Wiring Guide for Vector Controls Products

1 General

1.1 General warning

The wiring technician must be trained and experienced with electronic circuits. The power supply must be disconnected before attempting any wiring connections or changes. All connections must be made in accordance with the applicable wiring diagrams and all applicable local and national codes must be followed.

Disconnection and overload protection must be provided as required. If using electrical conduit, the attachment to the actuator must be made with flexible conduit.
The manufacturer's installation literature must be read carefully before making any connections. In case of any questions, contact the manufacturer of the devices involved and/or Vector Controls.

1.2 Sealing of cable entries

Important!
In the case of wall-mounted devices, all cable entries into the connection box must be sealed to prevent air drafts, which could otherwise affect the sensors in the device and prevent correct measurements!

2 Wiring of power supplies

2.1 Safety

Warning: Live Electrical Components!

During installation, testing, servicing and troubleshooting of Vector Controls products, it may be necessary to work with live electrical components. Have a qualified licensed electrician or other individual who has been properly trained and certified in handling live electrical components perform these tasks. Failure to follow all electrical safety precautions when exposed to live electrical components could result in death or serious injury.

2.2 Transformer and product standards

Vector Controls products require in general a 24 VAC Class 2 transformer.
The corresponding product literature must be followed to select the appropriate power supply.

2.3 Powering Controllers, Sensors and Actuators from different brands

CAUTION
It is good practice to power electronic or digital controllers from a separate power transformer than the ones used for actuators, transmitters or other end devices. Vector Controls controllers and transmitters use half wave rectified power supplies. Some manufacturers, especially the ones active in industrial controls use isolated power supplies. In these devices the power supply common is different to the signal common.

If a half wave rectified device shares the same transformer with a full wave rectified device, a short circuit is created, damaging the full wave rectified device. The moment a device is used with individual power and signal commons that are electrically isolated, individual transformers must be used to power each device in order to prevent damage.

In order to ensure trouble-free operation, the following cable cross-sections and cable lengths for the supply voltage 24V and the ground line must be adhered to. All devices within a control loop must be supplied by the same transformer or, if several transformers are used, they must be connected phase-wise on one side. The wiring of the power supply must be carried out in a star shape, keeping to the max. cable length as shown in the table below (column "1 Device").

2.4 Maximum cable lengths in m (ft) for number of devices with AC/DC operation

Conductor cross-section		1 Device		max. 8 devices		max. 16 devices	
0.5 mm²	AWG 22	40 m	(125 ft)	5.0 m	(15 ft)	2.5 m	(8 ft)
0.75 mm²	AWG 20	60 m	(200 ft)	7.5 m	(25 ft)	3.8 m	(12 ft)
1.00 mm²	AWG 18	80 m	(250 ft)	10 m	(30 ft)	5.0 m	(15 ft)
1.50 mm²	AWG 14	120 m	(400 ft)	15 m	(50 ft)	7.5 m	(25 ft)

2.5 Multiple devices, one transformer (all half wave rectified devices)

Multiple devices may be powered from one transformer, provided that the total current draw of the devices (VA rating) is less than or equal to the rating of the transformer AND the polarity on the secondary side of the transformer is strictly followed. This means that all common from all devices are connected to the common leg on the transformer and all power supply connectors from all devices are connected to the hot leg of the transformer. Mixing wire common and power supply input of the devices will result in erratic operation or failure of the devices.

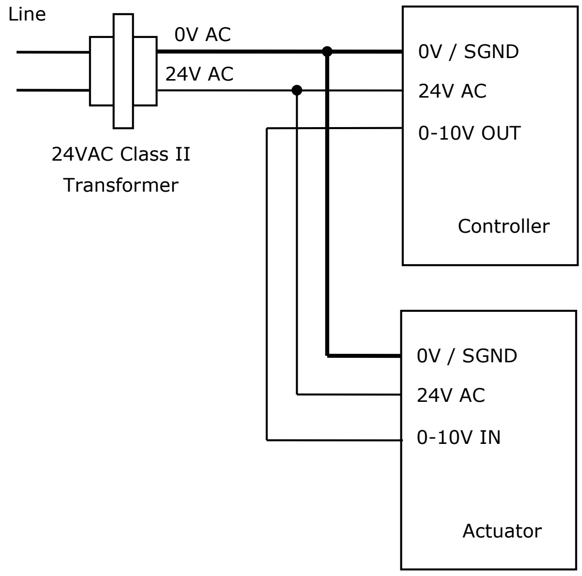
2.6 Multiple devices, multiple transformers

Multiple devices may be powered from multiple transformers, provided that all commons of half wave rectified devices and all signal grounds of full wave rectified devices are connected together.
See wiring diagrams below.

