Spyder Model 5

COMPACT VAV CONTROLLER

WEB-VA423B24N

INSTALLATION INSTRUCTIONS

Fig. 1. WEB-VA423B24N

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TRADEMARK INFORMATION

Sylk™ is a trademark of Honeywell International Inc.

BACnet®is a registered trademark of ASHRAE Inc.

PRODUCT DESCRIPTION

The WEB-VA423B24N controller is part of the Honeywell WEBs Spyder Model 5 family. The Honeywell Spyder Model 5 (WEB- VA423B24N) family of unitary controllers provide flexible, freely programmable, demand-led control that delivers tangible benefits to reduce energy spends while driving new levels of functionality and efficiency in today's buildings. These scalable and freely programmable BACnet MS/TP-based unitary controllers utilize smart engineering and commissioning tools and Sylk™ bus technology. Multiple flexible configurations can be achieved to address specific applications.

WEB-VA423B24N and replacement parts are described in Table 1 and Table 2 on pg.2.

SAFETY INSTRUCTIONS

- While performing any work (installation, mounting, startup), all instructions given by the manufacturer and the safety instructions provided in this document must be followed.
- The WEB-VA423B24N compact VAV controller must be installed and mounted only by authorized and trained personnel.
- If the unit is modified in any way, except by the manufacturer, all warranties concerning operation and safety become invalid.
- Make sure that applicable local standards and regulations are always observed.
- Use only Honeywell supplied or approved accessories.
- Before the system is dismantled, disconnect the power supply by either removing the power terminal block from the controller, or by means of local isolation. Read the following caution note carefully.

CAUTION

Disconnect the power supply before installing the WEB-VA423B24N controller. Do not reconnect the power supply until you have completed the installation.

Table 1. Ordering Information

Controller Model	Description	Power supply	UIs	AOs	Total no. of I/Os	Digital Outputs	Air flow sensor	Integrated Actuator / Declutch	Remarks
WEB-VA423B24N	**Spyder Model 5 Compact VAV with integrated actuator**	24 VAC	4	2	9	3	1	Yes	72 hours data retention

Table 2. Replacement Parts

Device Model	Description	Power supply	UIs	AOs	Total no. of I/Os	Digital Outputs	Air flow sensor	Integrated Actuator / Declutch	Remarks
WEB-V423B24N	**Spyder Model 5 Compact VAV controller only**	24 VAC	4	2	9	3	1	No	72 hours data retention
COVA	**Spyder Model 5 Compact VAV actuator only**	24 VAC	-	-	-	-	-	-	-

DIMENSIONS

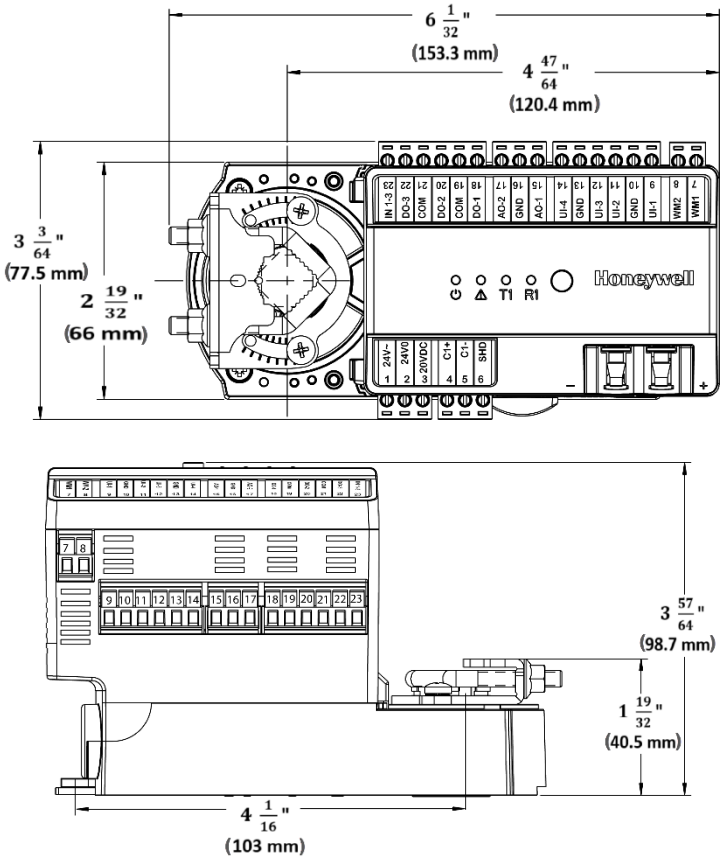


Fig. 2. WEB-VA423B24N controller dimension.

SPECIFICATIONS

General

For a complete list of all terminals and their description of their functions, see Table 4 on pg.4.

NOTE:

All terminal blocks capable of carrying either low voltage or line voltage are orange-colored.

The product package includes a plastic bag containing additional, removable terminal blocks.

Power Supply Terminals

Power is supplied to the controller via a removable terminal plug (Color coded grey, terminal 1 and 2).

CAUTION

Do not mix-up power terminal block (terminal 1 to 3, Grey color) with BACnet MS/TP terminal block (terminal 4 to 6, black color) located adjacent to each other. Interchanging the terminals will damage the controller.

See also section "Power supply" on pg. 9

Power Supply	20-30 VAC at 50/60 Hz, Class 2 transformer
Power Consumption	• **Controller with all connected loads**: 100 VA maximum • **Controller only:** 20 VA maximum
Auxiliary Output	20 VDC ± 10% at 75 mA

Ambient Environmental Limits

Storage	-40 °F to 150 °F (-40 °C to 66 °C)
Operation	32 °F to 122 °F (0 °C to 50 °C)
Humidity	5% to 95% RH., non-condensing

Differential Pressure Sensor

Bi-Directional
Operating Range: 0 to 2.0 in. H_2O (0 to 500 Pa).

Actuator Specifications

Rotation Stroke	95° ± 3° for CW or CCW opening dampers
Torque Rating	44 in-lbs (5 Nm)
Runtime for 90° rotation	108 seconds at 50 Hz
	90 seconds at 60 Hz

Real Time Clock

Operating Range: 24 hour, 365 day, multi-year calendar including day of week and configuration for automatic daylight savings time adjustment to occur at 2:00 a.m. local time on configured start and stop dates.
Power Failure Backup: 72 hours.
Accuracy: ±3.5 minute per month at 77 °F (25 °C)

Digital Relay Outputs (DO)

Voltage Rating: 24 VAC at 50/60Hz
Current Rating: 1.5 A continuous, and 3.5 A (AC RMS) for 100 milliseconds per DO channel.

Analog outputs (AO)

Analog outputs can be individually configured for current or voltage.

Analog Current Outputs

Current Output Range: 4.0 to 20.0 mA DC
Output Load Resistance: 550 Ω maximum

Analog Voltage Outputs

Voltage Output Range: 0.0 to 10.0 VDC
Maximum Output Current: 10.0 mA DC

Universal Inputs (UI) Circuits

See table below for the UI circuit specifications.

Table 3: Universal inputs types and characteristics

Input Type	Sensor Type	Operating Range
Room/Zone Discharge Air Outdoor Air Temperature	20k Ω NTC	-40 °F to 199 °F (-40 °C to 93 °C)
Outdoor Air Temperature	PT1000 (IEC751 3850)	-40 °F to 199 °F (-40 °C to 93 °C)
Resistive Input	Generic	100 Ω to 100K Ω
Voltage Input	Transducer Controller	0-10 VDC
Discrete Input	Dry Contact Closure	0-10 VDC without pull-up resistor, External 499 Ω resistor required to measure 0-20 mA
Pulse Input[a]	Counter/Meter	Maximum Frequency: 15 Hz Minimum Pulse Width: 33 ms.

[a] One Universal Input (UI-1) on the WEB-VA423B24N is user selectable as a fast digital pulse meter.

TERMINALS

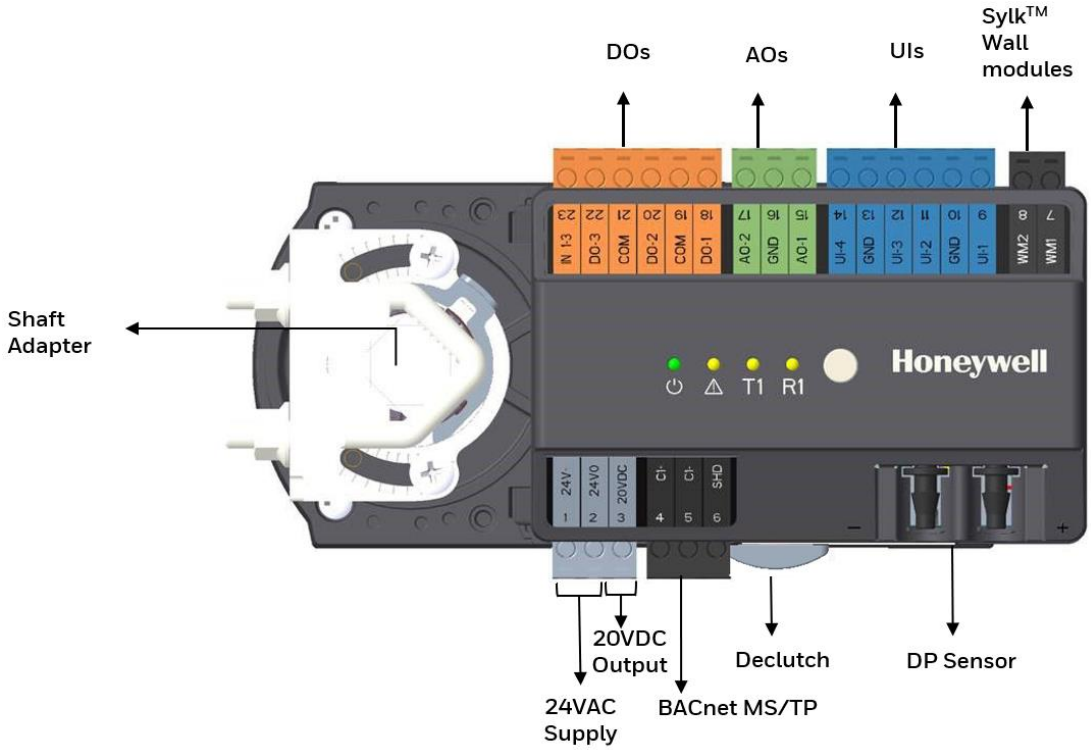


Table 4. WEB-VA423B24N: Overview of the terminals and functions

Fig. 3. WEB-VA423B24N: Overview of terminals and functions

Terminal	Printing	Details
1	24 V~	Supply Voltage (24 V)
2	24 V0	Supply Voltage (GND), internally connected with terminal 10, 13 & 16
3	20 VDC	20 VDC power out
4,5	C1+, C1-	Removable BACnet MS/TP interface
6	SHD	Shield for external wiring support. It is not connected internally.
7,8	WM1, WM2	Removable interface for Sylk™ bus
9	UI-1	Universal Input 1
10	GND	Ground
11	UI-2	Universal Input 2
12	UI-3	Universal Input 3
13	GND	Ground
14	UI-4	Universal Input 4
15	AO-1	Analog Output 1
16	GND	Ground
17	AO-2	Analog Output 2
18	DO-1	Digital Output 1
19	COM	Supply voltage common terminal for DO. It is internally connected to terminal 21 but not to the controller's GND terminal.
20	DO-2	Digital Output 2
21	COM	Supply voltage common terminal for DO. It is internally connected to terminal 19 but not to the controller's GND terminal.
22	DO-3	Digital Output 3
23	IN 1-3	24V AC/DC input for DOs 1-3

INSTALLATION

Before mounting the controller on damper shaft, review the power, inputs and output specification on pg.3.
Hardware driven by the analog current outputs must have a maximum resistance of 550 Ω.

