METASYS®

Variable Air Volume (VAV) Controller

* Indicates those sections where changes have occurred since the last printing.

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Introduction

Description

The Variable Air Volume (VAV) Controller is an electronic device for digital control of single duct, dual duct, fan powered, and supply/exhaust VAV box configurations. See Figure 1. You may use the VAV as a standalone controller or connected to the Metasys® network through a Network Control Module (NCM) or Companion™ system.

When connected to the Metasys Network, the VAV provides all point and control information to the rest of the network. The devices communicate through an N2 Bus.

Each VAV Controller application uses a different sequence of operation, all of which are covered in the *HVAC PRO for Windows User's Manual (FAN 637.5)*.

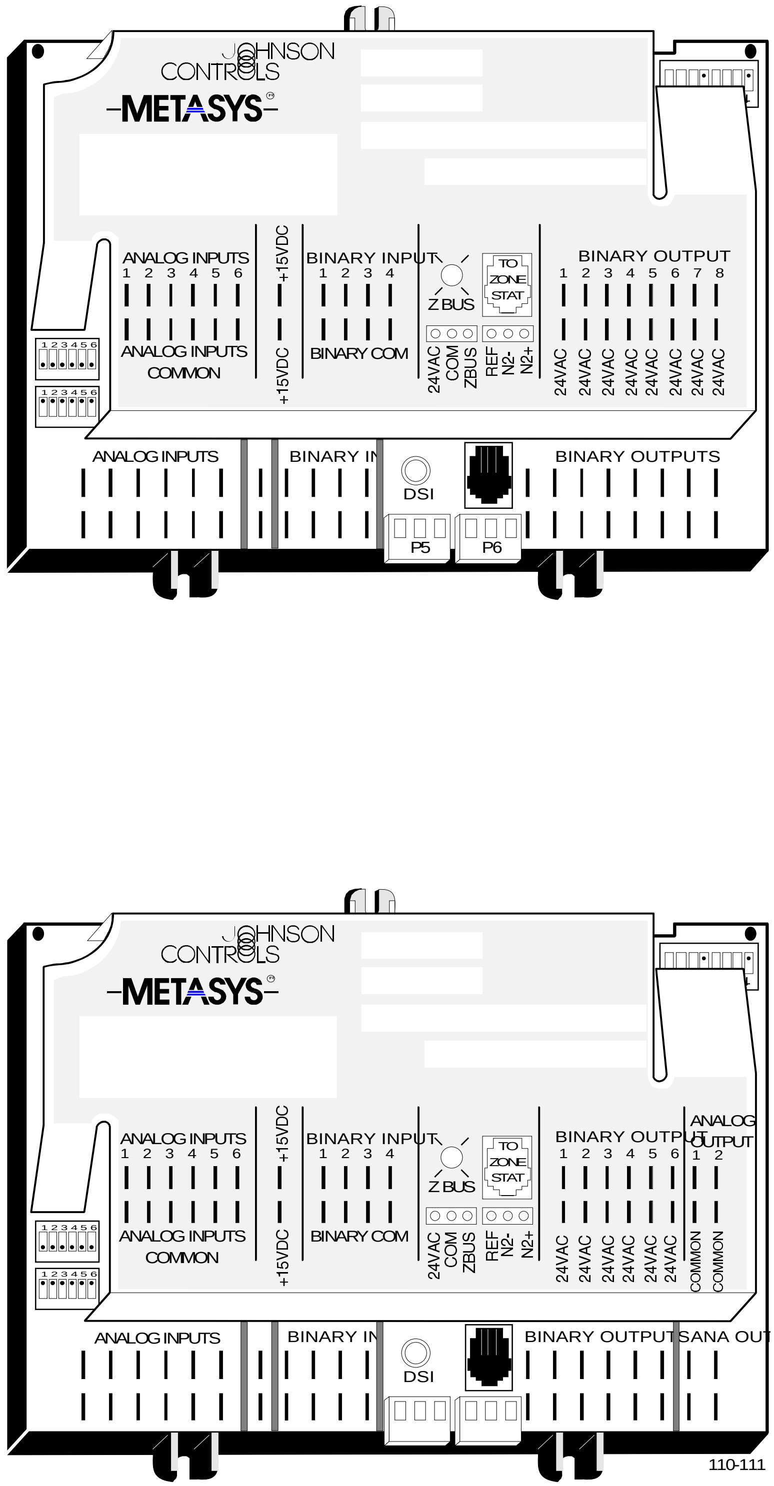


Figure 1: VAV110 (top) and VAV111 (bottom) Controller

Table 1: VAV Controller Model Features

Feature	VAV100/101 (Discontinued)	VAV110/111	VAV140/141
Ambient Temperature Rating	32 to 122°F (0 to 50°C)	32 to 122°F (0 to 50°C)	32 to 122°F (0 to 50°C)
Analog Inputs	6 RTD temperature elements (1000 ohm nickel, platinum, or silicon) 2k ohm setpoint potentiometers 0 to 10 VDC or 0 to 2 VDC transmitters	6 RTD temperature elements (1000 ohm nickel, platinum, or silicon) 2k ohm setpoint potentiometers 0 to 10 VDC or 0 to 2 VDC transmitters	6 RTD temperature elements (1000 ohm nickel, platinum, or silicon) 2k ohm setpoint potentiometers 0 to 10 VDC or 0 to 2 VDC transmitters
Binary Inputs	4 (4) Dry contacts (1) Momentary push button from zone sensor for temporary occupancy mode BI 4 may be used as an accumulator input for frequencies less than 100 Hz.	4 (4) Dry contacts (1) Momentary push button from zone sensor for temporary occupancy mode BI 4 may be used as an accumulator input for frequencies less than 100 Hz.	4 (4) Dry contacts (1) Momentary push button from zone sensor for temporary occupancy mode BI 4 may be used as an accumulator input for frequencies less than 100 Hz.
Analog Outputs	0/2 0 to 10 VDC @ 10 mA	0/2 0 to 10 VDC @ 10 mA	0/2 0 to 10 VDC @ 10 mA
Binary Outputs	8/6 24 VAC Triacs @ 0.5 amperes	8/6 24 VAC Triacs @ 0.5 amperes, or 0.8 amperes if total power is limited	8/6 24 VAC Triacs @ 0.5 amperes, or 0.8 amperes if total power is limited
N2 Bus	Not Isolated *	Isolated	Isolated
Zone Bus	Discrete connections at controller 8-pin phone jack on controller 6-pin phone jack at zone sensor	Discrete connections at controller 8-pin phone jack on controller 6-pin phone jack at zone sensor	Discrete connections at controller 8-pin **and** 6-pin phone jack on controller * 6-pin phone jack at zone sensor
		LED Indication *	LED Indication *
24 VAC Power Terminations	Quick Connects (Spade Lugs) *	Removable Screw Terminal Block	Removable Screw Terminal Block
I/O Terminations	Quick Connects (Spade Lugs)	Quick Connects (Spade Lugs)	Fixed Screw Terminal Block *
N2 Terminations	Fixed Screw Terminal Block *	Removable Screw Terminal Block	Removable Screw Terminal Block

* VAV Controller model feature differences

OEM Applications

When providing VAVs for projects which use Trane® or TITUS® terminal boxes, consider using the AS-VAVDPTx-1 product (refer to *Building VAVDPT Applications Application Note (LIT-6363042)* in the *Application Specific Controllers Technical Manual (FAN 636.3*). Trane and TITUS are both Original Equipment Manufacturers (OEMs) who provide VAV terminal boxes for projects. Trane typically provides the damper actuator with their terminal box, and TITUS provides the damper actuator with their QFPC Series Fan Powered Box. The VAVDPT comes in two models, which include a VAV Controller and a DPT-2015 Velocity Pressure Transducer. The DPT is mounted and prewired to the cover of the VAV. Refer to the *OEM Reference Manual (FAN 638)*.

Standards Compliance

The VAV Controller complies with the following standards:

- FCC Part 15, Subpart J, Class A
- UL 916 Listed
- IEEE 472, IEEE 518
- VDE 0871 Class B
- IEEE 587 Category A

Coordination of Factory Mounted VAV Systems

A factory mounted VAV box control system requires close coordination between a variety of different disciplines. Refer to the *OEM Reference Manual (FAN 638)* for factory manufacturer's details. Although the responsibilities may differ per city or region, the following parties are usually involved on the job:

- controls contractor
- mechanical contractor
- local VAV box manufacturer's representative
- balancing contractor
- electrical contractor

Typically, the mechanical contractor is the focal point for coordinating the entire process. The basic responsibilities under the domain of the mechanical contractor are:

1. Purchasing the VAV box system. Most specifications include the OEM mounting fees and enclosures for the control system in the mechanical contractor's price. Mounting fees vary per box manufacturer but ranges can be found in the *OEM Reference Manual (FAN 638)*.
2. Providing the release schedule for the VAV boxes to the job.
3. Contracting, or working closely with, the balancing contractor to ensure the system is set up per the mechanical prints.

   Note: The owner often directly hires the balancing contractor. This ensures neutrality in dealing with other contractors involved in the project.

In conjunction with the mechanical contractor, the controls contractor's responsibilities include:

1. Coordination of the control system release schedule to the box manufacturer to ensure the mechanical system delivery schedule can be met. Coordination with the local box manufacturer representative is normally required.
2. Coordination with the electrical contractor to ensure the following steps are covered.
   - 24 VAC power is provided at each VAV Controller.
   - N2 Bus wiring is pulled and terminated.
   - Valve actuator wiring is pulled and terminated.
   - Zone sensor cables are pulled. The use of phone cable for terminating zone sensor wiring allows basically anyone to terminate zone sensors in certain locales.
   - If desired, the N2 address switches can be set by the electrical contractor.
3. Initial loading of the HVAC PRO for Windows™ configuration files is done once the electrical contractor's functions are completed in preparation for the final system balancing.
4. Training of the balancing contractor to ensure the balancing contractor knows how to use the Zone Terminal (ZT) or HVAC PRO for Windows Commissioning mode so they can perform the final system balancing.
5. Mounting and terminating the cable connections for the zone temperature sensor. Set the N2 address switch if the electrical contractor was not contracted to perform this function.
6. Configuring, downloading, and commissioning the controller.

Configuring the Controller

Using HVAC PRO for Windows Configuration Tool

Use HVAC PRO for Windows to configure the VAV. VAV110/111 and VAV140/141 models require HVAC PRO for Windows. HVAC PRO for Windows also works with the VAV100/101 models. This easy-to-use software tool configures, commissions, and downloads the VAV Controller's data base.

Figure 2 illustrates the HVAC PRO for Windows configuration process. Refer to the *HVAC PRO for Windows User's Manual (FAN 637.5)* for specific information when configuring the VAV Controller.

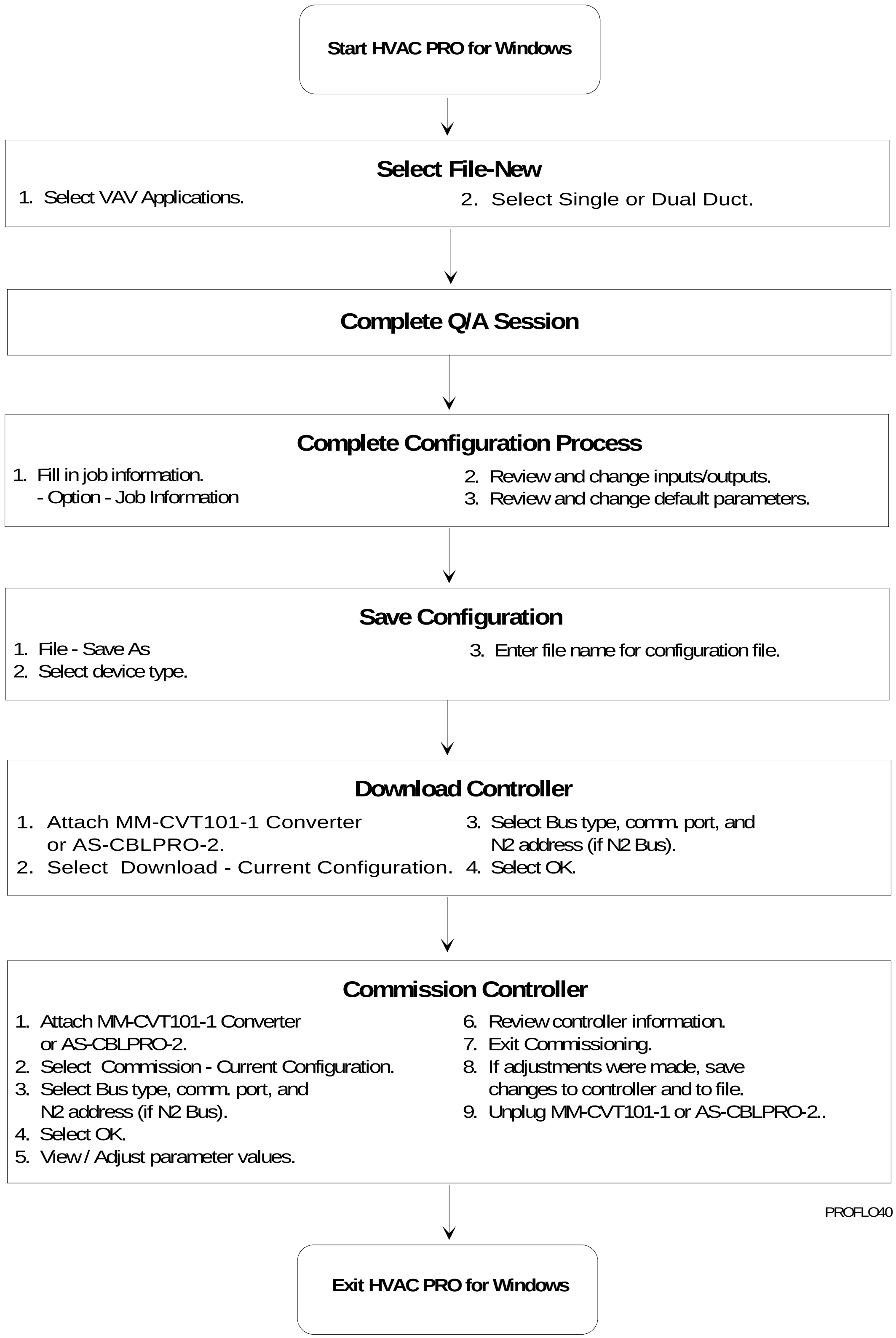


Figure 2: Steps in Configuring a VAV Controller Using HVAC PRO for Windows

Note: You can load and commission the controller either locally with the AS-CBLPRO-2 interface at the zone sensor (Figure 15) or from a central location where the N2 has been pulled, controller's field hardware addressed, and an MM-CVT101-1 interfaced to the laptop.

Defining a VAV Control Device Object in Metasys Software

Using a Metasys Network system, you need to define a VAV Controller device object by entering data into the Attribute menu as seen on the Operator Workstation.

1. Go to the Network Map.
2. Double-click the system name in which you want to add the new VAV object.
3. Click New in the Item pull-down menu.
4. Click on Type: N2 devices in the Item New dialog box.

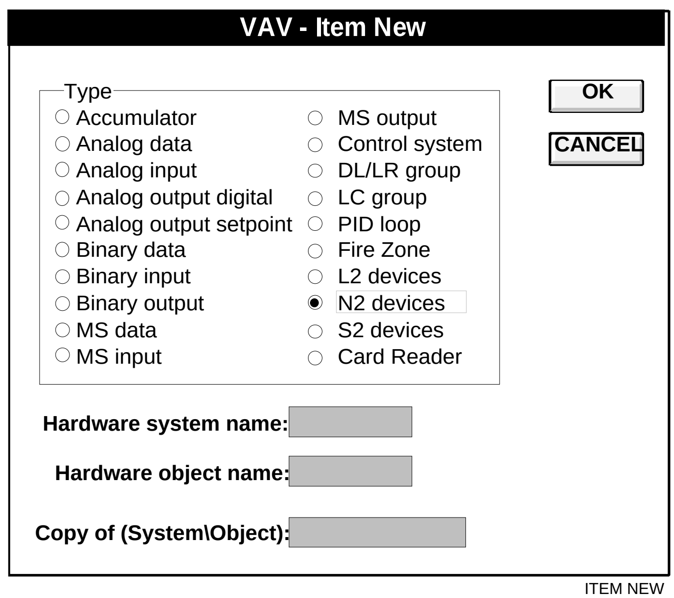


Figure 3: Item New Dialog Box

Note: The Hardware System and Hardware Object text fields are not used for this object type.

5. Click OK to display the Add N2 Device dialog box.

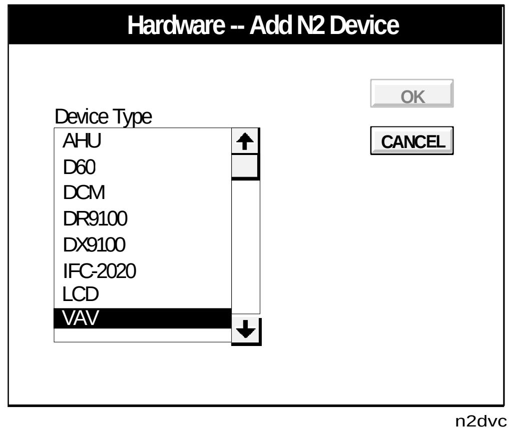


Figure 4: Add N2 Device Dialog Box

6. Highlight VAV.
7. Click OK to display the VAV Definition window (Figure 5).

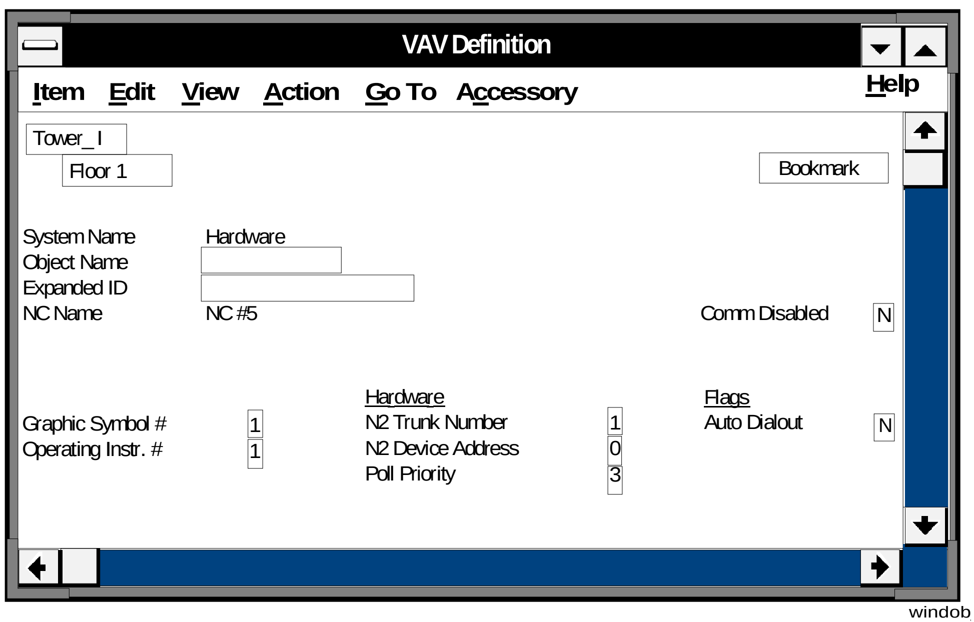


Figure 5: VAV Control Device Object Definition Window

Note that some of the fields in the window are blank and some are already filled in. You must fill in the blank attribute fields of required attributes. An N2 device address from 1 to 255 must also be specified. Attribute fields that are already filled in contain default values that may be accepted or changed.

Table 2 explains the blank attributes. The *Operator Workstation User's Manual (FAN 634)* describes the general procedures for entering and modifying data.

Table 2: Blank VAV Object Attributes

Attribute	Description	Entry Values . . .
Object Name	Identifies the object (i.e., ILC). The object name cannot be duplicated in the system.	1 to 8 alphanumeric characters
Expanded ID	Further identifies the object (i.e., LC Device 1)	0 to 24 alphanumeric characters (Optional)

8. To save the new VAV object, select Save from the Item pull-down menu. The object is added to the NCM data base.
9. Upload the NCM to make an archive copy of the new object following the instructions in the *Operator Workstation User's Manual (FAN 634),* the *Advanced User's Guide* tab, the *Uploading and Downloading Data Bases* chapter, the *Uploading from the NCM* section.

Modifying and Monitoring the VAV Object

Once you have defined the VAV object, you can modify or monitor its attribute values online using the VAV object Focus window. See the *Operator Workstation User's Manual (FAN 634)* for more information on using Focus windows.

Installation Procedures

Instructions for the installation of the VAV Controller and its accessory devices are detailed in this section. The types and numbers of components (sensors and actuators) selected for use with the VAV vary according to application. Analyze the proposed installation for logical places to locate these devices and draw up an inventory based on that study. Information on types of accessory devices available is in the *Ordering Information* section of this technical bulletin.

Most VAV installation should be coordinated with the VAV box manufacturer for factory mounting. The *OEM Reference Manual (FAN 638)* describes the steps and pricing to coordinate a factory mount solution.

Tools Needed

Tools needed for a typical installation include:

- HVAC PRO for Windows currently released software
- IBM® PC-compatible laptop computer
- Windows® 3.x or Windows 95
- two screwdrivers (1/8 in. and 1/4 in. flat-blade)
- AS-CBLPRO-2 (Zone Bus communication tool)
- MM-CVT101-0 (N2 Bus communication tool)
- AS-ZTU100-1 (Zone Bus interface to application specific controllers)

Environmental Information

The installation site of the VAV Controller must meet the following environmental standards.

- The atmosphere must be free of explosive vapors or escaping gases.
- The atmosphere must be free of exposure to corrosive chemical or salt vapors, which might damage electrical equipment.
- The temperature must be maintained between 32 to 122°F (0 to 50°C) with the relative humidity (non-condensing) maintained between 10 and 90%.
- The power line must be "clean," without electrical noise transients that are often present in industrial environments. Commercial and residential buildings typically have clean power, but may not, depending on the location, nearby equipment, etc. Follow the power line wiring transient noise precautions.

Mounting the Controller

Factory Mounting

Typically the most cost effective and highest quality installation of the VAV Controller, EDA-2040 Damper Operator, and DPT-2015 Velocity Pressure Transducer can be accomplished by the box manufacturer. The *OEM Reference Manual (FAN 638)* describes the relationship, pricing, and process to accomplish factory mounting of the VAV control system at most of the key box manufacturers.

