstation to verify system operation.

Caution

Changing the configuration of any object or program may result in unpredictable operation of a controller and damage to equipment that is under control of a controller. See the topic *Configuration and set up* on page 31 for detailed instructions on object configuration in new controllers.

Topics in this section

Input objects

The following BACnet input objects represent values at the physical inputs of the controller. For wiring details, see the topics *Connecting inputs* on page 18 and *Applications for BAC-7000 series VAV controllers* on page 45.

Table 8-1 Input objects

Input	Name	Description	Object type
AI1	ROOMTEMP	Room Temperature	KMC10K Type II
AI2	STESETPOINT	STE Setpoint	Table 4
AI3	DAT	Discharge Air Temp	KMC10K Type III
AI4	FLOWSNSR	Airflow Sensor	FPM 0-3000

Output objects

The following BACnet output objects represent values at the physical outputs of the controller. For wiring details, see the topics Connecting outputs on page 19 and Applications for BAC-7000 series VAV controllers on page 45.

Table 8-2 Output objects

Input	Name	Description	Object type
AO1	ANALOG_HEAT	Mod Heating	0-100%
BO2	BINARY_HEAT	Binary Heat	
BO3	FAN	Fan Start	
AO4	Damper Motor Drive	MOTOR	Volts 0-10

Value objects

BACnet value objects represent setpoints or other operational conditions in the controller.

Table 8-3 Analog Value objects

Object	Name	Description	Units
AV1	SPACETEMP	Space Temperature (auto)	°F
AV2	SPACESSTPT	Space Temp Setpoint	°F
AV3	OFFSET	Setpoint Offset	°F
AV4	NS4_ActMinFlow	User Button4 ActMinFlow	cfm
AV5	NS5_MinSP	User Button5 MinSP	cfm
AV6	NS6_ActMaxFlow	User Button6 ActMaxFlow	cfm
AV7	NS7_MaxSP	User Button7 MaxSP	cfm
AV8	NS_MOTION	Netsensor Motion	
AV9	HTDMPRPOS	PD Heat Damper Position	%
AV10	--available--		
AV11	STPT_MIN	Setpoint Limit Min	°F
AV12	STPT_MAX	Setpoint Limit Max	°F
AV13	STAT_DB	Thermostat Deadband	°F
AV14	--available--		
AV15	--available--		
AV16	LP1	Loop 1 (auto) ActiveSP%	%
AV17	LP2	Loop 2 (auto)	%
AV18	LP3	Loop 3 (auto) HtgSP%	%
AV19	LP4	Loop 4 (auto)	%
AV20	MIN_FLOW	Minimum Flow	cfm
AV21	MAX_FLOW	Maximum Flow	cfm
AV22	VOLFACTR	Volume correction	ft^2
AV23	SNSRFACTR	Sensor Correction (auto)	
AV24	ACT_FLOW	Actual Airflow (auto)	ft/min
AV25	RQSTFLOW	Requested Flow (auto)	ft/min
AV26	ACTIVESP	Active Temp Setpoint (auto)	°F
AV27	VOLUME1	Duct Volume Readout (auto)	cfm

Table 8-3 Analog Value objects (Continued)

Object	Name	Description	Units
AV28	AUX_FLOW	Auxillary Airflow	cfm
AV29	HEAT_SP	Heat Temperature	°F
AV30	COOL_SP	Cool Temperature Setpoint	°F
AV31	DRV_TIME	Damper Drive Time	DRV_TIME
AV32	DMPR_POS	Damper Position (auto)	%
AV33	--available--		
AV34	--available--		
AV35	--available--		
AV36	ACTFLOWMIN	Actual Flow at Min	cfm
AV37	ACTFLOWMAX	Actual Flow at Max	cfm
AV38	RQSTFLOWCFM	Requested Flow Volume (auto)	cfm
AV39	UNOCC_HTG_SP	Unoccupied Heating Setpoin	°F
AV40	UNOCC_CLG_SP	Unoccupied Cooling Setpoint	°F

Table 8-4 Binary value objects

Object	Name	Description	Units
BV1	STANDBY	Standby Mode	Inactive/Active
BV2	UNOCC	Unoccupied command	Off/On
BV3	HEATING	Changeover Mode	Cool/Heat
BV4	CW_CLOSE	Clockwise to Close	No/Yes
BV5	REHEAT	Reheat Status	Disabled/Enabled
BV6	--available--		
BV7	--available--		
BV8	BALANCE	Balancer OVRD	Off/On
BV9	NETSENSOR	NetSensor?	Off/On

Loop objects

BACnet PID loops are used for modulating the damper and controlling reheat.