IMPORTANT

Avoid mounting in areas where acid fumes or other deteriorating vapors can harm the metal parts of the controller, or in areas where escaping gas or other explosive vapors are present.

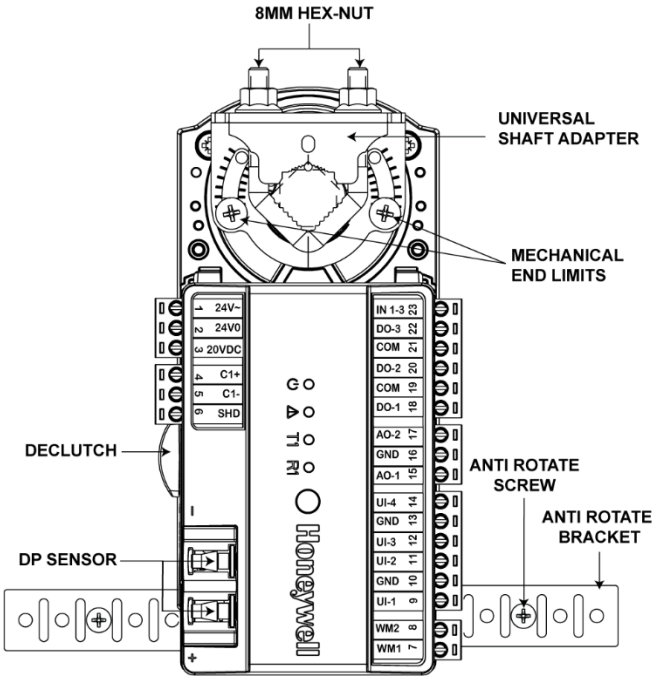


Fig. 4. WEB-VA423B24N controller

Before Mounting Actuator onto the Damper Shaft

WEB-VA423B24N controller includes the direct-coupled actuator with Declutch mechanism, which is shipped hard-wired to the controller.
Before mounting the WEB-VA423B24N onto the VAV damper shaft, do the following:

1. Ensure that the diameter of the damper shaft is within the allowed limits:

Square shaft	$^{1}/_{4}$ – $^{1}/_{2}$ in. (6-13 mm)
Round shaft	$^{5}/_{16}$ – $^{5}/_{8}$ in. (8-16 mm)

2. Ensure that the damper shaft has a length of at least 1 $^{3}/_{4}$ in. (44 mm).
3. Determine the direction in which the damper shaft rotates to open the damper (CW or CCW) (see Fig. 5). Typically, there is an etched line on the end of the damper shaft that indicates the position of the damper. In Fig. 6, the indicator shows the damper open in a CW direction.

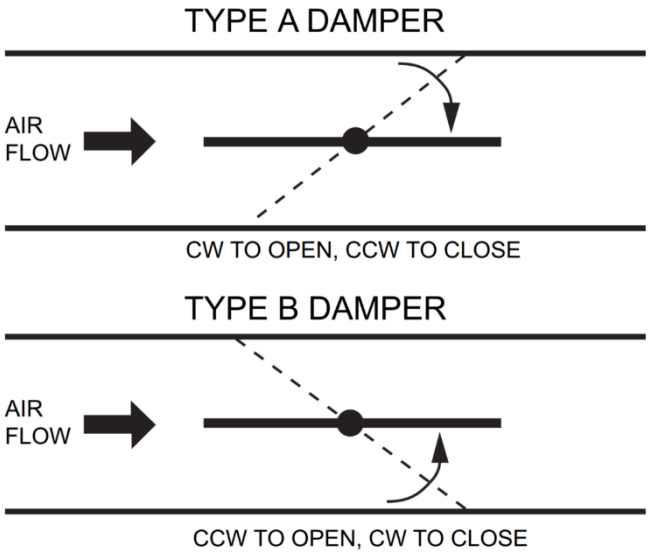


Fig. 5. Determining the rotation direction (CW or CCW)

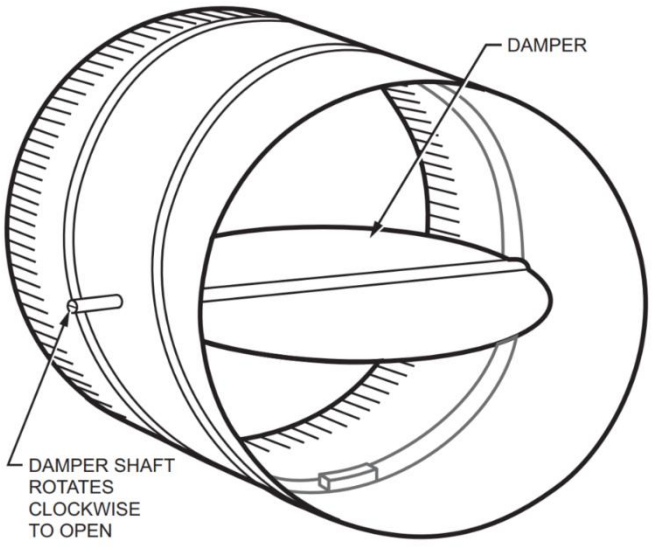


Fig. 6. Damper with 90 degree CW rotation to open

IMPORTANT

Mount the actuator flush with damper housing or add a spacer between the actuator mounting surface and damper box housing.

4. Determine the damper full opening angle (45, 60, or 90 degrees). In Fig. 6, the damper is open to its fully open position of 90 degrees.

Mounting Actuator onto Damper Shaft

WEB-VA423B24N compact VAV controller can be mounted in any orientation but should be mounted in a position that allows clearance for wiring, servicing, removal, connection of the BACnet connector and access to the service button.

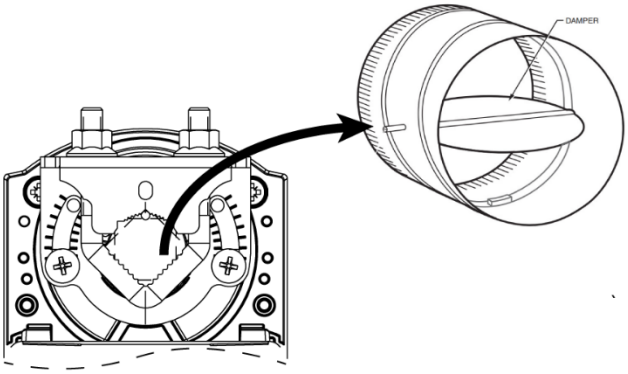


Fig. 7. Mounting an actuator

IMPORTANT

- The controller is not position sensitive and can be mounted sideways or upside down also.
- The Spyder Model 5 compact VAV controller's integral actuator does not float inside the housing therefore it should be installed with a floating mount to allow for non-concentric travel, which can occur with damper shaft that are out-of-round and/or have asymmetrical damper shaft mounts.
- If the actuator does not allow any wobble, then it is likely to bind. To prevent this, when installing the Spyder Model 5 VAV controller, install it over the damper shaft and then slide the anti-rotation bracket underneath and into the mounting slot but not at the very end of the slot (leave a little wiggle room).
- Screw the anti-rotation bracket using two screws on the sides of the controller.
- The anti-rotation bracket is designed to be bent as needed (it has built-in bend-it-easy slots) to accommodate difficult installation locations.

CAUTION

Do not hard-mount the Spyder Model 5 compact VAV controller with a screw directly into the anti-rotation slot.

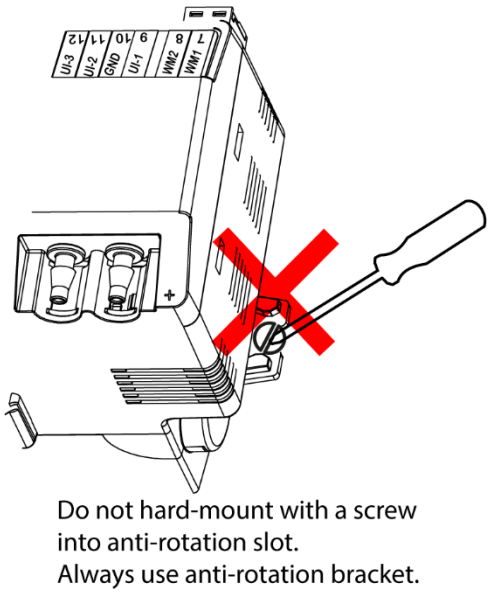


Fig. 8. Do not hard-mount the controller

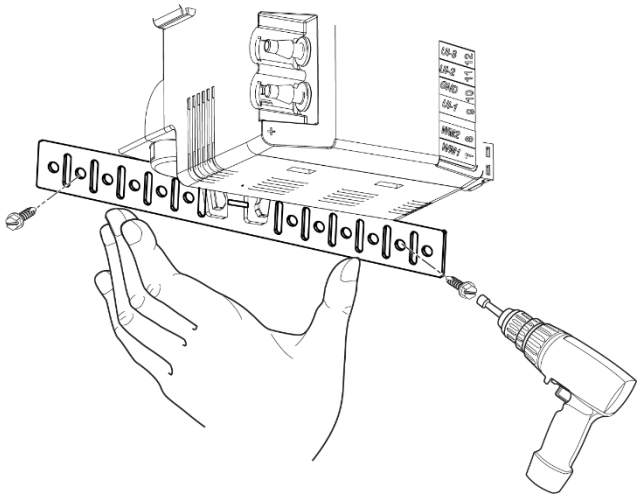


Fig. 9. Always use Anti-rotate bracket

Tools required:

- Phillips #2 screwdriver for end-limit set screw adjustment
- 8 mm wrench for centering clamp

The actuator mounts directly onto the VAV box damper shaft and has up to 44 in-lb. (5 Nm) torque, 90-degree stroke, and 108 second timing at 50 Hz and 90 second timing at 60 Hz.
The actuator is shipped with two mechanical end-limit set screws to control the amount of rotation from 12° to 95°. These set screws must be securely fastened in place. To ensure tight closing of the damper, the shaft adapter has a total rotation stroke of 95°.

NOTES:

- The actuator is shipped with the mechanical end-limit set screws set to 95 degrees of rotation. Adjust the two set screws closer together to reduce the

rotation travel. Each "hash mark" indicator on the bracket represents approximately 6.5° of rotation per side.

- The Declutch button, when pressed, allows you to rotate the universal shaft adapter.

The unit is shipped with the actuator set to rotate open in the clockwise (CW) direction to a full 95 degrees. The extra 5 degrees ensures a full opening range for a 90° damper. The installation procedure varies depending on the damper opening direction and angle:

1. If the damper rotates clockwise (CW) to open, and the angle of the damper open-to-closed is 90 degrees:

1.1. Manually open the damper fully (rotate clockwise).
1.2. Using the Declutch button, rotate the universal shaft adapter fully clockwise.
1.3. Mount the actuator to the VAV damper box and shaft.
1.4. Tighten the two bolts on the centering clamp (8 mm wrench; 70 lb.-in. [8 Nm] torque). When the actuator closes, the damper rotates CCW 90 degrees to fully close.

2. **If the damper rotates clockwise (CW) to open, and the angle of the damper open-to-closed is 45 or 60 degrees:**

2.1. Manually open the damper fully (rotate clockwise).
2.2. The actuator is shipped with the mechanical end limits set at 95 degrees. Adjust the two mechanical end-limit set screws to provide the desired amount of rotation. Adjust the two set screws closer together to reduce the rotation travel.