If the job cannot be factory mounted, check with the VAV box manufacturer to determine if a control enclosure for the VAV Controller and Actuator/Velocity Pressure Transducer combination is already available on the VAV box. If there is not an available enclosure, the common packaging for the VAV Controller is an enclosure provided by the contractor or the Johnson Controls EN-EWC10, EN-EWC15, BZ1000, or AS-ENC enclosure. The controller requires a flat mounting surface area to match its dimensions:

- 6.5 x 6.4 x 2.2 in./165 x 163 x 56 mm (H x W x D) without enclosure
- 6.8 x 7.3 x 4.7 in./173 x 185 x 119 mm (H x W x D) with the AS-ENC100-0 enclosure
- 7 x 13 x 6 in./180 x 330 x 150 mm (H x W x D) with the EN-EWC10-0 and EN-EWC15-0 enclosure

Make sure you allow enough room to install the enclosure and conduit for wiring terminations to the controller. Figure 7 shows a common packaging configuration for the VAV Controller.

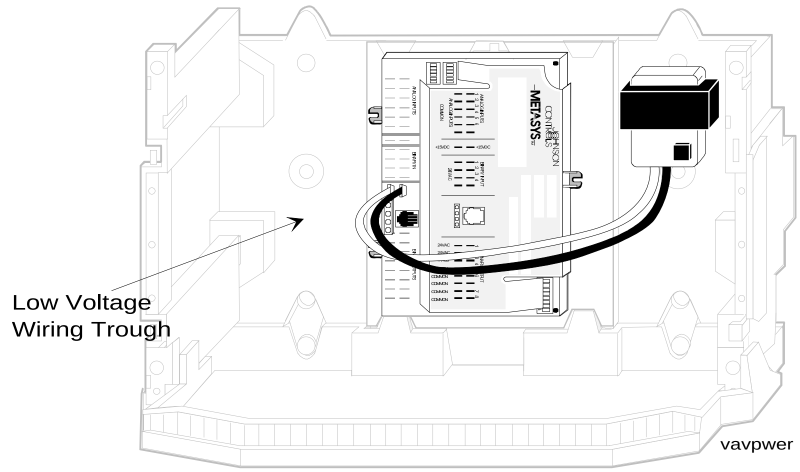


Figure 6: EWC10 Enclosure with VAV Controller and 50 VA Transformer

Mounting the VAV into a Universal Packaging Module

The VAV can be directly mounted into an EWC10/15 enclosure. You may also purchase the VAV premounted in a EWC10 enclosure with a 50 VA transformer. Refer to the *Application Specific Controllers Technical Manual (FAN 636.3)* for instructions on mounting the enclosure to a wall.

To mount the VAV in the EWC10:

1. Orient the VAV so that its terminals face the low voltage wiring trough (Figure 6).
2. Align the three mounting holes in the base of the controller with the holes in the back of the enclosure. On the side with four mounting holes, use the two outside holes for mounting in the EWC. See the *Universal Packaging Module Technical Bulletin (FAN 636.3)* for a more detailed explanation.
3. Secure the controller with three No. 8 x 1 in. screws. For best results, use a plastite-type thread. A thread-forming or sheet metal thread type may also be used.

Field Mounting

Position the controller (or controller's enclosure) on the mounting surface before installation to ensure the calculated mounting area is correct. You can make precise measurements for distance between controller terminals and sensor/actuator mounting points on the VAV terminal. Confirm electrical power source and conduit requirements prior to mounting.

You can install a VAV Controller into a control panel or an AS-ENC100-0 enclosure.

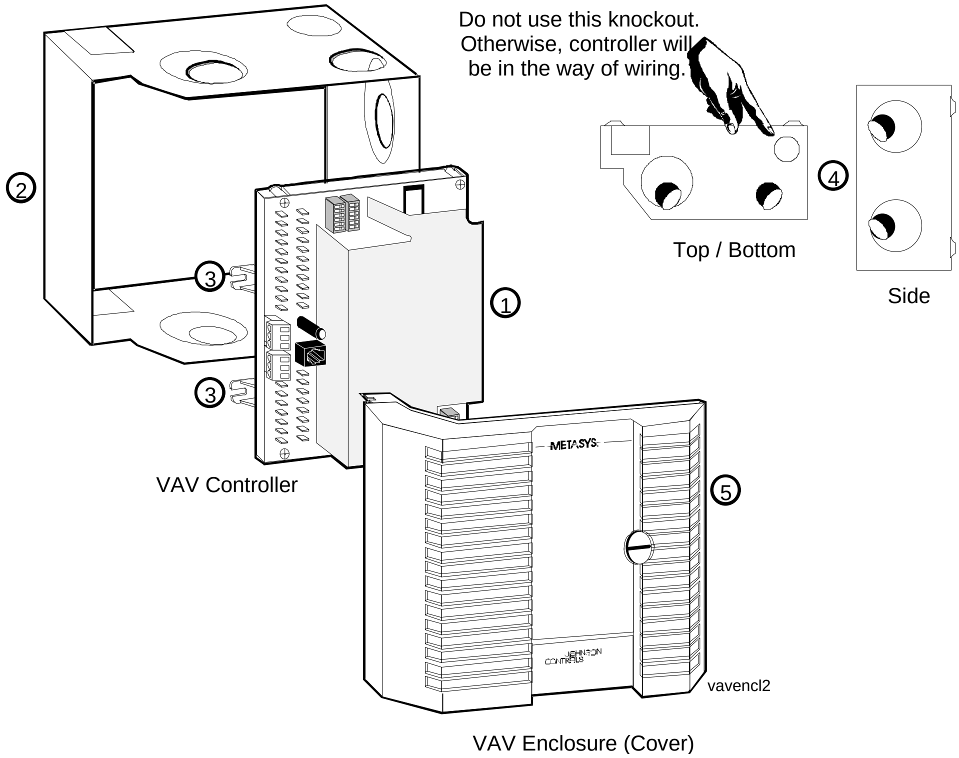


Figure 7: Installing the VAV Controller in an Enclosure Kit

Mount the VAV in any convenient location using the predrilled mounting holes. The controller must be mounted on a wall or panel where it can be easily wired through the enclosure cover. Mount the VAV vertically for best DPT (differential pressure transmitter) performance. The same instruction applies to remote location packages. Refer to Figure 7 when installing a VAV Controller.

1. Secure the VAV ✶ inside the enclosure kit ✸, using three screws through the mounting tabs ✹ on the sides of the controller board base.
2. Position the VAV and enclosure so that it rests firmly against the mounting surface.
3. Using a flat-blade screwdriver and pliers, remove the necessary wire passage knockouts ❊.

Note: Do not use knockouts on the opposite sides of enclosure, as you will not be able to remove the VAV board.

4. Attach the enclosure cover ⌖ after installing wiring.

Power Line Wiring Transient Noise Precautions

The standard VAV Controller, when powered by any typical separate isolation transformer or step-down transformer, operates reliably in an electrical environment defined as Location Category A by the IEEE 587 Standard, that is, when installed **more than 30 feet/9 meters** from electrical distribution panels or major bus and feeder systems in industrial plants.

IEEE 587 Location Category A power line surge/noise level is specified at 6 kV, 500A (Normal Mode Ringwave).

Surge Levels

In addition, the VAV Controller actually exceeds this category specification by meeting these surge levels as well:

IEEE-587 style Common Mode Pulse:	1.5 kV, 3 kA
IEEE-587 style Normal Mode Pulse:	3 kV, 3 kA
IEEE-472 style Common Mode Ringwave:	1.5 kV
IEEE-472 style Normal Mode Ringwave:	500V

You must take further precautions to prevent unwanted Binary Output cycling or other possible controller malfunctions, such as resetting, when the controller is installed within 30 feet/9 meters of electrical distribution panels or major bus and feeder systems in industrial plants. This electrical environment is defined as Location Category B by the IEEE 587 Standard.

To prevent electrical noise from adversely affecting the controller:

1. Connect an MOV (Metal Oxide Varistor) across the VAV supply transformer primary. The MOV must be rated appropriately for the line voltage.
2. Use the list in Table 3 to select the correct MOV sold through your electronics parts distributor.

The VAV Controller meets the following power line surge/noise standards when you correctly apply the MOV as described.

IEEE-577	Common Mode Pulse	1.5 kV, 3 kA
	Normal Mode Pulse	6 kV, 3 kA
	Normal Mode Ringwave	6 kV, 500A
IEEE-472	Common Mode Ringwave	1.5 kV
	Normal Mode Ringwave	500V

Table 3: MOV Selection

	Power Transformer Primary Voltage			
	120 VAC	**208 to 240 VAC**	**277 VAC**	**347 VAC**
Minimum Continuous Voltage Rating	130 to 135 VRMS	250 to 280 VRMS Only 250V types listed	300 to 320 VRMS	385 VRMS
Minimum Energy Rating	30 Joules	55 Joules	80 Joules	85 Joules
Minimum Peak Current (8 x 20 second pulse)	4,000 Amperes	4,000 Amperes	4,000 Amperes	4,000 Amperes
UL Recognized	Required	Required	Required	Required
Harris	V130LA10A V130LA20A* V130LA20B*	V250LA20A V250LA40A* V250LA40B*	None	None
Iskra	V130K14 V130K20*	V250K14 V250K20*	V300K14 V300K20*	V385K14 V385K20*
Malda	D6321ZOV131RA15* D6521ZOV131RA20* D6921ZOV131RA09	D6321ZOV251RA90* D6521ZOV251RA130* D6921ZOV251RA72	D6321ZOV301RA105* D6521ZOV301RA150* D6921ZOV301RA80	None
Mallory®	VSAC14DK201U VSAC20DK201U*	VSAC14DK391U VSAC20DK391U*	VSAC14DK471U VSAC20DK471U*	VSAC14DK621U VSAC20DK621U*
Marcon	TNR15G211KM TNR23G201KM* TNR23G211KM*	TNR15G391KM TNR23G391JM* TNR23G391KM*	TNR15G471K TNR23G471K*	None
Oneida® (CKE)	OZ130LA10A OZ130LA20A* OZ130LA20B* OZ21L221 0216NR14-3 0216NR20-4*	OZ250LA20A OZ250LA40A* OZ250LA40B*	OZ21L471	None
Panasonic	ERZ-C14DK201U ERZ-C20DK201U*	ERZ-C14DK391U ERZ-C20DK391U*	ERZ-C14DK471U ERZ-C20DK471U*	ERZ-C14DK621U ERZ-C20DK621U*
Phillips	2322-595-51316	2322-595-52516	2322-595-53016	2322-595-53816
Siemens	S14K130 S20K130*	S14K250 S20K250*	S14K300 S20K300*	S14K385 S20K385*
Stetron	0216NR14-3 0216NR20-4* 0216NR20DB*	0390NR14-3 0390NR20-4* 0416NR14-3 0416NR20-4*	0620NR14-3 0620NR20-4*	0620NR14-3 0620NR20-4*
Thomson	VE17M00131K VD24M00131K	VE17M00251K VD24M00251K	VE17M00301K VD24M00301K	None

* Indicates the preferred model if several are listed.

I/O and Communication Lines Wiring Transient Noise Precautions

The I/O wiring and N2 Bus must be clean, without electrical noise transients from nearby lightning, heavy equipment switching, or inductive loads being driven.

For the N2 Bus, the Transient Eliminator®, model TE/JC04C12, made by Advanced Protection Technologies (APT) is recommended. Refer to the *Metasys Network Technical Manual (FAN 636),* the *N2 Communications Bus Technical Bulletin (LIT-636018)* for more information.

Wiring Details

Take special precautions and follow certain grounding procedures when installing the VAV Controller.

> ⚠ CAUTION: **Possible Equipment Damage or Electrical Shock**. To avoid damaging equipment or possible electrical shock, ensure that all power supplies to the system have been disconnected prior to wiring installation. The CMOS (Complimentary Metal Oxide Semiconductor) circuits used in the controller are static sensitive. Use static protection (anti-static mats and/or grounding straps) when working on or near internal circuitry.

Follow these precautions:

- Make all wiring connections in accordance with the National Electrical Code (NEC) as well as within local regulations.
- Locate equipment and route the wiring so that signal wiring is twisted pair, and separated from power wiring to the maximum extent possible. To establish tight, reliable electrical connections, use the correct wire sizes for the terminals.
- Make all wiring connections to the VAV Controller using only copper conductors.
- The N2 must be daisy-chained. The use of Y or T connections without a repeater installed in the T tap may cause loss of communications.
- Do not run N2 Bus, Zone Bus, Analog Input (AI), Binary Input (BI), or Binary Output (BO) wiring in the same conduit as line voltage wiring (above 30 VAC), or with wiring that switches power to highly inductive loads such as contactors, coils, motors, or generators.
- Do not run non-shielded N2 Bus wiring in the same conduit or bundle as 24 VAC power wiring.
- You may run Zone Bus, Analog Input, Analog Output, and Binary Input wiring in the same bundle or conduit where convenient. If the Binary Output wiring is not wired through other switches or contacts, you may also bundle it with the other I/O wiring where convenient.

Power Source and Loads

Use a separate isolation transformer or step-down transformer for each VAV Controller. Refer to *Standards Compliance* in the *Introduction* section of this technical bulletin. The power transformer used must comply with:

- CSA 22.2 No. 205
- NEMA ICS 2, Part 2, 230

Limit the power to each VAV to 3 amperes or less. However, if you use one low voltage power trunk to power multiple controllers, follow these precautions:

- Ensure polarity is maintained at each 24 VAC connection.
- As per NEC code, you must enclose 24 VAC power trunks with greater than 4 amperes (100 VA) in conduit.

Note: See NEC Article 725/Class 2 (30 VRMS Max) and (100 VA Max).

Any individual binary output (triac) can drive up to 800 mA when you limit the total 24 VAC power draw. You must limit the power draw of a controller and its load to avoid heat dissipation problems. You must limit the total 24 VAC power draw of a VAV Controller installed in an enclosure to a maximum of 40 VA. You must limit the total 24 VAC power draw of a VAV Controller mounted in an open air environment to a maximum of 75 VA.

When you determine the system load, consider all the actual loads as well as the basic load of the controller. The following tables assist you in determining the total 24 VAC power draw of your system.

Table 4: VAV Power and Load Specifications

System Loads	Power Draw
VAV Controller with sensors/transmitters	10 VA (400 mA)
BO Load Relay, Contactor, Solenoid, Incremental Actuator* Maximum allowable load for any individual binary output (triac) is 19 VA** (800 mA at 24 VAC) Minimum required load for each binary output (triac) used is 1.2 VA (50 mA at 24 VAC) Note: Relay loads less than 50 mA may cause triac/relay chattering. If necessary, use a 1000 ohm 2W resistor across the binary output.	Refer to specific product documentation.
AO Load Actuator Maximum allowable load for each AO is 10 mA with a minimum load resistance of 1000 ohm.	Refer to Table 5.
Zone Terminal or CBLPRO	1.2 VA (50 mA)

*Actuator VA requirements are found in Table 5.
**With total controller power draw limited as described previously.

Table 5: Actuator VA Requirements

Actuator	Type	VA Requirements for 24 VAC Supply
EDA-2040 (ATP-2040)	Incremental	3 VA
VA-7150	Incremental	2.7 VA
VA-7200	Incremental	5.5 VA
VA-8020	Incremental	4 VA
VA-8050	Incremental	6 VA
J Series Electric Zone Valve	On-Off	7 VA
M9100-A, M9200-A	Floating	6.5 VA
M9100-G, M9200-G	Proportional (Voltage or Current)	6.5 VA
VA-7152	Voltage (0 to 10 VDC)	4.7 VA
VA-7202	Voltage (0 to 10 VDC)	7.5 VA
VA-8022	Voltage (0 to 10 VDC)	4 VA
VA-8052	Voltage (0 to 10 VDC)	6 VA

Grounding and Isolation

VAV100/101

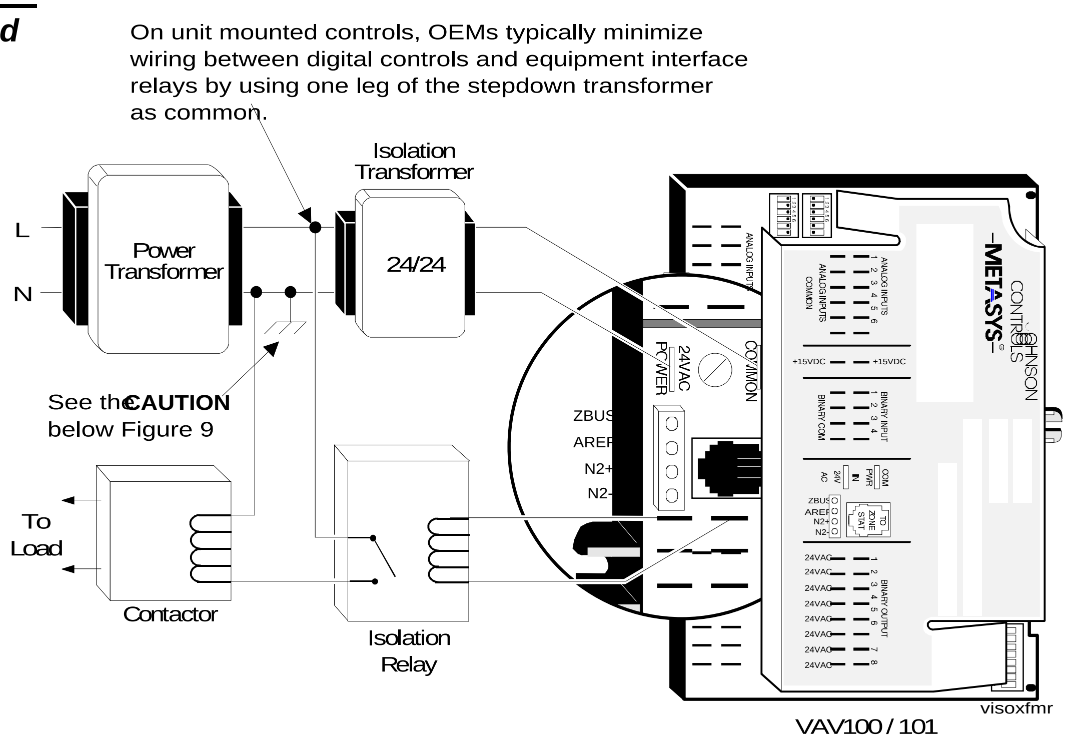


Figure 8: Transformer and Relay Isolation Wiring Diagram for Series 100/101 VAV Controllers

All VAV100/101 connections must be isolated from earth ground to protect the CBLPRO, laptop PC, or other system components from damage. Due to OEM system designs and/or electrical codes, the VAV may become earth grounded unless you take isolation measures. Typically, the VAV box manufacturer supplies a step-down isolation transformer as part of their mounting service.

CAUTION: **Potential Equipment Damage and Improper Functioning.** Do not earth ground the 24 VAC high side of the VAV's transformer or any of the VAV's BO terminals. If you do, the VAV's N2 Bus communications will cycle online and offline. You will also damage all of the interface components that are connected, including the CBLPRO, laptop PC, Companion PC, and MM-CVT101.

Depending on the primary voltage of the power transformer and the prevailing electrical code, the 24 VAC secondary might be earth grounded. Earth ground on one side of the secondary destroys hardware by creating a short circuit path through the CBLPRO and laptop PC serial card during a download. Earth ground on either side of the secondary can disrupt the isolation required for N2 communication integrity.

N2 Bus Isolation VAV 100/101

The box manufacturer supplies fan or electric heat relays that might also be earth grounded. This also disrupts the isolation required for N2 communication integrity.

Note: The *Troubleshooting* section of this technical bulletin contains a detailed process that will reduce installation errors by ensuring proper isolation.

Power Transformer Isolation VAV100/101

If the secondary of the power transformer is grounded, you must use a separate 24 VAC to 24 VAC isolation transformer such as the Y65GS (see Figure 8).

Load Isolation VAV100/101

If VAV output loads are grounded, such as a driven contactor or solenoid coil, you must use a separate isolation relay for each load (see Figure 8).

VAV110/111 and VAV140/141

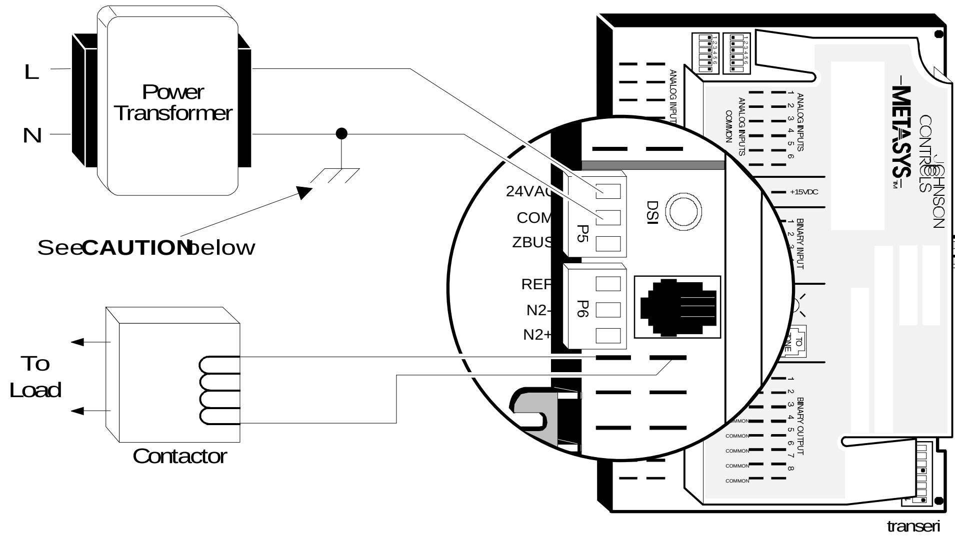


Figure 9: Transformer Wiring Diagram for Series 110/111 VAV Controllers

> CAUTION: Some local electric codes require the secondary common of stepdown transformers be connected to earth ground (typically on units powered by more than 150 VAC). You may have a maximum of **one** single earth ground connection, which **must** be at the transformer secondary common, whether one or multiple controllers are powered by the same transformer

Power Transformer Isolation VAV110/111 and VAV140/141

You may connect the Series VAV110/111 and VAV140/141 power transformer secondary directly to earth ground. If you elect to do so, the grounded side must connect to the Common power input terminal of the controller. You do not need a separate isolation transformer for these controllers.

Load Isolation VAV110/111 and VAV140/141

If VAV output loads such as contactor or solenoid coils are grounded, you must use a separate isolation relay for each load.

I/O and Communication Terminals

The VAV terminal designations, which identify sensor, actuator, and power connection points, are illustrated in Figures 10 through 12 and Tables 6 through 8. Use the HVAC PRO for Windows Configuration Tool to assign the inputs and outputs for a specific application. The *filename*.PRN file identifies these connections after you assemble the configuration.

You may make connections to the VAV by connecting single wires to the individual screw or spade terminals.

