



Do it right.

Delta Controls Wiring & Installation Guidelines

Rev 1.1

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Power Installation Guidelines

This document describes the wiring practices for all Delta Controls Class II (24VAC) products. It does not include 120V or 240V wiring practices. Following these guidelines will ensure the optimum performance of your Delta Controls products.



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

Summary Specifications

Table 1 Category Specifications

Category	Specification
Voltage	20 – 28 VAC
Electrical Class	Class II 100VA Max
Cable Type	2-conductor plenum-rated 16-18 AWG
Fuse Rating	4-Amp Slow-Blow should fuse the secondary side

Cable Type

Delta Controls requires that controller power must use a dedicated 2-conductor plenum-rated wire for its products. Wire size is dependant on the VA rating for the device and the length of the wire used.

Table 2 Cable Selection

Part Number	Description	Device VA Rating	Max Length
	Plenum 16 AWG Stranded FT6	100	100 ft
		75	150 ft
		50	250 ft
		25	500 ft

Part Number	Description	Device VA Rating	Max Length
	Plenum 18 AWG Stranded FT6	50	150 ft
		25	300 ft
		15	500 ft
		5	1000 ft

The above table does not take into account multiple devices on the same network. If multiple devices are using the same transformer, the VA ratings of all devices should be added together, then use the wire length of the device furthest away to determine wire selection in the table above.

Transformer Specifications

Transformers should be UL Listed, 24VAC, and rated to Class II. Delta Controls recommends the transformers listed in the table below.

Table 3 Recommended Transformers

Delta Part #	Primary Voltage	VA Rating	Hubs *	Circuit Breaker	Listings
440000	120 VAC	40 VA	2	NO	UL listed, CSA approved, Class II
440001	120 VAC	40 VA	1	NO	UL recognized, Class II
440002	120 VAC	50 VA	2	NO	UL listed, CSA approved, Class II
440003	120 VAC	50 VA	1	NO	UL recognized, Class II
440004	277 VAC	50 VA	2	NO	UL listed, CSA approved, Class II
440005	277 VAC	50 VA	1	NO	UL recognized, Class II

Delta Part #	Primary Voltage	VA Rating	Hubs *	Circuit Breaker	Listings
440006	120 VAC	75 VA	2	YES	UL listed, CSA approved, Class II
440007	120 VAC	75 VA	1	YES	UL recognized, Class II
440008	120 VAC	96 VA	2	YES	UL listed, CSA approved, Class II
440009	120 VAC	96 VA	1	YES	UL recognized, Class II
440010	120 VAC	150 VA	1	YES	UL listed, CSA approved, Class II
440011	120,208, 240,480 VAC	50 VA	1	YES	UL listed, CSA approved, Class II, LE160
440012	120,208, 240,480 VAC	75 VA	1	YES	UL listed, CSA approved, Class II, LE150
440013	120,208, 240,480 VAC	96 VA	1	YES	UL listed, CSA approved, Class II, LE170

* 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.

Power Supply Types

Delta products use both full and half-wave power supplies. The type of power supply used on a device affects the way power is wired to the device.

A half-wave device has ground referenced power circuitry. This means that all half-wave devices share a common ground.

The power circuitry of a full wave device is not ground referenced. Full wave devices must use dedicated transformers.



Carefully identify the type of power supply used in a device, as failing to do so can damage the device and the transformer.

Identifying the Type of Supply

It is essential to identify the type of power supply before wiring power to a device. There are two types of power supplies: half-wave and full wave (full wave is also known as bridge rectified). Identifying the type of power supply can prevent many potential problems.

The type of power supply a device uses can be easily determined by the labeling of the power port. If the power port is labeled "**24 ~ GND**", then the device uses a half-wave rectifier. If the port is labeled "**24 ~ 24 ~**", then the device uses full wave rectification.

Figure 1 Power Ports

Half-wave devices have their power port labeled "24 ~ GND" (left). Full Wave devices have their power port labeled "24 ~ 24 ~" (right).

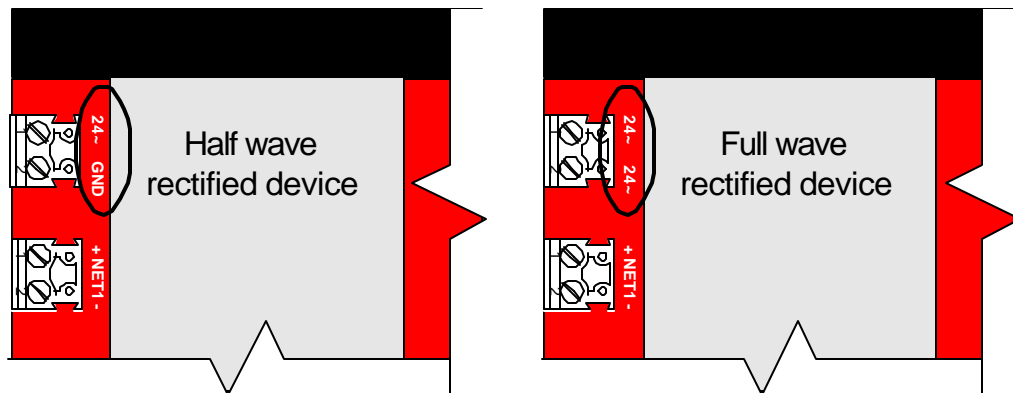


Table 4 Power Supply for Delta Product

Device	Half-Wave ¹	Full Wave ²
DCU-050/DSM-050		✓
ADM-2W704		✓
DAC/DSC Products	✓	
DVC Products	✓	
Room Controllers	✓	
BACStat I	✓	
BACStat II	✓	
Plus Panels (ICP030/035)		✓
Turbo Panels (ICP015)		✓
Mini-Turbo Panels (ICP025)		✓
Zone Controllers/Micro Panels (ICP04x)	✓	

1 – Half-Wave devices can share a single transformer

2 – Full-Wave devices require a dedicated transformer

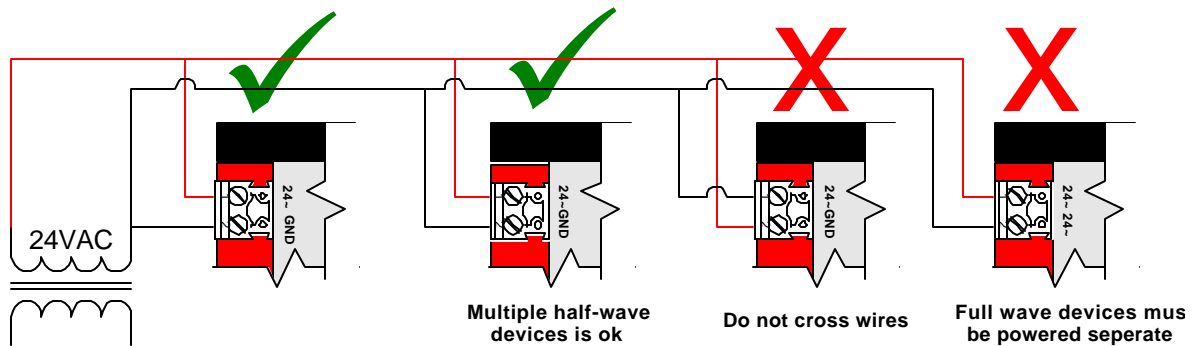
Half-Wave

A half-wave rectified signal draws current only from the positive half of the AC signal. Because of this, devices that use half-wave rectification are ground referenced.



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.

Figure 2 Wiring Half-Wave Devices



Full Wave

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.

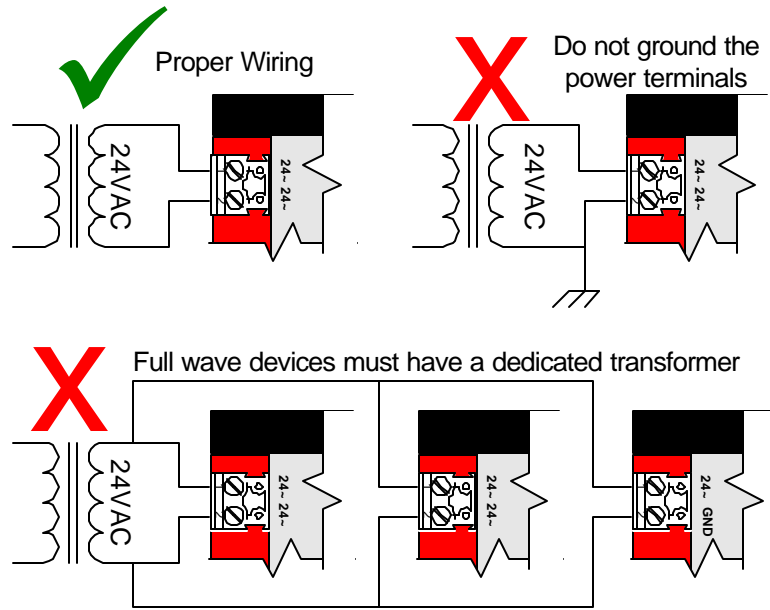
Full wave devices cannot be wired to the same transformer to which a half-wave device is connected. Wiring devices in this manner will create a ground loop and will damage both the device and the transformer.



*Full wave devices must use a **dedicated transformer**. Do not wire other devices to the same transformer. Doing so will damage both the device and the transformer.*

Do not ground the transformer of a full wave device. The transformer should be directly connected to the power port as shown in Figure 3.

Figure 3 Wiring Full Wave Devices



Grounding

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

This section will provide an overview of the different methods used to ground network devices.

Preferred Method

Delta Controls has found that the safest and simplest method to ensure proper grounding is to **ground each device**.

If the device contains a ground lug, then securely fasten the ground lug to earth ground.

— or —

If the device does not contain a ground lug, then securely fasten any terminal labeled "GND" to earth ground.

Figure 4 Ground Each Device

Preferred method of grounding devices Each device should be securely grounded to earth ground.

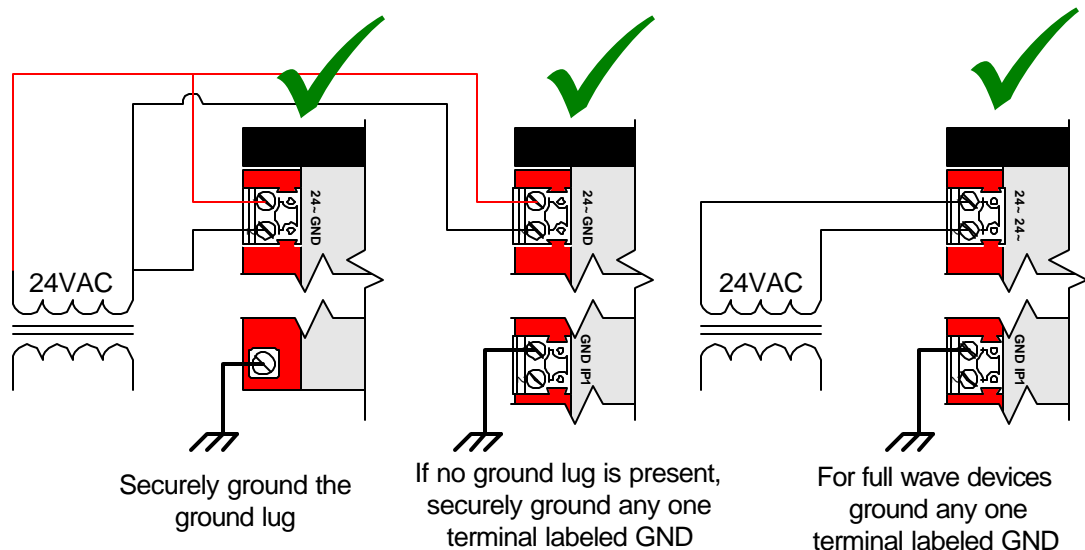
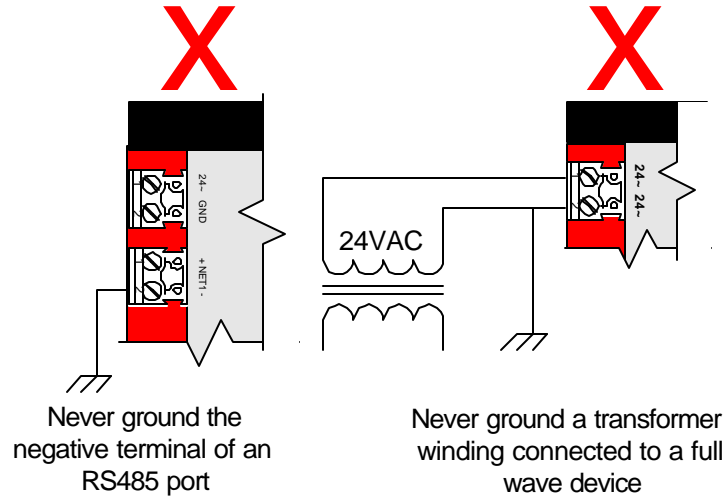


Figure 5 Do Not Ground These

RS-485 network should never be grounded. 24VAC ports for full wave devices should never be grounded.



