

Delta Controls

Wiring and Installation Guidelines



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Introduction

Delta Controls has written *Wiring and Installation Guidelines* to provide its Partners with a primary source of recommended practices for wiring power, inputs and outputs and networks for Delta Controls products.



This symbol identifies a note about a situation where damage to a device will occur if the instructions are not followed carefully. To protect the equipment you are using, please read and follow the instructions in these notes.

What this document contains

Chapter 1 - Power Installation Guidelines – covers power wiring practices for all Delta Controls Class 2 (24 V AC) products.

Chapter 2 - Inputs and Outputs Guidelines – covers the recommended wiring practices for inputs and outputs on Delta Controls HVAC products.

Chapter 3 - RS-485 Network Installation Guidelines – covers the Delta Controls recommended design and installation specifications for a RS-485 network and aids the installer in building robust networks.

Chapter 4 - Ethernet Network Installation Guidelines – provides a synopsis of Ethernet network wiring specifications and practices that are applicable to Delta Controls products.

Chapter 5 – RS-232 Information – provides wiring information about RS-232 connections used with Delta Controls products.

Chapter 6 – enteliBUS Network Installation Guidelines – covers recommended design and installation specifications for the enteliBUS network, known as the eBUS network, that connects components of the enteliBUS family.

Glossary of Terms - defines important terms used in this document.

Chapter 1 - Power Installation Guidelines

This chapter describes the power wiring practices for all Delta Controls Class 2 (24 V AC) products. Follow these guidelines to ensure optimum performance of your Delta Controls products.

This document does not describe line voltage wiring practices.

For details about a specific product, see the Product Installation Guide on the product page found on Delta Controls' technical support site.

Review Glossary of Terms to be sure you understand terms used in this chapter.

Power Supply Specifications

Table 1: Power Supply Specifications

Category	Specification
Voltage	20 – 28 V AC
Electrical Class	Class 2 100 VA Max
Fuse Rating	See Table 4 for correct fuse size

Power Wire

Delta Controls requires that device power for its products must use a dedicated 2-conductor stranded wire. Wire gauge depends on the VA rating for the device and the length of the wire used, as shown in Table 2.

Table 2 does not take into account multiple devices powered by the same transformer. If multiple devices use the same transformer, add the VA ratings of all devices together, then use the wire length to the furthest device to determine wire selection.

Table 2: Power Wire Selection

Description	Device VA Rating	Max Wire Length
16 AWG stranded	100	100 ft (30 m)
	75	150 ft (45 m)
	50	250 ft (75 m)
	25	500 ft (150 m)
18 AWG stranded	50	150 ft (45 m)
	25	300 ft (90 m)
	15	500 ft (150 m)
	5	1000 ft (300 m)

Transformer Specifications

Transformers must be UL Listed, 24 V AC and rated to Class 2. Delta Controls recommends the transformers listed in Table 3.

A 1-hub transformer has all wires coming out the same side. A 2-hub transformer has primary wires coming out the primary side and secondary wires coming out the secondary side.

Table 3: Recommended Transformers

Delta Part #	Primary Voltage	VA Rating	Hubs	Circuit Breaker	Agency Approvals and Listings
440000	120 VAC	40 VA	2	No	UL listed CSA approved Class 2
440001	120 VAC	40 VA	1	No	UL recognized Class 2
440002	120 VAC	50 VA	2	No	UL listed CSA approved Class 2
440003	120 VAC	50 VA	1	No	UL recognized Class 2
440004	277 VAC	50 VA	2	No	UL listed CSA approved Class 2
440005	277 VAC	50 VA	1	No	UL recognized Class 2
440006	120 VAC	75 VA	2	Yes	UL listed CSA approved Class 2
440007	120 VAC	75 VA	1	Yes	UL recognized Class 2
440008	120 VAC	96 VA	2	Yes	UL listed CSA approved Class 2
440009	120 VAC	96 VA	1	Yes	UL recognized Class 2
440010	120 VAC	150 VA	1	Yes	UL listed CSA approved Class 2

Delta Part #	Primary Voltage	VA Rating	Hubs	Circuit Breaker	Agency Approvals and Listings
440011	120,208, 240,480 VAC	50 VA	1	Yes	UL listed CSA approved Class 2
440012	120,208, 240,480 VAC	75 VA	1	Yes	UL listed CSA approved Class 2
440013	120,208, 240,480 VAC	96 VA	1	Yes	UL listed CSA approved Class 2

Power Supply Types

The type of power supply used on a device affects the way you wire power to the device. Delta Controls products use two types of power supply: full- and half-wave rectified power supplies.

Half-Wave Rectification

A half-wave rectified signal draws current from the positive voltage cycle only. Because of this, devices that use half-wave rectification have ground-referenced power circuitry; all half-wave devices share a common ground.

Full-Wave Rectification

Also known as bridge rectified, a full-wave rectified signal draws current from both the positive and negative voltage cycles. Full-wave devices have floating power supplies and are not referenced to ground.



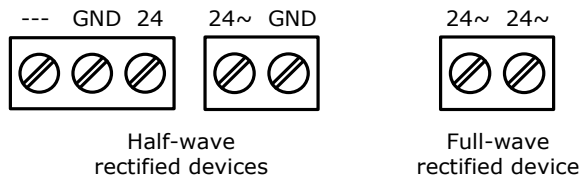
Identify the type of power supply used in a device carefully; failing to do so can damage the device and the transformer.

Identifying the Type of Power Supply

It is essential to identify whether the device's power supply is half-wave rectified or full-wave rectified before wiring power to it. Identifying the type of power supply correctly can prevent many potential problems.

To identify the type of power supply that a Delta Controls device uses, see the device's installation guide. Figure 1 shows typical power ports and controller labeling.

Figure 1: Typical Full and Half Wave Rectified Power Ports as Labeled on Controller



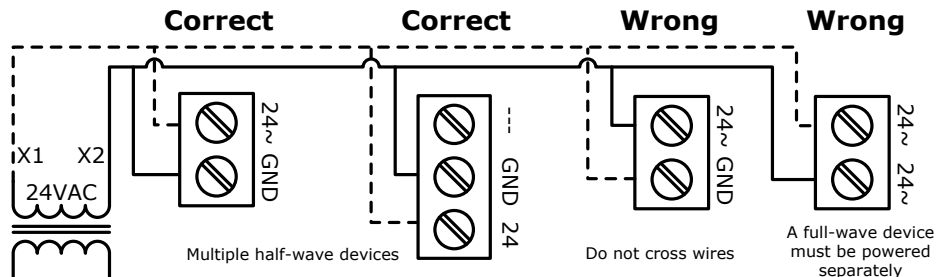
Wiring Half-Wave Rectified Devices



Multiple half-wave devices can be wired from the same transformer, providing that wire polarity is observed. Crossing wires between panels can quickly damage both devices and transformers.

Wire the transformer's X1 lead to the device power port's 24 VAC terminal and wire the transformer's X2 lead to the device power port's GND terminal, as shown in Figure 2.

Figure 2: Wiring Half-wave Rectified Devices



Wiring Full-Wave Rectified Devices

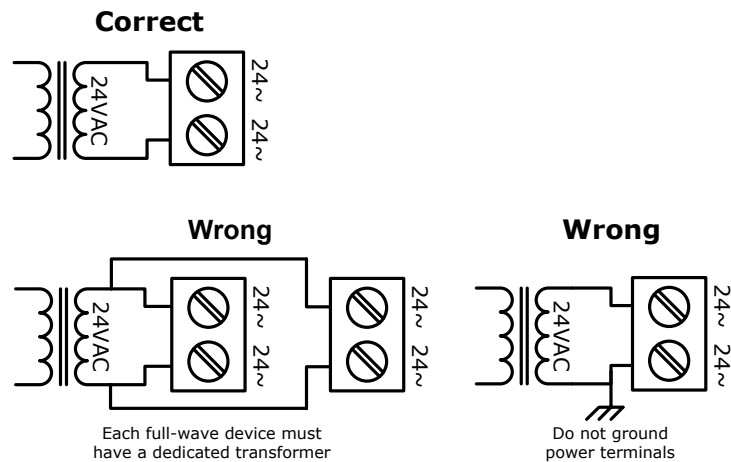


Full-wave devices must not be wired to the same transformer to which a half-wave device is connected. Wiring devices in this manner creates a ground loop and damages both the device and the transformer.

Each full-wave device must use a dedicated transformer. Do not wire other devices to the same transformer. Doing so damages both the device and the transformer.

Do not ground the transformer of a full-wave device. Connect the transformer directly to the power port as shown in Figure 3.

Figure 3: Wiring Full-wave Rectified Devices



Grounding

Proper grounding prevents many potential problems that can occur in a network of devices. Common symptoms of a poorly grounded network include inconsistent RS-485 communications and damage from voltage spikes.

This section describes the acceptable methods to use to ground Delta devices.

Preferred Method for Grounding a Version 3 Device

To ensure proper grounding for Version 3 devices ground each device.

When the device contains a ground lug, then connect the ground lug to earth ground.

If the device does not contain a ground lug, then connect any one of the terminals labeled GND to earth ground.

Figure 4: Correct Device Grounding - Version 3 Devices

Each device must be grounded securely to earth ground.

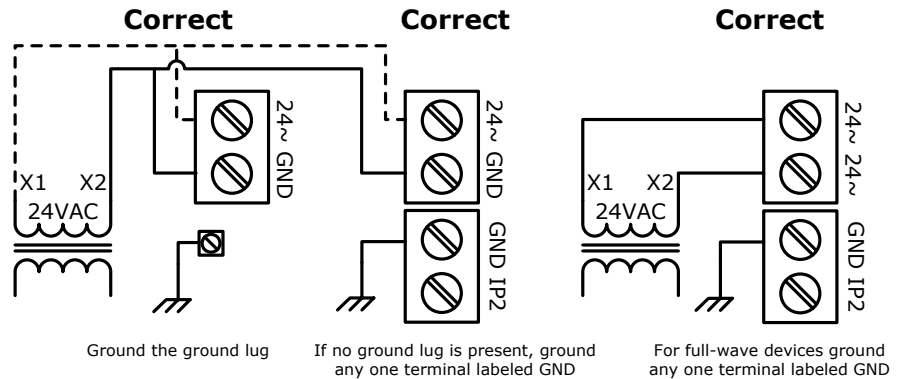
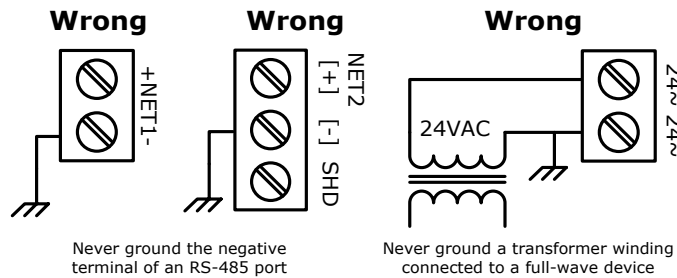


Figure 5: Wrong Device Grounding

Never ground RS-485 network or 24 V AC ports of full-wave devices.



Never ground one of the transformer's secondary wires when connected to a full-wave device. Doing so will damage both the device and the transformer.

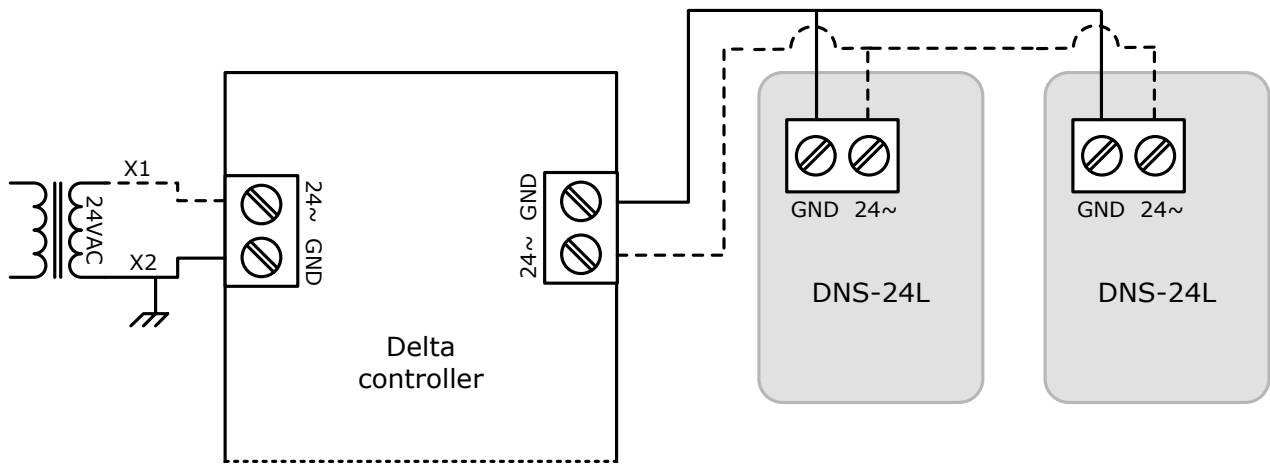
Alternate Method for Grounding a Version 3 Device

The preferred method is not always practical for some installations. There may be instances where grounding each device is difficult, for example a network of BACstats. In this case, the alternate method may be used.

If grounding each device is impractical, then a single ground point may be used. The most common place to ground in this manner is one of the secondary wires of the power transformer.

Figure 6: Single Ground Point – Version 3 LINKnet Devices

An alternate grounding method: single ground point on transformer secondary. The ground is passed internally through the properly grounded Delta controller to all devices in the network.

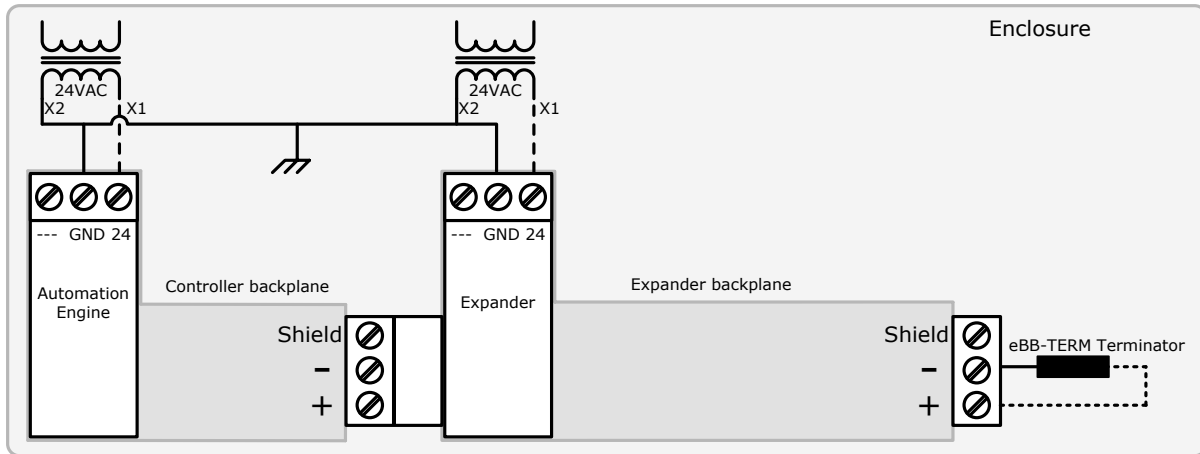


Grounding enteliBUS components in the same enclosure

When all enteliBUS components are in the same enclosure connect the power port GND on the automation engine and on each expander to the same earth ground, as shown in Figure 7. This recommendation applies when the components are connected by their integrated eBUS network connectors and when connected by eBUS network cable.

