SIEMENS

APOGEE

Wiring Guidelines for Field Panels and Equipment Controllers

125-3002
2017-05-04

Building Technologies

Copyright Notice

Warning

This equipment generates, uses, and can radiate radio frequency energy. If equipment is not installed and used in accordance with the instructions manual, it may cause interference to radio communications. Equipment has been tested and found to comply within the limits for a Class B digital device pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference. Residential area equipment users are required to take whatever measures necessary to correct the interference at their own expense.

Service Statement

Control devices are combined to make a system. Each control device is mechanical in nature and all mechanical components must be regularly serviced to optimize their operation. Siemens Industry, Inc. branch offices and authorized distributors offer Technical Support Programs that will ensure continuous, trouble-free system performance.

For further information, contact your nearest Siemens Industry representative.

FCC Regulations

The manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible could void the user’s authority to operate the equipment.

For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

To the Reader

Your feedback is important to us. If you have comments about this manual, please submit them to: SBT_technical.editor.us.sbt@siemens.com

Credits

APOGEE, APOGEE GO, InfoCenter Administrator, InfoCenter Report Manager, InfoCenter Server, InfoCenter Suite, and Insight are registered trademarks of Siemens Industry, Inc.

Desigo® and Desigo® CC™ are registered trademarks of Siemens Schweiz AG.

Other product or company names mentioned herein may be the trademarks of their respective owners.

Printed in the USA.

Cyber security disclaimer

Products, solutions and services from Siemens include security functions to ensure the secure operation of building automation and control, fire safety, security management, and physical security systems. The security functions on these products, solutions and services are important components of a comprehensive security concept.

Drafting, implementing and managing a comprehensive and up-to-date security concept, customized to individual needs, is nevertheless necessary, and may result in additional plant- or site-specific preventive measures to ensure secure operation of your site regarding building automation and control, fire safety, security management, and physical security. These measures may include, for example, separating networks, physically protecting system components, user training, multi-level defensive measures, etc.

For additional information on security as part of building technology and our product, solution and service offerings, please contact your Siemens sales representative or project department. We strongly recommend to always comply with our security advisories on the latest security threats, patches and other related measures.

http://www.siemens.com/cert/en/cert-security-advisories.htm

Table of Contents

How to Use This Manual

This wiring guidelines manual was developed to reduce the installed cost of Siemens Industry energy management systems through consistent estimating, installation, and operation. It provides information that can be shared with electrical contractors for proposals and training purposes. This manual does not provide wiring guidelines for specific field devices.

This section covers manual organization, manual conventions and symbols used in the manual, how to access help, related publications, and any other information that will help you use this manual.

Manual Organization

This manual contains the following chapters:

- Chapter 1, *Wiring Regulations and Specifications*, contains Regulatory and general wiring requirements for installing APOGEE products.
- Chapter 2, *Network Electrical Systems*, contains communications wiring guidelines for various network systems and the power trunk.
- Chapter 3, *Field Panels*, describes the wiring guidelines for Automation Level Network (ALN) devices that are currently available for purchase.
- Chapter 4, *Equipment Controllers*, describes the wiring guidelines for Field Level Network (FLN) controllers that are currently available for purchase.
- The *Glossary* describes the terms and acronyms used in this manual.
- Appendix A, *Discontinued Products*, describes the wiring guidelines for discontinued ALN and FLN devices.
- An *Index* helps you locate information presented in this manual.

Manual Conventions

The following table lists conventions to help you use this manual in a quick and efficient manner.

Convention	Examples
Numbered Lists (1, 2, 3…) indicate a procedure with sequential steps.	1. Turn OFF power to the field panel. 2. Turn ON power to the field panel. 3. Contact the local Siemens Industry representative.
Conditions that must be completed or met before beginning a task are designated with a ▹. Intermediate results (what will happen following the execution of a step), are designated with a ⇨. Results, which inform the user that a task was completed successfully, are designated with a ⇨.	▹Composer software is properly installed. ▹A Valid license is available. 1. Select **Start** > **Programs** > **Siemens** > **GMS** > **Composer**. ⇨The Project Management window displays. 2. Open an existing project or create a new one. ⇨The project window displays.
Actions that should be performed are specified in boldface font.	Type **F** for Field panels. Click **OK** to save changes and close the dialog box.
Error and system messages are displayed in Courier New font.	The message `Report Definition successfully renamed` displays in the status bar.

Convention	Examples
New terms appearing for the first time are italicized.	The field panel continuously executes a user-defined set of instructions called the *control program*.
	This symbol signifies Notes. Notes provide additional information or helpful hints.
Cross references to other information are indicated with an arrow and the page number, enclosed in brackets: [→92]	For more information on creating flowcharts, see Flowcharts [→92].
Placeholders indicate text that can vary based on your selection. Placeholders are specified in bold print, and enclosed with brackets [ ].	Type **A C D H [username] [field panel #].**

Manual Symbols

The following table lists the safety symbols used in this manual to draw attention to important information.

Symbol	Meaning	Description
NOTICE	CAUTION	Equipment damage may occur if a procedure or instruction is not followed as specified. (For online documentation, the NOTICE displays in white with a blue background.)
	CAUTION	Minor or moderate injury may occur if a procedure or instruction is not followed as specified.
	WARNING	Personal injury or property damage may occur if a procedure or instruction is not followed as specified.
	DANGER	Electric shock, death, or severe property damage may occur if a procedure or instruction is not followed as specified.

Getting Help

For more information about APOGEE products, contact your local Siemens Industry representative.

Where to Send Comments

Your feedback is important to us. If you have comments about this manual, please submit them to SBT_technical.editor.us.sbt@siemens.com

Chapter 1—Wiring Regulations and Specifications

Chapter 1 discusses the following topics:

Regulatory Subjects

The wiring procedures described in this manual are based on the following:

- National Electrical Code (NEC) requirements, articles 250, 725, and 800
- Underwriter's Laboratories (UL) and Canadian Standards Association (CSA) listing requirements
- ANSI/TIA/EIA-862 Building Automation Systems (BAS) Cabling Standard for Commercial Buildings
- Electromagnetic Interference (EMI) issues
- Economic considerations

CAUTION

Always refer to local codes or the local authorities having jurisdiction before proceeding.

ATTENTION
Veuillez vous référer aux règlementations locales en vigueur avant toute intervention.

Specific details on cable usage and specifications can be found in these guidelines. In some cases, these guidelines are stricter than NEC or local requirements to avoid costly operational problems caused by EMI. This will improve customer satisfaction and decrease the total installed cost of a job by minimizing costly callbacks.

Third-party hardware, such as Digital Equipment Corporation equipment, purchased instrumentation, etc., should be wired according to the manufacturer's recommendations.

Circuit Classes

Article 725 of the NEC applies to building control system installations and defines different classes of circuits. As applied to Siemens Industry, Inc. Building Automation Systems, these are:

- Class 1 Remote Control Circuits
- Class 1 Power Limited Circuits
- Class 2 Power Limited Circuits
- Class 3 Power Limited Circuits

Class 1 Remote Control Circuits

Circuits not exceeding 600 volts, used for controlling equipment. Typically, this covers DO-type circuits used to control motors by energizing motor starters. These DO circuits are also used to control lights and other items through pilot devices such as relays or electro-pneumatic valves.

Class 1 Power Limited Circuits

Circuits not exceeding 30 volts and 1000VA. Typically, this covers power trunks.

Class 2 Power Limited Circuits

Circuits of relatively low power (such as 24 volts and up to 4 amps).

This covers the bulk of our circuits and includes the ALN communication wiring (Ethernet TCP/IP, P2/P3 RS-485, and MS/TP RS-485), all FLN bus wiring (P1 RS-485, LON, and MS/TP RS-485), 24 Vac power trunk wiring (with 100 VA power limit), and DI, AI, and AO circuits.

Class 3 Power Limited Circuits

Circuits of relatively low power but of higher voltage than Class 2 (such as 120 volts and up to 1 amp). This circuit would be achieved if 1 amp fuses were installed in a 120-volt DO-type circuit. This is not a common application.

See the *Field Purchasing Guide* for recommended wire. The wire listed in the *Field Purchasing Guide* has been selected to meet the requirements of the APOGEE product line.

Radio Frequency Transmitter Limitations

CAUTION

Keep devices that can generate Radio Frequency Interference (RFI), such as Electro-pneumatic devices (EPs), relays, and walkie-talkies, at least 12 feet (3.7 m) away from all field panels.

Conduit Sharing—Class 1/Class 2 Separations

NOTE:
Separate knockouts should be used for high voltage and low voltage wiring. Leave at least 2 inches (50.8 mm) of space between the Class 2 wires and other wires in the panel.

Conduit sharing guidelines are based on the National Electrical Code (NEC) requirements that apply to the installation wiring of building automation systems.

- All wire must have insulation rated for the highest voltage in the conduit and must be approved or listed for the intended application by agencies such as UL, CSA, FM, etc. Protective signaling circuits cannot share conduit with any other circuits.
- Class 2 point wiring cannot share conduit with any Class 1 wiring except where local codes permit.
- Where local codes permit, both Class 1 and Class 2 wiring can be run in the field panel enclosure, providing the Class 2 wire is UL listed 300V 75°C (167°F) or higher, or the Class 2 wire is NEC type CM (FT4) (75°C or higher) or CMP (FT6) (75°C or higher).
- NEC type CL2 and CL2P is not acceptable unless UL listed for other type and rated for 300V 75°C (167°F) or higher.
- All low voltage and high voltage wiring must be routed separately within an enclosure so that low voltage and high voltage wiring cannot come in contact with each other.

Network Wiring Location Restrictions

	CAUTION
	Only low voltage signal wiring should be run on a low voltage tray. Do not place I/O or trunk wire in a tray used to carry Class 1 power wiring.

Parallel Wire Runs

Cable tray spacing

The minimum space between adjacent trays or from a top tray to a lower tray.

Cable tray and conduit spacing

The minimum distance between a cable tray and adjacent conduit.

Conduit spacing

NOTE:
Use cable tray spacing for non-metallic conduit.

The minimum distance between adjacent conduit runs.

The following guidelines reflect the recommendations given in IEEE 518-1982 for locating network wiring in proximity to sources of interference:

- For (ALN) trunk AIs, AOs, and DIs with circuits greater than 120 volts and carrying more than 20 amps:
  - Cable tray spacing = 26 in. (660.4 mm)
  - Cable tray and conduit spacing = 18 in. (457.2 mm)
  - Conduit spacing = 12 in. (304.8 mm)
- For circuits greater than 1000 volts or greater than 800 amps:
  - Cable tray spacing = 5 ft (1.5 m)
  - Cable tray and conduit spacing = 5 ft (1.5 m)
  - Conduit spacing = 2.5 ft (0.8 m)

Grounding

The following topics are discussed in this section:

National Electrical Code Grounding Guidelines Compliance

Grounding must comply with National Electrical Code (NEC) guidelines for grounding of electrical equipment. Under no circumstances should equipment be installed in violation of local electrical codes. In most cases, NEC guidelines have been incorporated into local electrical codes.

Earth Ground Current Loops

Earth ground current loops can interfere with AI, DI, and AO circuits. Building electrical grounds connected to the automation system must be referenced to the same potential levels within a facility.

CAUTION

Conduit entering an enclosure must be grounded to the enclosure.

If a poor electrical connection is found, scrape off the paint under the conduit locknut, tighten the locknut, and retest.

Single Earth Ground for AI, DI, and AO Circuits

- AI, DI, and AO circuits cannot be earth grounded at two points.
- The earth ground reference point on the controlling Building Automation System (BAS) equipment is the only place where AI, DI, or AO can be earth grounded; this is dependent on circuit design.

Equipment Grounding System Requirements

Earth Ground Reference

The earth ground reference for all field panels and equipment controllers must be supplied via a third wire run with the AC power source providing power to that cabinet. All AC power sources must be bonded per NEC 250 unless isolation is provided between the cabinets.

Equipment Grounding Conductor

The NEC and some building authorities allow the use of conduit as the equipment grounding conductor. Field panels require a third wire or heavy wall conduit (with threaded connections) for the equipment grounding conductor. In addition to an equipment grounding conductor, you may use building steel or water pipes to bond AC power sources if these are part of the earth grounding system approved by the Local Building Authority.

When setting up an equipment grounding system, which consists of an equipment ground connected to an earth ground, you must provide a third wire equipment grounding conductor for any products of Siemens Industry. The equipment grounding conductor must connect to neutral at only one point in the system; that point is the neutral side of the transformer providing power to the equipment being installed. The hot, neutral, and third wire conductors must all be contained in the same conduit (see Figure Earth Grounding System [→ 17]). This third wire may be connected to earth at more than one point (that is, Siemens Industry does not require an isolated equipment grounding conductor).

Grounding of Isolation Transformers and Standby Power Systems

The installation of isolation transformers and standby power systems follow the same rules as equipment grounding requirements. Again, the neutral side of the locally derived power system must be tied to the nearest approved earth grounding system.

NEC Article 250 Specifications

NEC article 250 states that the path-to-ground from circuits, equipment and metal enclosures for conductors shall:

1. Be permanent and continuous
2. Have capacity to safely conduct any fault current likely to be imposed on it, and
3. Have sufficiently low impedance to limit the voltage-to-ground and to facilitate the operation of circuit protection devices.

The NEC requires that all loads on a power source have their neutral side referenced to the power source neutral and that the power source neutral be connected to the earth grounding system at *only one* point. This is very important in preventing ground loops. If building steel is not the shortest path, then you must use a water pipe or other earth ground as designated by the *local authority*. You may still connect to building steel, although the water pipe is your approved earth grounding reference; however, you cannot connect from your source to steel, and then to the water pipe. Each wire must be separate and of the correct gauge.

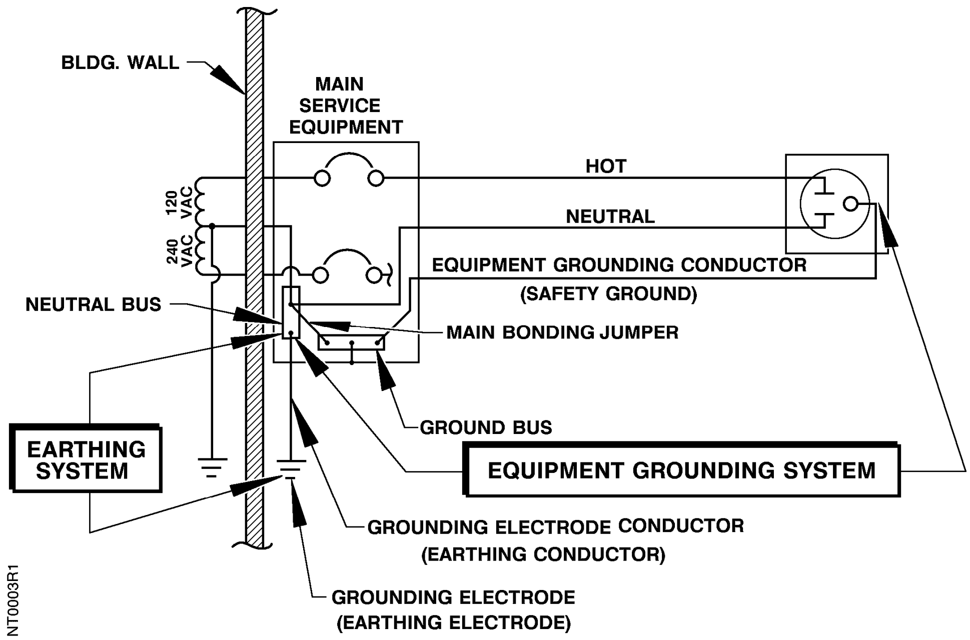


Figure 1: Earth Grounding System.

National Electric Code (NEC) Communications Requirements

The following topics are discussed in this section:

- Smoke and Flame Characteristics [→ 18]
- Common Grounding for Communication Circuits [→ 18]

Smoke and Flame Characteristics

The National Electrical Code (NEC) requires that communication and signaling cables in a building shall be listed for both smoke and flame characteristics suitable for the purpose.

Common Grounding for Communication Circuits

NEC Article 800 requires communications circuits to use a common ground. Use one of the following methods:

- Bond service grounds with No. 6 wire per NEC 250.
- Isolate communications circuits on separate services with an HSTIE or Fiber Optic Trunk Interface on each service.

NEC Article 800 covers communication wiring:

CMP	Use in plenums.
CMR	Use in risers.
CM	General purpose.

CMX	Residential and restricted commercial.

NEC Article 725 covers Class 1, Class 2, and Class 3 remote control, signaling and power limited circuits:

CL2P	Use in plenums.
CL2R	Use in risers.
CL2	General purpose.
CL2X	Residential and restricted commercial.

NEC Article 760 covers fire protective signaling systems.

FPLP	Use in plenums.
FPLR	Use in risers.
FPL	General purpose.

Multi-purpose cable types can be substituted for the cables listed in the applications shown above. The multi-purpose cable types are as follows:

MPP	Use in plenums.
MPR	Use in risers.
MP	General purpose.
PLTC	General purpose.

The following figure depicts the cable interchanges permitted by the NEC.

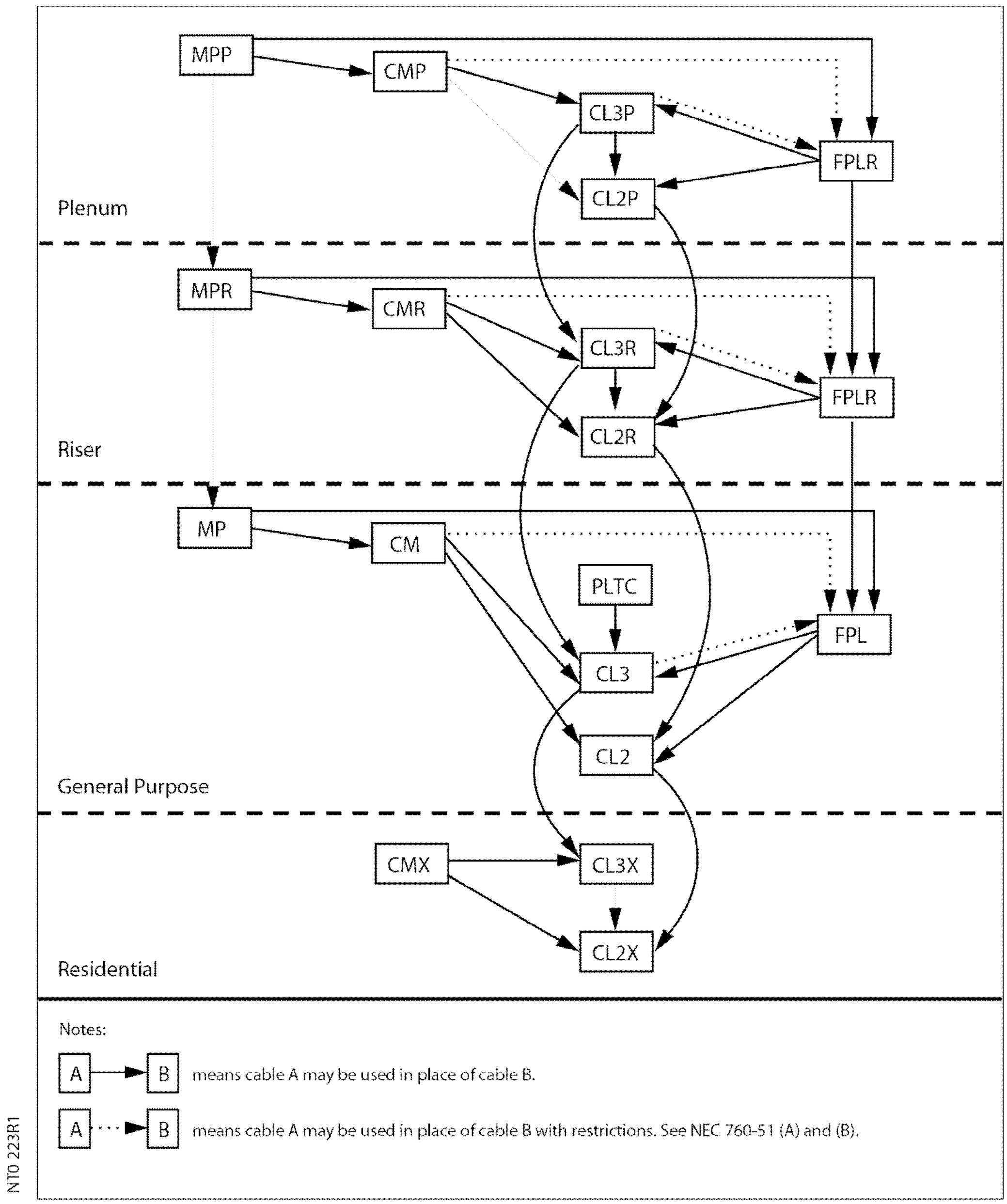


Figure 2: Interchanges Permitted by National Electric Code.

Conduit Fill

All wire must have insulation rated for the highest voltage in the conduit and must be approved or listed for the intended application by agencies such as UL, CSA, FM, etc.

The following tables contain wire specifications. For more information, see Circuit Classes [➙ 14] and Conduit Sharing–Class1/Class2 Separations [➙ 15] in this chapter and Using Existing Wiring [➙ 35] in Chapter 2.

Cables per Conduit Size – Siemens Industry Recommendation

Siemens Industry recommends a 40 percent conduit fill. Use the following table to determine the number of cables (twisted pairs and twisted shielded pairs) per conduit size at 40% fill. Plenum wiring can be used in place of any low voltage wiring without changes to length. The *Field Purchasing Guide* lists the outside diameter for each cable.

Conduit Fill.						
Outside Diameter*	Quantity in Conduit at 40% Fill					
	1/2" (12.7 mm)	3/4" (19.1 mm)	1" (25.4 mm)	1 1/4" (31.8 mm)	1 1/2" (38.1 mm)	2" (50.8 mm)
0.325" (8.255 mm)	1	3	4	7	10	16
0.3" (7.62 mm)	2	3	5	8	12	19
0.25" (6.35 mm)	2	4	7	12	17	27
0.225" (5.715 mm)	3	5	9	15	20	34
0.2" (5.08 mm)	4	7	11	19	26	43
0.175" (4.445 mm)	5	9	14	25	34	56
0.15" (3.81 mm)	7	12	20	34	46	76
0.125" (3.175 mm)	10	17	28	49	66	109

* Plenum-rated cable generally has a smaller diameter than equivalent non-plenum types. Check specific product tables in this chapter for specific applications where plenum cable must be used in conduit.

Cables per Conduit Size—NEC Requirements

NEC allowable conduit fill is 53 percent for 1 conductor, 31 percent for 2 conductors, and 40 percent for 3 or more conductors. Use the following table to determine the number of cables (twisted pairs and twisted shielded pairs) per conduit size in accordance with NEC fill requirements. The *Field Purchasing Guide* lists the outside diameter for each cable.

- Protective signaling circuits cannot share conduit with any other circuits.
- Class 2 circuits cannot share conduit with Class 1 circuits except as noted.

Nominal Conduit Fill—NEC Requirements.							
Insulated Conductor	Conduit I.D. Area	Quantity in Conduit [2]					
O.D. (inches) [1]	Conductor Area (sq. in.)	1/2" EMT 0.622 0.304	3/4" EMT 0.824 0.533	1" EMT 1.049 0.864	1-1/4" EMT 1.380 1.496	1-1/2" EMT 1.610 2.036	2" EMT 2.067 3.356
0.400	0.126	1	1	2	5	6	10
0.390	0.119	1	1	3	5	7	11
0.380	0.113	1	1	3	5	7	12
0.370	0.108	1	1	3	5	7	12
0.360	0.102	1	1	3	6	8	13
0.350	0.096	1	1	3	6	8	14
0.340	0.091	1	2	4	6	9	15
0.330	0.086	1	2	4	7	9	15
0.320	0.080	1	2	4	7	10	16
0.310	0.075	1	3	4	8	11	18
0.300	0.071	1	3	5	8	11	19
0.295	0.068	1	3	5	8	12	19
0.290	0.066	1	3	5	9	12	20
0.285	0.064	1	3	5	9	13	21
0.280	0.062	1	3	5	9	13	22
0.275	0.059	1	3	6	10	13	22
0.265	0.055	1	4	6	11	15	24
0.255	0.051	2	4	7	11	16	26
0.245	0.047	2	4	7	12	17	28
0.235	0.043	3	5	8	14	19	31
0.225	0.040	3	5	8	15	20	33
0.215	0.036	3	6	9	16	22	37
0.205	0.033	3	6	10	18	24	40
0.195	0.030	4	7	11	20	27	45
0.185	0.027	4	8	13	22	30	50
0.175	0.024	5	9	14	25	34	56
0.165	0.021	5	10	16	28	38	63

Nominal Conduit Fill—NEC Requirements.							
Insulated Conductor	Conduit I.D. Area	Quantity in Conduit [2]					
0.155	0.019	6	11	18	31	43	71
0.145	0.017	7	13	21	36	49	81
0.135	0.014	8	15	24	42	57	94
0.125	0.012	10	17	28	48	66	109
0.115	0.010	11	20	33	57	78	129
0.105	0.009	14	24	40	69	94	155
0.095	0.007	17	30	49	84	115	189
0.085	0.006	21	37	61	105	143	236
0.075	0.004	27	48	78	135	184	304
0.065	0.003	36	64	104	180	245	404

1) Plenum rated cable generally has a smaller diameter than equivalent non-plenum types. Check the tables in this section for specific applications where plenum cable must be used in conduit.

2) Based on NEC guidelines. Allowable fill: 53% for 1 conductor, 31% for 2 conductors, and 40% for 3 or more conductors.

General Wiring Guidelines

When installing an APOGEE Automation System in a building that is already equipped with a Building Automation System (BAS), the existing wiring can be used if the general guidelines in this section and the specific guidelines in Chapter 2—Network Electrical Systems [→ 30]are followed.

In many instances, existing conductors in a building may also be used for the trunk as long as they meet the requirements listed in the Network Electrical Systems [→ 30] chapter.

- Only APOGEE low voltage input signals are present in multi-pair cables.
- Multi-pair cable containing inductive loads is not shared with any APOGEE trunk or input wiring.
- All wiring, equipment controllers, and field panels are at least 5 ft (1.5 m) away from power sources greater than 100 kVA.

NOTE:
Verify motor generator size. Direct on line (DOL) starters for motors greater than 25 hp generally exceed 100 kVA.

- All equipment controllers and field panels are at least 5 ft (1.5 m) away from variable speed drives and variable frequency drives.
- Wire runs are limited to the lengths shown in specific product tables in this guide.
- Twisted pair or twisted shielded pair cable is used according to the specific product tables in this guide.

- Conduit-sharing rules in specific product tables in this guide are used.

No electrical equipment such as PEs, EPs, relays, etc., can be mounted and wired in any APOGEE field panel or equipment controller unless it is specifically mentioned in the product literature. This equipment can radiate electrical noise to the circuit boards. The metal enclosure of the control cabinet will shield the electronics from equipment outside the enclosure.

Controlling Transients

Any sensor or communication wiring that is exiting a building must have transient protection; effective protection requires proper wiring (grounding). Where protection is needed, use the parts listed in the following table.

MOV Part Numbers.		
Part Number	Description	Application
540-248	MOV (3)60V Ipk 1200 amp	(25 pack) 3 MOV pre-twisted for use on 24 Vac 3-wire power terminals.
550-809 P10	MOV 60V Ipk 4500A	(10 pack) MOV with ¼-inch spade terminals for use across flow switch power in VAV boxes.

The parts listed in the following table must be ordered from an external supplier.

MOV Information—Order from an External Supplier.	
Description	Application
MOV 30V IpK 2000 amp	24 Vac input power for use at transformer with earth grounded secondary neutral.
MOV 60V IpK 1200 amp	TEC damper/actuator 24 Vac outputs.
MOV 150V IpK 6500 amp	For use across the power line in 102V - 132V applications.
MOV 208 – 250V IpK 1200 amp	Termination boards or Controllers with on board digital outputs that do not have MOVs should use this part across the digital outputs. Not for use across power lines. Products without digital output MOVs: DXR2, PTM6.2Q250(-M) and TXM1.6R(-M). Products with digital output MOVs: Compact, ATEC, TEC, BTEC, PTEC
MOV 275V IpK 2500 amp	For use across the power line in 180V - 265V applications.
Receptacle Assembly with MOVs	Duplex 15A or 20A outlet with three 150V IpK 6500 MOVs configured for 102 - 132V across the line applications (two line-to-line MOVs and one line-to-earth ground MOV).
Ground Wire	12AWG with captive screw, for connecting 24 Vac neutral from Transformer to grounded enclosure chassis Protective Earth (PE) “ ” attachment point, or for connecting Equipment Controller “E” or “GND”, or Field Panel “ ” to enclosure chassis in locations with high levels of electrical noise that interfere with controller operation.

Network Terminators

Terminate Networks were required using following parts.

Terminator Part Numbers.		
Part Number	Description	Application
550-975P100	3-Wire Network Terminator, Pkg. of 100	The 3-wire network requires a new network terminator. The new terminator is a 120 ohm 1/2W carbon composition resistor. One terminator must be placed at each end of the 3-wire network section.
550-974P10	3-Wire Network RS-485 Reference Terminator, Pkg. of 10	The nodes that use a 3-wire network interface must have the RS-485 reference wire (yellow) of the network cable terminated to EARTH GROUND at ONE END ONLY through an RS-485 reference terminator.
538-664	PMD Trunk Terminator	The 2-wire P2 network terminator is a 120 ohm 1/2W carbon composition resistor in series with two surge diodes forming a capacitor. One terminator must be placed at each end of the 2-wire network section.
985-124	499 OHM RESISTOR ASSEMBLY KIT	Converts 4 – 20 mA to 2 – 10 V input signal for devices that do not have current inputs. Consists of 499 Ohm, ½ W, 1% metal film resistor with 4 ½” 18 AWG 300V insulated leads.

Wire Specification Tables

NOTE:
Wire that meets these specifications can be ordered from the *Field Purchasing Guide* under Siemens Industry corporate pricing agreements.

ALN, FLN, and TX-I/O IBE 3-Wire Cable.*	
Cable configuration	1.5-Pair (1 TP and 1 Conductor) w/overall Shield and drain wire
Gauge	24 AWG (stranded)
Capacitance	12.5 pf/foot or less
Twists per foot	4 minimum

ALN, FLN, and TX-I/O IBE 3-Wire Cable.*	
Shields	100% foil with drain wire
NEC class	UL listed, CM, CMP (75°C or higher)
CEC class	FT4, FT6 (75°C or higher)

*Required for ALN, FLN, and BACnet MS/TP networks that use the new 3-wire interface, (⏚ - +); preferred for TX-I/O island bus expansion. For PXC Compact, PXC Modular, P1 BIM, and BACnet equipment controllers, use the Network Wiring Requirements Decision Tree [→ 38] in Chapter 2 to determine if 1.5-pair or 1-pair cable should be used.

ALN, FLN (P1), Point Expansion Trunk, and TX-I/O IBE.*	
Cable configuration	Twisted shielded pair (TSP)
Gauge	24 AWG (stranded)
Capacitance	12.5 pf/foot or less
Twists per foot	4 minimum
Shields	100% foil with drain wire
NEC class	UL listed, CM, CMP (75°C or higher)
CEC class	FT4, FT6 (75°C or higher)

*For use with older 2 -wire networked products. (TEC, SCU, MEC, PXM, MBC). May be used for TX-I/O island bus expansion.

Class 1 Power Trunk.*	
Cable configuration	3 conductor
Gauge	12 AWG or 14 AWG THHN
UL type	THHN

*Circuit breaker sizes: 20 amp for 12 AWG THHN and 15 amp for 14 AWG THHN. Assumes minimum voltage of 102 Vac at circuit breaker and 5 Vac maximum voltage drop (97 Vac at loads).

Class 2 Power Trunk.	
Cable configuration	2 conductor
Gauge	14 AWG, 16 AWG, 18 AWG, 20 AWG
UL type	CL2, CL2R, CL2P
CSA type	FT4, FT6

Class 2 for Point Usage Only (in Conduit and per Local Codes).*	
Cable configuration	Twisted pair (unjacketed) or TSP
Gauge	No. 18 to No. 22 AWG (stranded)
Capacitance	N/A
Twists per foot	4 minimum
Shields	Not required (in case of TSP, 100% foil with drain wire)
UL (CSA) listed voltage rating	300 Vac
UL (CSA) listed temperature rating	75°C (167°F) or higher

*300 Vac wire can be used in field panels containing voltages below 150 Vac.

Class 2 for Low-Voltage Applications Only (Except Trunk).	
Cable configuration	Twisted pair or Twisted shielded pair (TSP)
Gauge	No. 18 to No. 22 AWG (stranded)
Capacitance	N/A
Twists per foot	4 minimum
Shields	Not required (in case of TSP, 100% foil with drain wire)
UL type	CM, CMP, CMR (75°C or higher)
CSA type	FT4, FT6 (75°C or higher)

Ethernet Basic Link.	
Cable configuration	4 Unshielded Twisted Pair (UTP)
Gauge	24 AWG (solid)
Capacitance	17 pf/foot @ 1 KHz, 1 MHz
IEEE 802.3	Category 5e or better
Shields	Optional where required
UL type	CM, CMP, CMR (75°C or higher)
CSA type	FT4, FT6 (75°C or higher)

Ethernet Patch Cable.	
Cable configuration	2 or 4 Unshielded Twisted Pair (UTP)
Gauge	24 AWG (stranded)
IEEE 802.3	Category 5e or better
UL type	CM, CMP, CMR (75°C or higher)
CSA type	FT4, FT6 (75°C or higher)

Punch Down Block Jumper Cable.	
Cable configuration	1 Unshielded Twisted Pair (UTP), no jacket
Gauge	24 AWG (solid)
IEEE 802.3	Category 5e or better
UL type	CM, CMP, CMR (75°C or higher)
CSA type	FT4, FT6 (75°C or higher)

LON Networking Wiring.	
Cable configuration	Unshielded or shielded pair
Gauge	22 AWG (stranded)
Capacitance	17 pf/foot @ 1 KHz, 1 MHz

LON Networking Wiring.	
UL type	CM, CMP, CMR (75°C or higher)
CSA type	FT4, FT6 (75°C or higher)

TX-I/O Island Bus Wiring.*	
Cable configuration	1 Twisted Shielded Pair (TSP) + 1 Twisted Shielded 3C (Triad) -or- 1 Twisted Shielded 4C -or- 2 Twisted Pair (TP)
Gauge	14 or 16 AWG (stranded)
Capacitance	54 pf/ft or less
Twists per foot	3 to 4
Shields	100% foil with drain wire (except TP)
NEC class	UL listed, CM, CMP (75°C or higher)
CEC class	FT4, FT6 (75°C or higher)

*See TX-I/O Island Bus Guidelines [➔ 95] in Chapter 3 for cable configuration.

Chapter 2—Network Electrical Systems

Chapter 2 discusses the following topics:

Dual Port Ethernet Controller Topology Basics

The most important aspect of dual port Ethernet controller topology is that it meets the requirements of the application with regard to fault tolerance.

- Fault Tolerant Loop (Ring) Topology with Spanning Tree Protocol (STP)
- Issues with Non-Fault Tolerant Line (Chain) Topology
- Fault Tolerant Loop (Ring) Topology with Rapid Spanning Tree Protocol (RSTP)
- Fault Tolerant Star (Home Run) Topology

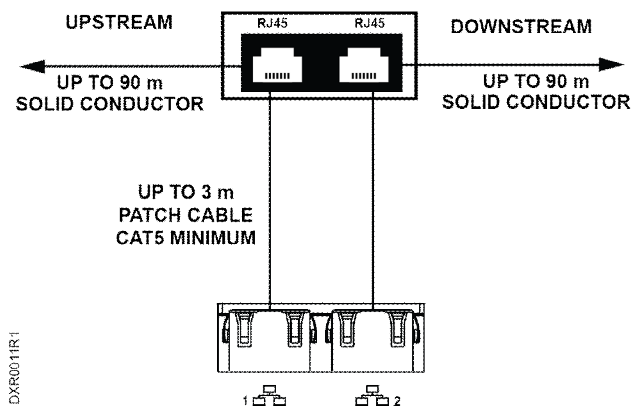


Figure 3: Dual Ethernet Connection Using Up to 90m Solid Copper Cable and Jack Boxes.

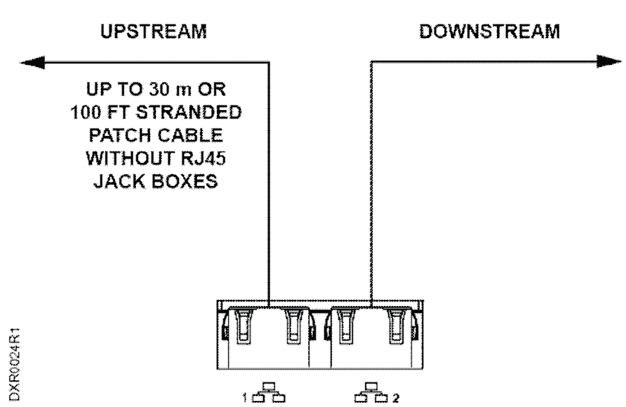


Figure 4: Dual Ethernet Connection Using Up to 30m Stranded Copper Patch Cables.

Requirements for Fault Tolerant Loop Topology with STP

- Controllers include embedded 3 port switch supporting STP and one IP Address
- Loop of up to 8 controllers installed in a line configuration with maximum cable distance of 810 m (2655 ft) consisting of 9 × 90 m (295 ft) runs between RJ45 jacks
- Managed Ethernet switches with STP support complete the loop configuration providing active 10/100BaseTX switch ports at each end of the controller line
- Forwarding is enabled on switch port connected to first controller upstream port 1
- Forwarding is disabled (blocking) on switch port connected to the last controller downstream port 2 to prevent loop from creating communication storm
- Controller fault such as power loss, malfunction or disconnect from the RJ45 jacks causes blocking switch port to changes state to forwarding so that downstream controllers are reconnected
- Controller fault correction causes downstream switch to resume blocking
- Network management using Internet Group Management Protocol (IGMP) allows alarming as otherwise, a line failure by the customer remains unknown
- Multiple STP loops may be installed in parallel as long as no two loops exceed 17 controllers
- No third-party devices or other switches will be installed in the loop

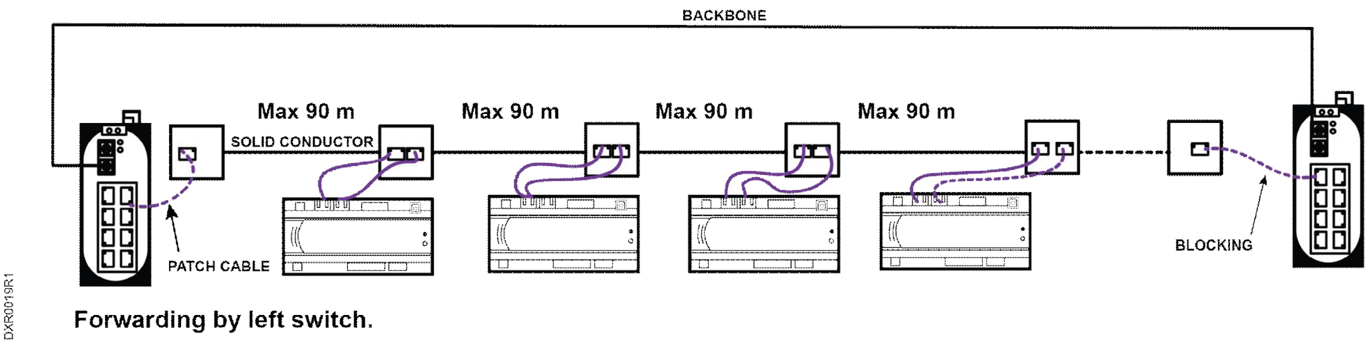


Figure 5: Wiring Diagram one Line of up to 8 Dual Port Ethernet Controllers within a STP Loop Configuration (fault tolerant).

Issues with Non-Fault Tolerant Line Topology

- Controller fault such as power loss, malfunction or disconnect from the RJ45 jacks causes all downstream controllers to lose connectivity until fault is corrected
- No network management for alarming a line failure so the fault location and status remains unknown by Customer

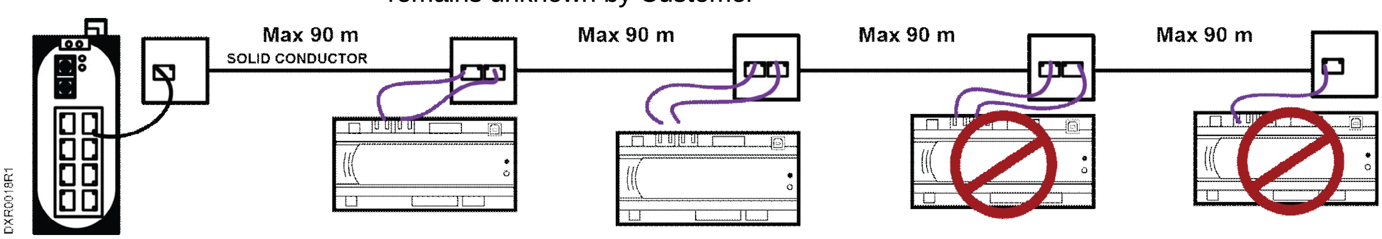


Figure 6: Wiring Diagram one Line of Dual Port Ethernet Controllers (not fault tolerant downstream will lose connectivity).