Second Method

However, the preferred method is not always practical for all installations. There may be instances where grounding each device is difficult. An example of this would be a network of BACStats. In a case like this, the second method may be used.

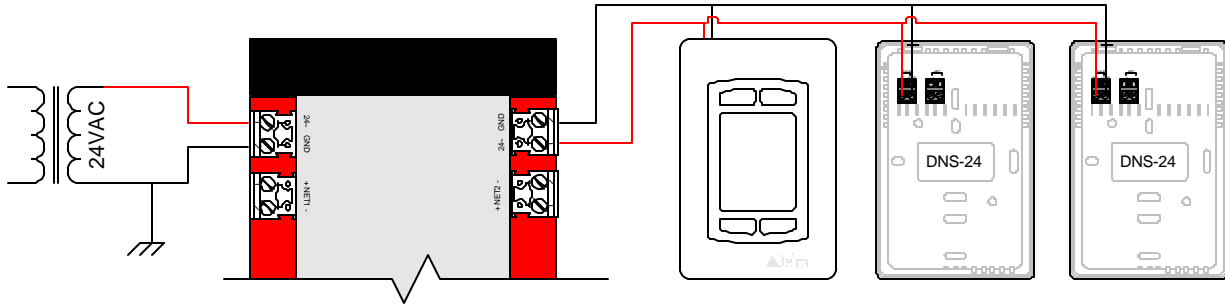
If grounding each device is impractical, then a **single ground point** may be used. The most common place to ground in this manner is one of the secondary wires of the power transformer.



Never ground one of the transformer's secondary lines if they are connected to a full wave device. Doing so will damage both the device and the transformer.

Figure 6 Single Ground Point

An alternate method of grounding – single ground point on secondary of transformer. The ground is passed internally to all devices in the network.



Fusing

When a transformer does not have a built-in circuit breaker, Delta Controls recommends using a Slow-Blow fuse on the secondary of every transformer. The fuse size is determined by the VA ratings of the devices. Use the table below to determine the correct fuse size. Installing a fuse not only provides protection for the transformer, but can also help with troubleshooting.

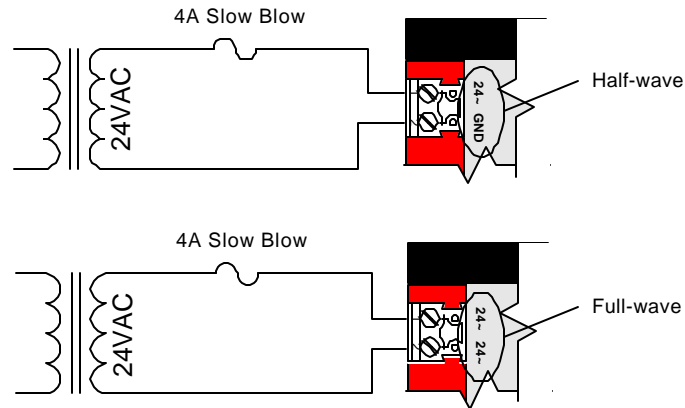
Transformer Rating [VA]	Max Fuse Size [A]
100	4
75	3
50	2
25	1

Without a fuse, the only protection a Class II circuit has is the primary circuit breaker (normally 15 or 20 amps). If a device were to fail, this is not sufficient protection to prevent damage to the transformer. The addition of a fuse on the secondary side of the transformer will prevent any damage to the device.

Delta’s Class II products have a maximum rating of 100VA. This means that the maximum allowable fuse size is 4 Amps.

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

Figure 7 Using 4Amp Slow-Blow Fuse



Multiple Service Entrances

A service entrance is a location in which the electrical service comes into 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.

— or —

- 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, a wiring diagram for the building should be obtained and checked.

Ground Isolation

Grounds from multiple services should never be tied together. Ground voltage differences across multiple services can be

quite high. During lightning storms, potential differences can reach hundreds, even thousands, of volts.

Multiple services should be treated as separate sites. Never connect power, I/O, or network wiring directly across multiple services. The RS-485 network between services should only be connected by an optically isolated repeater.



Never connect power, I/O, or network wiring directly across multiple services. The RS-485 network between services should only be connected by an optically isolated repeater.

See Using RS-485 Between Buildings, for more information about network and power isolation.

Input / Output Guidelines

Recommended Cable Type

Table 5 Recommended Cable for Inputs & Outputs

Belden Part Number	Description	Inputs				Outputs	
		10k	5V	10V	4-20mA	Analog	Binary
88442	2 Conductor, 22 AWG, Unshielded	X					
83552	2 Conductor, 22 AWG, Shielded		X				
83602	2 Conductor, 20 AWG, Shielded		X				
8772	3 Conductor, 20 AWG, Shielded		X				
83652	2 Conductor, 18 AWG, Unshielded	X		X	X	X	X
88870	3 Conductor, 18 AWG, Unshielded			X	X	X	
88489	4 Conductor, 18 AWG, Unshielded				X		

Externally Powered Inputs/Outputs

I/O that is externally powered receives its power from a power supply external to the controller. This power can be from a 24VAC Class II transformer or from a power supply that converts the transformer voltage into a more usable 24VDC.

Determining the type of power supply

Some I/O devices require a DC voltage for operation. If so, then a power supply external to the I/O device is required. Installation is easier when the controller's power and the I/O supply's power share the same transformer. To do this, both the controller and the power supply must both be half-wave rectified. If the controller is full-wave rectified, then the I/O

supply must use a dedicated transformer – regardless of whether it is full-wave or half-wave rectified.

To determine the type of power being used for an I/O device:

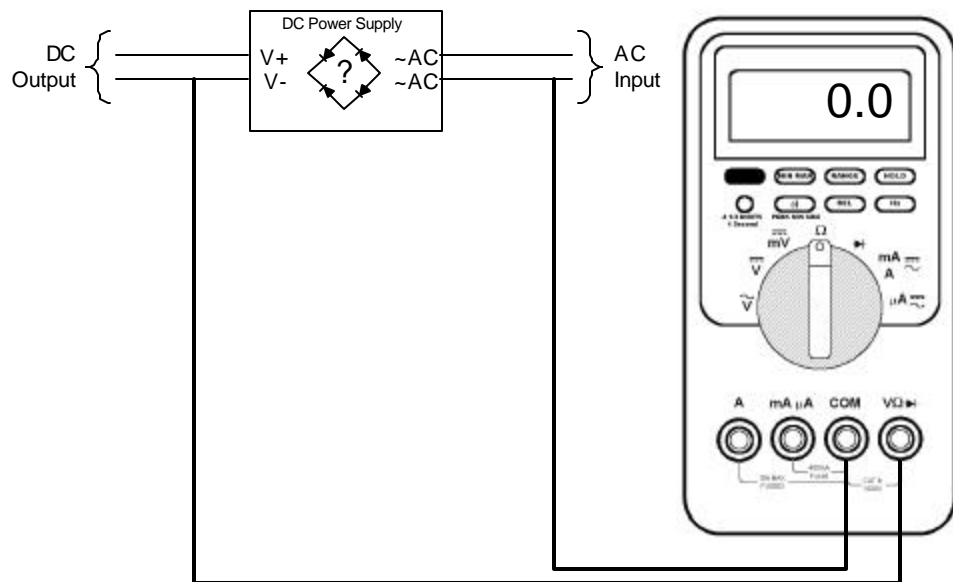
- 1 Disconnect all connections to the power supply.
- 2 Measure the resistance between the V- (often labeled GND) of the DC output and one of the AC input terminals. See Figure 8 for details.

If the resistance is **less than 0.5 Ohms**, then the power supply is half-wave rectified. The AC input terminal that has no resistance to V- of the DC output should be considered GROUND..

- 3 **If the resistance is greater than 0.5 Ohms, then** repeat steps 2 and 3 for the other AC input terminal.

If neither AC input terminals has a resistance to the V- pin of less than 0.5 Ohms, then the device is a full-wave device. It must be power by a dedicated transformer.

Figure 8 - Determining the type of I/O power supply.



Wiring Externally Powered I/O

The same principles apply to externally powered I/O devices that apply to controller wiring:

- Multiple controllers, I/O devices and power supplies may share the same transformer providing all devices using the

transformer are half wave devices and the transformer's VA rating is not exceeded.

- Full-wave controllers, I/O devices and power supplies must use dedicated transformers.

Figure 9 I/O Devices Requiring 24VAC

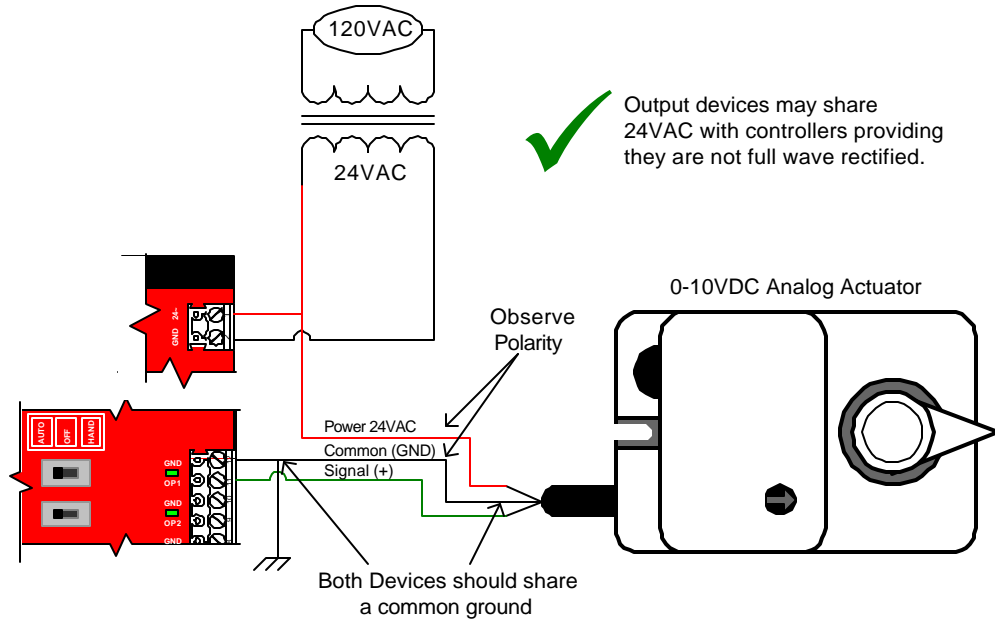


Figure 10 I/O Devices Using Half-Wave DC Power

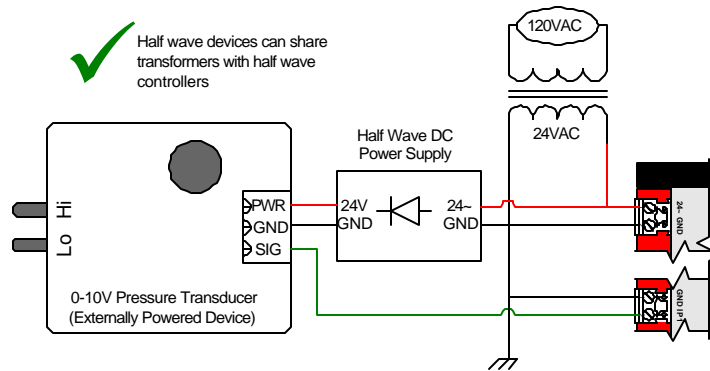
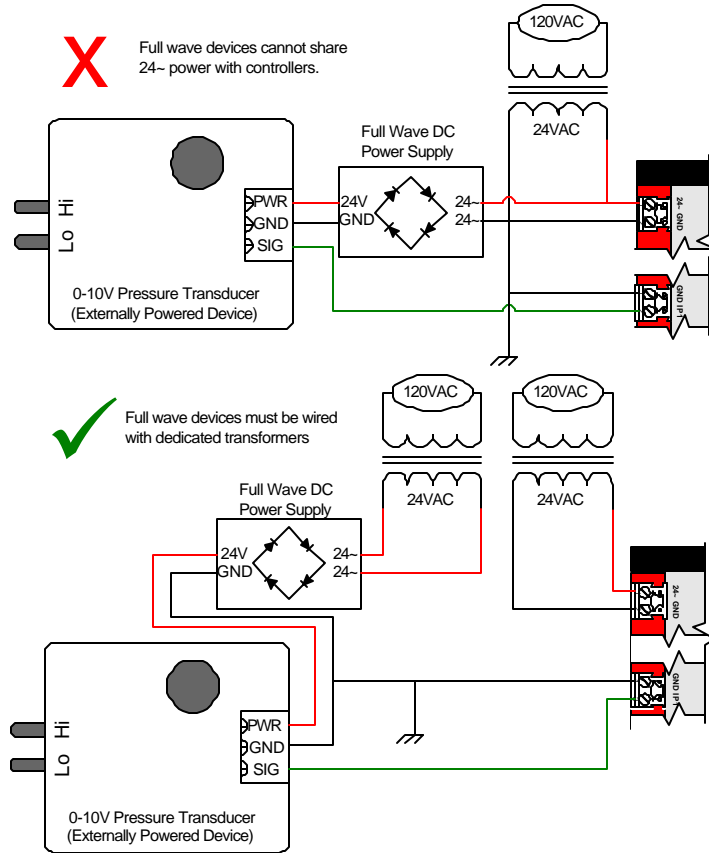


Figure 11 I/O Devices Using Full Wave DC Power



Inputs

Delta's controllers offer four types of industry standard inputs: 10k, 5V, 10V and 4-20mA. These inputs are compatible with most sensors and input devices available on the market.