I/O modules are grounded properly via the backplane they are plugged into.

Figure 7: Grounding enteliBUS components in the same enclosure



Grounding Distributed enteliBUS Components

When enteliBUS components are distributed (within the limitations of the eBUS network) and not in the same enclosure, connect the power port GND on the automation engine and on each expander to a local earth ground, as shown in Figure 8.

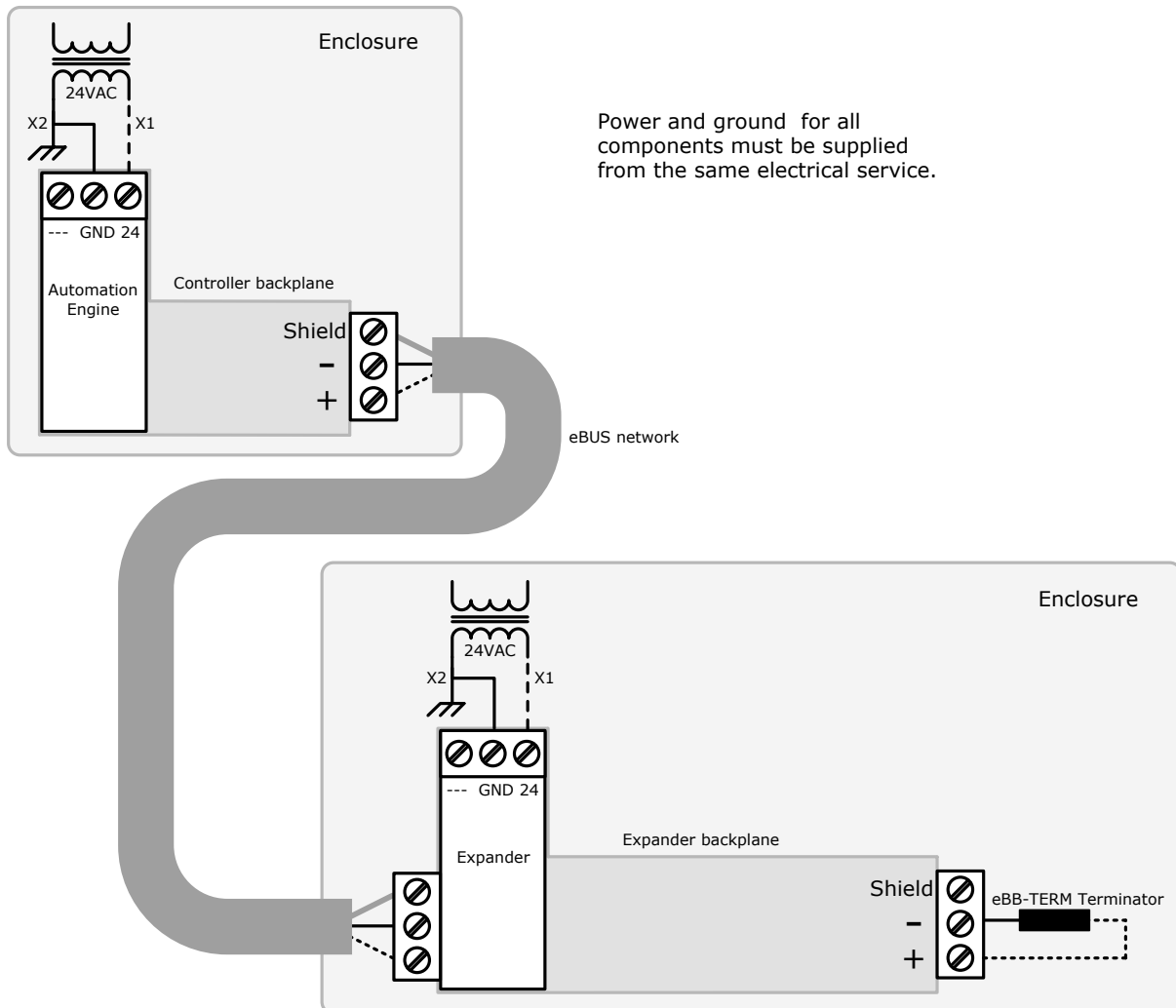
I/O modules are grounded properly via the backplane they are plugged into.

Power and ground must comply with following rules:



- Power for all components must be supplied from the same electrical service.
- All local earth grounds must be supplied from the same electrical service.

Figure 8: Grounding Distributed enteliBUS Components



Fusing

When a transformer does not have a built-in circuit breaker, Delta Controls recommends using a slow-blow fuse on the secondary side of the transformer. The fuse size is determined by the VA ratings of the devices. Use Table 4 to determine the correct fuse size. A fuse not only provides protection for the transformer, but can also help with troubleshooting.

Table 4: Correct Fuse Sizes

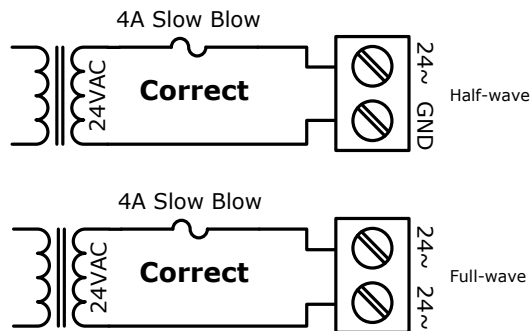
Transformer Rating	Fuse Size
100 VA	4 A
75 VA	3 A
50 VA	2 A
25 VA	1 A

Without a fuse, the only protection a Class 2 circuit has is the primary circuit breaker (normally 15 or 20 A). If a device were to fail, this circuit breaker is not sufficient protection to prevent damage to the transformer. A fuse on the transformer's secondary prevents damage to the device.

Delta Controls Class 2 products have a maximum rating of 100 VA. This means that the maximum allowable fuse size is 4 A.

Fuse one secondary transformer wire only. For half-wave devices, fuse the wire connected to the device's 24~ pin. For full-wave devices, either wire can be fused.

Figure 9: Using 4 A Slow-blow Fuse



Multiple Service Entrances

A service entrance is a location where the electrical service enters the building. Multiple services are common in large installations or installations where multiple buildings are on the same network.

Identifying Multiple Service Entrances

To identify whether or not the location uses multiple services, check for the following:

- If there is more than one electrical room that contains a primary transformer, then there are multiple service entrances.
- If the building has had a large addition to the original structure, then it likely has another service entrance.

If there is any question as to whether or not there are multiple service entrances, obtain and check a wiring diagram for the building.

Ground Isolation

Never tie grounds from multiple services together. Ground voltage differences across multiple services can be quite high. During lightning storms, potential differences can reach hundreds, even thousands, of volts.

Treat multiple services as separate sites. Never connect power, I/O or network wiring directly across multiple services.



Never connect power, I/O, or network wiring directly across multiple services.

See Chapter 3, section *Running RS-485 Between Buildings*, for more information about network and power isolation.

Chapter 2 - Inputs and Outputs Guidelines

This chapter describes the recommended wiring practices for inputs and outputs on Delta Controls HVAC products. Follow these guidelines to ensure optimum performance of your Delta Controls products.

For detailed information about specific controller's inputs and outputs see the controller's installation guide.

Review Glossary of Terms to be sure you understand terms used in this chapter.

Inputs

Delta Controls controllers provide five types of industry-standard inputs, compatible with most sensors available on the market:

A universal input that can be configured for:

- 10 kOhm / dry contact;
- 5 V;
- 10 V; or
- 4-20 mA.

A digital-only input.

Input Wiring Practices and Precautions

Although Delta Controls controllers' inputs are very robust, by following the wiring practices and precautions described in this document you can further improve input accuracy and reliability.

The following sections describe in detail how to wire each of these input types.

Powering Sensors

Some sensors need to receive power for proper operation. This power can be supplied from a 24 VAC Class 2 transformer or from a power supply that converts the transformer voltage into a more usable 24 VDC.

Delta recommends that sensor power be supplied from a source that is separate from the controller's power source for two important reasons:

1. When 24 VDC is required, you don't need to be concerned whether the DC converter is half-wave or full-wave rectified to match the controller's power requirement.
2. Controller power is not affected by electrical problems associated with the sensor; you may lose a sensor but the controller continues to function.

Further, Delta recommends you wire the sensor power supply input power according to the manufacturer's instructions.

In this document, all sensor wiring figures reflect these recommendations.

10 kOhm / Dry Contact Input

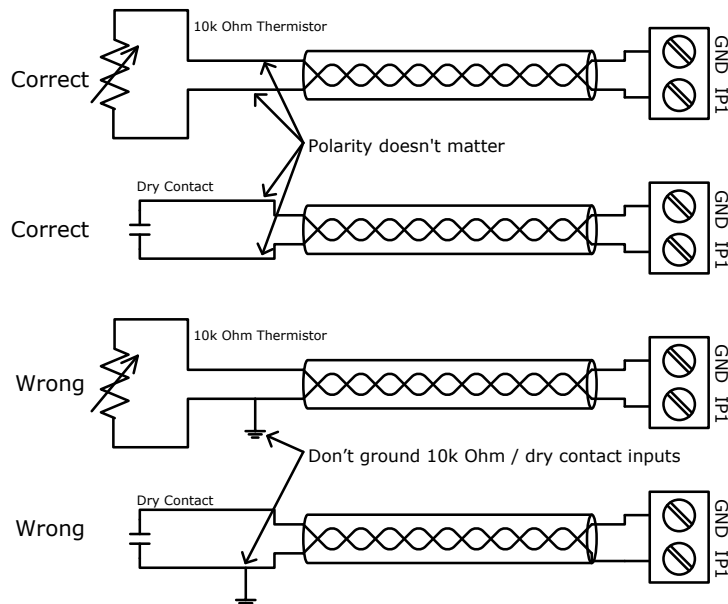
Delta Controls 10 kΩ inputs are typically used for a 10 kΩ thermistor or a dry contact such as a push button or switch. Internally to the controller, the input is connected to a 10 kΩ pull-up resistor. A resistance value of 10 kΩ wired to the input translates to a reading of 50% in the Analog Input object. An open circuit reads 100% and a short circuit reads 0%.

Table 5: 10 kOhm / Dry Contact Input – Specifications

Category	Specification
Full Scale Value	Open circuit (∞ Ohm) = 100%
Half Scale Value	10 kΩ = 50%
Input Impedance	10 kΩ
Cable Type	2 conductor 18 AWG (Belden 83652) 2 conductor 22 AWG (Belden 88442)
Max Cable Length	1500 ft (450 m) max using 22 AWG 3900 ft (1200 m) max using 18 AWG
Wiring Precautions	Ground only at controller input GND terminal

Proper grounding increases sensor reliability and accuracy. Proper grounding eliminates any ground noise effect and any potential differences that could develop during electrical storms. Figure 10 illustrates this.

Figure 10: Wiring 10k Ohm / Dry Contact Inputs



5 V Input

The 5 Volt input on Delta Controls controllers is a high input impedance input. Use a 5 Volt input with active devices that generate their signal source. The 5 V input's high input impedance makes it suitable for current transformers and other sensors that have high output impedance.

Table 6: 5 V Input – Specifications

Category	Specification
Full Scale Voltage	5 VDC
Maximum Voltage	20 VDC; higher voltages damage input circuit
Input Impedance	> 1 M Ω
Cable Types	2 conductor 22 AWG shielded (Belden 83552) 2 conductor 20 AWG shielded (Belden 83602) 3 conductor 20 AWG shielded (Belden 8772)
Max Cable Length	100 ft (30 m) 330 ft (100 m) with 20 k Ω load resistor
Wiring Precautions	Keep cable short Use dedicated shielded cable

While the input's high impedance characteristics can be advantageous for monitoring some sensors, the current flow from the sensor to the controller is low, making the signal very susceptible to noise.

Delta Controls strongly recommends using shielded wire for all 5 V inputs. Delta Controls also recommends using a dedicated cable because adjacent wires in the same cable can induce noise into the signal. A dedicated shielded cable protects the signal from outside noise sources.



When using shielded wire, earth ground the controller end of the shield only. When you ground both ends, difference in ground potentials can induce noise into the signal.

When the sensor has low output impedance (less than 200 Ω), Delta Controls recommends wiring a 20k Ω resistor in parallel with the input. The 20k Ω input impedance acts as a load for the sensor, increasing the current flow into the controller. The higher the current flow, the less susceptible the sensor is to external noise.

Keep the cable length as short as possible. Delta Controls recommends a maximum shielded cable length of 100 ft (30 m) for all 5 V inputs. The addition of a 20 kΩ resistor at the controller allows for increased cable lengths of up to 330 ft (100 m). Signal quality degrades quickly with long cable runs. Ensure that the addition of the 20 kΩ does not significantly affect the signal level generated at the input device.