Requirements for Fault Tolerant Loop Topology with RSTP

- Ethernet Bridges and Managed switches with support for RSTP.
- RSTP is interoperable with dual port Ethernet controllers which include embedded 3 port switch supporting STP and one IP Address

- RSTP allows larger loops of up to 20 controllers installed in a line configuration with maximum cable distance of 1890 m (6200 ft) consisting of 21 x 90 m (295 ft) runs between RJ45 jacks
- RSTP allows faster 10-30 second network fault recovery using discarding port
- Network management using Internet Group Management Protocol (IGMP) allows alarming as otherwise, a line failure by the customer remains unknown
- Multiple STP loops may be installed in parallel in RSTP configuration as long as no two loops exceed 40 controllers
- No third-party devices or other switches will be installed in the loop (BPDU messages must be transmitted transparently to the management switch)

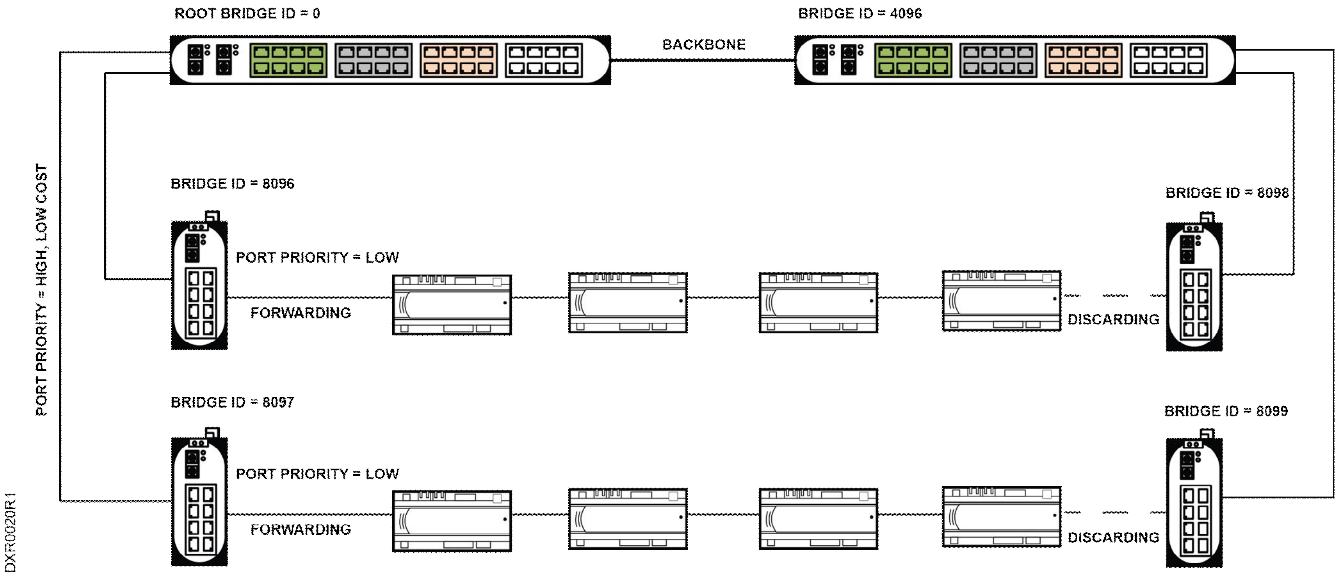


Figure 7: Logical Diagram multiple Lines of up to 20 Dual Port Ethernet Controllers within a RSTP Configuration (fault tolerant).

Requirements for Fault Tolerant Star Topology

- Ethernet switches must provide one active 10/100BaseTX port for each controller
- Maximum cable distance 90m between RJ45 jacks at switch and controller
- Switch active port connects to controller upstream port 1
- Controller downstream port 2 is not used
- Switch ports must be active at time of BACnet/IP commissioning
- Controller fault does not impact other controllers

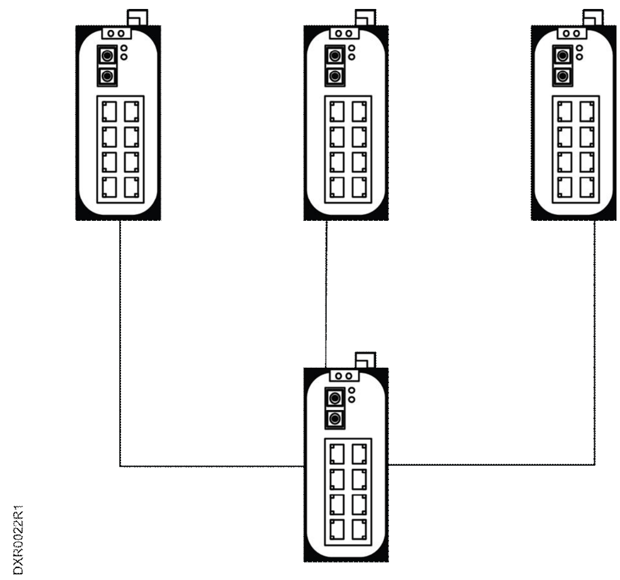


Figure 8: Star Topology requires one switch port for each controller.

Ethernet Communications Wiring

Preferred Cable Type

Standard TIA/EIA 802.3 (IEEE Std 802.3 or ISO/IEC 8802-3) provides background material on the basic functioning of the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) packet network. Wiring guidelines for TIA/EIA 802.3 links are described in *ANSI/TIA/EIA-568-B.1*, *Commercial Building Telecommunications Cabling Standard* and *ANSI/TIA/EIA-606 Cabling Administration*.

To minimize risk and reduce installed costs of Ethernet communications wiring, use the cables listed in the following table for all estimates and installations.

Preferred Cable Type.				
Equipment	**Connection Requirements**	**Basic Link ***	**Patch Cable***	**Jacks and Patch Panels**
• MLN • ALNs: – Ethernet – BACnet/IP – AEM • Hubs • Switches • Routers • Network Interface Card	10Base-T (10 Mbps)	IEEE 802.3 Category 3 certified solid cable or better, terminated in the field panel or at the computer with a standard RJ-45 jack.	IEEE 802.3 Category 3 certified stranded cable or better.	IEEE 802.3 Category 3 certified RJ-45 connectors or better.
	100Base-TX (100 Mbps)	IEEE 802.3 Category 5e certified solid cable or better, terminated in the field panel or at the computer with a standard RJ-45 jack.	IEEE 802.3 Category 5e certified stranded cable or better.	IEEE 802.3 Category 5e certified RJ-45 connectors or better.

*See Wire Specification Tables [→ 25] in Chapter 1.

MLN—Workstation to Ethernet Wiring

The Insight server and client workstations operate a Management Level Network (MLN) connected directly to an Ethernet network. The Ethernet type is TCP/IP running at 10Base-T minimum including connections between each switch. See Figure *Workstation to Ethernet Wiring*.

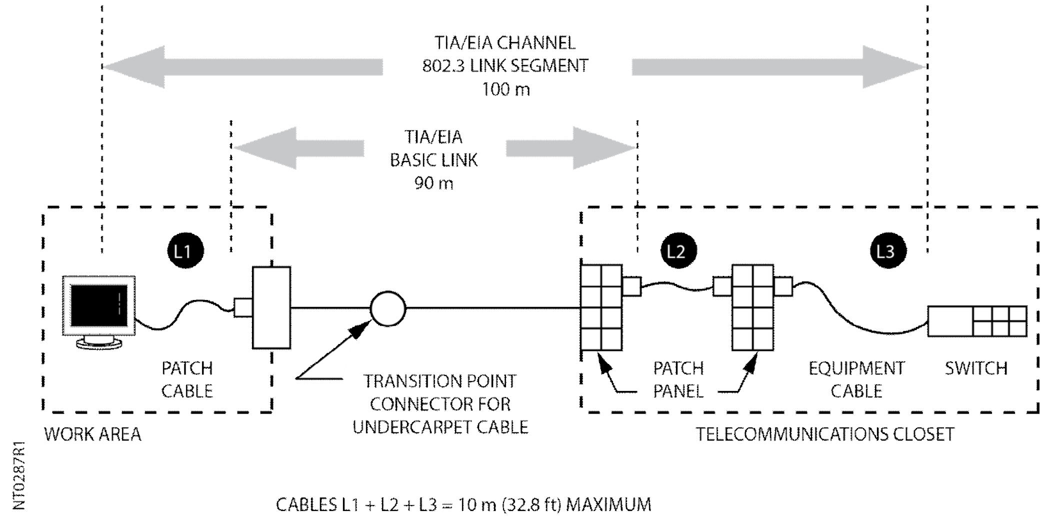


Figure 9: Workstation to Ethernet Wiring.

ALN—Workstation to Field Panel Ethernet Wiring

The Insight server and client workstations operate a Management Level Network (MLN) connected directly to an Ethernet network. The Ethernet type is TCP/IP running at 10Base-T minimum including connections between each switch. See Figure *Workstation to Ethernet Wiring*.

Ethernet/IP ALN

APOGEE Ethernet/IP uses a TCP/IP-based Automation Level Network (ALN) that communicates over a customer Ethernet cabling and IP network to reduce overall system and maintenance costs. Otherwise, system operation is identical to existing RS-485 ALN installations. See the Table Preferred Cable Type [→ 33] for Ethernet ALN cabling requirements. Wiring from the Ethernet switch to the Insight workstation or BACnet/IP field panel uses the same wiring guides as the MLN. See the section MLN—Workstation to Ethernet Wiring [→ 34] in this chapter.

BACnet/IP ALN

The BACnet client supports communication with BACnet devices over Ethernet or TCP/UDP.

Wiring from the Ethernet switch to the Insight workstation or BACnet/IP field panel uses the same wiring guides as the MLN. See the section MLN—Workstation to Ethernet Wiring [→ 34] in this chapter. Cabling requirements are the same as for Ethernet ALN devices; see the Table Preferred Cable Type [→ 33].

APOGEE Ethernet Microserver (AEM)—Remote ALN

The APOGEE Ethernet Microserver (AEM) allows a single field panel to be connected directly to an Ethernet network. This AEM field panel may host an RS-485 up to a maximum of 99 RS-485 field panels. See the following figure for an example of an AEM layout.

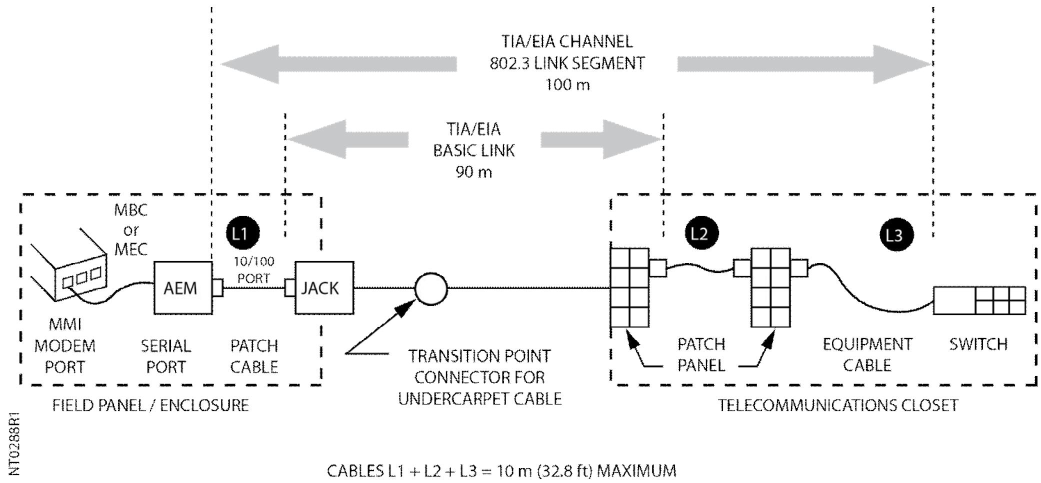


Figure 10: Workstation to Ethernet Wiring Using an AEM.

The AEM uses the TCP/IP communications protocol and connects to Ethernet via a 100Base-TS or 10Base-T half duplex switch or switch port and to the APOGEE field panel via the RS-232 modem port. The AEM can auto-connect to 10Base-T or 100Base-TX half duplex switch port (switch speed should be fixed).

NOTE:
Actual communication speed of hosted RS-485 ALN is 38400 bps so it is recommended to keep the number of hosted field panels to 40 and to monitor resident BATT point to ensure fastest recovery after power loss.

Using Existing Wiring

CAUTION

Configure IP addresses or DHCP names before plugging the AEM into the 10Base-T or 100Base-TX connector.

Existing Category 3 Ethernet wiring may be used, but connection is limited to 10Base-T. Category 5e or better cables (basic link, L1, L2, L3), jacks, and patch panels allow 100Base-TX operation with appropriate network equipment and are recommended for new installations. The solid copper basic link must be pulled into the field panel and terminated with an RJ-45 jack and connected to the AEM with an L1 patch cable. All wiring and connections should be certified Category 5e or better by the vendor.

RS-485 MS/TP Communications

Inter-node protocol communications on P1, P2 and BACnet MS/TP networks take place over RS-485 physical media.

- This media is defined as a 2-wire half-duplex, differential multipoint serial connection.
- The EIA standard also specifies a third wire interconnection.
  - This third wire connection is important to maintaining signal integrity in systems encompassing large networks in electrically noisy environments.
  - In some cases, the third wire reference is earth ground. In other cases, an actual third reference wire is run between all nodes.

Isolation may also be provided between the controller main electronics (earth referenced side) and the network. Interoperability between nodes with different grounding schemes and isolated versus non-isolated can be maintained by using guidelines discussed in this section.

Operating in Electrically Noisy Environments

Non-isolated network interfaces that are referenced to earth at each node are much more susceptible to noise due to differences in the earth ground potential. Large equipment often injects noise into the earth grounding system when starting, stopping, or changing speeds. (VFDs, with their carrier frequencies of 3 to 10 KHz and high harmonics, are right in the RS-485 communications baud rate band.)

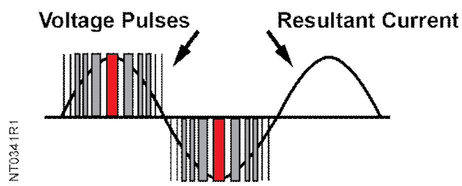


Figure 11: PWM Waveform Phase A to B.

Local surges from lighting and power grid switching cause more noise. If this noise is over the common mode voltage acceptable by the RS-485 interface circuits, it causes interruptions in communications.

3-wire RS-485 Network Interfaces

In order to provide higher noise immunity and high data reliability, the network interfaces for Siemens Industry RS-485 interfaces now provide the RS-485 common reference signal in the network interface connector. Older 2-wire interfaces provided the +/- signal lines and Earth (or in some cases just a convenient tie point (FLN devices)). By providing the RS-485 circuit common reference signal, all 3-wire nodes wired using a new 1.5-pair shielded cable are referenced together.

The older 2-wire circuit uses a capacitive connection to earth as the reference, which is more susceptible to earth ground noise. 2-wire connections are still supported per the Network Wiring Requirements Decision Tree, but 3-wire connections are highly recommended, especially for all new interfaces that provide a true 3-wire connection.

The use of 1-pair or 1.5-pair cabling is not a requirement of the RS-485 protocol. It is a result of the electrical interface, which was changed starting with the PXC Compact, PXC Modular, and P1-BIM.

Using Cimetrics Routers on an APOGEE BACnet MS/TP Network

NOTE
Cimetrics routers may only be used for non-smoke control applications.

Although Cimetrics BACnet routers are not the preferred solution, they may be used on an APOGEE BACnet MS/TP network. In order for Cimetrics routers to work properly, they must be wired as shown in the following illustration.

- Only one router is allowed per isolated network section and it must be an end device.
  - Limiting each isolated network section to one router and using 1.5-pair cable with the reference connection near the router minimizes the voltage difference between the two ground references.
  - The limitation of one router per network section is due to the type of environment in which the controllers are normally installed. Very few APOGEE network installations can be considered electrically quiet. For example, a small-sized office environment may be electrically quiet.
- The Cimetrics router's RS-485 circuitry is **not** earth grounded unless the paint on the chassis is removed and the chassis is then connected to earth.
  - In addition, an internal "Z" jumper must be removed to help ensure that the RS-485 circuit is isolated from earth.
  - In order to keep the Cimetrics router an isolated device, **do not** tie the chassis to earth.
- If Polycool devices are used on the network, do not enable the line termination feature.
- 1.5-pair cable is highly recommended. Using 1 TSP cable reduces noise immunity.
- The following must be done if single-pair cable is used:
  - The network must be terminated with 120 ohm resistors (550-975P100).
  - Do not tie the shield to the third terminal on the network plug. Instead, use a wire-nut to bypass the shield and make a continuous shield connection as shown in the following figure.

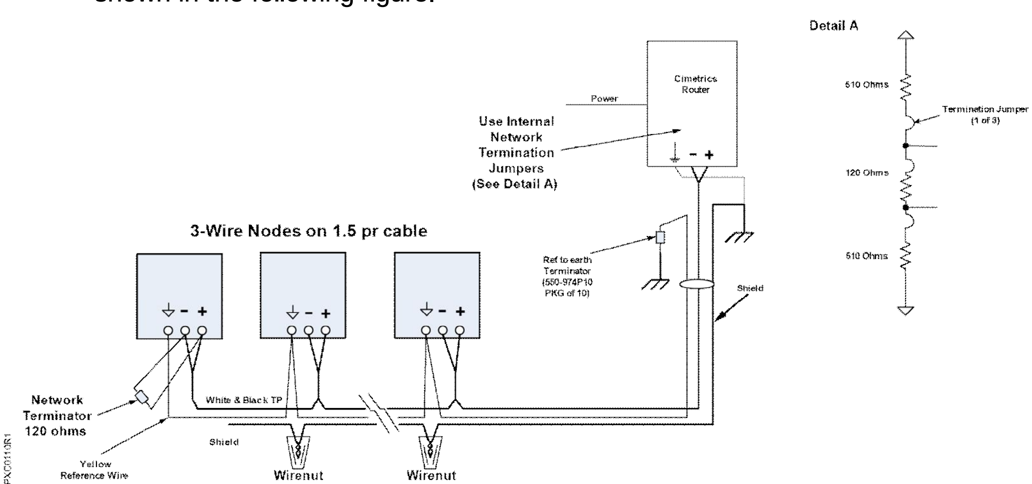


Figure 12: Using Cimetrics Routers on an APOGEE BACnet MS/TP Network.

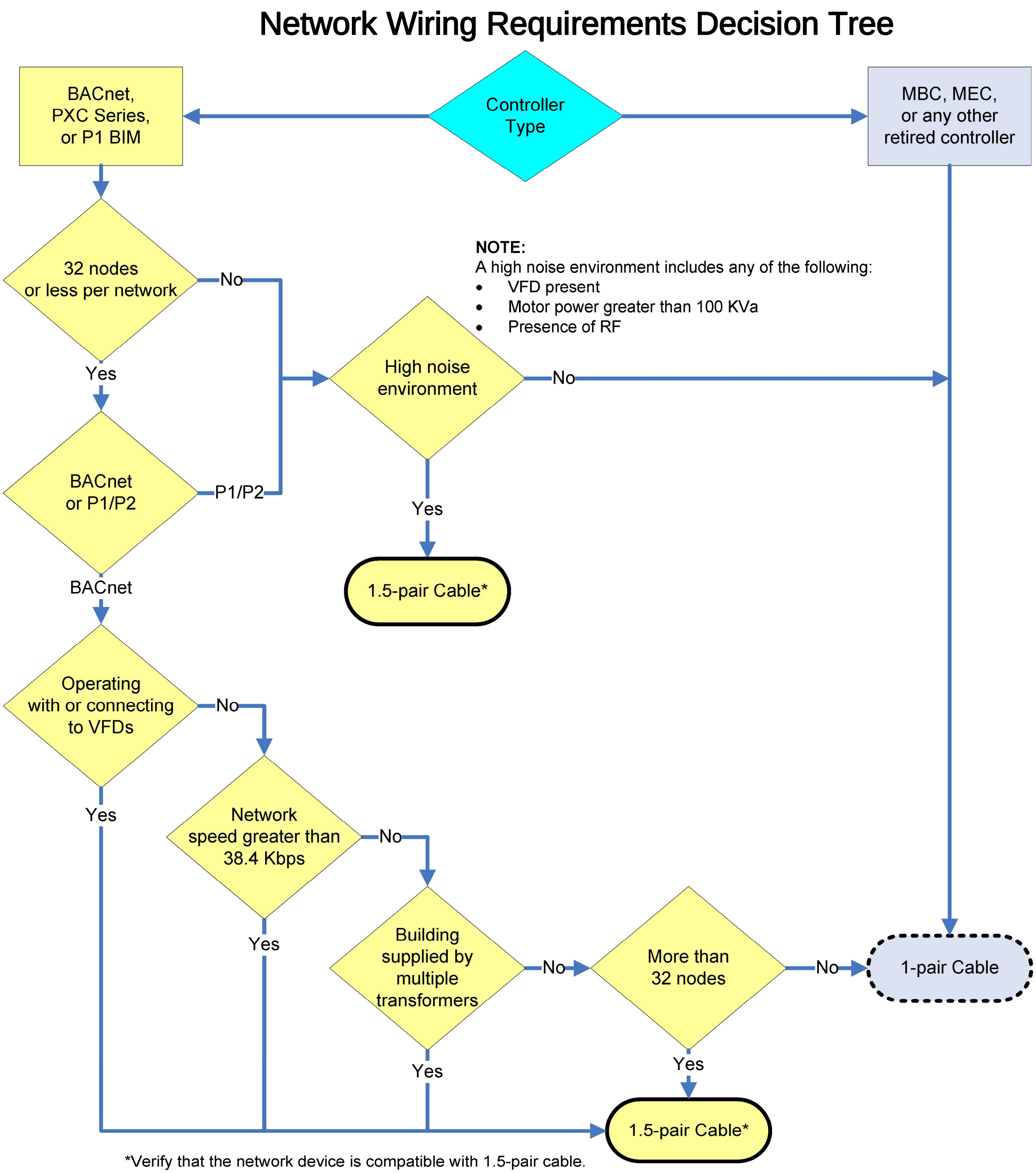


Figure 13: Network Wiring Requirements Decision Tree.

3-Wire Interface Nodes

NOTE:
The wiring method for devices with a 3-wire interface is the same whether they are on a BACnet ALN or FLN.

The following table outlines the Siemens Industry devices that were re-released with 3-wire RS-485 network interfaces.

3-Wire RS-485 Network Interface Terminal Wiring (Using 1.5-Twisted Shielded Pair Cable).				
Product Name	**Network Protocol** [2]	**Terminal Usage** [3]	**Terminal for 2-Wire** [4]	**Network Electrical Loading** [1]
DXR2.M	BACnet MS/TP	⏚- +	---	1/8
BACnet Actuator (550-430, 550-431)	BACnet MS/TP	⏚- +	E	1/8
BACnet Short Platform (550-432, 550-433)	BACnet MS/TP	⏚- +	E	1/8
BACnet Long Platform (Updated Version) (550-490, 550-491, and 550-492)	BACnet MS/TP	⏚- +	E	1/8
PXC Compact	ALN/FLN (P2, P1, MS/TP)	⏚- +	⏚	1/8
PXC Modular	ALN/FLN (P2, P1, MS/TP)	S - +	⏚	1/8
P1-BIM (TXB1.P1, TXB1.P1-4)	FLN (P1)	S - +	---	1/8

1) RS-485 spec allows for 32 electrical loads on a section of network cabling (a network repeater allows for more devices). Electrically 32 full loads (factor 1) have same resistance as 256 x 1/8 load devices.

2) RS-485 communication traffic and speed will limit number of MSTP devices per ALN/FLN, refer to BACnet Application Guide. Typical limit is 10 devices for MSTP ALN while limit is 50 devices per MSTP FLN at 76800 bps.

3) RS-485 network common may be marked with S, but functions as ⏚.

4) Terminal must be connected to earth ground for compatibility with 2-wire (1-Twisted Shielded Pair) cable.

1.5-Pair Network Cable

The network cable recommended for use with the 3-wire (isolated RS-485 common) is a single pair cable with third wire (1.5-pair) that is used to tie the RS-485 reference (communication common) of all the nodes on the network together.

All the Siemens Industry products listed in the Table *3-Wire RS-485 Network Interface Terminal Wiring (Using 1.5-Pair Cable)* use the 3-wire interface.

- By providing the RS-485 ground signal of the interface to the network termination plug, all node communication ports can be referenced together providing a high degree of noise immunity.

- The RS-485 common reference wire is terminated at one point (and only one point) to earth ground.
- An overall foil shield and drain wire provide additional noise protection.

The 1.5-pair cables can be found in the *Field Purchasing Guide*, section 14-01 (http://iknow.us009.siemens.net/fpg/sec14-01/default.asp). See the following table.

- Contact the cable supplier listed in the *Field Purchasing Guide* for availability. Some cable may be special order if it has never been stocked.
- The decision to use the orange jacket cable or orange jacket with blue stripe cable is up to the user/customer. The only difference in the cables is the addition of the blue stripe, which can be useful to indicate a different protocol usage.

Recommended 1.5-Pair Cable Types.			
Cable type	**Plenum Rating**	**Description**	**Use**
1.5-pair	plenum	orange jacket with blue stripe	FLN
1.5-pair	non-plenum	orange jacket with blue stripe	FLN
1.5-pair	plenum	orange jacket	ALN
1.5-pair	non-plenum	orange jacket	ALN

In all cases, cable impedance is 120 ohms.

1.5-pair cable is highly recommended for installation in electrically noisy environments, such as near VFDs, large inductive loads, high voltage circuits greater 480 Vac, and any time the network is expected to cross a building earth ground differential (between two connected buildings that may have slightly different earth ground potentials). See the Network Wiring Requirements Decision Tree [→ 38] for recommended cable usage.

- For any new installation, the choice of cable should be made for the entire network.
- It is not acceptable to switch back-and-forth between 1-pair and 1.5-pair cable.
- The use of the shield as the third wire is prohibited.
- When using a 1-pair cable on devices with the 3-wire interface, the shield should be daisy-chained through the controller and not connected to the "S" pin or ⏚. The shield bypasses the controller using wire nuts to continue the shield.

1.5-pair Cable Specifications

Table 1:

1.5-pair Cable Specifications.	
Twisted Pair	
• Gauge	24 AWG (stranded)
• Capacitance	12.5 picofarad/foot (conductor to conductor) 24 picofarad/foot (conductor to shield)

1.5-pair Cable Specifications.	
• Twists per foot	4
Reference Wire	24 AWG stranded, 3 inch lay with twisted pair
Shield	100% overall foil

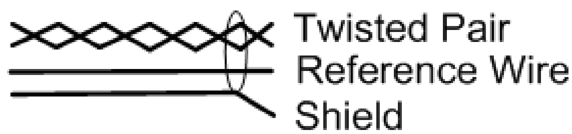


Figure 14: Figure. 1.5-pair Cable.

Network Loading

The RS-485 specification allows 32 full load devices on a section of network cable before a repeater is required. Most Siemens BACnet nodes are 1/8 load devices, so, in theory, you could place 256 on a network section. Response times normally limit the maximum number of devices on a network to lower values of around 96 devices.

The PXC Modular, PXC-36, and P1 BIM have 1/4 or 1/8 load interfaces, which would allow for a maximum of 128 devices on a network section. These limits are strictly electrical load limits, please check the network manager/next higher controller specs for limits on the total number of addressable nodes on a network.

The network distance for a fully or partially loaded network is 4000 feet (1220 meters) at a maximum network speed of 76.8K bps. Lower speeds do not mean longer network sections are possible. The maximum network section is 4000 feet. Network repeaters can be used to extend this distance.

To determine how many devices can be on a network section, add up all the loading numbers and do not exceed 32. Many third-party devices have full load interfaces. Check the manufacturer's literature for network loading information.

Network Cable Sharing and Distances from Higher Power Cables.
Network cable installed environment
Never run network cabling closer than 5 feet to a Variable Frequency or Variable Speed Drive except at the point where the network must connect to the VFD/VSD. Network entry into a VFD must be through separate conduit and all network wiring must be kept as far as possible for high power cabling in the drive.
Never run network cable closer than 5 feet from circuits carrying 100KVa or greater. Always cross high power cables (at a distance of 5 feet) at a 90 degree angle.
Network run in **open** cable trays with circuits carrying over 20 amps should be no closer than 26 inches to the higher power cables
Network run in **enclosed** trays with circuits carrying over 20 amps should be no closer than 18 inches to the higher power cables.

3-Wire Devices on a 2-Wire or 3-Wire Network Master Controller/Higher Level Controller

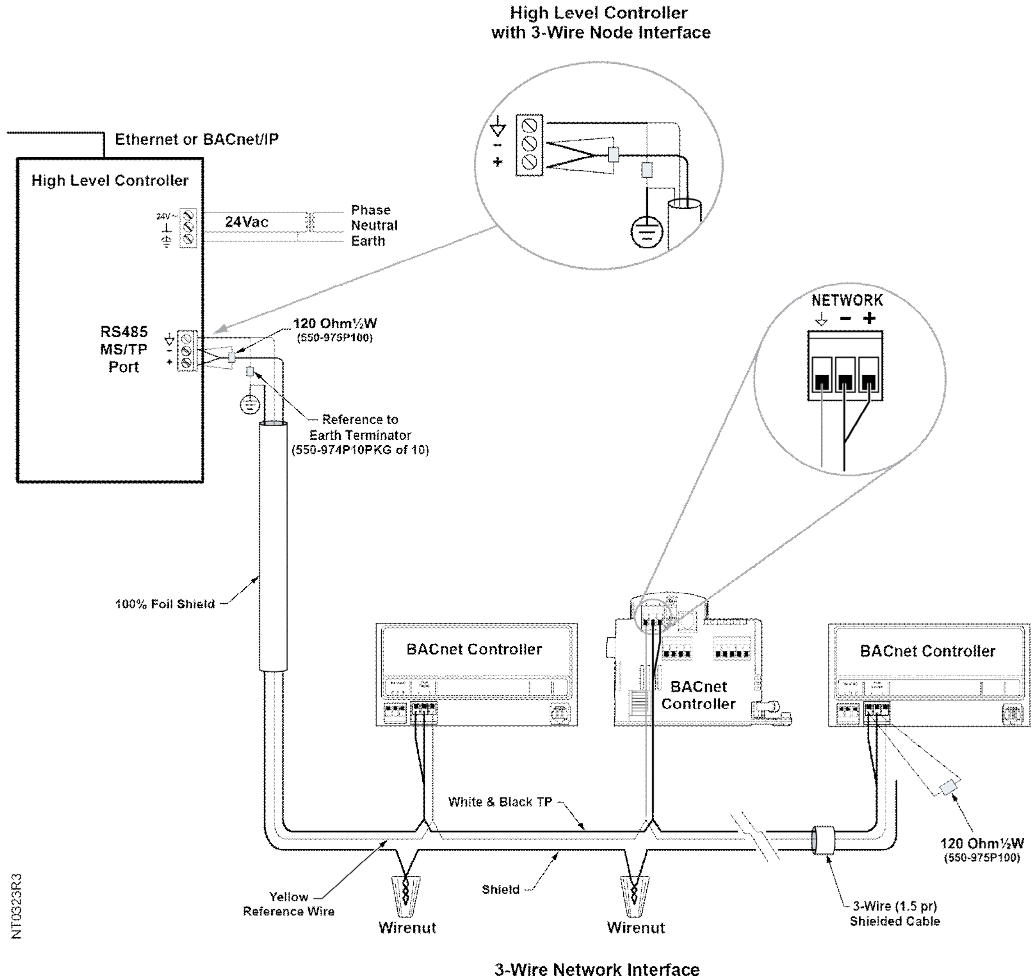


Figure 15: 3-Wire (1.5 pair) Network Wiring Detail.

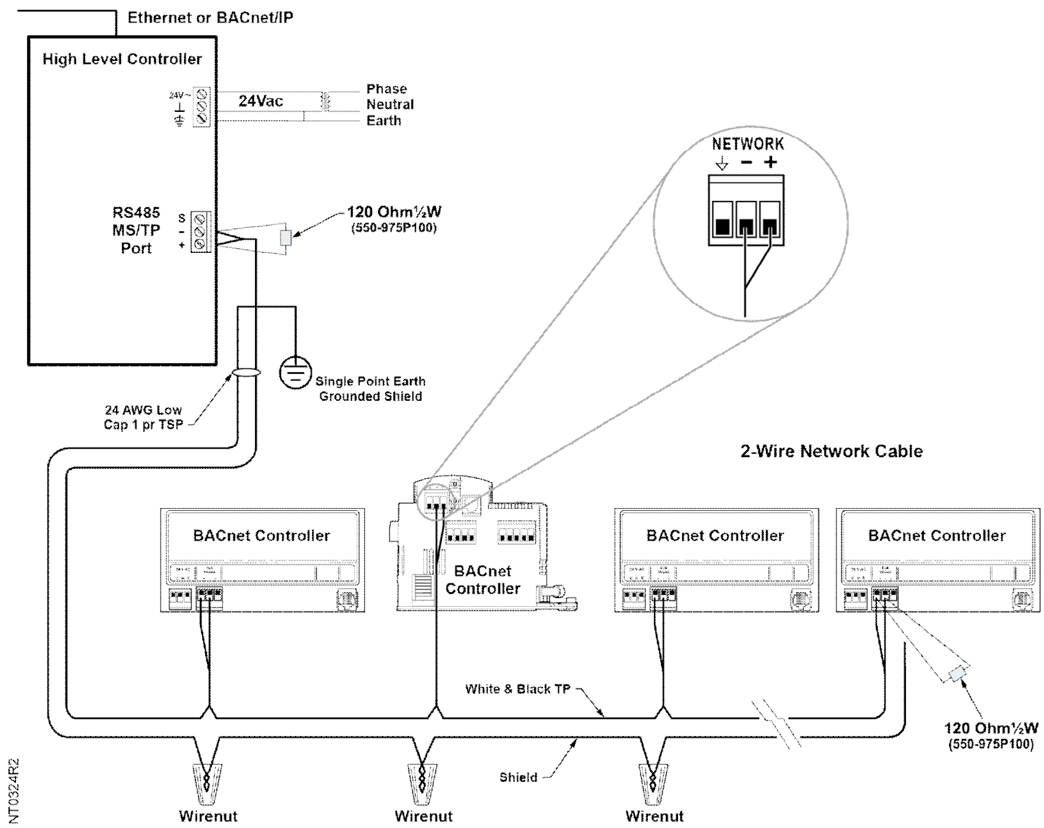


Figure 16: 3-Wire Nodes wired using 1 Pair Cable.

NOTE:
When replacing nodes that use a 3-wire interface on existing 2-wire networks, use the following wiring method.

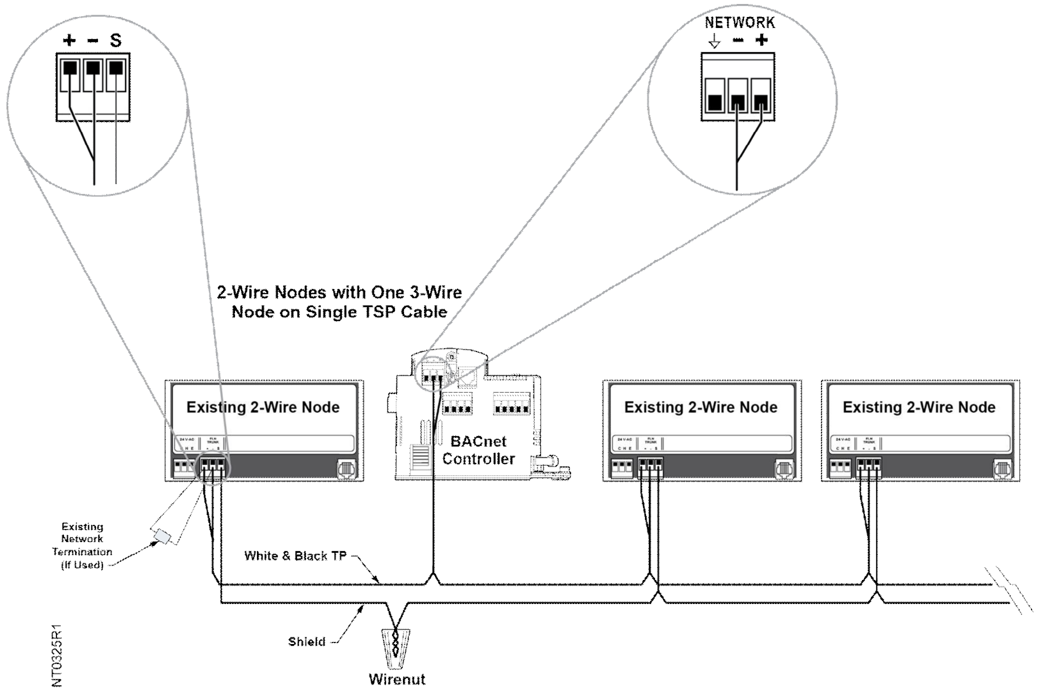


Figure 17: Replacing a 2-Wire Node with a 3-Wire Node.

Network Repeater for 3-Wire Networks

When placing nodes on a network repeater, (capable of supporting 3-wire networks), use the following sample connection methods. An RS-485 repeater that supports 3-wire interface cabling methods can be purchased from Black Box, (Model ICD107A along with 12Vdc power source (PSD100). This repeater is fully optically isolated. This repeater is recommended whenever cable is run between two buildings or sections of building supplied from separate power sources. Black Box can be found in the *Field Purchasing Guide* section 16-05 (http://iknow.us009.siemens.net/fpg/sec16-05/default.asp).

- Network traffic is only allowed to go though two repeaters in series.
- Baud rate and mode switches must be setup to conform to network speed and half duplex 2-wire (vs. 4-wire) operation

The following figures depict several scenarios for network repeater usage.

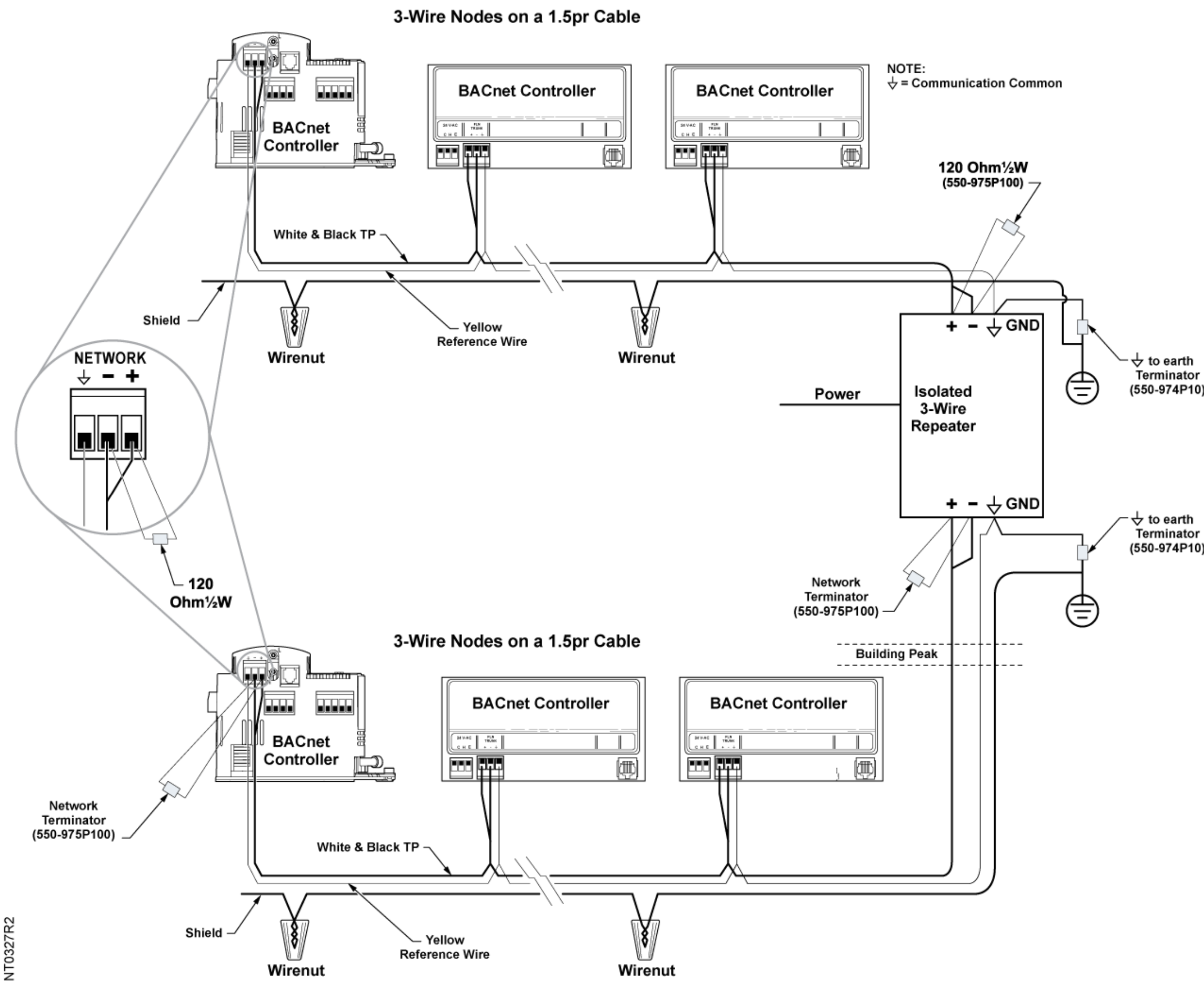


Figure 18: Intra-Building Repeater.