Input selection is done using jumpers. Figure 12 shows the user selectable jumpers found on Delta products.

Figure 12 - Input types are selected by jumpers.

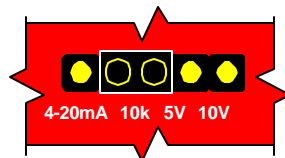


Table 6 Standard Inputs & Applications

Input Type	Common Applications
10k Ohm	10k Thermistor, Dry Contact
5V	5V Current, Position feedback
10V	10V Pressure, 10V Humidity
4-20mA	4-20mA Pressure

While Delta's inputs are very robust, there are some wiring practices and precautions that can further improve input accuracy and reliability. This section of the document outlines what these practices are.

10k Inputs

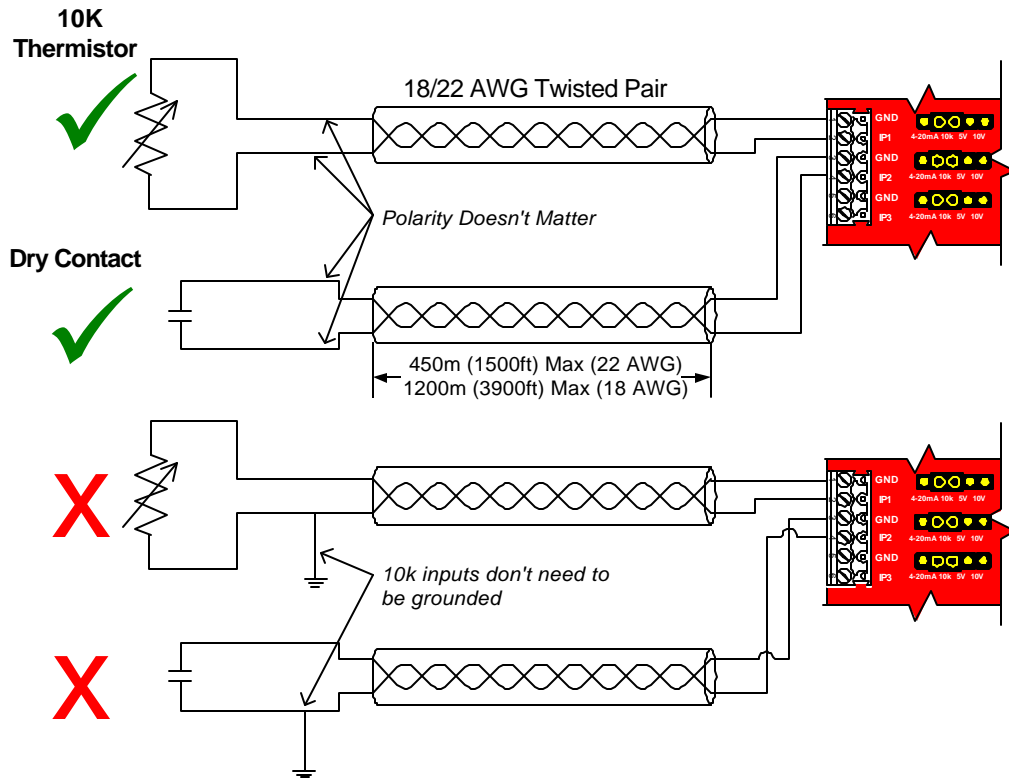
Delta's 10kΩ inputs are commonly used for a 10kΩ thermistor or a dry contact (i.e., push button or switch). Internally, the input is connected to a 10k pull-up resistor. A resistance value of 10k attached to the input translates to a value of 50% in the analog input object. An open circuit will read 100% and a short circuit will read 0%.

Table 7 10k Inputs – Category & Specifications

Category	Specification
Full Scale Value	Open Circuit (∞ Ohm) = 100%
Half Scale Value	10 kΩ = 50 %
Input Impedance	10 kΩ
Cable Type	2/4 conductor 18-22 AWG
Max Cable Length	450m (1500ft) Max (22 AWG) 1200m (3900ft) Max (18 AWG)
Wiring Precautions	Ground only at controller input terminal

Proper grounding practices will increase sensor reliability and accuracy. The only ground that should be attached is the GND pin on the input of the Delta Product. This eliminates any effect of ground noise, and any potential differences that could develop during electrical storms. Figure 13 illustrates this.

Figure 13 Wiring 10k Inputs



5V Inputs

The 5V inputs on Delta's controllers are a high input impedance (>200kΩ) input. These inputs are commonly used for both active and passive sensors. The high input impedance of 5V inputs makes them suitable for current transformers and other sensors that have high output impedance.

Table 8 5V Inputs – Category & Specifications

Category	Specification
Full Scale Voltage	5 VDC
Input Impedance	> 200 k Ω
Cable Types	2 conductor 22 AWG shielded Unshielded wire may be used when a 20k Ω load resistor is attached to input.
Max Cable Length	30m (100 ft) 100m (330 ft) with 20k Ω load resistor
Wiring Precautions	Keep cables short Use dedicated shielded cable

While the high impedance characteristics of the inputs can be advantageous for monitoring some sensors, very little current flows from the sensor to the controller, making it very susceptible to noise. Delta Controls highly recommends using shielded wire for all 5V inputs. Delta Controls also recommends using a dedicated cable. Adjacent wires can induce noise onto the signal. Using dedicated shielded wire will protect the signal from outside noise sources.

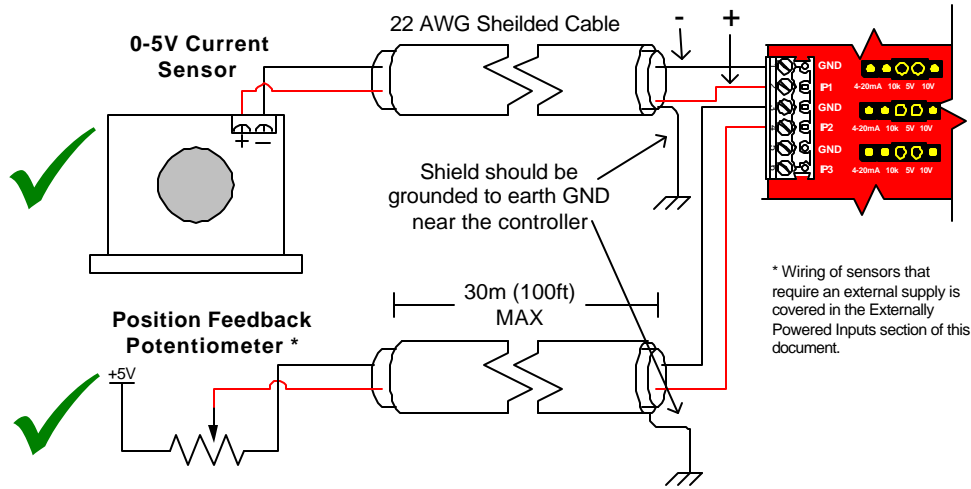


When using shielded wire, only earth ground the controller end of the shield. Differences in ground potentials can induce noise onto the signal.

If the sensor has low output impedance (less than 200 Ω), Delta recommends attaching 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 draw, the less susceptible it is to external noise.

The cable length should be kept as short as possible. Delta Controls recommends a maximum shielded cable length of 30m(100ft) for all 5V inputs. The addition of a 20K Ω resistor at the controller allows for increased cable lengths of up to 100m(330ft). Signal quality will degrade quickly with long cable runs.

Figure 14 Wiring 5V Inputs



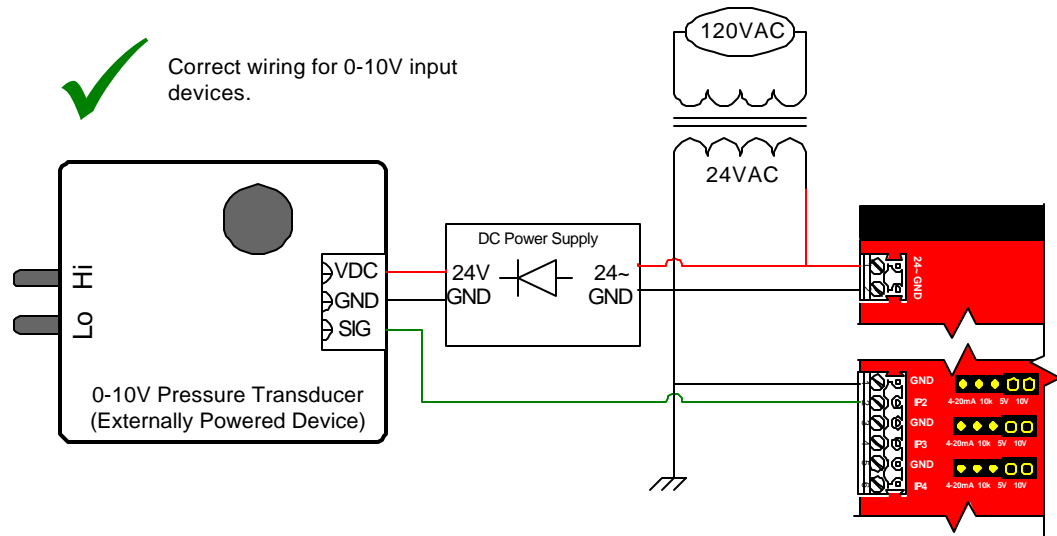
10V Inputs

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

Table 9 10V Inputs – Category & Specifications

Category	Specification
Full Scale Voltage	10 VDC
Input Impedance	20 kΩ
Cable Type	Multi-conductor 20-22 AWG
Max Cable Length	100m (330 ft)

Figure 15 Wiring 10V Inputs



4-20mA Inputs

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

Table 10 4-20mA – Category & Specifications

Category	Specification
Full Scale Current	20mA
Input Impedance	250 Ω
Cable Type	Multi-conductor 18-20 AWG
Max Cable Length	1000m (3300 ft)

Cable lengths of 1000m (3300ft) can be achieved by using 4-20mA inputs.

Figure 16 - Wiring 4-20mA Inputs

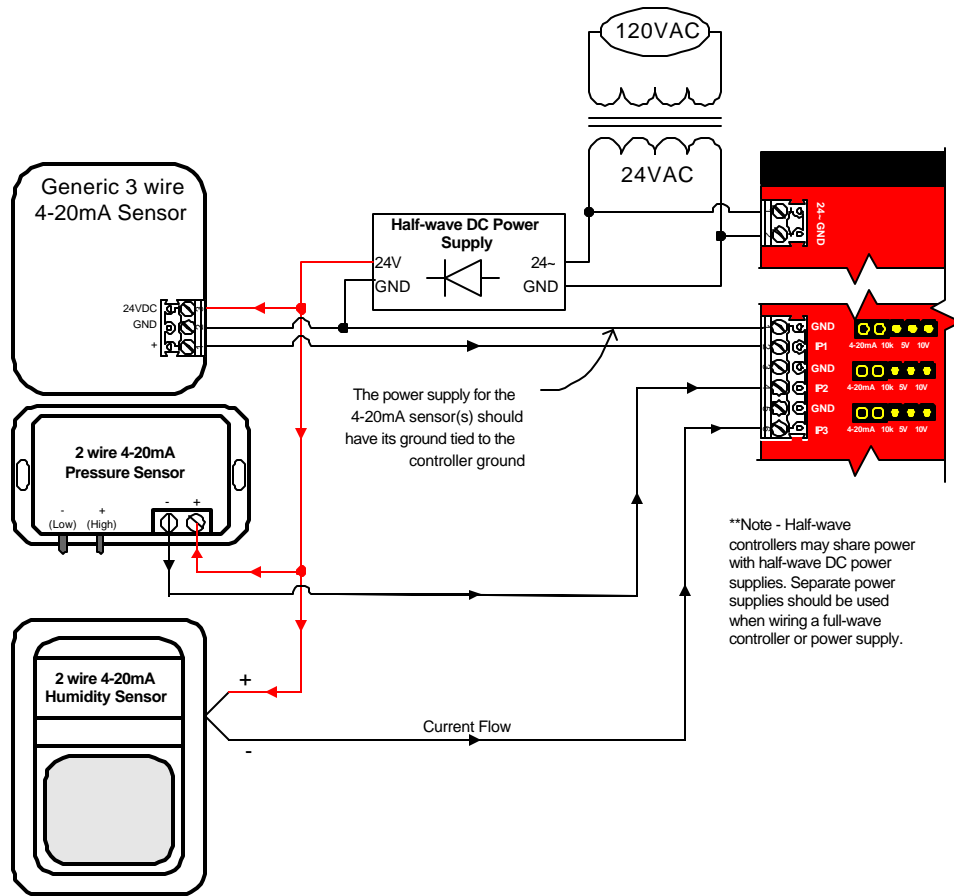
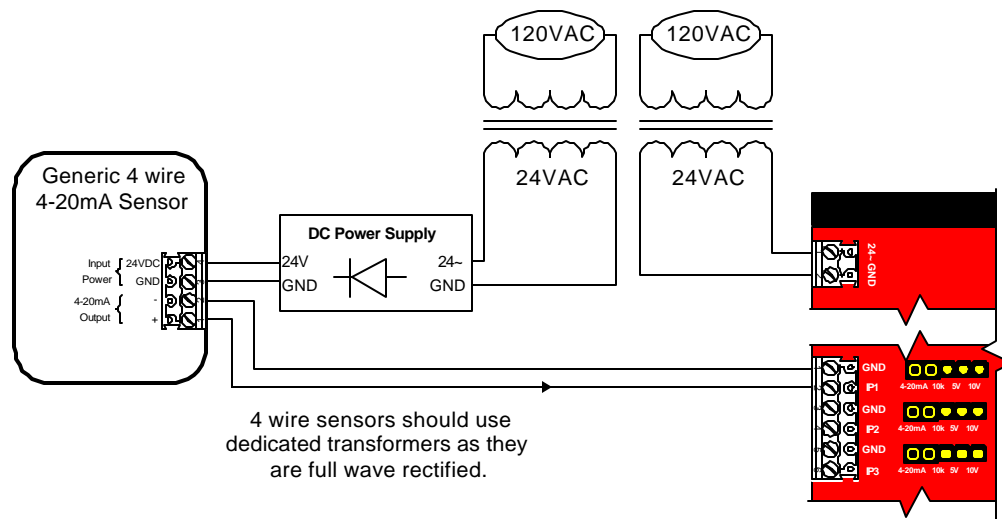