Figure 11: Wiring a 5 V Current Sensor

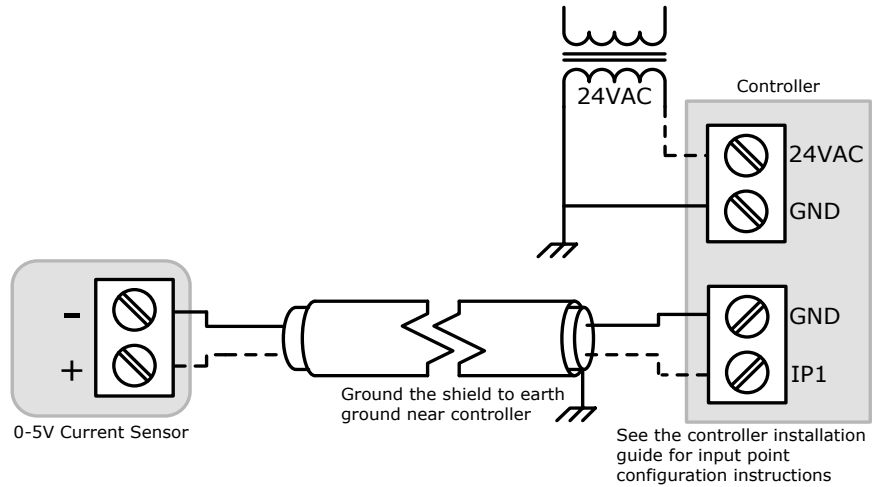
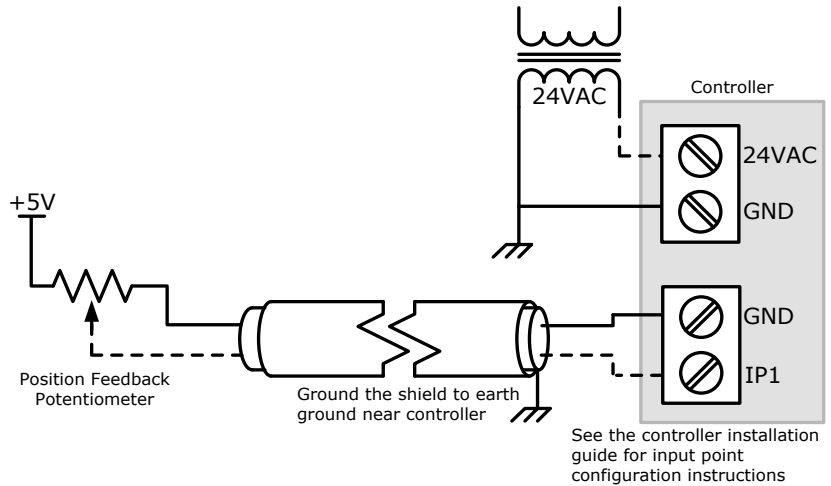


Figure 12: Wiring a 5 V Position Feedback Potentiometer



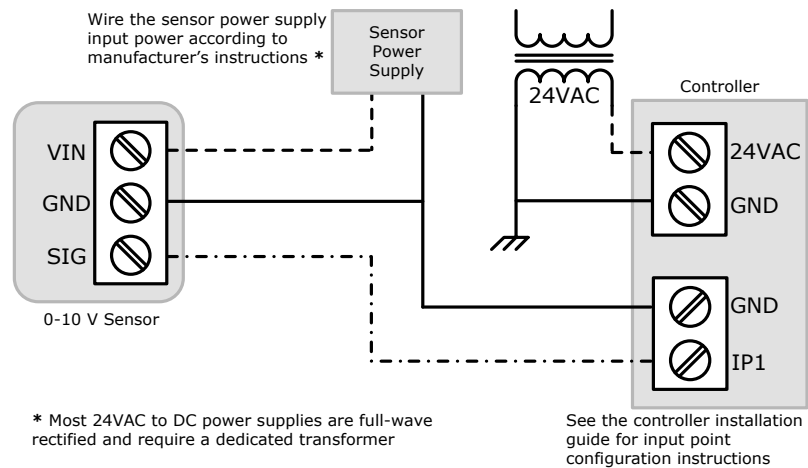
10 V Input

Delta Controls 10 Volt inputs have a wide variety of applications including humidity and pressure sensors. 10 V inputs have moderate input impedance, making them less susceptible to noise than 5 V inputs.

Table 7: 10 V Input – Specifications

Category	Specification
Full Scale Voltage	10 V DC
Input Impedance	20 kΩ
Cable Type	Multi-conductor 18 AWG unshielded (Belden 83652) 3-conductor 18 AWG unshielded (Belden 88870)
Max Cable Length	330 ft (100 m)

Figure 13: Wiring a 10 V Sensor



4-20 mA Input

4-20 mA inputs are used for a variety of sensors such as pressure sensors. 4-20 mA inputs are preferred over other input types because of the high current. The higher the current through a wire, the less susceptible it is to noise.

Table 8: 4-20 mA Input – Specifications

Category	Specification
Full Scale Current	20 mA
Input Impedance	250 Ω
Cable Type	2-conductor 18 AWG unshielded (Belden 83652) 4-conductor 18 AWG unshielded (Belden 88489)
Max Cable Length	3300 ft (1000 m)

Figure 14: Wiring a 2-wire 4-20 mA Sensor

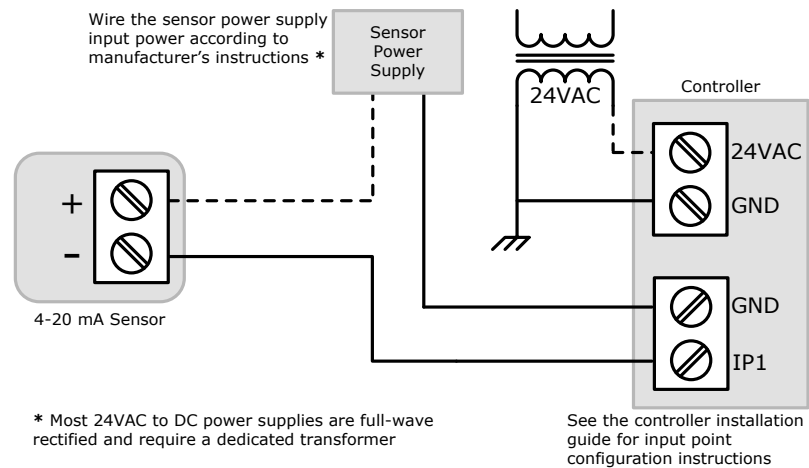
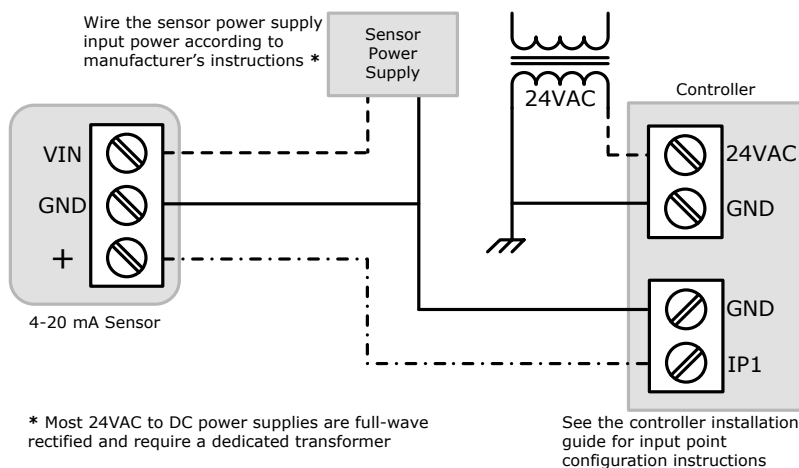


Figure 15: Wiring a 3-wire 4-20 mA Sensor



Digital-Only Input

Digital-only inputs are used to monitor dry contacts, push buttons and switches. The digital input described here is available on the enteliBUS modules.

Digital inputs can use either 24VAC or 24VDC. When a digital input is configured in software as direct acting, it switches off when voltage drops below a threshold of 5VDC or 5VAC and switches on when voltage rises above the threshold of 11VDC or 18VAC. When the voltage is between these thresholds, the input maintains its current state.

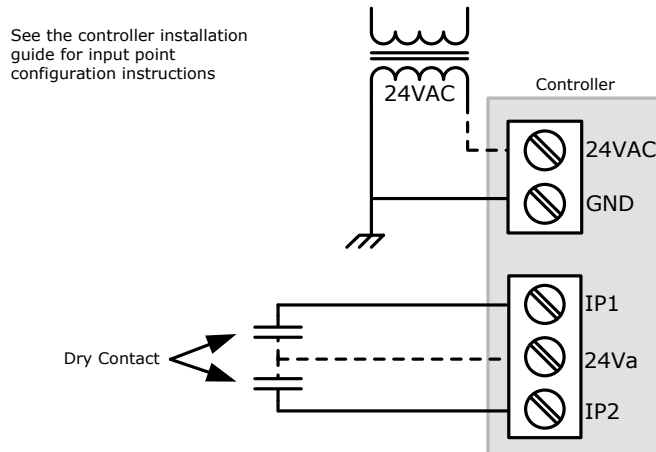
A 24VDC-powered digital input satisfies the switching requirements for IEC 61131-2 Type 1 and Type 3 switches. IEC 61131-2 Type 2 is not supported.

The digital input circuit includes hysteresis that provides noise immunity to minimize the detection of false transitions.

Table 9: Digital Input – Specifications

Category	Specification
Output current supplied	40 mA
Cable Type	2 conductor 18 AWG (Belden 83652) 2 conductor 22 AWG (Belden 88442)
Max. Cable Length	1500 ft (450 m) max using 22 AWG 3900 ft (1200 m) max using 18 AWG

Figure 16: Wiring a Digital Input Dry Contact



Outputs

Delta Controls controllers provide three types of industry-standard outputs, compatible with most actuators and relays available on the market:

- Analog: 0-10 VDC
- Binary: TRIAC
- Binary: Relay

Analog Output

Delta Controls analog outputs can be used for a variety of DC Voltage applications, including actuators, relays and heat units.

Table 10: Analog Output – Specifications

Category	Specification
Full Scale Voltage	10 VDC
Max Output Current	20 mA (500 Ohm minimum load)
Cable Type	2-conductor 18 AWG unshielded (Belden 83652)
Max Cable Length	330 ft (100 m)

Analog outputs can also be used as binary outputs to provide 0V or 10V signals. This signal is useful for driving solid state and low power DC relays. Figure 18 shows an example of this application.

Figure 17: Wiring an Analog Output to 0 – 10 V Actuator

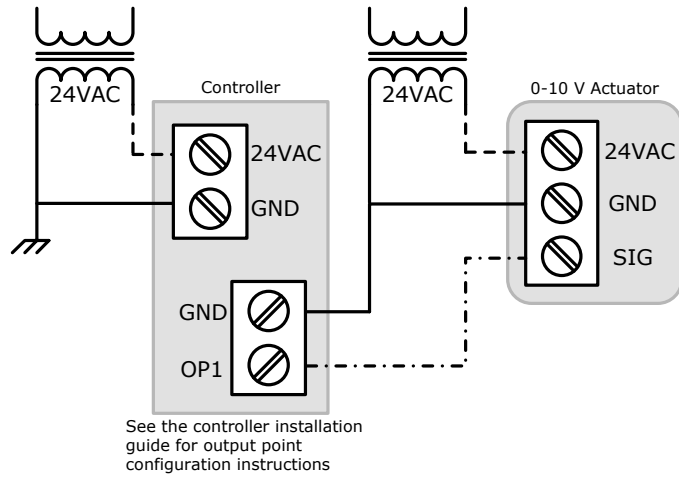
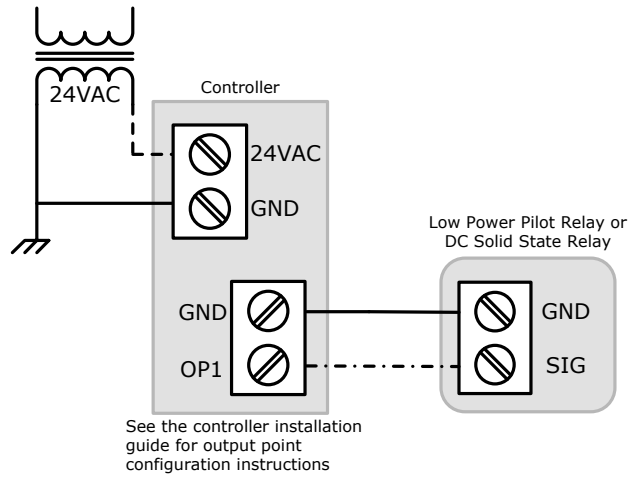


Figure 18: Wiring an Analog Output to Low Power Relay



Binary TRIAC Output

Binary TRIAC (TRIode for Alternating Current) outputs are used to provide switched 24VAC at up to 500 mA to an output device. On some controllers, the AC power source for the outputs is jumper selectable for internal or external power. When using the external power setting, the maximum voltage that can be applied is 28VAC. Never connect line voltage to a binary output.

enteliBUS modules with TRIAC or relay outputs include a PTC (Positive Temperature Coefficient) fuse on the internal power that supplies each pair of outputs. When too much current is drawn by the device connected to an output, the fuse opens and power is removed from that pair of outputs.

Table 11: Binary TRIAC Output – Specification

Category	Specification
Max External Voltage	28VAC
Max Output Current	Version 3 controllers: 500 mA enteliBUS I/O Modules: 500 mA when switching external power; 250 mA when switching internal controller-supplied power
Max Leakage Current	160 μ A
Cable Type	2-conductor 18 AWG unshielded (Belden 83652)
Max Cable Length	330 ft (100 m)
Minimum Turn-On Current	25 mA



Binary outputs are not meant to switch line voltage. Never connect line voltage to a binary output. Doing so will damage the controller.

When using the external power setting, apply AC power only. A TRIAC is an AC device; it doesn't turn off when DC voltage is applied. Never connect a DC voltage to the external power of a TRIAC output. This also applies to a Delta Controls controller that is being powered from a DC source. Binary outputs cannot be used on a device that is powered from a DC source.



Never connect a DC voltage to the external power pin of a TRIAC output. Similarly, never power a controller with binary outputs with a DC power source.