Table 8-5 Table 8–7 PID control loop objects

Loop	Name	Description	Units
LOOP1	ACTSETCON	Active Setpoint	%
LOOP2	FLWRQSTCON	Flow Request	%
LOOP3	HTSETCON	Heat Setpoint	%

Control Basic programs

The following sections provide the Control Basic supplied with the controllers. Program 1, 3, and 4 are configured to run automatically when the controller starts.

Table 8-6 Program objects

Program	Name	Description	Automaticaly run on coldstart
1	SINGLEVAV	Single Duct Pressure Indep VAV	Yes
2	SINGLEPRESS	Single Duct Pressure Depend VAV	Yes
3	REHEAT	Reheat (Mod & 2-Stg)	Yes
4	CALIB_UTIL	Calibration Utility	Yes
5-10	--available--		No

Program 1—Pressure independent VAV

Program 1 configures the controller to run as a pressure independent VAV controller. All input, output, value objects, and PID control loops are configured to support this program. The program is configured to start automatically when the controller is powered.

```
10 REM *** Pressure Independent BAC-70xx VAR 2.2 GS 5/27/14 ***
20 IF MODELNUMBER = 32 OR MODELNUMBER = 34 THEN AV31 = 300 ELSE
AV31 = 90

90 REM BALANCER OVRD
110 IF+ BV8 THEN S = AV2
130 IF- BV8 THEN START T , END
140 IF TIMEON( BV8 ) > 2:00:00 THEN BV8@8 = 0 , END
150 IF TIMEON( T ) > 20 THEN AV2@8 = S , STOP T , END
160 IF T THEN END

170 IF BV8 = 0 THEN GOTO 250
180 IF AV2 > 1 THEN AV2@8 = 1 : IF AV2 < 1 THEN AV2@8 = 0 : REM Bal
Limits
190 IF AV2 = 1 THEN AV25 = AV21 / AV22 ELSE AV25 = AV20 / AV22 :
REM Bal Flow Settings
200 GOTO 380

250 REM Temp SPs If no NetSensor use AI1 & AI2 (Not for STE-6012/
16)
260 BV9 = NETSENSORSTATUS
270 IF BV9 THEN GOTO 310
280 IF NOT BV9 THEN RLQ AV8@8
290 IF AI1 < 0 THEN RLQ AV1@8 , RLQ AV2@8 , GOTO 310 ELSE AV1@8 =
AI1 : REM Use Sensor if present
300 IF AI2 > 89 THEN GOTO 310 ELSE AV2@8 = AI2 : REM Use Setpoint
if present
310 IF BV3 THEN AV26 = AV29 ELSE AV26 = AV30
320 IF BV3 THEN A = 1 - AV16 / 100 ELSE A = AV16 / 100
330 AV2@8 = MIN( MAX( AV2 , AV11 ) , AV12 ) : REM Apply SP limits
340 IF BV1 = 0 THEN AV29 = AV2 - AV13 / 2 ELSE AV29 = AV2 - AV3
350 IF BV1 = 0 THEN AV30 = AV2 + AV13 / 2 ELSE AV30 = AV2 + AV3
355 IF BV2 = 1 THEN AV29 = AV39
356 IF BV2 = 1 THEN AV30 = AV40
```

```
360 REM Flow Calc (FPM & CFM)
370 AV25 = ( ( AV21 - AV20 ) * A + AV20 ) / AV22 : REM
RQSTFLOW(fpm)
380 AV24 = AI4 * AV23 : REM CORRECTED FPM
390 AV27 = AV24 * AV22 : REM CFM In

400 REM Damper Control
410 IF AV17 > 65 AND BV4 THEN START B
420 IF AV17 > 65 AND NOT BV4 THEN START C
430 IF AV17 < 35 AND BV4 THEN START C
440 IF AV17 < 35 AND NOT BV4 THEN START B
450 IF AV17 > 35 AND AV17 < 65 THEN STOP B , STOP C
460 IF B THEN STOP C
470 IF C THEN STOP B
480 X = 1 / SCANS
490 IF AV17 < 99 AND AV17 > 1 THEN GOTO 500 ELSE GOTO 560
500 IF AV17 < 36 OR AV17 > 64 THEN START D ELSE STOP D
510 IF TIMEON( D ) > 0:00:10 THEN GOTO 560
520 Y = X + Y
530 IF Y > 5 THEN Y = 0
540 Z = ABS( AV17 - 50 ) / 50
550 IF Y > Z THEN STOP B , STOP C
560 IF B THEN AO4 = 10
570 IF C THEN AO4 = 0
580 IF NOT B AND NOT C THEN AO4 = 5
590 IF AO4 > 7 THEN START G ELSE STOP G
600 IF AO4 < 3 THEN START H ELSE STOP H
610 IF TIMEON( G ) > 0:06:00 OR TIMEON( H ) > 0:06:00 THEN AO4 = 5
, START I ELSE STOP I
620 IF TIMEON( I ) > 0:06:00 THEN STOP G , STOP H , STOP B , STOP
C
630 IF BV4 AND AO4 < 3 THEN AV32 = AV32 + X * 100 / AV31
640 IF BV4 AND AO4 > 7 THEN AV32 = AV32 - X * 100 / AV31
650 IF NOT BV4 AND AO4 < 3 THEN AV32 = AV32 - X * 100 / AV31
660 IF NOT BV4 AND AO4 > 7 THEN AV32 = AV32 + X * 100 / AV31
670 IF AV32 > 100 THEN AV32 = 100
680 IF AV32 < 0 THEN AV32 = 0
690 END
```