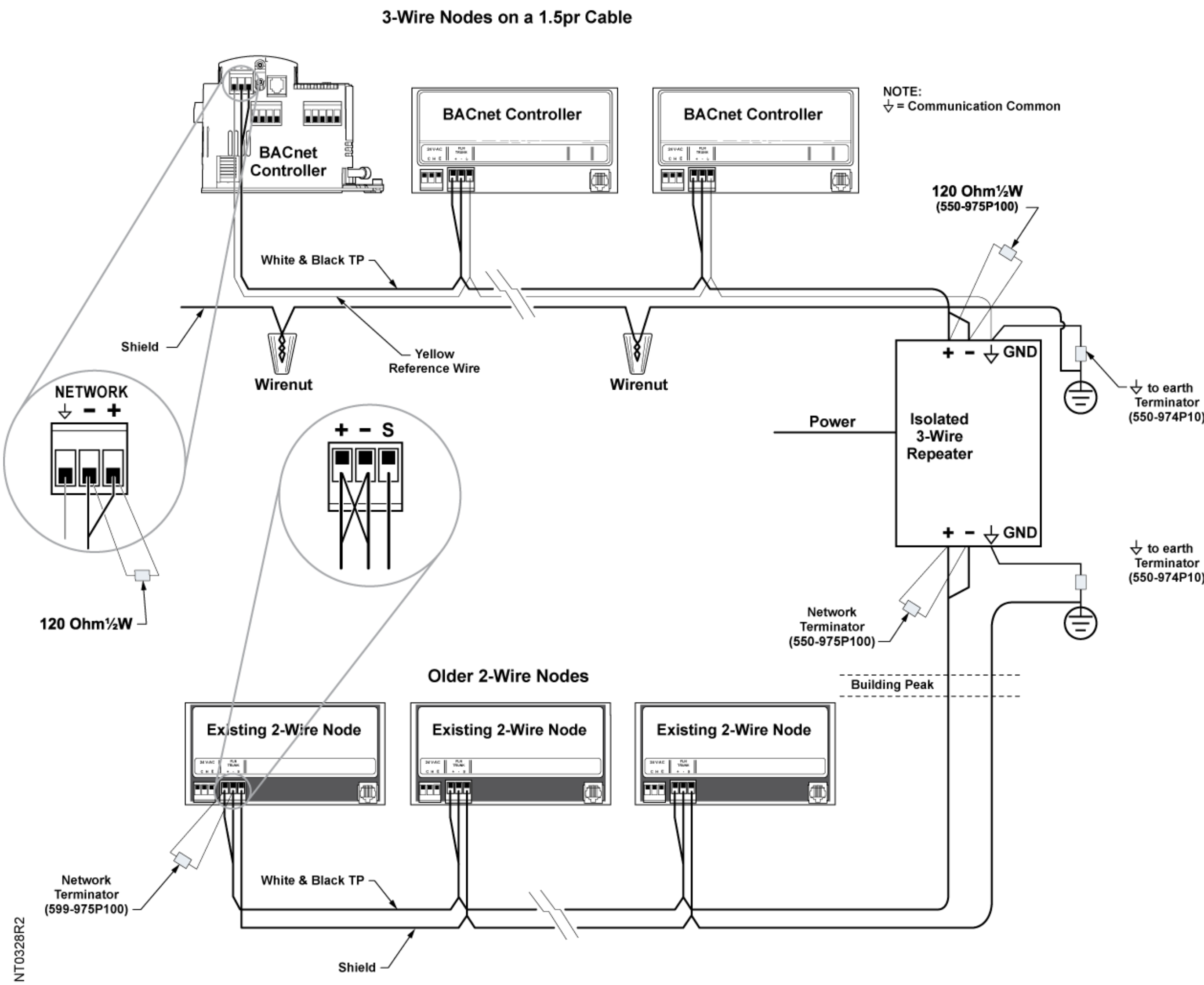


Figure 19: Intra-Building Repeater or Mixed 1pr & 1.5Pr Cable.

3-Wire Network Terminator (550-975P100, Pkg. of 100)

The 3-wire network requires a new network terminator. The new terminator is a 120 ohm 1/2W carbon composition resistor. One terminator must be placed at each end of the 3-wire network section.

3-Wire Network RS-485 Reference Terminator (550-974P10 Pkg. of 10)

The nodes that use a 3-wire network interface must have the RS-485 reference wire (yellow) of the network cable terminated to **EARTH GROUND** at **ONE END ONLY** through an RS-485 reference terminator (shown below). The RS-485 reference terminator consists of a PTC thermistor (polyfuse device) and wire to allow connection to earth ground. A PTC was chosen in case the third wire of the network cable, (the common reference between all 3-wire nodes), is accidentally grounded to earth ground at a second location that could cause high ground currents to flow, due to a difference in earth ground potential. The PTC would open during the short condition if large currents start to flow in the reference wire. Without the PTC or 100 ohm resistor, sufficient current could flow to damage the cable. The PTC will return to normal resistance (less than 1 ohm) when the fault condition is removed.

Before the RS-485 reference terminator is installed, the third wire (yellow) must be tested with a DMM to insure it is not already connected to earth ground. If the wire is connected to earth ground the fault condition must be remedied before terminating the wire using the RS-485 reference terminator.

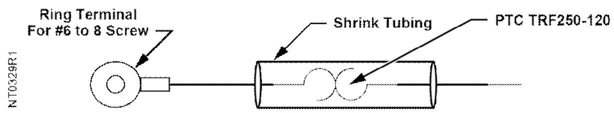


Figure 20: Network RS-485 Reference Terminator.

BACnet Nodes on Siemens Controllers or Third-Party Equipment (Using 1.5 pr cable)

Not all Siemens Building Technologies provide a 3-wire MS/TP network interface. In order to connect to a 3-wire network use the following diagram as a guide. This guide may also be used when connecting to third-party controllers that support a 2-wire interface. If the Master node supports a 3-wire network, then wire the network in the same manner as the BACnet slaves. The RS-485 common must be referenced to earth ground through the RS-485 reference terminator (550-974P10) at one end of the network, (master end preferred).

Depending on the manufacturer, the third wire on 3-wire network interfaces has several names (for example: Ref, Ground, Com. SC (Signal Common), R (for Reference), GND, SG (Signal Ground)).

SBT chose the General Ground symbol (⏚) as the international symbol for

Equipotential Point versus protective/earth ground or noiseless ground. Some early

BACnet controllers may be marked with the earth symbol (⏚) or the "S" designation.

This pin is not the termination point for the shield of the communications cable.

BACnet Nodes on Siemens Controllers or Third-Party Equipment (Using 1.5 pr cable)

NOTE:

The symbol (⏚), is the symbol being used to represent RS-485 communications common reference.

Early versions of some controllers may show the earth ground symbol (⏚) or the "S" designation.

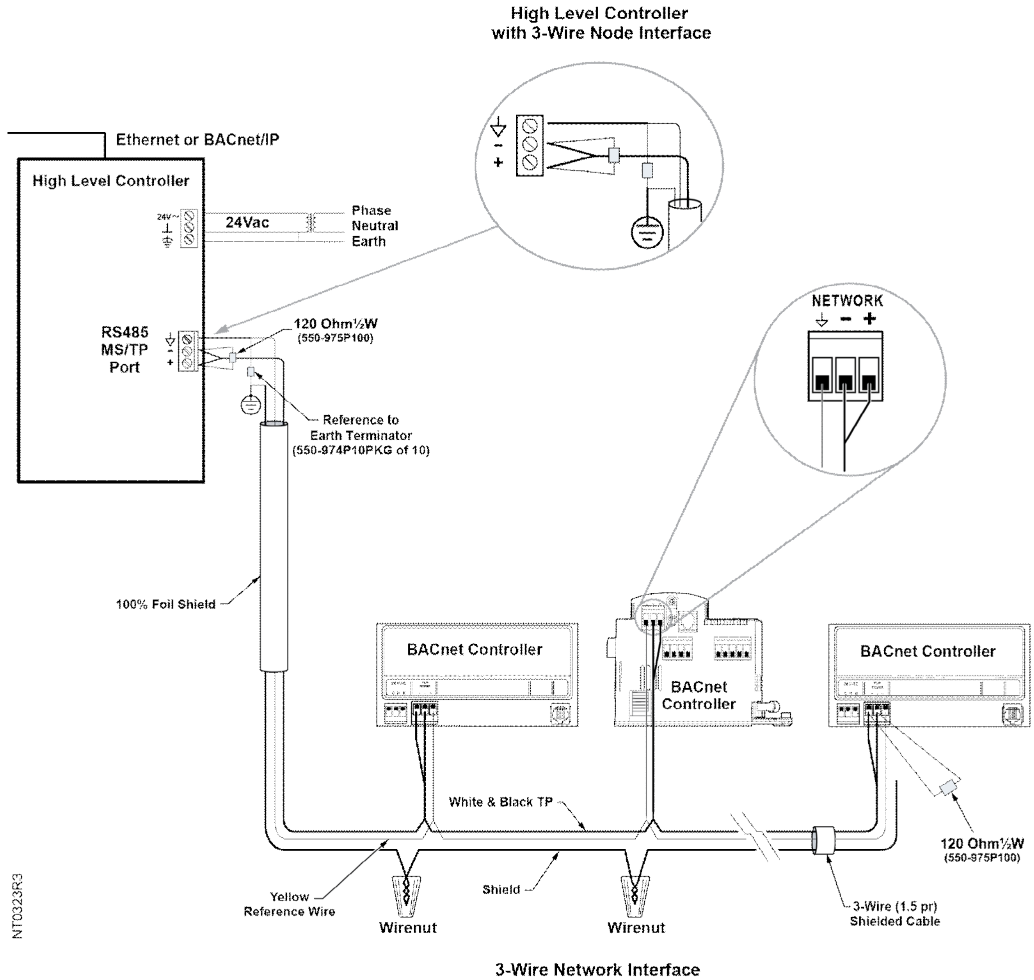


Figure 21: BACnet Nodes on Siemens Controllers or Third-Party Equipment.

RS-485 ALN (P2/P3) and FLN (P1) Trunk Communications Wiring

BACnet RS-485 FLN

The BACnet FLN supports communication for BACnet devices over 2-wire RS-485 trunks.

Wiring from the field panel FLN port to the BACnet device uses the same wiring guidelines as the RS-485 FLN (P1) trunk. See the Table 1.5-pair Cable Specifications [→ 40].

See the section RS-485 MS/TP Communications [→ 36] for connecting 3-wire RS-485 trunks.

Multi-Drop Trunk Cabling Limits

The following table provides the maximum wiring distances per 2-wire RS-485 trunk section. At bit rates over 9600 bps, no stubs or tees are permitted in the trunk cabling. A Trunk Terminator is required at each end of the trunk section at speeds over 9600 bps. See Figure Multi-Drop Trunk Terminator [➔ 52].

Distance per 2-wire Trunk Section. [1,2] (Using Recommended Cabling—Based on Cable Wire to Wire Capacitance.)								
	Speed and Maximum Distance							
Trunk Type	**4800 bps**	**Max. Distance**	**9600 bps**	**Max. Distance**	**19.2K – 57.6K bps**	**Max. Distance**	**> 57.6K bps**	**Max. Distance**
ALN Trunk	18 AWG	10,000 ft (3048 m)	18 AWG	4,000 ft (1219 m)	N/A			
ALN Trunk	20 AWG	4,000 ft (1219 m)	20 AWG	4,000 ft (1219 m)				
ALN Trunk	24 AWG	4,000 ft (1219 m)	24 AWG	4,000 ft (1219 m)	24 AWG (Low Cap)	4,000 ft (1219 m)	24 AWG (Low Cap)	3,280 ft (1 km)
FLN Trunk	18 AWG	5,000 ft (1524 m)	N/A					
FLN Trunk	20 AWG	4,000 ft (1219 m)						
FLN Trunk[3]	24 AWG	4,000 ft (1219 m)	24 AWG	4,000 ft (1219 m)	24 AWG (Low Cap)	4,000 ft (1219 m)	24 AWG (Low Cap)	3,280 ft (1 km)

1) A trunk section is referenced as a length of cable that is electrically isolated from another cable. Electrical isolation is obtained with network devices such as HSTIEs, TI2s, and Fiber Optic TIs.

2) The maximum amount of cable per logical trunk may be extended beyond the maximum physical trunk segments limits shown in this table via network devices, such as the HSTIE or TIE, that function as Trunk Extenders. See HSTIE Usage in this chapter for more information.

3) Reduce the FLN trunk length by 20 feet (6 m) for every BACnet TEC on the FLN above 150 devices.

RS-485 ALN Trunk Shield Connection Using 2-Wire Cabling

NOTE:
ALN trunk terminal "S" is grounded or connected to the field panel case. It is used only to provide a shield connection for the ALN trunk cable. NEC Article 800 does not allow a communication cable to provide a ground path between equipment chassis. The Figure *RS-485 ALN Trunk Shield Connection* shows how the ALN trunk shield is connected to only one field panel marked "OUT" and is tied back at the field panel marked "IN".

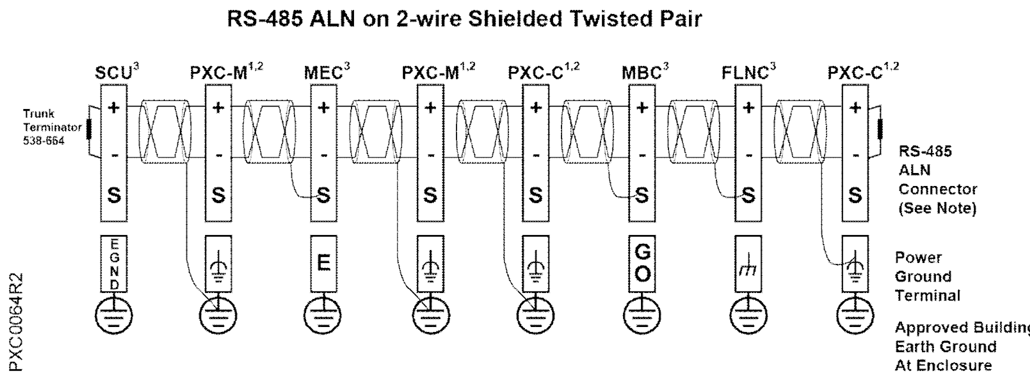


Figure 22: RS-485 ALN Trunk Shield Connection.

1. The “S” pin of the PXC-C and PXC-M must be left open, see NOTE.
2. The “E” pin of the MEC and the ⏚ pin of the PXC Compact and PXC Modular must be tied to earth ground.
3. The “S” pin of the MEC, MBC, SCU, and FLNC is earth grounded so the shield conductor can be connected there.

NOTE:

The equipotential symbol (▽), is the symbol being used to represent RS-485 communications common reference.

Early versions of some 3-Wire controllers (PXC Compact, PXC Modular, P1-BIM, Long Platform BACnet TECs and BACnet Equipment Controllers) may show the earth ground symbol (⏚) or the "S" designation.

RS-485 FLN (P1) Trunk Shield Connection

NOTE:

The symbol (▽), is the symbol being used to represent RS-485 communications common reference.

Early versions of some controllers may show the earth ground symbol (⏚) or the "S" designation.

FLN trunk terminal "S" is not grounded or connected to the equipment controller case. It is used only to tie shields together. The Figure *FLN P1 Trunk Connection to TEC—Electronic Output* shows how the FLN trunk is connected to electronic output Terminal Equipment Controllers.

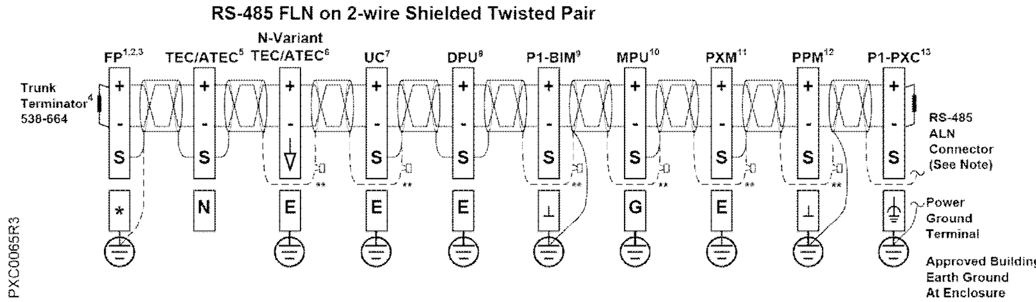


Figure 23: RS-485 FLN (P1) Trunk Shield Connection—Electronic Output.

* Field Panel Notes (FP begins shield earth ground)

1. MBC, SCU & FLNC: connect shield to FLN “S” pin; earth ground is internally connected.

2. MEC: connect “E” pin to enclosure earth ground or Service Box “E” pin and connect shield to FLN “S” pin.

3. PXC-M & PXC-C: connect ( ) and shield to enclosure earth ground and leave FLN “S” pin unconnected.

FLN Device Notes (shield is continuous from FP or tied back and earth ground restarted; if present connect Earth Ground)

4. When FLN Speed is set greater than 4800 bps use Trunk Terminator (538-664) at both ends of trunk wire.

5. TEC/ATEC: tie both shields to “S” pin and if required connect transformer neutral to earth ground; do not earth ground “N” pin.

6. N-VARIANT TEC/ATEC: tie both shields together and do not connect to controller leaving unconnected.
Connect transformer neutral to earth ground; if needed earth ground “E” pin to provide highest noise immunity.

7. UC: **bypass “S” pin or restart shield on “S” pin; connect “E” pin to enclosure earth ground.

8. DPU: tie both shields to “S” pin; earth ground is internally connected.

9. P1-BIM: leave “S” pin open - **bypass or restart shield on enclosure earth ground; connect (peg sym) to enclosure earth ground.

10. MPU: **bypass “S” pin or restart shield on “S” pin; connect “G” pin to enclosure earth ground.

11. PXM: **bypass “S” pin or restart shield on “S” pin; connect “E” pin to enclosure earth ground.

12. PPM: leave “S” pin open - **bypass or restart shield on enclosure earth ground; connect (peg sym) to enclosure earth ground.

13. P1-PXC: leave “S” pin open - **bypass or restart shield on enclosure earth ground; connect (peg sym) to enclosure earth ground.

Communications Ground

See Grounding [➙ 16], National Electric Code (NEC) Communications Requirements [➙ 18], and Controlling Transients [➙ 24], in Chapter 1 for definitions of NEC Articles and Local Building Ground.

⚠	**⚠ CAUTION**
	Buildings with unbonded electrical services should be considered separate buildings for communications purposes. All field panel, equipment controller, and network devices on one service should be isolated from those on another service. Failure to isolate will result in loss of communication.

All RS-485 ALN and FLN (P1) trunks must share the same electrical service and single building ground point. Wherever the electrical services are not bonded, as described in NEC Article 250 or by local authorities, appropriate network devices such as the HSTIE, Fiber Optic Trunk Interface or the Trunk Interface II should be used.

Only one side of the network device should be grounded to the single building ground point. Network devices plugged into the field panel may be grounded to the field panel chassis as shown in the *Installation Instructions*. The third wire (green or green/yellow) from the field panel enclosure is tied to the single building ground point. Either all RS-485 FLN (P1) equipment controller power trunk neutrals must be tied to the single building ground point or network isolation devices must be used.

Multi-Drop Trunk Terminator

The Multi-Drop Trunk Terminator (P/N 538-664) consists of a 120-ohm resistor in series with two opposing polarity diodes placed in parallel. See Figure *Multi-Drop Trunk Terminator*.

The Multi-Drop Trunk Terminator is required at each end of a 19.2K bps ALN or FLN (P1) trunk segment. See Figure *ALN Trunk Terminator Requirements*.

⚠	**⚠ CAUTION**
	No more than two trunk terminators should be used on a single trunk segment. Using more than two can cause unpredictable results.

NOTE:
While Trunk Terminators are required only on RS-485 ALN or FLN trunks running over 19.2K bps, due to accumulated cable distortion, Trunk Terminators are recommended on any RS-485 ALN or FLN trunk at 9600 bps if old style TIEs are installed (silver enclosures) or if the trunks are over 4000 ft (1219 m) in total length.

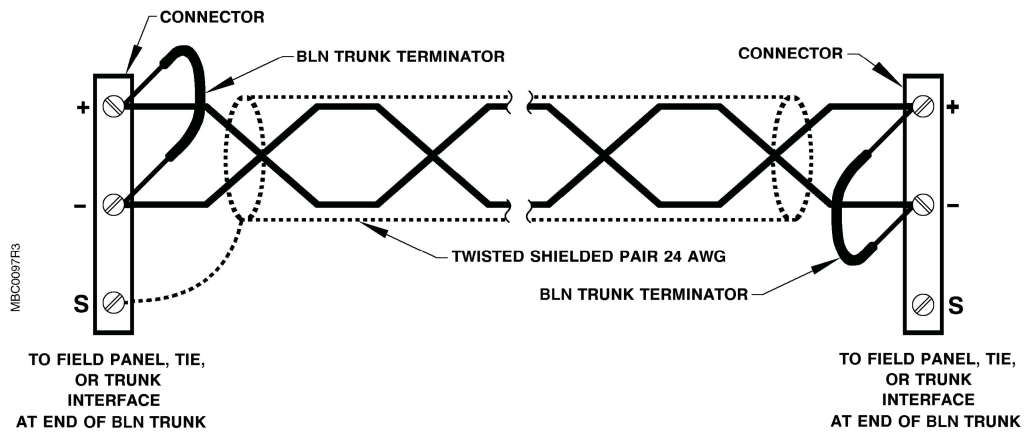


Figure 24: Multi-Drop Trunk Terminator.

NOTE:
Trunk terminators are internal switch settings inside the HSTIE (or TIE).
The Figure *ALN Trunk Terminator Requirements* shows three logical trunk segments and three sets of trunk terminators.

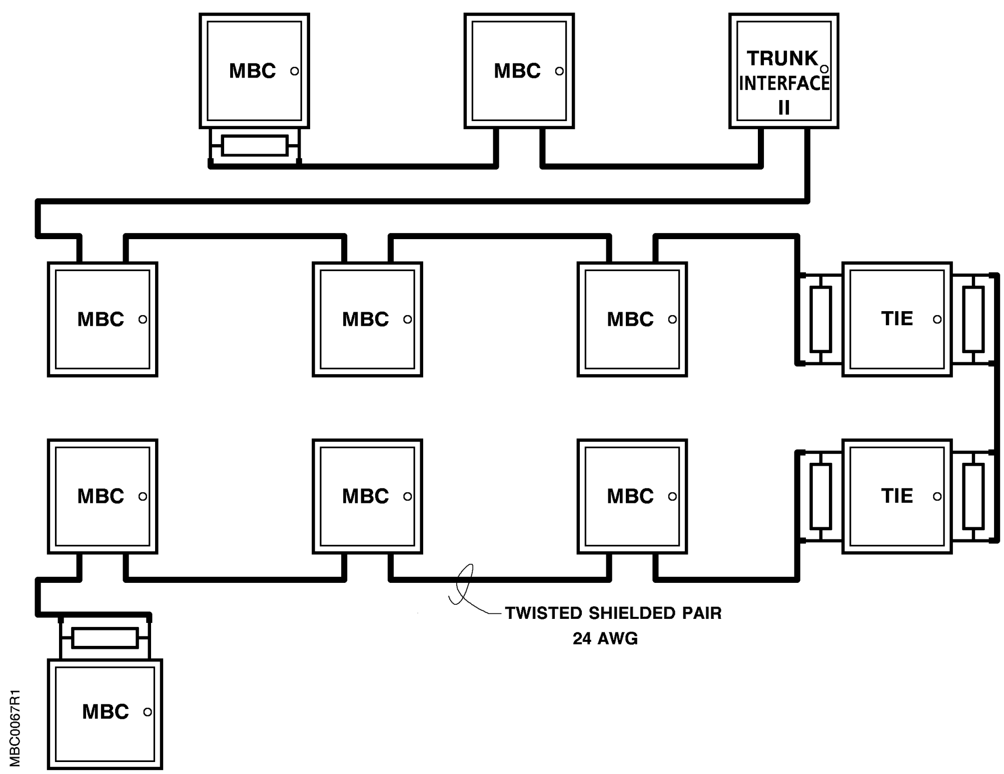


Figure 25: ALN Trunk Terminator Requirements.

RS-485 2-Wire Network Devices

To minimize risk and reduce installed costs, use only the network devices listed in the following table on RS-485 ALN and FLN trunks. The following table lists the power source requirements for each network device.

See each product section in this manual for specific device power source requirements.

Power Source Requirements for 2-wire RS-485 devices.			
Product	Input Voltage	Line Frequency	Maximum Power
HSTIE	115/230 Vac	50/60 Hz	6 VA
Trunk Interface II	115/230 Vac	50/60 Hz	6 VA
Fiber Optic Trunk Interface	115/230 Vac	50/60 Hz	6 VA
Fiber Optic Hub	115/230 Vac	50/60 Hz	10 VA

High Speed Trunk Interface (HSTIE)

The High Speed Trunk Isolator/Extender (HSTIE) is used to protect, isolate, extend (re-time) an RS-485 ALN or FLN trunk. Only the HSTIE can extend the maximum wire length of a trunk segment. Other devices such as Trunk Interfaces with leased line modems or fiber optics do not increase the maximum wire length of a trunk segment.

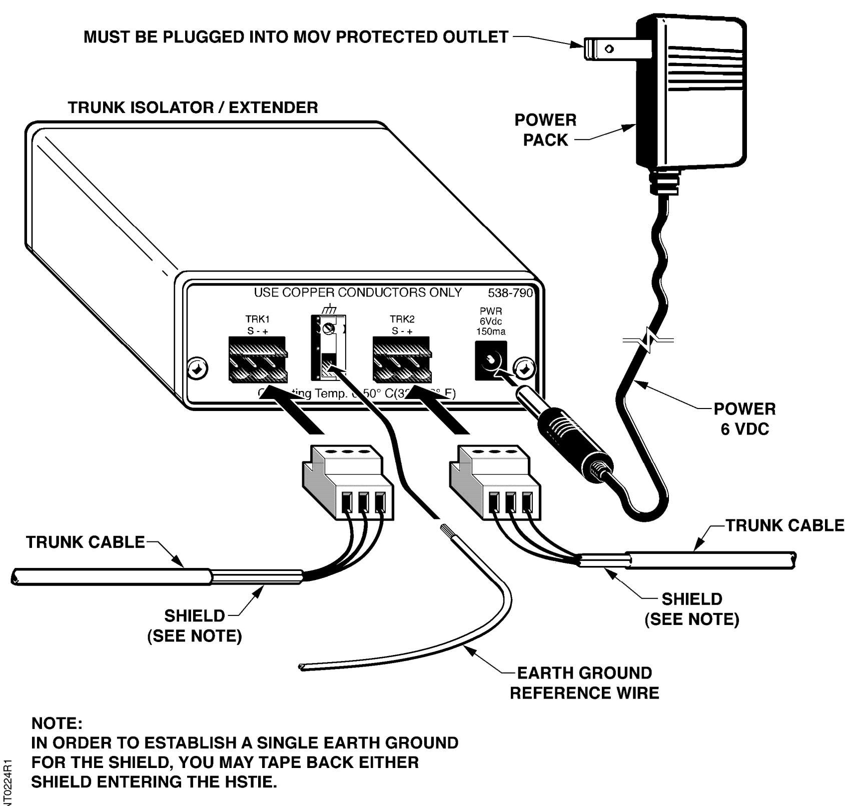


Figure 26: Connections to HSTIE.

HSTIE Usage

The number of High Speed Trunk Isolator Extenders (HSTIEs) on a logical RS-485 ALN or a logical FLN trunk is directly related to the total trunk length, type of trunk wire used, and the time delay allowed by the network protocol. Trunk cabling causes bit distortion that limits the total trunk length to the distances listed in table *Distance per 2-wire Trunk Section*.

Since the HSTIE re-times the packet bytes, the maximum amount of trunk a network can support has increased. The HSTIE introduces a delay limiting the number that can be used in series. Do not exceed the HSTIE usage limits shown in table *Speed vs. Maximum Number of HSTIEs in Series*.

Speed vs. Maximum Number of HSTIEs in Series.			
	Speed		
	1200 bps	**4800 bps**	**9600 bps through 115,200 bps**
ALN only	10	6	6
FLN only	N/A	6	6

RS-485 ALN and FLN (P1) Communications Wiring on Structured Cabling

NOTE:
The Insight Server and Client, APOGEE Ethernet Microserver (AEM), and other field panels operating Ethernet protocols do not use the chained patch cables referred to in this section. These devices must be plugged into an operational TCP/IP network using standard Ethernet patch cables.

Installation

The Structured Cable System (SCS) is installed per industry standards in a star distribution topology. This does not comply with the RS-485 wiring system used for HVAC or most other building automation systems (BAS). Special patch cables or punch down cables at each end of a wiring segment are used to convert the star topology to multi-drop trunk topology. The wiring segments and patch cables are individually certified. Once plugged in, the wiring segments and patch cables must be certified as an ALN or FLN.

CAUTION

Unplugging a patch cable from a structured cabling system will split the multi-drop trunk and disconnect part of the RS-485 ALN or FLN (P1) from the BAS.

Use of Shielded and Unshielded Twisted Pair Cable

Shielded Category 5 cabling is used where excessive noise is expected on the information system cabling, for example, when it is in close proximity to a high-power transmitter. In these cases, the same shielded Category 5 cable will be used for the RS-485 ALN and FLN trunks.

CAUTION

Use an HSTIE to isolate different wire types, such as shielded zone trunk cabling and SCS UTP.

Mixing wire types will result in loss of signal integrity and possible loss of RS-485 ALN or FLN communications.

Sheath Sharing and Cable Routing

- Use separate binder groups (a group of 4 or 25 cable pair cables in same sheath) for building automation system signals. Use blue binder group for HVAC.
- A riser cable may have many 25 pair binder groups. Building automation system signals and voice and data signals can share the same riser cable, but not the same binder group.
- Horizontal binder groups can have either 25 cable pairs or 4 cable pairs. Building automation system signals and voice and data signals can share the same cable tray, but not the same binder group.
- Use a 4-pair (blue) binder for each separate ALN.
- Use a separate 4-pair (blue) binder for FLN1, FLN2, and FLN3 on each Field Panel Controller. These FLN signals are multiplexed and may share the same binder. Do not mix with FLN signals from other controllers.

CAUTION

MLN, AEM ALN, and other Ethernet protocol signals do not use the same interconnects and must not share the same binder group as RS-485 ALN or FLN signals. Mixing Ethernet protocol signals within the same binder group will result in loss of signal integrity and possible loss of RS-485 ALN or FLN communications.

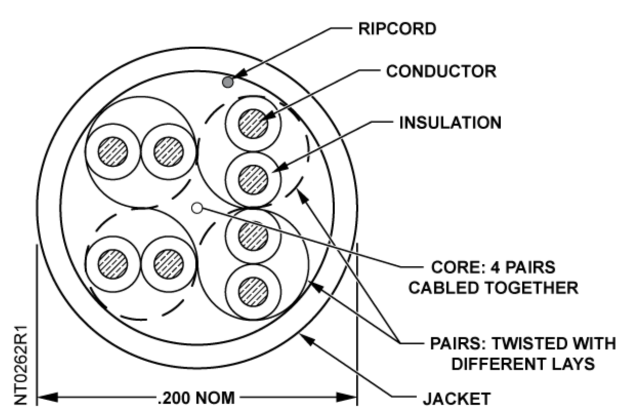


Figure 27: Components of an SCS 4 UTP Cable.

Riser Segment Length

The Telecommunications (wiring) Closet-to-riser interface will generally be Category 5 riser cable on new installations. Following information systems standards, basic link cable runs are limited to 600 ft (190 m) of solid copper terminated by punch down blocks in the main and intermediate wiring closets.

SCS segments are wired per TIA 568A (preferred) or 568B. Observing the 600 ft (190 m) restriction allows future conversion to Ethernet devices in the field panel without rewiring the SCS segment. See the following table for RS-485 ALN and FLN pinout. The Figure *Punching Down the Riser Cabling for an RS-485 ALN or FLN* shows incoming cable punch down in an intermediate wiring closet from a main wiring closet.

Wiring Procedure for ALN and FLN (P1) on Structured Cabling.				
Wiring Block Position	Device Connection	Conductor Pair Color	Signal Path	RJ45 TIA568A (Preferred)
1	+	White-Blue	Outgoing RS-485 ALN or FLN	5
2	–	Blue		4
3	+	White-Orange	Incoming RS-485 ALN or FLN	3
4	–	Orange		6
5	Not used	White-Green	Second outgoing signal pair or initiating device (contact closure)	1
6	Not used	Green		2
7	Not used	White-Brown	Second incoming signal pair or indication device (4-20 mA)	7
8	Not used	Brown		8

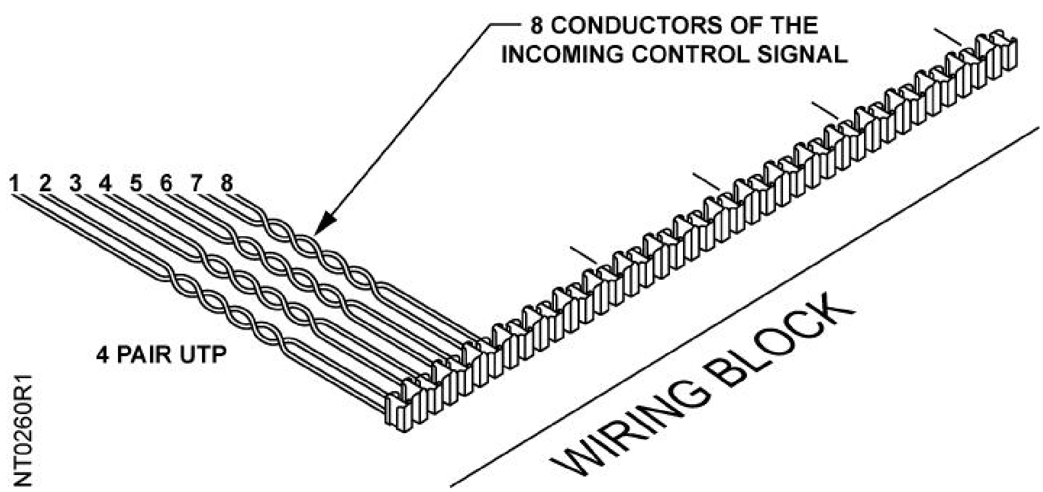


Figure 28: Punching Down the Riser Cabling for an RS-485 ALN or FLN.

Converting SCS Star Segments to RS-485 ALN and FLN Chain Segments

The Telecommunications (wiring) Closet-to-device outlet will generally be Commercial Category 5E or IEEE Category 6 cable on new installations. Following information systems standards, basic link cable runs are limited to 295 ft (90 m) of solid copper terminated by punch down blocks in the wiring closet and RJ-45 jacks in the field panel or zone.

SCS segments are wired per TIA 568A (preferred) or 568B. Observing the 295 ft (90 m) restriction allows future conversion to Ethernet Devices in the field panel without rewiring the SCS segment.

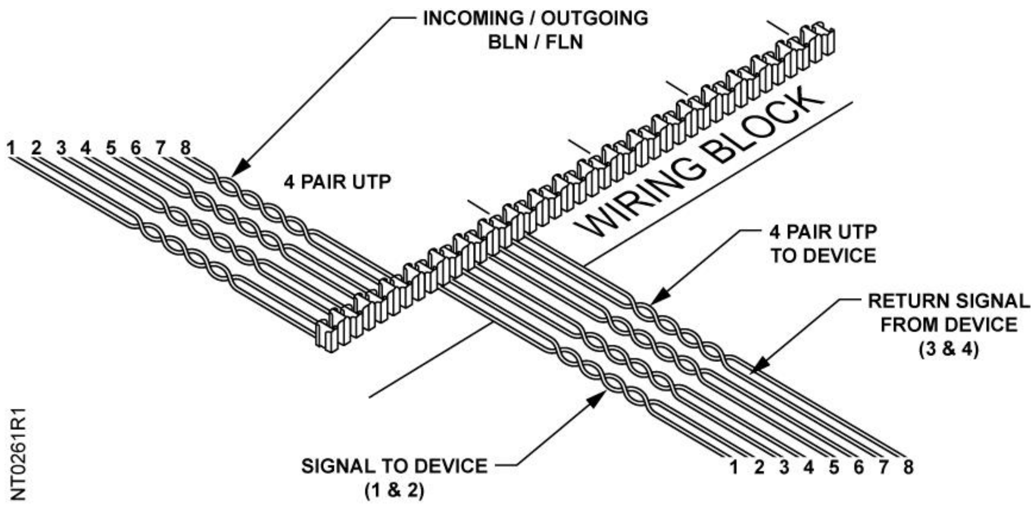


Figure 29: Punching Down a Device.

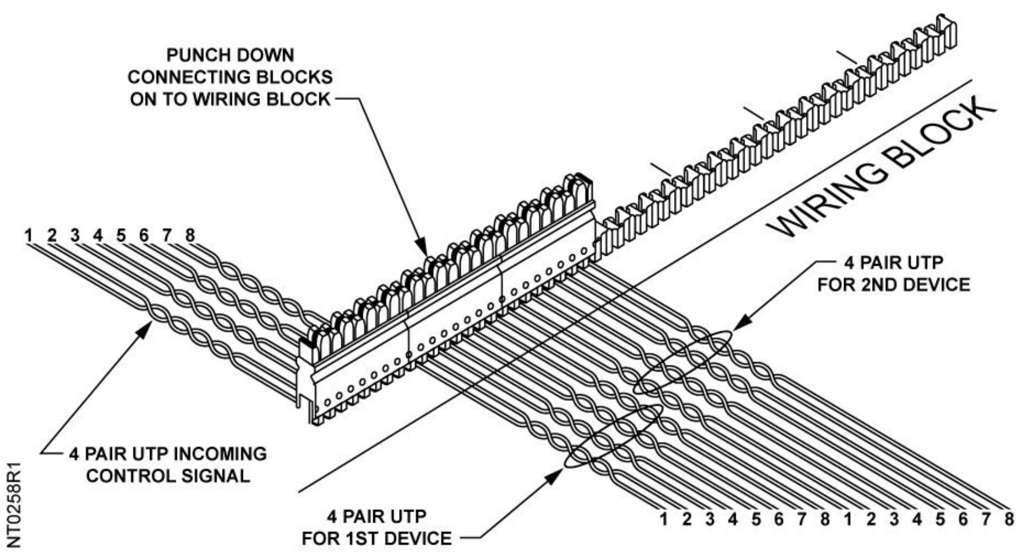


Figure 30: Punching Down the Connecting Blocks to the Wiring Block.

Punch Down Jumper Wires

The following table shows the cross-connect terminations used to create the chained multi-drop RS-485 ALN and FLN communications signal in the wiring closet. Use Note 4a for floor-to-centralized distribution chain (Figure *Punching Down CAT5 Cross-Connect Wires to Connecting Blocks*) and use Note 4b with a second riser cable for floor-to-floor distribution chain (not shown).

Punching Down CAT5 Cross-Connect Wires to Connecting Blocks.		
Note Number	Description of Riser and Horizontal Cross-Connect Signals	Cross-Connect Terminations
1	Incoming signal to floor (riser cable 1, pair 2) to incoming signal of first device or zone (horizontal cable 1, pair 2)	3 to 3 (white/blue jumper) 4 to 4 (blue jumper)
2	Outgoing signal (horizontal cable 1, pair 1 to incoming signal of next device or zone (horizontal cable 2, pair 2)	1 to 3 (white/blue jumper) 2 to 4 (blue jumper)
3	Outgoing signal (horizontal cable 2, pair 1) to incoming signal of next device or zone (horizontal cable 3, pair 2)	1 to 3 (white/blue jumper) 2 to 4 (blue jumper)
4a (See the following figure)	Outgoing signal (horizontal cable 3, pair 1) from last device or zone to outgoing signal from floor (riser cable 1, pair 1) back to main distribution	1 to 1 (white/blue jumper) 2 to 2 (blue jumper)
4b (Not shown)	Outgoing signal (horizontal cable 3, pair 1) from last device or zone to outgoing signal to next floor (riser cable 2, pair 2) telecommunication closet	1 to 3 (white/blue jumper) 2 to 4 (blue jumper)

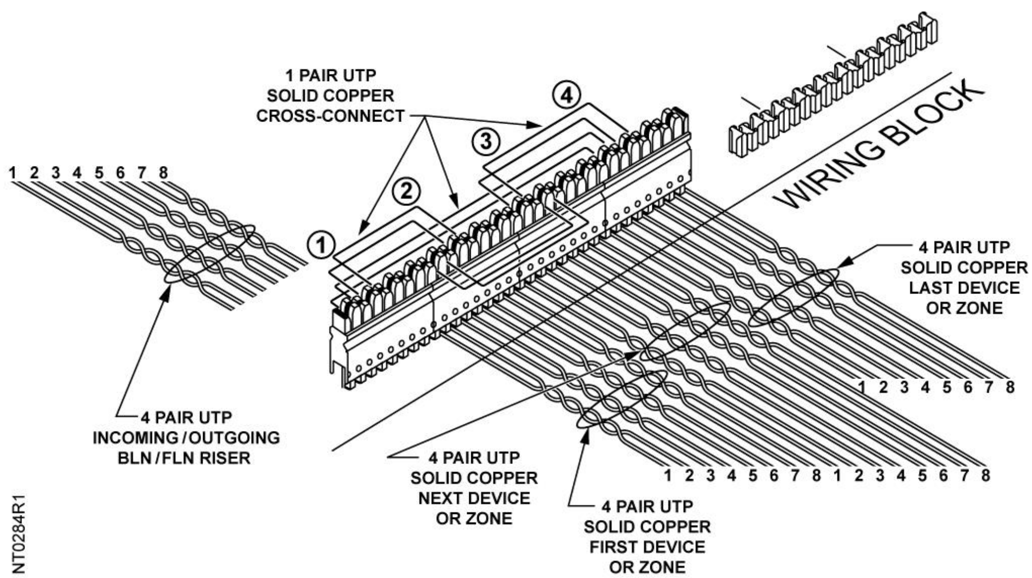


Figure 31: Punching Down CAT5 Cross-Connect Wires to Connecting Blocks.