Figure 19: Wiring an Internally-Powered Binary TRIAC Output

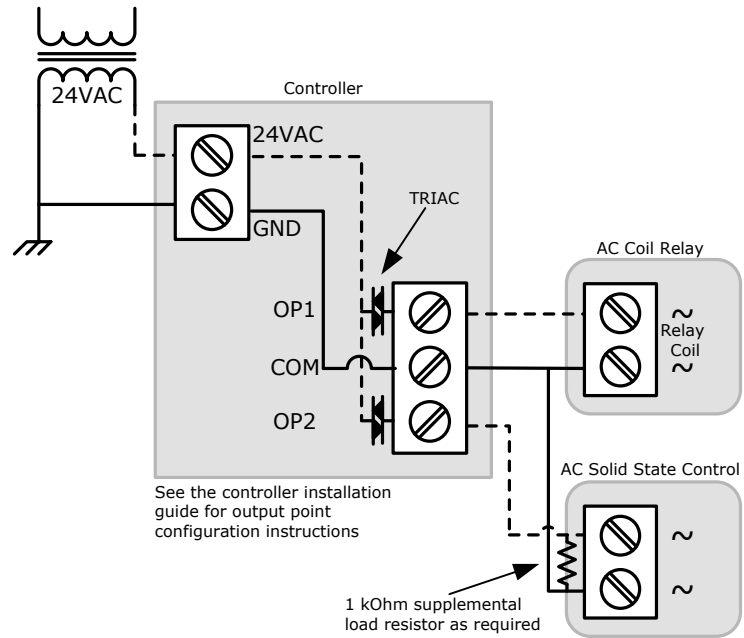


Figure 20: Wiring an Externally-Powered Binary TRIAC Output

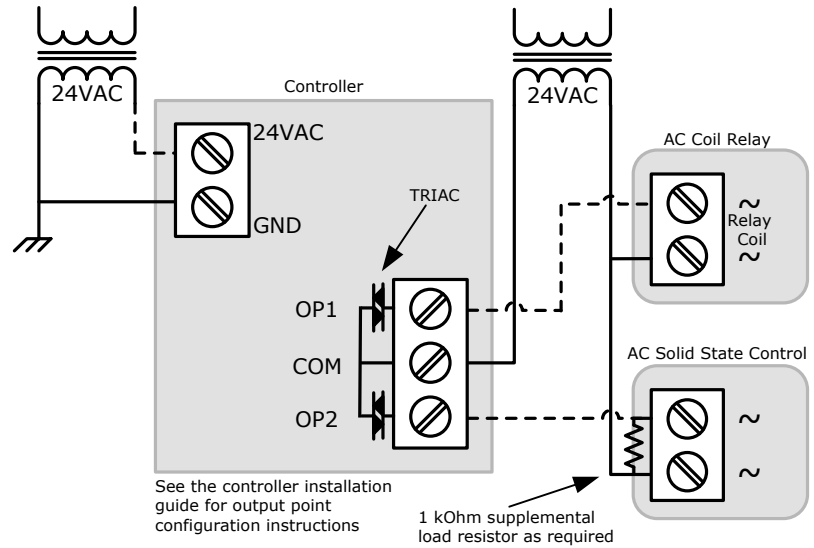
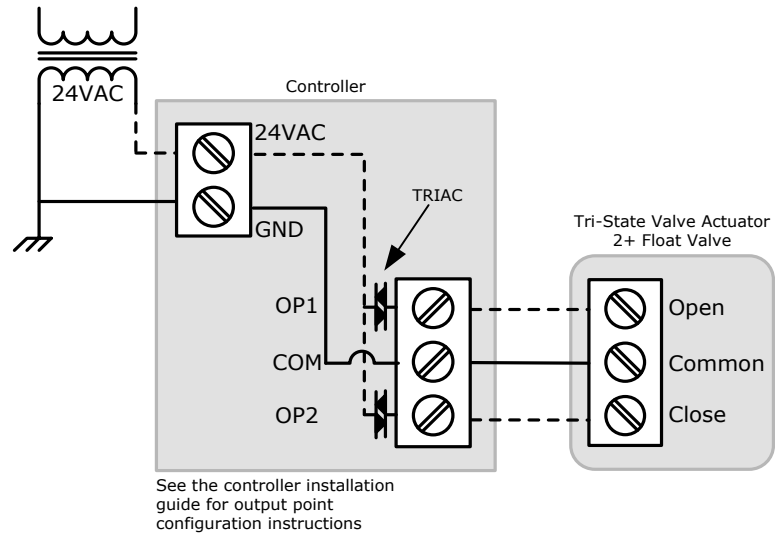


Figure 21: Wiring Tri-State Valve with an Internally-Powered Binary TRIAC Output



TRIAC Leakage and Load Current Considerations

All TRIACs have a specified leakage current when in the off state. Delta Controls TRIAC outputs have a maximum leakage current of 160 μ A. This amount of leakage is not normally high enough to cause concern; however, there are conditions when it could be enough to trigger a device.

For devices that trigger on the leakage current, wire a 1 kOhm, 1 Watt resistor in parallel with the output to provide a path for the leakage current.

TRIACs require a minimum 25 mA current draw to turn on and off properly. When an AC solid-state relay load current is less than 25 mA, wire a 1 kOhm, 1 Watt resistor in parallel with the output to provide the additional current required to power the device, as shown in Figure 19 and Figure 20.



Wire a 1 kOhm 1 Watt resistor in parallel with the output when:

- The load is an AC solid-state relay that draws less than 25 mA.
- The device being power requires less than 160 μ A to turn on.

Binary Relay Output

Binary relay outputs are used to provide switched 24 VAC or VDC at up to 0.5 A to an output device. The power source for the relay output is jumper-selectable for internal or for external power source. Never connect line voltage to a binary output.

enteliBUS modules with TRIAC or relay outputs include a PTC (Positive Temperature Coefficient) fuse on the power circuit that supplies each pair of outputs. When too much current is drawn by the device connected to an output, the fuse opens and power is removed from that pair of outputs.

Table 12: Binary Relay Output – Specification

Category	Specification
Max External Voltage	28 VAC 28 VDC
Max Output Current per Relay	enteliBUS I/O Modules: 0.5 A when switching external power; 250 mA when switching internal controller-supplied power
Cable Type	2-conductor 18 AWG unshielded (Belden 83652)
Max Cable Length	330 ft (100 m)



Binary outputs are not meant to switch line voltage. Never connect line voltage to a binary output. Doing so will damage the controller.

Figure 22: Wiring an Internally-Powered Binary Relay Output

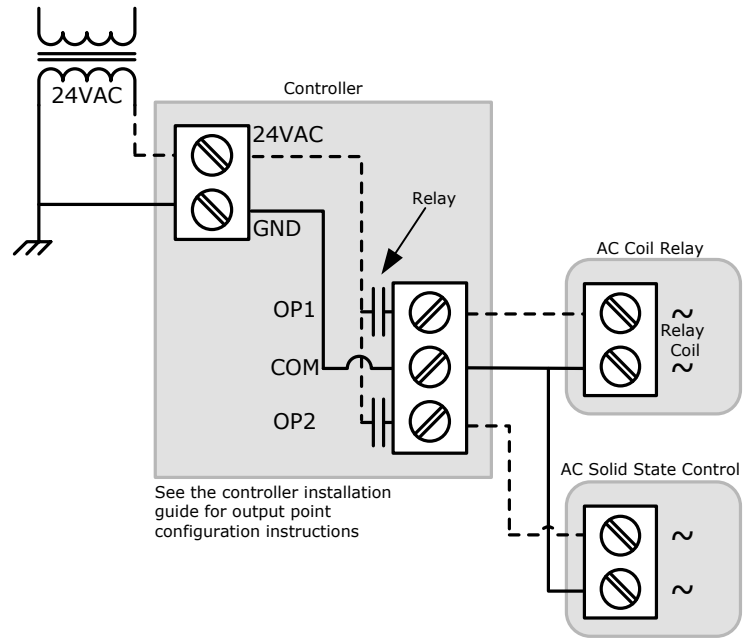
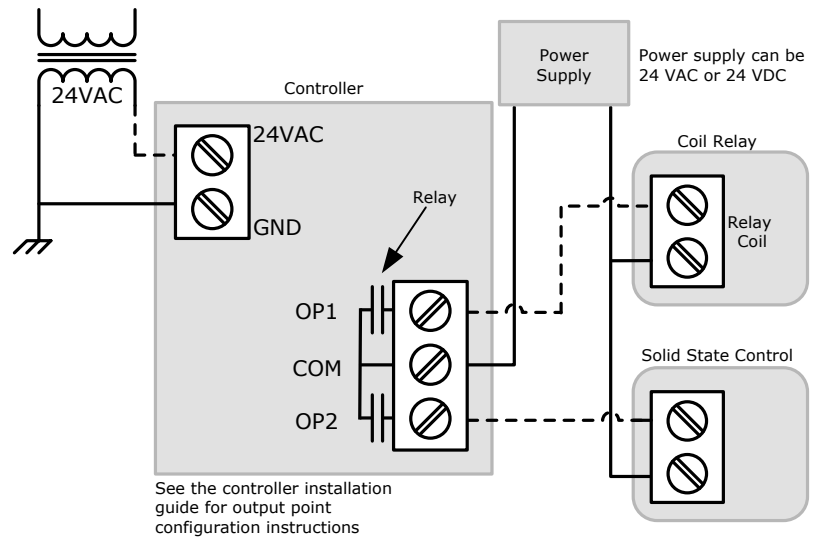


Figure 23: Wiring an Externally-Powered Binary Relay Output



Wiring Internal/External Power Jumpers for Binary Outputs

Figure 24 and Figure 25 detail the jumpers for internally-powered and for externally-powered binary outputs. These figures apply to both TRIAC and relay binary outputs.

Figure 24 Wiring Internally-powered Binary Output, Jumpers Details

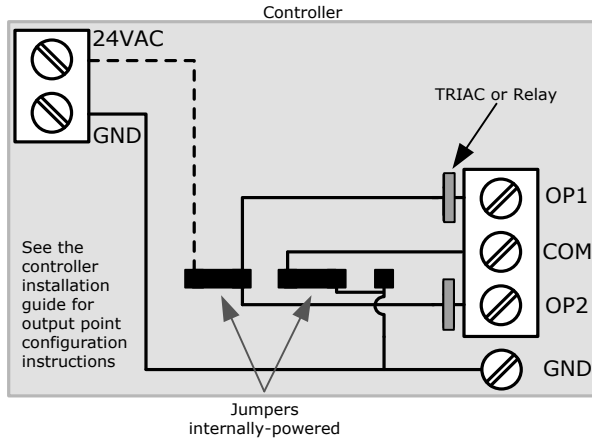
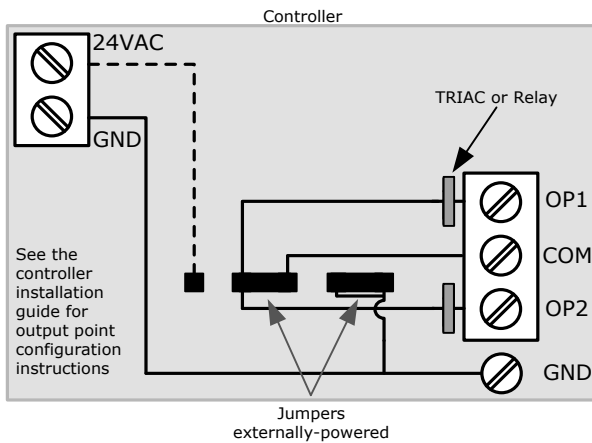


Figure 25: Wiring Externally-powered Binary Output, Jumpers Details



Chapter 3 - RS-485 Network Installation Guidelines

This chapter describes the Delta Controls recommended design and installation specifications for a RS-485 network.

Delta Controls uses RS-485 as the physical network between devices in BACnet MS/TP, LINKnet and V2 Subnet networks.

Review Glossary of Terms to be sure you understand terms used in this chapter.

Cable Type

Delta Controls RS-485 networks require cable that meets all of the following specifications:

Twisted Pair Cable

- 22-24 AWG twisted pair, shielded jacketed communication cable
- Characteristic impedance of 100-120 ohms
- Capacitance of 17 pF/ft conductor-to-conductor or less. 18 AWG cable doesn't meet this specification.
- Braided or aluminum foil shield
- Velocity of propagation of 66% or higher

Example compatible cable products are Belden 9841, Belden 82841 and Windy City Wire 42002-S.

CAT5 Cable

- Industry-standard Category 5 (CAT5) straight-through unshielded twisted pair communication cable or better (CAT5e, CAT6) when used with applicable Delta products such as the DZNT-VAV.

Network Configuration

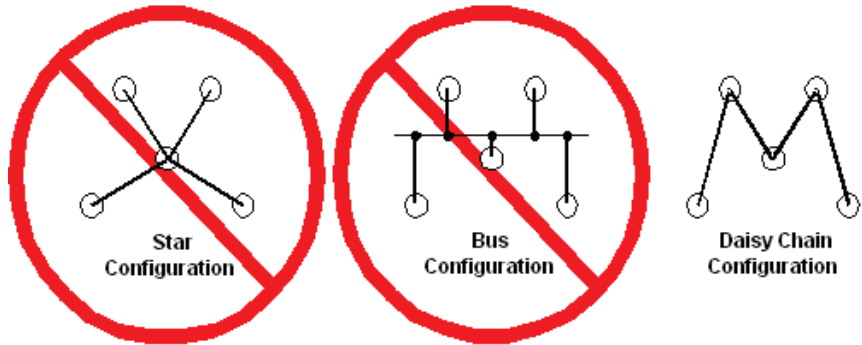
Delta Controls requires that RS-485 networks use a daisy chain configuration. No other RS-485 network wiring configuration is acceptable.

Daisy chain means that there is one cable with only two ends and every network device is connected directly along its path.

Figure 26 illustrates two unacceptable network configurations and the required daisy chain configuration.

Figure 26: Daisy Chain Network Configuration

Only the daisy chain configuration is acceptable for a RS-485 network.



Maximum RS-485 Network Cable Length

Twisted Pair Cable Length

Using proper cable, the maximum length of an RS-485 twisted-pair network segment is 4000 ft (1220 m). A segment of this length works reliably for data rates up to Delta Controls' maximum data rate of 76,800 bps.

CAT5 Cable Length

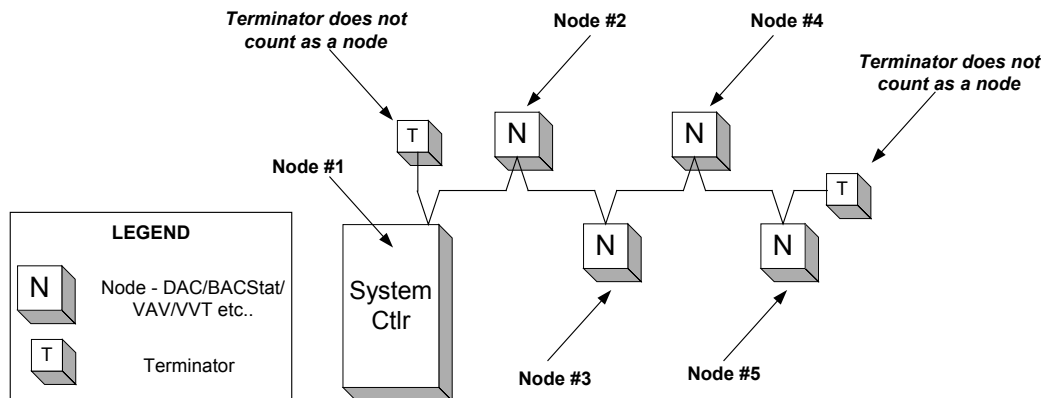
The maximum length of Delta's CAT5 RS-485 network segment is 2000 ft (610 m). A segment of this length works reliably for data rates up to Delta Controls' maximum data rate of 76,800 bps when used with applicable products such as the DZNT-VAV.

Maximum Number of Nodes

A maximum of 64 nodes are allowed on a network segment. For the example in Figure 27 there are five nodes: one node for the system controller plus four for the other controllers.

A maximum of 99 nodes are allowed on a network. When you have more than 64 nodes a repeater is required to drive the network. See Figure 33 for an example using a repeater.

Figure 27: Five Node Network Example



Shield Continuity and Termination

When properly installed, shielded twisted pair cable improves the protection of the network and equipment against harmful electromagnetic interference (EMI) and transient voltage spikes.

Delta Controls does not support unshielded cable in twisted pair networks except when using the Delta CAT5 wiring technique.

Proper installation of the cable's shield involves two steps:

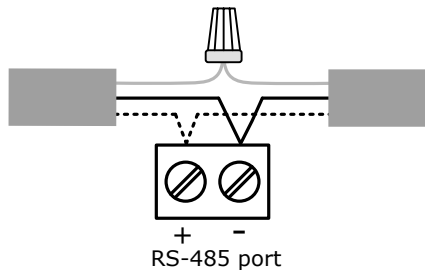
1. Tying the shield through at each node
2. Terminating the shield

When the network shield is connected to different ground potentials, current flows through the shield and induces noise into the network. This causes unreliable network communications and could damage the controllers.