Figure 17 - 4 Wire sensors should use a dedicated transformer.



Outputs

Analog Outputs

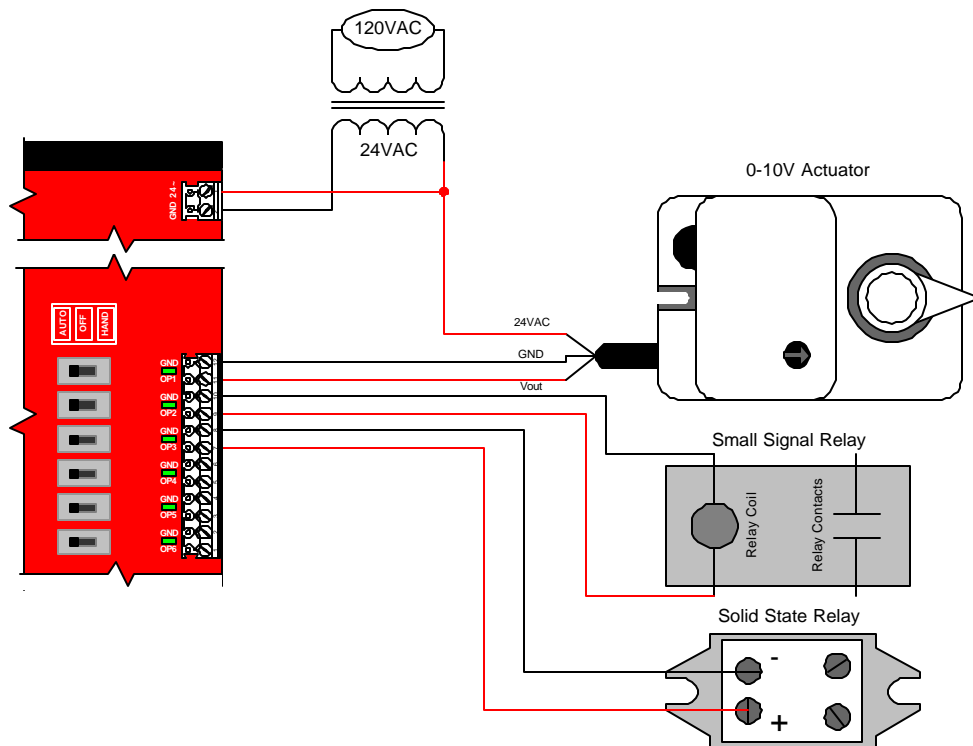
Delta's analog outputs can be used for a variety of applications, including actuators, relays, and heat units. They have a full range of 0-10 VDC with a maximum output current of 20mA.

Table 11 Analog Outputs – Category & Specifications

Category	Specification
Full Scale Voltage	10V
Max Output Current	20 mA
Cable Type	Multi-conductor 18-20 AWG
Max Cable Length	100m (330 ft)

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

Figure 18 Wiring Analog Inputs



Binary Outputs

Binary or Triac outputs are used to provide switched 24VAC at up to 500mA to an output device. On some controllers, the AC power source for the outputs is jumper selectable for internal/external power. When using the external voltage setting, the maximum voltage that can be applied is 28 VAC. Never connect 120V to a binary output.

Table 12 Binary Outputs –
Category & Specification

Category	Specification
Max External Voltage	28VAC
Max Output Current	500 mA
Max Leakage Current	160 μ A
Cable Type	Multi-conductor 18 AWG
Max Cable Length	100m (330 ft)
Minimum Turn-On Current	25 mA



Binary outputs are not meant to switch 120VAC. Never connect 120VAC to a binary output. Doing so will damage the controller.

When using the external power setting, only AC power can be applied. Triacs are AC devices. The triac will not turn off if a DC voltage is applied. Never connect a DC voltage to the external power pin of a triac output. This also applies to a Delta 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.

All Triacs have a specified leakage current when in the OFF state. Delta's outputs have a maximum leakage current of 160 μ A. This is not normally large enough to cause any concern; however, there are conditions when this could be enough to trigger a device. In cases where the device connected to the binary output requires a low drive current to operate, a 1Watt,

1kΩ resistor should be placed in parallel with the output. This will provide a path for the leakage current.

To properly turn on and off a triac, there is a minimum current requirement of 25mA. In cases where the load current is less than 25 mA, the addition of a 1 Watt, 1kΩ resistor in parallel with the output will provide the additional current required to power the device.

A 1 Watt, 1kW resistor should be placed in parallel with the output if:



- The load is an AC solid-state relay and the current is less than 25mA.
- The device being power requires < 160 μA to turn on.

Figure 19 Wiring Internal Setting Binary Outputs

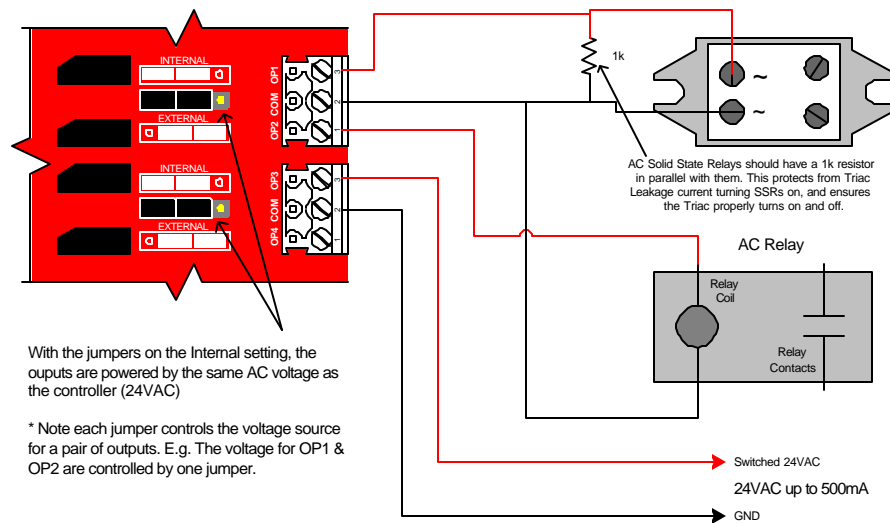
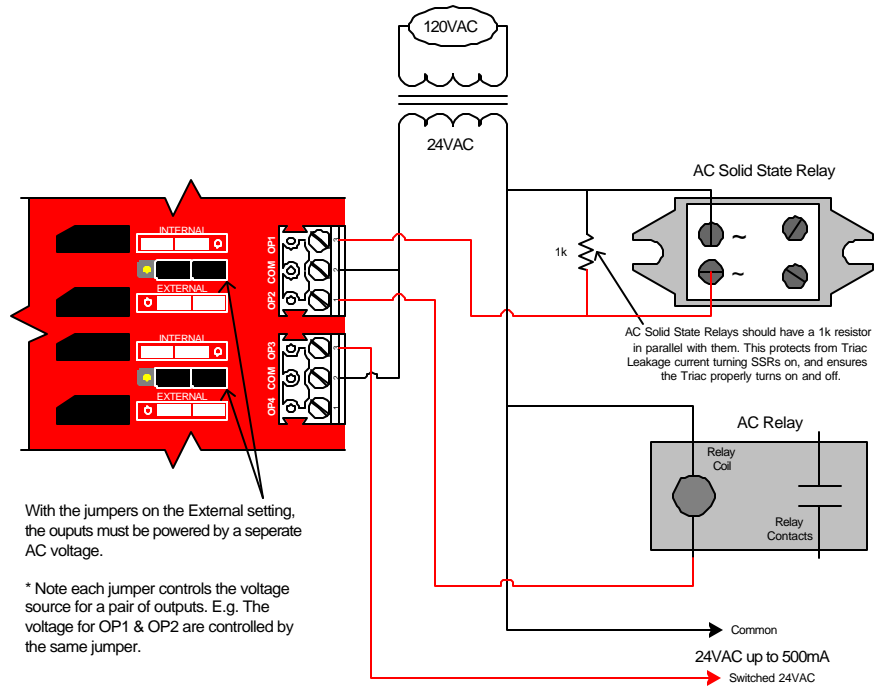


Figure 20 Wiring External Setting Binary Outputs



RS-485 Installation Guidelines (V2 Subnet, BACnet MSTP, and LINKnet Networks)

Delta Controls uses RS-485 as the physical network between controllers, using either a proprietary Delta protocol or BACnet MS/TP. There has been speculation over the proper installation and design specifications for this RS-485 network. This section attempts to clarify installation requirements and aids the user in building robust networks.

For clarity, we will use the term “node” to denote any product with an active RS-485 network connection, including System Controllers, VAV/VVT Controllers, Application Controllers, BACStats, etc.

Summary Specifications

Table 13 RS-485 Summary Specifications

Category	Specification
Cable Type	100-120 ohm balanced, shielded, twisted pair
Network Configuration	Daisy Chain
Maximum Distance of a Chain	4000 ft (1200 m)
Maximum Number of Devices	50 devices per daisy chain segment, expandable to 99 using a repeater (RPT-768).
Termination	Use TRM768 Network Terminator at both ends of a segment.
Shielding	Connect Shield to TRM768 Network Terminator (Preferred Method) — Or — Earth ground one end of the shield. Leave the other end floating. (Second Method)

Cable Type

Delta's RS485 networks require cable that meets the following specifications:

- 22-24 AWG twisted pair.
- Characteristic impedance of 100-120 ohms.
- Capacitance of 17 pF/ft or lower.
- Braided or aluminum foil shield.

Network Configuration

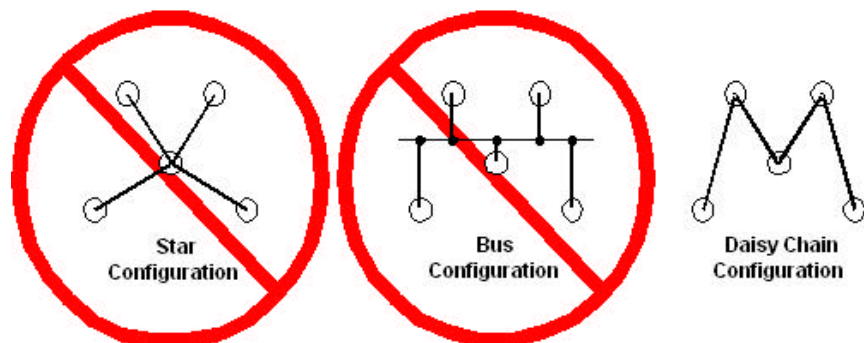
RS-485 networks use a daisy chain configuration. A daisy chain means that there is only one main cable and every network device is connected directly along its path.

Figure 21 illustrates two improper network configurations and the proper daisy chain configuration.

Other methods of wiring an RS-485 network may give unreliable and unpredictable results. There are no troubleshooting methods for these types of networks. Therefore, a great deal of site experimentation may have to be done, making this a difficult task with no guarantee of success. As a result, Delta Controls can only support daisy chain configurations.