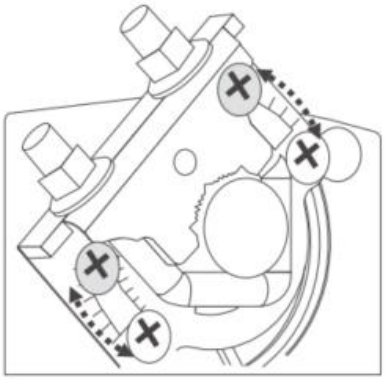


Fig. 10. Setting the mechanical end limits

2.3. Tighten the two mechanical end-limit screws (Phillips #2 screwdriver; (26.5-31 lb.-in. [3.0-3.5 Nm] torque).
2.4. Using the Declutch button, rotate the universal shaft adapter fully clockwise.
2.5. Mount the actuator to the VAV damper box and shaft.
2.6. Tighten the two bolts on the centering clamp (8 mm wrench; 70 lb. in. [8-10 Nm] torque).
2.7. When the actuator closes, the damper rotates CCW either 45 or 60 degrees to fully close.

3. **If the damper rotates counterclockwise (CCW) to open, and the angle of the damper open-to-closed is 90 degrees:**

3.1. Manually open the damper fully (rotate counterclockwise).
3.2. Using the Declutch button, rotate the universal shaft adapter fully counterclockwise.
3.3. Mount the actuator to the damper box and shaft.
3.4. Tighten the two bolts on the centering clamp (8 mm wrench; 70 lb.-in. [8Nm] torque). When the actuator closes, the damper rotates CW 90 degrees to fully close.

4. **If the damper rotates counterclockwise (CCW) to open, and the angle of the damper open-to-closed is 45 or 60 degrees:**

4.1. Manually open the damper fully (rotate counterclockwise).
4.2. The actuator is shipped with the mechanical end limits set at 95 degrees. Adjust the two mechanical end-limit set screws to provide the desired amount of rotation. Adjust the two set screws closer together to reduce the rotation travel.
4.3. Tighten the two mechanical end-limit screws (Phillips #2 screwdriver; (26.5-31 lb.-in. [3.0-3.5 Nm] torque).
4.4. Using the Declutch button, rotate the universal shaft adapter fully counter-clockwise.
4.5. Mount the actuator to the VAV damper box and shaft.
4.6. Tighten the two bolts on the centering clamp (8 mm wrench; 70 lb.-in. [8Nm] torque).
4.7. When the actuator closes, the damper rotates CW either 45 or 60 degrees to fully close.

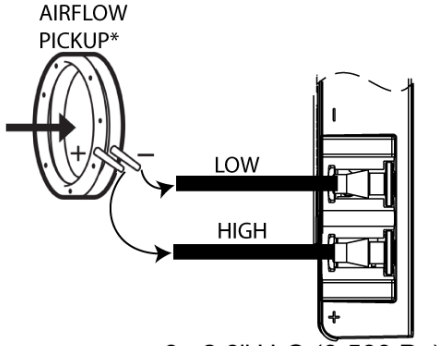
PIPING

Connect the air flow pickup to the two restrictor ports on the controller.

Note:

- Use $^{1}/_{4}$ in. (6 mm) outside diameter, with a $^{3}/_{64}$ in. (1 mm) wall thickness, plenum-rated 1219 FR (94V-2) tubing.
- Always use a fresh cut on the end of the tubing that connects to the air flow pickups and the restrictor ports on the controller.

It is recommended (not compulsory) to connect the high pressure or upstream tube to the plastic restrictor port labeled (+), and the low pressure or downstream tube to the restrictor port labeled (-). See labeling in Fig. 11. When twin tubing is used from the pickup, split the pickup tubing a short length to accommodate the connections.



* Maximum pressure: 0 - 2.0" H_2O (0-500 Pa)

Blowing and sucking air through mouth into the pressure tubes will damage the pressure sensor.

Fig. 11. Airflow pickup connections

NOTES:

- If controllers are mounted in unusually dusty or dirty environments, an inline, 5-micron disposable air filter (use 5-micron filters compatible with pneumatic controls) is recommended for the high-pressure line connected to the air flow pickup.
- The tubing from the air flow pickup to the controller should not exceed three feet (1 m). Any length greater than this will degrade the flow sensing accuracy.
- Use caution when removing tubing from a connector. Always pull straight away from the connector or use diagonal cutters to cut the edge of the tubing attached to the connector. Never remove by pulling at an angle.

Best practice for zero calibration of air flow sensor

The controller must be powered up for a minimum of 1 hour before performing the zero calibration for the air flow sensor.

POWER SUPPLY

General Information

To prevent a risk of injury due to electrical shock and/or damage to device due to short-circuiting, low-voltage and high-voltage lines must be kept physically separate from one another. Further, to prevent a risk of short-circuiting and damage to your unit, do not reverse the polarity of the power connection cables, and avoid ground loops (i.e., avoid connecting one field device to several controllers).

Before wiring the controller, determine the input and output device requirements for each controller used in the system. Select input and output devices compatible with the controller and the application. Consider the operating range, wiring requirements, and the environment conditions when selecting input/output devices. The Actuator, COVA must be used in combination with the controller WEB-V423B24N. See Product Data 31-00361 for individual part model numbers.

Determine the location of controllers, sensors, actuators and other input/output devices and create wiring diagrams for illustrations of typical controller wiring for various configurations. Refer Fig. 18 on pg.16 for example wiring.

The application engineer must review the control job requirements. This includes the sequences of operation for the controller, and for the system as a whole. Usually, there are variables that must be passed between the controller and other Spyder BACnet controllers that are required for optimum system wide operation. Typical examples are the TOD, Occ/Unocc signal, the outdoor air temperature, the demand limit control signal, and the smoke control mode signal.

It is important to understand these interrelationships early in the job engineering process, to ensure proper implementation when configuring the controllers.

NOTES:

- All wiring must comply with applicable electrical codes and ordinances. Refer to job or manufacturers' drawings for details. Local wiring guidelines (for example, IEC 364-6-61 or VDE 0100) may take precedence over recommendations provided in these installation instructions.
- To comply with CE requirements, devices having a voltage of 50-1000 VAC or 75-1500 VDC but lacking a supply cord, plug, or other means for disconnecting from the power supply must have the means of disconnection incorporated in the fixed wiring. This type of disconnection must have a contact separation of at least 3 mm at all poles.

Wiring

All wiring must comply with applicable electrical codes and ordinances, or as specified on installation wiring diagrams. Controller wiring is terminated to the screw terminal blocks located on the device.

NOTES:

- For multiple controllers operating from a single transformer, the same side of the transformer secondary must be connected to the same power input terminal in each controller. Controller configurations will not necessarily be limited to three devices, but the total power draw, including accessories, cannot exceed 100 VA when powered by the same transformer (U.S. only).

- All loads on the controller must be powered by the same transformer that powers the controller itself. A controller can use separate transformers for controller power and output power.

The 24 VAC power from an energy limited Class II power source must be provided to the controller. To conform to Class II restrictions (U.S. only), the transformer must not be larger than 100 VA. Fig. 12 depicts a single controller using one transformer

IMPORTANT

- Power must be off prior to connecting to or removing connections from the 24 VAC power (24 V~/24 V0), and 20 VDC power (20 VDC) terminals.
- Use the heaviest gauge wire available, up to 18 AWG (0.8 mm^2), with a minimum of 22 AWG (0.3 mm^2), for all power wiring.

More than one controller can be powered by a single transformer. Fig. 13 shows power wiring details for multiple controllers.

CAUTION

Controller configurations are not necessarily limited to three devices, but the total power draw, including accessories, cannot exceed 100 VA when powered by the same transformer (U.S. only)

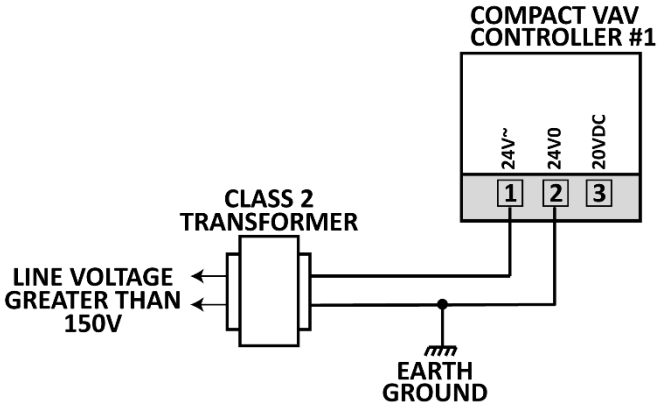


Fig. 12. Power wiring details for one controller per transformer.

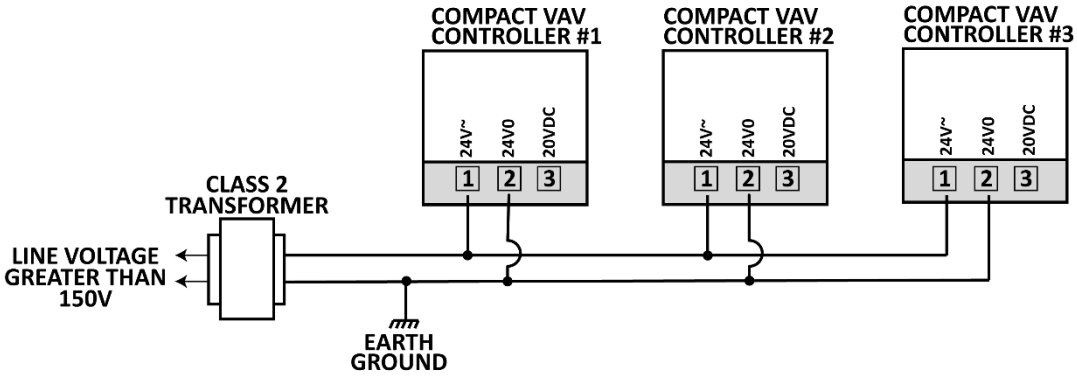


Fig. 13. Power wiring details for two or more controllers per transformer

COMMUNICATION

BACnet MS/TP Interface

The controller features an RS485 interface (terminals 4, 5, and 6) suitable for BACnet MS/TP communication. The terminal block containing it is black. The cable length affects the baud rate (See Table 5 below)

Table 5. Baud rate vs. Maximum cable length

Baud rate	Maximum cable length (L)
9.6, 19.2, **38.4**, 57.6, and 76.8 kbps	4000 ft (1200 m)

The controller supports auto-baud rate adaption for BACnet MS/TP communication at all of the aforementioned baud rates (default: 38.4 kbps). For information on wire gauge, maximum permissible cable length, possible shielding and grounding requirements, and the maximum number of devices which can be connected to a bus, refer to standard EIA-485.

IMPORTANT

- This controller is insensitive to bias voltages because of failsafe chip-set inside and can share the BACnet bus with other devices with or without bias voltages.

Connecting to BACnet MS/TP Buses

The controller communicates via its BACnet MS/TP interface with other BACnet MS/TP-capable devices (for example, other room controllers or MS/TP controllers). In doing so, the following considerations should be taken into account.