Patch Cables

Field panels and zones are chained with patch cables.

- Figure *RS-485 ALN and FLN to RJ-45 Chained Patch Cable, 538-908(S)* shows a middle device chain for the field panel or zone.
- Figure *RS-485 ALN and FLN to RJ-45 Terminated Patch Cable, 538-909(S)* shows a terminated chain for the field panel or Zone.
- Figure *Multiplexed FLN 1, 2, 3 to RJ-45 Terminated Patch Cable, 538-911(S)* shows three Zones of FLN (P1) multiplexed from a single Field Panel Controller.

Shields (S suffix on part number) are used only where shielded cable is brought to the field panel or zone, ensuring impedance is maintained. Terminators are used for all end-of-line connections including both the RS-485 ALN and FLN.

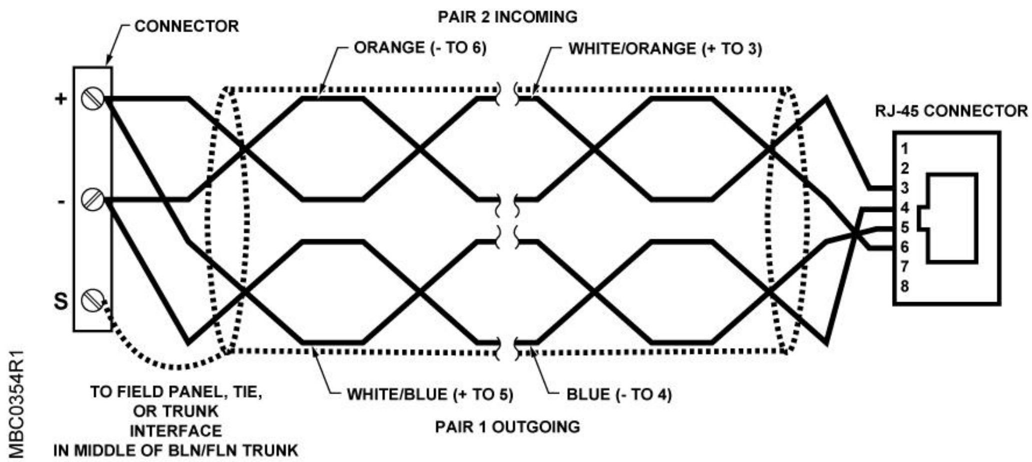


Figure 32: RS-485 ALN and FLN to RJ-45 Chained Patch Cable, 538-908(S).

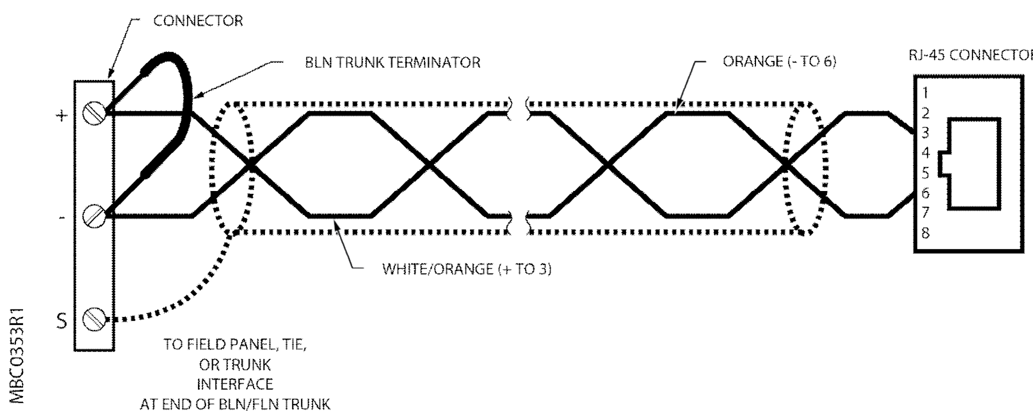


Figure 33: RS-485 ALN and FLN to RJ-45 Terminated Patch Cable, 538-909(S).

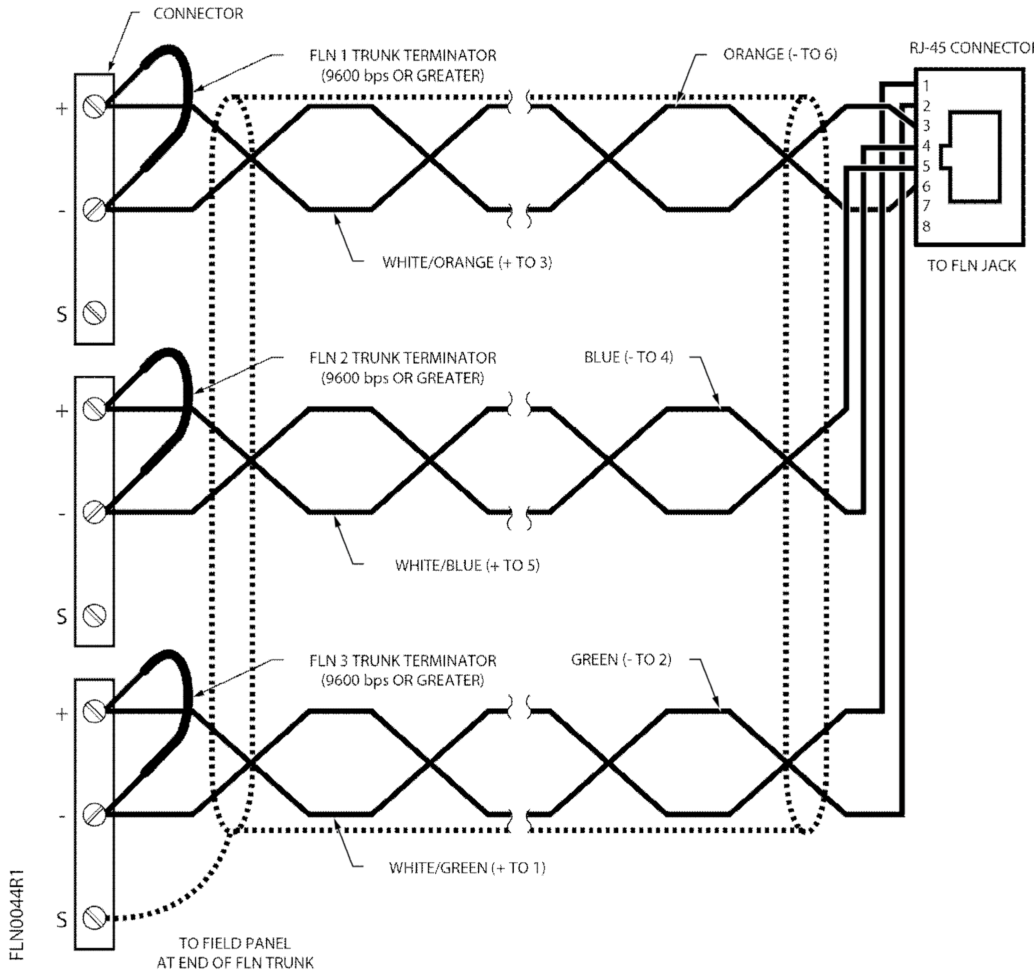


Figure 34: Multiplexed FLN 1, 2, 3 to RJ-45 Terminated Patch Cable, 538-911(S).

Converting Chain Segments to SCS Star Segments

⚠	**CAUTION**
	All field panels should be taken offline and controlled devices placed under manual control prior to changing field panels and network from RS-485 to Ethernet ALN.

1. Remove chained patch cables from the field panel ALN port and RJ-45 jack box.
2. Install Ethernet controller and RJ-45 patch cable in the field panel.
3. Remove all UTP cross-connect wires from punchdown connecting blocks. See Figure 12.
4. Install RJ-45 patch panel to the punch-down connecting blocks per TIA 568A or TIA 568B, as required, and install RJ-45 patch cable between the patch panel and the network device.

LONWORKS FLN Communications Wiring

NOTE:
L model MECs provide a LonWorks® floor level network. Read this section if you are installing an L model MEC. For F model MECs, see the *P1 FLN* section of this document. Other types of MEC do not provide floor level networks.

Network Requirements

The APOGEE with LonWorks system communicates on a LonWorks compatible Free Topology floor level network (LonWorks FLN). You must observe the limitations of the LonTalk® communication protocol (node count, load count, wire specifications, and wire length limits) when designing the network wiring. Use approved cables only; these include unshielded and shielded (where specified) two conductor 22 AWG Level IV cable. See tables in this section, as well as the Table LONWORKS FLN Wiring Specifications [➙ 62] and Figure LONWORKS Floor Level Network [➙ 62].

Logical Network Limitations.	
Maximum number of subnets per network	255
Maximum number of nodes per subnet	127
Maximum number of nodes per network	32,385
A system may contain an unlimited number of domains	
A node may be a member of two domains	
A device may contain more than one node	

Physical Network Limitations.	
Specification	**Limit**
Maximum electrical bus loads per segment	64
Maximum repeater depth	1
Network terminators (resistors) per segment	2, 105 ohm, wired in parallel
Network speeds	78K bps

Communication Wiring Requirements

To connect to the LonWorks® network, use 22 AWG twisted pair (TP), level 4, Echelon® approved wire.

	WARNING
	Use the recommended LonWorks® cable: 22 AWG unshielded or shielded (where specified), Level IV per NEMA standards (not equivalent to EIA/TIA Level 4 cable). Network cabling is not polarity sensitive.

LonWorks FLN Wiring Specifications.		
Wire Type and Gauge	**Max. Total Wire Length (1 Segment)**	**Max. Node-to-Node Length**
22 AWG 1 pair, stranded, unshielded, level IV per NEMA standards, blue plenum jacket	1640 ft (500 m)	1312 ft (400 m)

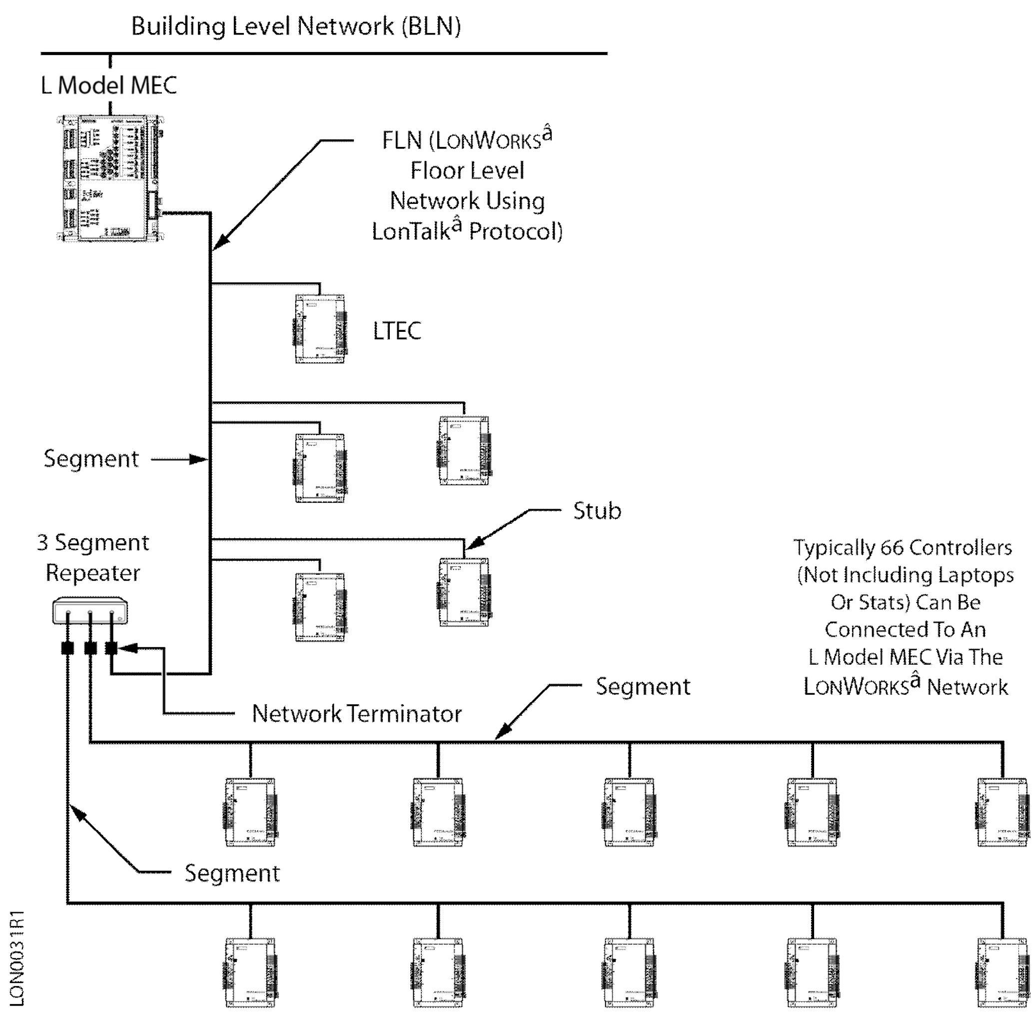


Figure 35: LonWorks Floor Level Network.

Nodes per Subnet/Network

Any device that contains a Neuron ID (and therefore a unique address) is counted as a node. Devices such as repeaters and network terminators do not have addresses and thus are not counted as nodes.

Electrical Loads

The number of electrical LonWorks bus loads allowed per segment is 64. All devices, with the exception of the network terminator, count as one electrical load. Networks with more than 60 nodes should use a repeater. Two-port (P/N 587-450) and three-port (P/N 587-455) repeaters are available.

Segment

A LonWorks FLN consists of 1, 2, or 3 network segments. A segment is defined as a part of the physical network containing nodes that can communicate with each other without requiring intervention from an intermediate device, such as a repeater.

Wiring Between Buildings

Use a LonWorks repeater for segments that run between buildings to protect the network against lightning or other high voltage spikes. Additional communication grade surge suppressors should be used as well.

Repeater Depth

Repeater depth refers to the number of repeaters that can be connected in series to any given segment. The APOGEE with LonWorks system repeater depth is 1, which means that only one end of a segment can be connected to a repeater. This allows you to extend the channel wire length by either one or two segments, depending on which repeater type you use. Two-port (P/N 587-450) and three-port (P/N 587-455) repeaters are available.

Network Speeds

The LonWorks FLN operates at 78K bps.

Conduit Sharing

The LON FLN cable can be run in the same conduit or raceway with 24 Vac power and AI, DI, and AO circuits. For more information on conduit sharing, see Conduit Sharing—Class 1/Class 2 Separations [→ 15] in this document.

Wire Lengths

The maximum total wire length per segment is calculated by summing the lengths of all network wire on a segment. The maximum node-to-node length is the maximum distance allowed between adjacent nodes on the same segment. See Figure *Determining Network Length—Example*.

Two-port and three-port repeaters can extend the subnet by providing one or two additional segments, with wire lengths as defined inTable LonWorks FLN Wiring Specifications [→ 62].

NOTE:
Sensor wiring (the wiring from the LTEC to the LTEC room temperature sensor) must be included in the wire length calculations for a segment, because the sensor wiring carries the network signal.

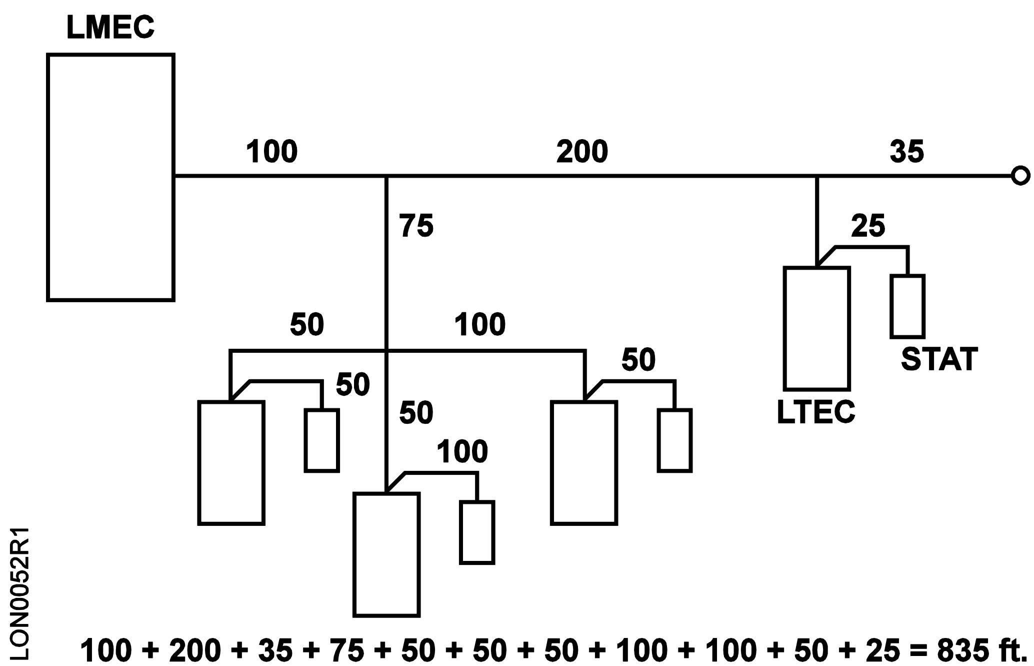


Figure 36: Determining Network Length—Example.

Network Wiring

Only approved cables may be used for network wiring. These include unshielded and shielded (where specified) to conductor 22 AWG Level IV cable.

	WARNING
	Use the recommended LonWorks cable: 22 AWG shielded or unshielded, Level IV per NEMA standards (not equivalent to EIA/TIA Level 4 cable). Connect Air brand cable, 22/1 pair, stranded, unshielded, blue plenum jacketed, Level IV, part number W221P-2001, or an approved equal for network wiring. Network wiring is NOT polarity sensitive.

LTEC Controllers use the FTT-10 transceiver that allows free topology wiring. This includes
T-taps, stars, branches, loops, as well as standard daisy chain. In all cases, maximum network wire length, including each sensor cable, cannot exceed 1640 feet (500 meters). See Figure *LonWorks Network Topology*.

For network lengths that exceed 500 meters (1640 feet), a two-port or three-port repeater can be used (part numbers 587-450 and 587-455, respectively). This will allow three separate network lengths of 500 meters.

Each network segment (1 without repeater, 3 with repeater) requires a pair of terminating resistors (part number 587-649, packs of 100) wired in parallel anywhere on the segment, at the field panel, or at the repeater. See LonWorks FLN Network Terminations [→ 66] in this chapter for more information on segment termination.

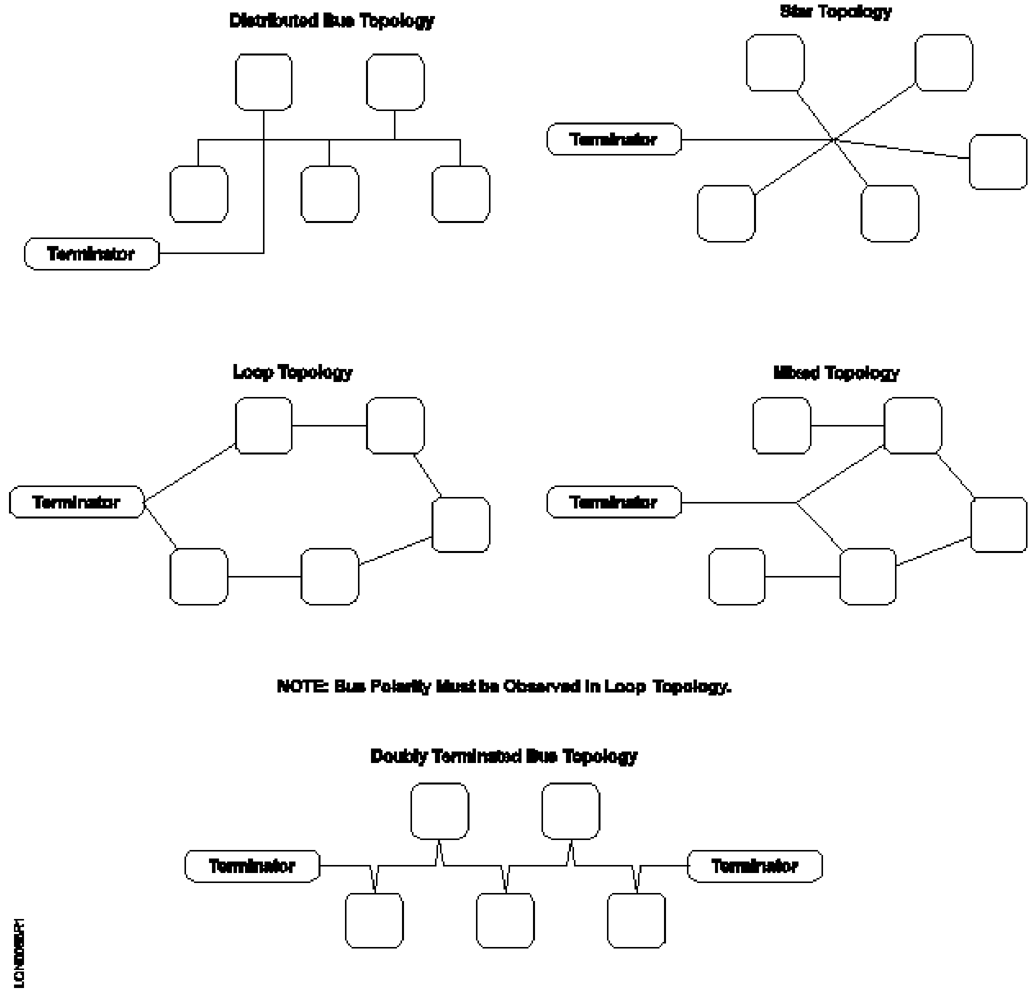


Figure 37: LONWORKS Network Topology

LonWorks FLN Network Terminations

All LonWorks FLN segments must have a single 52 ohm network termination, made up of two 105 ohm, 1% tolerance, 1/4-watt resistors wired in parallel. These resistors are available in packages of 100 (P/N 587-649P100).

Recommended Terminator Installation

Install the network terminations as follows:

- On a single segment LonWorks FLN, install the termination at the L model MEC.
- On a 2 or 3 segment LonWorks FLN, install each segment termination at the repeater.

Power Trunk Guidelines

A Class 2 circuit, as defined in the National Electrical Code (NEC, operates at less than 30 volts AC (Vac), and is limited to 100 volt-amps (VA) or less. Class 2 circuits are granted special exceptions in the NEC for installation wiring, making it unnecessary to use conduit in most applications.

Class 2 Power Sources

There are two types of Class 2 power sources:

- Inherently limited
- Not inherently limited

Inherently Limited Class 2 Power Source

An inherently limited Class 2 power source has some form of current-limiting characteristic designed into the product. Sources of this type are often protected by a current-limiting impedance or embedded fusible link, but other methods are also used. As long as the current limiting is an integral part of the power supply, it will fall into this category.

NOTE:
Because of this built-in current-limiting characteristic, a circuit powered by this type of source needs no further protection to qualify as a Class 2 circuit.

Inherently limited Class 2 transformers are generally available with ratings up to about 60 VA. They will often be direct plug-in type transformers, similar to those used to power calculators or other small devices. This makes them well suited to applications using a separate transformer for each controller. They can also be used for small power trunk applications, up to the VA rating of the transformer.

Not Inherently Limited Class 2 Power Source

A Class 2 source that is not inherently limited does not have built-in current limiting protection. At the time of installation, a current-limiting device must be installed between the source and the loads. The most common current limiting device for this application is a single fuse or integral transformer circuit breaker, which must be sized so that the power available to the loads does not exceed 100 VA.

Transformers that are not inherently limited are most commonly used for power trunk applications. Transformers of this type are usually direct wire types, and are available in sizes that permit power trunks up to the full 100 VA allowed. It should be noted that with the additional power capabilities come additional requirements and restrictions at the time of application.

NOTE:
In order to meet NEC Class 2 requirements, using a transformer that is not inherently limited is subject to the following rules:

- Each transformer must have a nameplate rating of 100 VA or less.
- Unloaded (open circuit) voltage on any circuit cannot exceed 30 Vac.
- Each trunk must be limited to 100 VA or less.

- For 24V power trunks, each transformer circuit must be protected by a single fuse or integral circuit breaker rated 4 amps or less. This protection is required even if the transformer is rated at 100 VA or less.
- A fuse block for the trunk fuses may be required by local code.

⚠	⚠ CAUTION
	Always check local codes to determine whether there are differences from the NEC. Specifically, you should determine whether fused circuits are acceptable as Class 2 in your area.

Class 2 Power Trunks

The following information will help you lay out power trunks for supplying power to multiple controllers.

Each power trunk will be supplied by a step-down transformer located near a convenient source of line voltage. In general, over-current protection will be required between the step-down transformer and the controllers. See Figures Power Trunk Layout, Class 2 Circuits [→ 68] and Power Trunk Layout, Class 1 Circuit [→ 68] and Table Power Trunk Transformer Specification Data [→ 68] for details.

Use Class 2 power trunks where possible because they can often be run without conduit. Where conduit is required, Class 2 power trunks can be run in the same conduit with FLN trunks and AI or DI wiring.

Grounding

Earth ground point for Class 2 power trunk transformer secondary neutral must be connected back to earth ground for Service using a dedicated ground wire. Service must be same as used for FLN Controller and all other FLN devices.

Restrictions

- When using power trunks, any relays, EPs, or contactors must be protected with MOVs at their connection to the trunk.
- The fused side of each power trunk must only be connected to terminals labeled +, 24 Vac, or HOT.
- Where different services are used, they must be banded per NEC Article 250, or Communication Isolation devices must be used.
- Multiple power trunks from the same transformer must be kept in phase. Avoid using different transformers to power the loads and the controllers. If unavoidable, use relay modules to provide isolation for loads connected to different transformers.
- If power trunks are connected to UCs, the unfused side of the transformer must be grounded at the transformer and can only be connected to device terminals labeled COMMON or NEUTRAL.

⚠	⚠ CAUTION
	Failure to adhere to these polarity conventions can result in equipment damage.

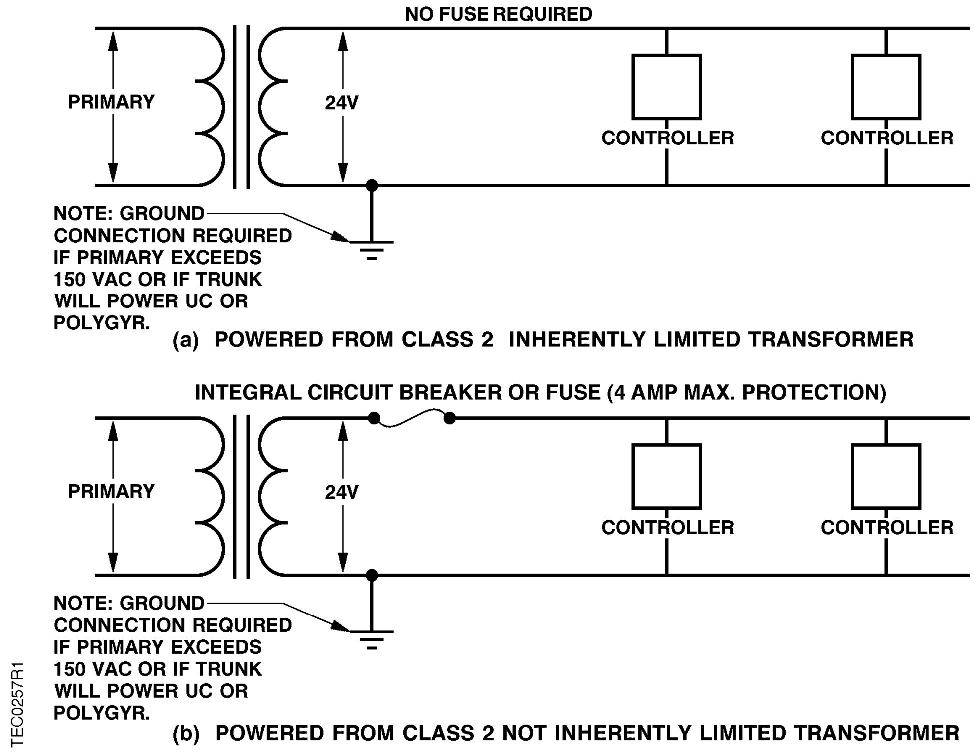


Figure 38: Power Trunk Layout, Class 2 Circuits.

⚠	⚠ CAUTION
	Circuits connected to transformers rated over 100 VA must be treated as Class 1, that is, in conduit, separate from ALN, FLN, and point wiring. When power requirements exceed 100 VA, it is recommended that multiple transformers 100 VA or less be used, rather than a single transformer.

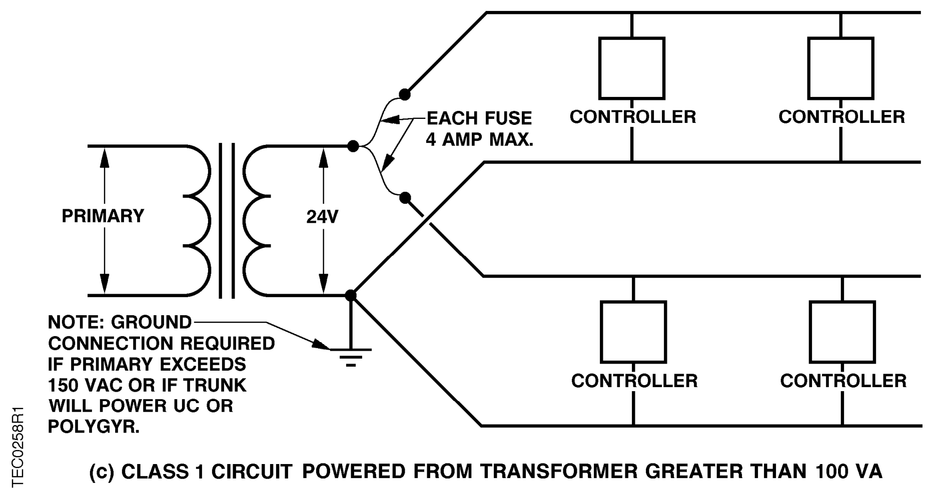


Figure 39: Power Trunk Layout, Class 1 Circuit.

Power Trunk Transformer Specification Data		
Primary Volts: As Required Secondary Volts 24 (50/60 Hz) [1]		24 Volts Secondary
Volt-Amp Rating	Output Amperage	Fuse Amps [2]
50	2.08	2.5
75	3.12	3.2
100	4.16	4.0
150 [3]	6.35	4.0
250 [3]	10.4	4.0
350 [3]	14.6	4.0
500 [3]	20.8	4.0
750 [3]	31.2	4.0
1000 [3]	41.7	4.0

1) NEC requires that the Secondary must be grounded if the Primary exceeds 150 volts to ground.

2) The fuse for each circuit from a transformer rated greater than 100 VA must be 4.0 amps maximum. The type of fuse required depends on local interpretation of the National Electric Code. Most frequently, transformers with multiple output circuits and multiple fuses are interpreted as Class 1 circuits.

3) To comply with NEC Class 2 requirements, each circuit from transformers cannot be greater than 100 VA and transformers cannot exceed 100 VA. Circuits connected to transformers rated over 100

VA must be treated as Class 1 – that is, in conduit, separate from trunk and point wiring. When power requirements exceed 100 VA, it is recommended that multiple transformers 100 VA or less be used, rather than a single transformer. Check local codes to determine whether larger transformers, in combination with fused circuits, can be classified as Class 2 circuits.

Power Trunk Layout

Layout is accomplished by completing the following procedures:

1. Determine the VA rating minimum voltage input for each controller.
2. Determine the number of power trunks required.
3. Determine the wring runs and calculate the voltage at the last controller of each trunk type.
4. Select and locate the transformers.

Step 1 - Determine the VA Rating for Each Controller

VA ratings can be found under the heading Power Source Requirements in the chapter that covers each type of controller.

If future options are to be installed, the VA rating of the affected controllers can be increased. Therefore, if future upgrades will be implemented, include their power consumption in your calculations.

Example

Controller	Type		VA Required
C1	DXR2.M18-101B (Fan Coil Application with Actuator GMA151.1P – 1 DO, 1 Y, 1U)		15 VA
C2, C3, C4	TEC (Dual Duct Controller—1 AVS, Application 35 with Hot Water Heat)		13.6 VA
C5	Standard UC 4 UI @ 1.25 each 3 UO @ 1.25 each 2nd I/0 card Keypad display Total	15.0 VA 5.0 VA 3.75 VA 4.0 VA 5.0 VA 32.75 VA	32.75 VA
C6, C7	TEC (Dual Duct Controller—1 AVS, Application 35 with 2-stage Electric Heat)		27.9 VA
C8	Standard UC 3 UI @ 1.25 each 1 UO @ 1.25 each Total	15.0 VA 3.75 VA 1.25 VA 20.0 VA	20.0 VA
C9, C10	TEC (Dual Duct Controller—1 AVS, Application 35, with Electric Heat)		19.4 VA
C11	M12P-102B-GDE (Variable Air Volume with Actuator, Room Automation QMX3.P37)		19.4 VA
C12	TEC (Constant Volume Controller—Electronic Output, Application 30)		5.7 VA

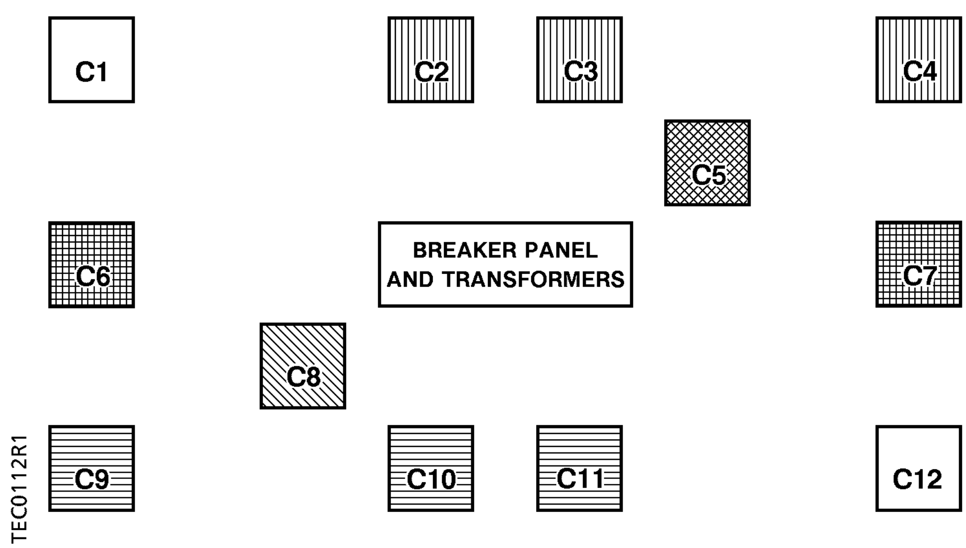


Figure 40: Example Layout.

Step 2 - Determine the Number of Power Trunks Required

Use the following steps to select and locate the transformers.

1. Based on the total VA, determine the transformer(s) you will use to supply power to the trunks.

   a For example, if the total VA required for all controllers is 129.3 VA, you could use any combination of inherently limited Class 2 transformers that supply the required power. Or, based on the transformers listed in Table *Physical Network Limitations*, you could use two 75 VA not inherently limited transformers, each with a field installed 4A fuse. Or, if acceptable to the authority having jurisdiction, use one 150 VA transformer with two 4A fuses. See Figures Power Trunk Layout, Class 2 Circuits [→ 68] and Power Trunk Layout, Class 1 Circuit [→ 68] and Table Power Trunk Transformer Specification Data [→ 68] for details.

NOTE:
All transformers listed in Table Power Trunk Transformer Specification Data [→ 68] are the “not inherently limited” type. Therefore, you must adhere to the following guidelines to comply with NEC Class 2 requirements.
- Each transformer must be limited to 100 VA or less.
- Unloaded (open circuit) voltage on any circuit must not exceed 30 Vac.
- Each trunk must be limited to 100 VA or less.
- For 24V power trunks, each circuit must be protected by fuses rated 4 amps or less. A fuse block for the trunk fuses can be required by local code.

---

2. Determine the minimum number of power trunks needed:

   a Minimum number of trunks = Total VA/100 VA.
   a Depending on your loads and how they are positioned, it may be necessary to use more than the minimum number of trunks.

3. Locate the transformers and fuse blocks, with one fuse for each of the trunks at the breaker panel. Connect the line side of all fuses to the secondary of the transformer. One power trunk will be connected to the load side of each fuse.

Example

1. Determine the total VA ratings for all controllers. In this example, the VA required is:

1	×	5.7	VA	=	5.7	VA
1	X	15.0	VA	=	15.0	
3	×	13.6	VA	=	40.8	VA
1	×	32.75	VA	=	32.75	VA
2	×	27.9	VA	=	55.8	VA
1	×	20.0	VA	=	20.0	VA
3	×	19.4	VA	=	58.2	VA
					228.25	**VA**

2. Determine the minimum number of power trunks you will need:

   - Minimum number of trunks = 228.25 VA ÷ 100 VA = 2.28
   - Since this number is greater than 2, it will be necessary to use a minimum of

three power trunks.

NOTE:
This does not imply that transformers totaling 300 VA will be required.

Step 3 - Determine the Wiring Runs and Calculate the Voltage Available at the Last Controllers of Each Trunk Type

A wiring run is the distance from the transformer to the end controller in a series. It can be composed of one or more legs. A leg is the distance from the transformer to the first controller, or the distance from one controller to the next controller.

Figure *Wiring Run* shows the following:

- L1, L2, and L3 are all legs of a wiring run to C3.
- L1, L4, and L6 are all legs in a wiring run to C6.
- L1, L2, and L5 are all legs in a wiring run to C5.

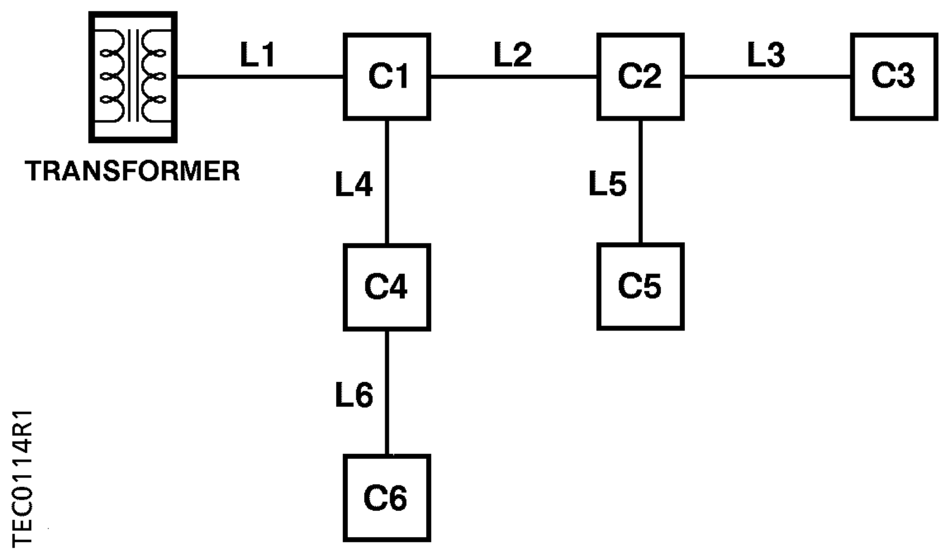


Figure 41: Wiring Run.

1. Configure the power trunks so that the total VA rating of all controllers does not exceed 100 VA per trunk.
2. Calculate the voltage available at the last controller on each run. Verify that it is greater than the minimum required voltage for the controller.

NOTE:
Different controllers have different power ratings. You may need to calculate the voltage available at the last controller of each type on each wiring run. To calculate these voltages, you must know the following:
- The length of each leg of the wiring run.
- The VA rating for each controller on the wiring run.
- Which devices pull power through each leg.

3. Determine how many VA are being drawn through each leg by summing the VA ratings for all controllers pulling power through each leg.
4. Determine the voltage drop for each leg:

   a Voltage drop = (total VA)/24V × 0.005 ohms/ft × distance in feet
   a *Where*:
   0.005 is the resistance in ohms/ft for a pair of No. 14 AWG wires.

NOTE:
If a different wire gauge is used, the corresponding resistance must also be used. The values for all approved wire pairs are as follows:
- AWG 14 = 0.005 ohms/ft
- AWG 16 = 0.008 ohms/ft
- AWG 18 = 0.012 ohms/ft
- AWG 20 = 0.020 ohms/ft
- AWG 22 = 0.033 ohms/ft
- AWG 24 = 0.051 ohms/ft (UTP resistance greater than 2C = 0.048 ohms/ft)

5. Determine the voltage available at the last controllers:

   a. Calculate the starting voltage:
   Starting voltage = transformer voltage × 0.9
   Where:
   0.9 is an efficiency factor to account for transformer inefficiencies and lint voltage variations.

   b. Calculate the voltage drop to the last controllers:
   Sum the voltage drops of all legs between the transformer and the last controller
   For example, in Figure *Wiring Run*
   Voltage drop to C5= (Vdrop L1) + (Vdrop L2) + (Vdrop L5)

   c. Calculate the voltage at the last controller
   Starting voltage – Voltage drop to the last controller
   (Step 5a minus Step 5b)

   d. Check the power source requirements for the DXR2 or PTEC/TEC and verify that your total (the voltage available at the last controller) is greater than the minimum required for that controller type. If your total is not greater than the minimum, the power trunk must be reconfigured.