Figure 21 Three Network Configurations

(left to right) star, bus, and daisy chain. Only the daisy chain configuration is correct for a RS-485 network.



Maximum Cable Length

The maximum length of a chain is related to its transmission speed. The longer the chain, the slower the speed. Using proper cable, the maximum length of an RS-485 daisy chain is 4000-ft (1200 m). This will work reliably for data rates up to 100,000 bps. Currently, Delta Controls' maximum data rate is 76,800 bps.

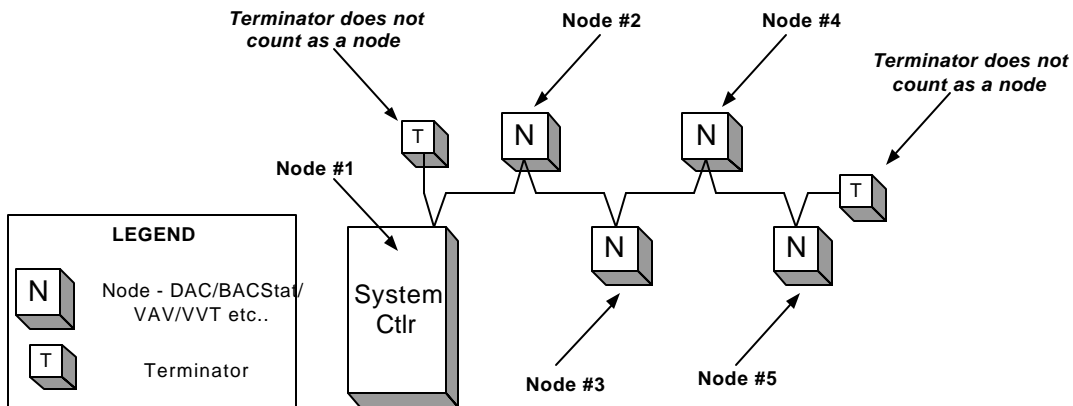
If you require a maximum network length of more than 4000 feet, then repeaters (RPT-768) are required to extend the network. However, the maximum network length is limited to 8000 feet.

Maximum Number of Devices

A maximum of 50 nodes is allowed on a single daisy chain segment. A node is defined as any device (DSC, DAC, DCU, DFM, Panel, Zone, Repeater, etc.) connected to the RS-485 network. Terminators do not count as a node.

For the example in Figure 22, we have one node for the System Controller, plus 4 for the other controllers, for a total of 5 nodes.

Figure 22 Five Node Network



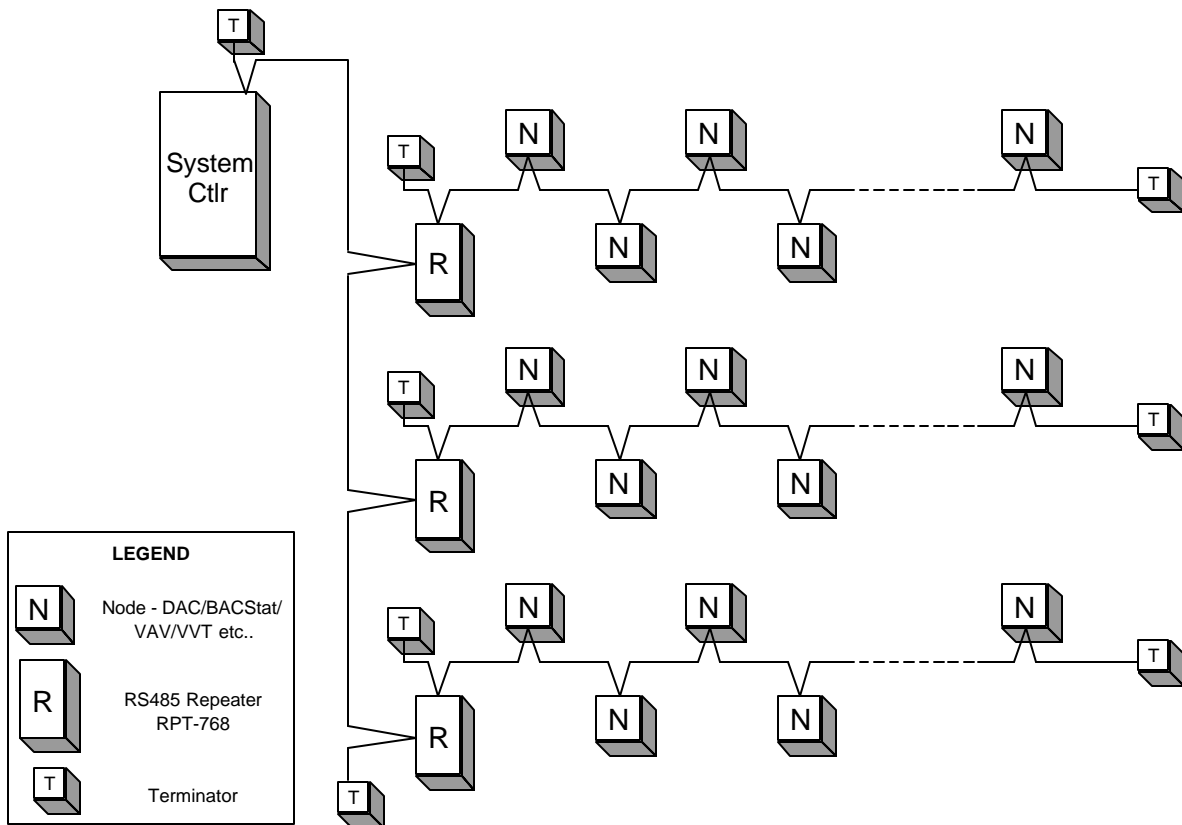
If you have more than 50 devices, then repeaters are required to extend the network.

RS-485 Repeaters (RPT-768)

If you have more than 50 devices, or require a maximum network length of more than 4000 feet, then repeaters are required to extend the network. The best configuration is to daisy chain the repeaters to the main panel. From each of these repeaters, a separate daisy chain will branch off. Figure 23 demonstrates a valid use of RPT768 repeaters & terminators in a RS-485 network.

Figure 23 Daisy-Chained Repeaters – Correct Usage

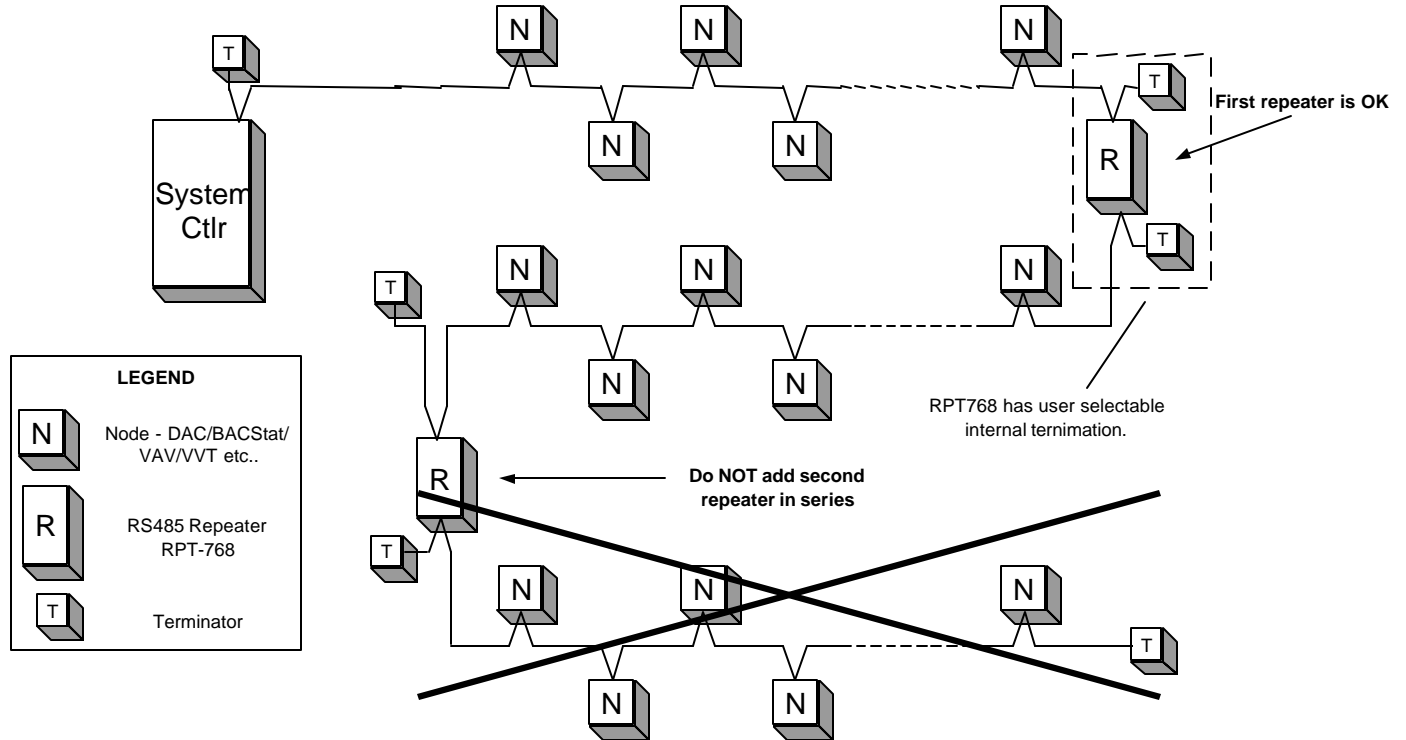
Repeaters are daisy-chained to the main panel and separate daisy chains branch from each repeater.



Do not install repeaters in series or use more than one repeater to extend a segment, as this may result in network reliability problems. Figure 24 demonstrates an incorrect use of a repeater in an RS-485 network.

Figure 24 Daisy-Chained Repeaters – Incorrect Usage

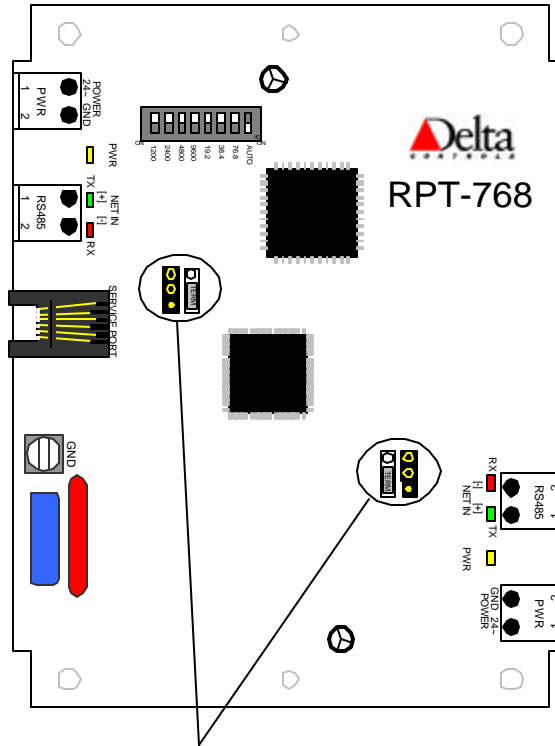
The second repeater in series may result in an unreliable network.



Delta's RS-485 repeaters have user selectable built-in termination, which has the same effect as a TRM768 terminator. When using built-in termination, care should be taken to properly terminate the shield. See the Termination section of this document for more details.

Figure 25 RS-485 repeater
RPT768

User selectable Termination is identical to termination on a TRM-768 (Delta standard RS-485 network terminator)



User Selectable Termination.

When wired with a single transformer, the RPT768 provides 50V isolation. When wired using two separate transformers, the RPT768 provides 500V of isolation. Wiring the RPT768 with two transformers is recommended whenever wiring RS-485 between buildings.



When wiring a RS485 network between buildings, the two-transformer method of wiring the RPT768 should always be used. This provides 500V isolation between buildings.

Figure 26 – Wiring with 1 Transformer

This provides 50V network isolation.