- Maximum BACnet MS/TP bus length (= "L" in Fig. 14). (See Table 5 above).
- Twisted-pair cable, for example,
  - AWG 18
  - J-Y(ST)Y 4 x 2 x 0.8 mm^2 or a special RS485 cable.
  - CAT 5,6,7 cable – use only one single pair for one bus
  - Belden 9842 or 9842NH and
  - Daisy-chain topology.
- Must conform to EIA-RS485 cabling guidelines and ANSI/ASHRAE Standard 135-2010.
- There are two limitations regarding the number of controllers per BACnet MS/TP channel:

Physical limitation:

32 loads as per TIA/EIA-485 standard. One Spyder Model 5 controller represents ¼ load. The physical limitation is important in case 3rd party devices representing a full load are connected.

AutoMAC limitation:

We have tested with a maximum of 64 for maxMaster. A maxMaster of 64 means we support a maximum of 62 Spyder Model 5 VAV controllers, one supervisor, and one BACnet client (tool) per BACnet MS/TP channel. The default value for maxMaster is 35, as this is the maximum supported by some plant controllers. In the event that you have a plant controller capable of supporting more than 35 devices, it will therefore be necessary for you to increase the maxMaster setting to the actual required number of devices (e.g., to the maximum number of 64). Refer to the Spyder Model 5 – Engineering Tool User Guide for more information on how to do this.

Thus, depending upon your actual performance needs and required communication rates, it is recommended to connect a smaller number of BACnet MS/TP devices per channel.

NOTE 1:

- If any of the devices are electrically isolated, it is recommended that those devices be connected to signal ground.

NOTE 2:

- Matched terminating resistors are required at each end of a segment bus wired across (+) and (-). Use matched precision resistors rated ¼ W ±1% / 80 - 130 Ω. Ideally, the value of the terminating resistors should match the rated characteristic impedance of the installed cable. For example, if the installed MS/TP cable has a listed characteristic impedance of 120 Ω, install 120 Ω matched precision resistors.

NOTE 3:

- Following proper MS/TP cabling shield grounding procedures is important to minimize the risk of communication problems and equipment damage caused by capacitive coupling. Capacitive coupling is caused by placing MS/TP cabling close to lines carrying higher voltage. If shielding is used, the shielding of each individual bus segment should be separately connected at one end to earth.

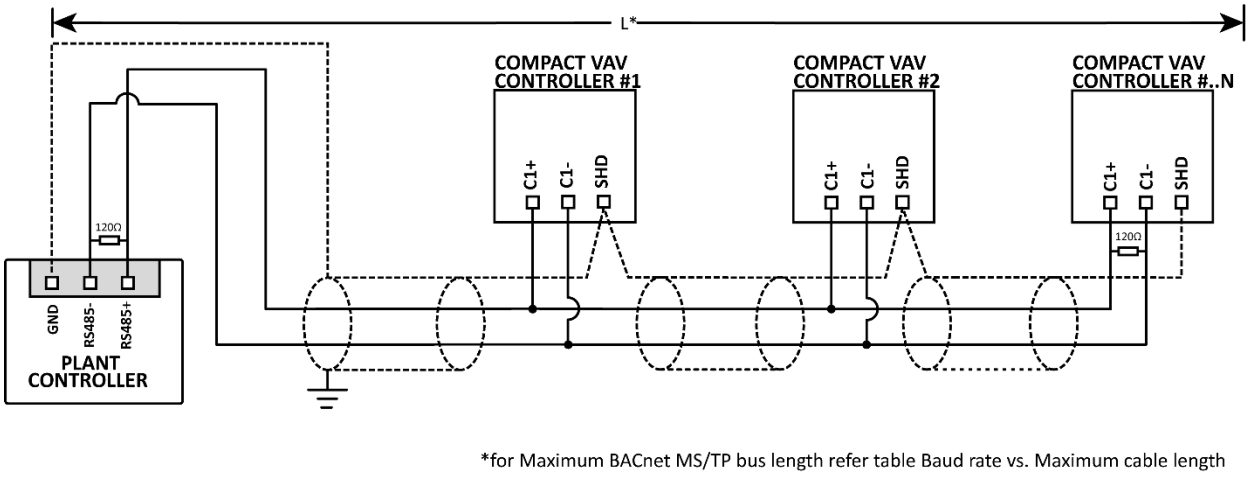


Fig. 14. Connection to a BACnet MS/TP Bus

Sylk Bus™

Sylk™ Bus capable wall modules such asTR40x / T42x can be connected to the controller's Sylk™ Interface (terminals 7 and 8).

- The Sylk™ Bus is single pair, and polarity-insensitive.
- Maximum current provided at the Sylk™ Bus interface: 96 mA.
- The maximum number of wall modules depends on the following wall module specific information:
  1. Sylk™ bus power consumption
  2. Number of parameters used
  3. Total config file size

The IRM NX tool has an inbuilt resource calculator to calculate the amount of Sylk™ wall modules.

The Sylk™ devices supported by the WEB-VA423B24N are; TR40, TR40-H, TR40-CO2, TR40-H-CO2, TR42, TR42-H, TR42-CO2, TR42-H-CO2, TR71, TR71-H, TR75, TR75-H, TR120, TR120H wall modules and C7400S Sylk™ sensor.

Single twisted pair, Non-Shielded, Stranded or Solid [a]		**Standard non-twisted thermostat wire shielded or Non-Shielded, Stranded or Solid [b,c]**
18 - 22 AWG (0.33 to 0.82 mm^2)	24 AWG (0.20 mm^2)	18 - 24 AWG (0.20 to 0.82 mm^2)
500 ft (150 m)	400 ft (120 m)	100 ft (30 m)

[a] As a rule of thumb, single twisted pair (two wires per cable, only), thicker gauge, non-shielded cable yields the best results for longer runs.
[b] The 100 ft (30 m) distance for standard thermostat wire is conservative but is meant to reduce the impact of any sources of electrical noise (incl. but not limited to VFDs, electronic ballasts, etc.). Shielded cable recommended only if there is a need to reduce the effect of electrical noise.
[c] These distances apply also for shielded twisted pair.

The RS485 Standard

According to the RS485 standard (TIA/EIA-485: "Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems"), only one driver communicating via an RS485 interface may transmit data at a time. Further, according to U.L. requirements, each RS485 interface may be loaded with a max. of 32 unit loads. For example, if a controller utilizes as little as $^1/_8$ unit load each, up to 256 devices can be connected.

BACnet connections to the RS485 interfaces must comply with the RS485 standard. Thus, it is recommended that each end of every bus should be equipped with a termination resistor (not included in shipment) having a resistance equal to the cable impedance (120 Ω; the wattage should be in the range of 0.25 – 0.5 W).

RS485 systems frequently lack a separate signal ground wire. However, the laws of physics still require that a solid ground connection be provided for in order to ensure error-free communication between drivers and receivers – unless all of the devices are electrically isolated, and no earth grounding exists.

IMPORTANT

A separate signal ground wire must be used. Failing to obey this requirement can lead to unpredictable behavior if other electrically non-isolated devices are connected and the potential difference is too high.

EIA 485 Cable Specifications

The following cable specification is valid for BACnet MS/TP EIA 485 buses.

Table 6. EIA 485 cable specifications

Maximum length	4000 ft (9.6–78.8 kbps) or 2600 ft (115.2 kbps).
Cable type	Twisted pair shielded (foil or braided shields are acceptable)
Characteristic impedance	100-130 Ω
Distributed capacitance between conductors	Less than 100 pF per meter (30 pF per foot)
Distributed cap. between conductors and shield	Less than 200 pF per meter (60 pF per foot)

The following cables fulfill this requirement:

- AWG 18
- Shielded, twisted pair cable J-Y-(St)-Y 4 x 2 x 0.8 mm^2.
- CAT 5,6,7 cable - use only one single pair for one bus
- Belden 9842 or 9842NH.

Wiring Method

NOTES:

- When attaching two or more wires to the same terminal, other than 14 AWG (2.0 mm^2), be sure to twist them together. Deviation from this rule can result in improper electrical contact (see Fig. 15).

Each terminal can accommodate the following gauges of wire:

- Single wire: from 22 AWG to 18 AWG solid or stranded
- Multiple wires: up to two 18 AWG stranded, with 1/4 watt wire-wound resistor

Prepare wiring for the terminal blocks, as follows:

- Strip $^1/_2$ in. (13 mm) insulation from the conductor.
- Cut a single wire to $^3/_{16}$ in. (5 mm). Insert the wire in the required terminal location and tighten the screw.
- If two or more wires are being inserted into one terminal location, twist the wires together a minimum of three turns before inserting them (see Fig. 15).
- Cut the twisted end of the wires to $^3/_{16}$ in. (5 mm) before inserting them into the terminal and tightening the screw.
- Pull on each wire in all terminals to check for good mechanical connection.

NOTES:

- Do not overtighten the terminal screws to avoid deformation and damage of the terminal block. The maximum torque for the terminal screws 4.4 lb.-in. (0.5 Nm).

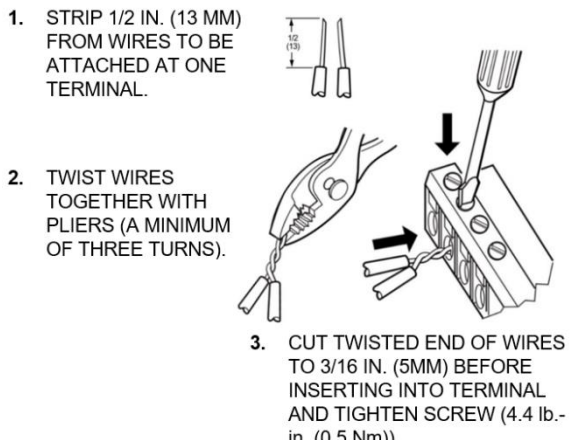


Fig. 15. Attaching two or more wires at terminal blocks

COMMISSIONING

Automatic MAC Addressing

In contrast to other controllers the WEB-VA423B24N controller features automatic MAC addressing.

The MAC addresses which the individual WEB-VA423B24N controllers in the BACnet MS/TP channel assign to themselves are not assigned in sequential order.

Rather, they assign those numbers (MAC Address) in the range of 1 to maxMaster currently not in use by another device in the BACnet MS/TP channel (the MAC Address of "0" is reserved by default for the router / plant controller, itself).

All WEB-VA423B24N controllers are BACnet MS/TP masters. Every master performs periodic polling for the possible appearance of new masters. Each master "knows" the identity of the "next" master (i.e., that WEB-VA423B24N controller with the next-highest MAC Address) on the BACnet MS/TP bus and to which it must therefore pass the token. The polling process includes a search for new masters which might have MAC addresses lying between its own MAC address and that of the "next" master.

The property maxMaster specifies the highest-allowable address for master nodes. The maxMaster is set to 35 by default, thus guaranteeing that, on a BACnet MS/TP bus with, for example, 35 WEB-VA423B24N controllers, all of the other WEB- VA423B24N controllers will be found. Both the property maxMaster and the property MAC address are writeable properties that can be changed.

NOTE: You should not attempt to program a MAC Address outside the range of 1 to maxMaster.

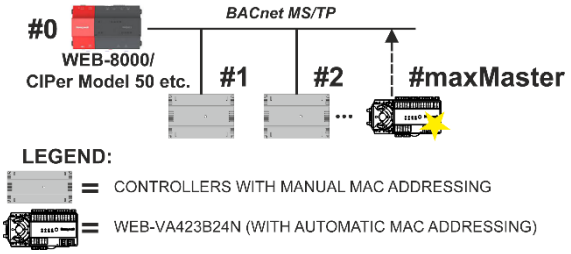


Fig. 16. Automatic MAC addressing

In the scenario depicted in Fig. 16, some of the controllers in the BACnet MS/TP channel do not feature automatic MAC addressing; rather, their MAC addresses were assigned manually (for example, using their two dip switches). Thus, when a new WEB- VA423B24N is added to the channel, when its automatic MAC addressing function is triggered, it will assign itself an available (i.e., unoccupied) MAC address.