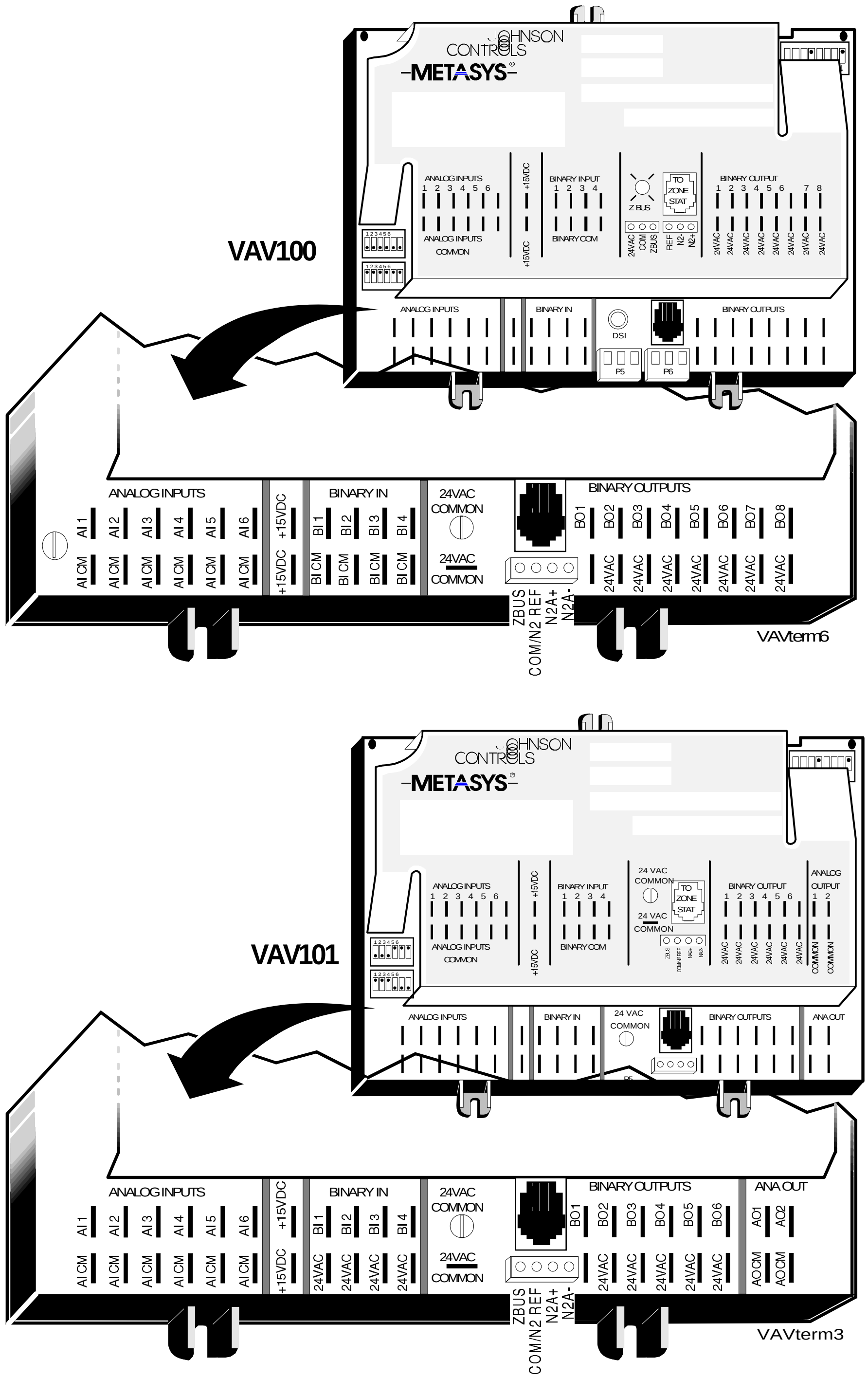


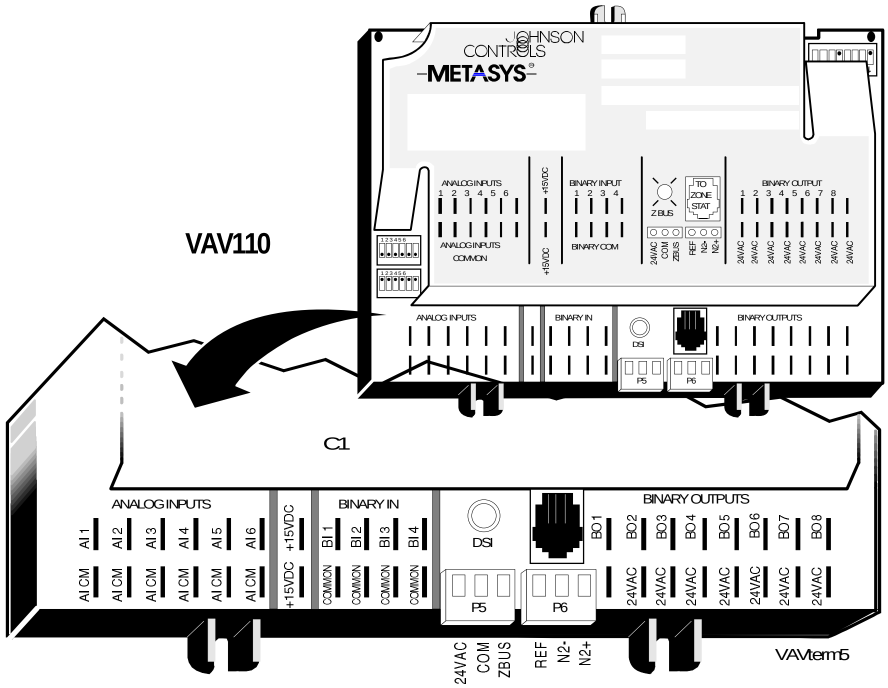
Figure 10: VAV100/VAV101 Terminal Designations

Table 6: VAV100/101 Terminal Identification

Series 100/101 Controller			
Terminal	**Description**	**Terminal**	**Description**
AI COM	Analog Input Common	**AI 1**	Analog Input 1
AI COM	Analog Input Common	**AI 2**	Analog Input 2
AI COM	Analog Input Common	**AI 3**	Analog Input 3
AI COM	Analog Input Common	**AI 4**	Analog Input 4
AI COM	Analog Input Common	**AI 5**	Analog Input 5
AI COM	Analog Input Common	**AI 6**	Analog Input 6
+15 VDC	+15 Volts DC	**+15 VDC**	+15 Volts DC
BI CM	Binary Input Common	**BI 1**	Binary Input 1
BI CM	Binary Input Common	**BI 2**	Binary Input 2
BI CM	Binary Input Common	**BI 3**	Binary Input 3
BI CM	Binary Input Common	**BI 4**	Binary Input 4
24 VAC POWER	Transformer High Side	**24 VAC COMMON**	Transformer Low Side
ZBUS	Zone Bus	**AREF**	N2 Reference and ZBus Common
N2A+	N2 Bus +	**N2A–**	N2 Bus –
24 VAC	24 Volts AC	**BO 1**	Binary Output 1
24 VAC	24 Volts AC	**BO 2**	Binary Output 2
24 VAC	24 Volts AC	**BO 3**	Binary Output 3
24 VAC	24 Volts AC	**BO 4**	Binary Output 4
24 VAC	24 Volts AC	**BO 5**	Binary Output 5
24 VAC	24 Volts AC	**BO 6**	Binary Output 6
24 VAC/AOCM*	24 Volts AC/ AO Common	**BO 7/AO 1***	Binary Output 7/ Analog Output 1
24 VAC/AOCM**	24 Volts AC/ AO Common	**BO 8/AO 2****	Binary Output 8/ Analog Output 2

***** VAV100 has eight BOs.

****** VAV101 has six BOs and two AOs.



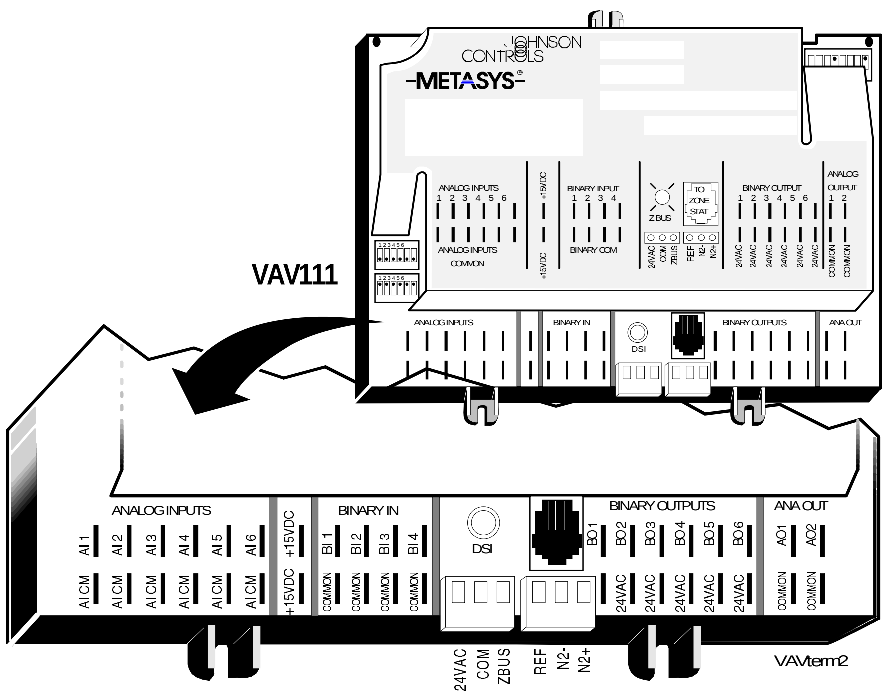


Figure 11: VAV110/VAV111 Terminal Designations

Table 7: VAV 110/111 Terminal Identification

Series 110/111 Controller			
Terminal	**Description**	**Terminal**	**Description**
AI CM	Analog Input Common	**AI 1**	Analog Input 1
AI CM	Analog Input Common	**AI 2**	Analog Input 2
AI CM	Analog Input Common	**AI 3**	Analog Input 3
AI CM	Analog Input Common	**AI 4**	Analog Input 4
AI CM	Analog Input Common	**AI 5**	Analog Input 5
AI CM	Analog Input Common	**AI 6**	Analog Input 6
+15 VDC	+15 Volts DC	**+15 VDC**	+15 Volts DC
BI CM	Binary Input Common	**BI 1**	Binary Input 1
BI CM	Binary Input Common	**BI 2**	Binary Input 2
BI CM	Binary Input Common	**BI 3**	Binary Input 3
BI CM	Binary Input Common	**BI 4**	Binary Input 4
24 VAC POWER	Transformer High Side		
COMMON	Transformer Low Side		
ZBUS	Zone Bus		
REF	N2 Reference		
N2-	N2 Bus -		
N2+	N2 Bus +		
24 VAC	24 Volts AC	**BO 1**	Binary Output 1
24 VAC	24 Volts AC	**BO 2**	Binary Output 2
24 VAC	24 Volts AC	**BO 3**	Binary Output 3
24 VAC	24 Volts AC	**BO 4**	Binary Output 4
24 VAC	24 Volts AC	**BO 5**	Binary Output 5
24 VAC	24 Volts AC	**BO 6**	Binary Output 6
24 VAC/AO CM	24 Volts AC/AO Common	**BO 7/AO 1**	Binary Output 7/ Analog Output 1
24 VAC/AO CM	24 Volts AC/AO Common	**BO 8/AO 2**	Binary Output 8/ Analog Output 2

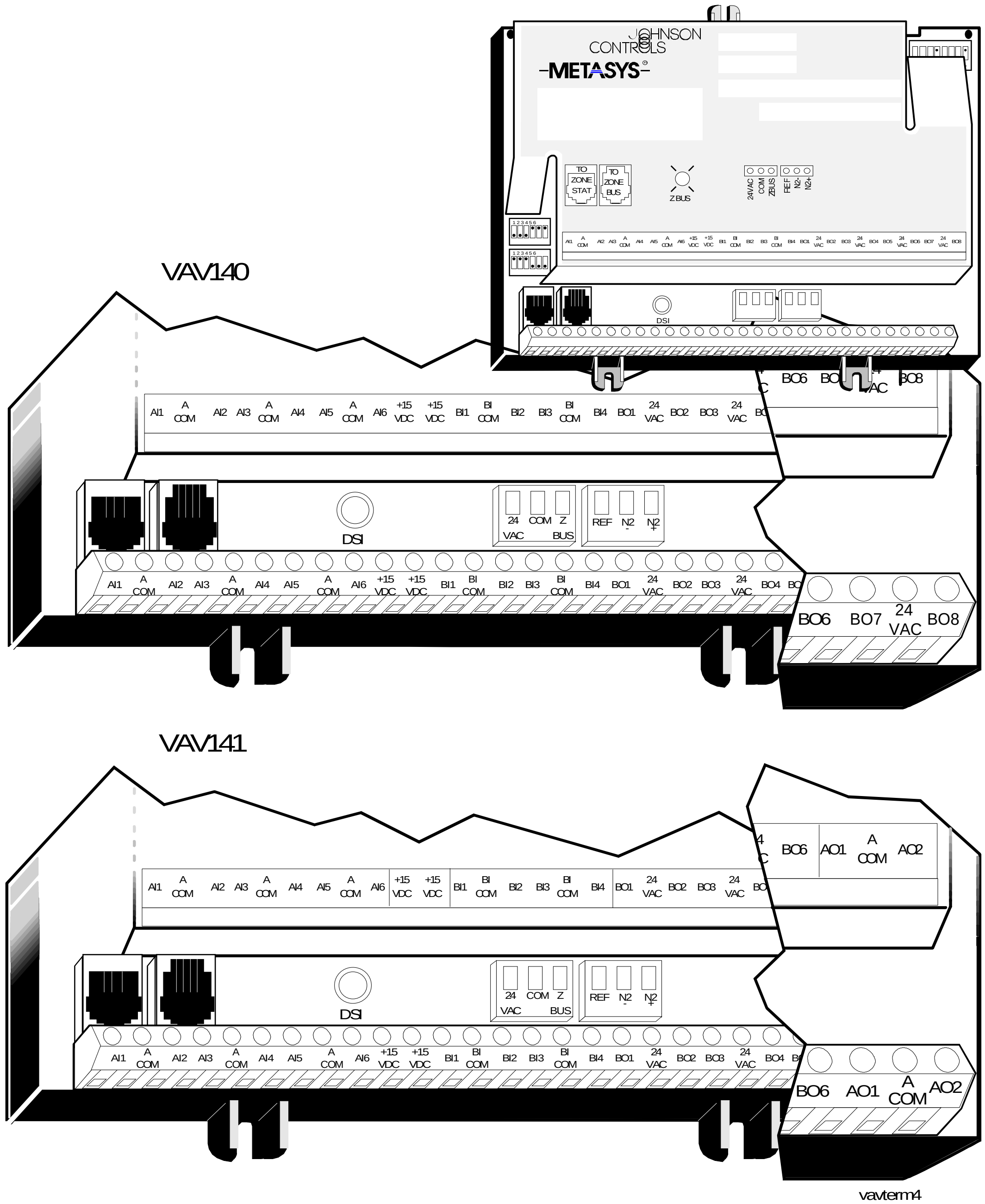


Figure 12: VAV140 and VAV141--Terminal Strip Models

Table 8: Series 140/141 Controller

Terminal	Description
AI1	Analog Input 1
A COM	Analog Input Common
AI2	Analog Input 2
AI3	Analog Input 3
A COM	Analog Input Common
AI4	Analog Input 4
AI5	Analog Input 5
A COM	Analog Input Common
AI6	Analog Input 6
+15 VDC	+15 Volts DC
+15 VDC	+15 Volts DC
BI1	Binary Input 1
BI COM	Binary Input Common
BI2	Binary Input 2
BI3	Binary Input 3
BI COM	Binary Input Common
BI4	Binary Input 4
BO1	Binary Output 1
24 VAC	24 Volts AC
BO2	Binary Output 2
BO3	Binary Output 3
24 VAC	24 Volts AC
BO4	Binary Output 4
BO5	Binary Output 5
24 VAC	24 Volts AC
BO6	Binary Output 6
BO7/AO1	Binary Output 7/Analog Output 1
24 VAC/A COM	24 Volts AC/Analog Output Common
BO8/AO2	Binary Output 8/Analog Output 2
24 VAC	24 VAC Power–Transformer High Side
COM	Common–Transformer Low Side
Z Bus	Zone Bus
REF	N2 Reference
N2-	N2 Bus -
N2+	N2 Bus +

Power, Zone Bus, and N2 Connections

The 24 VAC power connection to VAV100/101 is at the quick connects identified as 24 VAC Power and Common. The 24 VAC power connection to VAV110/111 or VAV140/141 is at the far left two positions of the 3-position screw terminal block. The removable terminal block also allows you to disconnect power to the VAV without disrupting the 24 VAC that is daisy-chained to other controllers.

Zone Bus may be hard-wired to the VAV Controller instead of using the phone jack as described later in this technical bulletin. The Zone Bus connection to VAV100/101 is at the far left position of the 4-position terminal block identified as ZBUS/COM-N2 REF/N+/N2-. The Zone Bus connection to VAV110/111 or VAV 140/141 is at the far right position of the 3-position screw terminal block identified as 24 VAC/COM/ZBUS. For all VAVs, the other side of the two wire Zone Bus, the common side, may be connected to any available Common terminal.

The N2 connection to VAV100/101 is at the 4-position screw terminal block identified as ZBUS/COM-N2 REF/N2+/N2-. The N2 connection to VAV110/111 or VAV140/141 is at the 3-position screw terminal block identified as REF/N2-/N2+. The N2 screw terminal block is removable to allow you to disconnect the communication trunk without disrupting the N2 that is daisy-chained to other controllers.

Analog Inputs

The six analog input terminals, their power supply, and their common points occupy the terminal strip. These inputs may be of two types: resistive or voltage. The VAV Controller processes and controls the configured control strategy. It reads the analog inputs through the analog input DIP switches located directly above the analog input terminals.

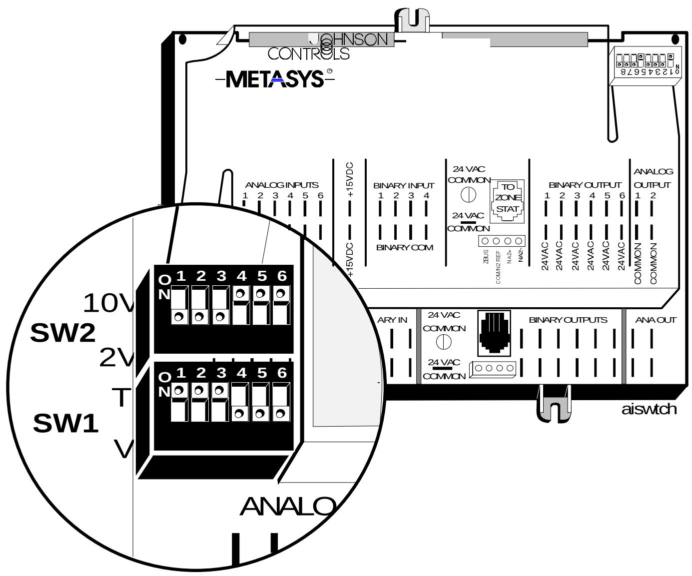
You use these switches and HVAC PRO for Windows to select the type of analog input. Use T for all RTD temperature sensors and setpoint potentiometers. Use 10V for DPT-2015 differential pressure transmitters. For 3-wire voltage transmitters such as the DPT-2015 Series, use the 15 VDC power supply terminals next to the inputs for AI 6. You can source 90 mA from 15V supply. The following table shows each configuration.

Table 9: Analog Input Configurations

AI Type	Range	Switch Position-Set SW1	SW2
Voltage (V)	0 to 2 VDC	V	2 V
Voltage (V)	0 to 10 VDC	V	10 V
Resistance	(T)1000 ohm Nickel, Platinum, Silicon, 2k Potentiometer	T	2 V
Slaving	(T)1000 ohm Nickel, Platinum, Silicon, 2k Potentiometer	V	2 V

The VAV Controller has two sets of DIP switches. One set is for configuring the analog input points, and the other for setting the address of the controller. Use Tables 9 and 10 to set the SW1 and SW2 analog input DIP switches.

Refer to the *Networking the Controller* section of this technical bulletin for instructions on setting the N2 address DIP switches.



Analog Input Switches

Figure 13: Setting the Analog Input DIP Switches

The AI switches are factory set with AI 1, 2, and 3 as resistive inputs and AI 4, 5, and 6 as 0 to 10 VDC inputs. However, you may configure them to any combination. Use the following table to set the switches. For example, if you connect a 10 VDC input to AI 4, set SW1-4 to Off and SW2-4 to On.

Table 10: Analog Input DIP Switch Settings

Hardware Point	Switch		Temperature (Resistive Input)		2 VDC (0 to 2 VDC Input)		10 VDC (0 to 10 VDC Input)	
AI 1	SW1-1	SW2-1	ON	OFF	OFF	OFF	OFF	ON
AI 2	SW1-2	SW2-2	ON	OFF	OFF	OFF	OFF	ON
AI 3	SW1-3	SW2-3	ON	OFF	OFF	OFF	OFF	ON
AI 4	SW1-4	SW2-4	ON	OFF	OFF	OFF	OFF	ON
AI 5	SW1-5	SW2-5	ON	OFF	OFF	OFF	OFF	ON
AI 6	SW1-6	SW2-6	ON	OFF	OFF	OFF	OFF	ON

Binary Inputs

There are four dry contact binary inputs on the controller. They are located in the center of the terminal strip. The VAV Controllers have an available momentary binary input option. This input is connected at the zone sensor input to initiate a temporary occupancy or boost mode of operation.

The binary inputs on the VAV Controllers are inactive when open. They are active when a contact closure to BI Common is applied. BI 4 may be used as an accumulator input for frequencies less than 100 Hz.

Binary Outputs

There are six or eight binary outputs (depending on the selected model) on the controller. Binary outputs are triacs on the controller hardware. These outputs switch the transformer's **low side** (or common) to the output.

Each binary output must be connected between the BO terminal and 24 VAC terminal since it is low side switching.

IMPORTANT:	**Chattering Relays Driven by Binary Outputs.** Chattering may occasionally occur in relays from manufacturers other than Johnson Controls due to a low load condition across the binary output triac. The chattering relays are audible, and arcing may be visible at the contacts. The minimum holding current for the triac is 50 mA. To eliminate chattering, use a 360 ohm, 5W resistor across the binary output, or use the AS-RLY100-1 Relay Kit. There have been a few instances where loads have met the 50 mA current requirement, but still chattered. To date, the exceptions are Honeywell® damper actuator (Model ML6161) and Finder relay (Model 60.12). In these instances we recommend a 1000 ohm, 2W resistor in parallel across the load.