Example

1. Configure the power trunks so that the total VA rating of all devices does not exceed 100 VA per trunk. (Many configurations are possible. See Figure *Completed Example Layout* for the configuration used in this example.)
   - Trunk A: (1 × 5.7) + (3 × 13.6) + (1 × 32.75) = (1 x 15 = 88.55 VA)
   - Trunk B: (1 × 27.9) + (1 × 20) + (2 × 19.4) = 86.7 VA
   - Trunk C: (1 × 27.9) + (1 × 19.4) + (1 × 5.7) = 53.0 VA
2. Calculate the voltage available at the last controller on each run to verify that it is greater than the minimum required voltage for the device.

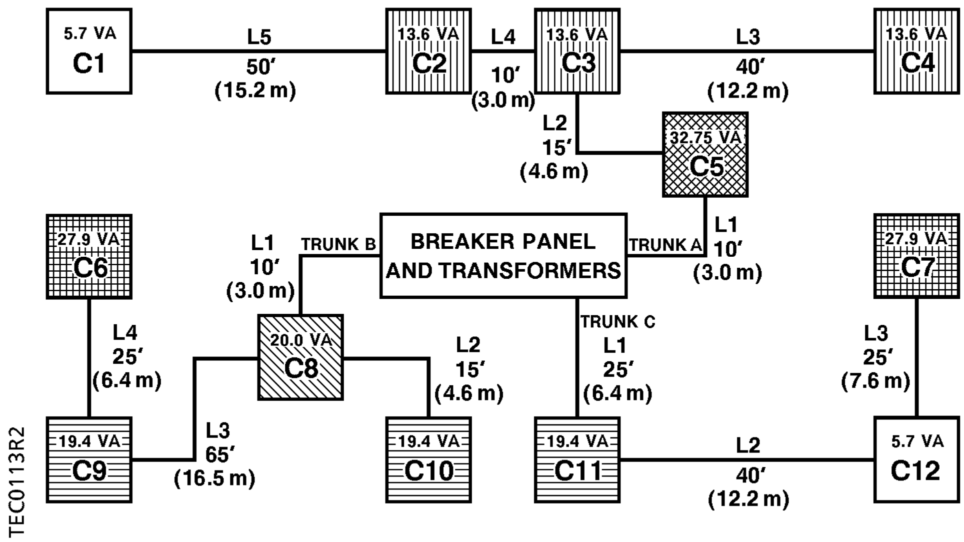


Figure 42: Completed Example Layout.

3. Calculate how much power is drawn through each leg:

Trunk A	
Leg 1	= VA (C1) + VA (C2) + VA (C3) + VA (C4) + VA (C5)
	= 15 + 13.6 + 13.6 + 13.6 + 32.75
	= 88.55 VA
Leg 2	= VA (C1) + VA (C2) + VA (C3) + VA (C4)
	= 10 + 13.6 + 13.6 + 13.6
	= 55.8 VA
Leg 3	= VA (C4)
	= 13.6 VA
Leg 4	= VA (C1) + VA (C2)
	= 15 + 13.6

Trunk A	
	= 28.6 VA
Leg 5	= VA (C1)
	= 15 VA

By similar calculations, power drawn through the remaining legs is:

Trunk B	Trunk C
Leg 1 = 66.7 VA	Leg 1 = 42.6 VA
Leg 2 = 19.4 VA	Leg 2 = 33.6 VA
Leg 3 = 47.3 VA	Leg 3 = 27.9 VA
Leg 4 = 27.9 VA	

- Determine the voltage drop for each leg:
  - a **Voltage drop = (total VA)/24V × 0.005 ohms/ft × distance in feet**
  - a *Where*:
    0.005 is the resistance in ohms/ft. for a pair of No. 14 AWG wires.

Trunk A
Vdrop (Leg 1) = (74.75 VA / 24V) × 0.005 ohms/ft × 10 ft. = 0.16V
Vdrop (Leg 2) = (42.2 VA / 24V) × 0.005 ohms/ft × 15 ft. = 0.13V
Vdrop (Leg 3) = (13.6 VA / 24V) × 0.005 ohms/ft × 40 ft. = 0.11V
Vdrop (Leg 4) = (28.6 VA / 24V) × 0.005 ohms/ft × 10 ft. = 0.06V
Vdrop (Leg 5) = (15 VA / 24V) × 0.005 ohms/ft × 50 ft. = 0.16V

By similar calculations, the voltage drops for the remaining legs are:

Trunk B	Trunk C
Vdrop (Leg 1) = 0.18 V	Vdrop (Leg 1) = 0.28V
Vdrop (Leg 2) = 0.06V	Vdrop (Leg 2) = 0.28V
Vdrop (Leg 3) = 0.64V	Vdrop (Leg 3) = 0.15V
Vdrop (Leg 4) = 0.15V	

- Determine the voltage available at the last remote actuator (A1) on controller (C1):

  a. Calculate the starting voltage:
     Starting voltage = 24V × 0.9 = 21.6V
     Where:
     0.9 is an efficiency factor.

  b. Calculate the voltage drop to the last controllers or remote actuators:

Vdrop (to C1) = Vdrop (Leg 5) + Vdrop (Leg 4) + Vdrop (Leg 2) + Vdrop (Leg 1)
= 0.16V + 0.06V + 0.13V + 0.16V
= 0.51V

c. Calculate the voltage at the last controller remote actuator
V(A1) = Starting voltage – Vdrop (to A1)
= 21.6V – 0.51V
= 21.09V

d. Check that your calculation is greater than the minimum required voltage
The minimum voltage for a DXR2 Automation Station: 20.4V
Since 21.09V is greater than the 20.4V required this leg is correct.

If these calculations had resulted in a voltage less than the minimum required, it would have been necessary to reconfigure the layout of the power trunk.

NOTE:
Rerouting the power trunk so that controllers with the lowest minimum voltage requirements are at the end of the run, and controllers with the highest minimum voltage requirements are closest to the transformer can help correct voltage drop problems.
If this is not possible, or still does not provide the necessary voltage at the last device, try using a T-shaped power trunk (such as Trunks A or B) rather than a straight line (such as Trunk C) to reduce the voltage drop even further. In other words, a T-shaped power trunk allows you to obtain a higher voltage at the last controller. Using larger gauge wire for the power trunk will also help reduce the voltage drop.

To complete this example, the results for the last controllers on the remaining runs are found to be:

	Voltage	Minimum	Status
V(C4)	21.16	19.2	OK
V(C6)	20.63	19.2	OK
V(C10)	21.36	19.2	OK
V(C7)	20.89	19.2	OK

Since there are different types of equipment controllers (various DXR2s, PTEC/TECs, etc.) with different minimum power requirements mixed on the same trunk, you must identify the last type of each controller on each trunk. Determine if any of these controllers has a higher minimum voltage requirement than the controller at the end of the run. In this example, calculations are also necessary to determine the following:

	Voltage	Minimum	Status
V(C5)	20.94	20.4	OK
V(C8)	21.42	20.4	OK

Since the voltage at each controller was found to be greater than the minimum requirement, this layout is correct.

Step 4 - Select and Locate the Transformers

1. Using the trunk configuration that was defined and verified in Step 3 above, there are a number of options available:
   - Two 100 VA transformers and one 75 VA transformer can be chosen from Table *Physical Network Limitations* and provided with 4A fuses.
   - Two 100 VA transformers can be chosen from Table *Physical Network Limitations*, each provided with 4A fuses, and one 55 VA or larger inherently limited transformer from a local source could be used.
   - If local codes permit, one 250 VA transformer can be chosen from Table *Physical Network Limitations* and provided with three fuses.
2. Locate the transformers and fuse block, with three fuses, if required, at the breaker panel. Not all transformers require fuses; however, those that do should be connected as follows:
   - Connect the line side of fuses to the secondaries of the transformers.
   - One power trunk will be connected to the load side of each fuse where required.

Chapter 3—Field Panels

Control Circuit Point Wiring

The following illustrations apply to the PXC Modular (TX-I/O), PXC Compact, and MEC.

LFSSL (Logical FAST/SLOW/STOP Latched

	WARNING
	Do not install the Field Panel HAND/OFF/AUTO (HOA) option for points defined as LFSSL.

NOTE:
DO-1 and DO-2 invert value: NO
DI-3 normally closed: NO

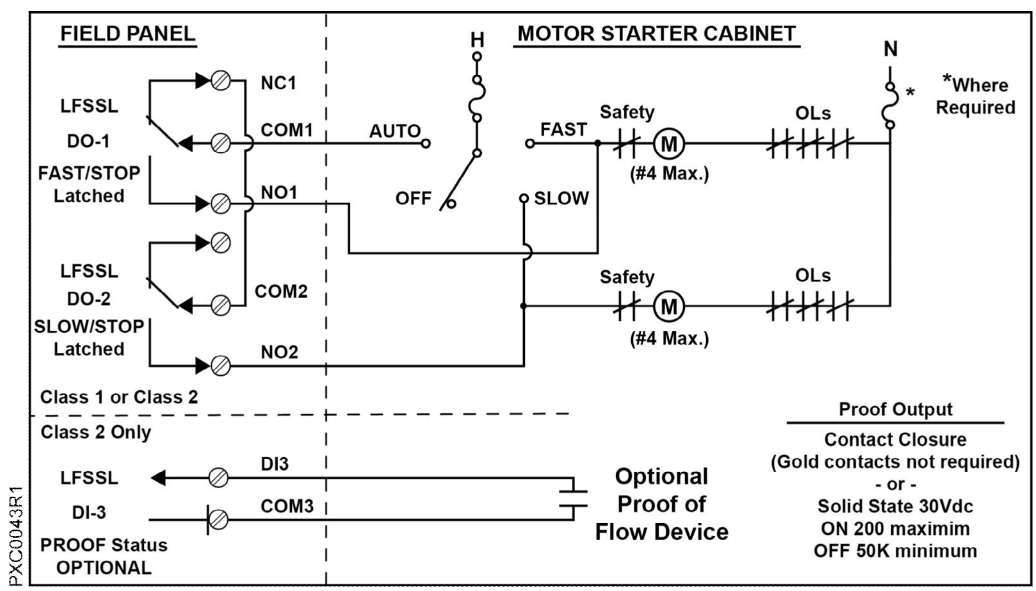


Figure 43: Connecting an LFSSL (Proof Optional)

LFSSL Control Circuit States.			
State	**DO-1**	**DO-2**	**DI-3**
FAST	ON	OFF	ON
SLOW	OFF	ON	ON
STOP	OFF	OFF	OFF

LFSSP (Logical FAST/SLOW/STOP Pulsed)

	⚠ WARNING
	Do not install the Field Panel HAND/OFF/AUTO (HOA) option for points defined as LFSSP.

NOTE:
DI-4 normally closed: NO

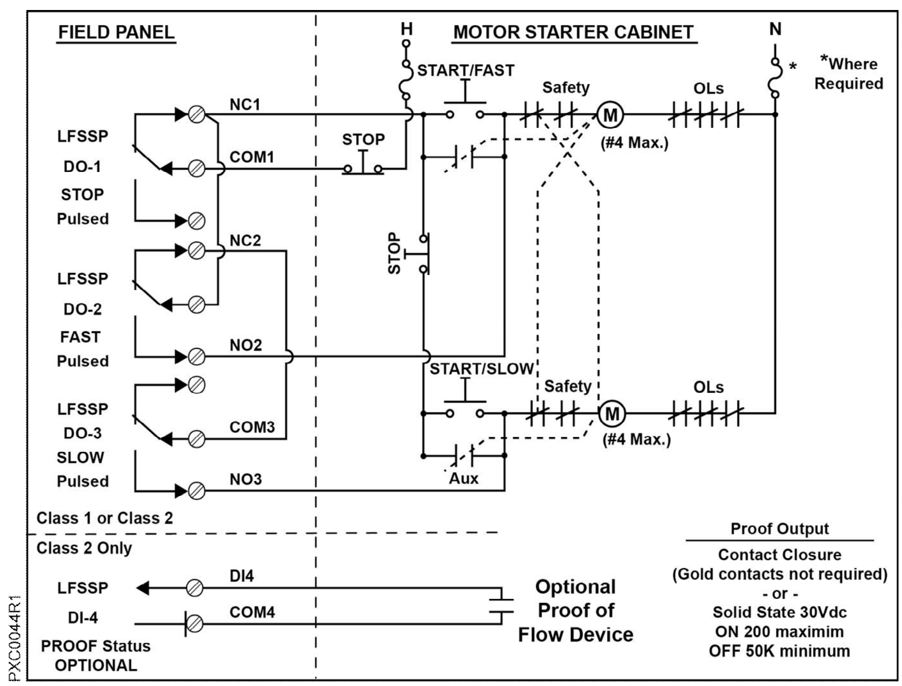


Figure 44: Connecting an LFSSL (Proof Optional)

LFSSP Control Circuit States.				
State	DO-1	DO-2	DO-3	DI-4
STOP	Pulsed ON	OFF	OFF	OFF
FAST	OFF	Pulsed ON	OFF	ON
SLOW	OFF	OFF	Pulsed ON	ON

LOOAL (Logical ON/OFF/AUTO Latched)

WARNING

Do not install the Field Panel HAND/OFF/AUTO (HOA) option for points defined as LOOAL.

NOTE:
DO-1 and DO-2 invert value: NO
DI-3 normally closed: NO

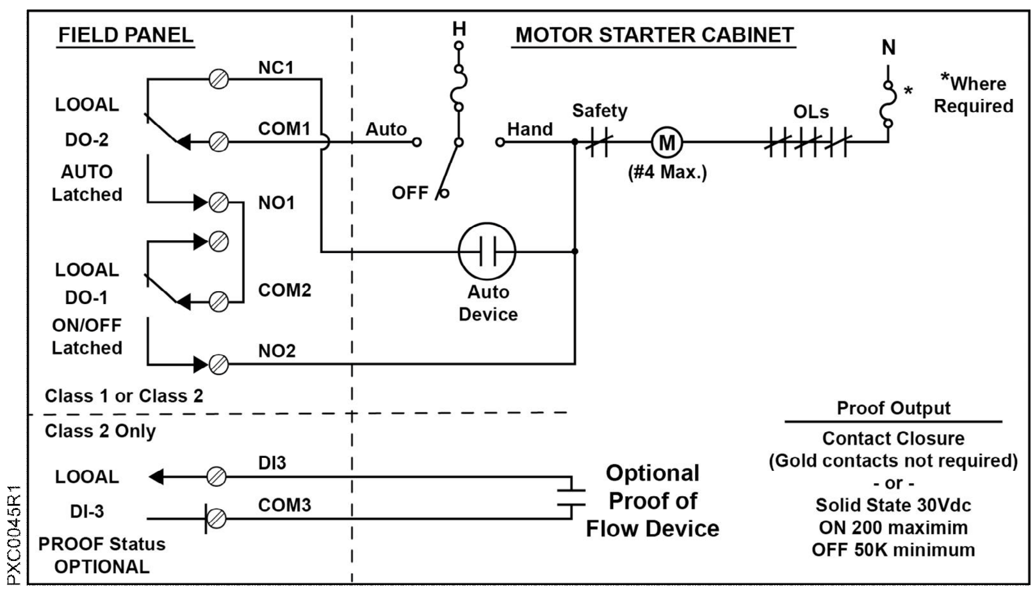


Figure 45: Connecting an LOOAL (Proof Optional).

LOOAL Control Circuit States.			
State	DO-1	DO-2	DI-3
ON	ON	ON	ON
OFF	OFF	ON	OFF
AUTO	OFF	OFF	AUTO

LOOAP (Logical ON/OFF/AUTO Pulsed)

	WARNING
	Do not install the Field Panel HAND/OFF/AUTO (HOA) option for points defined as LOOAP.

NOTE:
DO-3 invert value: NO
DI-4 normally closed: NO

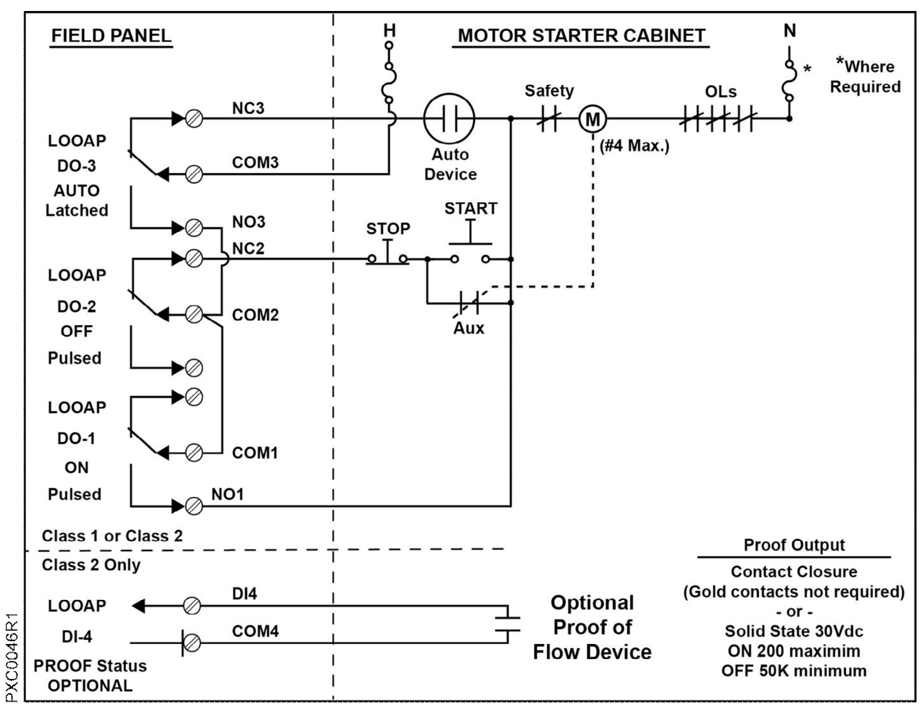


Figure 46: Connecting an LOOAP (Proof Optional).

LOOAP Control Circuit States.				
State	DO-1	DO-3	DO-3	DI-4
ON	Pulsed ON	OFF	ON	ON
OFF	OFF	Pulsed ON	ON	OFF
AUTO	OFF	OFF	OFF	AUTO

L2SL (Logical Two State Latched)

WARNING

Do not install the Field Panel HAND/OFF/AUTO (HOA) option for points defined as L2SL.

NOTE:
DO-1 invert value: NO
DI-2 normally closed: NO

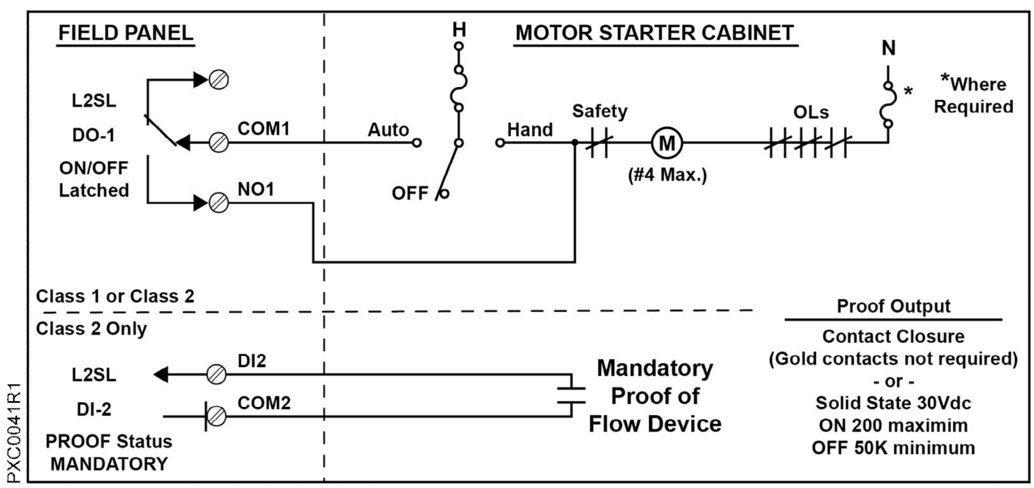


Figure 47: Connecting an L2SL (Proof Mandatory).

L2SL Control Circuit States.		
State	DO-1	DI-2
ON	ON	ON
OFF	OFF	OFF

L2SP (Logical Two State Pulsed)

	WARNING
	Do not install the Field Panel HAND/OFF/AUTO (HOA) option for points defined as L2SP.

NOTE:
DI-3 normally closed: NO

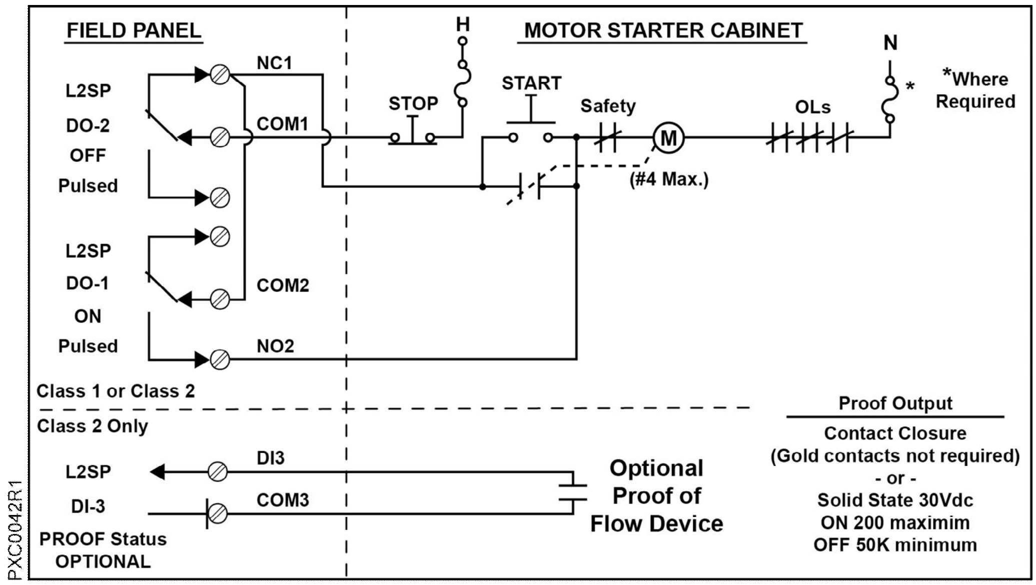


Figure 48: Connecting an L2SP (Proof Optional).

L2SP Control Circuit States.			
State	DO-1	DO-2	DI-3
ON	Pulsed ON	OFF	ON
ON	OFF	Pulsed ON	OFF

PX Series Service Boxes

	CAUTION
	Do not connect inductive loads, such as drill motors, vacuum cleaners, or compressors, to the duplex receptacle on the 115V Service Box.

PX Series Service Box Source Requirements and Outputs						
			Maximum Input		Maximum 24 Vac Output	
PX Series Service Box Model	Input Voltage	Line Frequency	Transformer	Service Outlets	Total[1]	Class [2]
115V 192VA	115 Vac	50/60 Hz	2A	2A[2]	192 VA	96 VA
115V 384VA	115 Vac	50/60 Hz	4A	2A[2]	384 VA	96 VA
230V 192VA	230 Vac	50/60 Hz	1A	N/A	192 VA	96 VA
230V 384VA	230 Vac	50/60 Hz	2A	N/A	384 VA	96 VA

1) Total 24 Vac Output Power is distributed to both Class 1 Power Limited Terminations, for use inside the enclosure only, and a Class 2 Termination, which may also be used outside the enclosure.

2) Service outlets (115 Vac only) are not fused or switched, but are restricted to continuously-powered network devices (0.5A) and reserve power for laptop computers (1.5A). Plan Branch circuit for each additional 2A.

PX Series 115V Service Boxes (192 VA or 384 VA)

DANGER

Possible shock hazard! The power switch only disables power to the control side of the 24 Vac transformer. Power remains ON at the duplex receptacle (115V versions) and in the service box. Power may be present at the field devices. To avoid injury, follow proper safety precautions.

115 Vac source power to the service box enters the enclosure from the top right or right-hand side conduit knockouts. Source voltage must be current-limited to 20 amps or less (15 amps or less for Smoke Control), depending on the requirements of the particular installation.

Two pigtails and an earth grounding stud are provided under the wire cover for easy connection by an electrician. The AC hot is pre-wired to the transformer through a single pole On/Off switch and a circuit breaker. The pigtails are also connected to a duplex receptacle, which is not internally switched or fused. MOVs (3 × 150V) are installed on input power. Earth ground is available at the CTLR connector and at the duplex receptacle. Transformer secondary neutral (green) and Service Box earth ground (green/yellow) have ring terminals for mounting on earth ground stud.

Low voltage is routed from the transformer and supplies 24 Vac power at either 192 VA or 384 VA maximum. The CTLR and PS connectors are rated Class 1 power limited and connected equipment must reside in the enclosure with the service box. The Class 2 connector is limited to 96 VA and may also be connected to equipment outside of the enclosure. A MOV (30V) is installed on the transformer secondary. See the following figure for a wiring diagram.

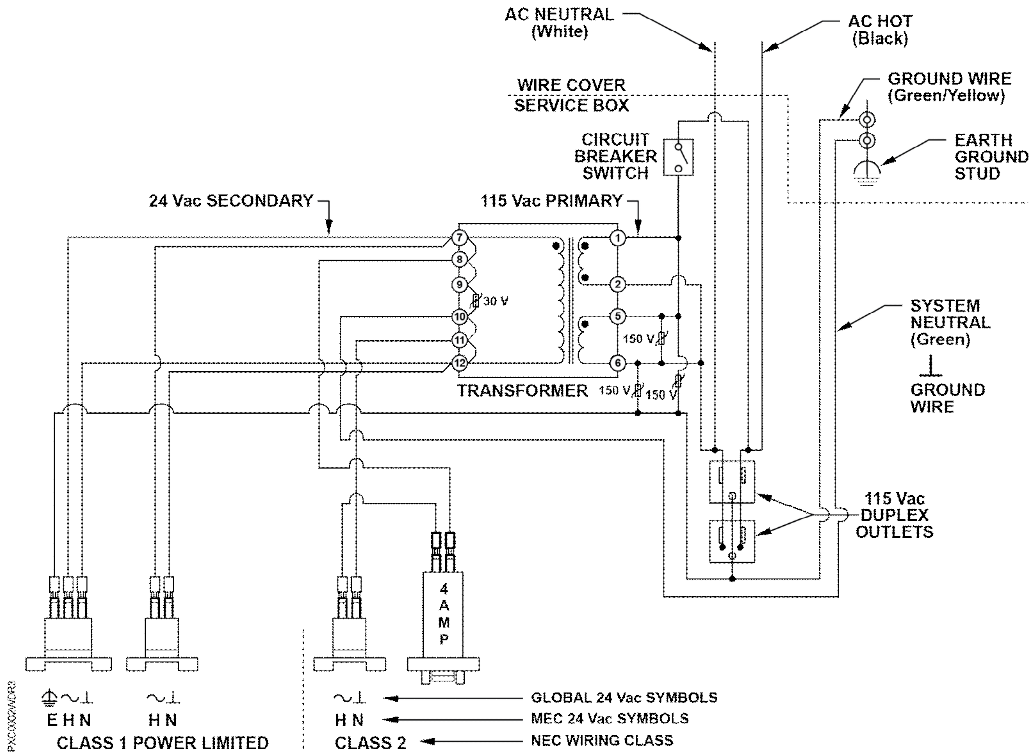


Figure 49: Wiring Diagram for 115V Service Box (192 VA or 384 VA).

PX Series 230V Service Boxes (192 VA or 384 VA)

230V (high-voltage) source power to the service box enters the enclosure from the top right or right-hand side conduit knockouts. Source voltage must be current limited to 10 amps or less, depending on the requirements of the particular installation.

A termination block for power and ground termination is provided on the wire cover for easy connection by an electrician. The termination block is pre-wired to the transformer through a double pole On/Off switch and a circuit breaker. MOVs (3 × 275V) are installed on input power. Termination block earth ground (green/yellow), transformer secondary neutral (green) and Service Box earth ground (green/yellow) have ring terminals for mounting on earth ground stud.

Low voltage is routed from the transformer and supplies 24 Vac power at either 192 VA or 384 VA maximum. The CTLR and PS connectors are rated Class 1 power limited and connected equipment must reside in the enclosure with the service box. The Class 2 connector is limited to 96 VA and may also be connected to equipment outside of the enclosure. A MOV (30V) is installed on the transformer secondary. See the following figure for a wiring diagram.

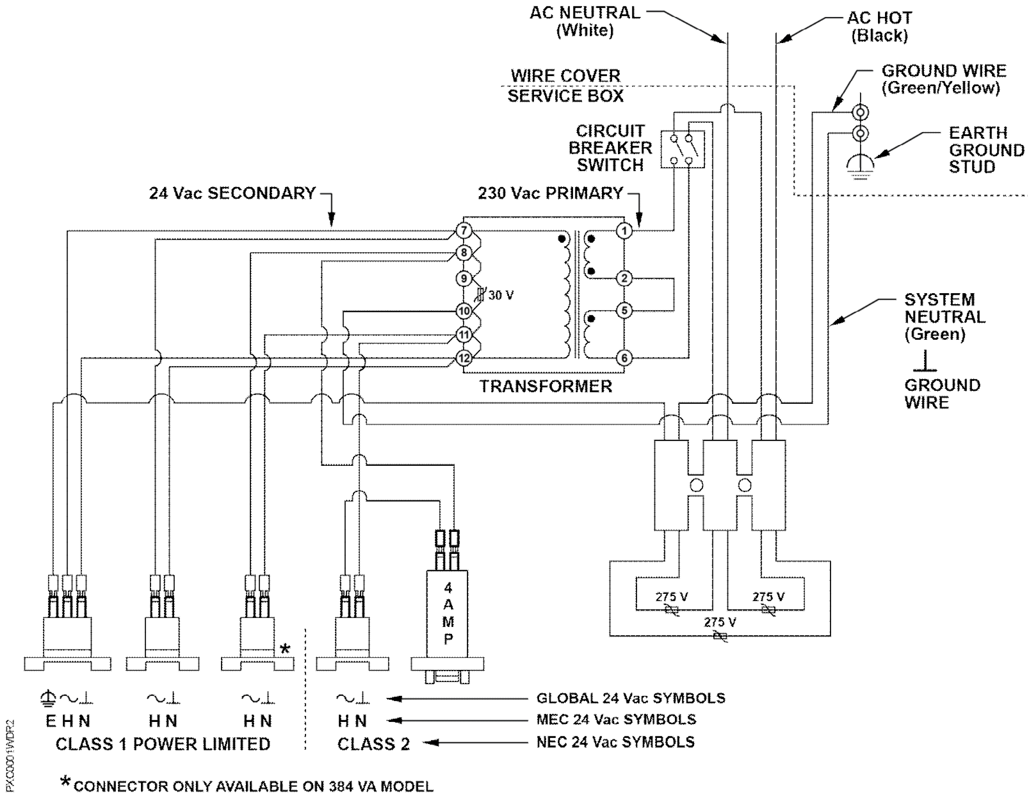


Figure 50: Wiring Diagram for 230V Service Box (192 VA or 384 VA).

PX Series Service Box Grounding

System Neutral (⊥) must be continuous throughout the TX-I/O bus.

- Whenever the entire system is not intentionally floating, including all I/O devices or peripherals, System Neutral is required to be earth-grounded at a single point only.
- The earth ground is installed in the primary field panel by a single jumper between the service box **E** terminal and **N** terminal.
- A jumper is not installed in any secondary field panel.

See the following figures for wiring information.

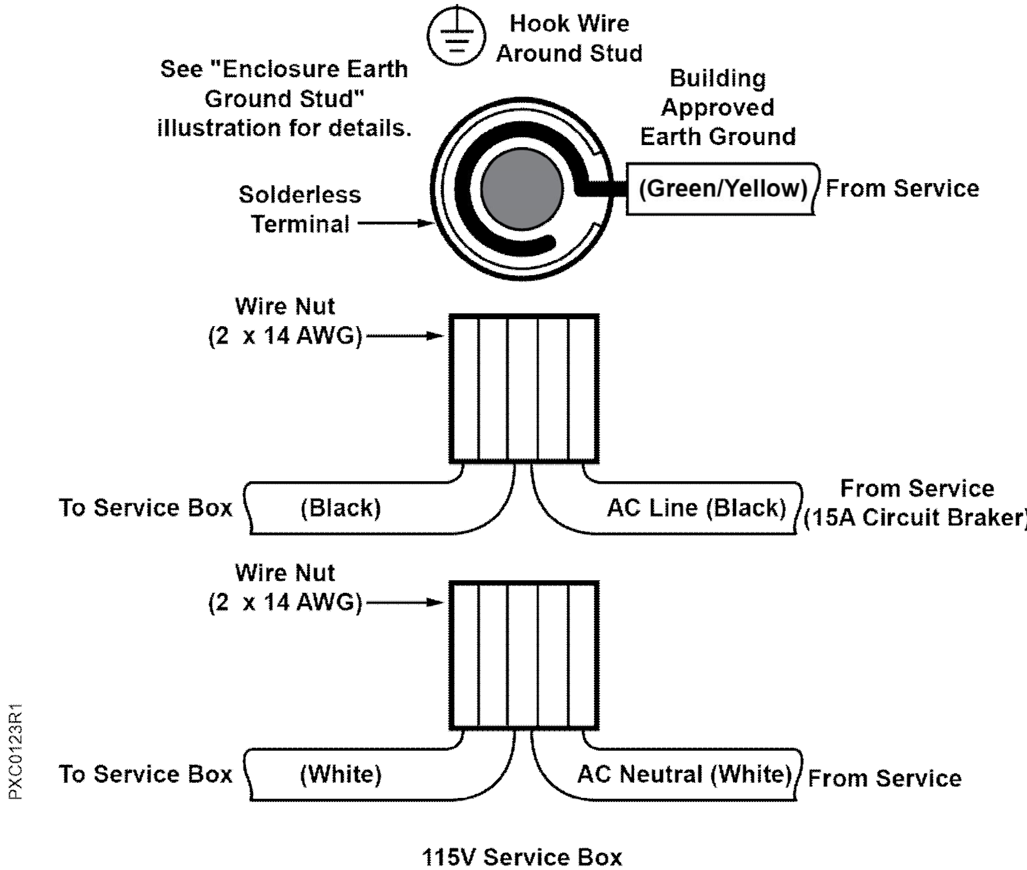


Figure 51: Grounding Diagram for 115V Service Box (192 VA or 384 VA).

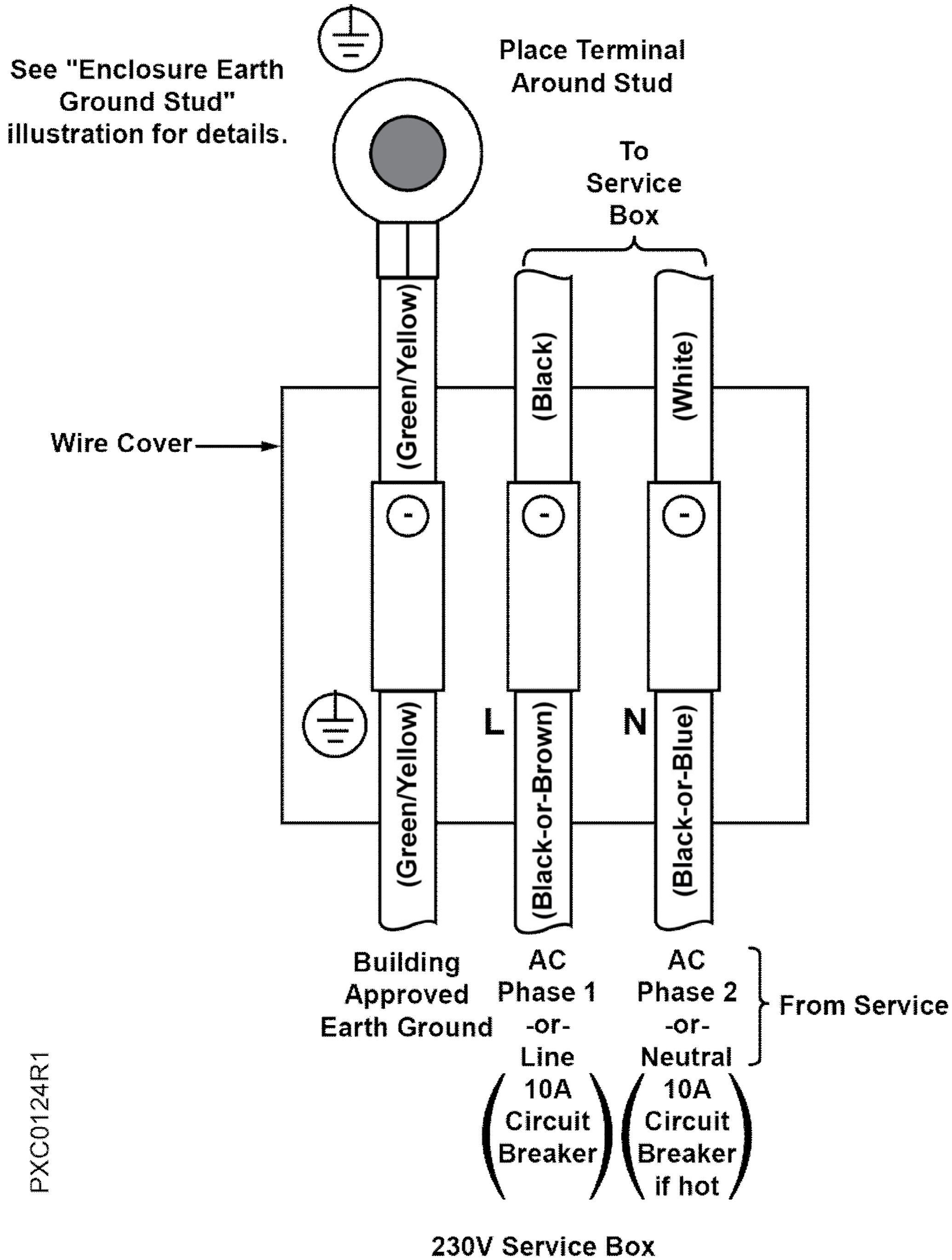


Figure 52: Grounding Diagram for 230V Service Box (192 VA or 384 VA).

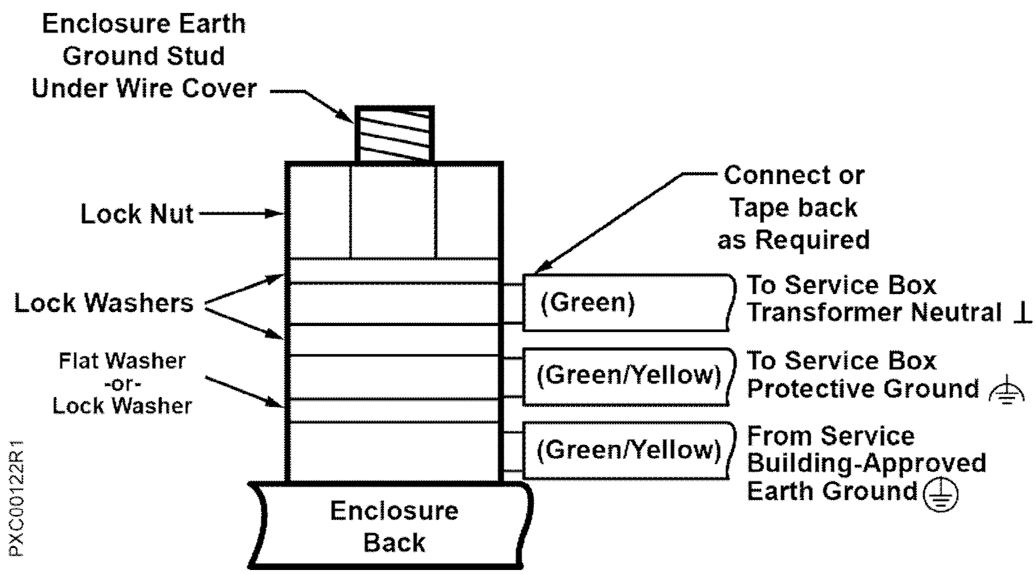


Figure 53: Detail of PX Series Enclosure Earth Ground Stud (Under Wire Cover).

Multiple PX Series Service Boxes on One Power Source

The following table shows the number of PX Series Service Boxes allowed on a single three-wire (ACH, an ACN, and earth ground) circuit, if local code permits.

Number of PX Series Service Boxes Allowed on a Single Three-Wire Circuit.				
	Maximum Values for Concentrated Loads		Maximum Values for Evenly Spaced Loads	
Circuit Breaker Size [1]	**Length**[2]	**192/384 VA**[3]	**Length**[2]	**192/384 VA**[3]
10 amp (No.14 AWG THHN) (230V models only)	115 ft (35.06 m)	6/3	130 ft (40.63 m)	8/4
15 amp (No.14 AWG THHN)	75 ft (22.87 m)	3/2	100 ft (30.48 m)	3/2
20 amp (No.12 AWG THHN)	115 ft (35.06 m)	4/3	130 ft (40.63 m)	4/3

1) For 115 Vac versions, assume minimum voltage of 102 Vac at the circuit breaker and 5 Vac maximum voltage drop (97 Vac) at loads. For 230 Vac versions assume minimum voltage of 204 Vac at the circuit breaker and 10 Vac maximum voltage drop (194 Vac) at loads. See Class 1 power trunk information in the *Wire Specification Tables* section of Chapter 1. Smoke control applications may not exceed 15 ampcircuit breakers.

2) Conduit length from PX Series Service Box to PX Series Service Box.