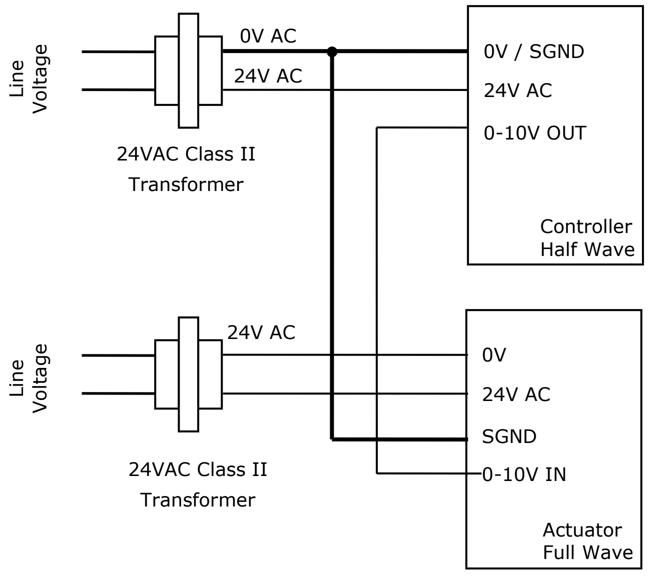
2.7 Earth, ground and signal ground

It is not ideal to connect signal ground to earth ground as disturbances on earth ground can be coupled onto signal ground. If it is inevitable, it must be made sure that signal and earth grounds are connected in only one single point (neutral point).

2.8 Wiring controllers and actuators which are all half-wave rectified



2.9 Wiring controllers and actuators which are mixed full wave and half-wave rectified



3 Wiring of transmitters

3.1 Maximum cable length

Important!
For all signals care must be taken to prevent conductors carrying high current installed in parallel to the conductor carrying the analog signal. Shielded wire is recommended in case of substantial electromagnetical interference.
The shielding should only be grounded on one side to avoid cross currents!

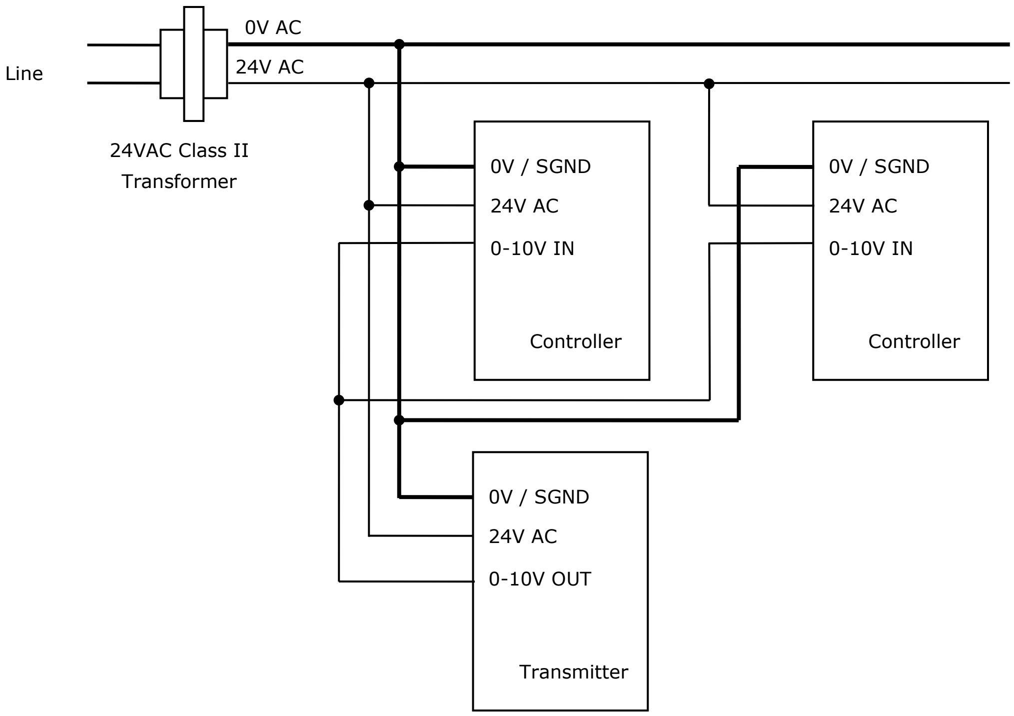
The maximum cable length for a VDC signal is outlined in the table below. This table is based on the assumption of a maximum 100-mV voltage drop. A negative offset may have to be set in the controller depending on the connected device and the actual cable length and type.