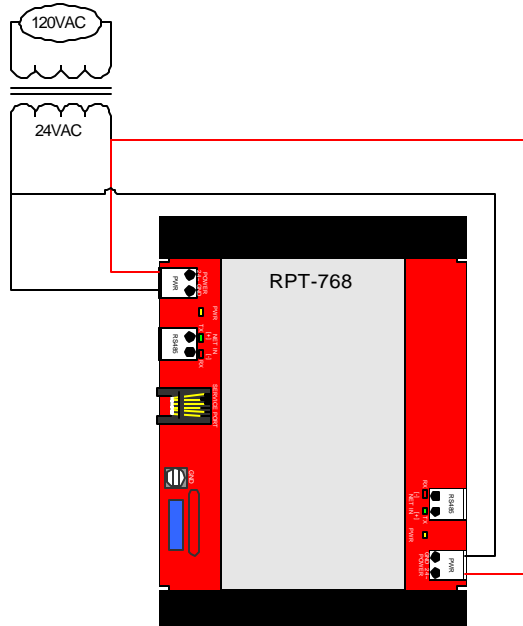
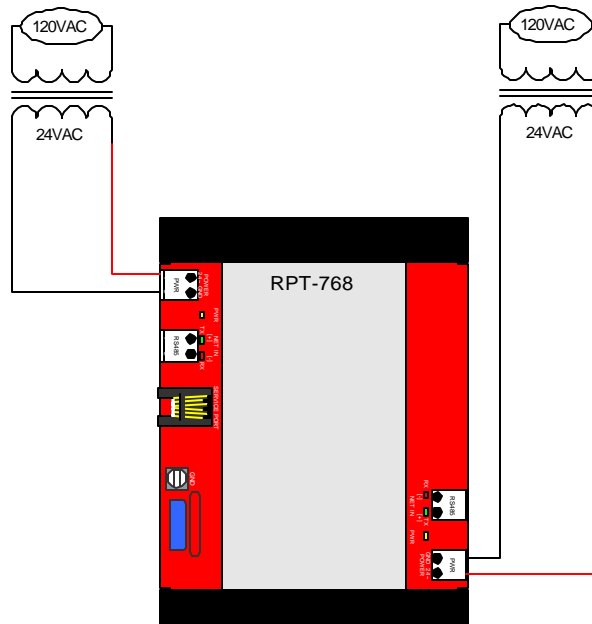


Figure 27 - Wiring with 2 Transformers

This provides 500V network isolation. This configuration is usually used when wiring RS485 between multiple floors or buildings.



Termination

Both ends of a daisy chain segment require termination to ensure reliable operation. Proper termination will ensure network stability and help to prevent damage to controllers during high electrical activity.



*Termination is **only** effective if proper RS485 network cable is being used (See section on Cable Type). Otherwise, termination may provide unpredictable results.*

Termination involves two things:

- 1) Terminating the RS485 network itself.
- 2) Terminating the shield.

Both of these are essential to maintain network reliability. There are two methods that can be used to terminate networks.

Regardless of which method used, the installer should be careful to never ground the shield at more than one point along the daisy chain. Ground potentials in a large building can reach substantially different values. If the network shield is connected to different ground potentials, current will flow through the shield, and induce noise onto the network. This will lead to unreliable network communications, and could even damage the controllers.



Never directly ground the shield of a network at more than one point along the network. Doing so may induce current onto the network, and could cause unreliable communications.

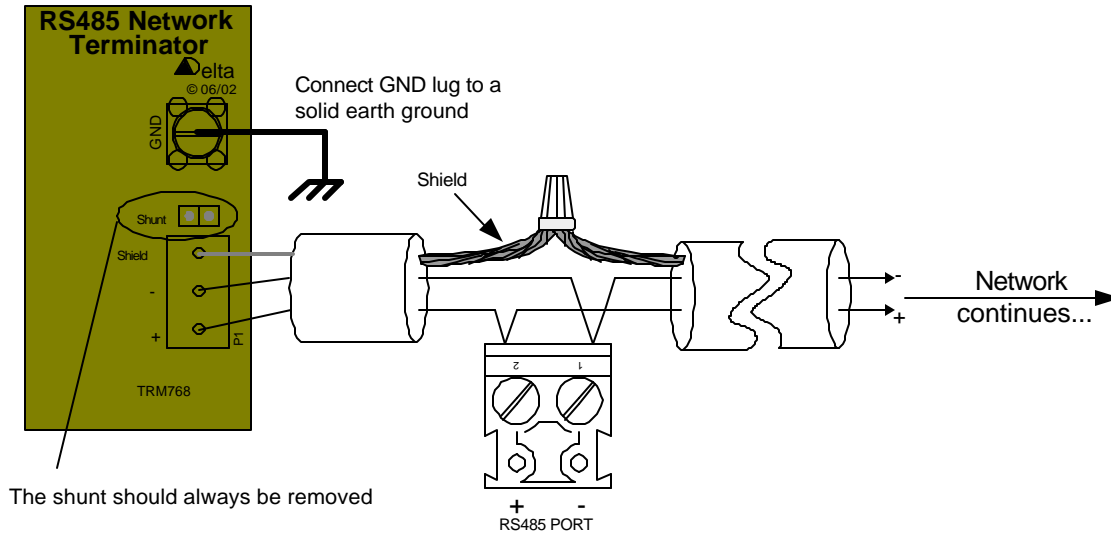
Preferred Method – Using TRM-768s

This method of wiring a RS485 network provides the most reliable results. It properly terminates the shield, providing proper transient protection, and proper protection against electromagnetic interference. Whenever possible the preferred method should be used.

After the last device on each end of an RS-485 network, install a TRM768 Network Terminator. The TRM768 provides the correct termination, not only for the network, but for the proper termination of the shield as well.

With the shunt removed, the TRM768 provides a path for the shield to ground through a 180V MOV and additional protection components. Both the start and end network terminators should have the shunt removed to ensure proper transient protection while still providing a ground reference.

Figure 28 TRM768 Network Terminator



Second Method – Using Built-in Termination.

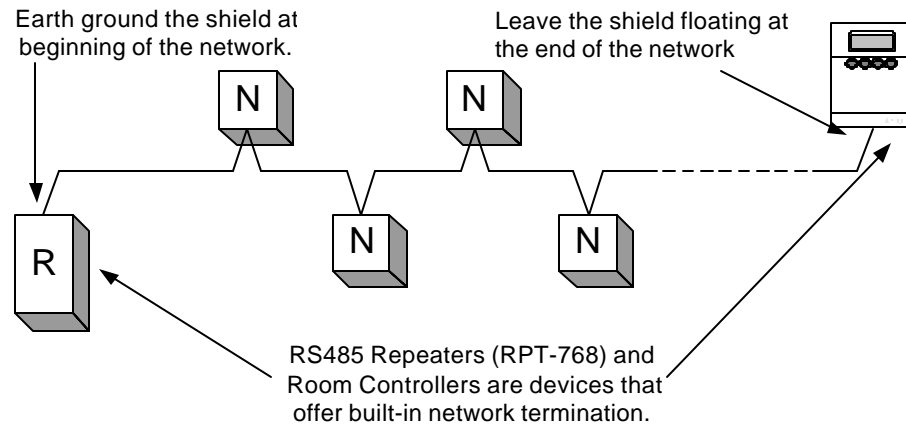
Delta Controls manufactures several products that provide the option of built-in termination. Some of these products include the RPT-768, and the Room Controller. While these products provide proper termination for the network, they do not provide termination for the shield. When built-in network termination is used, care must be taken to properly terminate the shield.

The network cable shield should be grounded at one end of the network and left floating at the other end. Never ground the shield of a network in more than one place along the network. Differences in ground potentials in large buildings can cause current to flow. If the shield is connected to two different ground potentials, the resulting current will induce noise into the network.



Only ground the shield of a network at one end of the network when using devices with built-in termination. Grounding the shield in multiple locations can induce noise into the RS485 network.

Figure 29 – Using devices with built-in termination to terminate the network



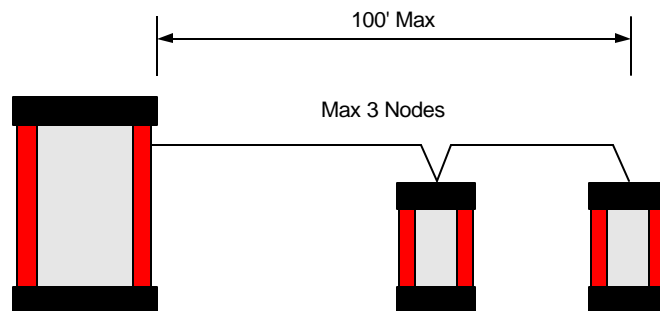
LINKnet and other small Networks

Network terminators should always be used with larger networks, however when installing an RS485 network, there will often be times where the network is small enough that terminators are not required.

A good example of this is having 2 DFMs on a short LINKnet network. Since there are only three nodes on this network and the overall network distance is short, it is not necessary to install network terminators.

Network terminators do not have to be used if the number of nodes is less than 3, and the overall length is less than 100 ft.

Figure 30 - Terminators are not required for networks less than 3 nodes and less than 100 ft.



Shielding

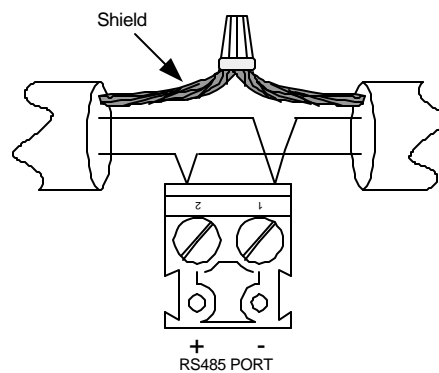
When properly installed, shielded cable can improve the protection of your network and equipment against harmful electromagnetic interference (EMI) and transient voltage spikes. Delta Controls strongly recommends using shielded cable.

The cable shielding should be tied through at every device to make a continuous shield that runs the whole length of the segment, as shown in Figure 31. Do not connect the shield to ground at each node.



The shield should never be tied to ground in more than one place along the network. See the Network Termination section of this document for details on how to properly ground the shield.

Figure 31 Shield Tie Through at Each Device



Using RS-485 Between Buildings

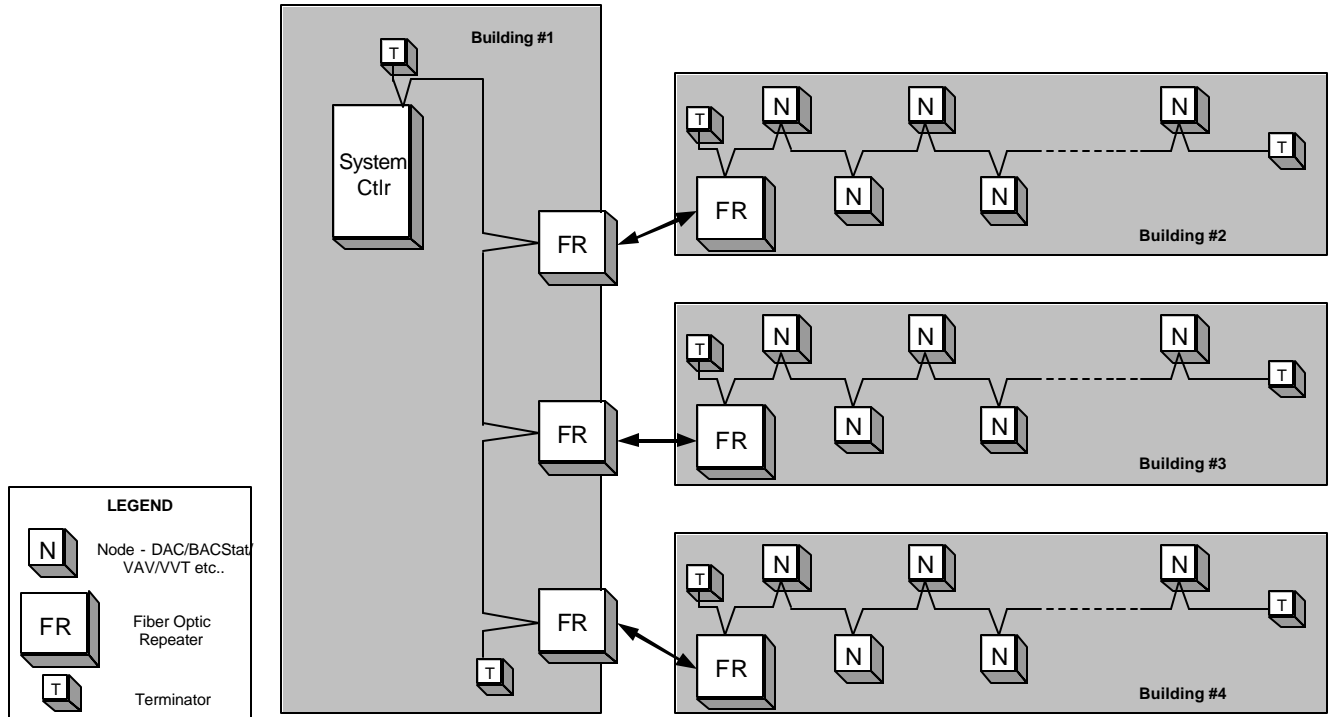
While we recognize running RS-485 communications between buildings may be an installation requirement, doing so greatly increases your exposure to communication problems and/or damage to equipment.

The safest 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 your exposure to damage due to inherent voltage transients and even lightning.

Delta Controls does not currently manufacture a RS-485-to-Fiber optic repeater. However, the Model 276A Optoverter - 2 Wire, RS-485 to Fiber Optic Line Driver/Converter from Telebyte has been used in a number of installations, and has shown to be effective. Please be aware that as a 3rd party

product, Delta Controls cannot guarantee future successful use of this product with our own.