3) Number includes 2A reserved for duplex outlet on 115 Vac versions; not used with 10A circuit breakers.

TX-I/O Product Range

Wire Type Requirements

TX-I/O Wire Type Requirements.				
Circuit Type	Class	Wire Type	Maximum Distance[1]	Conduit Sharing[2]
AC Line Power (120V or greater) to transformer	1	No. 12 to No. 14 AWG THHN	See NEC and PX Series Service Boxes [→ 85]	Check local codes
Universal Input/Output	2	No.18 to No.22 AWG, TP[3] or TSP[4] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)[1]	Check local codes
Low Voltage Input/Output on SCS (Basic Link)	2	24 AWG UTP[5], solid 4 pair unshielded	295 ft (90 m)[1]	Check local codes
Low Voltage Input/Output on SCS (Patch Cables)	2	24 AWG UTP[5], stranded 4 pair unshielded	33 ft (10 m) [1]	Check local codes
Dedicated Digital Input	2	No.14 to No.22 AWG. TP not required below 1 Hz. at faster pulse speeds, use TP or TSP[4]; check job specifications and local codes.	750 ft (230 m)	Check local codes
Digital Output	1, 2	No.14 to No.22 AWG. TP not required; check job specifications and local codes.	Check local codes	Check local codes
TX-I/O Island Bus Low voltage AC, low voltage DC, and communication inside low voltage enclosure.	2	No. 14 or 16 AWG, 2 Twisted Pair (TP)	10 ft (3 m)	N/A
TX-I/O Island Bus Low voltage AC, low voltage DC, and communication between enclosures or inside high voltage enclosures[7].	2	1 Twisted Shielded Pair (TSP) + 1 Twisted Shielded 3C (Triad) -or- 1 Twisted Shielded 4C, No. 14 AWG or 16 AWG	164 ft (50m)[6]	Check local codes
TX-I/O Island Bus Expansion Communication and Power	2	24 AWG 1.5-pair (1 TP & 1 Conductor) with overall shield and drain wire. 24 AWG Low Cap Twisted shielded pair (TSP).	2 × 200 ft (61 m)	Check local codes

1) Wire length affects point intercept entry. Adjust intercept accordingly.

2) Conduit sharing rules: No Class 2 point wiring can share conduit with any Class 1 wiring except where local codes permit. (Both Class 1 and Class 2 wiring can be run in the field panel providing the Class 2 wire is UL listed 300V 75°C (167°F) or higher, or the Class 2 wire is NEC type CM (FT4) (75°C or higher) or CMP (FT6) (75°C or higher). NEC type CL2 and CL2P is not acceptable unless UL listed and marked 300V 75°C (167°F) or higher.

3) Twisted pair, non-jacketed, UL listed 75°C (167°F) and 300V cable can be used in place of CM (FT4) or CMP (FT6) (both must be rated 75°C or higher) cable when contained in conduit per local codes. See the *Field Purchasing Guide* for wire.

4) Twisted Shielded Pair TSP is not required for general installation, does not affect TXIO Module specifications, and may be substituted where otherwise specified. TSP should be used in areas of high electrical noise (for example when in proximity to VFDs and other large motors). Where used, connect the shield drain wire to the grounding system inside enclosure.

5) Cable must be part of a Structured Cabling System (SCS).

6) Maximum distance is total of all cable on the TX-I/O island bus for 14 AWG four conductor cable. See the formulas in this section for associated maximum power and maximum distance for each wire type.

7) See TX-I/O Island Bus Guidelines [→ 95] in this section for cable configuration.

See also

2 PX Series Service Boxes [→ 85]

Power Source Requirements

TX-I/O Power Source Requirements – I/O Modules.			
Product	**Part Number**	**Input Voltage**	**Maximum Power[1]**
Digital Input Module	TXM1.8D	24 Vdc	1.1 W
Digital Input Module	TXM1.16D	24 Vdc	1.4 W
Relay Module	TXM1.6R	24 Vdc	1.7 W
Relay Module	TXM1.6R-M	24 Vdc	1.9 W
Universal Module	TXM1.8U	24 Vdc	1.5 W [2]
Universal Module	TXM1.8U-ML	24 Vdc	1.8 W [2]
Super Universal Module	TXM1.8X	24 Vdc	2.2 W [2,3]
Super Universal Module	TXM1.8X-ML	24 Vdc	2.3 W [2,3]

1) The 24 Vdc self forming TX-I/O Bus and interconnecting wiring is Class 2.

2) Class 2 Distribution Terminals are provided for 24 Vac.

3) Class 2 Distribution Terminals are provided for 24 Vdc. A maximum of 4.8 W per module may be distributed for external sensors. This is not included in the maximum power shown above.

PXC Series Power Source Requirements.			
Product	Input Voltage	Maximum Power Consumption	24 Vdc Sensor Power Output
PXC Modular	24 Vac	24 VA	N/A
PXC Compact 36	24 Vac	35 VA	200 mA
PXC Compact 24	24 Vac	20 VA	200 mA
PXC Compact 16	24 Vac	18 VA	200 mA

1) 24 Vdc for up to eight external sensors at 25 mA each. Combined total of the external sensor power outputs cannot exceed 200 mA ±10% over full operating temperature range.

TX-I/O Power Source Requirements – Power Modules and Bus Modules.					
Product	Input Voltage	Line Frequency	Maximum Input Power	Maximum Output	
				24 Vdc[1]	24 Vdc
Power Supply Module	24 Vac	50/60 Hz	150 VA	28.8 W	96 VA
Bus Connection Module	24 Vac	50/60 Hz	96 VA	0 W	96 VA
Island Bus Expansion Module	24 Vdc	N/A	1.2 W	N/A	N/A
P1 Bus Interface Module	24 Vac	50/60 Hz	125 VA	14.4 W	96 VA

1) 24 Vdc power may be shared.

Powering Options

Input 24 Vac

One of the options for powering TX-I/O modules and 24V devices is the PX Series Service Box.

See PX Series Service Boxes [→ 85] in this chapter for more information.

Analog Input Powered Devices

The 24 Vdc output terminals on TXM1.8X and TXM1.8X-ML modules can power approved sensors or devices that draw less than 4.8 W (200 mA) total. Subtract the sensor or device power source requirements and the TX-I/O power source requirements from the maximum output of the TX-I/O Power Supply or P1 BIM.

An external source must power sensors that require more power than the TX-I/O Power Supply or P1 BIM can provide. The external source can be connected to the same AC line as the 24 Vac transformer or service box as long as it is only used to power low voltage devices (less than 30 volts).

Analog Output Powered Devices

The TX-I/O Power Supply and P1 BIM each provide 24 Vac 96 VA maximum Class 2 power distribution from the service box to the TX-I/O module AC outputs.

Metal Oxide Varistors (MOVs)

MOVs are not factory installed on the Digital Output module terminals. Install MOVs at the appropriate voltage rating on the DO terminals to prolong contact life. See Table *MOV part number* in the Controlling Transients [→ 24] section of Chapter 1 for recommended MOV types.

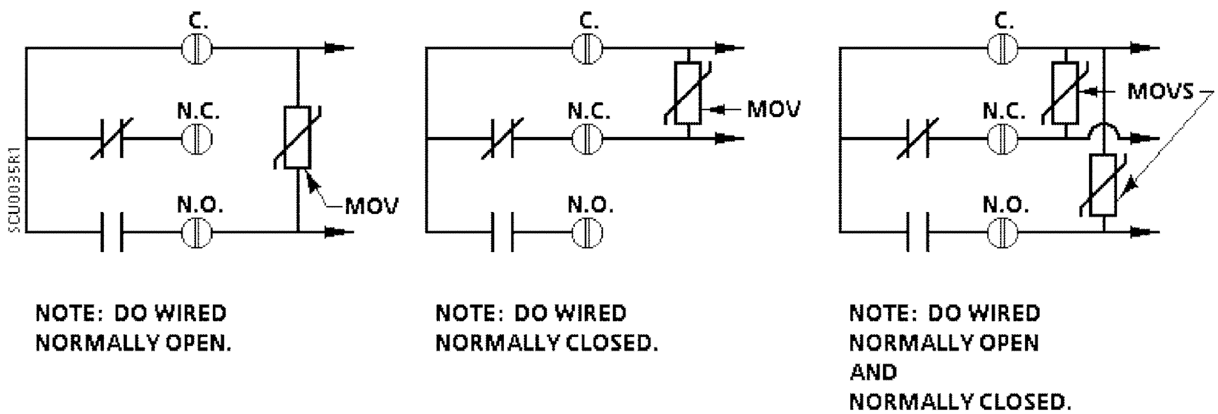


Figure 54: Figure 47. Field Installed MOVs.

TX-I/O Island Bus Guidelines

Power and Communications	Specifics	Diagram
ALN	RS-485; Supervised	Figure ALN Trunk Shield Connection [→ 49]
FLN	RS-485; Supervised	Figure FLN P1 Trunk Shield Connection [→ 50]
Power	24 Vac; Supervised	See the TX-I/O Island Bus Wiring Diagrams
TX-I/O island bus	24 Vdc; Supervised	
TX-I/O island bus expansion	RS-485; Supervised	

Power and Communications	Specifics
ALN	RS-485; Supervised
FLN	RS-485; Supervised
Power	24 Vac; Supervised
TX-I/O island bus	24 Vdc; Supervised

	⚠ CAUTION
⚠	To ensure error free communication and prevent equipment damage, observe the TX-I/O island bus wiring guidelines in this section.

- All connections to 24 Vac must be home run back to transformer.
- Distribute 24V~ transformer power to additional TX-I/O Power Supplies and Bus Connection Modules using twisted pair cable in a star configuration.
- Distribute 24 Vdc Communication Supply and Data (CS/CD/⊥) from the TX-I/O Power Supply or P1 BIM to other power supplies or Bus Connection Modules using twisted pair cable in a chain configuration.
- When using NEC Class 2 wiring on a TX-I/O island bus extended from an enclosure with a transformer, install a circuit interrupter to limit up to 4A maximum where necessary. A 4A interrupted output is available on the PX Series Service Boxes.
- TX-I/O island bus cables (24V~/⊥/CS/CD) must be run together either by NEC Class 2 methods or, where not limited by local code, by NEC Class 1 power limited methods.

See also
2 RS-485 ALN Trunk Shield Connection Using 2-Wire Cabling [→ 49]
2 RS-485 FLN (P1) Trunk Shield Connection [→ 50]
2 RS-485 ALN Trunk Shield Connection Using 2-Wire Cabling [→ 49]
2 RS-485 FLN (P1) Trunk Shield Connection [→ 50]

TX-I/O Island Bus Power and Communication Options

	⚠ WARNING
⚠	Equipment damage may occur if system neutral (⊥) is not connected to building approved earth ground at the transformer.

TX-I/O Island Bus

The TX-I/O island bus consists of the following signals:

- Communication and supply (CS)
- Communication data (CD)
- AC power (24V~)
- System neutral (⊥)

These signals operate over the self-forming TX-I/O module rails and are externally available at TX-I/O Power Supply and Bus Connection Module connectors.

TX-I/O Island Bus Expansion

The TX-I/O island bus expansion consists of the following signals:

- Communication data (CD) over RS-485 (+)
- Communication data (CD) over RS-485 (–)
- Signal common over RS-485 (⏚)

These signals operate over RS-485 cable and are available at Island Bus Expansion module connectors.

TX-I/O Module Support

Controllers that Support a TX-I/O Island Bus.			
	PXC Modular Series	PXC Compact 36	P1 Bus Interface Module (BIM)
Points Supported	500	32	80
TX-I/O Modules Supported (Maximum)	64	4	10
Power Supplies Supported	4	4	3
TX-I/O Power Supply	N/A[1]	N/A[1]	14.4 W[2]

1) Use a TX-I/O Power Supply to power TX-I/O modules. See Figure RS-485 ALN Trunk Shield Connection [➞ 49].

2) See Figure RS-485 FLN (P1) Trunk Shield Connection—Electronic Output [➞ 50].

- A maximum of 16 bus connections are permitted per island bus. For example, 1 P1 BIM + 3 TX-I/O Power Supply modules + 12 Bus Connection Modules = 16 bus connection points.

Controllers that Support a TX-I/O Island Bus.		
	TC Modular Series	TC Compact 36
Points Supported	500	32
TX-I/O Modules Supported (Maximum)	64	4
Power Supplies Supported	4	4

- A maximum of 16 bus connections are permitted per island bus. For example, 4 TX-I/O Power Supply modules + 12 Bus Connection Modules = 16 bus connection points
- On a TX-I/O island bus, multiple power supplies may be used in parallel (connected using CS/CD terminals), or up to two power supplies may be used in series (self-forming bus rails).

See Table TX-I/O Wire Type Requirements [➞ 92] for the maximum island bus distance.

See also

2 RS-485 ALN Trunk Shield Connection Using 2-Wire Cabling [→ 49]
2 RS-485 FLN (P1) Trunk Shield Connection [→ 50]

TX-I/O Island Bus Wiring Diagrams

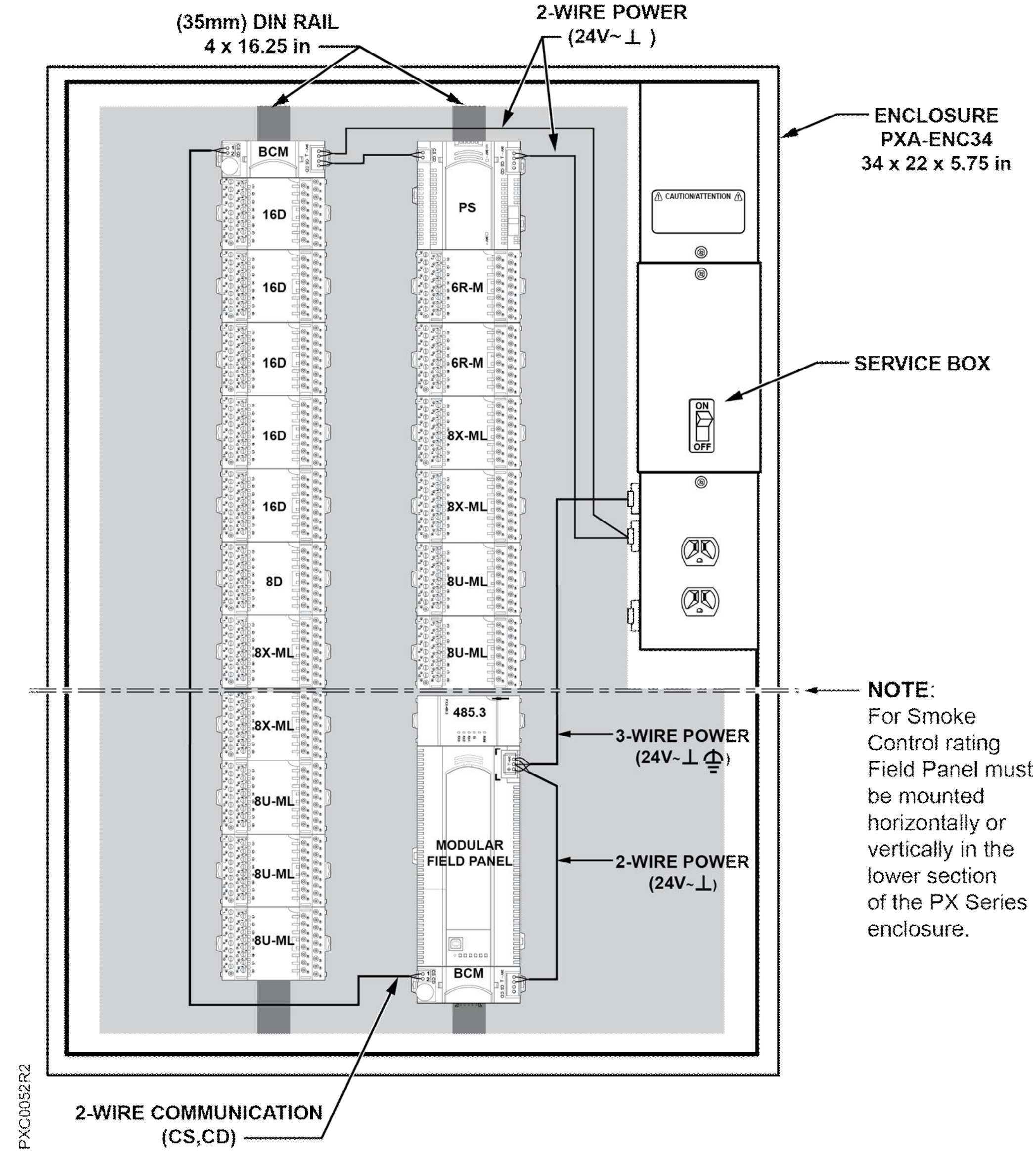


Figure 55: PXC Modular with TX-I/O Island Bus—Power and Communication Wiring.

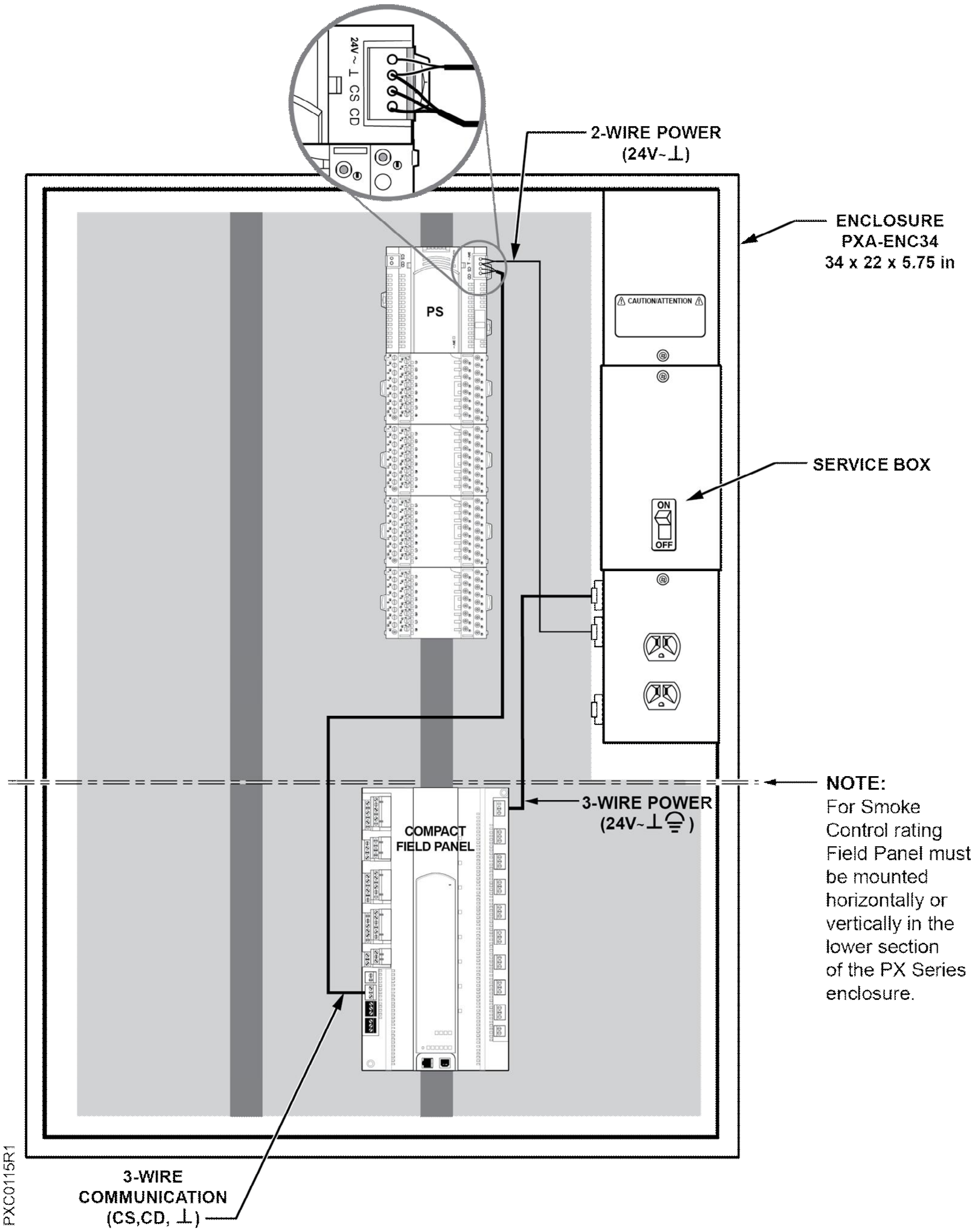


Figure 56: PXC-36 with TX-I/O Island Bus—Power and Communication Wiring.

NOTE: The common terminal from the PXC-36 to the Power Supply module on the Island Bus *must* be connected.

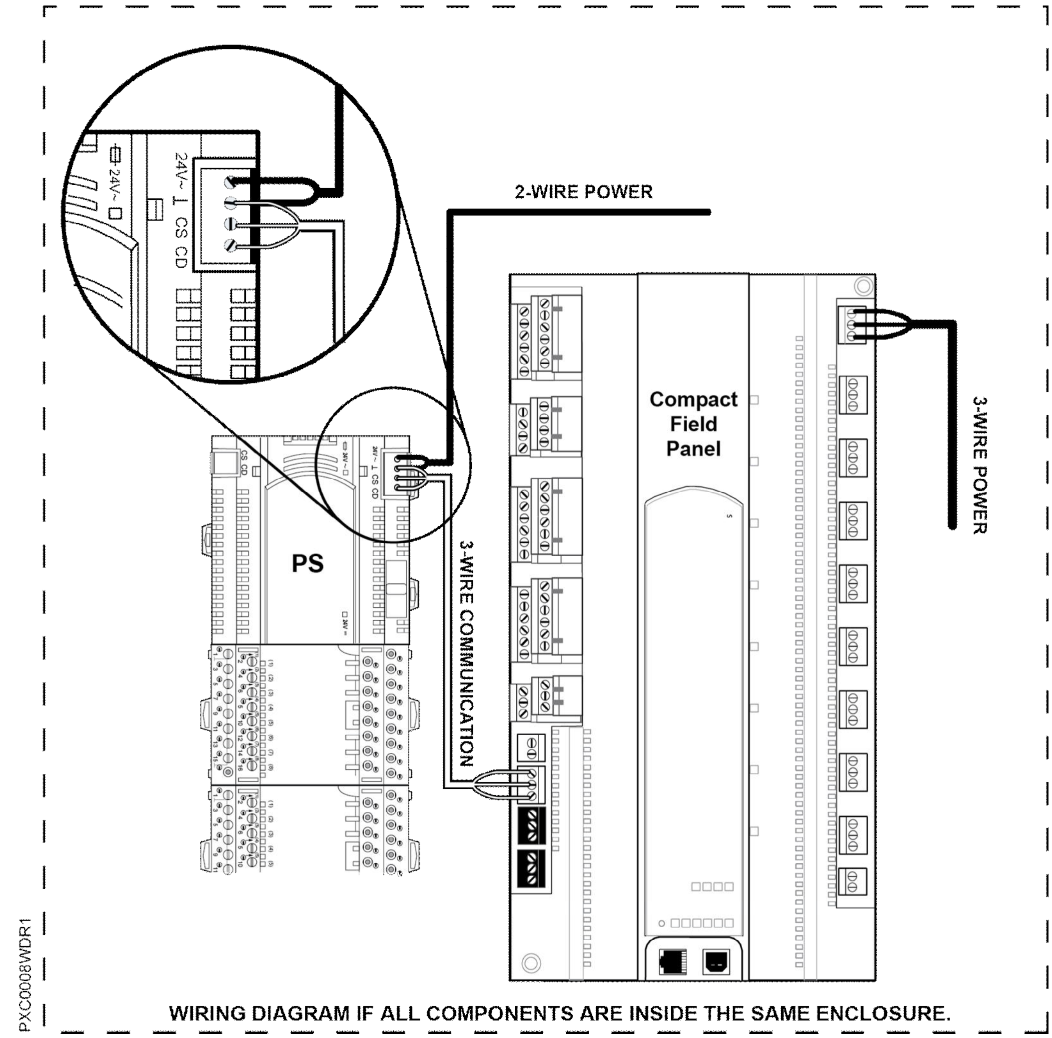


Figure 57: Compact 36 to TX-I/O Power Supply Wiring.

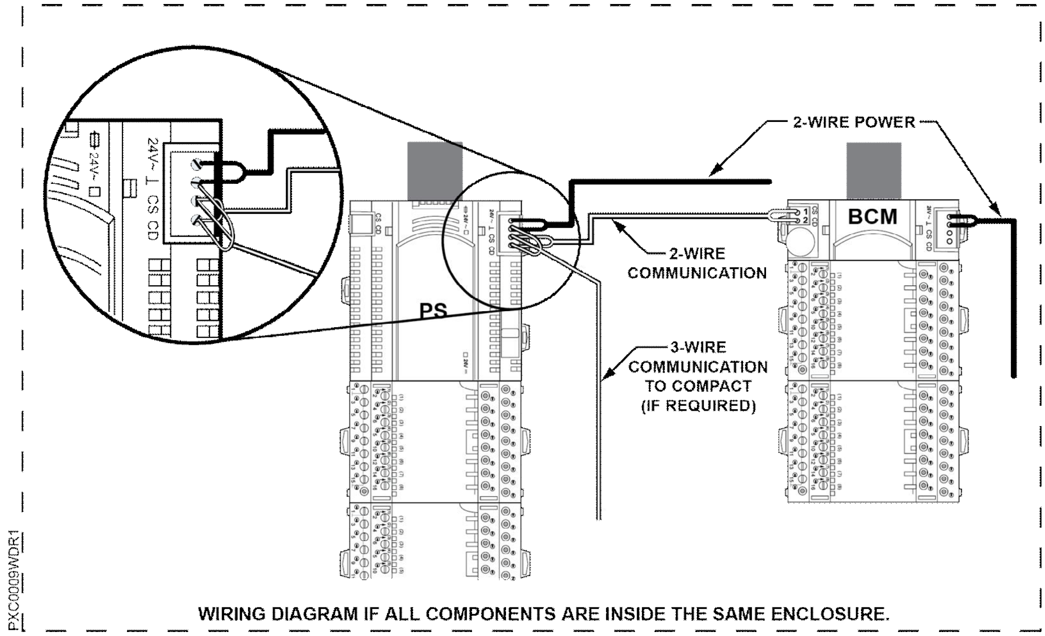


Figure 58: TX-I/O Power Supply to Bus Connection Module Wiring.

TX-I/O Island Bus Extension Cable Options

The maximum TX-I/O island bus cable length is 164 ft (50 m). This length is based on 54 picofarads per foot (pF/ft) capacitance, which is typical of shielded PVC tray cable.

- When the TX-I/O island bus is inside an electrically quiet enclosure, use 2 Twisted Pair (TP) with 24V~/⊥ home run to the transformer and CS/CD run between the Power Supply or Bus Connection Module. System Neutral (⊥) is not required to run with CS/CD.
- For use between enclosures or in an electronically noisy enclosure where AC and DC power require the same size cable, use 1 Twisted Shielded 4C for CS/CD/⊥/24V~.
- For use between enclosures or in an electronically noisy enclosure where AC and DC power require different size cable, use 1 TSP for 24V~/⊥ and 1 Twisted Shielded 3C (Triad) for CS/CD/⊥.

Operating the TX-I/O Bus in an Electrically Noisy Enclosure

Electrically noisy enclosures include motor control cabinets with VFD or motor power greater than 100 kVA, such as direct online (DOL) starters for motors greater than 25 HP.

The TX-I/O island bus cable must be shielded and separated from high voltage wire as described in Chapter 1 [→ 15].

Calculating the Maximum TX-I/O Island Bus Cable Length

The following factors are used to determine the maximum TX-I/O island bus cable length or power transfer:

- Total capacitance
- Vdc drop
- Vac drop

Total capacitance includes all branches. Total TX-I/O island bus cable capacitance must be less than 9 nanofarads (nF). Exceeding this limit causes communication errors.

Maximum power delivered to each branch is determined by TX-I/O island bus length for the branch, cable resistance and allowable voltage drop factor (12 for DC or 48 for AC).

R = 2 × branch length in feet × Ω/ft cable, or

R = 2 × branch length in meters × Ω/m cable

Where:

R is determined using maximum ambient temperature of wire at 75°C not mean 25°C.

14 AWG = 0.006 Ω/ft	2.0mm² = 0.0104 Ω/m
16 AWG = 0.009 Ω/ft	1.25mm² = 0.0168 Ω/m

Maximum DC Power (CS, CD, ⊥) = Vdrop × Vdc / R = 0.5 Vdc × 24 Vdc / R = 12 V2 / R

Maximum AC Power (24V~, ⊥) = Vdrop × Vac / R = 2 Vac × 24 Vac / R = 48 V2 / R

Example 1

Calculating the maximum TX-I/O island bus power that a Power Supply can deliver to a Bus Connection Module over the maximum wire length (164 ft).

- One 14 AWG shielded triad (CS, CD, ⊥)

  + One 14 AWG twisted shielded pair (24V~, ⊥)
- R(14 AWG) = 2 × 164 ft × 0.006 Ω/ft = 1.968 Ω ~ 2 Ω
- Maximum DC Power = 12 V^2 / 2 Ω = 6 W
- Maximum AC Power = 48 V^2 / 2 Ω = 24 VA

- or -

- One 16 AWG twisted shielded 4 Conductor (CS, CD, ⊥, 24V~)
- R(16 AWG) = 2 × 164 ft × 0.009 Ω/ft = 2.952 Ω ~ 3 Ω
- Maximum DC Power = 12 V^2 / 3 Ω = 4 W
- Maximum AC Power = 48 V^2 / 3 Ω = 16 VA

Example 2

Calculating the maximum distance between a fully-loaded Bus Connection Module and a Power Supply.

- One 14 AWG twisted shielded 4 Conductor (CS, CD, ⊥, 24V~)
- R(14 AWG) = 2 × 164 ft × 0.006 Ω/ft = 1.968 Ω ~ 2 Ω
- DC Length = 12 V^2 / (2 × 0.006 Ω/ft × 28.8 W) = 35 ft
- AC Length = 48 V^2 / (2 × 0.006 Ω/ft × 96 VA) = 42 ft
- DC Length must be no greater than 35 ft
- If 4 branches are used, the total length of 140 ft is within the 164 ft maximum.
- Transformer at the power supplies must be at least 4 × 150 VA + 24 VA (PXC) = 624 VA

- Each branch must have a 24V~ interrupt to be run as Class 2

TX-IO Module Wiring Diagrams

Module Type	Specifics [Page Number]
Digital Input Modules (TXM1.8D and TXM1.16D)	Digital Input Module Terminal Layout [→ 104]
	Dry Contacts; Supervised
Digital Output Modules (TXM1.6R and TXM1.6R-M)	Digital Output Module Terminal Layout [→ 106]
	Latched; Not Supervised
	Pulsed; Not Supervised
Universal and Super Universal Input/Output Modules (TXM1.8U, TXM1.8U-ML, TXM1.8X, and TXM1.8X-ML)	Universal Module Terminal Layout [→ 108]
	Super Universal Module Terminal Layout [→ 108]
	Digital Input (Dry Contacts; Not Supervised) [→ 109]
	Digital Input (Using AI, Supervised) See MEC Wiring Diagram to Use an AI as a DI [→ 158]
	Temperature Sensor Input (RTD and Thermistor; Supervised) [→ 110]
	0-10 Vdc Input (Voltage; Supervised) [→ 110]
	2-wire and 3-wire Active Input (Current; Supervised)—Super Universal Modules Only [→ 111]
	Analog Output (Voltage or Current; Not Supervised) [→ 112]

See also

2 Digital Input Modules (TXM1.8D and TXM1.16D) [→ 104]

2 Digital Output Modules (TXM1.6R and TXM1.6R-M) [→ 106]

2 Universal and Super Universal Modules (TXM1.8U and TXM1.8U-ML; TXM1.8X and TXM1.8X-ML) [→ 108]

2 Digital Input, Dry Contacts; Not Supervised, Universal and Super Universal Modules [→ 109]

2 Universal Inputs [→ 158]

2 Temperature Sensor Input (RTD and Thermistor); Supervised, Universal and Super Universal Modules [→ 110]

2 0-10 Vdc Input (Voltage); Supervised, Universal and Super Universal Modules [→ 110]

2 2-wire and 3-wire Active Input (Current); Supervised, Super Universal Modules Only [→ 111]

2 Analog Ouput (Voltage or Current); Not Supervised, Universal and Super Universal Modules [→ 112]

Symbols

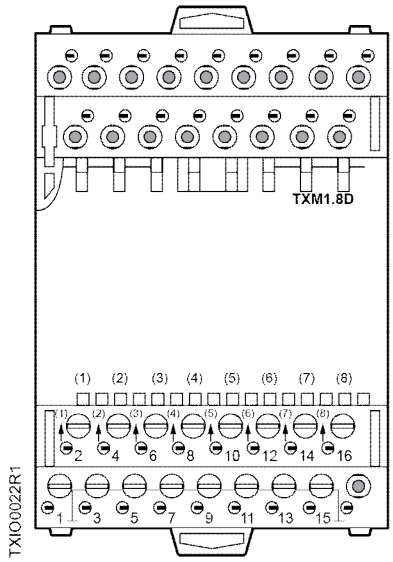
TX-I/O modules use the following set of symbols.

⊥	System neutral (‘N’ on MEC Service Box)
⏚	Protective Earth (PE) is Approved Building Earth Ground terminal at enclosure (output to terminal “⏚” on PX Series Service Boxes or terminal ‘E’ on MEC Service Box)
⏚	Protective Ground input on equipment for connection to PE
	Equipotential (RS-485 communications common reference terminal)
↕	Configurable point
	Output (arrow pointing OUT from center of module)
	Input (arrow pointing IN toward center of module)
V⎓	24 Vdc output (field supply)
V≈	AC/DC output, 12 to 24V (field supply)
~	24 Vac input from Service Box (‘H’ on MEC Service Box)

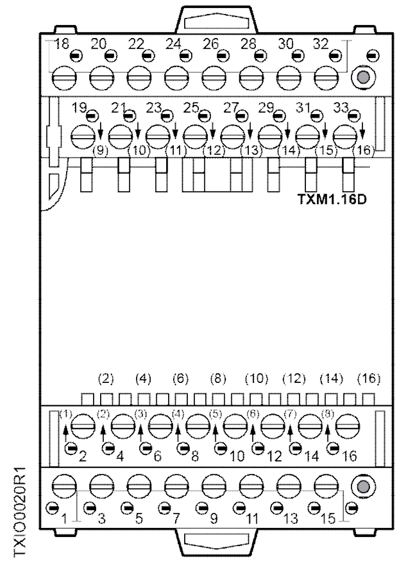
Digital Input Modules (TXM1.8D and TXM1.16D)

NOTE:
Potential free (dry contact) for all points.
The neutral of a digital input can be connected to any neutral terminal on the same module. Several digital inputs can also share a neutral terminal on the same module.

NOTE:
Counter inputs faster than 1 Hz that are routed for more than 33 ft (10 m) in the same wire runs as analog inputs must be shielded.



TXM1.8D



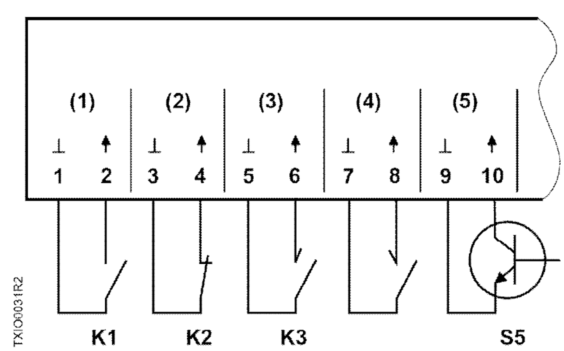
TXM1.16D

Digital Input Module Terminal Layout.																
	TXM1.8D, TXM1.16 D								TXM1.16D only							
I/O point	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
System Neutral ⊥ (–)[1]	1	3	5	7	9	11	13	15	18	20	22	24	26	28	30	32
Input (+)	2	4	6	8	10	12	14	16	19	21	23	25	27	29	31	33

1) Terminals 1, 3, 5 etc. are neutral terminals. They are connected in the plug-in I/O module but not in the terminal base. When the I/O module is removed, there is no connection.

Dry Contacts; Supervised, Digital Input Module

K1	Status contact (N/O)
K2	Status contact (N/C)
K3	Pulsed accumulator
S5	Electronic switch (rated for 30V, 10 mA)



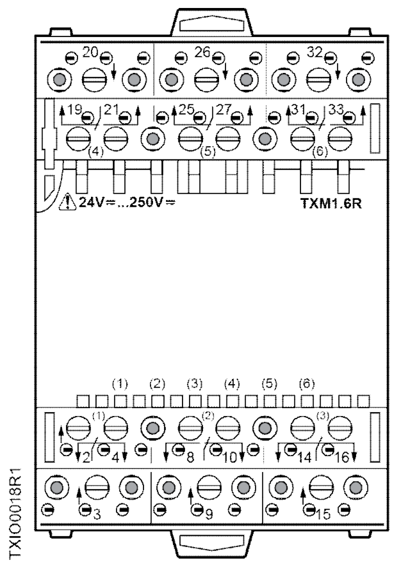
Dry Contacts; Supervised, Digital Input Module.

Digital Output Modules (TXM1.6R and TXM1.6R-M)

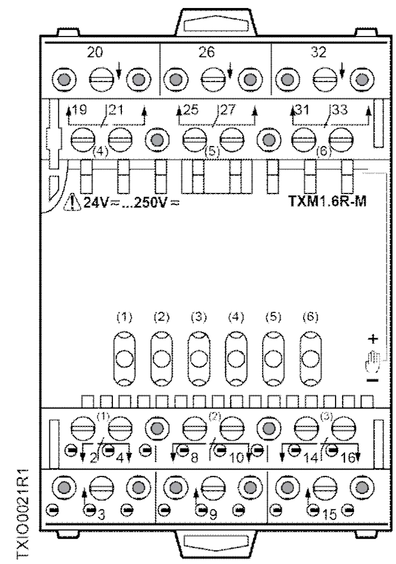
DANGER

Digital Output modules connected to high voltage should incorporate a readily accessible disconnect device outside the panel.

All low voltage and high voltage wiring must be routed separately within an enclosure so that low voltage and high voltage wiring cannot come in contact with each other. High- and low-voltage circuits cannot be located on adjacent terminals within a module.



TXM1.6R



TXM1.6R-M

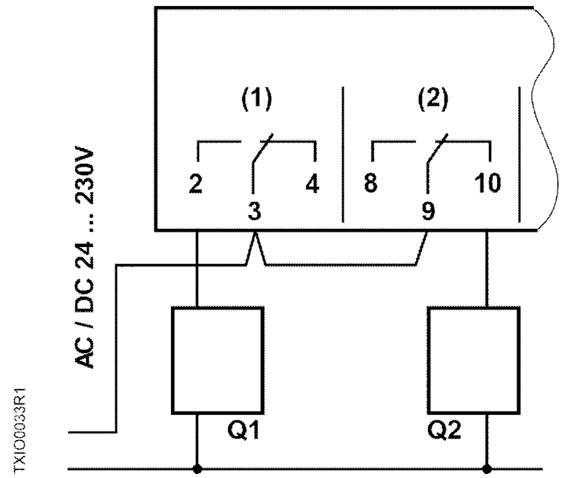
Digital Output Module Terminal Layout.						
Output Point	(1)	(2)	(3)	(4)	(5)	(6)
Common	3	9	15	20	26	32
N/O Contact	2	8	14	21	27	33
N/C Contact	4	10	16	19	25	31

For logical point types with several I/O points, do the following:

- Always use adjacent I/O points.
- Confine each logical point type to one module only.

Latched; Not Supervised, Digital Output Module

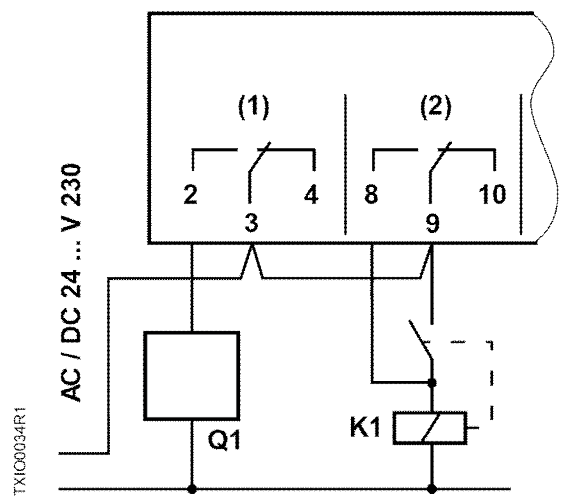
Q1	Switched load (NO contact)
Q2	Switched load (NC contact)



Latched; Not Supervised, Digital Output Module.

Pulsed; Not Supervised, Digital Output Module

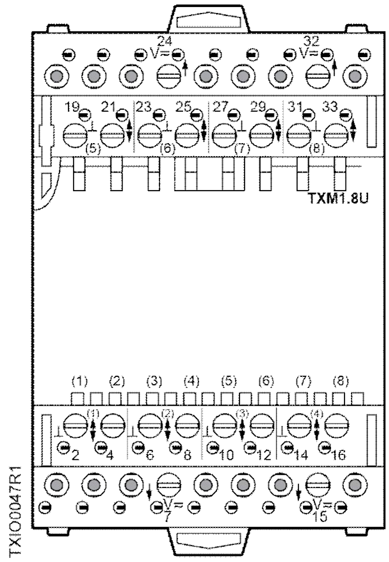
Q1	Pulse-driven device (for example, a stepping switch)
K1	Power contactor, self-latching



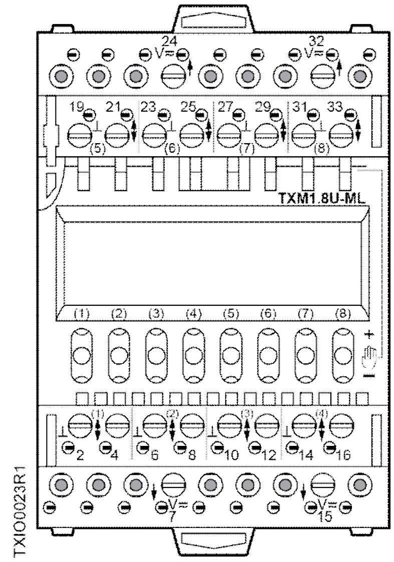
Pulsed; Not Supervised, Digital Output Module.