Wire [mm²]	Wire [AWG]	Cable type	Distance [m]	Distance [ft]
1.5	14	Stranded copper	1400	4600
1.25	16	Stranded copper	700	2300
1.0	18	Stranded copper	500	1640
0.75	20	Stranded copper, twisted wire	300	1000
0.5	22	Stranded, copper, twisted wire	200	650
0.25	24	Stranded, copper, twisted wire	100	330

A mA signal is less sensitive to electromagnetically interference. A cable length of 2000 m (6550 ft) is acceptable.

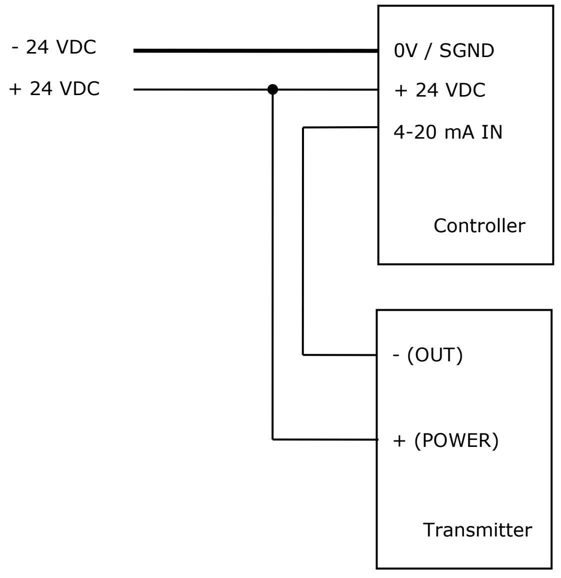
3.2 Connecting one transmitter to multiple controllers through a VDC signal

1. The input must be set to voltage mode.
2. All controllers must have a common 0V / SGND potential.
3. Use twisted pair conductors with 0V and the analog signal being in one pair.
4. Arrange the controllers in a star connection with the transmitter being the center if possible. This is to keep transmitter – controller distance as short as possible.
5. The total number of controllers depends on the maximum load of the analog output and the input impedance of the controller. The maximum load of Vector SxC transmitters is 5 kΩ for all X2 devices it is 1 kΩ.
   The impedance of X2 devices is at least 75kΩ. To calculate the total number of possible connected devices, divide the input impedance through the output load. For example, 75k /5k = 15 devices
   a. For Vector Controls devices we therefore recommend a maximum of 15 devices.
   b. For non-Vector Controls products, a maximum of 8 controllers is recommended.
6. Maximum total wiring distance is 200 m.