Analog Outputs

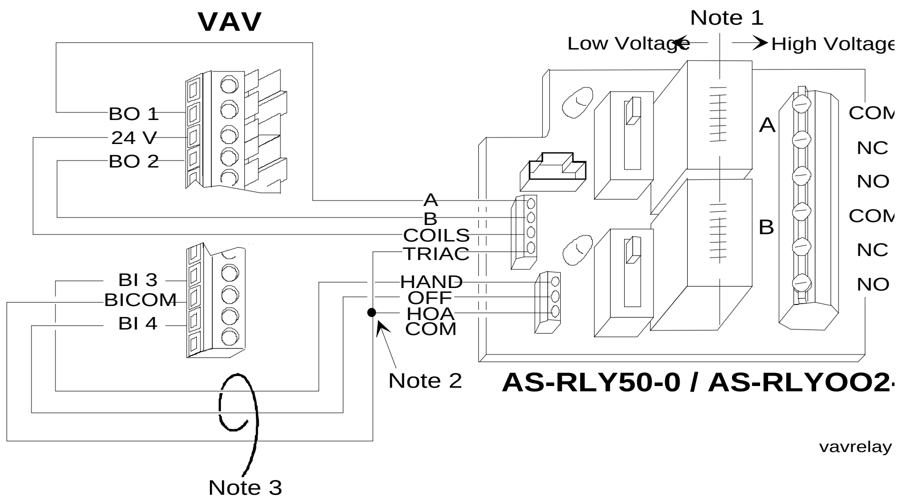
There are two analog outputs on the VAV101, VAV111, and VAV141 Controller. The load is connected between the analog output and analog output common terminals. Each output is controlled to generate a proportional voltage output of 0 to 10 VDC to common. The maximum load for each output is 10 mA with a minimum load resistance of 1000 ohm.

Zone Bus

The Zone Bus allows you to connect CBLPRO or the Zone Terminal to the VAV Controller. With CBLPRO connected, use HVAC PRO for Windows for commissioning downloading and uploading. The Zone Bus is available for connection at Metastat™ or a zone temperature sensor.

Wiring to RLY50/002 Relays

Connect power to the relay module and the transformer through the conduit knockouts in each box. Wire the module according to the following diagram, an example of a VAV140/141 wired to an RLY50/002. All BOs must be isolated from earth ground. VAV110/111 connections are similar.



Note 1: Separate low voltage and line wiring with line voltage on the right.

Note 2: Hand operation using the H-O-A (Hand-Off-Auto) switch requires 24 VAC to the COILS terminal and COM to the TRIAC terminal to energize the relay.

Note 3: The Hand or Off position signals the binary input connected to those terminals. These switches can be hardwire "OR"ed and connected to one BI. This switch uses the HOA COM terminal, which is isolated from the relays.

Note 4: Choose BIs desired for H-O-A feedback.

Figure 14: VAV140/141 Wired to RLY50/002

CAUTION: **Possible Equipment Damage or Electrical Shock**. Disconnect power circuit before wiring Relay Kit.

You can obtain a DPDT (Double-Pull, Double-Throw) relay configuration by connecting the BO signal to two terminals on the Relay Kit terminal block (e.g., B and C).

If you require a phone jack at a remote RLY kit, add an AS-CBLCON-0.

For additional information, refer to the *Grounding and Isolation* section of this technical bulletin.

Wiring Sensors and Actuators

Use 18 AWG/1.5 mm^2 twisted pair wire for all sensor and output wiring. Shielding is not required but, if used, earth ground the shield at the transformer or the controller. You may use 24 AWG/0.6 mm diameter wire in some applications. However, the length of wire is reduced due to the resistance. To minimize sensor error caused by field wiring, the total resistance of all resistive sensor wiring should be less than 3 ohm.

CAUTIONS: **Potential Controller Malfunctioning.**

..Do not run AI, BI, AO, BO, ZBus, or N2 Bus wiring in the same conduit as wiring carrying
30 VAC or more.

Do not run AI, BI, AO, BO, ZBus, or N2 Bus wiring in the same conduit as wiring that switches power to highly inductive loads (such as contactors, coils, motors, or generators).

Table 11: Sensor Wire Sizes and Lengths

Sensor Type	Run Length		Wire Size	
	Feet	Meters	AWG	mm^2
AI Temperature	500	150	18	1.5
AI Voltage	500	150	18	1.5
BI Voltage/Contact	500	150	24 to 18	0.6 mm diameter to 1.5 mm^2
Single BO at 0.1 ampere	500	150	18	1.5
Single BO at 0.5 ampere	100	30	18	1.5
Zone Bus	500	150	18	1.5
Zone Thermostat	100*	30*	Eight conductor phone cable	Eight conductor phone cable

* Note: If an AS-CBLPRO-1 and a Zone Terminal are used, the cable length must be limited to 50 feet/15 meters.

Input and Load Impedances

Table 12: Input and Load Impedances

Function	Range	DC Input Impedance	Sensor or Load Impedance
AI Voltage	0-2 VDC	470k ohm	0-5k ohm
AI Voltage	0-10 VDC	128k ohm	0-5k ohm
AI Temp/Pot	1000 ohm Si, Ni, Pt, or 0-2k ohm potentiometer	3540 ohm	0-2k ohm
BI DC Sense	0-15 VDC, 2.5V Trig	47k ohm	0-5k ohm
AO Voltage	0-10 VDC @ 10 mA maximum	N/A	1K-10M ohm
BO AC Triac	24 VAC @ 50-800 mA*	N/A	*30-480 ohm

DC Supply Out	14.6-17 VDC @ 90 mA	N/A	162-10M ohm

* With total controller power draw limited as described previously.

Temperature Sensors

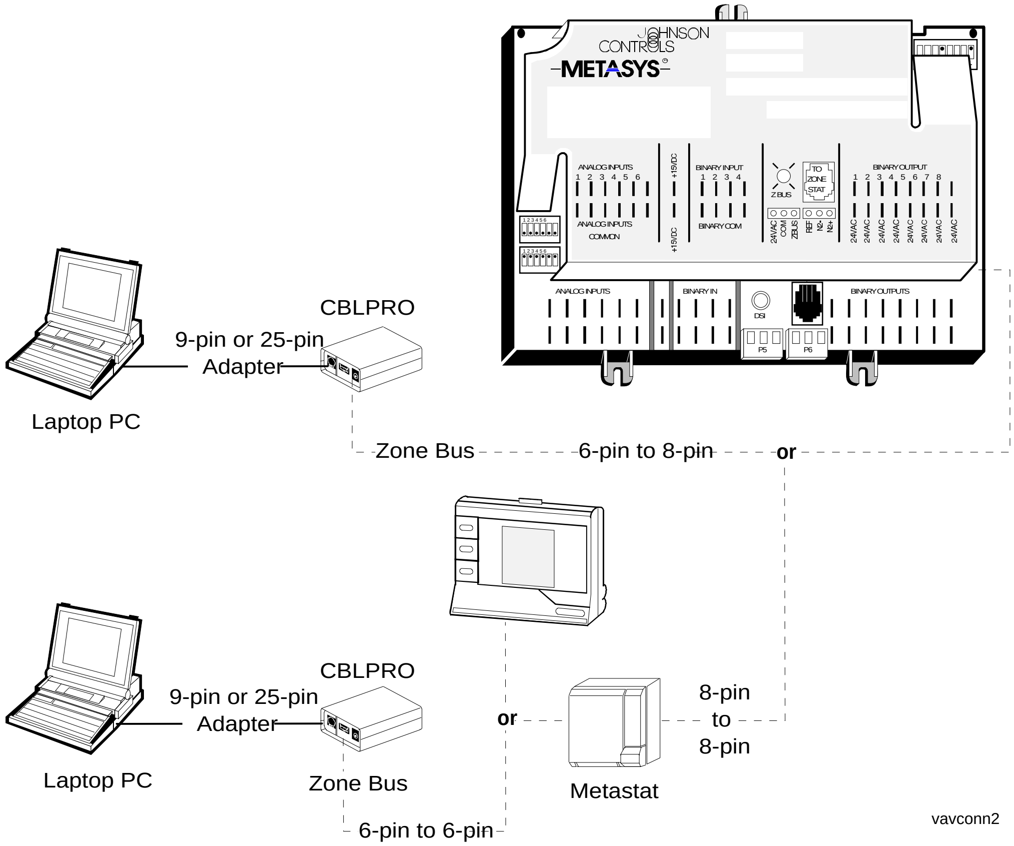


Figure 15: VAV Interconnection

To make all of the necessary wiring terminations between the VAV Controller and the TE-6410 Series Metastat, use phone cable that has preterminated 8-pin RJ-45 connectors. These cables are available from Anixter. Refer to the *Vendor Code Numbers* in the *Ordering Information* section of this technical bulletin for specific information regarding cables.

Connect one end of the cable to the Zone Bus connector on the controller and the other end to the 8-pin connector on the back of the sensor as shown in Figure 15. In addition to the 8-pin RJ-45 connection, the TE-6410 Metastat also has a 6-pin RJ-12 connection under its cover. This allows remote connection of the CBLPRO (used during commissioning) or the Zone Terminal (used for system monitoring).

For VAV140/141 Series Controller, there is an additional 6-pin jack for Zone Bus communication. You may permanently connect a Metastat to the 8-pin jack of the controller and simultaneously connect a laptop PC, CBLPRO, or Zone Terminal to the Zone Bus via the 6-pin jack.

Phone Jack Polarization

Figure 16 illustrates the polarization of the 6-pin and 8-pin phone jacks on the VAV Controller or Metastat. Terminal 1 is to the extreme left as you face the jack opening, tab notch down.

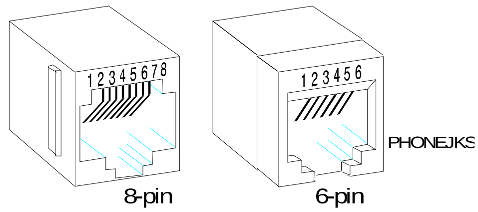


Figure 16: Phone Jack Polarization

The following table defines the pin usage for each jack.

Table 13: Phone Jack Pin Identification

8-Pin Jack (VAV Controller to Metastat)		6-Pin Jack (VAV140/141 Controller to CBLPRO or ZT and CBLPRO or Zone Terminal to Metastat)	
Pin	**Signal**	**Pin**	**Signal**
1	AI 3 Heating Setpoint	**1**	Not used
2	AI 2 Warmer, Cooler, or Cooling Setpoint	**2**	24 VAC
3	AI 1 Temperature Sensor	**3**	24 VAC/ZBus Common
4	AI 1 Sensor Common	**4**	Not used
5	24 VAC	**5**	Zone Bus
6	24 VAC/ZnBs Common	**6**	Not Used
7	AI 2/3 Common		
8	Zone Bus		

Note: Refer to the *Vendor Code Numbers* in the *Ordering Information* section of this technical bulletin for information on cables.

Fabricating an Interconnection Cable

You must construct any fabricated interconnection cable so the same color wire on both ends of the cable align with Pin 1 in the plug. This provides a consistent field assembly of the cable. Figure 17 illustrates the interconnection cable.

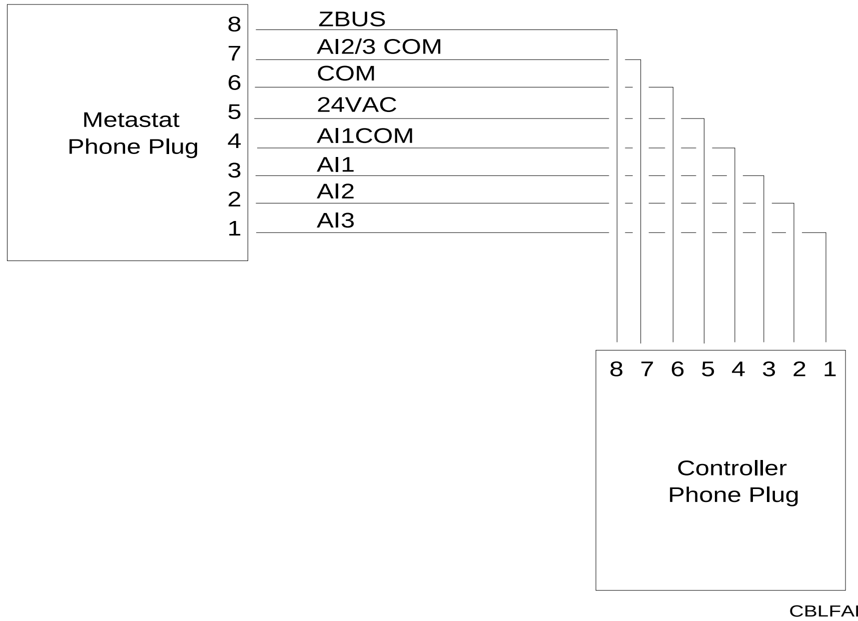


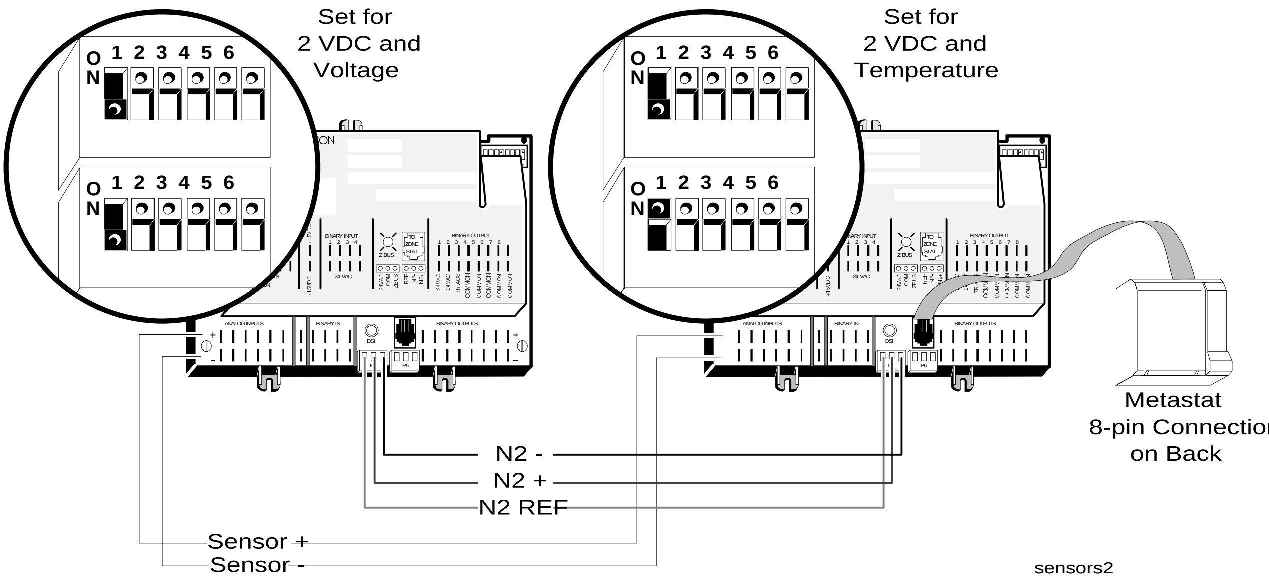
Figure 17: Interconnection Cable

Note: This is not typical of pre-assembled phone cable purchased in retail stores. A telephone system cable is wired opposite the zone sensor requirements.

Sharing a Sensor

You may use one sensor as a master input to multiple VAV Controllers instead of mounting and wiring separate zone sensors for each controller. This application is especially beneficial when you have a mechanical system that uses more than one terminal unit to serve the same area, for example, a large conference room or open office space.

Note: The practical limitation to this application is four VAV Controllers to one sensor.



Note: Route sensor wiring and N2 wiring together. Since the VAV Controller is a self-terminating device, end-of-line termination for the N2 Bus is not required.

Figure 18: Example of Sharing a Sensor Among VAV Controllers

Figure 18 shows the wiring and analog input switch settings for two controllers that use one zone sensor. To ensure the noise immunity of the VAV Controllers, pull the N2 Bus wiring with the sensor wiring between controllers that share the same zone sensor.

Notes: This configuration shifts the AI value by one degree for each added controller. Compensate for this temperature shift by entering an offset of -1°F (for each added controller) through the AI Offset Table. You can find this table in the Commissioning mode of HVAC PRO for Windows.

On the HVAC PRO for Windows Analog Input Modify screen, verify that both controllers are set to the same temperature sensor type.

If the master zone sensor uses the Zone Bus connection, only the master controller can be loaded and commissioned from the sensor connection.

Networking the Controller

N2 Bus Overview

If you are familiar with the N2 Bus, go to the next section of this technical bulletin: *Installing the N2 Bus*.

Wiring the Controller to an NCU

A hardware connection between the N2 Communications Bus and the NCM of the Network Control Unit (NCU) is required if the NCM is to service N2 devices. Refer to Table 14 for terminal locations and to the *N2 Communications Bus Technical Bulletin* for termination resistor values.

N2 Bus Characteristics

When installed in a Metasys Network, the VAV Controller receives commands from the Network Control Module (NCM) or Companion on the N2 Bus, and transmits status reports in return. The maximum electrical limitation on the N2 Bus is 255 devices. However, the number of controllers on the N2 Bus is a data base memory issue at the NCU or Companion. Refer to the *N2 Communications Bus Technical Bulletin (FAN 636)* and either the *Metasys Companion Technical Manual (FAN 628.1)* or the *Metasys Technical Manual (FAN 636)* to determine practical limitations to the number of controllers on the N2 Bus.

The N2 Bus connections are electrically isolated from other series VAV110/111 and VAV140/141 Controller circuitry by optical and magnetic coupling.

For runs of up to 5,000 feet/1,500 meters, use 22 AWG/0.6 mm diameter or higher twisted pair wire. (Electrically, 26 AWG wire works, but it is too fragile and prone to nicks and breaks.) Runs longer than 5,000 feet/1,500 meters require use of a bus repeater. An N2 network may be extended to a maximum length of 15,000 feet/4,500 meters, using two repeaters.

The N2 Bus is a daisy chain communications line. Essentially, it consists of three wires, which carry three signals: N2+, N2–, and REF. The N2+ and N2– lines carry the actual data signals. The REF line provides a common reference so that each connected device is capable of electrically receiving and transmitting data by creating a common voltage reference among all the devices connected together by the N2 lines. Three lines are required for optimum reliability. It is important that the N2+ and N2– lines *must be twisted pair lines,* which allows most induced noise (common-mode noise) from external sources to affect both lines equally, thereby canceling the noise.

Note: Do not run N2 Bus wiring in the same conduits as line voltage wiring (above 30 VAC) or wiring that switches power to highly inductive loads (such as contactors, coils, motors, or generators).

Installing the N2 Bus

Set the N2 address and test for N2 voltage, polarity, and isolation before actually wiring the VAV Controller for operation. Refer to the *ASC and N2 Bus Networking and Troubleshooting Guide (LIT-6363003)* in the *Application Specific Controllers Technical Manual (FAN 636.3)* for more information.

Setting the N2 Address

The switches located in the upper right corner of the VAV are set to the same number as was assigned to the module through software. The Metasys (or Companion) Facility Management System (FMS) uses this address for polling and commanding. The numbers are in binary format and vertically arranged with the least significant digit to the right.

For example, if the controller address is 17 (decimal), the binary representation is 00010001–Switches 1 and 16 must be set to the On position (1 + 16 = 17), as shown in Figure 19.

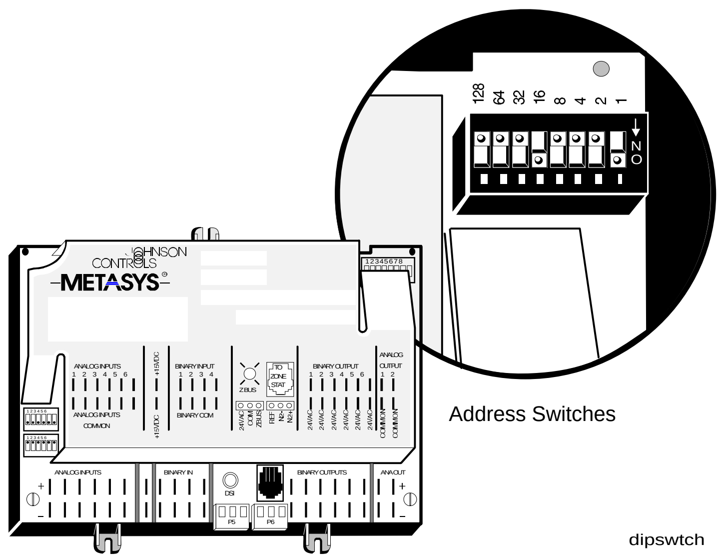
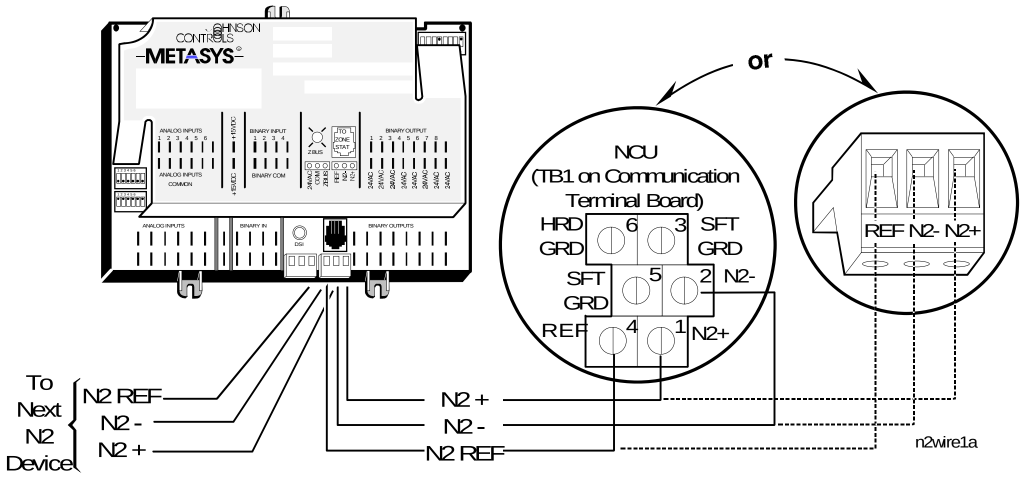


Figure 19: Setting the N2 Address DIP Switches

IMPORTANT: When setting the N2 Address, do not use address "0."

N2 Wiring to the Network Control Module



Note: Since the VAV Controller is a self-terminating device, end-of-line termination for the N2 Bus is not required.