Figure 32 Using Fiber Optic RS-485 Converters



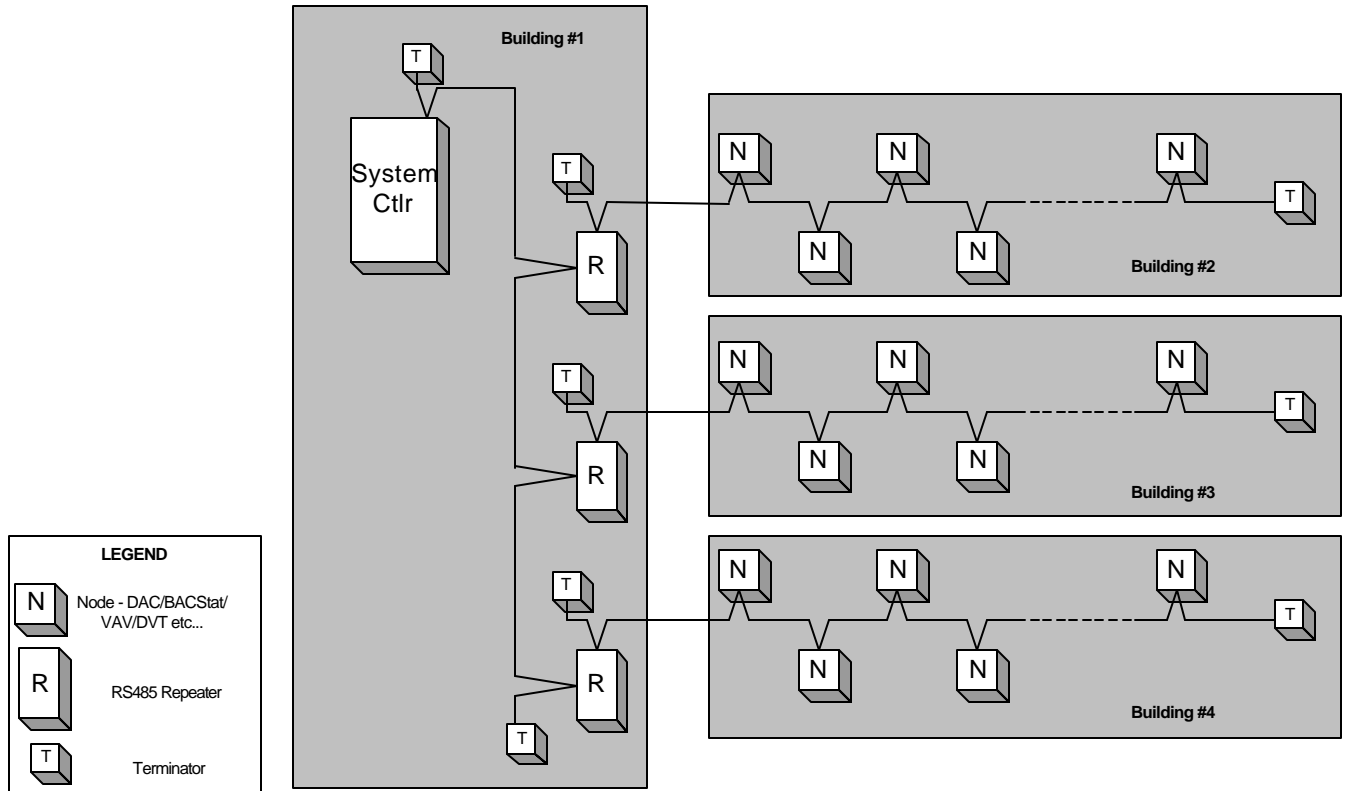
An alternative is to use Delta’s RPT-768 RS-485 repeater. While it cannot provide the same level of protection against transient voltages as a fiber optic repeater, they will provide 24VAC separation, as well as ensuring correct network topology and termination.

The RPT768 can be powered using one or two transformers. When one transformer is used, the RPT768 provides 50V isolation. When two transformers are used, the RPT768 provides 500V isolation. Powering the RPT768 with two transformers is recommended whenever wiring RS-485 between buildings. See the “RS-485 Repeaters” Section of this document for details.



When wiring RS485 networks between buildings, the two-transformer method of powering the RPT768 should be used. This provides 500V isolation between buildings. See the “RS-485 Repeaters” section of this document for details.

Figure 33 Using RS-485 Repeater

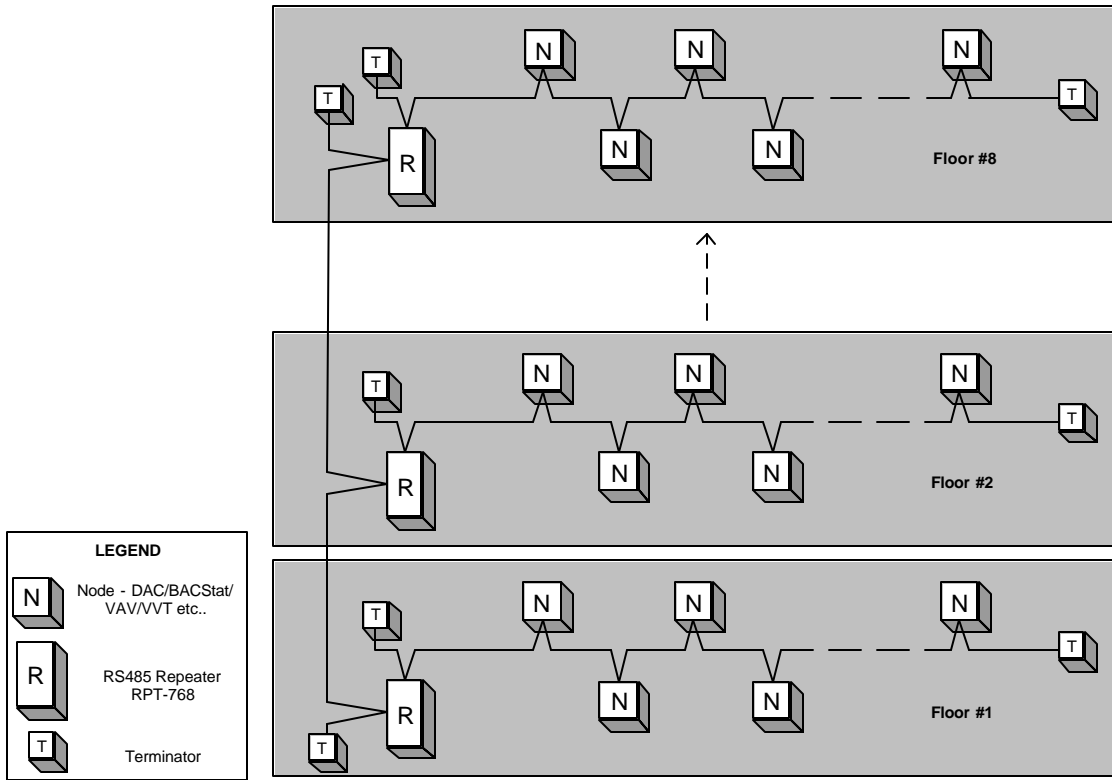


Using RS-485 Between Floors

The same problems that can occur when using RS-485 between buildings can occur when using RS-485 between multiple floors. In larger installations, each floor will have a slightly different ground potential than others. During electrical storms, the voltage difference between floors can be quite large.

It is recommended that for large installations, a repeater be used on each floor as the beginning of the network. This will provide 50-500 V (depending on how you power the repeater) isolation between floors.

Figure 34 Using Repeaters Between Floors



Ethernet

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

When wiring an Ethernet network, the installer should conform to the IEEE 802.3 Standard. This Standard can be found online at <http://standards.ieee.org/getieee802/802.3.html>. This section of the wiring guide is intended to provide a brief overview of Ethernet wiring specifications and practices. It is recommended that the installer be familiar with the IEEE 802.3 Standard before installing any Ethernet network.

Specifications

Table 14 Ethernet – Category & Specifications

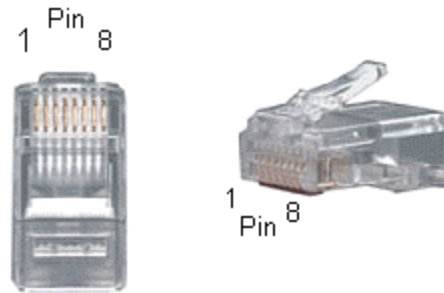
Category	Specification
Maximum length of segment	100m (330 ft)
Maximum number of repeaters (hubs etc..) between Ethernet devices	4
Cable Type	CAT5 / CAT5E / CAT6

10BaseT is 10Mbps 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. 10BaseT 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 put on the cable by utilizing a tool made specifically for this task.

Cable Wiring

The maximum distance for a single 10BaseT UTP cable is 100m or 330Ft. This is either the distance between the PC and the hub (in the case of a straight through cable), or the distance between the PC and the Controller (in the case of a cross over cable).

Figure 35 RJ45 Connector Pinout



Straight-Through Cable

When connecting multiple devices (PCs, Controllers, etc.) by a hub, 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.

Table 15 Wiring Pinout for Straight-Through Cables

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 hubs by using a cable referred to as a *cross-over* or *flip* cable. A cross-over cable basically crosses some of the conductors between the two ends of the cable. This is similar in concept to serial RS-232 cables, which cross Receive and Transmit. For example, to connect a DCU050 or DSC-1212E directly to a PC, a cross-over cable could be used and would not require a hub.

Table 16 Wiring Pinout for
Cross-Over Cables

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

Quick Reference

Power

Table 17 - Summary of Power Specifications

Category	Specification
Voltage	20 – 28 VAC
Electrical Class	Class II 100VA Max
Cable Type	2-conductor plenum-rated 16-18 AWG
Fuse Rating	4-Amp Slow-Blow should fuse the secondary side
Power Supply Types	Half wave / Full wave Half wave devices may be powered from the same transformer (VA requirements must be met) Full wave devices require a dedicated transformer.

Table 18 - 24VAC Power Cable Reference

Description	Device VA Rating	Max Length
Plenum 16 AWG Stranded FT6	100	100 ft
	75	150 ft
	50	250 ft
	25	500 ft
Plenum 18 AWG Stranded FT6	50	150 ft
	25	300 ft
	15	500 ft
	5	1000 ft

Inputs / Outputs

Table 19 - Input/Output Cable Selection

Belden Part Number	Description	Inputs				Outputs	
		10k	5V	10V	4-20mA	Analog	Binary
88442	2 Conductor, 22 AWG, Unshielded	X					
83552	2 Conductor, 22 AWG, Shielded		X				
83602	2 Conductor, 20 AWG, Shielded		X				
8772	3 Conductor, 20 AWG, Shielded		X				
83652	2 Conductor, 18 AWG, Unshielded	X		X	X	X	X
88870	3 Conductor, 18 AWG, Unshielded			X	X	X	
88489	4 Conductor, 18 AWG, Unshielded				X		

Table 20 - Input/Output Cable Lengths

Type	Max Cable Length
5V Input	30m (100 ft) 100m (330 ft) with 20k Ω load resistor
10k Input	450m (1500ft) Max (22 AWG) 1200m (3900ft) Max (18 AWG)
10V Input	100m (330 ft)
4-20mA Input	1000m (3300 ft)
Analog Outputs	100m (330 ft)
Binary Outputs	100m (330 ft)

RS485 Wiring

Table 21 - RS485 Summary Specifications

Category	Specification
Cable Type	100- 120 ohm balanced, shielded, twisted pair
Network Configuration	Daisy Chain
Maximum Distance of a Chain	4000 ft (1200 m)
Maximum Stub Length (Tee)	10 inches (0.25 m)
Maximum Number of Devices	50 devices per daisy chain segment, expandable to 99 using a repeater (RPT-768).
Termination	Use TRM768 Network Terminator at both ends of a segment.
Shielding	<p>Connect Shield to TRM768 Network Terminator (Preferred Method)</p> <p>— Or —</p> <p>Earth ground one end of the shield. Leave the other end floating. (Second Method)</p>

Figure 36 - Proper network wiring of a common RS485 network.