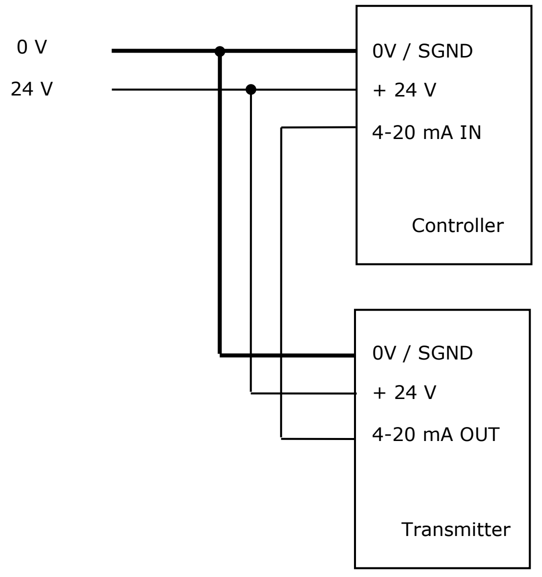


3.3 Connecting of 2-wire current transmitters

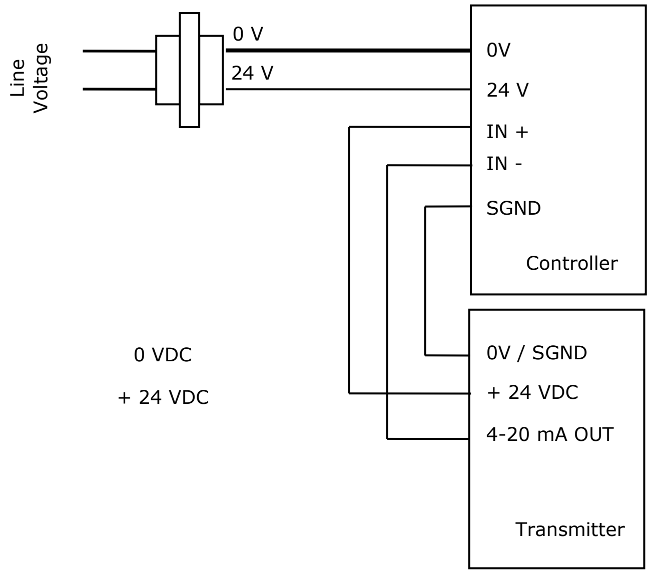
1. The input must be set to current mode
2. All X2-controllers do not offer a power supply on the current inputs; therefore, an external current supply must be used to power the sensor. One power supply may be used for both sensor and controller. Maximum power consumption must be observed when choosing power supply.
   In case two power supplies are used, the common of the sensor power supply must be connected to the common of the controller.



3.4 Connecting a 3-wire current transmitter to an input for 2-wire current transmitters on the controller with common power supply ground and signal ground



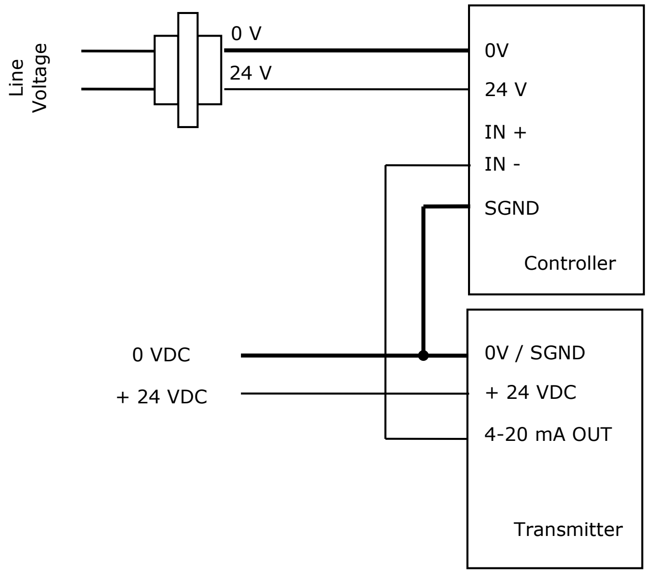
3.5 Connecting a 3-wire current transmitter to an input for a 2-wire current sensor on the controller with different power supply ground and signal ground. The transmitter is powered by the controller



Warning!
The controller must be able to supply 15 – 35VDC and **> 25mA** on the IN+ pin.

If not sure, use a separate power supply as shown under the next section.

3.6 Connecting a 3-wire current transmitter to a controller with an input for a 2-wire current transmitter with different power supply ground and signal ground. The transmitter powered by own power supply



4 Wiring of passive sensors

Important!
For all signals care must be taken to prevent conductors carrying high current installed in parallel to the conductor carrying the sensor signal. Shielded wire is recommended in case of substantial electromagnetical interference.
The shield must be grounded only on side to prevent cross currents.

Passive temperature sensors may be placed up to 200 m (650 ft) away from the controller.
The controller calculates the temperature by measuring the resistance of the sensing element. A long conductor increases this resistance. The added resistance of the conductor needs to be deducted through calibration in order to prevent an error into the measurement.

4.1 Calibration

To calibrate, calculate the ratio of the conductor resistance to the resistance change per degree of the sensing element.