During the automatic MAC addressing process, LED behavior (See Table 8 on pg. 14) is displayed.

OPERATOR INTERFACE LEDs

The controller features the following LEDs:

Table 7. Description of LED behaviors

Symbol	Color	Function
⏻	Green	Power LED indicating firmware problems, hardware problems, etc.
⚠	Yellow	Status LED indicating firmware problems, hardware problems, etc.
T1	Yellow	LED indicating transmission of communication signals via the BACnet MS/TP interface. In case of no communication LED will be off.
R1	Yellow	LED indicating reception of communication signals via the BACnet MS/TP interface. In case of no communication LED will be off.

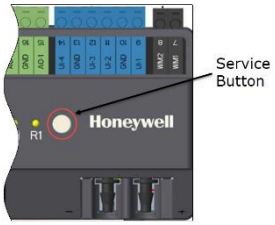
Table 8. Status LED and power LED behaviors

Mode	Power LED (green)	Status LEDs (yellow)
Power Failure	OFF	OFF
Device Error*	ON	ON
Firmware Download	ON/OFF (1 Hz)	ON/OFF (1 Hz)
No Application	ON/OFF (0.5 Hz)	ON/OFF (0.25 Hz)
Broken Sensor	ON/OFF (0.25 Hz)	Stays ON
Short-Circuiting	ON/OFF (0.5 Hz)	Stays ON
Auto-MAC	ON/OFF (1 Hz)	ON/OFF (0.5 Hz)
Unacknowledged Alarm	ON/OFF (2 Hz)	ON/OFF (2 Hz)
Normal Operation	ON/OFF (0.5 Hz)	Stays OFF

*Please return the controller for repair. Contact Honeywell WEBs Customer Care for assistance.

The ON/OFF frequencies listed in Table 8 above can be converted from "Hz" (i.e., "ON/OFF per second") to "ON/OFF per minute" by multiplying them by 60.

Service Button



The Service Button is used to trigger dedicated events.
It is important to distinguish different controller behaviors which are elicited depending upon whether the Service Button is pressed when the controller is powering up or when it is in normal operation. See the following dedicated events.

Pressing Service Button during Power-Up

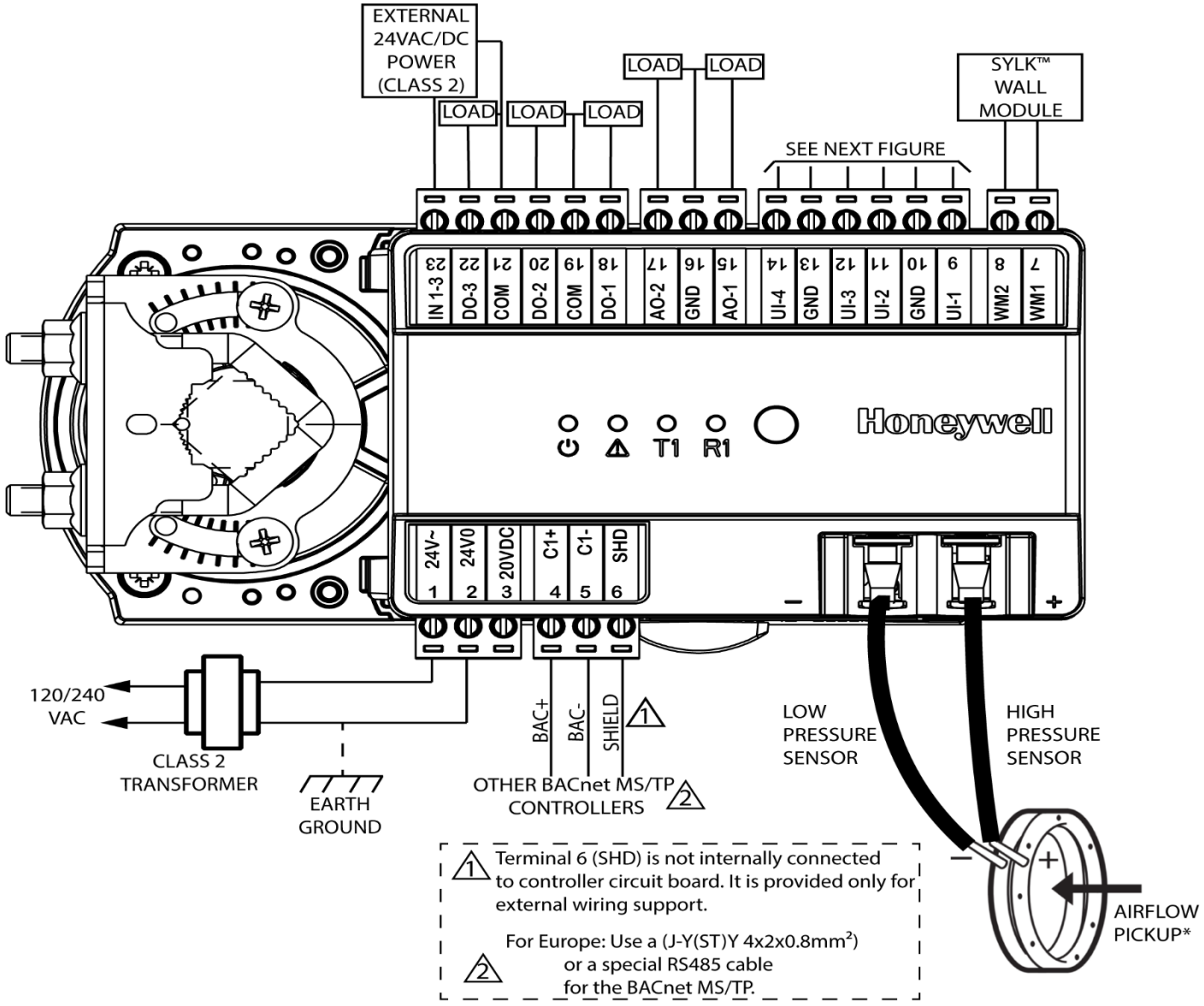
During controller power-up, pressing the Service Button until LED behavior (See Table 8 on pg.14) is displayed will reset the controller to its factory settings, which are as follows:

- The application is cleared from the controller.
- The MAC address will be set to 0xFF, meaning that the controller will now search for a new mac address (Auto-MAC will be automatically triggered after controller power-up).
- The maxMaster setting will revert to its default value of 35.
- The Max info frames will revert to 10.
- The device instance will revert to its default of 4194302.
- The device name will revert to WEB-[ModelName].
- The values of Auto MAC, Min MAC and Max MAC will be reset to 1 and maxMaster, respectively.

Pressing Service Button during Normal Operation

During normal operation of the controller, a short press (< 1 sec) of the Service Button will cause a Service Pin Message (BACnet WhoAmI as a Private Transfer (SerialNo. = 130)) to be sent.

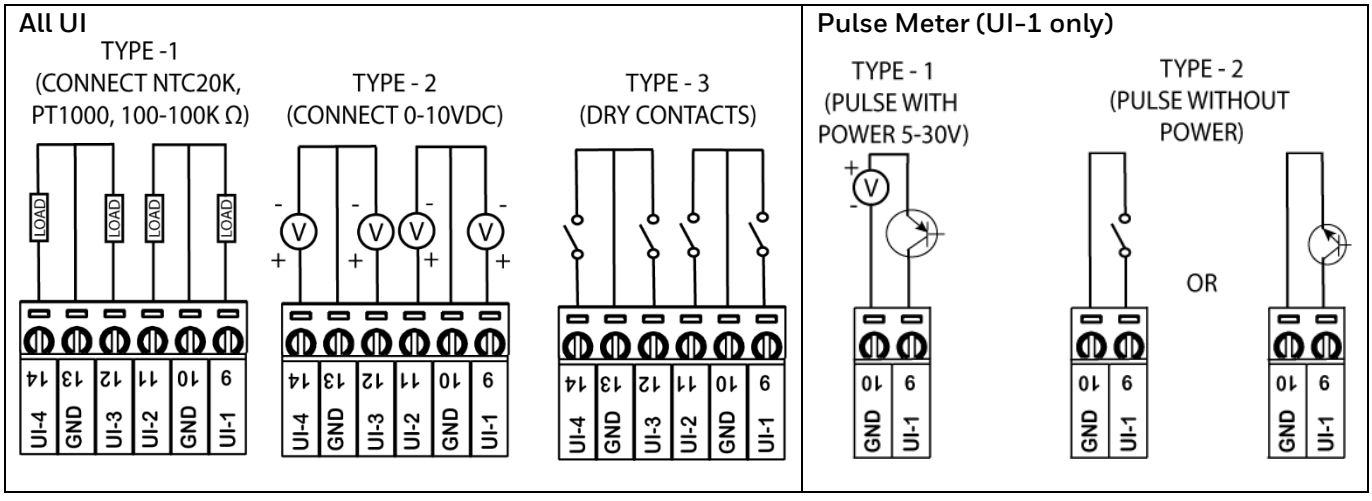
SCHEMATIC DIAGRAM



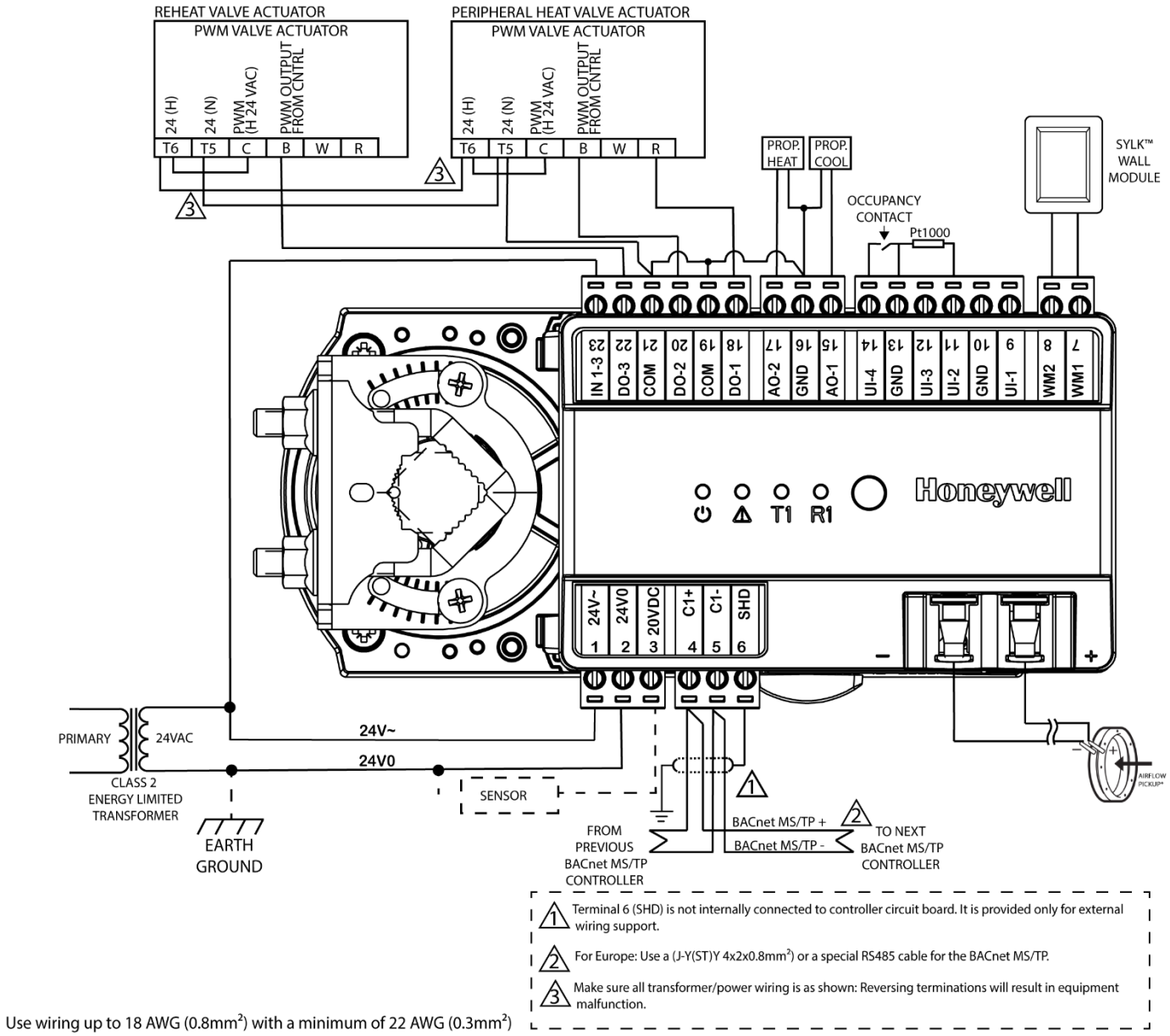
Use wiring up to 18 AWG (0.8mm²) with a minimum of 22 AWG (0.3mm²)