Ensuring Shield Continuity

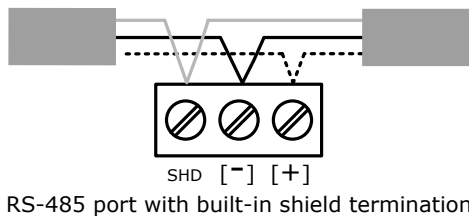
The cable's shield must be tied through at each node to make a continuous shield that runs the entire length of the RS-485 segment, as shown in Figure 28 and Figure 29. Do not connect the shield to ground at the node.

Figure 28: Shield Continuity at Node – V3 devices



As shown in Figure 29, enteliBUS automation controllers come with a three-terminal RS-485 port. The SHD terminal is connected via a capacitive path to ground similar to the Shield terminal on the Delta TRM-768 Network Terminator.

Figure 29: Shield Continuity at Node – built-in shield termination



Terminating the Shield

In a typical RS-485 network segment, the shield, along with the data wires are terminated with a TRM-768 terminator at both ends of the segment, as shown in Figure 30.

While the recommendation for terminating the shield at both ends may seem to contradict the RS-485 standard, components in the TRM-768 provide a transient path to ground while preventing ground loops. By always terminating the shield at both ends with a TRM-768, the installer doesn't inadvertently ground the shield incorrectly.

Some Delta devices provide the built-in equivalent to the TRM-768 for terminating the shield, as shown in Figure 29.

Network Data Wires End-of-Line Termination

The data wires at both ends of an RS-485 network segment must be terminated to ensure reliable operation. Proper termination ensures network stability and helps to prevent damage to controllers during high electrical activity.



Termination is effective only when proper RS-485 network cable is used (see Cable Type). Otherwise, termination may provide unpredictable results.

Two methods can be used to terminate network data wires:

- Using two TRM-768s
- Using one TRM-768 and a device's built-in termination

Using Two TRM-768s

Using a TRM-768 at each end for terminating a RS-485 network provides the most reliable results by providing proper transient protection and proper protection against electromagnetic interference. Whenever possible use this method.

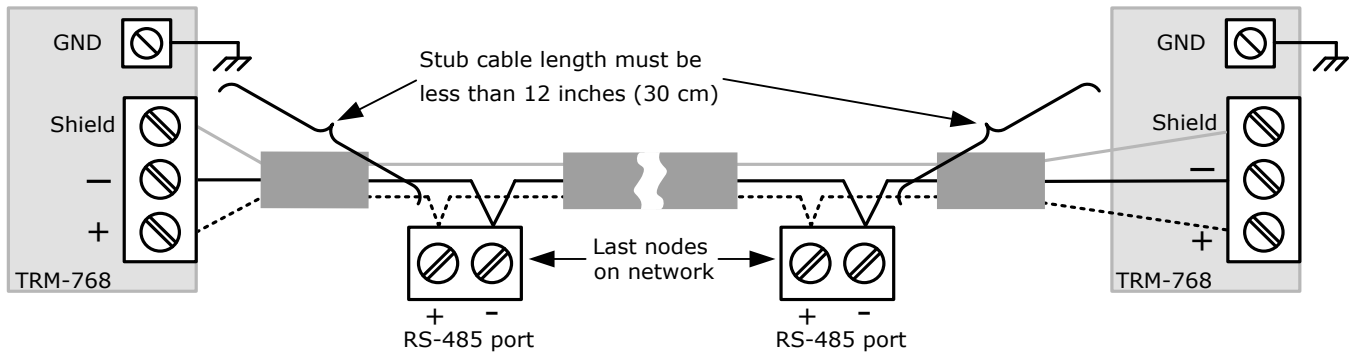
After the last node on each end of an RS-485 network, install a TRM-768. The TRM-768 provides the correct termination impedance not only for the network data wires but also for the network cable shield.

The stub cable from the last node to the TRM-768 must be kept as short as possible and be no longer than 12 inches (30 cm). A long stub causes a significant impedance mismatch and thus reflections. The RS-485 specification doesn't specify maximum stub length.

The TRM-768 provides a capacitive path for the shield to ground and additional protection through a 180 V MOV.

Connect the TRM-768 network terminators to earth ground, as shown in Figure 30.

Figure 30: Network Data Wires Termination using Two TRM-768s



Using one TRM-768 and Built-in Termination

Delta Controls manufactures several products that provide built-in jumper-selectable termination for the data wires. However, most of Delta’s controllers don’t include built-in termination; review the product installation guide to confirm.

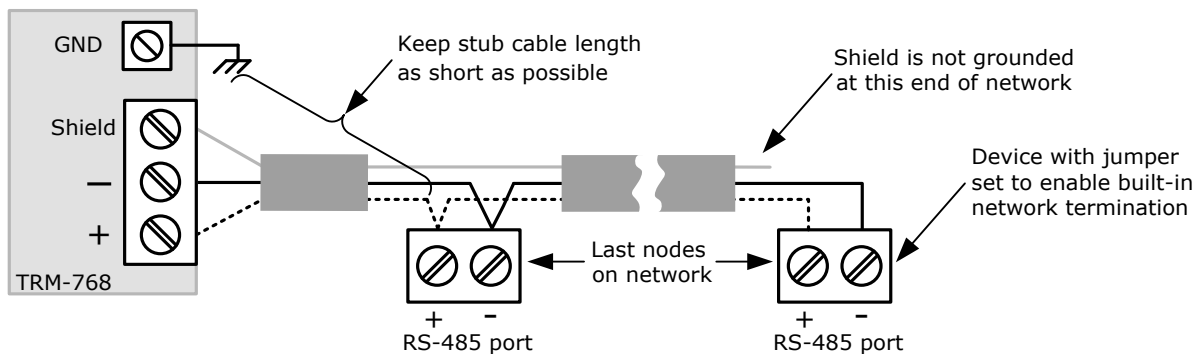
The Delta Controls DZNR-768 repeater includes built-in termination, as shown in Figure 33.

Although products with built-in termination provide proper termination for the data wires, they don’t provide termination for the shield.

In this case, the network cable shield is terminated at the TRM-768 end of the network and left unconnected at the controller end, as shown in Figure 31.

Never connect the shield directly to the ground. Differences in ground potentials in large buildings can cause current to flow. When the shield is connected to two different ground potentials, the resulting current induces noise into the network.

Figure 31: Network Data Wires Termination using One TRM-768 and Built-in Termination



LINKnet Networks

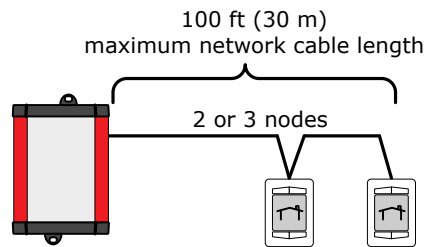
LINKnet is an RS-485 network; all guidelines described in this chapter apply. Use network terminators with larger LINKnet networks: networks with more than three nodes or network cables longer than 100 ft (30 m).

However, sometimes the LINKnet network is limited enough that terminators are not required. In a LINKnet network, terminators do not have to be used when the number of nodes is three or less and the overall cable length is less than 100 ft (30 m).

A good example is two DNS-24s on a short LINKnet network, as shown in Figure 32. Since there are only three nodes on this network and the overall network distance is short, it is not necessary to install network terminators.

In this case, connect the shield to the LINKnet master controller's ground lug and leave it unconnected at the other end of the segment.

Figure 32: Example Limited LINKnet Network



Repeaters

No more than 64 nodes are allowed on an RS-485 segment and no more than 99 nodes are allowed per network. All standards in this document for wire length, shielding, and grounding must be followed for each wiring segment.

A repeater strengthens the RS-485 signals to allow a network to be extended to accommodate more than 64 nodes.

The DZNR-768 multi-port repeater accommodates both twisted pair and Category 5 (CAT5) wiring methods for Delta RS-485 networks. Each of the repeater's four ports divides the network into a separate segment.

The network's system controller is normally placed on DZNR-768 port 1. Ports 2, 3 and 4 are used to interconnect the remaining nodes.

On ports 1 and 2, select either twisted pair or CAT5 cable. Use only one or the other wiring method on each port. Do not connect both the twisted pair and CAT5 types to the same port.

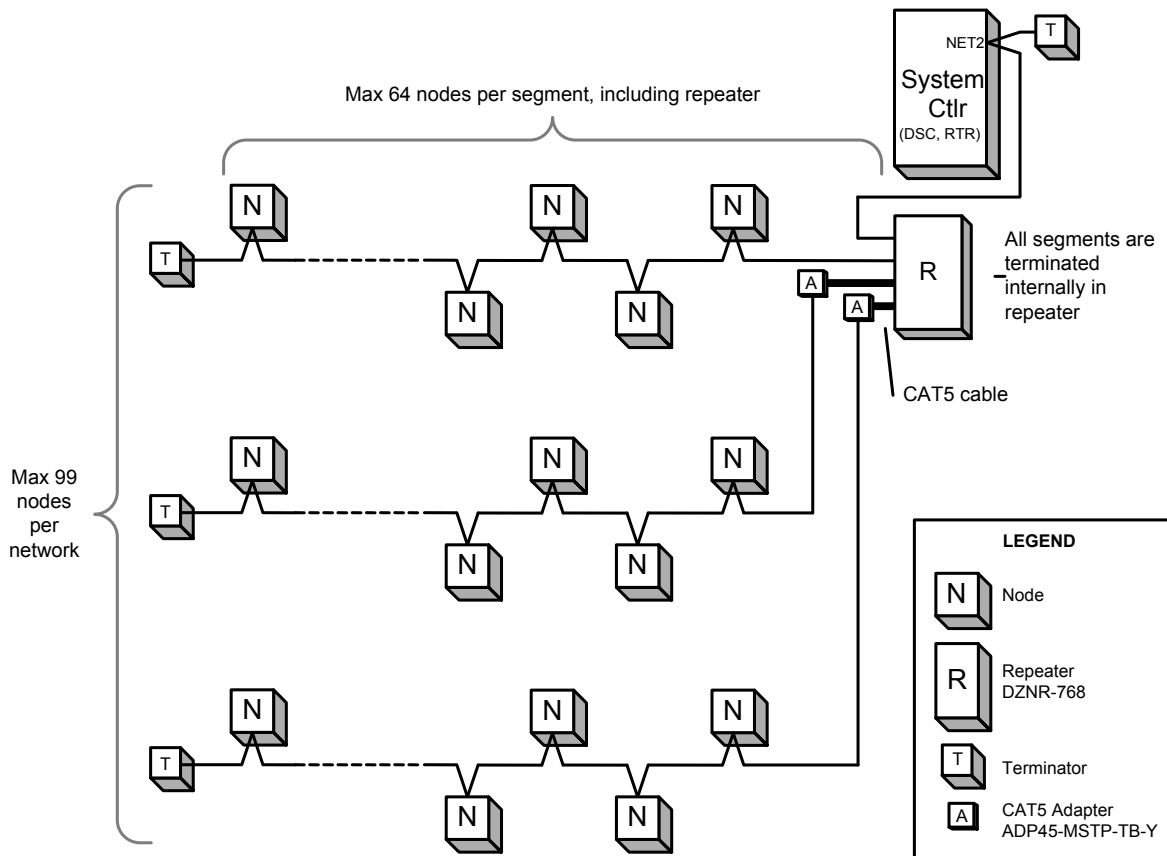
On ports 3 and 4 the DZNR-768 is built for Delta CAT5 MS/TP cabling technique. This approach allows quick, error-free connections across the controllers on the segment.

Using a DZNR-768 Repeater with Twisted Pair Network

Figure 33 illustrates the recommended use of the DZNR-768 repeater, CAT 5 adapters and terminators in a twisted pair RS-485 network.

Notice that a Delta Controls ADP45-MSTP-TB-Y adapter is required to convert between twisted pair and CAT5 type RS-485 configuration on ports 3 and 4. Nothing must be connected to the second Cat5 port on the TB-Y.

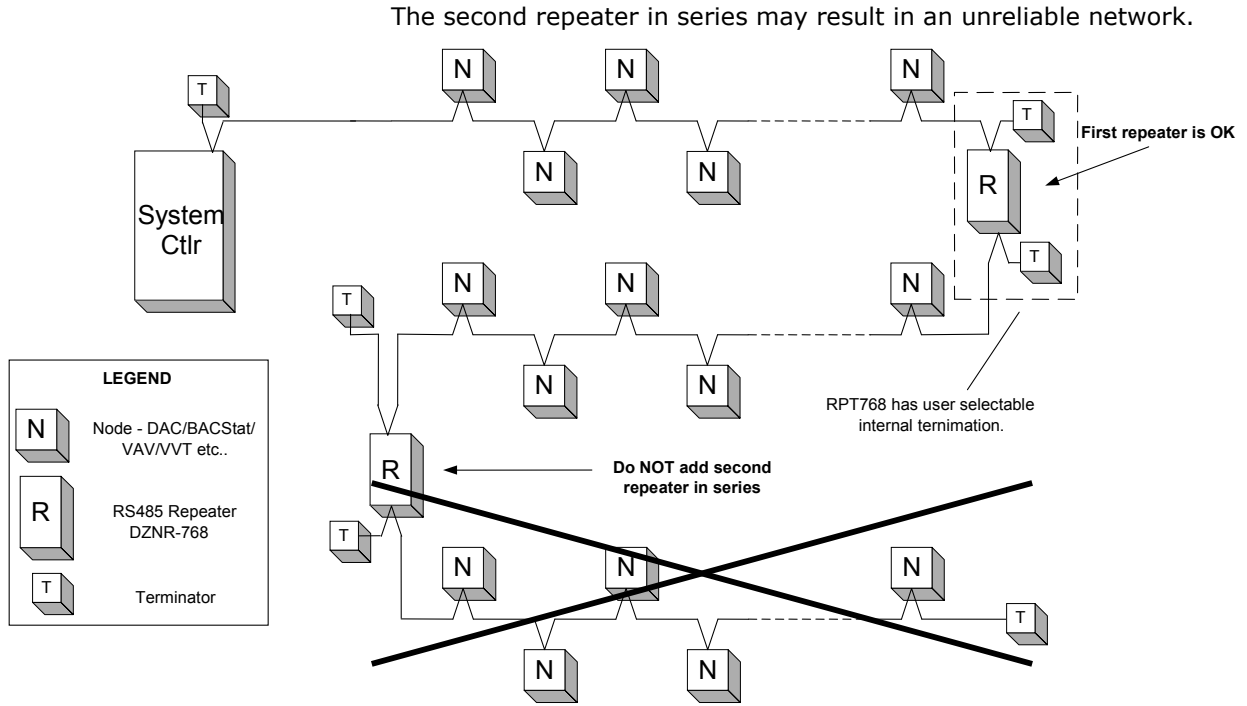
Figure 33: Twisted Pair Segments and DZNR-768 Repeater



Using Repeaters Incorrectly

Do not install repeaters in series or use more than one repeater to extend a network. This results in network reliability problems. Figure 34 demonstrates an incorrect use of a repeater in an RS-485 network.