Figure 20: Connecting the VAV Controller to an NCM

Table 14: Terminal Locations

TB1 Terminal Function	Number	VAV Connection
Chassis Ground	6	None
Soft Ground	5	None
N2B Ref Ground	4	AREF
Soft Ground	3	None
-N2B Connection	2	N2 Bus: N2-
+N2B Connection	1	N2 Bus: N2+

N2 Wiring to Companion

A hardware connection between the N2 Communications Bus and the Companion PC/Panel/*LTD* is required to service N2 devices. An MM-CVT101-0 Communications Converter is required to network to the PC Companion. See Figure 21 for terminal locations. Refer to the *Metasys Companion Technical Manual (FAN 628.1)* for information specific to the CVT101 or Companion Panel/*LTD*.

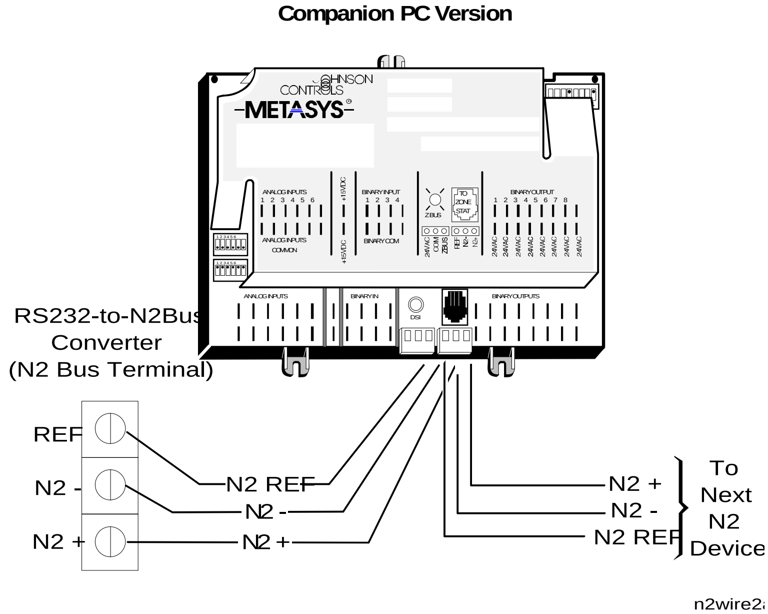


Figure 21: Connecting the VAV Controller to Companion

Zone Bus Communications

Zone Bus Description

The Zone Bus is a 2-wire communications bus that allows a computer to communicate with the VAV to download the VAV's data base and to communicate with Zone Terminals and M100 Actuators. A third wire is used for 24 VAC power to the CBLPRO, Zone Terminal, and CBLCON. The bus interface sustains no damage in presence of fault voltages of 24 VAC.

M100C Actuators must be powered with separate transformers; therefore, only the Zone Bus and Common wires need to be pulled.

The Zone Bus has the following specifications:

Table 15: Zone Bus Specifications

Type	Multidrop serial communications bus
Speed	1200 baud (bits per second)
Recommended Cable Type	18 AWG/1.5 mm^2 with shield (Beldon 8760) or 24 AWG/0.6 mm diameter with no shield (unshielded telephone cable)
Maximum Bus Length	500 feet/150 meters with 18 AWG/1.5 mm^2 cable or 50 feet/15 meters with 24 AWG/0.6 mm diameter cable
Range of Addresses	0 to 63
Voltages **Logic High-Voltage** **Logic Low-Voltage**	 4 VDC minimum (approximately) 1 VDC maximum (approximately)
Data Transmission	1 Start Bit (low level) 8 Data Bits (least significant bit first) 1 Stop Bit (high level)

The VAV110/111 and VAV140/141 Series Controllers contain an LED that blinks to indicate Zone Bus activity with or without external connection. When a PC via CBLPRO communicates with the controller, the blink rate may appear to be more steady. See *Table 37: Zone Bus LED Indications* in the *Troubleshooting* section of this document for more information.

CBLPRO Description

CBLPRO (AS-CBLPRO) is an interface device for use between a computer running HVAC PRO for Windows and application specific controllers such as the VAV Controller. It is used for data base downloading, uploading, or commissioning via the Zone Bus communication port.

When used with a Zone Bus device, such as the VAV or ZT, the CBLPRO is strictly an electrical interface between the serial RS-232 port of the computer and the Zone Bus. CBLPRO operates on 24 VAC drawn from a VAV over the wire used to make the Zone Bus connections. The data rate on both the RS-232 and the Zone Bus is 1200 baud.

The connection to the RS-232 COM port of the computer is by means of a DB9 or DB25 connector supplied with the CBLPRO. After connecting it, make sure the CBLPRO is about a foot or more away from the computer monitor and system unit.

IMPORTANT:	In some cases, a computer monitor or PC will give off electromagnetic noise that may disturb CBLPRO communications. Therefore, do not position the CBLPRO near the monitor or PC.

Zone Bus communications to the application specific controllers or ZT may also be monitored with a CBLCON (AS-CBLCON-0). This device has a red and green LED whose purposes are described in the following table.

Table 16: CBLCON LEDs

Red LED--Power	Green LED--COMM	Cause
OFF	OFF	No power to VAV
ON	OFF	Zone Bus wire open
ON	ON	Zone Bus wire shorted to Common or 24 VAC, or CBLCON-0 switch in download position
ON	Blinking	Normal communications

Application Examples

Single Duct Applications

The following examples are created by answering configuration questions using HVAC PRO for Windows to identify terminal locations of the inputs and outputs. Refer to the *HVAC PRO for Windows User's Manual (FAN 637.5),* the *VAV Controller* section, for detailed information regarding controller configuration.

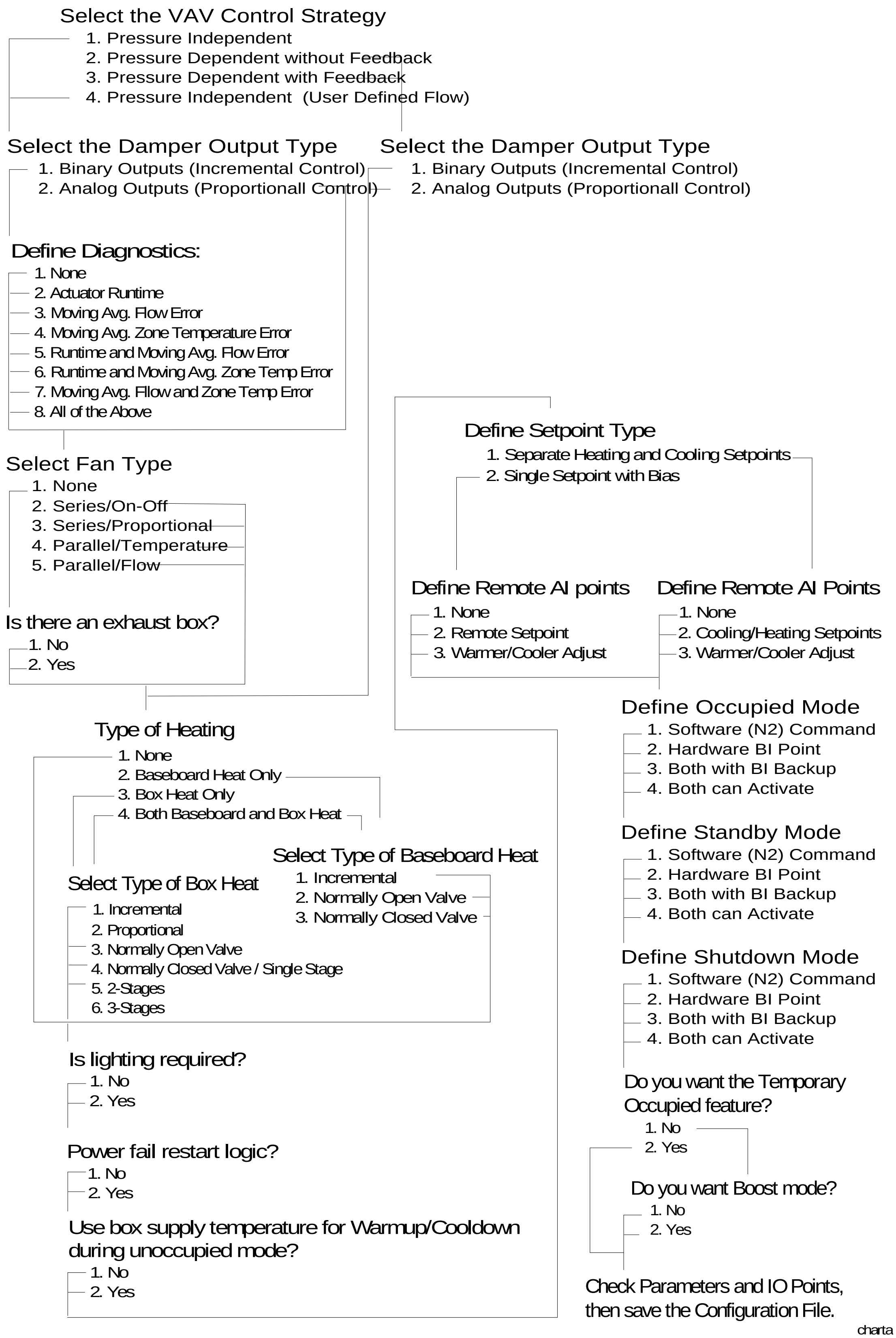


Figure 22: HVAC PRO for Windows Single Duct Configuration

Hardware Point Assignment Table

The following table shows the HVAC PRO for Windows hardware point assignments and options for single duct configurations.

Table 17: Single Duct Point Assignments and Options

Point Type	Point Name	HVAC PRO for Windows Configuration Assignments and Defaults	HVAC PRO for Windows Configuration Options
Analog Inputs	AI 1	Zone Temperature Unused	None Rename Warmer/Cooler Adjust Potentiometer Cooling Setpoint Potentiometer
	AI 3	Unused	Heating Setpoint Potentiometer Rename
	AI 4	Actuator Feedback on Pressure Dependent CFM on Pressure Independent Unused	None None Rename
	AI 5	Proportional Series Fan CFM Exhaust Box CFM Unused	None None Rename
	AI 6	Unused	Box Supply Temperature for Standalone Warmup in Pressure Dependent with Feedback and Independent Path Rename
Binary Inputs	BI 1	Unused	Rename Occupied
	BI 2	Unused	Rename Standby
	BI 3	Unused	Rename Shutdown Box Open
	BI 4	Unused	Rename Shutdown Box Closed
Momentary BI	BI 5	Unused	Temporary Occupancy Mode Boost Mode

Continued on next page . . .

Point Type (Cont.)	Point Name	HVAC PRO for Windows Configuration Assignments and Defaults	HVAC PRO for Windows Configuration Options
Binary Outputs	BO 1	Supply Damper Open	None
	BO 2	Supply Damper Close	None
	BO 3	Parallel and Series On-Off Fans	None
		Exhaust Box Open	Unused
		Unused	Rename
	BO 4	Exhaust Box Close	None
		Baseboard Heat On-Off	None
		First Stage Box Heat***	None
		Unused	Rename
	BO 5	Baseboard Incremental Open	None
		Box Heat Incremental Open	None
		First Stage Box Heat**	None
		Second Stage Box Heat***	None
		Lights On for VAV101	None
		Unused	Rename
	BO 6	Baseboard Incremental Close	None
		Box Heat Incremental Close	None
		On-Off/Single Stage Box Heat	None
		Second Stage Box Heat**	None
		Third Stage Box Heat***	None
		Lights Off for VAV101	None
		Unused	Rename
	BO 7	Baseboard Incremental Open on VAV100	None
		Lights On for VAV100	None
		Unused	Rename
	BO 8	Baseboard Incremental Close on VAV100	None
		Lights Off for VAV100	None
		Unused	Rename
Analog Outputs	AO 1	S66 Output for Proportional Series Fan	None
		Unused	Rename
	AO 2	Proportional Box Heat	None
		Unused	Rename

** 2-Stages Box Heat

*** 3-Stages Box Heat

Note: The examples contained in this technical bulletin do not reflect *all* of the possible questions and answers. These examples are provided as a basic overview of wiring locations you might expect to see.

Table 18: Single Duct Wiring Example 1 Questions and Configuration Selections

HVAC PRO for Windows Questions	Configuration Selections
Control Strategy	Pressure Independent
Fan Type	Series/On-Off
Exhaust Box Required	Not Available
Baseboard Heat Type	None
Box Heat Type	3-Stages
Lighting Integration	Yes

Note: The OEM box manufacturer typically supplies the fan relays and electric heat relays.

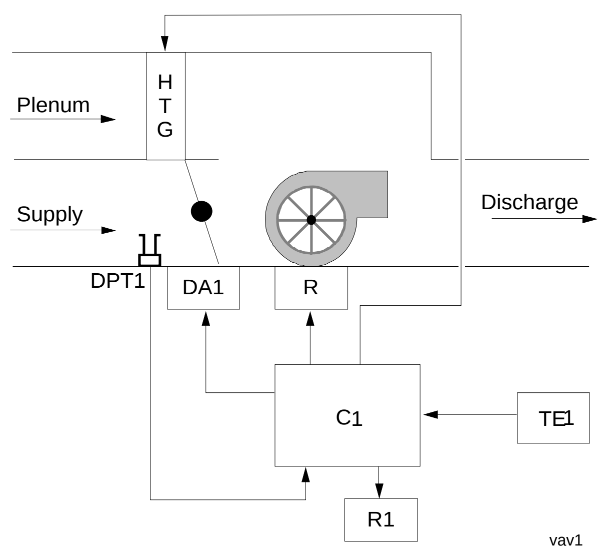


Figure 23: Single Duct Wiring Example 1 Mechanical Flow Diagram

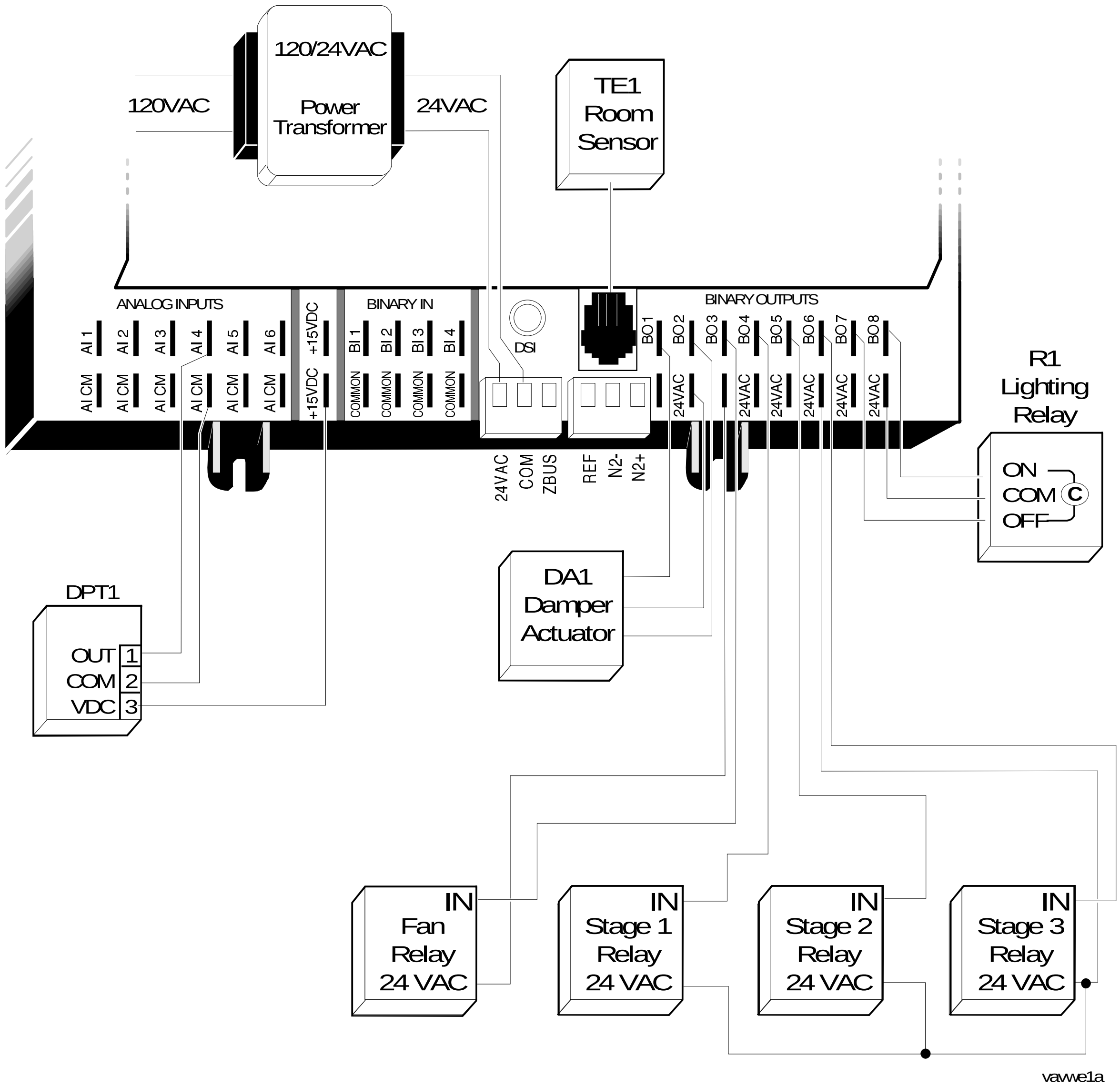


Figure 24: Single Duct Wiring Example 1
Pressure Independent Configuration

Table 19: Single Duct Wiring Example 1 Bill of Materials

Component Description		Part Number
C1	Digital Controller	AS-VAV110-1
TE1	Metastat	TE-6400 Series
R1	Lighting Relay	GE-RR7
DA1 and DPT1	Actuator/Flow Sensor	ATP-2040

Note: Box OEM manufacturers typically supply fan relays and electric heat relays.

The following table illustrates the selections made through HVAC PRO for Windows for this example.

Note: The examples contained in this technical bulletin do not reflect *all* of the possible questions and answers. These examples are provided as a basic overview of wiring locations you might expect to see.

Table 20: Single Duct Wiring Example 2 Questions and Configuration Selections

HVAC PRO for Windows Questions	Configuration Selections
Control Strategy	Pressure Independent
Fan Type	None
Exhaust Box Required	Yes
Baseboard Heat Type	None
Box Heat Type	Proportional
Lighting Integration	Not Available

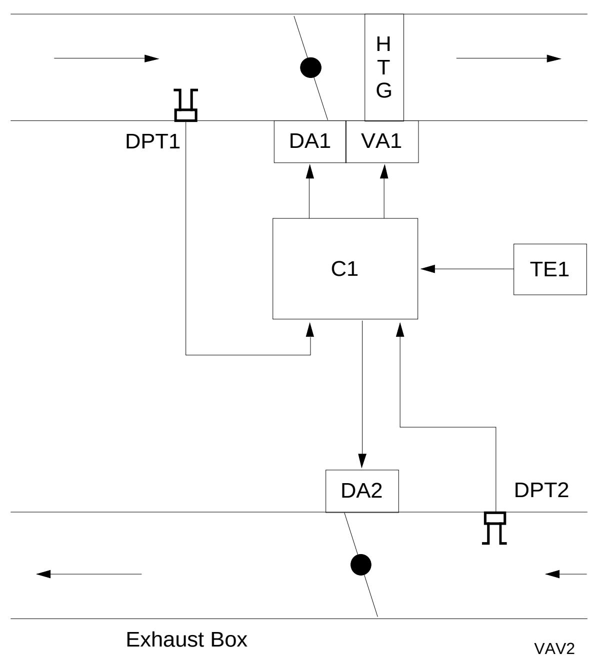


Figure 25: Single Duct Wiring Example 2 Mechanical Flow Diagram

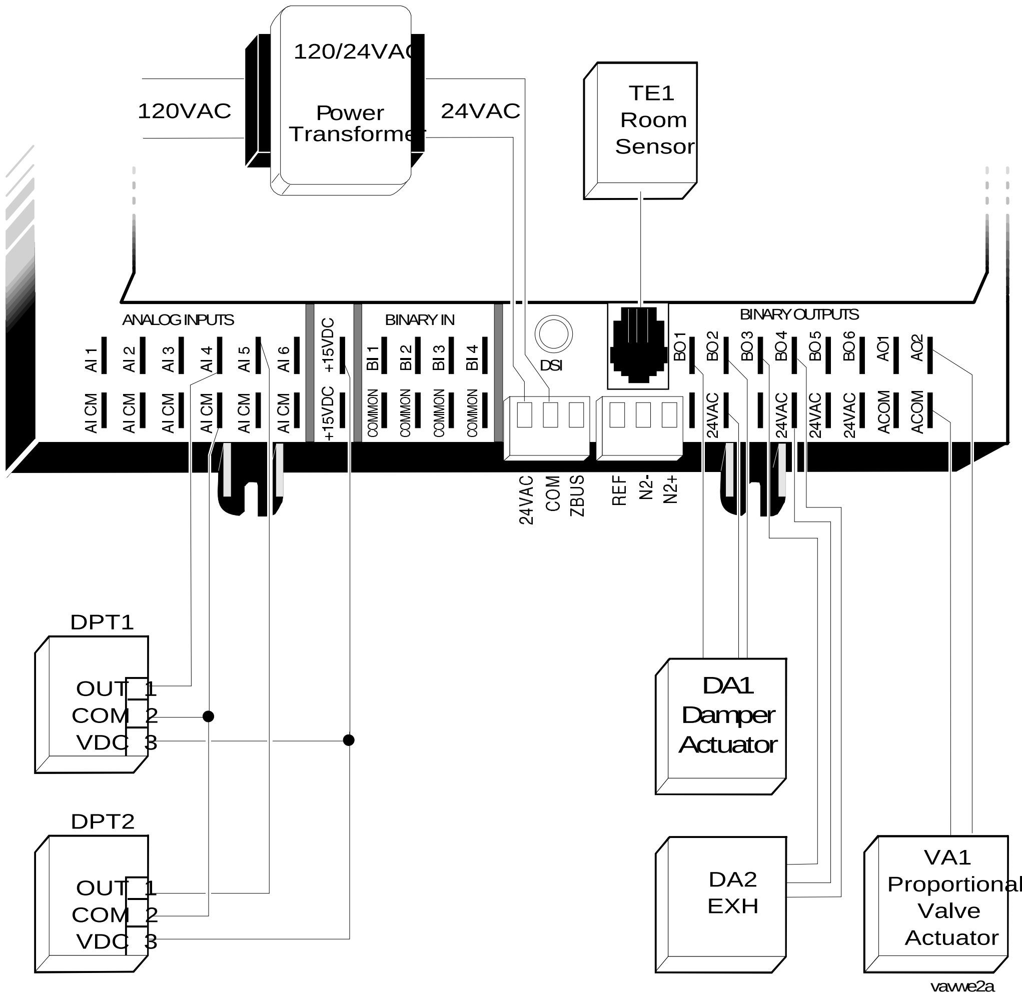


Figure 26: Single Duct Wiring Example 2

Table 21: Single Duct Wiring Example 2 Bill of Materials

Component Description		Part Number
C1	Digital Controller	AS-VAV111-1
TE1	Metastat	TE-6400 Series
DA1 and DPT1	Actuator/ΔP Sensor	ATP-2040
VA1	Valve Actuator	VA-8022 Series
DA2 and DPT2	Actuator/DP Sensor	ATP-2040

The following table illustrates the selections made through HVAC PRO for Windows for this example.