Universal and Super Universal Modules (TXM1.8U and TXM1.8U-ML; TXM1.8X and TXM1.8X-ML)

Universal Modules

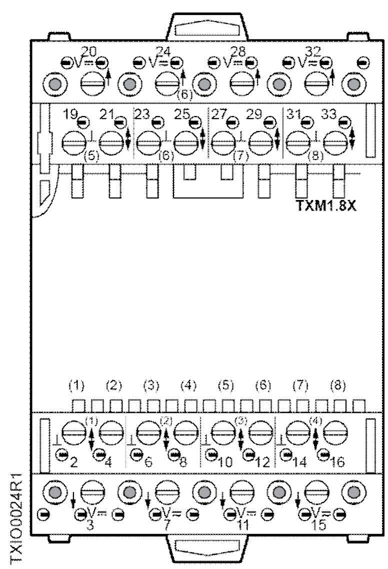


TXM1.8U

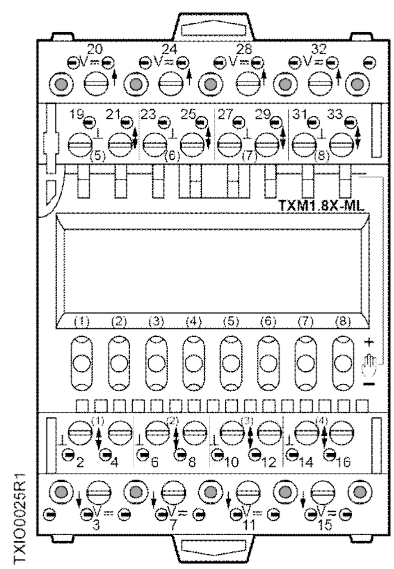


TXM1.8U-ML

Super Universal Modules



TXM1.8X



TXM1.8X-ML

Universal Module Terminal Layout.								
I/O Point	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Measuring Neutral ⊥ (-)1	2	6	10	14	19	23	27	31
Input ↕ (+)	4	8	12	16	21	25	29	33
AC Actuator Supply Voltage2	Selected from: 7, 15, 24, 32							

1) All measuring/neutral terminals are connected in the plug-in I/O module, not in the terminal base. When the I/O module is removed, there is no connection. The neutral of a digital input can be connected to any neutral terminal on the same module. Several digital inputs can also share a neutral terminal.

2) All AC actuator supply voltage terminals are connected in the I/O module, not in the terminal base. They are protected through the fuse on the TX-I/O Power Supply or P1 BIM.

Super Universal Module Terminal Layout.								
I/O Point	(1)	(2)	(3)	(4)	(5)*	(6)*	(7)*	(8)*
Measuring Neutral ⊥ (-)1	2	6	10	14	19	23	27	31
Input ↕ (+)	4	8	12	16	21	25	29	33
AC Actuator Supply Voltage2	Selected from: 7, 15, 24, 32							
24 Vdc Sensor Supply Voltage3	Selected from: 3, 11, 20, 28							

* 0 to 20 mA output is available on points 5 through 8 only.

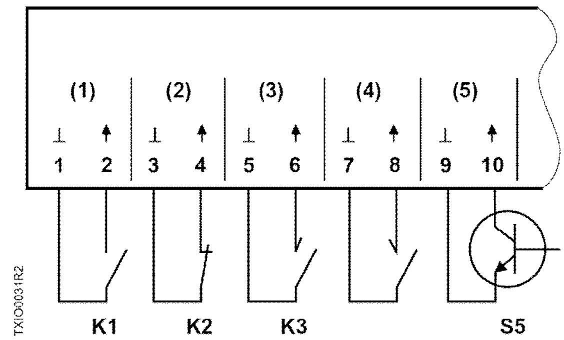
1) All measuring/neutral terminals are connected in the plug-in I/O module, not in the terminal base. When the I/O module is removed, there is no connection. The neutral of a digital input can be connected to any neutral terminal on the same module. Several digital inputs can also share a neutral terminal.

2) All AC actuator supply voltage terminals are connected in the I/O module, not in the terminal base. They are protected through the fuse on the TX-I/O Power Supply or P1 BIM.

3) All 24 Vdc supply terminals are connected. They are overload protected in the module.

Digital Input, Dry Contacts; Not Supervised, Universal and Super Universal Modules

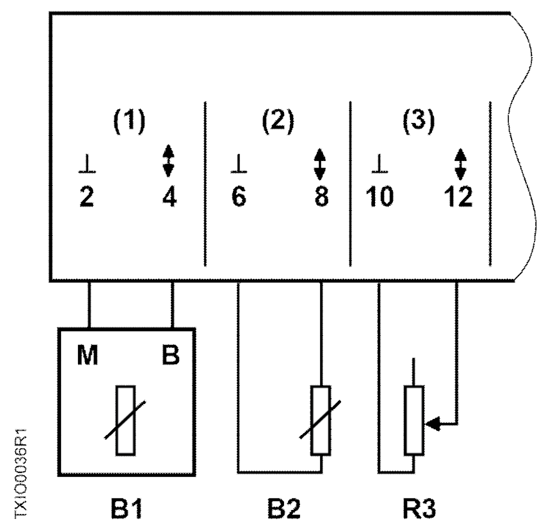
K1	Status contact (N/O)
K2	Status contact (N/C)
K3	Pulsed accumulator
S5	Electronic switch (rated for 30V, 6 mA for 150 ms, then 1 mA)



Digital Input, Dry Contacts; Not Supervised, Universal and Super Universal Modules.

Temperature Sensor Input (RTD and Thermistor); Supervised, Universal and Super Universal Modules

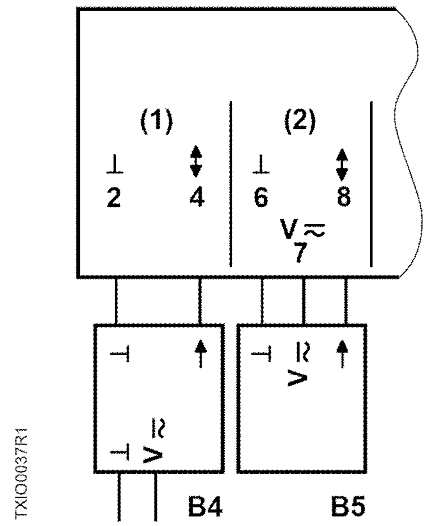
B1	Ni 1000 LS
B2	RTD or 100K, 10K Type II and 10K Type III Thermistor temperature sensors
R3	Resistive Input – Not supported



Temperature Sensor Input (RTD and Thermistor); Supervised, Universal and Super Universal Modules.

0-10 Vdc Input (Voltage); Supervised, Universal and Super Universal Modules

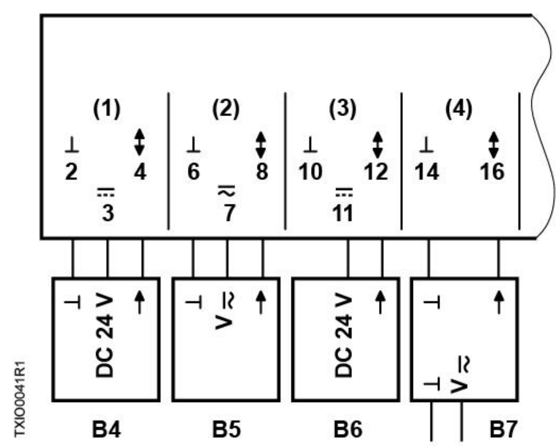
B4	0-10V sensor with external supply
B5	0-10V sensor with 24 Vac supply



0-10 Vdc Input (Voltage); Supervised, Universal and Super Universal Modules.

2-wire and 3-wire Active Input (Current); Supervised, Super Universal Modules Only

B4	Active sensor with 24 Vdc supply
B5	Active sensor with 24 Vac supply
B6	Active sensor 4 to 20 mA (2 wire)
B7	Active sensor with external supply (earth ground only at Service Box)



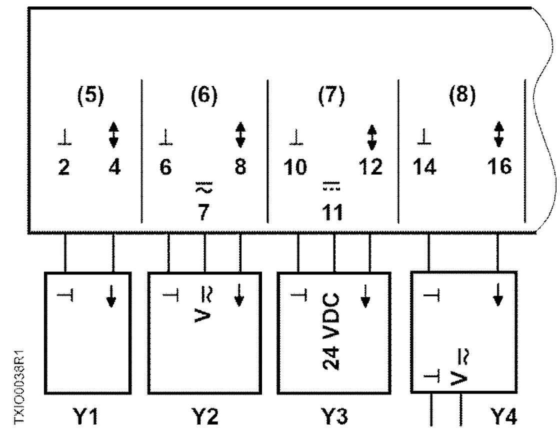
2-wire and 3-wire Active Input (Current); Supervised, Super Universal Modules Only.

Analog Ouput (Voltage or Current); Not Supervised, Universal and Super Universal Modules

0-10 Vdc available on Universal and Super Universal modules, points 1-8.

4-20 mA only available on Super Universal modules, points 5-8.

Y1	Actuator with control input only
Y2	24 Vac internal
Y3	24 Vdc internal
Y4	24 Vac external



Analog Ouput (Voltage or Current); Not Supervised, Universal and Super Universal Modules.

PXC Compact Series Controller

NOTE:
UL-recognized wire (labeled with a backwards "RU") is not field-installable. Use only UL-listed wire.

For analog inputs, termination for shield is provided, if required. Termination for shield is not provided for digital inputs. For more information, see the PXC Compact Series wiring diagrams [→ 119].

Wire Type Requirements

NOTE:
UL-recognized wire (labeled with a backwards "RU") is not field-installable. Use only UL-listed wire.

For analog inputs, termination for shield is provided, if required. Termination for shield is not provided for digital inputs. For more information, see the wiring diagrams.

PXC Compact Series Wire Type Requirements.				
Circuit Type	Class	Wire Type	Maximum Distance[1]	Conduit Sharing[2]
AC Line Power (120V or greater)	1	No. 12 to No. 14 AWG THHN	See NEC*	Check local codes
AC Low Voltage Power	2	No. 12 to No. 18 AWG THHN	See NEC*	Check local codes

PXC Compact Series Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type**	**Maximum Distance[1]**	**Conduit Sharing[2]**
Universal Input/Output	2	No.18 to No.22 AWG, TP[3] or TSP[4] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)	Check local codes
Universal Input/Output on SCS (Basic Link)	2	24 AWG UTP[5], solid	295 ft (90 m)	Check local codes
Universal Input/Output on SCS (Patch Cables)	2	24 AWG UTP[5], stranded	33 ft (10 m)	Check local codes
Dedicated Digital Input	2	No.14 to No.22 AWG. TP not required[4]; check job specifications and local codes.	750 ft (230 m)	Check local codes
Digital Output	1, 2	No.14 to No.22 AWG. TP not required; check job specifications and local codes.	Check local codes	Check local codes
TX-I/O Island Bus Cable	See *Wire Type Requirements* in the section, TX-I/O Product Range [→ 92].			

* National Electric Code.

1) Wire length affects point intercept entry. Adjust intercept accordingly.

2) Conduit sharing rules: No Class 2 point wiring can share conduit with any Class 1 wiring except where local codes permit. (Both Class 1 and Class 2 wiring can be run in the field panel providing the Class 2 wire is UL listed 300V 75°C (167°F) or higher, or the Class 2 wire is NEC type CM (FT4) (75°C or higher) or CMP (FT6) (75°C or higher). NEC type CL2 and CL2P is not acceptable unless UL listed and marked 300V 75°C (167°F) or higher.

3) Twisted pair, non-jacketed, UL listed 75°C (167°F) and 300V cable can be used in place of CM (FT4) or CMP (FT6) (both must be rated 75°C or higher) cable when contained in conduit per local codes. See the *Field Purchasing Guide* for wire.

4) Twisted Shielded Pair TSP is not required for general installation, does not affect PXC Compact specifications, and may be substituted where otherwise specified. TSP should be used in areas of high electrical noise (for example when in proximity to VFDs and 100 kVa or larger motors). Where used, connect the shield drain wire to the grounding system inside enclosure.

5) Cable must be part of a Structured Cabling System (SCS).

Power Source Requirements

PXC Compact Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power[1,2]**
PXC-16	24 Vac	50/60 Hz	18 VA
PXC-24	24 Vac	50/60 Hz	20 VA
PXC-36	24 Vac	50/60 Hz	35 VA

1) The 24V wiring is Class 2.

2) An external connection is provided for power at 24 Vdc at 50 mA per termination (200 mA maximum all terminations) for external sensors.

Analog Input Powered Devices

Approved sensors can be powered by the PXC Compact Series 24 Vdc Sensor Supply.

- Version 1 of the PXC-16 and PXC-24 support up to 100 mA. The Version 1 model number format is PXC16-*xxx*.A or PXC24-*xxx*.A.
- All versions of PXC-36 and Version 2 and later of the PXC-16 and PXC-24 support 200 mA. The Version 2 model number format is PXC16.**2**-*xxx*.A or PXC24.**2**-*xxx*.A.

Sensors requiring more power must be powered by an external source.

- The external source can be connected to the same 24 Vac line as the PX Series Service Box power supply as long as it is only used to power low voltage devices (less than 30 volts).
- An external sensor supply must be connected to the same Building Earth Ground as the PXC Compact

Analog Output Powered Devices

The PXC Compact does not provide actuator output power. See the PX Series Service Box [→ 85] section in this chapter.

Powering Options

One of the options for powering the PXC Compact, point blocks, and 24V devices is the PX Series Service Box.

See PX Series Service Boxes [→ 85] in this chapter for more information.

Metal Oxide Varistors (MOVs)

MOVs are factory installed on the DO terminals.

Line Voltage Receptacle

Line voltage MOVs are factory-installed on all service boxes. If using a third-party transformer, use an appropriate MOV. See Table *MOV part number* in the Controlling Transients [→ 24] section of Chapter 1.

PXC Compact Series Universal I/O

The PXC Compact Series provides Universal Input and Universal Input/Output points that are software-configurable to be 0 to 10 Vdc input, 4 to 20 mA input, 1K RTD input, 10K or 100K Thermistor input, digital input, pulse accumulator input, or 0 to 10Vdc analog output. The point types and their possible configurations are shown in this section.

PXC-16 Supported Point Types.						
		Configurable Points		Dedicated Points		
Point Type		Universal Input (UI) Points 1-3	Universal Input/Output (U) Points 4-8	Analog Output (AO) Points 9-11	Digital Input (DI) Points 12-13	Digital Output (DO) Points 14-16
Analog Input[4]	Voltage 0 to 10 Vdc	•	•			
	Current 4 to 20 mA	•	•			
	RTD Pt 1K[1]	•	•			
	RTD Ni 1K[2]	•	•			
	Thermistor 10K NTC[3]	•	•			
	Thermistor 100K NTC[3]	•	•			
Digital Input	Status (Binary Input)	•	•		•	
	Pulse Accumulator (Counter)	•	•			
Analog Output	Voltage 0 to 10 Vdc		•	•		
Digital Output	Binary/Digital Output					•

1) Platinum 1K 375 or 385 alpha.

2) Siemens, Johnson Controls, and DIN Standard Nickel.

3) 10K and 100K Type 2 and 10K Type 3.

4) Sensor supply 24 Vdc, 4.8W

PXC-24 Supported Point Types.						
		Configurable Points			Dedicated Points	
Point Type		Universal Input (UI) Points 1-3	Universal Input/Output (U) Points 4-12	Super Universal (X) Points 13-16	Analog Output (AO) Points 17-19	Digital Output (DO) Points 20-24
Analog Input[5]	Voltage 0 to 10 Vdc	•	•	•		
	Current 4 to 20 mA	•	•	•		
	RTD Pt 1K[1]	•	•	•		
	RTD Ni 1K[2]	•	•	•		

PXC-24 Supported Point Types.						
		Configurable Points			Dedicated Points	
Point Type		Universal Input (UI) Points 1-3	Universal Input/Output (U) Points 4-12	Super Universal (X) Points 13-16	Analog Output (AO) Points 17-19	Digital Output (DO) Points 20-24
	Thermistor 10K NTC[3]	•	•	•		
	Thermistor 100K NTC[3]	•	•	•		
Digital Input	Status (Binary Input)	•	•	•		
	Pulse Accumulator (Counter)	•	•	•		
Analog Output	Voltage 0 to 10 Vdc		•	•	•	
	Current 0 to 20 mA			•		
Digital Output	Binary/Digital Output			•[4]		•

1) Platinum 1K 375 or 385 alpha.

2) Siemens, Johnson Controls, and DIN Standard Nickel.

3) 10K and 100K Type 2 and 10K Type 3.

4) Requires an external relay.

5) Sensor supply 24 Vdc, 4.8W

PXC-36 Supported Point Types.					
		Configurable Points		Dedicated Points	
Point Type		Super Universal (X) Points 1-6	Universal Input/Output (U) Points 7-24	Digital Input (DI) Points 25-28	Digital Output (DO) Points 29-36
Analog Input[5]	Voltage 0 to 10 Vdc	•	•		
	Current 4 to 20 mA	•	•		
	RTD Pt 1K[1]	•	•		
	RTD Ni 1K[2]	•	•		
	Thermistor 10K NTC[3]	•	•		
	Thermistor 100K NTC[3]	•	•		
Digital	Status (Binary Input)	•	•	•	

PXC-36 Supported Point Types.					
		Configurable Points		Dedicated Points	
Point Type		Super Universal (X) Points 1-6	Universal Input/Output (U) Points 7-24	Digital Input (DI) Points 25-28	Digital Output (DO) Points 29-36
Input	Pulse Accumulator (Counter)	•	•		
Analog Output	Voltage 0 to 10 Vdc	•	•		
	Current 0 to 20 mA	•			
Digital Output	Binary/Digital Output	•[4]			•

1) Platinum 1K 375 or 385 alpha.

2) Siemens, Johnson Controls, and DIN Standard Nickel.

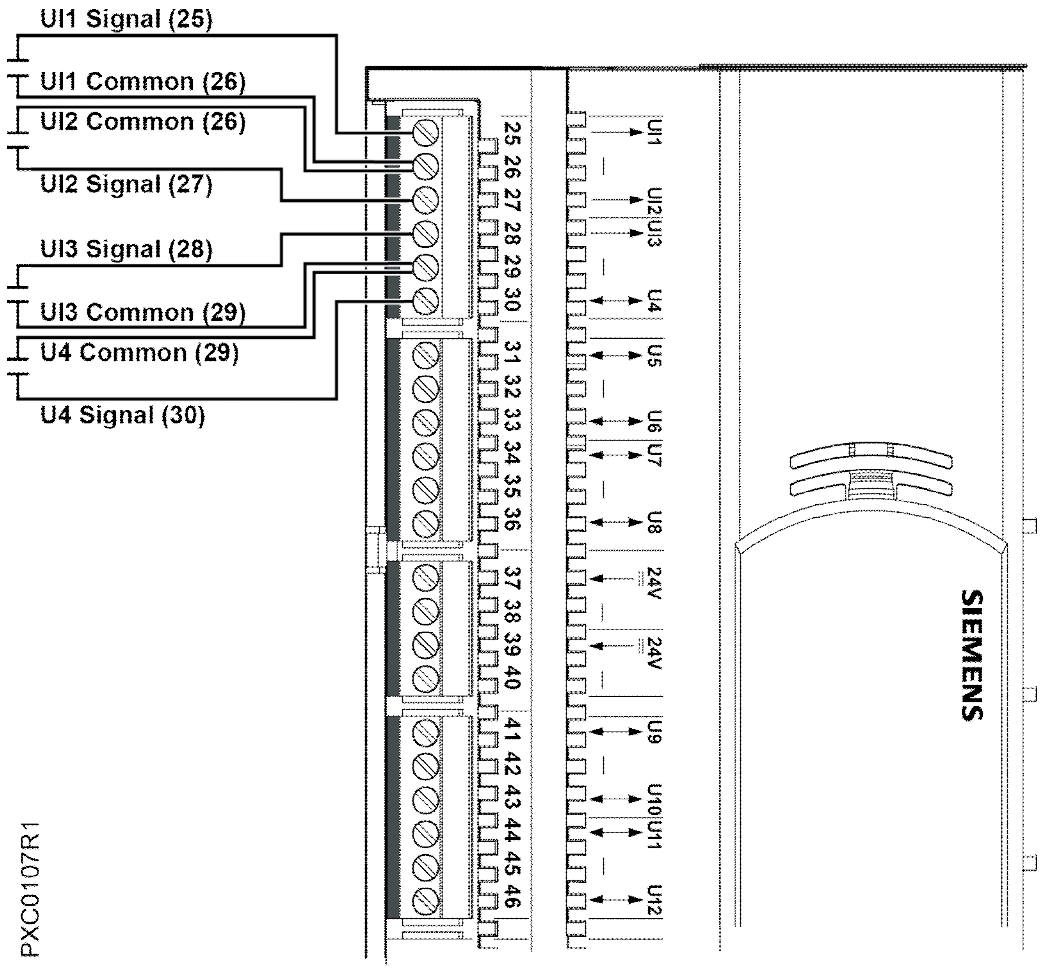
3) 10K and 100K Type 2 and 10K Type 3.

4) Requires an external relay.

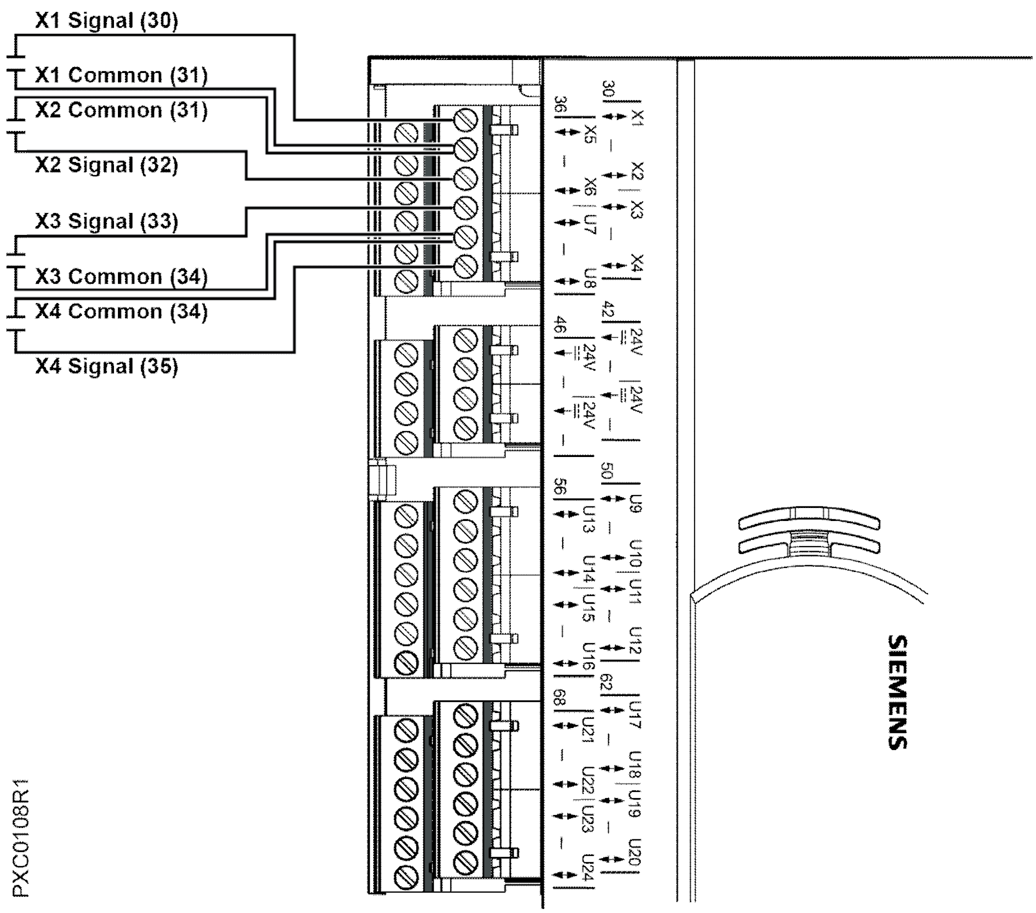
5) Sensor supply 24 Vdc, 4.8W

Compact Series Sensor Wiring

The PXC Compact uses a shared ground between sensors to reduce the number of required terminal connections. The PXC Compact ground contacts are shared as shown the following figures.



Shared Ground Connections (PXC-16 and PXC-24).



Shared Ground Connections (PXC-36).

PXC Compact Series Wiring Diagrams

	WARNING
	All transformer or isolated power supply secondary neutrals requiring connection to earth ground must be directly connected to an approved building earth ground terminal located at the point termination module where the signal is terminated. This is represented in the following diagrams by “E” at the earth ground symbol.

Point Type	Specifics [Page Number]
Analog Input	Internally powered, voltage or current, supervised [→ 121]
	Externally powered, voltage or current, supervised [→ 122]
	RTDs or Thermistors, supervised [→ 123]
Analog Output	0-10 Vdc, not supervised [→ 124]
	0-20 mA, not supervised [→ 125]

Point Type	Specifics [Page Number]
Digital Input	Dry contacts, not supervised [→ 127]
	Pulse accumulating, not supervised [→ 128]
	Using AI, Supervised – See the MEC wiring diagram [→ 158]
Digital Output	Pulsed or latched, not supervised [→ 129]

See also

2 Analog Input, Internally Powered; Supervised [→ 121]
2 Analog Input, Externally Powered; Supervised [→ 122]
2 Analog Input, RTDs or Thermistors; Supervised [→ 123]
2 Analog Output, 0-10 Vdc; Not Supervised [→ 124]
2 Analog Output, 0-20 mA [→ 125]
2 Digital Input, Dry Contacts; Not Supervised [→ 127]
2 Digital Input, Pulse Accumulating; Not Supervised [→ 128]
2 Digital Output, Pulsed or Latched; Not Supervised [→ 129]
2 Universal Inputs [→ 158]

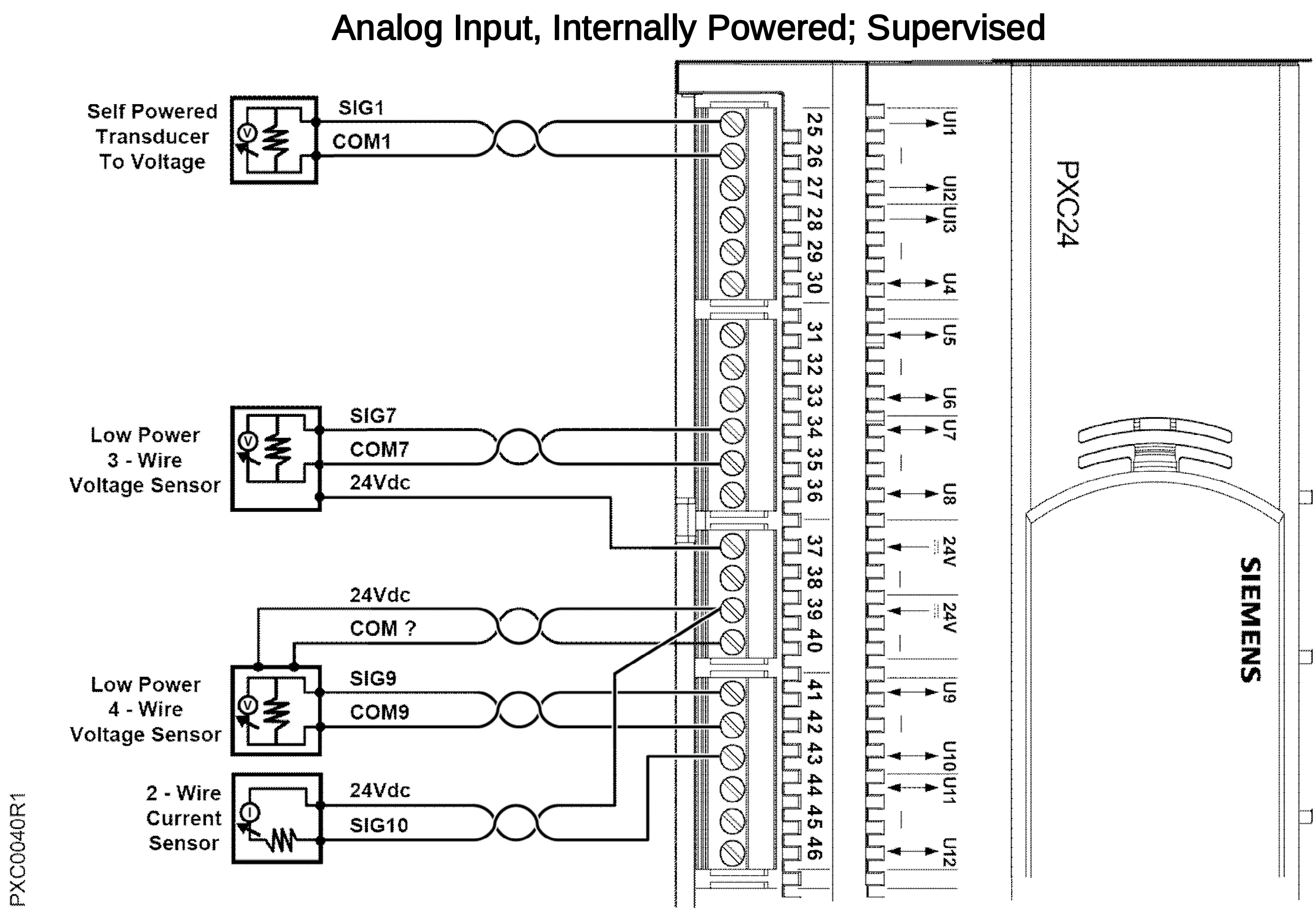


Figure 59: Connecting an Internally Powered Analog Input (Voltage or Current).

Analog Input, Externally Powered; Supervised

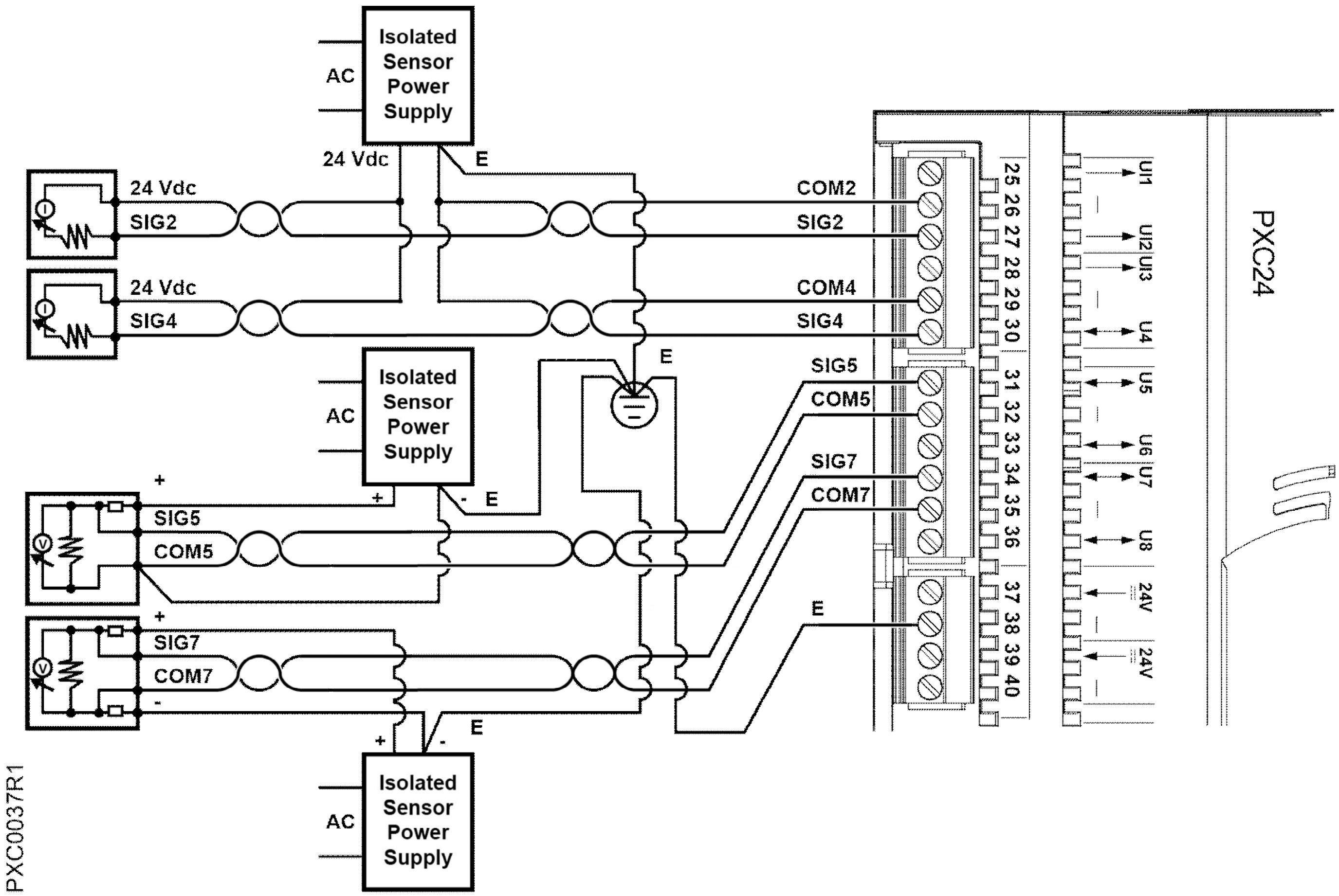


Figure 60: Connecting an Externally Powered Analog Input (Voltage or Current).

Analog Input, RTDs or Thermistors; Supervised

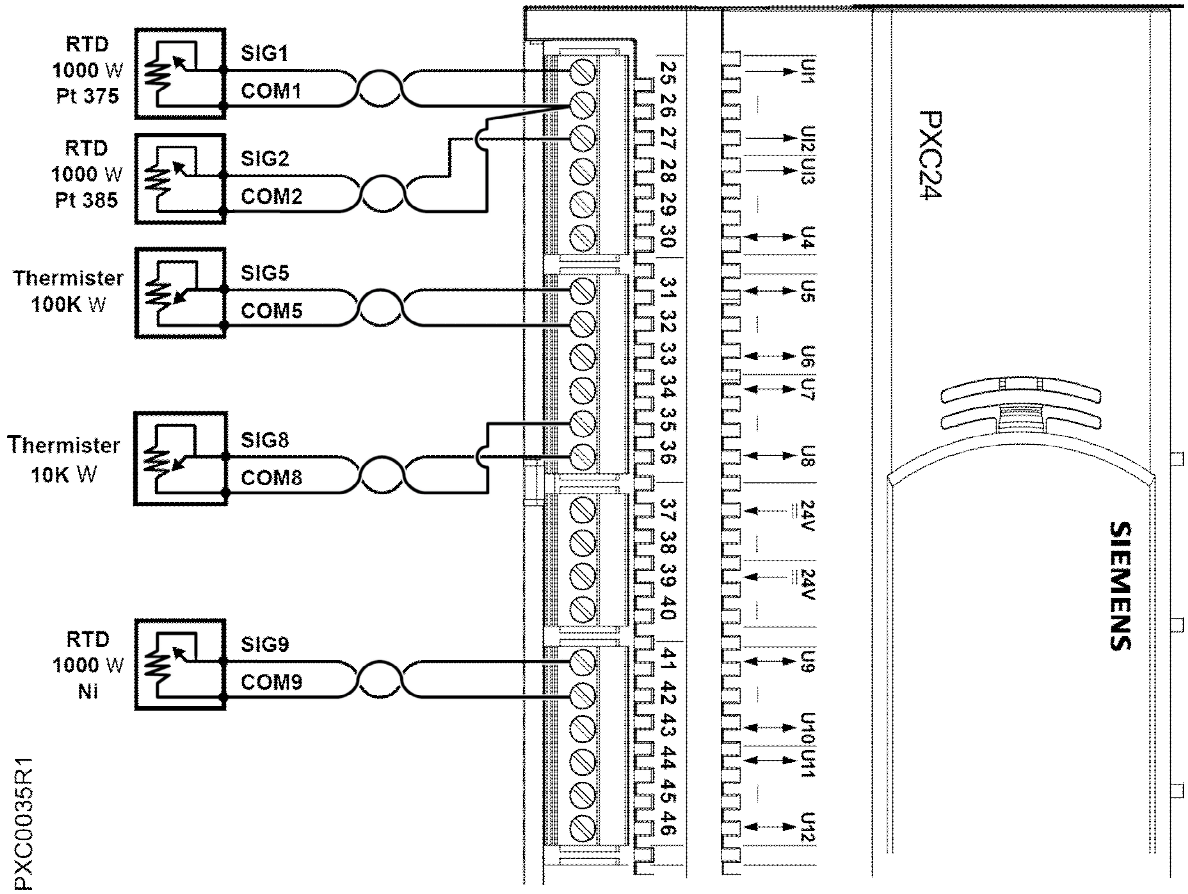


Figure 61: Connecting an Analog Input (RTD or Thermistor).