To measure the conductor resistance, short circuit the wires at the sensor, disconnect one conductor at the controller, connect the other to signal GND and measure resistance between the disconnected conductor and M.

4.1.1 NTC (Tn10) Calibration

To calculate the change of resistance per °C or °F, follow this general guideline:
NTC (Sxx-Tn10): An NTC-device has a non-linear temperature- resistance curve. In normal room temperature, the resistance is so high that the conductor resistance is negligible. For higher temperatures above 60°C (140 °F), the conductor resistance has an impact and calibration is advisable.

In order to estimate the required calibration, the resistance of the conductor may be divided by a factor, depending on the working point of the application. That factor is the resistance required for 1 °C. For °F those factors may be halved.

Resistance table of a Tn10 temperature sensor (simplified)

Temperature °C	60 °C	70 °C	80 °C	90 °C	100 °C	110 °C	120 °C
Temperature °F	140 °F	158 °F	176 °F	194 °F	212 °F	230 °F	248 °F
Resistance / °C	80 Ω	65 Ω	48 Ω	30 Ω	22 Ω	15 Ω	11 Ω
Resistance / °F	40 Ω	32 Ω	24 Ω	15 Ω	11 Ω	7.5 Ω	5.5 Ω

Sample of calibration value:
For example, for 80°C (176 °F) for Tn10 the difference per °C = 48 Ω (°F = 24 Ω). If the conductor resistance would be 12 Ω: 12 / 48 = 0.25 → the temperature needs to be increased by ***+0.25°C*** or by ***+0.5°F***.

4.1.2 PT1000 / NI1000 Calibration

PT1000/NI1000: These PTC sensing elements have a more linear relationship. The same factor may be used over the entire range: This factor is calculated from the average difference in resistance per °C or °F. For the PT1000 or NI1000 it is 4 Ω in °C and in 2 Ω in °F.

Table for calibration values of PT1000/NI1000 sensors and different conductors

Wire [mm²]	**Wire [AWG]**	**mΩ/m**	**mΩ/ft**	**Distance 50m (165ft)**		**Distance 100m (330ft)**		**Distance 200m (650ft)**	
				[°C]	**[°F]**	**[°C]**	**[°F]**	**[°C]**	**[°F]**
1.5	14	8.2	2.5	-0.2	-0.4	-0.4	-0.8	-0.8	-1.7
1.25	16	16.4	5.0	-0.4	-0.8	-0.8	-1.7	-1.6	-3-3
1.0	18	24.6	7.5	-0.6	-1.2	-1.2	-2.4	-2.5	-4.9
0.75	20	32.8	10	-0.8	-1.6	-1.6	-3.3	-3.3	-6.6
0.5	22	49.2	15	-1.2	-2.5	-2.5	-5.0	-5.0	-9.9

Note: The distance refers to the distance between the probe and the controller. The calibration value includes the back-and-forth distance!

5 Wiring of Modbus and BACnet RS485

5.1 Cable Type

Important!
For RS485 wiring twisted shielded pair cable (TSP) is recommended.

AWG 22 (0.5mm^2) is generally sufficient for the data line. The recommended maximum length of the network is 1000m. Cables with a Characteristic Impedance of 120Ω +/-10%, especially for 19200 and higher baud rates should be used. If the impedance is given as meter/foot the wrong cable type has been chosen.

5.2 What is Twisted Pair

A twisted pair is simply a pair of wires that are of equal length and are twisted together as depicted below.

5.3 Termination Resistors

Termination resistors should have the same value as the characteristic impedance of the twisted pair cable and they should be placed at the far ends of the cable.

5.4 Shield

A shield may not be necessary for short leads and if there are no power lines in proximity. The twisted pair used for Tx and Rx is more effective at noise cancellation than the shield. However, in industrial applications or if there are high power lines in a neighboring cable channel, shielded conductors may be required.

5.5 Cable Routing

Take care where you run your cables. Don’t wind your cable around other cables of power sources or power lines. The worst sources of induced noise are switching DC loads and variable-frequency drives (VFD).

5.6 Connection Order

Ground reference conductor must always be connected first in case a device is connected to the network that is powered. Best is to choose only devices that have optical isolation - this protects the RS485 transmitter / receivers.

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