Note: The examples contained in this technical bulletin do not reflect *all* of the possible questions and answers. These examples are provided as a basic overview of wiring locations you might expect to see.

Table 22: Single Duct Wiring Example 3 Questions and Configuration Selections

HVAC PRO for Windows Questions	Configuration Selections
Control Strategy	Pressure Dependent Without Feedback
Fan Type	Not Available
Exhaust Box Required	Not Available
Baseboard Heat Type	On-Off
Box Heat Type	Incremental
Lighting Integration	Yes

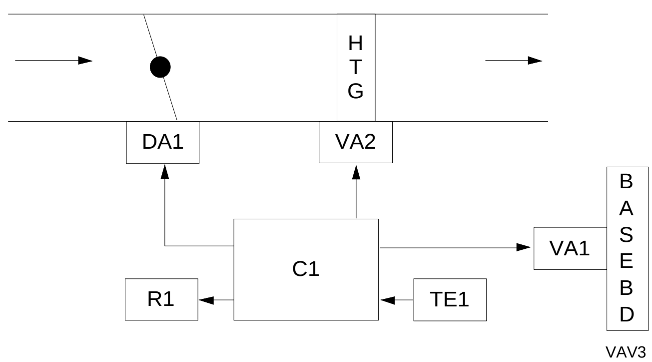


Figure 27: Single Duct Wiring Example 3 Mechanical Flow Diagram

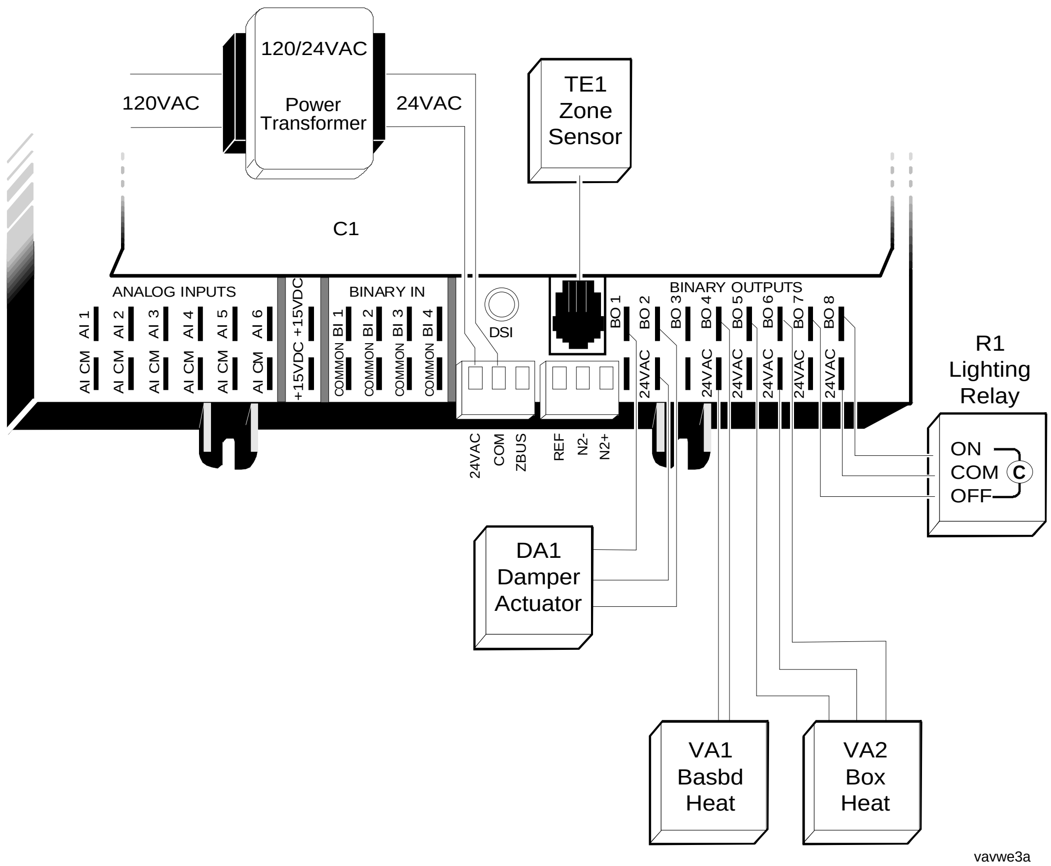


Figure 28: Single Duct Wiring Example 3

Table 23: Single Duct Wiring Example 3 Bill of Materials

Component Description		**Part Number**
C1	Digital Controller	AS-VAV110-1
TE1	Metastat	TE-6400 Series
VA1	Baseboard Valve Actuator	J Series
VA2	Box Heat Valve Actuator	VA-8020
DA1	Damper Actuator	EDA-2040-nn
R1	Lighting Relay	GE-RR7

The following table illustrates the selections made through HVAC PRO for Windows for this example.

Note: The examples contained in this technical bulletin do not reflect *all* of the possible questions and answers. These examples are provided as a basic overview of wiring locations you might expect to see.

Table 24: Example 4--Pressure Independent with Parallel Fan

HVAC PRO for Windows Questions	Configuration Selections
Control Strategy	Pressure Independent
Fan Type	Parallel Fan Temp Controlled
Exhaust Box Required	No
Baseboard Heat Type	Analog Output
Box Heat Type	Incremental
Lighting Integration	No

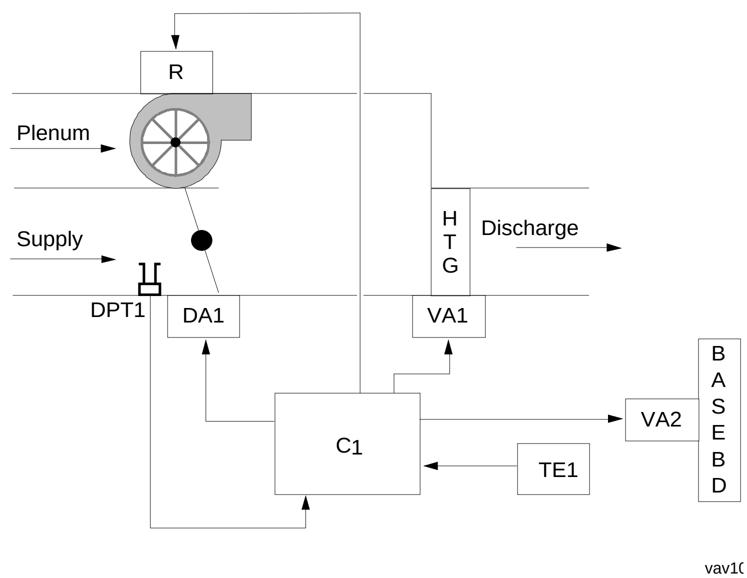


Figure 29: Mechanical System Flow Example 4
Pressure Independent w/Parallel Fan

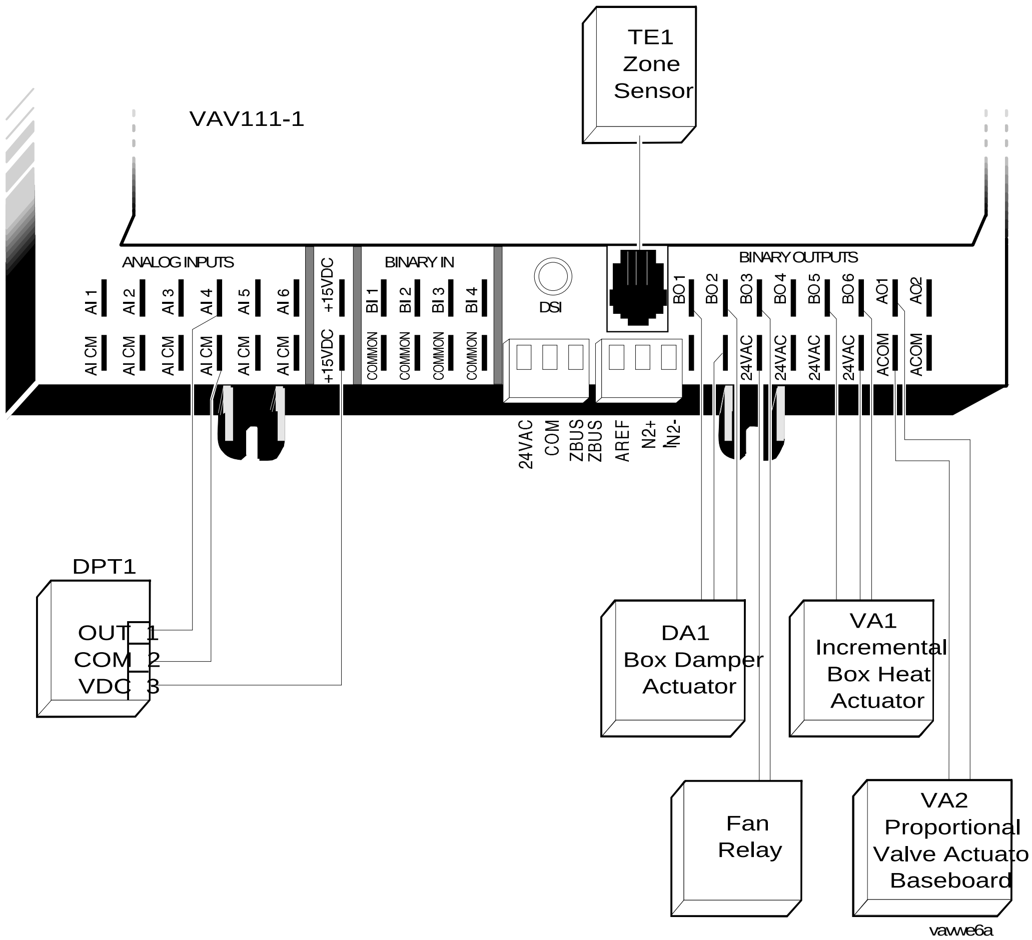


Figure 30: Single Duct Fan Powered Box Wiring Example 4

Table 25: Fan Powered Box Wiring Example 4 Bill of Materials

Component Description		Part Number
C1	VAV w/6 BOs and 2 AOs	AS-VAV111-1
TE1	Temperature Sensor	TE-6400 Series
DPT-1/DA-1	Delta P Transducer/Damper Actuator	ATP-2040
VA-1	Valve Actuator Box Heat	VA-8020-1
VA-2	Electro-pneumatic Transducer Baseboard Heat	EP-8000-2

Note: Box OEM manufacturers typically supply fan relays and electric heat relays.

Dual Duct Applications

The following examples are created by answering configuration questions using HVAC PRO for Windows to identify terminal locations of the inputs and outputs. Refer to the *HVAC PRO for Windows User's Manual (FAN 637.5)*, the *VAV Controller* section, for detailed information regarding controller configuration.

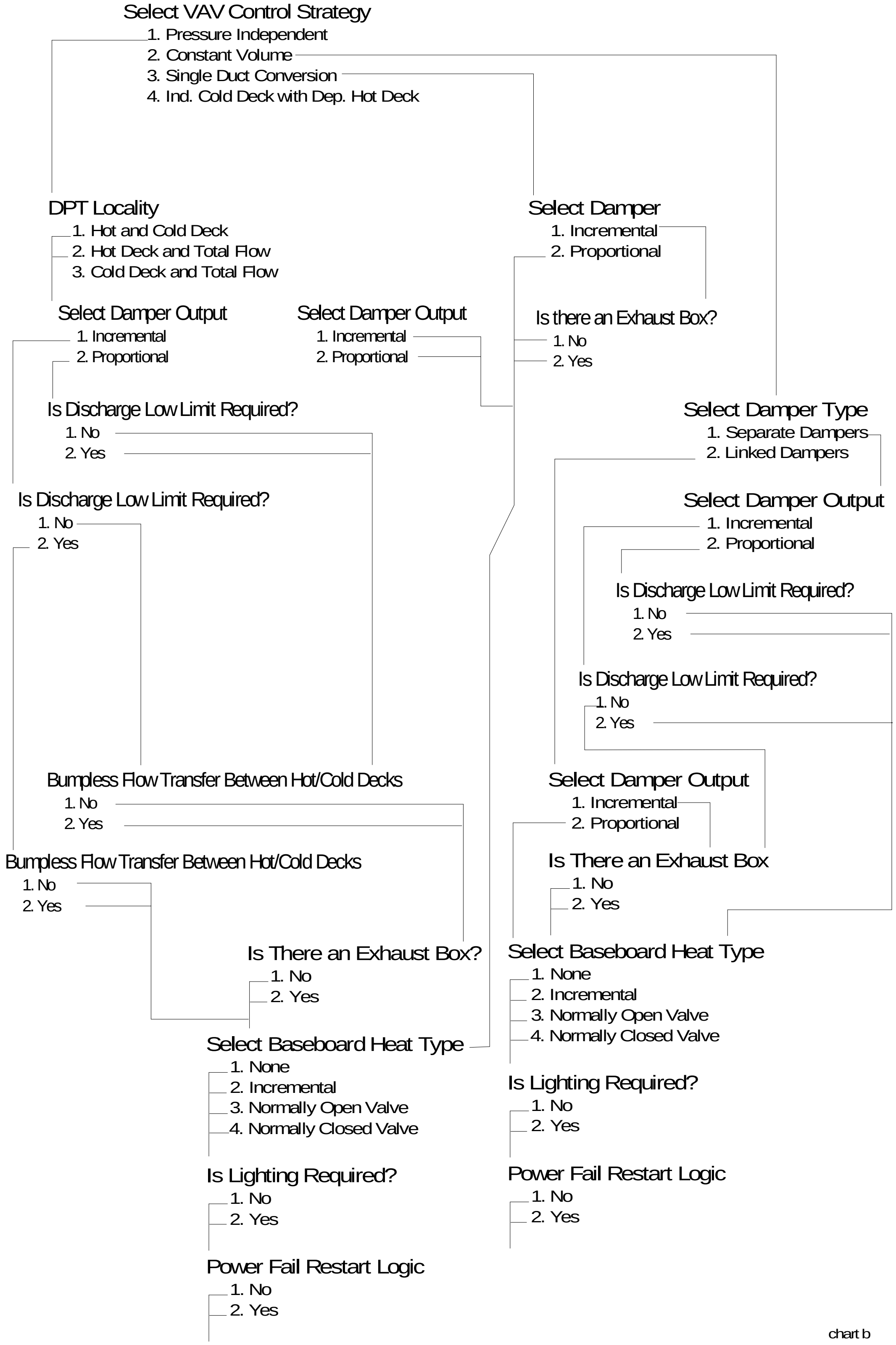


Figure 31: HVAC PRO for Windows Dual Duct Configuration Flowchart (Part One of Two)

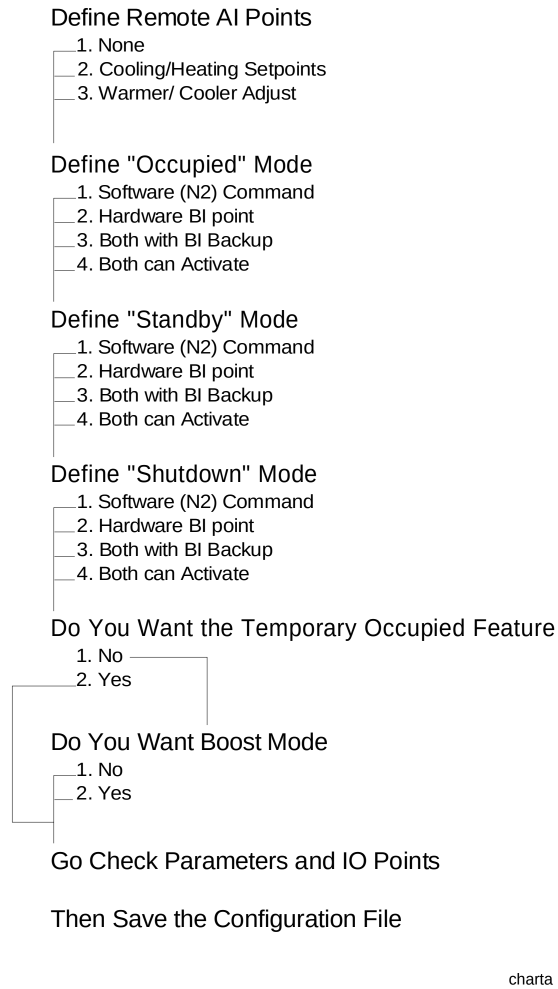


Figure 32: HVAC PRO for Windows Dual Duct Configuration Flowchart (Part Two of Two)

Table 26: Dual Duct Hardware Point Assignments and Options

Point Type	Point Name	HVAC PRO for Windows Configuration Assignments and Defaults	HVAC PRO for Windows Configuration Options
Analog Inputs	AI 1	Zone Temperature	None
	AI 2	Unused	Rename Cooling Setpoint Warmer/Cooler Adjust
	AI 3	Unused	Rename Heating Setpoint
	AI 4	Cold Deck Delta P Supply Delta P	None None
	AI 5	Hot Deck Delta P Unused	None Rename
	AI 6	Discharge Air Temp Exhaust Delta P Unused	None None Rename
Binary Inputs	BI 1	Unused	Rename Occupied
	BI 2	Unused	Rename Standby
	BI 3	Unused	Rename Shutdown Box Open
	BI 4	Unused	Rename Shutdown Box Closed
Momentary BI	BI 5	Unused	Rename Temp Occupancy Boost
Binary Outputs	BO 1	Damper Open Cold Deck Open	None None
	BO 2	Damper Close Cold Deck Close	None None
	BO 3	Heating/Cooling Changeover Hot Deck Open	None None
	BO 4	Unused Hot Deck Close	Rename None
	BO 5	Unused Exhaust Open	Rename None
	BO 6	Unused Exhaust Close	Rename None
	BO 7	Unused Basebd Heat Basebd Open Lights On	Rename None None None
	BO 8	Unused Basebd Close Lights Off	Rename None None

The following table illustrates the selections made through HVAC PRO for Windows for this example.

Note: The examples contained in this technical bulletin do not reflect *all* of the possible questions and answers. These examples are provided as a basic overview of wiring locations you might expect to see.

Table 27: Dual Duct Wiring Example 1 Questions and Configuration Selections

HVAC PRO for Windows Questions	Configuration Selections
Control Strategy	Constant Volume/Separate Dampers
Discharge Air Low Limit	No
Exhaust Box Required	No
Baseboard Heat Type	No
Lighting Integration	No

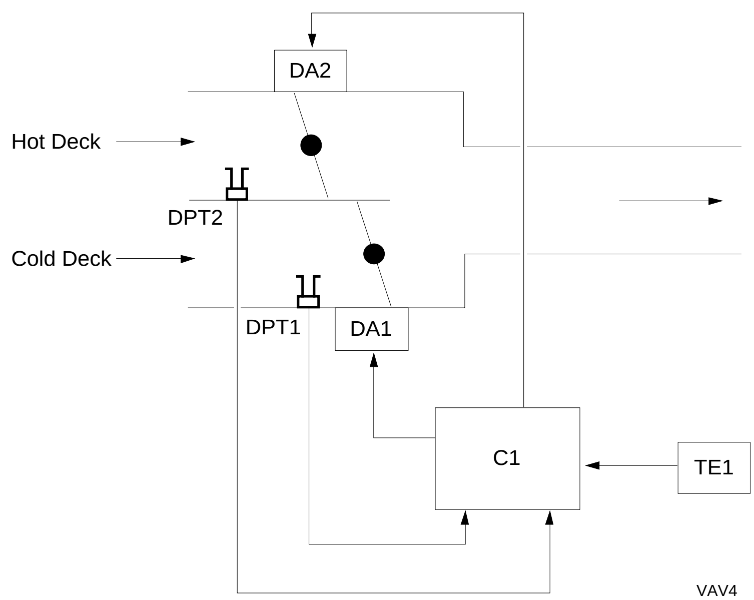


Figure 33: Dual Duct Wiring Example 1 Mechanical Flow Diagram

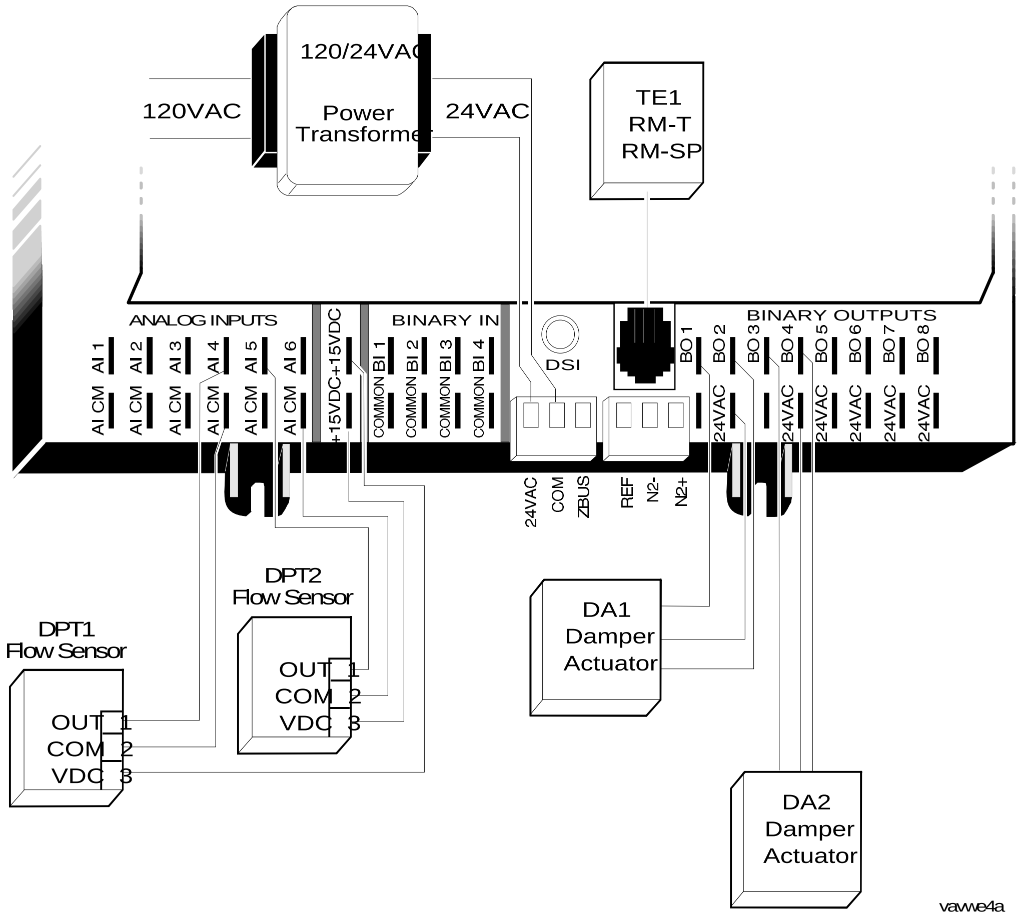


Figure 34: Dual Duct Wiring Example 1

Table 28: Dual Duct Wiring Example 1 Bill of Materials

Component Description		Part Number
C1	Digital Controller	AS-VAV110-1
TE1	Metastat	TE-6400 Series
DA1 and DPT1	Cold Deck	ATP-2040-nn
DA2 AND DPT2	Hot Deck	ATP-2040-nn

The following table illustrates the selections made through HVAC PRO for Windows for this example.