Fig. 17. Schematic diagram for WEB-VA423B24N

UI wiring



TYPICAL VAV APPLICATION – EXAMPLE WIRING



Use wiring up to 18 AWG (0.8mm²) with a minimum of 22 AWG (0.3mm²)

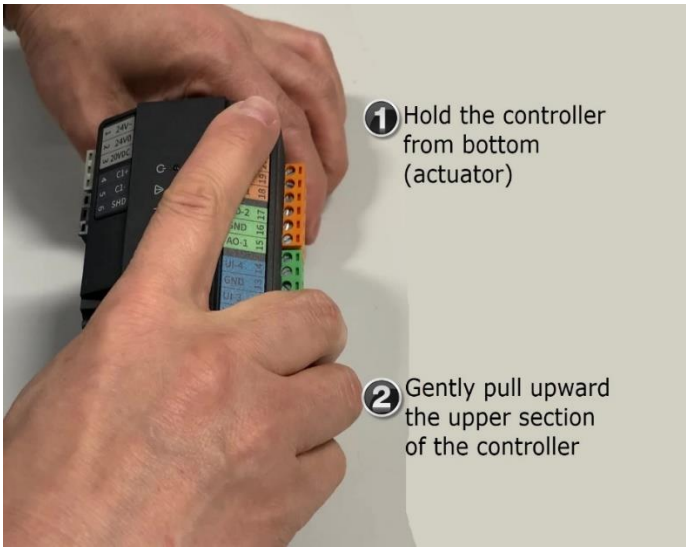
Fig. 18. WEB-VA423B24N Example wiring

REPLACING ACTUATOR

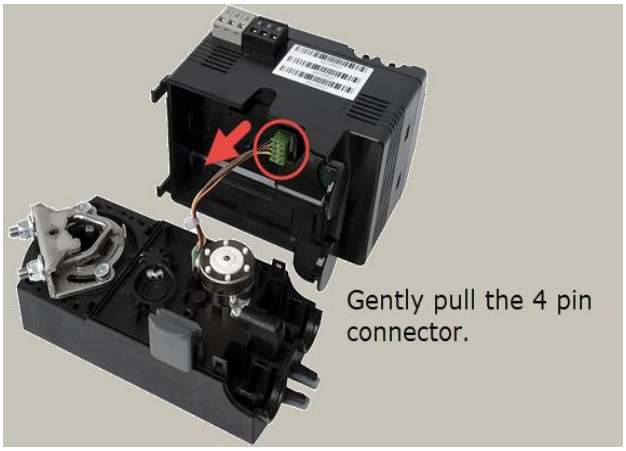
The integrated actuator of compact VAV can be replaced. To replace the actuator, follow the steps mentioned below.

1. Remove the screw on the side of the controller.

2. Separate the controller from the actuator by gently pulling them apart.



3. Remove the 4-pin connector that links the actuator to the controller, by pulling away from the actuator circuit board.



4. Replace the actuator.

APPROVALS, CERTIFICATIONS, ETC.

- UL916
- UL2043
- CB certificate
- RoHS Conformity
- Industry Canada (IC) certified
- CE-approved
- FCC part 15B-compliant: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment OFF and ON, the user is encouraged to try to correct the interference by one or more of the following measures:
    - Reorient or relocate the receiving antenna.
    - Increase the separation between the equipment and receiver.
    - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
    - Consult the dealer or an experienced radio/TV technician for help.

WEEE DIRECTIVE

WEEE: Waste Electrical and Electronic Equipment Directive	
	▪ At the end of the product life, dispose of the packaging and product in an appropriate recycling center. ▪ Do not dispose of the device with the usual domestic refuse. ▪ Do not burn the device.

ARTICLE 33 COMMUNICATION

REGULATION (EC) No 1907/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 December 2006

Concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)

Honeywell takes compliance with REACH very seriously.

According to Article 33 “Duty to communicate information on substances in articles”:

1. Any supplier of an article containing a substance meeting the criteria in Article 57 and identified in accordance with Article 59(1) in a concentration above 0,1 % weight by weight (w/w) shall provide the recipient of the article with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance.

2. On request by a consumer any supplier of an article containing a substance meeting the criteria in Article 57 and identified in accordance with Article 59(1) in a concentration above 0,1 % weight by weight (w/w) shall provide the consumer with sufficient information, available to the supplier, to allow safe use of the article including, as a minimum, the name of that substance. Our duty is to inform you that the substance(s) listed below may be contained in these products above the threshold level of 0.1% by weight of the listed article.

Product / Part Name	Substance Name
WEB-VA423B24N / PWBA	Lead (Pb)

We confirm that our products do not use any other REACH restricted materials during the manufacturing, storage or handling process.

RELATED TECHNICAL LITERATURE

Table 9. Related Technical Literature

Title	Product Literature Number
Spyder Model 5 WEB- Compact VAV controller VA423B24N - Mounting instructions	31-00347
Spyder Model 5 WEB- Compact VAV controller VA423B24N – Product data	31-00361
Spyder Model 5 – Engineering Tool User Guide	31-00282
TR40x/TR42x – Specification Data	63-1389
TR40x/TR42x – Installation Instructions	62-0467
TR40x/TR42x – Operating Guide	63-2741
TR2x Series – Specification Data	63-1321
TR2x Series – Installation Instructions	62-0267
TR120 – Specification Data	31-00312
TR120 – Installation Instructions	31-00275
TR120 – Operating Guide	63-2719
TR75 – Specification Data	63-1322
TR75 – Installation Instructions	62-0271
TR75 – Operating Guide	63-2719
C7400S – Specification Data	63-1365
C7400S – Installation Instructions	62-0332

APPENDIX

Sensor Input Accuracy

The controller's internal sensor inputs support NTC20 kΩ sensors. The following table lists the typical minimum accuracies of the hardware and software for these temperature sensors.

Table 10. Accuracies of internal NTC20kΩ sensor inputs of the controller

Range	Measurement error (excluding sensor characteristics)
-58 to -4 °F (-50 to -20 °C)	≤ 5.0 K
-4 to +32 °F (-20 to 0 °C)	≤ 1.0 K
32 to 86 °F (0 to 30 °C)	≤ 0.3 K
86 to 158 °F (30 to 70 °C)	≤ 0.5 K
158 to 212 °F (70 to 100 °C)	≤ 1.0 K
212 to 266 °F (100 to 130 °C)	≤ 3.0 K
266 to 302 °F (130 to 150 °C)	≤ 5.5 K
302 to 752 °F (150 to 400 °C)	--

NOTE:

- This is the accuracy of the internal sensor input (hardware + software [linearization]), only. This table does not include the characteristics of the sensors, themselves (see section "Sensor Characteristics below). If a different sensor or sensor accuracy is required, one may instead use the inputs of, such as a connected Panel I/O module.

Recognition of Sensor Failure of Sensor Inputs

The thresholds at which sensor failures – i.e., sensor breaks (SB) and short-circuits (SC) – are recognized depends upon the given sensor type. In the event of a recognized sensor failure, the sensor assume the safety values configured in CARE. Table 11 lists the measurement ranges and the corresponding thresholds for the recognition of sensor failure for the various different sensor types:

Table 11. Thresholds for short-circuit (SC) and sensor-break (SB) recognition

I/O configuration	Measurement range	Recognition thresholds
2to10 V	2to10 V / 4to20 mA (without pull-up)	SC: < 1.5 V / 3 mA; SB: no recognition
NTC20kΩ	-58 to +302 °F (-50 to +150 °C)	SC: < 20 Ω; SB: < -94 °F (-70 °C)
PT1000	-22 to +752 °F (-30 to + 400 °C)	SC: < 775 Ω; SB: < -58 °F (-50 °C)

NOTE:

In the case of temperatures lying *outside* the aforementioned ranges, the lowest/highest value *within* the range, instead, will be communicated. Thus, a temperature of -51 °F will be communicated as "-50 °F."

Sensor Characteristics

The characteristics (resistance in relation to temperature) of the sensors and the resultant voltage are listed on the following pages. The stated values do not include failures due to sensor failures; wiring resistance or wiring failures; misreading's due to a meter connected to measure resistance or voltage at the input.