Program 2—Pressure dependent VAV

Program 2 configures the controller to run as a pressure dependent VAV controller. All input, output, value objects, and PID control loops are configured to support this program. The program is not configured to run automatically when the controller is powered. To change the controller to pressure dependent VAV, use a BACnet operator workstation to halt Program 1 and start Program 2.

```
10 REM *** Pressure Dependent BAC-70xx VAR 2.2 GS 5/27/14 ***
80 REM Temp SPs If no NetSensor use AI1 & AI2 (Not for STE-6012/
16)
90 BV9 = NETSENSORSTATUS
100 IF BV9 THEN GOTO 140
110 IF NOT BV9 THEN RLQ AV8@8
120 IF AI1 < 0 THEN RLQ AV1@8 , RLQ AV2@8 , GOTO 140 ELSE AV1@8 =
AI1 : REM Use Sensor if present
130 IF AI2 > 89 THEN GOTO 140 ELSE AV2@8 = AI2 : REM Use Setpoint
if present
140 IF BV3 THEN AV26 = AV29 ELSE AV26 = AV30
150 AV2@8 = MIN( MAX( AV2 , AV11 ) , AV12 ) : REM Apply SP limits
160 IF BV1 = 0 THEN AV29 = AV2 - AV13 / 2 ELSE AV29 = AV2 - AV3
170 IF BV1 = 0 THEN AV30 = AV2 + AV13 / 2 ELSE AV30 = AV2 + AV3

180 REM HEAT MODE
190 IF LOOP3 > 30 THEN START Q
200 IF LOOP3 < 1 THEN STOP Q
210 IF TIMEON( Q ) > 0:01:00 THEN START BV3 ELSE STOP BV3

220 REM CALIBRATE DAMPER
230 IF+ INT( TIME / 100 ) < 1 THEN START U
240 IF POWERLOSS THEN START U
250 IF TIMEON( U ) > AV31 THEN STOP U
260 IF U AND BV4 THEN AO4 = 0 , STOP BV3
270 IF U AND NOT BV4 THEN AO4 = 10 , STOP BV3
280 IF U OR BV3 THEN GOTO 520

290 REM Damper Control
300 IF AV16 > 70 THEN START C , STOP B
310 IF AV16 < 30 THEN START B , STOP C
320 IF AV16 > 35 AND AV16 < 65 THEN STOP B , STOP C
330 X = 1 / SCANS
340 IF AV16 < 99 AND AV16 > 1 THEN GOTO 350 ELSE GOTO 420
350 IF AV16 < 36 OR AV16 > 64 THEN START D ELSE STOP D
360 IF TIMEON( D ) > 0:00:10 THEN GOTO 420
370 REM The following will pulse the actuator as it nears
satisfied position to reduce overshoot
380 Y = X + Y : IF Y > 5 THEN Y = 0
390 Z = ABS( AV16 - 50 ) / 50
400 IF Y > Z THEN STOP B , STOP C
410 REM Drive Damper
420 IF B AND NOT BV4 THEN AO4 = 0 : REM Close damper CCW
430 IF B AND BV4 THEN AO4 = 10 : REM Close damper CW
440 IF C AND NOT BV4 THEN AO4 = 10 : REM Open damper CW
450 IF C AND BV4 THEN AO4 = 0 : REM Open damper CCW
460 IF NOT B AND NOT C THEN AO4 = 5 : REM Stop Damper
470 IF AO4 > 7 THEN START G ELSE STOP G : REM Check Drive Time
480 IF AO4 < 3 THEN START H ELSE STOP H : REM Check Drive Time
490 IF TIMEON( G ) > 0:06:00 OR TIMEON( H ) > 0:06:00 THEN AO4 = 5
, START I ELSE STOP I : REM Stop Driving Damper
500 IF TIMEON( I ) > 0:03:00 THEN STOP G , STOP H , STOP B , STOP
C : REM Allow Damper to be Driven
```

```
510 REM ESTIMATE DAMPER POSITION
520 P = 1 / SCANS
530 IF NOT BV4 AND AO4 < 3 THEN AV32 = AV32 - P * 100 / AV31
540 IF NOT BV4 AND AO4 > 7 THEN AV32 = AV32 + P * 100 / AV31
550 IF BV4 AND AO4 < 3 THEN AV32 = AV32 + P * 100 / AV31
560 IF BV4 AND AO4 > 7 THEN AV32 = AV32 - P * 100 / AV31
570 IF AV32 > 100 THEN AV32 = 100
580 IF AV32 < 0 THEN AV32 = 0
590 END
```