Figure 34: Repeaters – Incorrect Usage



Using a DZNR-768 Repeater with Delta’s CAT5 Network

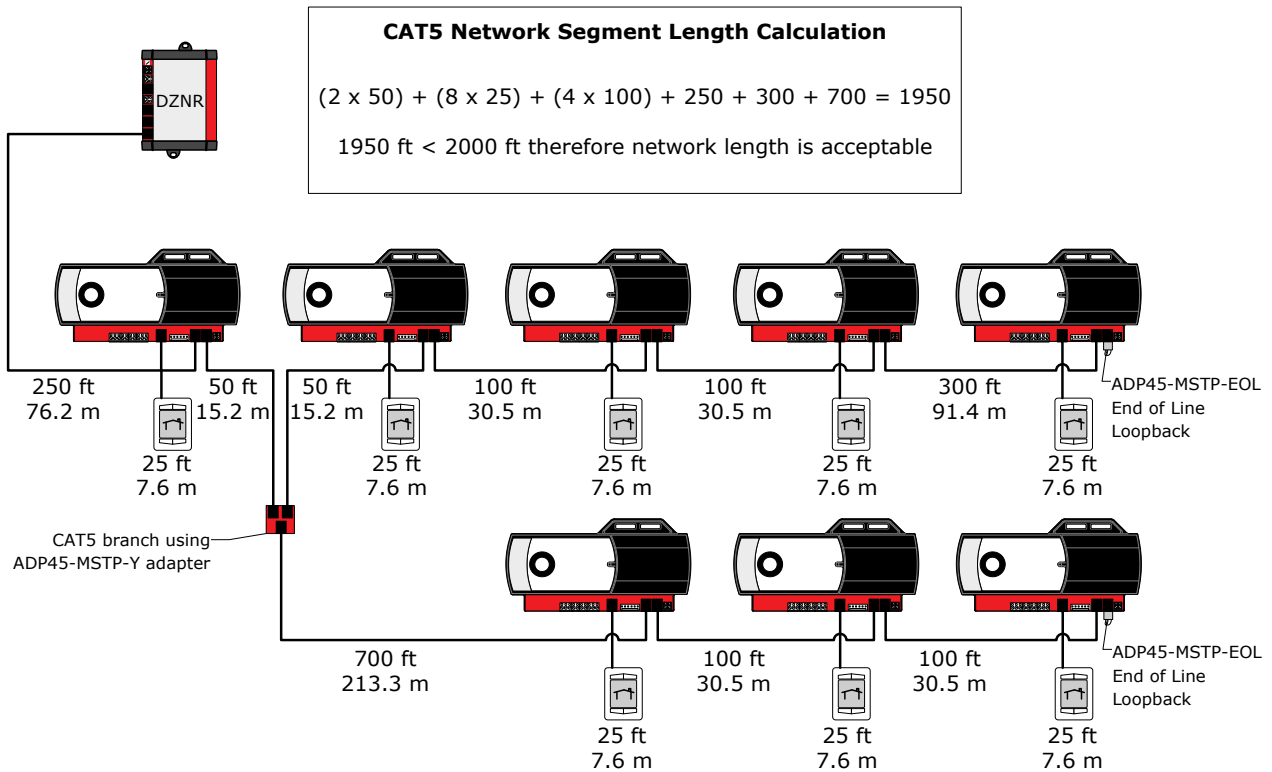
Each of the four ports of the DZNR-768 repeater has an RJ-45 jack for straight through unshielded twisted pair CAT5 cables.

Accessory adapters are available to split the line, provide end-of-loop termination, convert between types of wiring media and temporarily bypass missing or defective controllers, while maintaining a strict daisy-chain configuration.

Calculating CAT5 Network Segment Length

The total length of each network segment can’t exceed 2000 ft (610 m). This length is determined by the sum of all cable lengths including runs between termination boards, controllers and sensors, as shown in Figure 35.

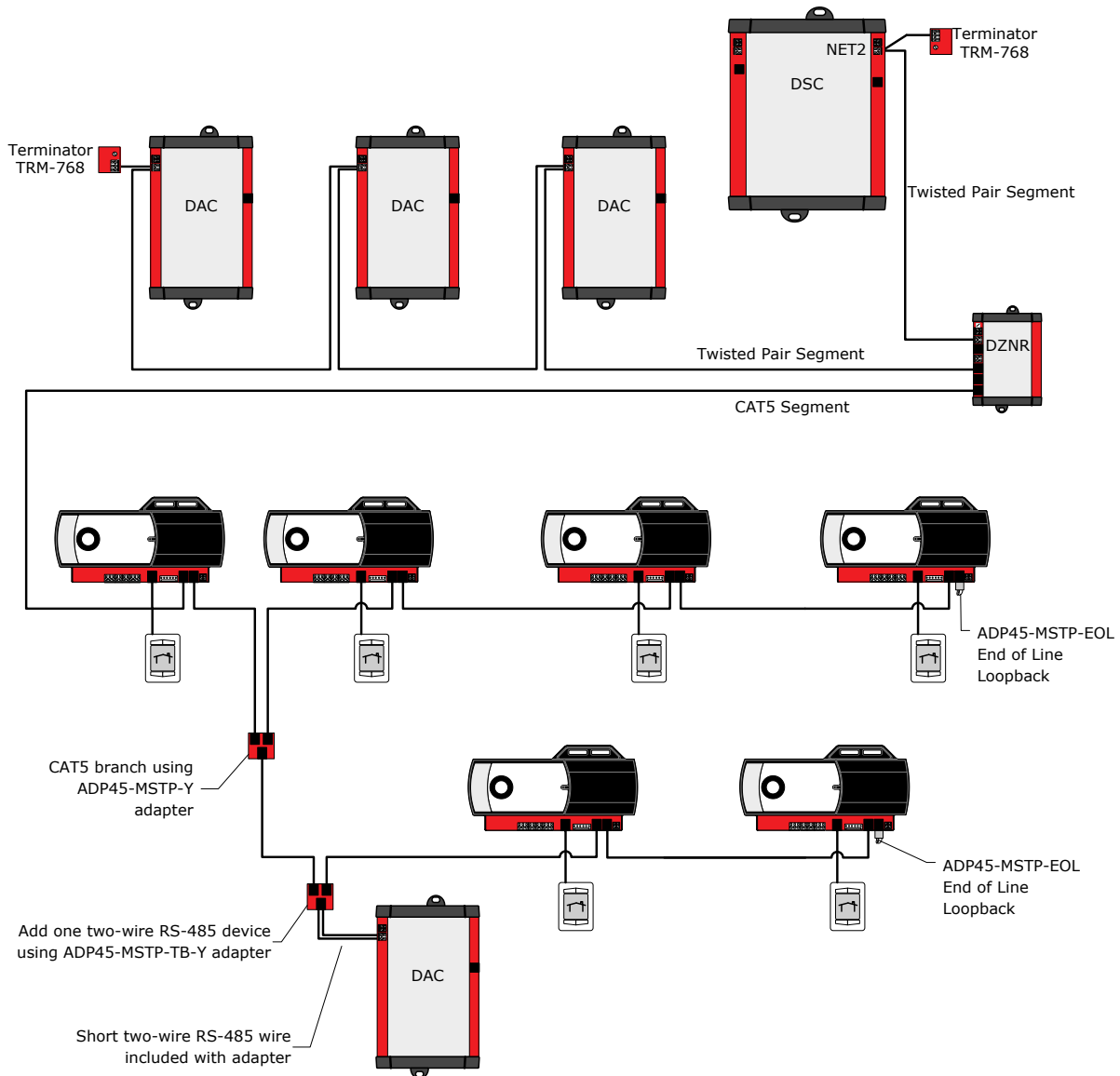
Figure 35: CAT5 Network Segment Length Calculation



Network Configuration for DZNR-768 Repeater

Figure 36 shows a typical installation using a combination of twisted pair cable and CAT5 cable.

Figure 36: DZNR-768 Multi-segment Configuration



Accessories for Wiring a CAT5 RS-485 Network

The following accessories are available to aid in CAT5 RS-485 network wiring and maintenance.

ADP45-MSTP-BYPASS - an adaptor that allows a DZNT stat to be disconnected from service for troubleshooting purposes while maintaining the integrity of the network.

ADP45-MSTP-EOL - an end-of-line loopback adaptor in the form of an RJ-45 plug that completes the network at the first and last devices in the CAT5 RS-485 network.

ADP45-MSTP-TB-Y - allows for one 2-wire RS-485 conventional device to be added to the CAT5 RS-485 network. You must use the short 2-wire RS-485 cable included with the adaptor.

ADP45-MSTP-Y - an adaptor that allows a branch expansion to the CAT5 RS-485 network while maintaining the daisy chain connection requirements of the basic RS-485 network.

Running RS-485 Between Buildings

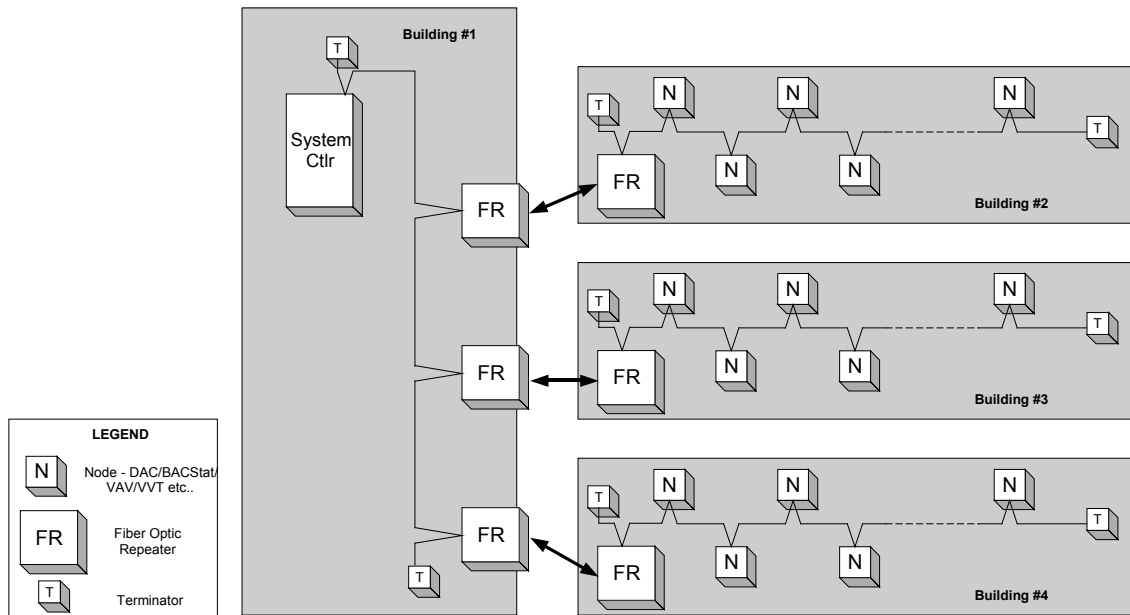
Although running RS-485 communications between buildings may be an installation requirement, doing so greatly increases the network's exposure to communication problems and/or damage to equipment.

Using Fiber Optic Repeaters

The most reliable method of running RS-485 between buildings is by using RS-485-to-fiber optic repeaters. By utilizing a fiber link, you eliminate the electrical connection and dramatically reduce exposure to damage due to inherent voltage transients and to lightning.

Delta Controls does not manufacture a RS-485-to-fiber optic repeater. However, the Telebyte Model 276A Optoverter - 2 Wire, RS-485 to Fiber Optic Line Driver/Converter has been used effectively in a number of installations. Because this device is a third party product, Delta Controls cannot guarantee its future compatibility with Delta products.

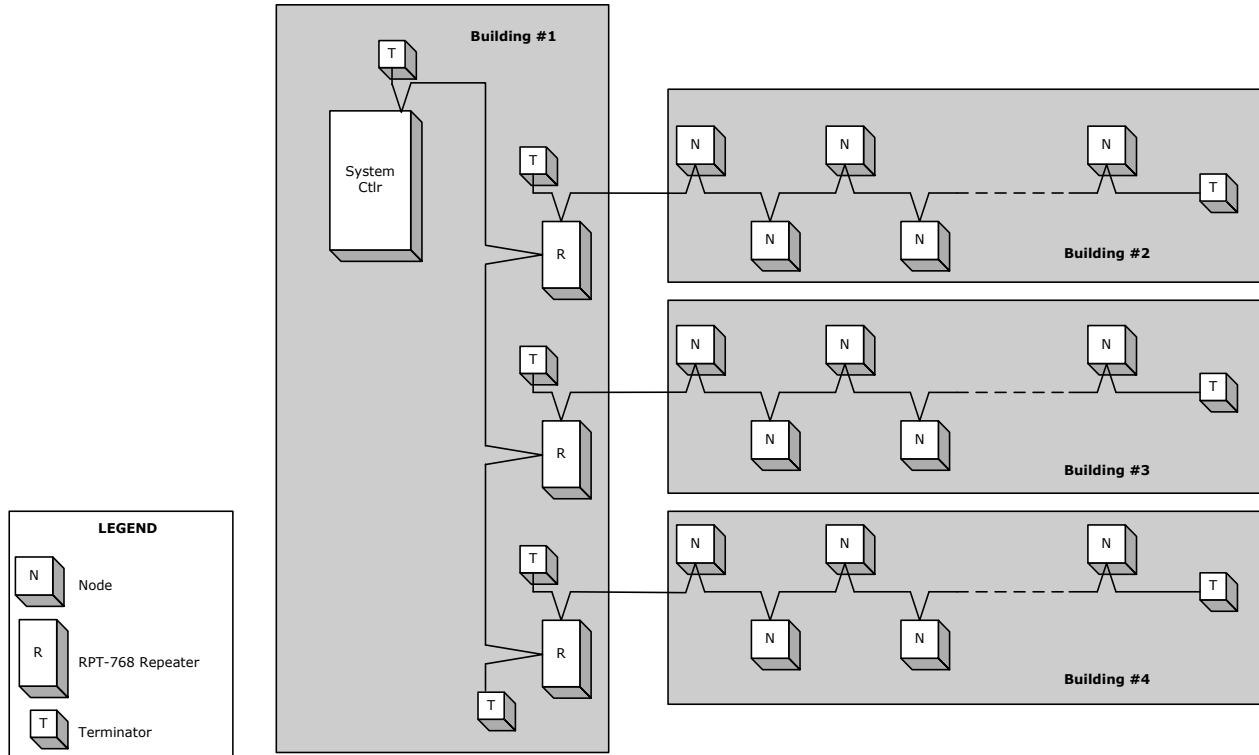
Figure 37: Using RS-485-to-fiber optic Repeaters between Buildings



Using a RPT-768 Repeater

An alternative is to use the Delta Controls RPT-768 repeater. While it can't provide the same level of protection against transient voltages as a fiber optic repeater, it provides 24 V AC separation as well as ensuring correct network topology and termination.