NTC 20 kΩ

Temp. °F (°C)	Resistance [kΩ]	Terminal voltage [V]
-58 (-50)	1659	8.78
-56.2 (-49)	1541	8.77
-54.4 (-48)	1432	8.76
-52.6 (-47)	1331	8.75
-50.8 (-46)	1239	8.74
-49 (-45)	1153	8.72
-47.2 (-44)	1073	8.71
-45.4 (-43)	1000	8.70
-43.6 (-42)	932	8.69
-41.8 (-41)	869	8.67
-40 (-40)	811	8.66
-38.2 (-39)	757	8.64
-36.4 (-38)	706	8.62
-34.6 (-37)	660	8.60
-32.8 (-36)	617	8.58
-31 (-35)	577	8.56
-29.2 (-34)	539	8.54
-27.4 (-33)	505	8.52
-25.6 (-32)	473	8.49
-23.8 (-31)	443	8.47
-22 (-30)	415	8.44
-20.2 (-29)	389	8.41
-18.4 (-28)	364	8.38
-16.6 (-27)	342	8.35
-14.8 (-26)	321	8.32
-13 (-25)	301	8.28
-11.2 (-24)	283	8.25
-9.4 (-23)	266	8.21
-7.6 (-22)	250	8.17
-5.8 (-21)	235	8.13
-4 (-20)	221	8.08
-2.2 (-19)	208	8.04
-0.4 (-18)	196	7.99
1.4 (-17)	184	7.94
3.2 (-16)	174	7.89
5 (-15)	164	7.83
6.8 (-14)	154	7.78
8.6 (-13)	146	7.72
10.4 (-12)	137	7.66
12.2 (-11)	130	7.60
14 (-10)	122	7.53
15.8 (-9)	116	7.46
17.6 (-8)	109	7.39
19.4 (-7)	103	7.32
21.2 (-6)	97.6	7.25
23 (-5)	92.3	7.17
24.8 (-4)	87.3	7.09
26.6 (-3)	82.6	7.01
28.4 (-2)	78.2	6.93
30.2 (-1)	74.1	6.85
32 (0)	70.2	6.76
33.8 (1)	66.5	6.67
35.6 (2)	63.0	6.58
37.4 (3)	59.8	6.49
39.2 (4)	56.7	6.40
41 (5)	53.8	6.30
42.8 (6)	51.1	6.20
44.6 (7)	48.5	6.10
46.4 (8)	46.0	6.00
48.2 (9)	43.7	5.90
50 (10)	41.6	5.80
51.8 (11)	39.5	5.70
53.6 (12)	37.6	5.59
55.4 (13)	35.7	5.49
57.2 (14)	34.0	5.38
59 (15)	32.3	5.28
60.8 (16)	30.8	5.17
62.6 (17)	29.3	5.07
64.4 (18)	27.9	4.96
66.2 (19)	26.6	4.85
68 (20)	25.3	4.75
69.8 (21)	24.2	4.64
71.6 (22)	23.0	4.53
73.4 (23)	22.0	4.43
75.2 (24)	21.0	4.32
77 (25)	20.0	4.22
78.8 (26)	19.1	4.12
80.6 (27)	18.2	4.01
82.4 (28)	17.4	3.91
84.2 (29)	16.6	3.81
86 (30)	15.9	3.71
87.8 (31)	15.2	3.62
89.6 (32)	14.5	3.52
91.4 (33)	13.9	3.43
93.2 (34)	13.3	3.33
95 (35)	12.7	3.24
96.8 (36)	12.1	3.15
98.6 (37)	11.6	3.06
100.4 (38)	11.1	2.97
102.2 (39)	10.7	2.89
104 (40)	10.2	2.81
105.8 (41)	9.78	2.72
107.6 (42)	9.37	2.64
109.4 (43)	8.98	2.57
111.2 (44)	8.61	2.49
113 (45)	8.26	2.42
114.8 (46)	7.92	2.34
116.6 (47)	7.60	2.27
118.4 (48)	7.29	2.20
120.2 (49)	7.00	2.14
122 (50)	6.72	2.07
123.8 (51)	6.45	2.01
125.6 (52)	6.19	1.94
127.4 (53)	5.95	1.88
129.2 (54)	5.72	1.82
131 (55)	5.49	1.77
132.8 (56)	5.28	1.71
134.6 (57)	5.08	1.66
136.4 (58)	4.88	1.61
138.2 (59)	4.69	1.56
140 (60)	4.52	1.51
141.8 (61)	4.35	1.46
143.6 (62)	4.18	1.41
145.4 (63)	4.03	1.37
147.2 (64)	3.88	1.32
149 (65)	3.73	1.28
150.8 (66)	3.59	1.24
152.6 (67)	3.46	1.20
154.4 (68)	3.34	1.16
156.2 (69)	3.21	1.13
158 (70)	3.10	1.09
159.8 (71)	2.99	1.06
161.6 (72)	2.88	1.02
163.4 (73)	2.78	0.991
165.2 (74)	2.68	0.960
167 (75)	2.58	0.929
168.8 (76)	2.49	0.900
170.6 (77)	2.41	0.872
172.4 (78)	2.32	0.844
174.2 (79)	2.24	0.818
176 (80)	2.17	0.792
177.8 (81)	2.09	0.767
179.6 (82)	2.02	0.744
181.4 (83)	1.95	0.720
183.2 (84)	1.89	0.698
185 (85)	1.82	0.676
186.8 (86)	1.76	0.655
188.6 (87)	1.70	0.635
190.4 (88)	1.65	0.616
192.2 (89)	1.59	0.597
194 (90)	1.54	0.578
195.8 (91)	1.49	0.561
197.6 (92)	1.44	0.544
199.4 (93)	1.40	0.527
201.2 (94)	1.35	0.511
203 (95)	1.31	0.496
204.8 (96)	1.27	0.481
206.6 (97)	1.23	0.466
208.4 (98)	1.19	0.452
210.2 (99)	1.15	0.439
212 (100)	1.11	0.425
213.8 (101)	1.08	0.413
215.6 (102)	1.05	0.401
217.4 (103)	1.01	0.389
219.2 (104)	0.98	0.378
221 (105)	0.95	0.367
222.8 (106)	0.92	0.356
224.6 (107)	0.90	0.346
226.4 (108)	0.87	0.336
228.2 (109)	0.84	0.326
230 (110)	0.82	0.317
231.8 (111)	0.79	0.308
233.6 (112)	0.77	0.299
235.4 (113)	0.75	0.290
237.2 (114)	0.73	0.282
239 (115)	0.70	0.274
240.8 (116)	0.68	0.266
242.6 (117)	0.66	0.259
244.4 (118)	0.64	0.252
246.2 (119)	0.63	0.245
248 (120)	0.61	0.238
249.8 (121)	0.59	0.231
251.6 (122)	0.57	0.225
253.4 (123)	0.56	0.219
255.2 (124)	0.54	0.213
257 (125)	0.53	0.207
258.8 (126)	0.51	0.201
260.6 (127)	0.50	0.196
262.4 (128)	0.49	0.191
264.2 (129)	0.47	0.186
266 (130)	0.46	0.181
267.8 (131)	0.45	0.176
269.6 (132)	0.43	0.171
271.4 (133)	0.42	0.167
273.2 (134)	0.41	0.162
275 (135)	0.40	0.158
276.8 (136)	0.39	0.154
278.6 (137)	0.38	0.150
280.4 (138)	0.37	0.146
282.2 (139)	0.36	0.142
284 (140)	0.35	0.139
285.8 (141)	0.34	0.135
287.6 (142)	0.33	0.132
289.4 (143)	0.32	0.128
291.2 (144)	0.32	0.125
293 (145)	0.31	0.122
294.8 (146)	0.30	0.119
296.6 (147)	0.29	0.116
298.4 (148)	0.29	0.113
300.2 (149)	0.28	0.110
302 (150)	0.27	0.107

PT 1000

Temp. °F (°C)	Resistance [Ω]	Terminal voltage [V]
-58 (-50)	803	0.312
-56.2 (-49)	807	0.314
-54.4 (-48)	811	0.315
-52.6 (-47)	815	0.317
-50.8 (-46)	819	0.318
-49 (-45)	823	0.320
-47.2 (-44)	827	0.321
-45.4 (-43)	831	0.323
-43.6 (-42)	835	0.324
-41.8 (-41)	839	0.326
-40 (-40)	843	0.327
-38.2 (-39)	847	0.329
-36.4 (-38)	851	0.330
-34.6 (-37)	855	0.332
-32.8 (-36)	859	0.333
-31 (-35)	862	0.335
-29.2 (-34)	866	0.336
-27.4 (-33)	870	0.338
-25.6 (-32)	874	0.339
-23.8 (-31)	878	0.341
-22 (-30)	882	0.342
-20.2 (-29)	886	0.344
-18.4 (-28)	890	0.345
-16.6 (-27)	894	0.347
-14.8 (-26)	898	0.348
-13 (-25)	902	0.350
-11.2 (-24)	906	0.351
-9.4 (-23)	910	0.353
-7.6 (-22)	914	0.354
-5.8 (-21)	918	0.356
-4 (-20)	922	0.357
-2.2 (-19)	926	0.359
-0.4 (-18)	929	0.360
1.4 (-17)	933	0.361
3.2 (-16)	937	0.363
5 (-15)	941	0.364
6.8 (-14)	945	0.366
8.6 (-13)	949	0.367
10.4 (-12)	953	0.369
12.2 (-11)	957	0.370
14 (-10)	961	0.372
15.8 (-9)	965	0.373
17.6 (-8)	969	0.375
19.4 (-7)	973	0.376
21.2 (-6)	977	0.378
23 (-5)	980	0.379
24.8 (-4)	984	0.380
26.6 (-3)	988	0.382
28.4 (-2)	992	0.383
30.2 (-1)	996	0.385
32 (0)	1000	0.386
33.8 (1)	1004	0.388
35.6 (2)	1008	0.389
37.4 (3)	1012	0.391
39.2 (4)	1016	0.392
41 (5)	1020	0.394
42.8 (6)	1023	0.395
44.6 (7)	1027	0.396
46.4 (8)	1031	0.398
48.2 (9)	1035	0.399
50 (10)	1039	0.401
51.8 (11)	1043	0.402
53.6 (12)	1047	0.404
55.4 (13)	1051	0.405
57.2 (14)	1055	0.406
59 (15)	1058	0.408
60.8 (16)	1062	0.409
62.6 (17)	1066	0.411
64.4 (18)	1070	0.412
66.2 (19)	1074	0.413
68 (20)	1078	0.415
69.8 (21)	1082	0.416
71.6 (22)	1086	0.418
73.4 (23)	1090	0.419
75.2 (24)	1093	0.420
77 (25)	1097	0.422
78.8 (26)	1101	0.423
80.6 (27)	1105	0.425
82.4 (28)	1109	0.426
84.2 (29)	1113	0.428
86 (30)	1117	0.429
87.8 (31)	1121	0.431
89.6 (32)	1124	0.432
91.4 (33)	1128	0.433
93.2 (34)	1132	0.435
95 (35)	1136	0.436
96.8 (36)	1140	0.438
98.6 (37)	1144	0.439
100.4 (38)	1148	0.441
102.2 (39)	1152	0.442
104 (40)	1155	0.443
105.8 (41)	1159	0.445
107.6 (42)	1163	0.446
109.4 (43)	1167	0.448
111.2 (44)	1171	0.449
113 (45)	1175	0.451
114.8 (46)	1179	0.452
116.6 (47)	1182	0.453
118.4 (48)	1186	0.455
120.2 (49)	1190	0.456
122 (50)	1194	0.458
123.8 (51)	1198	0.459
125.6 (52)	1202	0.461
127.4 (53)	1205	0.462
129.2 (54)	1209	0.463
131 (55)	1213	0.465
132.8 (56)	1217	0.466
134.6 (57)	1221	0.467
136.4 (58)	1225	0.469
138.2 (59)	1229	0.470
140 (60)	1232	0.471
141.8 (61)	1236	0.473
143.6 (62)	1240	0.474
145.4 (63)	1244	0.476
147.2 (64)	1248	0.477
149 (65)	1252	0.479
150.8 (66)	1255	0.480
152.6 (67)	1259	0.481
154.4 (68)	1263	0.483
156.2 (69)	1267	0.484
158 (70)	1271	0.486
159.8 (71)	1275	0.487
161.6 (72)	1278	0.488
163.4 (73)	1282	0.490
165.2 (74)	1286	0.491
167 (75)	1290	0.493
168.8 (76)	1294	0.494
170.6 (77)	1297	0.495
172.4 (78)	1301	0.497
174.2 (79)	1305	0.498
176 (80)	1309	0.499
177.8 (81)	1313	0.501
179.6 (82)	1317	0.502
181.4 (83)	1320	0.503
183.2 (84)	1324	0.505
185 (85)	1328	0.506
186.8 (86)	1332	0.508
188.6 (87)	1336	0.509
190.4 (88)	1339	0.510
192.2 (89)	1343	0.512
194 (90)	1347	0.513
195.8 (91)	1351	0.515
197.6 (92)	1355	0.516
199.4 (93)	1358	0.517
201.2 (94)	1362	0.519
203 (95)	1366	0.520
204.8 (96)	1370	0.522
206.6 (97)	1374	0.523
208.4 (98)	1377	0.524
210.2 (99)	1381	0.525
212 (100)	1385	0.527
213.8 (101)	1389	0.528
215.6 (102)	1393	0.530
217.4 (103)	1396	0.531
219.2 (104)	1400	0.532
221 (105)	1404	0.534
222.8 (106)	1408	0.535
224.6 (107)	1412	0.537
226.4 (108)	1415	0.538
228.2 (109)	1419	0.539
230 (110)	1423	0.541
231.8 (111)	1427	0.542
233.6 (112)	1430	0.543
235.4 (113)	1434	0.545
237.2 (114)	1438	0.546
239 (115)	1442	0.547
240.8 (116)	1446	0.549
242.6 (117)	1449	0.550
244.4 (118)	1453	0.551
246.2 (119)	1457	0.553
248 (120)	1461	0.554
249.8 (121)	1464	0.555
251.6 (122)	1468	0.557
253.4 (123)	1472	0.558
255.2 (124)	1476	0.560
257 (125)	1479	0.561
258.8 (126)	1483	0.562
260.6 (127)	1487	0.564
262.4 (128)	1491	0.565
264.2 (129)	1494	0.566
266 (130)	1498	0.567
267.8 (131)	1502	0.569
269.6 (132)	1506	0.570
271.4 (133)	1510	0.572
273.2 (134)	1513	0.573
275 (135)	1517	0.574
276.8 (136)	1521	0.576
278.6 (137)	1525	0.577
280.4 (138)	1528	0.578
282.2 (139)	1532	0.580
284 (140)	1536	0.581
285.8 (141)	1539	0.582
287.6 (142)	1543	0.584
289.4 (143)	1547	0.585
291.2 (144)	1551	0.586
293 (145)	1554	0.587
294.8 (146)	1558	0.589
296.6 (147)	1562	0.590
298.4 (148)	1566	0.592
300.2 (149)	1569	0.593
302 (150)	1573	0.594
303.8 (151)	1577	0.596
305.6 (152)	1581	0.597
307.4 (153)	1584	0.598
309.2 (154)	1588	0.600
311 (155)	1592	0.601
312.8 (156)	1596	0.602
314.6 (157)	1599	0.603
316.4 (158)	1603	0.605
318.2 (159)	1607	0.606
320 (160)	1610	0.607
321.8 (161)	1614	0.609
323.6 (162)	1618	0.610
325.4 (163)	1622	0.612
327.2 (164)	1625	0.613
329 (165)	1629	0.614
330.8 (166)	1633	0.615
332.6 (167)	1636	0.617
334.4 (168)	1640	0.618
336.2 (169)	1644	0.619
338 (170)	1648	0.621
339.8 (171)	1651	0.622
341.6 (172)	1655	0.623
343.4 (173)	1659	0.625
345.2 (174)	1662	0.626
347 (175)	1666	0.627
348.8 (176)	1670	0.629
350.6 (177)	1674	0.630
352.4 (178)	1677	0.631
354.2 (179)	1681	0.632
356 (180)	1685	0.634
357.8 (181)	1688	0.635
359.6 (182)	1692	0.636
361.4 (183)	1696	0.638
363.2 (184)	1699	0.639
365 (185)	1703	0.640
366.8 (186)	1707	0.642
368.6 (187)	1711	0.643
370.4 (188)	1714	0.644
372.2 (189)	1718	0.645
374 (190)	1722	0.647
375.8 (191)	1725	0.648
377.6 (192)	1729	0.649
379.4 (193)	1733	0.651
381.2 (194)	1736	0.652
383 (195)	1740	0.653