Note: The examples contained in this technical bulletin do not reflect *all* of the possible questions and answers. These examples are provided as a basic overview of wiring locations you might expect to see.

Table 29: Dual Duct Wiring Example 2 Questions and Configuration Selections

HVAC PRO for Windows Questions	Configuration Selections
Control Strategy	Pressure Independent
Discharge Air Low Limit	Yes
Exhaust Box Required	No
Baseboard Heat Type	No
Lighting Integration	Yes

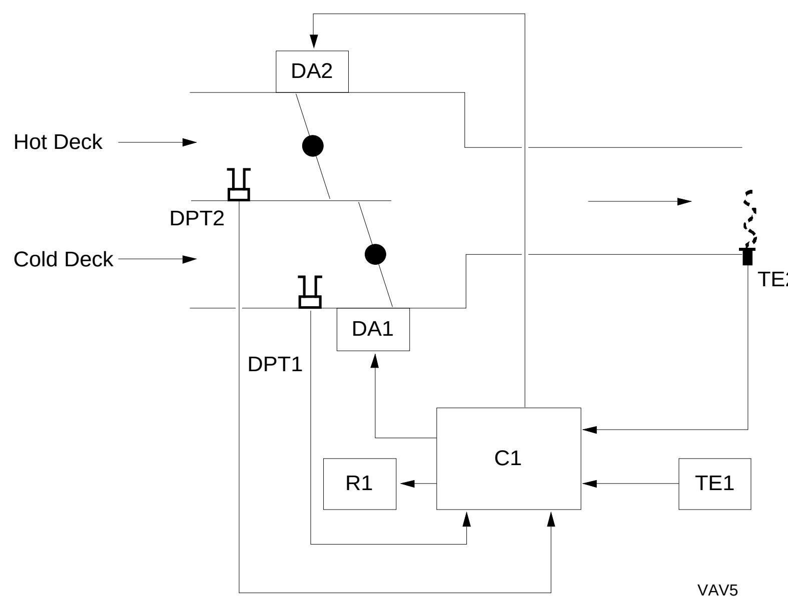


Figure 35: Dual Duct Wiring Example 2 Mechanical Flow Diagram

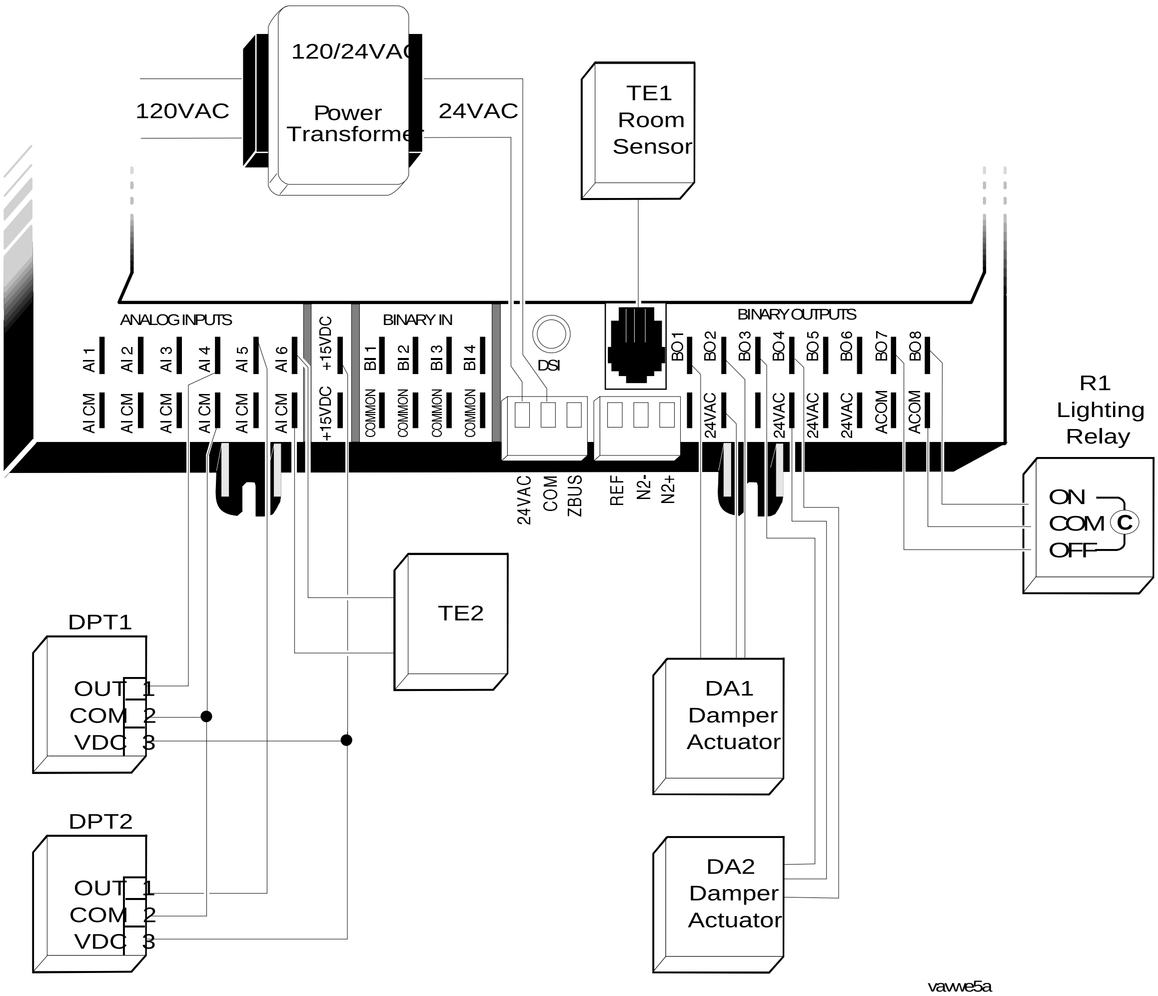


Figure 36: Dual Duct Wiring Example 2

Table 30: Dual Duct Wiring Example 2 Bill of Materials

Component Description		Part Number
C1	Digital Controller	AS-VAV110-1
TE1	Metastat	TE-6400
TE2	Discharge Air	TE-6000 Series
DPT1 and DA1	Cold Deck	ATP-2040-nn
DPT2 and DA2	Hot Deck	ATP-2040-nn
R1	Lighting Relay	GE-RR7

Downloading/Commissioning

We recommend that you connect the zone sensor prior to performing the initial configuration download. Even if you do not permanently install the zone sensor at this time, terminate the N2 Bus wiring and pull it back to the equipment room location of the NCM or Companion System. Refer to *HVAC PRO for Windows User's Manual (FAN 637.5)* for upload features.

Via Zone Bus

Downloading and commissioning via the Zone Bus requires the use of the CBLPRO interface and a laptop or PC running the HVAC PRO for Windows software. You can connect to the Metastat 6-pin connector or directly at the controller. VAV140/141 models have a spare 6-pin connector making it unnecessary to disconnect the Metastat or zone sensor during download/commissioning. Communication rate is 1200 baud over the Zone Bus.

Via N2 Bus

HVAC PRO for Windows allows you to perform downloading and commissioning over the N2 Bus. Because the communication rate is 9600 baud, performing downloading and commissioning over the N2 Bus saves a great deal of time in loading the initial controller configuration files and parameters into the controller prior to the balancing contractor's final testing.

To perform the downloading and commissioning process over the N2 Bus, we recommend that you create a job file spreadsheet similar to the one illustrated in the following table.

Table 31: Example File per N2 Trunk for Pressure Independent Job

Filename	N2 Address	Cooling Min CFM	Cooling Max CFM	Heating Min CFM	Heating Max CFM	Damper Deadband
Size 8	1	300	800	300	300	80
Size 10	2	300	1200	300	300	120

You should develop a separate filename for each size box with a different configuration style. For example, if the inlet is 8 inches in diameter, "Size 8" would be a logical filename (Table 31). This allows you to have your base set of requirements in place before you adjust the CFM setpoint schedule per the mechanical prints.

Incremental Valve Actuator Stroke Time

The stroke time of an incremental valve actuator is important because the controller uses it to position the actuator in reference to an analog 0-100% open position command. If the stroke time is grossly inaccurate, the controller drives the actuator under an incorrect assumption of total stroke time and causes inaccurate positioning, particularly at the near closed or near full open positions. If possible, measure the actual stroke time of the incremental actuator with water flow through the valve. Some valves have 1/2, 5/16, or 3/4 inch strokes, which require different stroke times.

If you do not measure the actual stroke time, you at least need to know the approximate stroke time of the valve and enter that in the HVAC PRO for Windows configuration tool. Conservatively, you can add up to 20% to the nominal time. Always **add** to the stroke time, never subtract. The controller modulates the valve based on a calculated stroke time of 150% of the stroke time you specify. This is done to compensate for variations in water system pressure, actuator wear, and manufacturing tolerances.

The VAV controller has a built-in overdrive algorithm that drives the actuator closed for an additional 50% of the entered stroke time when a 0 or 100% open command is issued. This ensures that the valve is fully closed or open. This fully opens or closes the valve, but does not correct the mid-stroke position errors due to a grossly incorrect valve stroke time. Refer to the following table for approximate stroke times.

Table 32: Approximate Stroke Times

Incremental Valve Actuators		Stroke Time
VA-8050-1	1/2 in. stroke	65 sec (1.1 min)
VA-8051-1	1/2 in. stroke	65 sec (1.1 min)
VA-8050-1	3/4 in. stroke	90 sec (1.5 min)
VA-8051-1	3/4 in. stroke	90 sec (1.5 min)
VA-8020-1	5/16 in. stroke	90 sec (1.5 min)
VA-8050-1	5/16 in. stroke	45 sec (0.75 min)
VA-8051-1	5/l6 in. stroke	45 sec (0.75 min)

Note: There may be no correlation between valve position and controller output (0 to 100%). If you require correlation, use proportional control or actuators with position feedback.

Incremental Damper Actuator Stroke Time

The position accuracy of the VAV box damper is dependent upon the actuator stroke time entered. It is important that the true damper actuator stroke time be entered. The listed actuator times of 1, 2, or 5.5 minutes are for 90 degrees of rotational travel. If a VAV box has 45 or 60 degrees of travel, the stroke time must be adjusted. Multiply the listed stroke time by 0.5 for 45 degrees of travel by 0.667 for 60 degrees of rotation.

Drive times that are inaccurate cause the controller to calculate a software damper position that is not synchronous to the actual damper position. This error is particularly noticeable at the very end of the travel when the controller thinks the damper is fully closed, but is physically open. If a box has 45 or 60 degree travel, it is highly recommended that the entered stroke time used in HVAC PRO for Windows be tested under field conditions to verify that the box can be driven fully closed and open.

Zone Terminal Setup for Balancing Contractors

For simplicity, program a Zone Terminal to access only those values required for testing and balancing processes. For each box configuration style, determine which parameters the test and balance will require. Build a controller display file for each configuration. Up to three display files can be combined into one ZT load file. For example, a single duct box with reheat might require the values shown in Table 33.

Table 33: Parameters for Balancing a Single Duct Box with Reheat

Parameter name	Function	Purpose
Supply Setpt	view	display present flow setpoint
Supply Flow	view	display present flow rate
Supply Box Area	view & adjust	verify & correct box inlet area
Supply Mult	view & adjust	calibration of flow measurement
Supply Delta P	view	secondary information
Damper Command	view	secondary information
Occ Clg Max	view & adjust	verify & correct flow setpoint
Occ Clg Min	view & adjust	verify & correct flow setpoint
Occ Htg Min	view & adjust	verify & correct flow setpoint
Occ Htg Max	view & adjust	verify & correct flow setpoint
Occ Setpt	view & adjust	change present control point
Occupied Status	view	verify mode

Once you load the base configuration files into each controller, the balancing contractor can use a Zone Terminal to officially set the CFM schedules.

Troubleshooting

Hardware Installation Inspection

We recommend that once the mechanical contractor starts receiving delivery of the VAV boxes with factory mounted controls, arrangements are made to pull a sample of the shipment and bench test it by loading a job configuration before all the boxes are mounted in the ceiling.

It can also be advantageous to keep a box off to the side for use in training the balancing contractor on a bench setup, rather than a live box mounted in the ceiling.

> ⚠ CAUTION: **Equipment Damage Hazard**. Before starting, make sure power is switched off.

Tools Needed for Troubleshooting

Tools needed for typical troubleshooting include:

- *ASC and N2 Bus Networking and Troubleshooting Guide (LIT-6363003)*
- Digital Multimeter (DMM)
- 100k ohm resistor
- double banana plug (optional; shown in Figure 37; available from local electronics store or ITT Pomona Stock No. 34F856 or 3F845), 1/4 watt for earth ground voltage tests

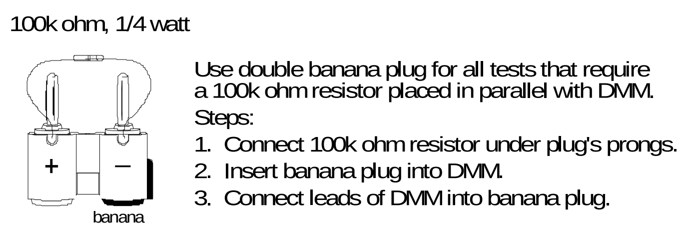


Figure 37: Double Banana Plug Used with 100k ohm Resistor

Installation Checkout

Inspect the mounted VAV to ensure proper installation. Refer to the appropriate illustrations in the section of this technical bulletin titled *Installation Procedures* and to the engineering drawings.

1. Check that the mounting screws holding the subassembly onto the base frame are secure.
2. Verify that accessory equipment is connected and labeled correctly.
3. Ensure that the controller terminal connections are secure.
4. Verify that the N2 connections are secure and labeled correctly.
5. Verify that the VAV switches are appropriately positioned. (Refer to the *Wiring Details* and *Networking the Controller* sections of this technical bulletin.)
6. Verify that there are no unwanted earth ground connections to the controller following the procedures below.

No earth ground connections are allowed when wiring a Series VAV100/101 Controller. Although a single earth ground connection to the common terminal of Series VAV110/111 and VAV140/141 Controller is allowed, you may not want to use one. The same procedure as described in the following text for VAV100/101 may be used when no earth ground connections to VAV are intended.

Isolation and Grounding VAV100/101

This section will help you ensure proper isolation within your system. These procedures are not required, but are recommended to reduce installation errors. Use the following procedures to ensure proper isolation. Test the:

- field device wiring for proper isolation
- transformer for isolation and correct polarity termination
- connected field devices, transformer, and VAV for proper isolation
- transformer and VAV for proper VA load requirements

Field Device Wiring Isolation – VAV100/101

This section assists you in measuring field wiring terminated to the VAV. If you are confident that the field wiring has no earth grounds, you may go to the following section called *Power Transformer Isolation - VAV100/101*. A field device that is earth grounded becomes apparent when you test the entire controller.

- Before you terminate the field wires to the VAV, measure the resistance of each wire to earth ground using an LED test circuit (preferred) or a DVM. For the LED test circuit, assemble the test circuit illustrated in Figure 38. Then, connect the circuit from each input to earth ground and then to each output to ground. For the DVM test, connect the DVM from each input to earth ground and then to each output to ground (Figure 38).

  If the LED turns On (or you read a value less than 1 Megohm at any input or output), the circuit is improperly isolated. Replace or repair the wiring or the field device; or, for a binary output, add an isolation relay. Repeat the DVM test only.

  If the LED does not turn On (or you read a value greater than 1 Megohm), the circuit may be properly isolated. (It will not be isolated if there are earth grounds that exist at higher voltages.) A value of infinite ohms indicates a completely isolated circuit at approximately zero volts. Connect this wire to the appropriate VAV terminal and check the next wire.

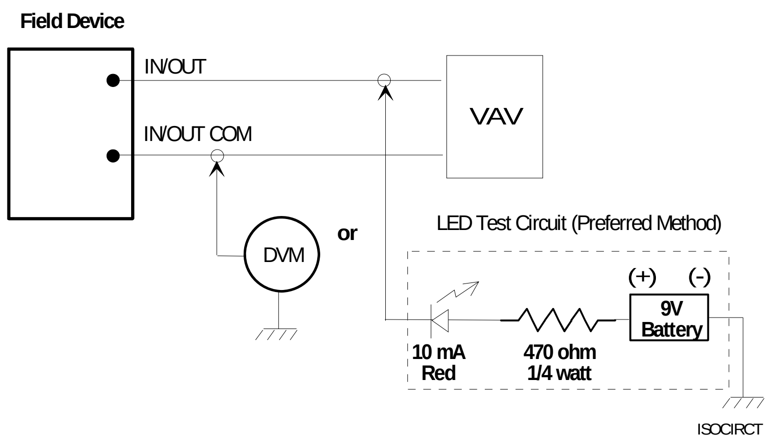


Figure 38: Testing for an Isolated Circuit

Power Transformer Isolation – VAV100/101

- Before connecting the transformer to the VAV, connect the input power to the primary leads of the 24 VAC transformer.

  Note: If you ground the secondary of the power transformer, you must use a separate 24 VAC to 24 VAC isolation transformer (such as the Y65GS.)

- Measure the voltage of each secondary transformer lead to earth ground with the DVM in parallel with a 100k ohm 1/4 watt resistor (Figure 39; if using double banana plug, insert plug into DVM).

  - **If you read 5 VAC or greater**, the transformer is earth grounded. You need an isolation transformer in order to isolate the connections from earth ground and protect system components. Wire a separate 24 VAC to 24 VAC isolation transformer (such as the Y65GS) to the VAV.

  - **If you read less than 5 VAC**, the circuit is properly isolated. Usually a value less than 0.10 VAC indicates a completely isolated circuit.

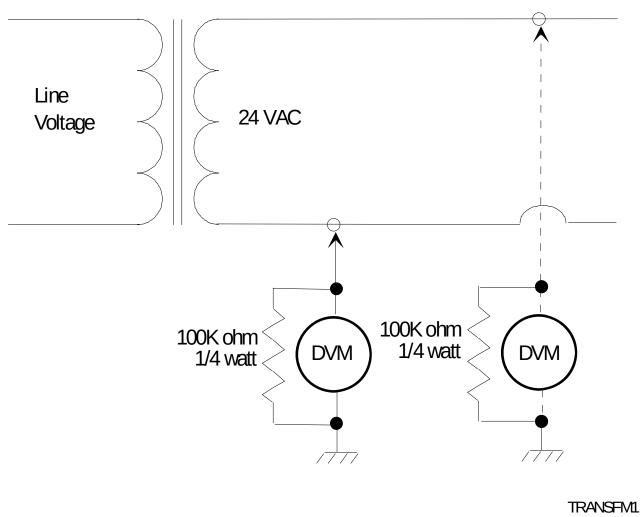


Figure 39: Testing the Transformer

- Determine the polarity of the transformer's leads by using a DVM referenced to earth ground without the 100k ohm resistor. Connect the transformer's secondary lead with the higher voltage potential to the 24 VAC terminal on the VAV. Connect the transformer's secondary lead with the lower potential to the 24 VAC Common terminal on the VAV.

Load Isolation – VAV100/101

If the field wires are not yet connected (because you skipped the section called *Field Device Wiring Isolation - VAV100/101*), disconnect one 24 VAC wire and terminate the field wires. Reconnect the 24 VAC wire.

Note: If you ground the contactor or solenoid coils to be driven by the VAV, you must use a separate isolation relay for each load.

- Connect the leads of the DVM in parallel with the 100k ohm resistor from the DC power supply (+15 VDC) output terminal of the VAV to earth ground (Figure 40). This tests whether the field devices, the VAV, and the transformer assembly are properly isolated.

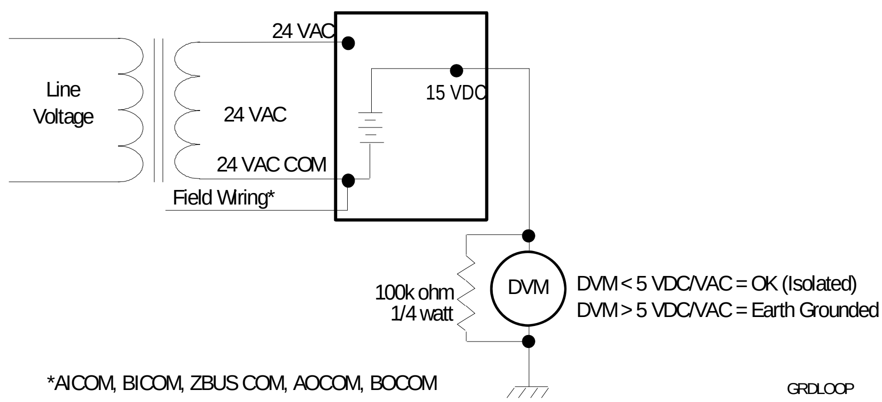


Figure 40: Testing for Ground Loops

- **If you read 5 VDC/VAC or greater**, the circuit is improperly isolated. Follow these steps:

  1. Remove all the field wires and N2 Bus wires from the VAV, but leave the transformer wires attached. With the DVM still connected, reconnect each set of field wires, one at a time, until you read 5 VDC/VAC or greater. At this point, you have discovered one cause of the ground loop. Correct the problem.
  2. Continue to reconnect each set of field wires until all ground loops are found and corrected. You'll know that all grounds are corrected when you read less than 5 VDC/VAC on the DVM.
  3. However, if you check all the field wires and you still read greater than 5 VDC/VAC, the transformer secondary is earth grounded. In this case, wire a 24 VAC to 24 VAC isolation transformer to the VAV and measure again. If the value is still 5 VDC/VAC or greater, replace the VAV.