Figure 38: Using RPT-768 Repeater between Buildings



Wiring Power to the RPT-768 Repeater

The RPT-768 can be powered using one or two transformers. When one transformer is used, as shown in Figure 39, the RPT-768 provides 50 V isolation. When two transformers are used, as shown in Figure 40, the RPT-768 provides 500 V isolation.

Power the RPT-768 with two transformers whenever wiring RS-485 between buildings.



When wiring RS-485 networks between buildings, use the two-transformer method of powering the RPT-768 for 500 V isolation.

Figure 39: Wiring RPT-768 with One Transformer for 50 V Isolation

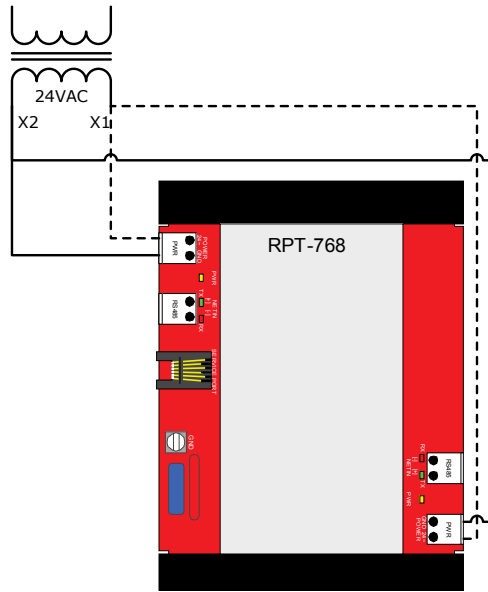
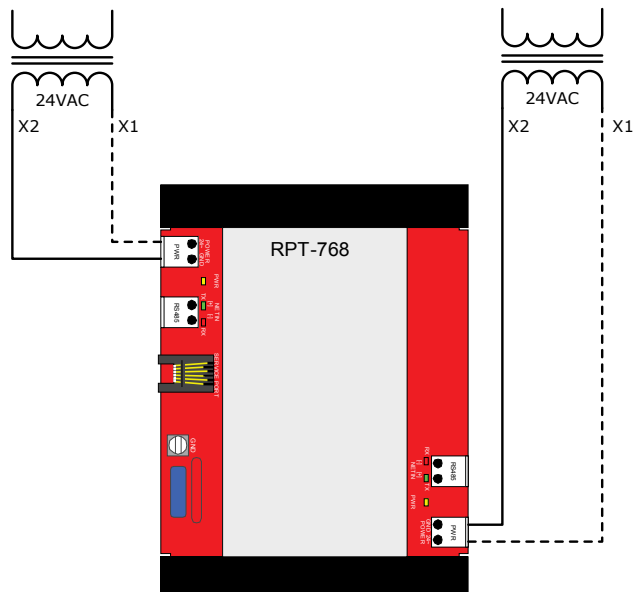


Figure 40: Wiring RPT-768 with Two Transformers for 500 V Isolation

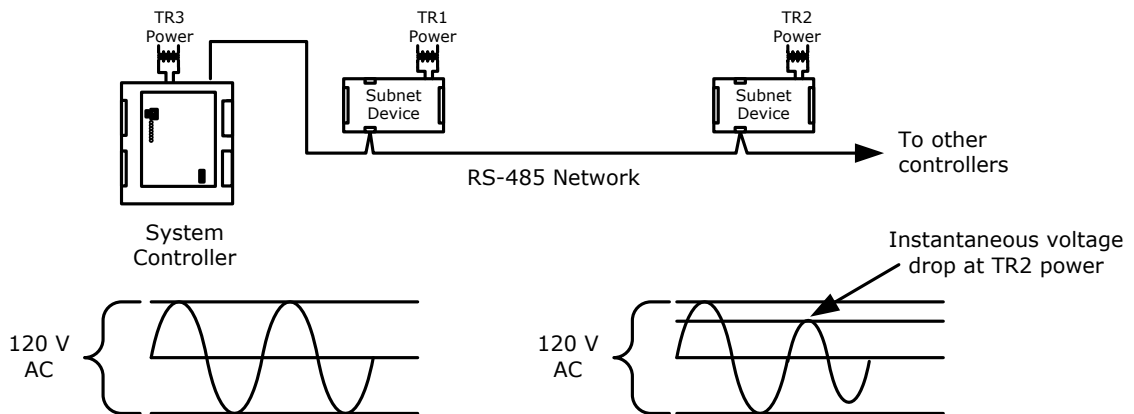


Transients and RS-485 Transceiver Failure

High voltage transients are the primary cause of RS-485 transceiver failure. Although there is no way to completely eliminate voltage transients, their harmful effects can be reduced by using the techniques previously described in this document.

A rapid drop in line voltage at one controller on a network results in a voltage transient. The parasitic capacitance of electronic devices allows this transient to pass over the RS-485 network as it tries to equalize the voltage difference between devices.

Figure 41: Example of a Voltage Transient



In Figure 41, if the line voltage at TR2 (Transformer 2) drops rapidly and other line voltages (TR1 and TR3) remain constant, the rapid drop results in a voltage transient that may cause damage to the RS-485 communication chips.

Using a dedicated line voltage source for all control device power, for example 120 V AC: 24 V AC transformers, significantly improves your chances of completing a project successfully.

Chapter 4 - Ethernet Network Installation Guidelines

This chapter provides a summary of Ethernet network wiring specifications and practices that are applicable to Delta Controls products.

The installer should be familiar with the IEEE 802.3 standard before installing any Ethernet network. This standard can be found at <http://standards.ieee.org/getieee802/802.3.html>. See also <http://www.ethermanage.com/>

Many Delta Controls products use Ethernet as a mode of communication. Ethernet's much higher bandwidth provides many advantages over RS-485.

Review Glossary of Terms to be sure you understand terms used in this chapter.

Communications Devices

Ethernet communications devices such as switches, hubs and routers provide flexibility and solve many network problems.

Switch

Switches improve network speeds compared to hubs because they allow full port speed to be used for every pair of devices connected to the switch and they allow simultaneous communications paths to be established between devices.

10BaseT Ethernet networks that use switches are called switched networks and have no limitation as to number of segments or switches.

A switch also provides a central point of connection used in networks that are arranged in a star topology.

Delta Controls recommends using switches in all BACnet Ethernet networks.

Hub

A hub has no way of distinguishing which port the data should be sent to. Broadcasting the data to every port ensures that it will reach its intended destination. This places a lot of traffic on the network and can lead to poor network response times due to collisions.

A hub also provides a central point of connection used in networks that are arranged in a star topology.

10BaseT Ethernet networks that use hubs are called shared access networks and must adhere to the IEEE 5-4-3 rule. This rule limits the number of hubs and segments in the network. Switches, which do not have this limitation, have replaced hubs because the cost difference is essentially nil. See the Specifications section below for a definition of the IEEE 5-4-3 rule.

Delta Controls recommends using switches rather than hubs in all BACnet Ethernet networks.

A repeater is essentially a two-port hub.

Router

As an OSI Layer 3 device, a router move packets (unlike switches which route frames) from one network to another until that packet ultimately reaches its destination. A packet not only contains data, but also the destination address of where it's going.

Interfacing to High Speed Ethernet Networks

Many Delta Controls devices provide fixed 10 Mbps Ethernet that can't adjust automatically to higher speeds such as 100 Mbps.

To interface to a high speed Ethernet segment, insert a 10/100 Mbps switch between the high speed segment and the Delta Controls' segment. The switch senses and adjusts automatically to both segments' speeds.

Delta Controls' enteliTOUCH and enteliBUS devices operate at either 10 Mbps or 100 Mbps Ethernet.

Because the enteliTOUCH includes two Ethernet ports it can function as a 10/100 Mbps switch.

10/100BaseT Specifications

10/100BaseT is 10 Mbps Ethernet running over unshielded, twisted-pair (UTP) cabling. UTP cabling for Ethernet comes in different grades, with higher grade numbers called Category numbers, indicating better quality and bandwidth.

10/100BaseT requires Category 5 (commonly referred to as CAT5) cabling. CAT6 may also be used. The UTP cable connection at either end is made by an RJ45 connector. These connectors are attached to the cable using a tool made specifically for this task.

Table 13: Ethernet – Specifications

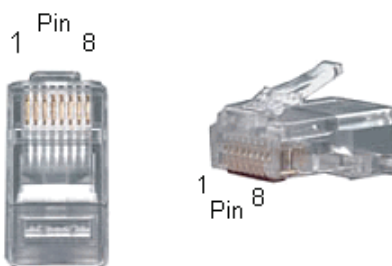
Category	Specification
Maximum length of segment (port-to-port length)	330 ft (100 m)
Cable type	10/100BaseT CAT5 / CAT5E / CAT6
Maximum segments when using switches	no limit
Maximum segments when using hubs/repeaters	See IEEE rule below

The IEEE rule for shared access networks states: there shall be no more than five repeated segments or more than four hubs between any two Ethernet interfaces and of the five cable segments, only three may be populated.

This is referred to as the "5-4-3" rule: 5 segments, 4 hubs/repeaters, 3 populated segments. The IEEE rule doesn't apply to switched networks.

10BaseT/100BaseT Cable Wiring

Two types of cable connections are used in 10/100BaseT: straight-through and cross-over cables. Both use RJ45 connectors.

Figure 42: RJ45 Connector Pinout

Straight-Through Cable

To connect multiple devices such as computers and controllers, by a switch, the cable required is referred to as a straight-through connection, meaning that Pin 1 on one end is connected to Pin 1 on the other end, and so on, for all 8 conductors.

See pinouts in Table 14.

Table 14: Wiring Pinout for Straight-through Cable

Pinout (end 1)	Pinout (end 2)	Striped Color
Pin 1 (TD+)	Pin 1 (TD+)	White/orange
Pin 2 (TD-)	Pin 2 (TD-)	Orange
Pin 3 (RD+)	Pin 3 (RD+)	White/green
Pin 4	Pin 4	Blue
Pin 5	Pin 5	White/blue
Pin 6 (RD-)	Pin 6 (RD-)	Green
Pin 7	Pin 7	White/brown
Pin 8	Pin 8	Brown

Cross-over Cable

Two devices can be connected together without using a switch by using a cable called a cross-over or flip cable. A cross-over cable crosses some of the conductors between the two ends of the cable. For example, to connect a DSC-1212E directly to a PC, a cross-over cable could be used; this would not require a switch.

See pinouts in Table 15.

Table 15: Wiring Pinout for Cross-over Cable

Pinout (end 1)	Pinout (end 2)	Striped Color
Pin 1 (TD+)	Pin 3 (RD+)	White/orange
Pin 2 (TD-)	Pin 6 (RD-)	Orange
Pin 3 (RD+)	Pin 1 (TD+)	White/green
Pin 4	Pin 4	Blue
Pin 5	Pin 5	White/blue
Pin 6 (RD-)	Pin 2 (TD-)	Green
Pin 7	Pin 7	White/brown
Pin 8	Pin 8	Brown

Chapter 5 – RS-232 Information

This chapter provides wiring information about RS-232 connections used with Delta Controls products.

Factory-Built RS-232 Cables

An RS-232 cable may be used to connect a controller to your PC or modem. Delta manufactures ready-made cables you can order, as shown in Table 16 and Table 17.

Table 16: Factory-built Direct Connection RS-232 Cables

Product Number	Description
CBL930-2	Female DB9 connector, 3 pin direct to panel connector, DSC/DSM, 10 ft. (3 m)
CBL930-4	Female DB9 connector, AMP connector, direct to Room Controller, 10 ft. (3 m)

Table 17: Factory-built Modem RS-232 Cables

Product Number	Description
CBL931-1	Male DB25 connector, 5 pin connector, DSC modem cable, 10 ft. (3 m)
CBL931-2	Male DB25 connector, 7 pin connector, DSM modem cable, 10 ft. (3 m)
CBL931-3	Male DB25 connector, AMP connector, Room Controller modem cable, 10 ft. (3 m)

Delta Controller Serial Port Pin-outs

DSC Serial Port

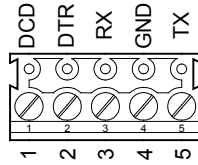
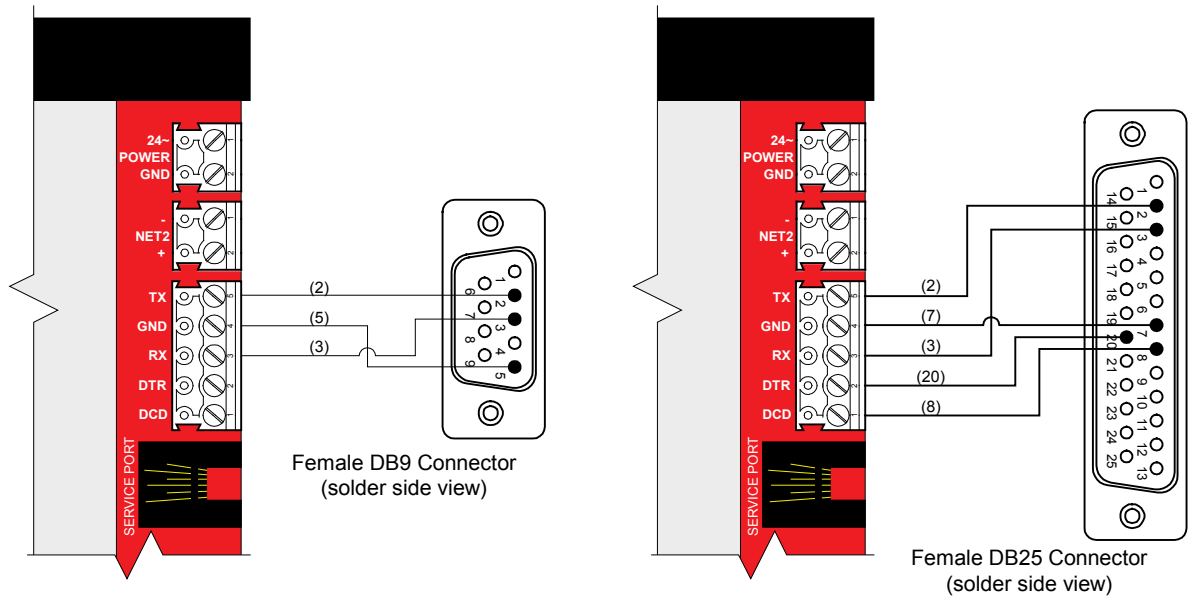