Temp. °F (°C)	Resistance [Ω]	Terminal voltage [V]
384.8 (196)	1744	0.655
386.6 (197)	1747	0.656
388.4 (198)	1751	0.657
390.2 (199)	1755	0.658
392 (200)	1758	0.659
393.8 (201)	1762	0.661
395.6 (202)	1766	0.662
397.4 (203)	1769	0.663
399.2 (204)	1773	0.665
401 (205)	1777	0.666
402.8 (206)	1780	0.667
404.6 (207)	1784	0.669
406.4 (208)	1788	0.670
408.2 (209)	1791	0.671
410 (210)	1795	0.672
411.8 (211)	1799	0.674
413.6 (212)	1802	0.675
415.4 (213)	1806	0.676
417.2 (214)	1810	0.678
419 (215)	1813	0.679
420.8 (216)	1817	0.680
422.6 (217)	1821	0.681
424.4 (218)	1824	0.683
426.2 (219)	1828	0.684
428 (220)	1832	0.685
429.8 (221)	1835	0.686
431.6 (222)	1839	0.688
433.4 (223)	1843	0.689
435.2 (224)	1846	0.690
437 (225)	1850	0.692
438.8 (226)	1854	0.693
440.6 (227)	1857	0.694
442.4 (228)	1861	0.695
444.2 (229)	1865	0.697
446 (230)	1868	0.698
447.8 (231)	1872	0.699
449.6 (232)	1875	0.700
451.4 (233)	1879	0.702
453.2 (234)	1883	0.703
455 (235)	1886	0.704
456.8 (236)	1890	0.705
458.6 (237)	1894	0.707
460.4 (238)	1897	0.708
462.2 (239)	1901	0.709
464 (240)	1905	0.711
465.8 (241)	1908	0.712
467.6 (242)	1912	0.713
469.4 (243)	1915	0.714
471.2 (244)	1919	0.716
473 (245)	1923	0.717
474.8 (246)	1926	0.718
476.6 (247)	1930	0.719

Temp. °F (°C)	Resistance [Ω]	Terminal voltage [V]
478.4 (248)	1934	0.721
480.2 (249)	1937	0.722
482 (250)	1941	0.723
483.8 (251)	1944	0.724
485.6 (252)	1948	0.726
487.4 (253)	1952	0.727
489.2 (254)	1955	0.728
491 (255)	1959	0.729
492.8 (256)	1962	0.730
494.6 (257)	1966	0.732
496.4 (258)	1970	0.733
498.2 (259)	1973	0.734
500 (260)	1977	0.736
501.8 (261)	1980	0.737
503.6 (262)	1984	0.738
505.4 (263)	1988	0.739
507.2 (264)	1991	0.740
509 (265)	1995	0.742
510.8 (266)	1998	0.743
512.6 (267)	2002	0.744
514.4 (268)	2006	0.746
516.2 (269)	2009	0.747
518 (270)	2013	0.748
519.8 (271)	2016	0.749
521.6 (272)	2020	0.750
523.4 (273)	2024	0.752
525.2 (274)	2027	0.753
527 (275)	2031	0.754
528.8 (276)	2034	0.755
530.6 (277)	2038	0.757
532.4 (278)	2042	0.758
534.2 (279)	2045	0.759
536 (280)	2049	0.760
537.8 (281)	2052	0.761
539.6 (282)	2056	0.763
541.4 (283)	2060	0.764
543.2 (284)	2063	0.765
545 (285)	2067	0.766
546.8 (286)	2070	0.768
548.6 (287)	2074	0.769
550.4 (288)	2077	0.770
552.2 (289)	2081	0.771
554 (290)	2085	0.773
555.8 (291)	2088	0.774
557.6 (292)	2092	0.775
559.4 (293)	2095	0.776
561.2 (294)	2099	0.777
563 (295)	2102	0.778
564.8 (296)	2106	0.780
566.6 (297)	2110	0.781
568.4 (298)	2113	0.782
570.2 (299)	2117	0.784

Temp. °F (°C)	Resistance [Ω]	Terminal voltage [V]
572 (300)	2120	0.785
573.8 (301)	2124	0.786
575.6 (302)	2127	0.787
577.4 (303)	2131	0.788
579.2 (304)	2134	0.789
581 (305)	2138	0.791
582.8 (306)	2142	0.792
584.6 (307)	2145	0.793
586.4 (308)	2149	0.794
588.2 (309)	2152	0.796
590 (310)	2156	0.797
591.8 (311)	2159	0.798
593.6 (312)	2163	0.799
595.4 (313)	2166	0.800
597.2 (314)	2170	0.802
599 (315)	2173	0.803
600.8 (316)	2177	0.804
602.6 (317)	2181	0.805
604.4 (318)	2184	0.806
606.2 (319)	2188	0.808
608 (320)	2191	0.809
609.8 (321)	2195	0.810
611.6 (322)	2198	0.811
613.4 (323)	2202	0.812
615.2 (324)	2205	0.814
617 (325)	2209	0.815
618.8 (326)	2212	0.816
620.6 (327)	2216	0.817
622.4 (328)	2219	0.818
624.2 (329)	2223	0.820
626 (330)	2226	0.821
627.8 (331)	2230	0.822
629.6 (332)	2234	0.823
631.4 (333)	2237	0.824
633.2 (334)	2241	0.826
635 (335)	2244	0.827
636.8 (336)	2248	0.828
638.6 (337)	2251	0.829
640.4 (338)	2255	0.830
642.2 (339)	2258	0.831
644 (340)	2262	0.833
645.8 (341)	2265	0.834
647.6 (342)	2269	0.835
649.4 (343)	2272	0.836
651.2 (344)	2276	0.838
653 (345)	2279	0.839
654.8 (346)	2283	0.840
656.6 (347)	2286	0.841
658.4 (348)	2290	0.842
660.2 (349)	2293	0.843
662 (350)	2297	0.845
663.8 (351)	2300	0.846

Temp. °F (°C)	Resistance [Ω]	Terminal voltage [V]
665.6 (352)	2304	0.847
667.4 (353)	2307	0.848
669.2 (354)	2311	0.849
671 (355)	2314	0.850
672.8 (356)	2318	0.852
674.6 (357)	2321	0.853
676.4 (358)	2325	0.854
678.2 (359)	2328	0.855
680 (360)	2332	0.856
681.8 (361)	2335	0.857
683.6 (362)	2339	0.859
685.4 (363)	2342	0.860
687.2 (364)	2346	0.861
689 (365)	2349	0.862
690.8 (366)	2353	0.863
692.6 (367)	2356	0.864
694.4 (368)	2360	0.866
696.2 (369)	2363	0.867
698 (370)	2367	0.868
699.8 (371)	2370	0.869
701.6 (372)	2373	0.870
703.4 (373)	2377	0.871
705.2 (374)	2380	0.872
707 (375)	2384	0.874
708.8 (376)	2387	0.875
710.6 (377)	2391	0.876
712.4 (378)	2394	0.877
714.2 (379)	2398	0.878
716 (380)	2401	0.879
717.8 (381)	2405	0.881
719.6 (382)	2408	0.882
721.4 (383)	2412	0.883
723.2 (384)	2415	0.884
725 (385)	2419	0.885
726.8 (386)	2422	0.886
728.6 (387)	2426	0.888
730.4 (388)	2429	0.889
732.2 (389)	2432	0.890
734 (390)	2436	0.891
735.8 (391)	2439	0.892
737.6 (392)	2443	0.893
739.4 (393)	2446	0.894
741.2 (394)	2450	0.896
743 (395)	2453	0.897
744.8 (396)	2457	0.898
746.6 (397)	2460	0.899
748.4 (398)	2463	0.900
750.2 (399)	2467	0.901
752 (400)	2470	0.902

Honeywell Building Technologies
Honeywell International Inc.
1985 Douglas Drive North
Golden Valley, MN 55422
customer.honeywell.com

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