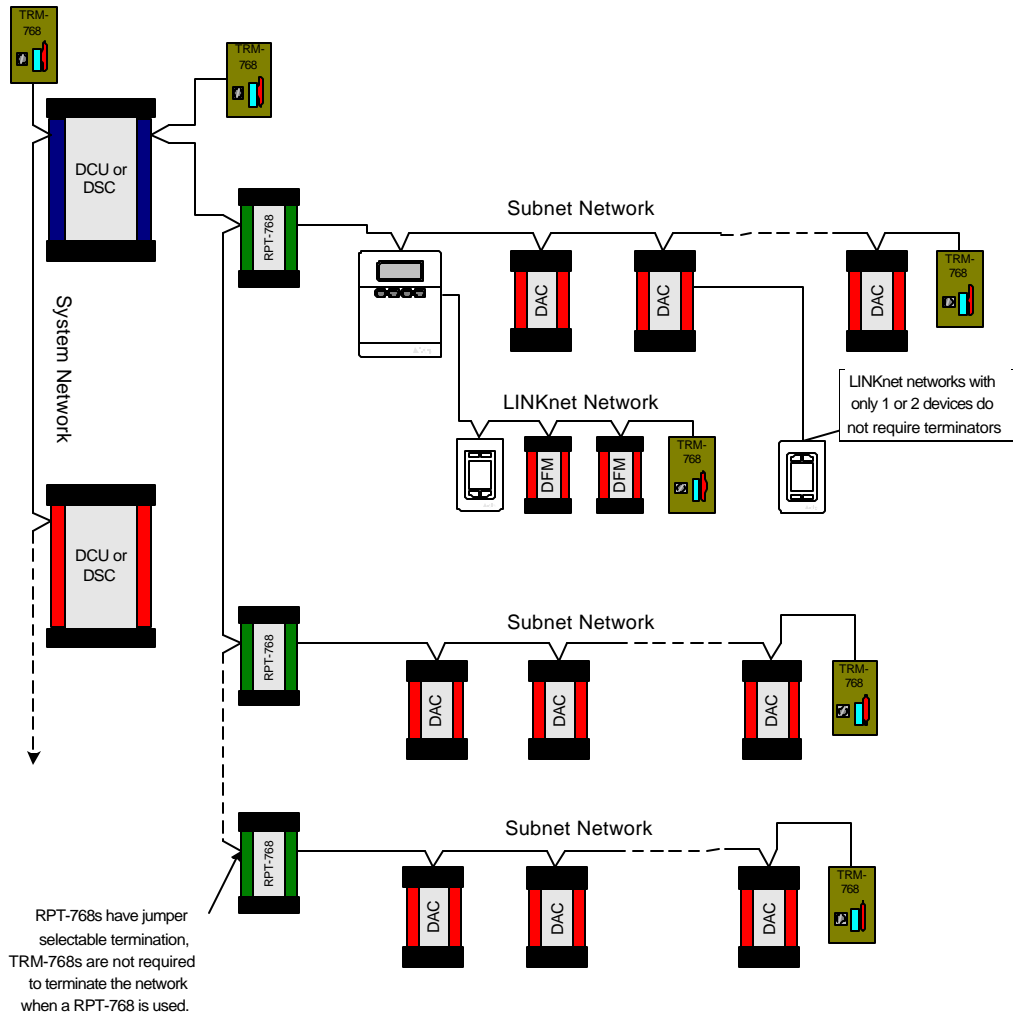
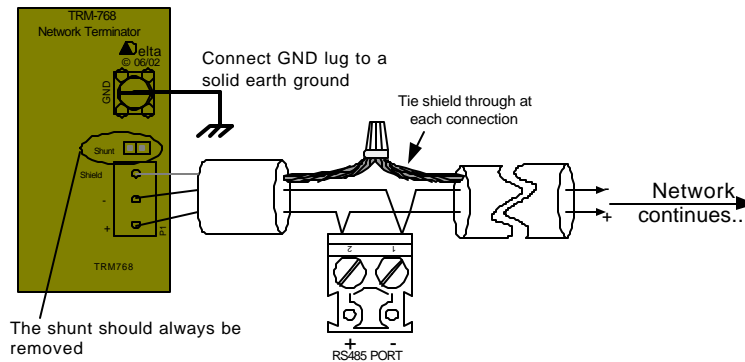


Figure 37 - Proper Network Termination



Additional Information

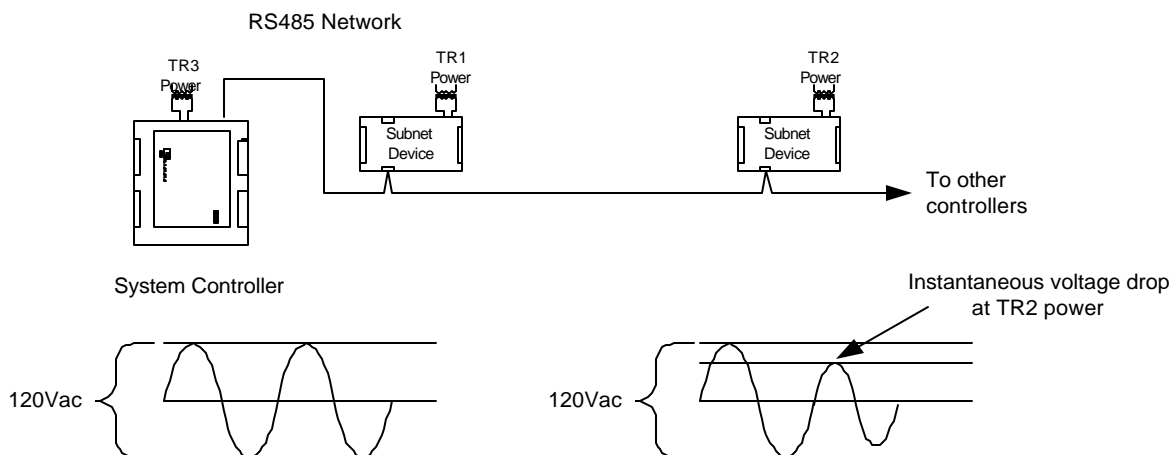
This section includes further information that may assist you with the wiring and installation guidelines described in this document.

Transients

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 will result in a voltage transient. The parasitic capacitance of electronic devices will allow this transient to pass over the RS-485 network as it tries to equalize the voltage difference between devices on the network. See Figure 38.

Figure 38 Example of a Voltage Transient



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

Using a dedicated 120VAC source for all your control device power (120VAC:24VAC transformers) will also significantly improve your chances of successfully completing a project.

RS232 Pinouts

Serial Cables may be used to connect a controller to your PC or modem.

Factory Cables Available

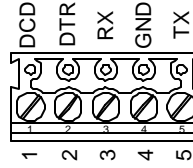
Table 22 - Direct connection cables available from Delta Controls

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

Table 23 - Modem cables available from Delta Controls

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

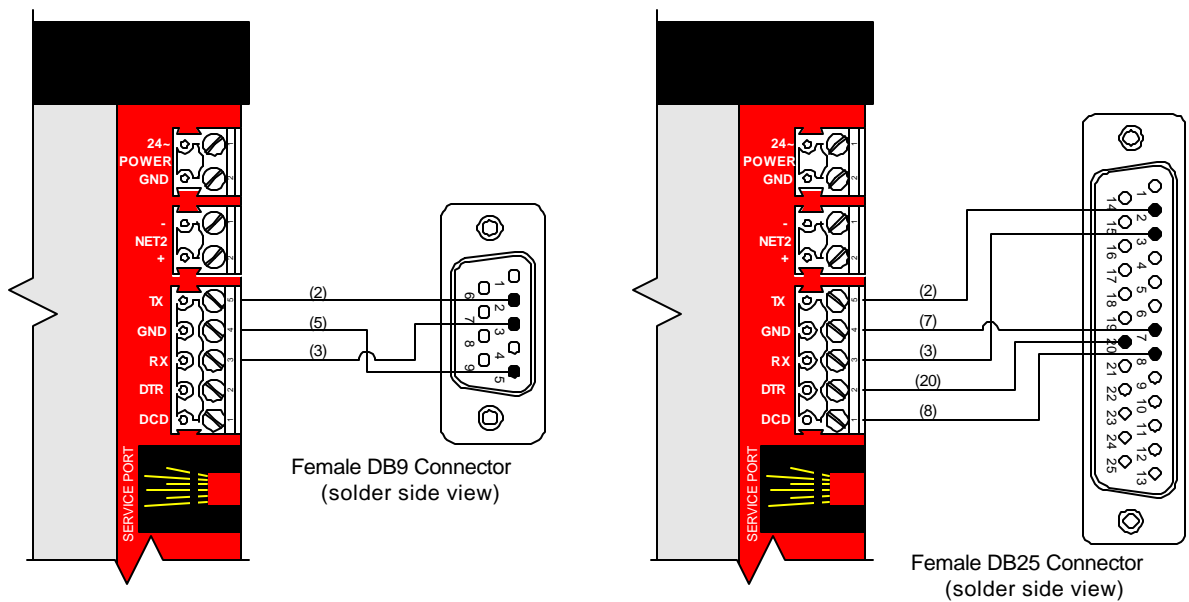
DSC



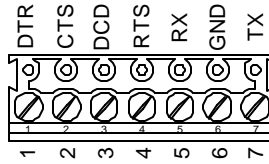
Signal	DB9	DB25
(1) DCD*	1	8
(2) DTR*	4	20
(3) RX	2	3
(4) GND	5	7
(5) TX	3	2

* Only required for modem cables

Figure 39 - (Left) Direct connection to a female DB9 connector. (Right) Modem connection to a female DB25 connector.



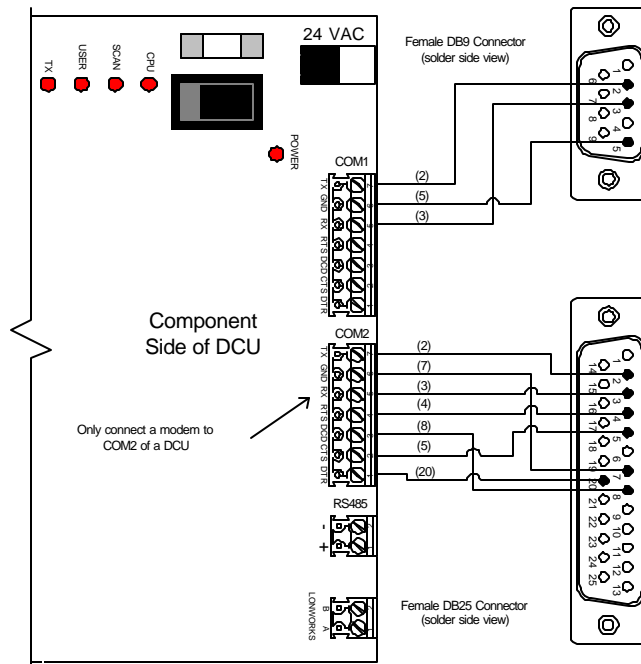
DCU-050/DSM-050



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

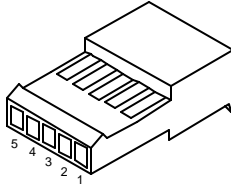
* Only required for modem cables

Figure 40 - (Top) Direct connection to a female DB9 connector. (Bottom) Modem connection to a female DB25 connector.



Room Controller

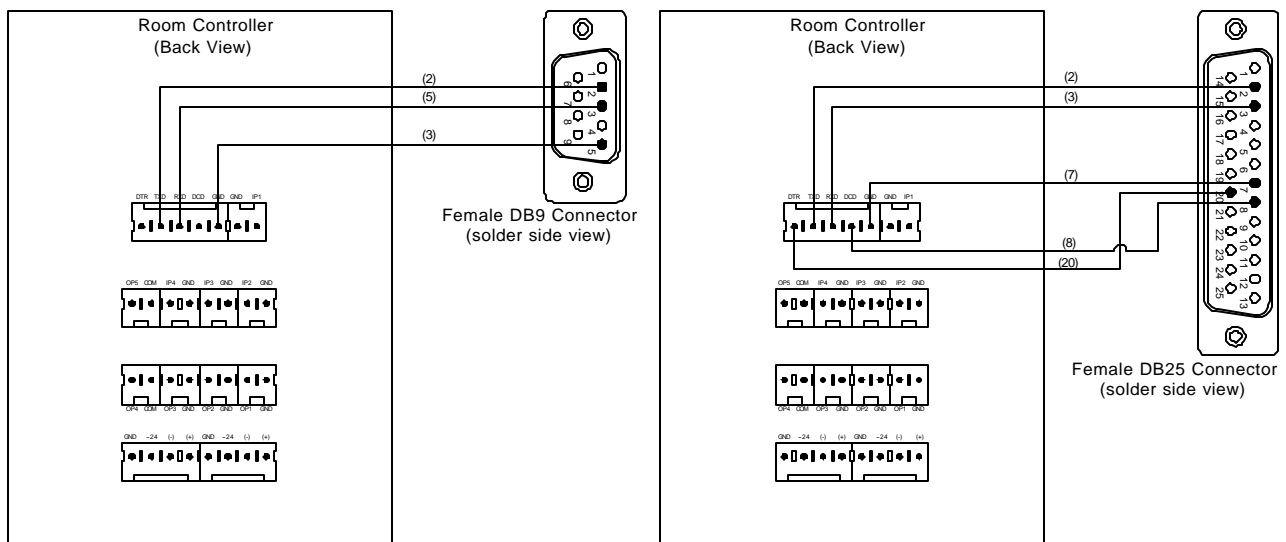
The RS232 port of the Room Controller uses a MTA-156 5 Pin Connector.



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

* Only required for modem cables

Figure 41 - (Left) Direct connection to a female DB9 connector. (Right) Modem connection to a female DB25 connector.



Document Control

Title *Wiring & 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)