Table 18: DSC Serial Port Pin-outs

Signal	DB9	DB25
(1) DCD*	1	8
(2) DTR*	4	20
(3) RX	2	3
(4) GND	5	7
(5) TX	3	2

*required for modem cables only

Figure 43: (Left) Direct Connection to a Female DB9 Connector. (Right) Modem Connection to a Female DB25 Connector



DCU-050/DSM-050 Serial Port

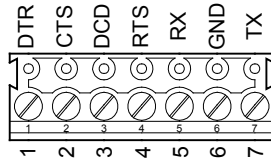
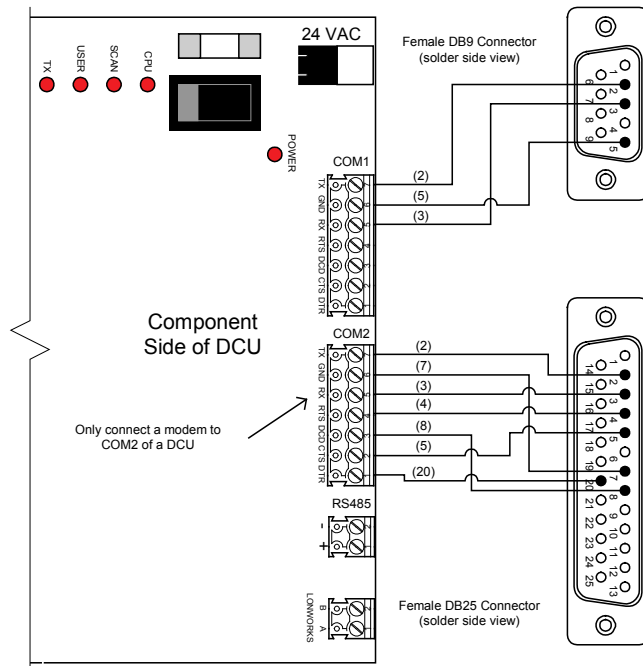


Table 19: DCU-050/DSM-050 Serial Port Pin-outs

Signal	DB9	DB25
(1) DTR*	4	20
(2) CTS*	8	5
(3) DCD*	1	8
(4) RTS*	7	4
(5) RX	2	3
(6) GND	5	7
(7) TX	3	2

* required for modem cables only

**Figure 44: (Top) Direct Connection to a Female DB9 Connector.
(Bottom) Modem Connection to a Female DB25 Connector**



Room Controller Serial Port

The RS-232 port of the Room Controller uses a MTA-156 5 pin connector.

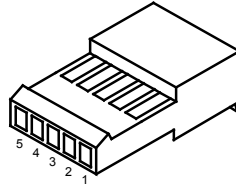
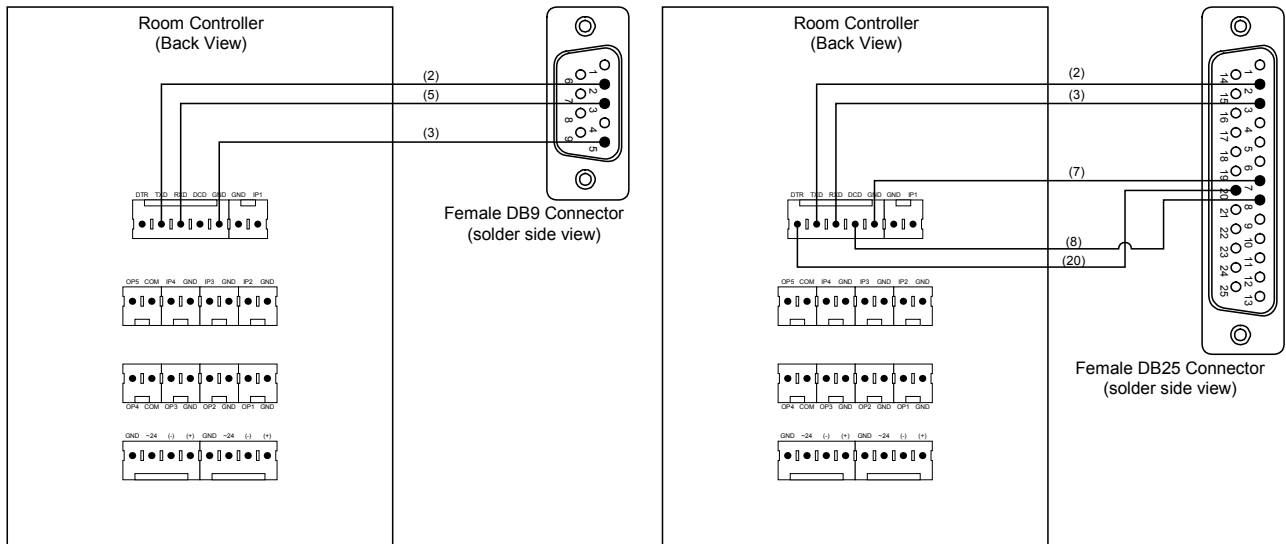


Table 20: Room Controller Serial Port Pin-outs

Signal	DB9	DB25
(1) DTR	4	20
(2) TX	3	2
(3) RX	2	3
(4) DCD	1	8
(5) GND	5	7

* required for modem cables only

Figure 45: (Left) Direct Connection to a Female DB9 Connector. (Right) Modem Connection to a Female DB25 Connector



Chapter 6 – enteliBUS Network Installation Guidelines

This chapter describes the Delta Controls recommended design and installation specifications for the enteliBUS network. The enteliBUS network, also known as the eBUS network, connects components of the enteliBUS family.

The eBUS network is an implementation of the ISO-standard Controller Area Network (CAN or CAN-bus).

Review Glossary of Terms to be sure you understand terms used in this chapter.

Cable Type

The eBUS network can be extended with cable that meets all of the following specifications:

- 22-24 AWG twisted pair, shielded jacketed communication cable
- Characteristic impedance of 100-120 Ohms
- Capacitance of 17 pF/ft conductor-to-conductor or less. 18 AWG cable doesn't meet this specification.
- Braided or aluminum foil shield
- Velocity of propagation of 66% or higher

Suggested compatible cable products are Belden 9841, Belden 82841 and Windy City Wire 42002-S.

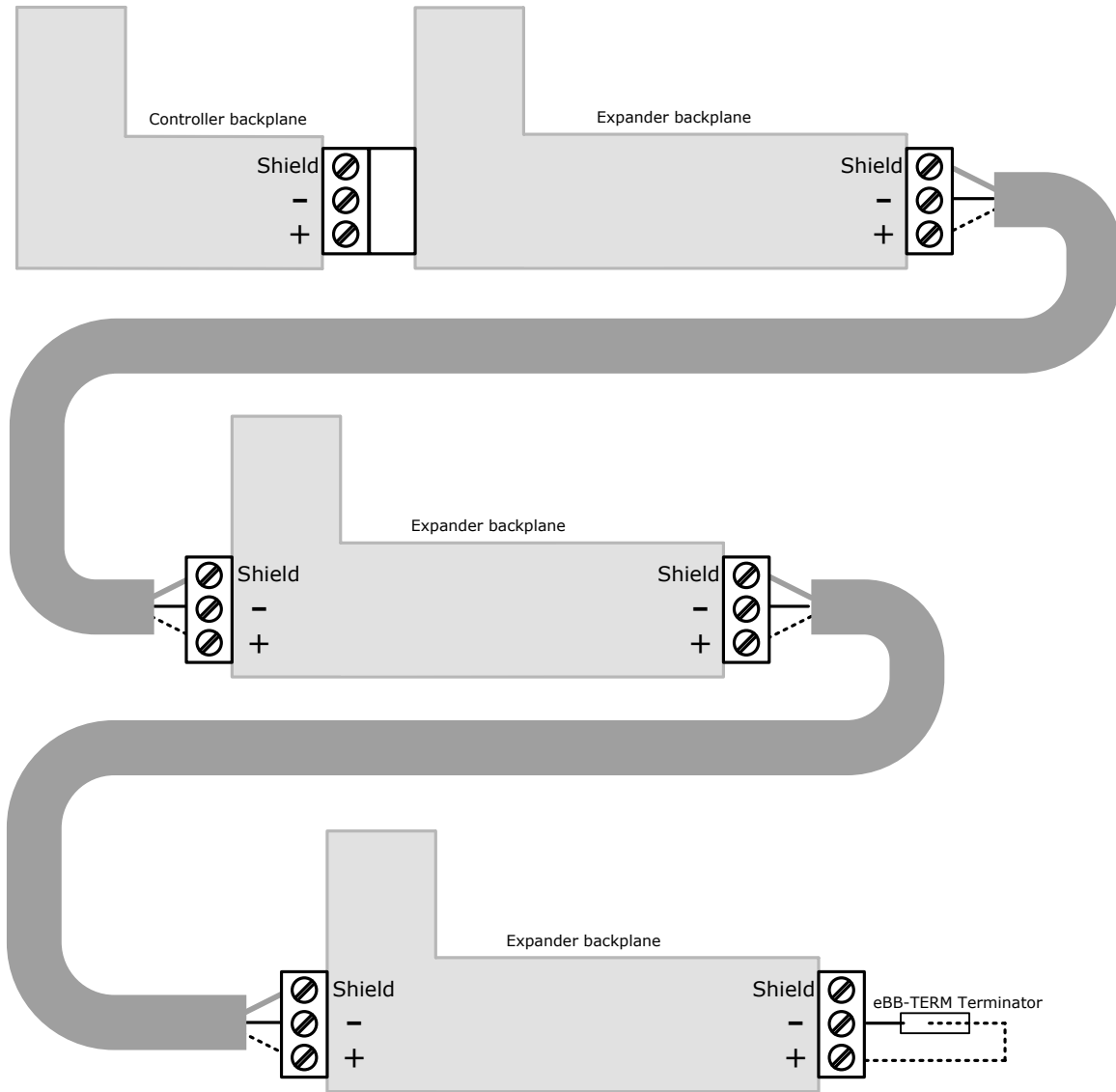
Network Configuration

The eBUS network uses a daisy chain configuration. The eBUS network has two ends joined by a single path comprising one enteliBUS controller backplane and multiple enteliBUS expander backplanes.

The backplanes are connected to each other by plugging them together by the connectors at each end of the backplanes or by wiring network cable between the backplane connectors. Any combination of plugging backplanes together and wiring them with network cabling is acceptable as long as the daisy chain configuration is maintained.

Figure 46 shows an example eBUS network.

Figure 46: Example eBUS Network Configuration



Maximum Network Length

The maximum end-to-end length for an eBUS network is 330 ft (100 m).

End-to-end means from the automation engine on the controller backplane at one end of the network to the eBB-TERM terminator at the other end taking into account all enteliBUS expander backplane boards and network cable in between them.

Maximum Number of enteliBUS Backplanes

The eBUS network allows one controller backplane and up to eight expander backplanes for a total maximum of nine backplanes.

Shield Continuity and Termination

When properly installed, shielded twisted pair cable can improve the protection of the network and equipment against harmful electromagnetic interference (EMI) and transient voltage spikes.

Ensuring Shield Continuity

The eBUS network cable's shield must be tied through at each expander backplane to make a continuous shield that runs the entire length of the eBUS network, as shown in Figure 46.

Terminating the Shield

Do not ground the shield at any point in the eBUS network.

The shield is not terminated or grounded on the last expander backplane at the eBB-TERM-terminated end of the eBUS network. Leave the shield unconnected.

At the automation engine end, shield termination is built-in, providing a transient path to ground; do not otherwise terminate or ground the shield at the automation engine.

Network Data Wires Termination

Both ends of the eBUS network data wires must be terminated properly to ensure reliable operation and network stability.

Terminating the eBUS Network Data Wires

As shown in Figure 46, the eBUS network data wires must be terminated on the last expander backplane using the Delta eBUS terminator, eBB-TERM. Do not use a TRM-768.

At the automation engine end, termination is built-in. No additional termination is required.

Repeaters

Repeaters are not used or required in an eBUS network.

Running the eBUS Network Between Buildings


Do not run the eBUS network between buildings or between areas of a building with different electrical services.

Running the eBUS Network Between Electrical Services

Do not run the eBUS network between electrical services. All expander backplane modules must be powered by the same electrical service.

Glossary of Terms

Daisy chain – a network topology in which there is one cable with only two ends and every network device is connected directly along its path.

Earth ground - provides metallic continuity to the Earth; sometimes referred to as conduit ground. In this document, earth ground is indicated by  .

Electrical service - the wiring that connects the electric utility's cables in the street to the building. Specifically, electrical service is the wiring from the street, through the meter and up to the panel board, but no farther.

Grounding or ground - provides metallic continuity to a common return path for current from many different components in an electrical circuit. The terms *ground* and *grounding* are used in North American electrical practice. In the UK the equivalent terms are *earthing* and *earth*.

Hub - an OSI Layer 1 device used in an Ethernet network that repeats data frames received at any of its ports to all ports in the device.

Line voltage - voltage provided by a power line at the point of use, usually a general-purpose alternating current (AC) electric power supply. Also known as mains.

Node - any device with an active RS-485 network connection including system controllers, VAV controllers, application controllers, BACstats, enteliBUS automation engines, repeaters and so on.

Repeater - a node that joins two RS-485 segments. A repeater strengthens the RS-485 signals to allow a network to be extended.

Router - An OSI Layer 3 device used in an Ethernet network that move packets (unlike switches which route frames) from one network to another until that packet ultimately reaches its destination.

Segment – in an RS-485 network, the network cable between terminators or between a terminator and a repeater. In an Ethernet network, the network cable between switches.

Switch - As an OSI Layer 2 device used in an Ethernet network, a switch uses the MAC address in each data frame to send it only to the port connecting the device the data is intended for. A switch extends the reach of each segment and allows traffic to pass selectively between two network segments.

Terminating or terminate RS-485 data wires - providing a path with correct impedance between the RS-485 data wires.

Terminating or terminate shield - providing an isolating path to ground using resistive and/or capacitive components.

Document Control

Title *Wiring and Installation Guidelines*

Rev	Date	Changes
1.0	9 Mar 2004	Original (Jonathan Littlejohn, author)
1.1	27 May 2004	Added second shield termination method (J Littlejohn) Added Quick Reference section (J Littlejohn)
1.2	12 February 2008	Added wire colors to wiring diagrams. (D Khatri)
1.3	December 2009	Chapter 3: added CAT5 wiring and DZNR-768, reorganized flow, changed 50 nodes/segment to 64 nodes/segment. Chapter 4: updated. Chapter 5 moved Transients section to end of Chapter 3. Removed Quick Reference section. (J. Halliday)
1.4	December 2011	Added Chapter 6 enteliBUS Network Added Introduction Added Glossary of Terms Updated figures in Chapters 1 through 4 to be more generic; instructed reader to see the specific controller installation guide on George Support site for details such as jumpers. (J. Halliday)
1.5	June 2012	Added Digital Input Added Digital Relay Output (J. Halliday)

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