Note: Binary outputs are often the cause of ground loops. Therefore, we recommend that you test the binary outputs of the VAV before testing other points.

- **If you read a value less than 5 VDC/VAC**, the circuit is properly isolated. A value of less than 0.10 VDC/VAC indicates a completely isolated circuit.
- Connect the DVM across the 24 VAC and the 24 VAC Common terminal of the VAV. Read the voltage with all typical loads energized.

  A reading of 24 VAC is required when the line voltage is nominal.

  If you read a value less than 20 VAC, make sure the primary voltage matches the transformer's voltage rating. For details, refer to the *Power Source and Loads* section of this technical bulletin and recalculate the VA requirements for the VAV Controller.

You have completed the VAV isolation tests. If you plan to connect this VAV to the N2 Bus for communication to other devices, refer to the *Application Specific Controllers Technical Manual (FAN 636.3)*, the *Introduction* tab, the *ASC and N2 Bus Networking and Troubleshooting Guide Technical Bulletin*.

Troubleshooting the VAV Controller with HVAC PRO for Windows

The following table indicates symptoms and corrections for typical control system malfunctions (primarily in pressure independent applications). We recommend that you use HVAC PRO for Windows Commissioning mode during all troubleshooting procedures.

Table 34: VAV Controller Troubleshooting Symptoms and Corrective Actions

Symptom	Possible Cause	Corrective Action
VAV Controller CFM readings are not within ±10 percent of balancing contractors readings or flow readings are not repeatable.	Velocity Pressure Transducer out of calibration by more than ±20 percent.	Command Auto Zero mode using HVAC PRO for Windows and read the offset value for the DPT sensor. If the value is greater than ±20 percent of the sensor range, you need to replace or manually calibrate the transducer.
	Damper does not seal.	Override damper closed and verify.
	Box Multiplier Constant and/or Box Area parameters are not set correctly.	Verify the numbers displayed in the HVAC PRO for Windows parameters screen against the information on the box, or check the *OEM Reference Manual (FAN 638)* for the recommended numbers per box type.
	One or both airflow pickup to DPT tubing connections are crossed, plugged, or open.	Check that the high or upstream side of the pickup connects to the DPT high side, and the downstream side of the pickup connects to the DPT low side. Check that the tubing is not plugged and that the test taps are capped.
	The ductwork configuration upstream of the airflow pickup is disturbing the air flow across the pickup.	Turns, transitions, and flex duct should be no closer than one duct diameter upstream from the airflow pickup. The takeoff should be at least three duct diameters upstream from the pickup.
No change in the CFM value while you are manually overriding the damper by changing the temperature setpoint or issuing a direct override to the damper command.	Damper linkage is slipping or linked incorrectly.	Inspect the linkage while the actuator is being commanded to ensure tight connection.
	Main system is not supplying enough air.	If the VAV box actuator is linked correctly and you cannot obtain the maximum CFM setpoint, check the Central System Static Pressure to ensure enough primary air is being provided to properly balance the system.
The damper actuator cycles excessively.	The Supply Deadband and/or Heating/Cooling Prop Bands are too narrow.	Check the Supply Deadband value to ensure that it is greater than (48*(box inlet area))ft^2/(4.5*(box inlet area))m^2. If the cycling persists after changing the supply deadbands, check the heating and cooling prop bands to see if they are greater than 4°F/-15.5°C. If not, increase the prop band values to at least 4°F/-15.5°C and add an integration timer of 400.
	Electrical noise is present on zone temperature signal.	Diagnose with HVAC PRO for Windows data graphing. If present, reroute wire or use twisted pair and/or shielded cable.
Series fan is not running.	Unit is not in Occupied mode.	Check HVAC PRO for Windows parameter table to ensure occupied status shows on.
	Unit in initial startup.	Before the series fan is commanded on, the damper fully closes to ensure the fan does not turn backwards.

Troubleshooting the N2 Bus and Networked VAV Controller

You need to troubleshoot the N2 Bus if the Metasys system is not properly communicating with the VAVs. This section first presents a troubleshooting table. Table 35 covers VAV or N2 communication problems and suggests which actions to take.

Second, specific troubleshooting tests are given. Before trying one of these tests, you may be able to determine the cause of the problem by asking yourself the following questions:

- Are the N2 Bus wires securely terminated to each VAV?
- Is the N2 polarity correct?
- Is the VAV powered and ready to respond?
- Are the end-of-line device settings correct?
- Have you cycled power on a VAV after changing its N2 address?
- Is the W3 loop back jumper on the Companion Panel/*LTD* fully pushed down on Pins 1 and 2?
- Are the VAVs configured properly with the correct number of points?

> ⚠ CAUTION: **Electrical Shock Hazard**. To avoid electrical shocks when troubleshooting, always measure the REF to earth ground voltage with the DMM. If line voltage is measured, have a qualified electrician locate the fault.

Table 35: N2 Bus Troubleshooting Symptoms and Corrective Action

Symptom	Possible Cause	Action
N2 Bus is offline.	EOL jumpers and/or W3 jumper on MM-CVT101 or Companion Panel/*LTD* are not installed.	Install EOL jumpers and W3 jumper properly.
	MM-CVT101 is not plugged into PC or 9 VDC source.	Plug MM-CVT101 into PC or plug it into a 9 VDC source.
	N2 Bus polarity is incorrect.	Rewire N2 Bus wires for proper polarity.
VAV cycles online and offline.	A read-only point is defined in the Companion data base as a read/write point (AO or BO).	Delete the AO or BO point and read it as an AI or BI point to the Companion data base.
	A Companion process is using an unconfigured point (i.e., not listed in HVACPRO.SYM file).	Delete the use of the unconfigured point in the Companion process.
VAV does not come online.	Two or more VAVs have the same address.	Change each duplicate VAV address to a unique number.
	The address of the VAV was changed without its power being cycled afterward.	Cycle power on the VAV.
	The ten second delay after downloading the VAV has not yet expired (HVAC PRO Revision 1.0 or earlier).	Wait until the delay expires or cycle power on the VAV.

Zone Bus Troubleshooting -- HVAC PRO for Windows

Table 36 lists and describes the errors that may occur while using the HVAC PRO for Windows commissioning tool with the VAVs over the Zone Bus. The cause of the error is often a loose or improper connection between the CBLPRO (AS-CBLPRO), laptop PC, and the controller. A defective COM port on the laptop could also be at fault. Other times, a defective controller can cause an error.

Note: It takes ten seconds for a VAV Controller to reset and resume communication after being downloaded.

An effective troubleshooting technique is to use a CBLCON and observe its LEDs, which will indicate the problem. You may also try exchanging the component that you believe is defective with a working component of the same type.

A noisy wire adjacent to the Zone Bus can also cause communication errors. Noise can be periodically induced into the Zone Bus, thereby causing sporadic communication failures between the laptop and the VAV. Most often, noisy lines cause intermittent disruption, not total loss of communication.

For more information on the HVAC PRO for Windows, refer to the *HVAC PRO for Windows User's Manual (FAN 637.5).*

Table 36: Communication Errors on Download

Error Number or Description	Cause	Description	Solution
1	Undefined command	The device is being sent a message that contains an invalid command.	Check for tight and proper connections between the laptop PC, CBLPRO, and the VAV.
5	Invalid message size	The size of the message sent does not correspond to the type of message sent.	
11	Invalid command	The command issued is not valid for the data type.	
14	Not ready	The VAV cannot process this message at this time. For example, the EEPROM is not functioning properly.	Cycle power on the VAV. If problem persists, return VAV for repair or replacement.
15	Bad E^2 Write	A problem with the EEPROM exists.	Return the VAV for repair or replacement.
16	No communication	Some hardware problem exists, such as a loose connection or a failed component.	Check for tight and proper connections between the laptop PC, CBLPRO, and the VAV.
Hardware Communication Error		Controller is still in reset mode. Resetting takes ten seconds after a download.	Wait ten seconds for the reset period to expire before trying to commission the controller.
17	Bad CRC	The Cyclical Redundancy Check of the message received is incorrect due to an error in transmission.	Check for tight and proper connections between the laptop PC, CBLPRO, and the VAV.
18	Invalid response	The message received is not what the HVAC PRO for Windows Load Utility expected.	

The green LED on the VAV110/111 and VAV140/141 Series Controllers may be used to troubleshoot problems with the Zone Bus.

Table 37: Zone Bus LED Indications

LED Status	Indication
Off	There is no power to the ASC.
On	The Zone Bus is shorted to Common or 24 VAC.
Blinking	Normal communication is taking place.

Ordering Information

Johnson Controls Code Numbers

Controllers

Table 38: Controller Code Numbers

Code Number	Description
AS-VAV110-1	VAV Controller with eight Binary Outputs (Quick Connects)
AS-VAV111-1	VAV Controller with six Binary Outputs and two Analog Outputs (Quick Connects)
AS-VAV140-1	VAV Controller with screw terminals and eight BOs
AS-VAV141-1	VAV Controller with screw terminals, six BOs and two AOs
AS-VAVDPT1-1*	AS-VAV110-1 Control and DPT-2015-1 for Trane Single Duct Applications
AS-VAVDPT2-1*	AS-VAV111-1 Control and DPT-2015-1 for Trane Single Duct Applications

* Refer to *Building VAVDPT Applications Application Note (LIT-6363042)* in the *Application Specific Controllers Technical Manual (FAN 636.3).*

Sensors/ Transmitters

Table 39: Sensor/Transmitters Code Numbers

Code Number	Description	Type
DPT-2015-1*	Velocity Pressure Transducer (1.5 in. W.C.)	1 to 5 VDC with 15 VDC Supply
HE-6300	Wall Mount Humidity Sensor	0 to 5 VDC with 12 to 30 VDC Supply
HE-6310	Duct Mount Humidity	0 to 5 VDC with 12 to 30 VDC Supply
TE-6000 Series	Temperature Sensor	RTD Resistance
TE-6100-11, TE-6100-12 Series	Zone Temperature Sensor (for T-4000 Cover)	Nickel, 1000 ohm with Phone Jack
TE-6300 Series	Temperature Sensor	Nickel, Platinum, Silicon
TE-6400 Series	Metastat Zone Temperature Sensor Series	Resistance

* DPT Transmitters are typically supplied as part of the actuator assembly (ATP Series) or a controller assembly (VAV DPT Series).

Damper Actuator Assemblies

Table 40: Damper/Actuator Code Numbers

Code Number	Description	
EDA-2040-21 or -22	2-minute Rotation Time	24 VAC Incremental
EDA-2040-61 or -62	6-minute Rotation Time	24 VAC Incremental
ATP-2040-212	EDA-2040-1 and DPT-2015-1 with Cable	24 VAC Incremental 1 to 5 VDC Transmitter
ATP-2040-612	EDA-2040-2 and DPT-2015-1 with Cable	24 VAC Incremental 1 to 5 VDC Transmitter
M100C Series	Zone Bus Damper Actuators	Zone Bus Addressable
M9000-500 Series	Valve Linkage Assembly for M9100 and M9200 Direct Mount Actuators	
M9100-G Series	Direct Mount Actuators	Proportional - Voltage or Current
M9100-H Series	Direct Mount Actuators	Proportional - Voltage or Current
M9200-G Series	Direct Mount Actuators	Proportional - Voltage or Current
M9200-H Series	Direct Mount Actuators	Proportional - Voltage or Current

Valve Actuator Assemblies

Table 41: Valve Actuator Code Numbers

Code Number	Description	Type
VA-715x Series	Valve Actuator	Incremental or 0-10 VDC Proportional
VA-7200 Series	Valve Actuator	Incremental or 0-10 VDC Proportional
VA-8020 Series	Valve Actuator Assemblies 1/2 in.	24 VAC Triac/Incremental
VA-8022 Series	Valve Actuator Assemblies 1/2 in.	0-10 VDC
VA-8050 Series	Valve Actuator Assemblies " 1/2 in., 3/4 in., 1 in., and 1-1/2 in.	24 VAC Triac/Incremental
VA-8051 Series	Valve Actuator Assemblies " 1/2 in., 3/4 in., 1 in., and 1-1/2 in.	24 VAC Triac/Incremental/ with Feedback
VA-8052 Series	Valve Actuator Assemblies " 1/2 in., 3/4 in., 1 in., and 1-1/2 in.	0-10 VDC
VG-5000 Series	Valve/Actuator Assemblies 1/2 in., 3/4 in., and 1 in.	24 VAC On/Off Incremental 0-10 VDC
EP-8000-1 and -2	Electric to Pneumatic Transducer for Pneumatic Valves	0 to 10 VDC to Pneumatic High or Low Volume

Accessories

Table 42: Accessories Code Numbers

Code Number	Description
AS-CBLPRO-2	Zone Bus Communication Tool
AS-ENC100--0	VAV System Enclosure for Field Installed Systems (Sheet Metal)
AS-TBKIT-0	Five Replacement N2 Bus and Five Power Terminal Block Connectors
AS-XFR050-0	Transformer (50 VA)
AS-ZTU100-1*	Zone Terminal
EN-EWC10-0	Enclosure (UPM)
EN-EWC15-0	Enclosure with 50 VA Transformer (UPM)
MM-CVT101-0	RS-232/RS-485 Converter for N2 Download/Commissioning with HVAC PRO for Windows
P32 Series	Air Flow Switch
TE-6001-961	Momentary Button Kit for Temporary Occupancy or Boost Modes (for TE-6100-11,12 only)
WS-WINPRO-0	Configuration Tools Software (includes HVAC PRO for Windows)
WS-WINPRO-6	Configuration Tools Software Upgrade (includes HVAC PRO for Windows)
Y65XX-X Series	Transformer Option (24/120/220/277-480 VAC to 24 VAC)

* Note: The AS-ZTU100-1 supports both AS-VAVxxx-0 and AS-VAVxxx-1 models.
The AS-ZTU100-0 supports AS-VAVxxx-0 models only.

Vendor Code Numbers

The following tables list code numbers and descriptions for VAV Controller equipment requirements. This equipment is available from:

Anixter
4701 W. Schroeder Drive
Brown Deer, WI 53223
(414) 355-0222 (in Milwaukee)
1-800-242-5575 (structure wiring)
1-800-447-8565 (wire and cable)

Use the following table to order preconfigured cables from the factory.

Table 43: Preconfigured Cables

Description	Cable Length		Part Number
	Feet	Meters	
RJ45 Straight-through Cable Assembly Non-plenum	25	7.5	889158
Non-keyed plugs	50	15	889161
24 Gauge/0.6 mm diameter	100	30	889166
8 Conductor			
Solid Wire			
RJ45 Straight-through Cable Assembly Plenum	25	7.5	889315
Non-keyed plugs	50	15	889318
24 Gauge/0.6 mm diameter	100	30	889324
8 Conductor			
Solid Wire			

Use the following table to order cable components for creating your own cables.

Table 44: Cable Components

Description	Part Number
1000 ft/300 m Roll of Non-plenum Rated **24 Gauge/0.6 mm diameter** **8 Conductor** **Solid Wire**	CM-00424BAG-3
1000 ft/300 m Roll of Plenum Rated **24 Gauge/0.6 mm diameter** **8 Conductor** **Solid Wire**	CMP-0042EAC-3
8-position Non-keyed Plugs for Solid Cable **(Bag of 25)**	074683 Stewart
Hand Tool with 8-position Die Set for **24 AWG/0.6 mm diameter Solid Wire**	060612

Specifications

Table 45: General Specifications

Product Name	Variable Air Volume (VAV) Controller
Product Code Numbers	AS-VAV100-0, AS-VAV101-0; AS-VAV110-1, AS-VAV111-1; AS-VAV140-1, AS-VAV141-1
Power Input	20-30 VAC @ 10 VA
Power Draw	VAV with sensors/transmitters: 10 VA (400 mA)
Ambient Operating Conditions	32 to 122°F/0 to 50°C 10 to 90% RH
Ambient Storage Conditions	-40 to 158°F/-40 to 70°C 10 to 90% RH
Dimensions (H x W x D)	6.5 x 6.4 x 2.2 in./165 x 163 x 56 mm without enclosure 6.8 x 7.3 x 4.7 in./173 x 185 x 119 mm with the AS-ENC100-0 enclosure
Shipping Weight	1.4 lb./0.64 kg
Processor	80C652 @ 11 MHz
Word Size	8 bit
EEPROM Size	8k byte (2k byte for VAV 100/101)
ROM/EPROM Size	64k byte
RAM Size	8k byte
Interfaces	N2 and Zone Bus
Inputs/Outputs	8 Analog Inputs (0-10 VDC) 4 Binary Inputs 0/2 Analog Outputs (0-10 VDC) 8/6 Binary Outputs (24 VAC Triacs)
Standard Compliance	IEEE 472 IEEE 518 IEEE 587 Category A FCC Part 15, Subpart J, Class A UL 916, Energy Management Listed, Class PAZX VDE 0871 Class B
Agency Listings	UL 916 Listed and CSA Certified as part of the Metasys Network.

Table 46: Input/Output Specifications for VAV 100/101

Function	Reso-lution	Sam-pling Time	Accu-racy	Range	DC Input Imped-ance	Sensor/ Load Impedance	Noise Protection*	Noise/Surge Standard Tested To*
AI-Voltage	14 bit	1.5 sec	±20 mV	0-2 V or 0-10 VDC	470k ohm	0-5k ohm	NM ResCap + CM Cap	**IEEE-587** a) CM Ringwave: 1.5k V b) NM Bi-Wave: 1.5k V, 3k A **IEEE-472** a) CM Ringwave: 1.5k V b) NM Ringwave: 500V
AI-Temperature	14 bit	1.5 sec	±0.5°F	1000 ohm Si	3540 ohm	0-2k ohm	NM ResCap + CM Cap	
AI-Temperature	15 bit	1.5 sec	±0.7°F	1000 ohm Ni	3540 ohm	0-2k ohm	NM ResCap + CM Cap	
AI-Temperature	16 bit	1.5 sec	±1.3°F	1000 ohm Pt	3540 ohm	0-2k ohm	NM ResCap + CM Cap	
AI-Potentiometer	17 bit	1.5 sec	±0.1°F	0-2k ohm Potentiometer	3540 ohm	0-2k ohm	NM ResCap + CM Cap	
ACCUM-DC	32 bit	10 ms (100 Hz)	N/A	0-15 VDC, 2.5 V Trig **	47k ohm	0-5k ohm	NM ResCap + CM Cap	
BI-DC Sense	1 bit	10 ms	N/A	0-15 VDC, 2.5 V Trig **	47k ohm	0-5k ohm	NM ResCap + CM Cap	
AO Voltage	8 bit	1.5 sec	N/A	0-10 VDC @ 10 mA maximum	N/A	1k-10M ohm	No Special Parts	
BO-AC Triac	N/A	1.5 sec	N/A	24 VAC @ 50-500 mA	N/A	48-480 ohm	Opto + CM Cap	
DC Supply Out	N/A	N/A	N/A	14.6-17 VDC @ 90 mA	N/A	162-10M ohm	Opto + CM Cap	
N2 Bus	N/A	N/A	N/A	5000 ft/ 1500 m	N/A	N/A	PTC + Tranzorb	**IEEE-587** CM Ringwave: 1.5k V NM Ringwave: 500V
Zone Bus	N/A	N/A	N/A	500 ft/150 m	N/A	N/A	PTC + Tranzorb	**IEEE-472** CM Ringwave: 1.5k V NM Ringwave: 500V

State of Outputs During PWR. Fail = Disables when 24 VAC PWR drops below 18 VAC

State of Outputs After PWR. is Restored = Remain disabled for 10 seconds minimum, and then come on per Restart Configuration.

* NM = normal mode, CM = common mode.
CM Cap is a common mode capacitor connected from the I/O point to a separate ground plane.

** To interface to TTL outputs such as demand meters, use an open collector output to drive the +15 VDC pull-up resistor and contact cleaning current capacitor.

Table 47: Input/Output Specifications for VAV 110/111 and VAV 140/141

Function	Reso- lution	Sam- pling Time	Accu- racy	Range	DC Input Imped- ance	Sensor / Load Impedance	Noise Protection*	Noise/Surge Standard Tested To*
AI-Voltage	14 bit	1.5 sec	±20 mV	0-2 V or 0-10 VDC	470k ohm	0-5k ohm	NM ResCap + CM Cap	**IEEE-587**
AI-Temperature	14 bit	1.5 sec	±0.5°F	1000 ohm Si	3540 ohm	0-2k ohm	NM ResCap + CM Cap	a) CM Ringwave: 1.5k V
AI-Temperature	15 bit	1.5 sec	±0.7°F	1000 ohm Ni	3541 ohm	0-2k ohm	NM ResCap + CM Cap	b) NM Bi-Wave: 1.5k V, 3k A
AI-Temperature	16 bit	1.5 sec	±1.3°F	1000 ohm Pt	3542 ohm	0-2k ohm	NM ResCap + CM Cap	**IEEE-472**
AI-Potentiometer	17 bit	1.5 sec		0-2k ohm Potentiometer	3543 ohm	0-2k ohm	NM ResCap + CM Cap	a) CM Ringwave: 1.5k V
ACCUM-DC	32 bit	10 ms (100 Hz)	N/A	0-15 VDC, 2.5 V Trig **	47k ohm	0-5k ohm	NM ResCap + CM Cap	b) NM Ringwave: 500 V
BI-DC Sense	1 bit	10 ms	N/A	0-15 VDC, 2.5 V Trig **	47k ohm	0-5k ohm	NM ResCap + CM Cap	
AO Voltage	8 bit	1.5 sec		0-10 VDC @ 10 mA maximum	N/A	1k-10M ohm	No Special Parts	
BO-AC Triac	N/A	1.5 sec	N/A	24 VAC @ 50-500 mA	N/A	48-480 ohm	CM Cap	
DC Supply Out	N/A	N/A	N/A	14.6-17 VDC @ 90 mA	N/A	162-10M ohm	CM Cap	
N2 Bus	N/A	N/A	N/A	5000 ft/1500 m	N/A	N/A	PTC + Opto + Tranzorb	**IEEE-587** CM Ringwave: 1.5k V NM Ringwave: 500 V
Zone Bus	N/A	N/A	N/A	500 ft/150 m	N/A	N/A	PTC + Tranzorb	**IEEE-472** CM Ringwave: 1.5k V NM Ringwave: 500 V

State of Outputs During PWR. Fail = Disables when 24 VAC PWR drops below 18 VAC

State of Outputs After PAR. is Restored = Remain disabled for 10 seconds minimum, and then come on per Restart Configuration.

* NM = normal mode, CM = common mode.
CM Cap is a common mode capacitor connected from the I/O point to a separate ground plane.

** To interface to TTL outputs such as demand meters, use an open collector output to drive the +15 VDC pull-up resistor and contact cleaning current capacitor.

Notes

Controls Group
507 E. Michigan Street
P.O. Box 423
Milwaukee, WI 53201

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