Program 3—Reheat

Program 3 configures the controller for a parallel fan and On/Off and modulating reheat. The program is configured to start automatically when the controller is powered. For custom reheat programming, halt this program and add custom programming to Programs 5-10.

```
10 REM *** Reheat BAC-70xx VAR 2.2 GS 5/27/14 ***
20 REM ---------FAN POWERED 1-STAGE AND/OR MODULATING REHEAT
SEQUENCE----------
30 REM Entire reheat sequence is easily disabled by toggling BV5
on-off.
40 REM Auxillary flow setpoint is used if AUXILLARY FLOW( AV28 ) >
MIN FLOW( AV20 )

50 IF BV5 THEN GOTO 90
60 AO1 = 0 : STOP BO2
70 IF TIMEOFF( BO2 ) > 0:00:30 THEN STOP BO3
80 END : REM If no reheat then stop

90 REM Reheat With Fan
100 AO1 = AV18 : REM Modulating Valve
110 IF AV18 > 50 THEN BO2 = 1 , AO1 = LOOP3 : REM Start Reheat
120 IF AV18 < 5 THEN BO2 = 0 , AO1 = 0 : REM Stop Reheat
130 IF AO1 > 10 OR BO2 = 1 THEN BO3 = 1
140 IF BV8 = 1 THEN GOTO 160
150 IF AO1 > 10 OR BO2 = 1 THEN AV25 = MAX( AV20 , AV28 ) / AV22
160 IF AO1 < 5 AND TIMEOFF( BO2 ) > 0:00:30 THEN STOP BO3 : REM
STOP FAN
170 END
```

Program 4—Calibration

Program 4 calculates airflow correction factors for the balancing routine. This program is only required for pressure independent VAV control.

```
10 REM *** Calibration BAC-70xx VAR 2.2 GS 5/27/14 ***
20 REM -- NetSensor Buttons --

30 IF POWERLOSS THEN GOTO 230

40 IF BV8 = 0 THEN GOTO 110
50 REM Balancing Mode
60 AV20@8 = AV5 : REM AV20 = MinCFMSP Btn 5
70 AV21@8 = AV7 : REM AV21 = MaxCFMSP Btn 7
80 AV36@8 = AV4 : REM AV36 = ActualMinCFM Btn 4
90 AV37@8 = AV6 : REM AV37 = ActualMaxCFM Btn 6
100 GOTO 160
```

```
110 REM Normal Mode
120 AV5@8 = AV20 : REM MinCFMSP Btn 5 = AV20
130 AV7@8 = AV21 : REM MaxCFMSP Btn 7 = AV21
140 AV4@8 = AV36 : REM ActualMinCFM Btn 4 = AV36
150 AV6@8 = AV37 : REM ActualMaxCFM Btn 6 = AV37

160 REM Calculate SensorCorrection AV23 (using AV36 & AV37 values
)
170 H = AV37 / AV21 : L = AV36 / AV20
180 AV23 = ( AV38 - AV20 ) * ( H - L ) / ( AV21 - AV20 ) + L

190 REM Calculate Requested Flow in CFM
200 AV38 = AV25 * AV22 : REM RQSTFLOW in CFM..AV38 for display on
graphics
210 AV36@10 = AV20 : AV37@10 = AV21 : REM Sets temporary values
220 END

230 REM ------ Saves Balance Data After Power loss -----
240 IF ABS( AV6 - 150 ) > 0.5 THEN AV37@8 = AV6
250 IF ABS( AV4 - 50 ) > 0.5 THEN AV36@8 = AV4
260 END
```

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