Analog Output, 0-10 Vdc; Not Supervised

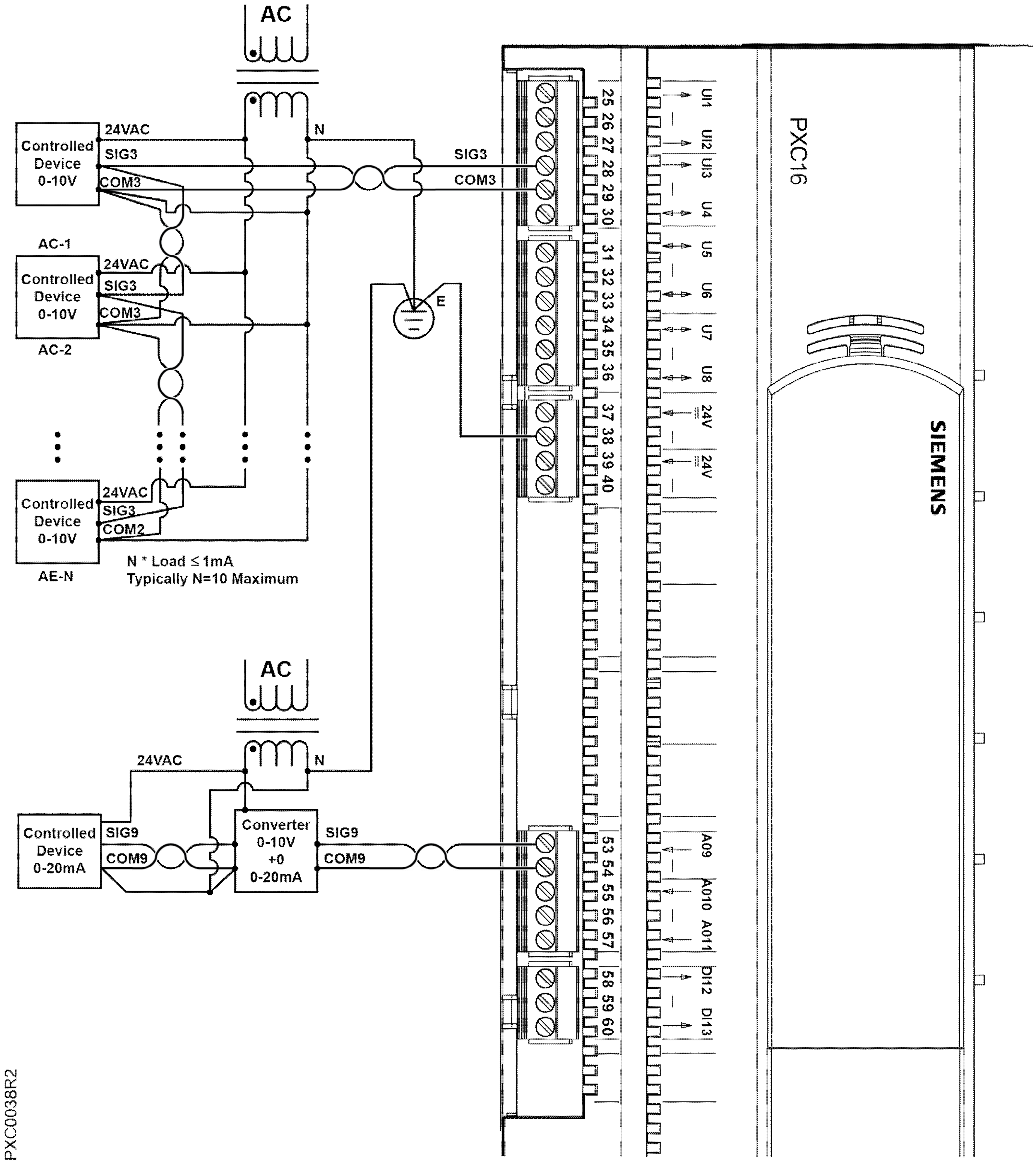
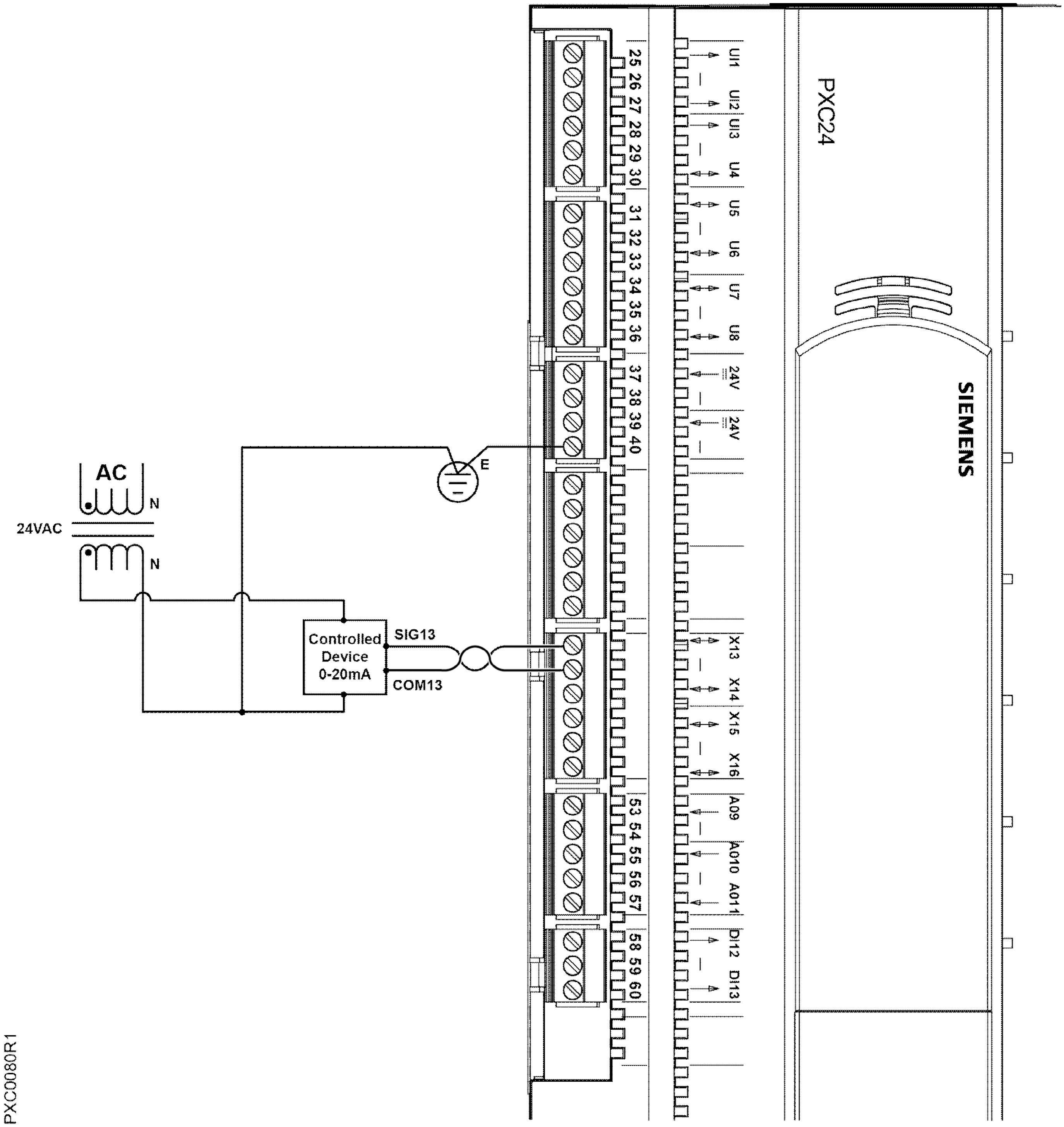
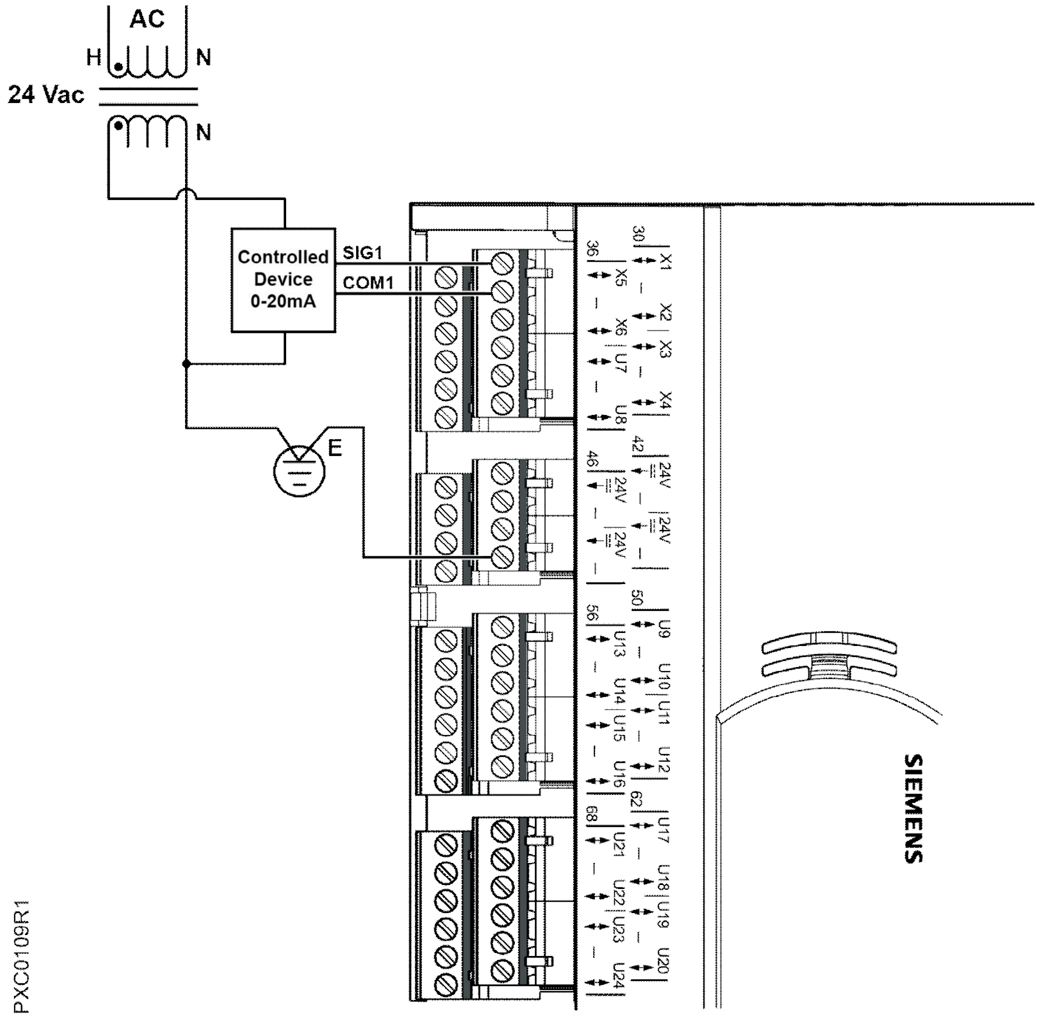


Figure 62: Connecting an Analog Output (0 to 10 Vdc).

Analog Output, 0-20 mA



Connecting an Analog Output (0 to 20 mA) (PXC-16 and PXC-24).



Connecting an Analog Output (0 to 20 mA) (PXC-36).

Digital Input, Dry Contacts; Not Supervised

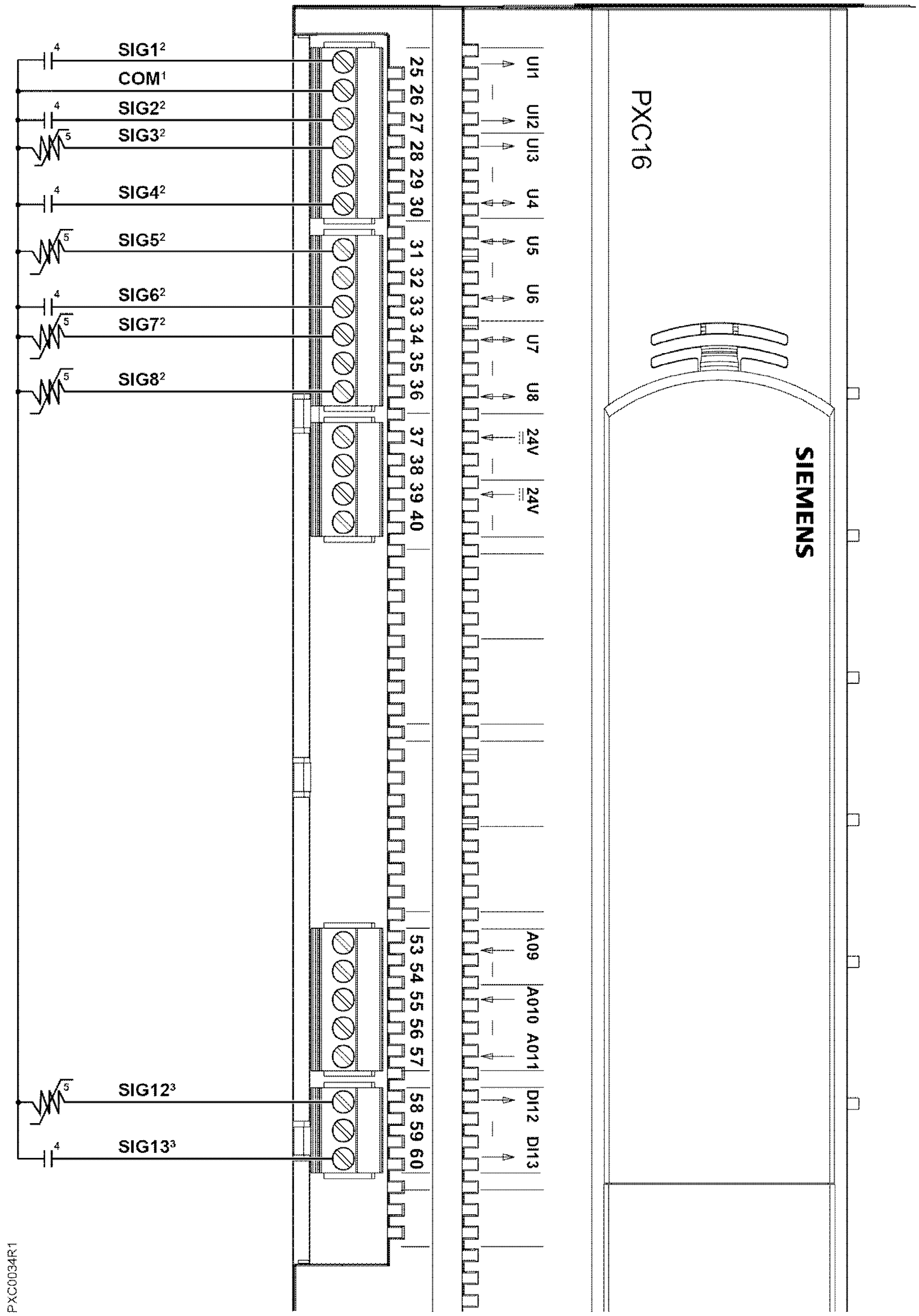


Figure 63: Connecting a Digital Input (Dry Contacts).

1) A single common may be used for all digital inputs.

2) Excitation equals 24 Vdc at 6 mA for 150 msec, then 1 mA. Must be stable for 100 msec.

3) Excitation equals 24 Vdc at 10 mA. Cannot be used for pulse accumulating.

4) Dry contact only. Does not require gold contacts.

5) Solid state device must be rated for 30V minimum, with RDS on less than 1K ohms and RDS off greater than 100K ohms.

Digital Input, Pulse Accumulating; Not Supervised

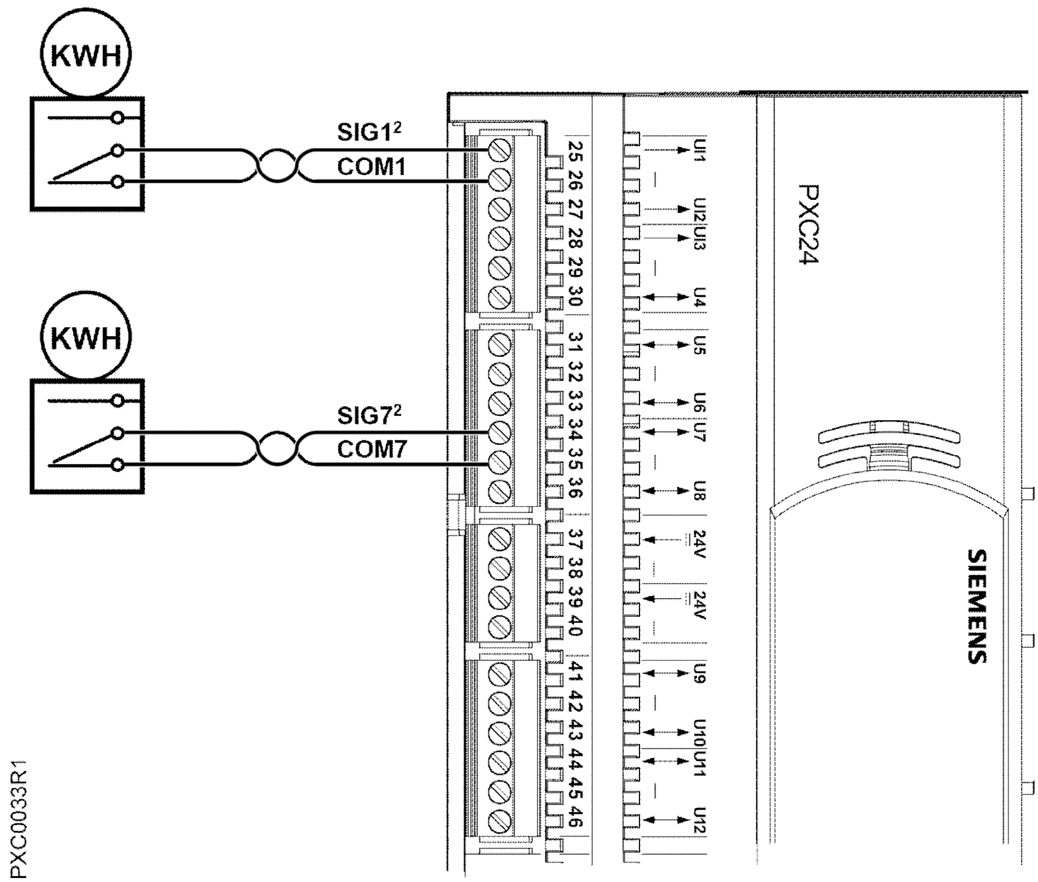


Figure 64: Connecting a Digital Input (Pulse Accumulating).

1) Excitation equals 24VDC at 6 mA for 150 msec, then 1 mA. Pulse rate equals 20 Hz.

2) Separate commons for each input.

Digital Output, Pulsed or Latched; Not Supervised

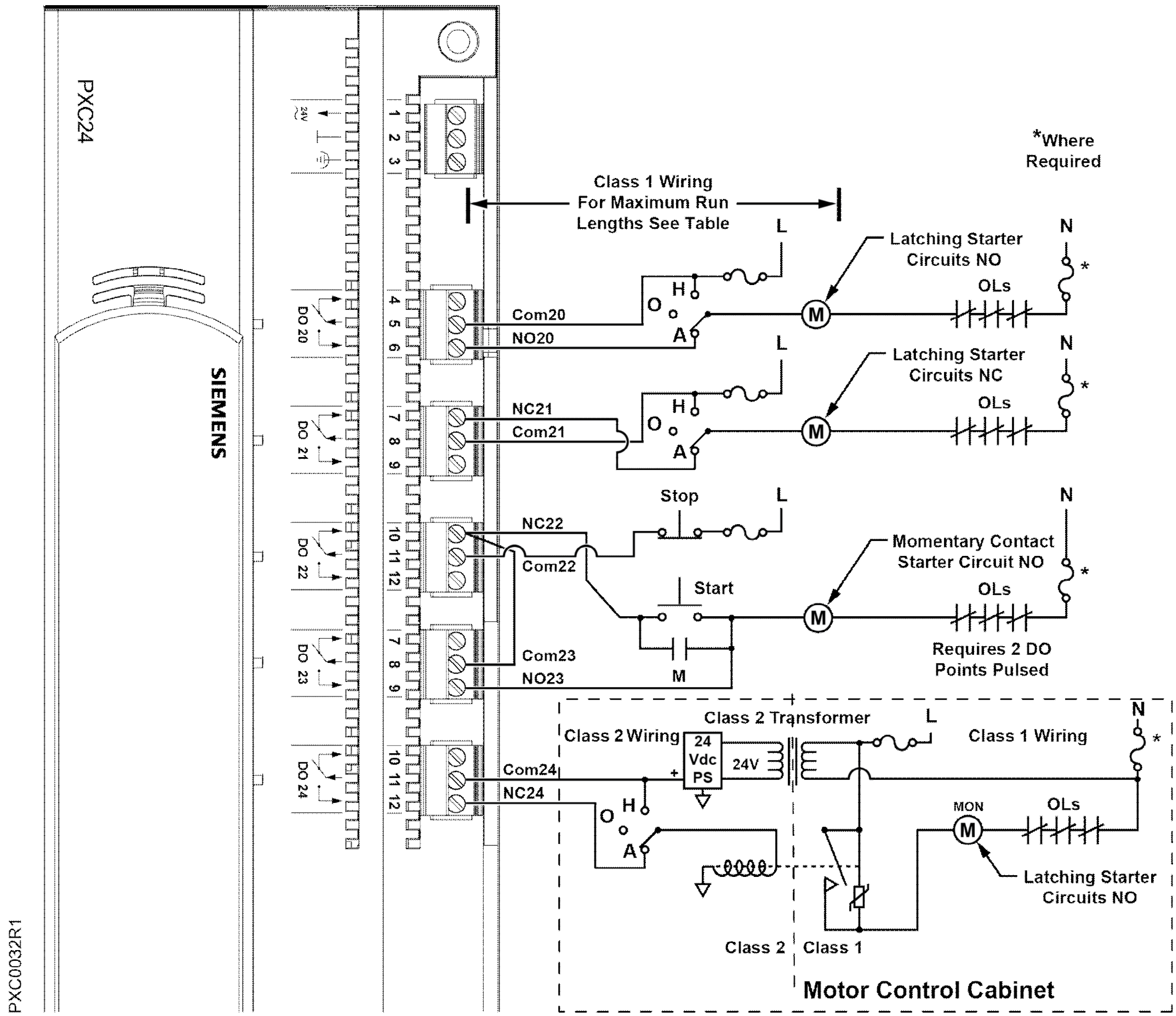


Figure 65: Connecting a Digital Output (Pulsed or Latched).

Point Expansion or Conversion

AO-P Transducer

The AO-P Transducer converts field panel voltage output or current output to pneumatic output.

Recommended maximum wiring runs for the AO-P Transducer Remote Mount (545-208) and the AO-P Transducer Panel Mount (545-113) are listed in table *AO-P Transducer Remote Mount and Panel Mount Wiring Run Limitations*.

AO-P Transducer Remote Mount and Panel Mount Wiring Run Limitations.			
Circuit Type	Class	Wire Type[1]	Maximum Distance
24 Vac Power	2	No. 18 to 22	750 ft (230 m)
0 to 10 Vdc (Signal)	2	No. 18 to 22 TP	1000 ft (305 m)
0 to 5 Vdc (feedback)	2	No. 18 to 22 TP	1000 ft (305 m)
Digital Output	2	No. 18 to 22	1000 ft (305 m)
4 to 20 mA	2	No. 18 to 22 TP	1000 ft (305 m)

1) See the *Wire Specification Tables* section in Chapter 1—Wiring for more information.

Power Source Requirements

Power Source Requirements for AO-P Transducer.			
Product	Input Voltage	Line Frequency	Maximum Power
AO-P Transducer	24 Vac	50/60 Hz	1 VA

AO-P Wiring Connections.	
AO-P Transducer Wire Color	Connection
Red (HK)	24 Vac
Black (N)	Neutral
Yellow (+)	0 to 10 Vdc, or 4 to 20 mA (Signal +)
White (F)	0 to 5 Vdc (Feedback +)
Gray (I-)	Signal/Feedback Negative (-)
Orange (A)*	DO (Dry Contact)
Orange (B)*	DO (Dry Contact)

* Together, the two orange wires make up the DO. These connections are optional. The DO reports the position of the Hand-Auto switch:
- Open Contact=Auto Mode
- Closed Contact=Hand Mode

AO-P Transducer Wiring Diagram

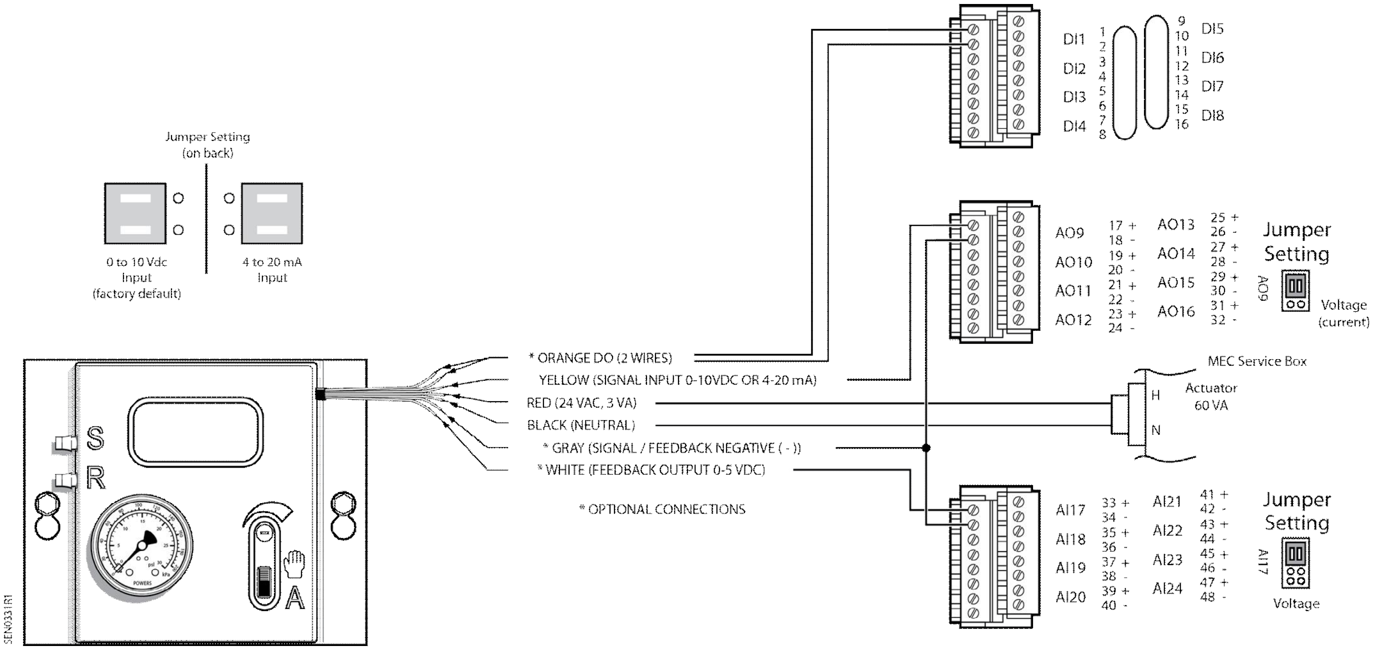


Figure 66: Connecting an AO-P Transducer Input.

NOTE:
Both the jumper on the back and the jumper for A09 must be set to current for 4 to 20 mA input.

Chapter 4—Equipment Controllers

Wire Type Requirements

BACnet Equipment Controller Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance**	**Conduit Sharing[1]**
Input Power	2	Check local codes	Check local codes	Class 2
Digital Output	2	Check local codes	150 ft (46 m)	Class 2
Analog Output	2	Check local codes	150 ft (46 m)	Class 2
Digital Inputs	2	No. 18 to No. 22 TP	150 ft (46 m)	Class 2
Analog Inputs	2	No. 18 to No. 22 TP	100 ft (30 m)	Class 2
Room Temperature Sensor	2	Pre-terminated 3 TP	100 ft (30 m)	Class 2

1) Conduit sharing rules were determined through EMI and shared conduit testing. These rules indicate wiring methods that have no adverse effect on the proper operation of the equipment, but do not necessarily indicate compliance with local codes.

Power Source Requirements

BACnet Equipment Controllers can be powered in three ways. Correct sizing and fusing must be maintained for each of these powering techniques:

- Individual transformer using a transformer rated for Class 2 service.
- Class 2 power trunk. For more information, see *Power Trunk Guidelines in Chapter 2.*
- Low voltage source of the device the controller is controlling (for example, fan powered boxes, electric room heat, fan coils, and heat pumps).

CAUTION

The phase of all devices on a power trunk must be identical.

Phase differences can destroy equipment. Any relays, EPs, or contactors sharing power must be clamped with MOVs at their locations.

1) Total VA rating is dependent upon the controlled DO loads (for example, actuators, contactors, etc.).

Metal Oxide Varistors (MOVs)

All DOs are normally open, 24 Vac switched triacs. Metal Oxide Varistors (MOVs) must be used across the DO terminals when connected to loads. MOVs are factory-installed in all ATEC, PTEC, and TEC products.

When installing MOVs across the DO relay contacts on termination boards, keeping the MOV leads as short as possible makes the MOV more effective at reducing spikes from field wiring or controlled devices. Remove and reinstall any MOVs with leads longer than 1 in. (2.5 cm). See the *Controlling Transients* section in Chapter 1 for MOV part numbers.

BACnet DXR2 Room Automation Station

Power Data

Power supply	
Operating voltage	AC 24 V -15%/+20%
Frequency	50/60 Hz
Controller Voltage Input Required for attached Field Devices	AC 20.4 V minimum Increase this value by the voltage drop of wire to remote field device

CAUTION

Observe Polarity of AC 24 V~ Power Cable.

Reversing HOT ~ and COMMON wires on 24V~ connector input can destroy DXR2. Observe color of wire used for HOT and COMMON throughout the power trunk. COMMON originates with neutral side of the 24 Vac power transformer which must be tied to earth at the transformer and only at this point.

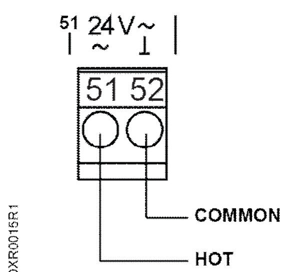


Figure 67: Connecting Power Cable.

Maximum Apparent power (VA) for transformer sizing						
Base Model	Base load	Max. load Triac output AC 24 V~ 0.25 A each	Max. load all Aux. outputs AC 24 V~	Max. load KNX PL-Link (at 50 mA)	Max. load DC 24V+ (2.4 W)	Max. Allowed Power consumption including connected field devices
DXR2.E12P	8	6 x 6 = 36	12	4	-	60
DXR2.E18	8	8 x 6 = 48	18	4	6	72
DXR2.M11	6	6 x 6 = 36	12	4	-	58
DXR2.M12P	6	6 x 6 = 36	12	4	-	58

Maximum Apparent power (VA) for transformer sizing						
Base Model	Base load	Max. load Triac output AC 24 V~ 0.25 A each	Max. load all Aux. outputs AC 24 V~	Max. load KNX PL-Link (at 50 mA)	Max. load DC 24V+ (2.4 W)	Max. Allowed Power consumption including connected field devices
DXR2.M18	6	8 x 6 = 48	18	4	6	70

Engineering

Engineering [24V] [Content Released]

Identification

Each device has a unique serial number to ensure efficient commissioning. It is provided on the adhesive barcode label. The serial number can be read directly into the engineering tool using a barcode reader.

Wiring

Wiring must be sufficiently insulated to the available rated voltage. Sizing and fusing of the wiring depends on the connected load.

Triac outputs AC 24V

Individual Triac outputs may have a maximum load of 6 VA (heating up the device). The following possibilities are permitted:

- Multiple motorized actuators with a total of maximum 6 VA.
- 1 thermal actuator with 6 VA (0.25 A) start load in a cold state, controlled using the algorithm PWM 0 through 100%.
- 1 thermal actuator with 9 VA (0.37 A)start load each in a cold state, controlled using the algorithm PWM 5 through 50%.

For transformer design (voltage drop off), each thermal actuator must be counted at the full start load, since the Triac outputs can be freely controlled.
The heating sequence and cooling sequence are not normally active at the same time (Exception: Downdraft compensation).

The sum total of the base load, bus power, field supply, and Triacs may not exceed 72 VA (DXR2.E..) or 70 VA (DXR2.M..). Power consumption is 96 VA with pulse width modulation.
See the *Power data* Section.

For the DXR2.. 24 V variant, the high side switch Triacs (closed the contact at AC 24V) are used. As a result, the VAV compact controllers GDB181.1E/3 or GLB181.1E/3 can only be set to operating mode **con** using 0 through 10V.

DC 0 through 10 Voutputs

The DC 0 through 10V outputs supply maximum 1 mA.

AC 24 V supply for field devices (V~)

Actuators (valves, dampers) and active sensors are supplied directly by the device. Separate AC 24V power supply is only required if field devices consume more than 12 VA (on DXR2.x11.. and DXR2.x12..) or 18 VA (on DXR2.x18).

DC 24 V power supply for field devices (V+), DXR2.x18 only

Actuators (valves, dampers) and active sensors are supplied directly by the device. A separate DC 24V field supply is only required if field devices use more than 2.4 Watts.

Digital inputs

Digital inputs are not suitable for operating lighting or blinds. Use the **KNK PL-Link** push button.

Inputs

Analog Inputs		
Resistance sensor	Temperature measurement	Voltage measurement
AI 1000 Ω	AI PT1K 375 (NA)*)	AI 0 to 10V
AI 2500 Ω	AI PT1K 385 (EU)*)	AI 0 to 10V (0 to 100%)
AI 10 KΩ	AI (LG-)Ni1000*)	
AI 100 KΩ	AI Ni1000 DIN*)	
	AI T1 (PTC)*)	
	AI NTC10K**)	
	AI NTC100K**)	

* A fixed value of 1 Ω is calibrated to correct line resistance.

** Configurable default.

Digital Inputs	
Contact voltage	Universal input: 18V Digital input: 21V
Contact current	Universal input: 1.2 mA; 7.4 mA initial current Digital input: 1.6 mA; 9.4 mA initial current
Contact resistance for closed contacts	Maximum 100 Ω
Contact resistance for open contacts	Minimum 50 kΩ

Outputs

Analog Outputs	
0 to 10V	Maximum 1 mA

Digital Outputs	
Type (Switching outputs triacs)	High side The Triac closes the contact to AC 24V
Switching voltage	AC 24V
Permissible load	250 mA/6 VA per output (cos phi 0.35) (500 mA/12 VA per output with PWM*)
Protection	Short-circuit proof

Conformity

CAUTION

National safety regulations

Failure to comply with national safety regulations may result in personal injury and property damage.
Observe national provisions and comply with the appropriate safety regulations.

Ambient conditions and protection classification	
Climatic ambient conditions • Transport and Storage • Operation	 • Temperature -25 to 70°C (-13 to 158°F) Air humidity 5 to 95% rh. • Temperature -5 to 45°C (23 to 113°F) -5 to 50 °C (23 to 122°F) Air humidity 5 to 95% rh.

Standards, directives and approvals	
UL Listing	UL916
Federal Communications Commission	FCC CFR 47 Part 15 Class B
CSA Compliance	C22.2 No. 205
Environmental compatibility - RoHS Compliant	The product environmental declaration contains data on environmentally compatible product design and assessments (composition, packaging, environmental benefit, disposal).
BACnet BTL Listing	BTL-AAC

Standards, directives and approvals	
CEC Title 24 Supported	
ASHRAE 90.1 Supported	
Quality	ISO 9001 (Quality).

MS/TP Connection

Use the recommended 3-Wire (1.5 STP, Chapter 1). Wire the nut shield of both cables or tie back shield for end of line, shield terminated at MSTP port of router. Connect the yellow reference wire to common terminal 21, black wire to – terminal 22 and white wire to + terminal 23. If DXR2.M is at MSTP cable end of line install a 120 Ohm resistor between – terminal 22 and + terminal 23. Observe polarity throughout MSTP Network.

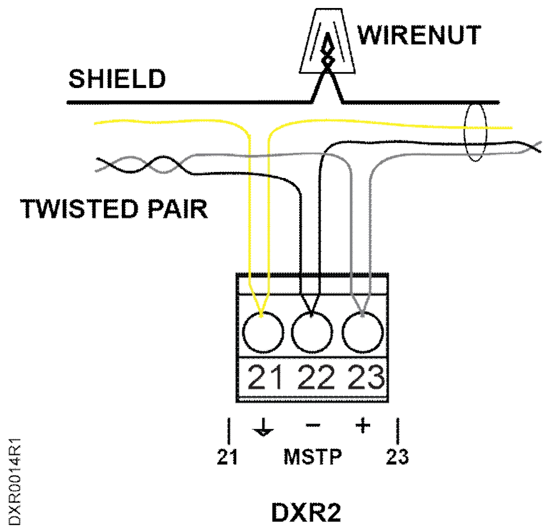


Figure 68: Connecting MS/TP Port to 3-Wire (1.5 STP) Cable.

Ethernet Connection

Room automation stations are connected to one another using switches and Ethernet cables with RJ45 connectors. For more information on interconnection between controllers see, Dual Port Ethernet Controller Topology Basics [→ 30].

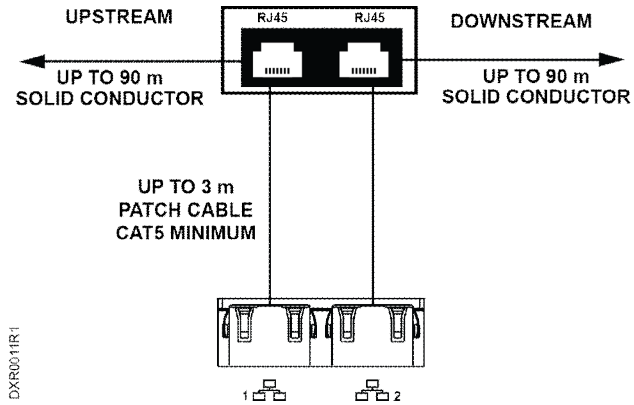


Figure 69: Dual Ethernet Connection Using Up to 90m Solid Copper Cable and Jack Boxes.

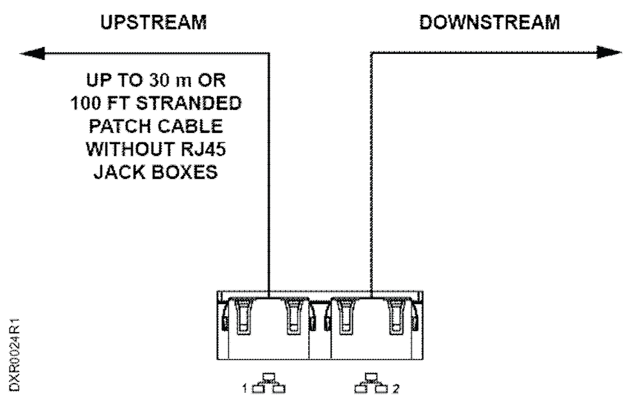


Figure 70: Dual Ethernet Connection Using Up to 30m Stranded Copper Patch Cables.

KNX PL-Link Connection

KNX PL-Link distances within the APOGEE Automation system are typically short and not subject to large electrical noise. It is recommended that you use 18 AWG solid copper unshielded twisted pair cables. The Belden 6320 FE is available from Anixter. It is shielded with a drain wire; however, the drain wire must not to be connected. Use CMP where plenum rating is required.

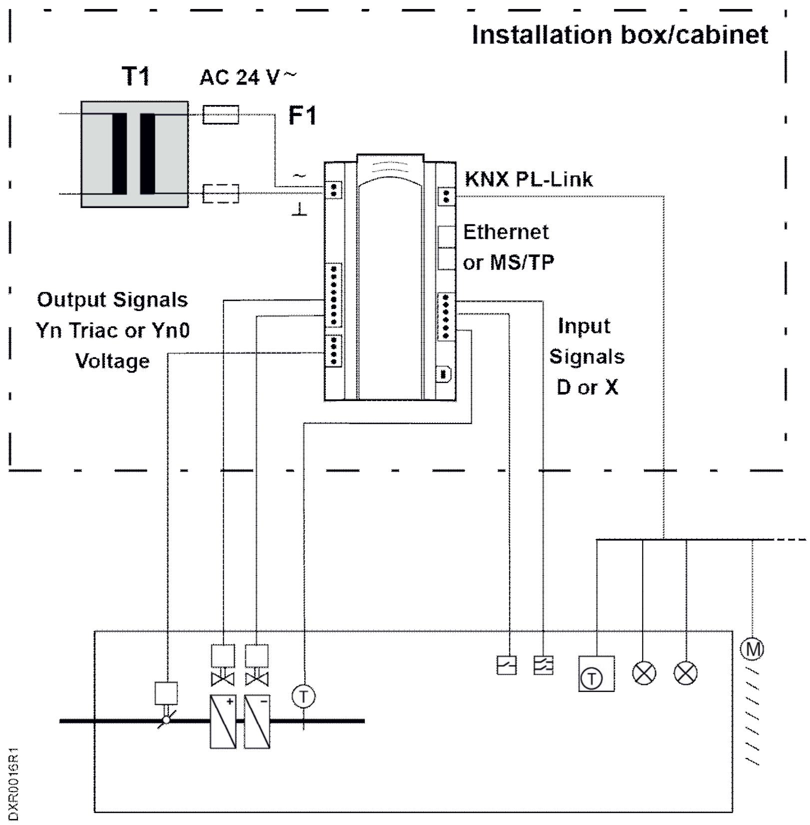


Figure 71: Connecting KNX PL-Link.

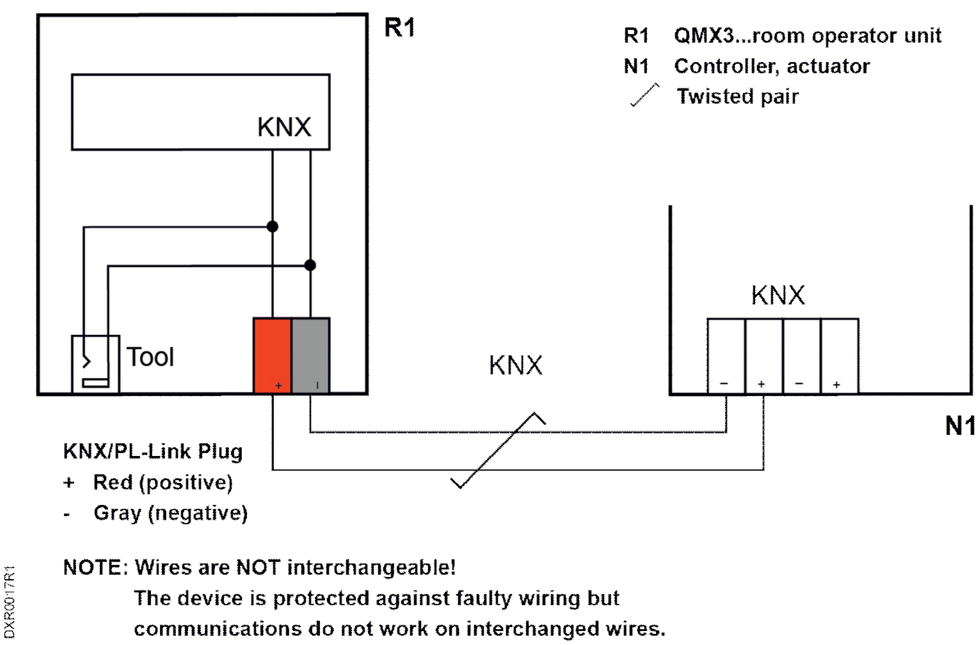


Figure 72: KNX PL-Link Device Termination.

NOTE:
Operating supply voltage range KNX / PL-Link DC 21 through 30V.
DXR2 supplies 50 mA that may not be shared. To obtain more power, shut off the DXR2 KNX/PL-Link supply and connect up to 8 JB125C23 KNX Power Supplies. The devices receive power from the connected room automation station using the KNX PL-Link Terminals + 11 and – 12. Calculate voltage drop using cable resistance in Chapter 2 Power Trunk. All devices must have a minimum input of DC 21V.

KNX/PL-Link interface Power consumption (from room automation station).		
Part Number	Description	Maximum mA at DC 24V
QMX3.P02	Wall Temperature Sensor with Switches	7.5
QMX3.P30	Wall Temperature Sensor Only	7.5
QMX3.P34	Wall Temperature Sensor with Display	7.5
QMX3.P37	Wall Temperature Sensor with Switches and Display	10
QMX3.P70	Wall Temperature/RH/C02 Sensor	15
QMX3.P74	Wall Temperature/RH/C02 Sensor with Display	15
JB260C23	Binary Input (4x)	10
JB510C23	Binary Output (2x Relay)	10
JB512C23	Switching actuator (1x 20A Relay)	10
JB513C23	Binary Output (3x Relay)	10
JB520C23	Solar protection (1x actuator)	10
JB521C23	Solar protection (2x actuator)	10
JB525C23	Universal 120V dimmer	10
JB125C23	KNX Power Supply 80mA at DC 29V AC 120 V, 50 through 60 Hz (maximum 8 on Bus)	(80 … 640)

Actuator Terminal Equipment Controller (ATEC) BACnet or N-Variant P1

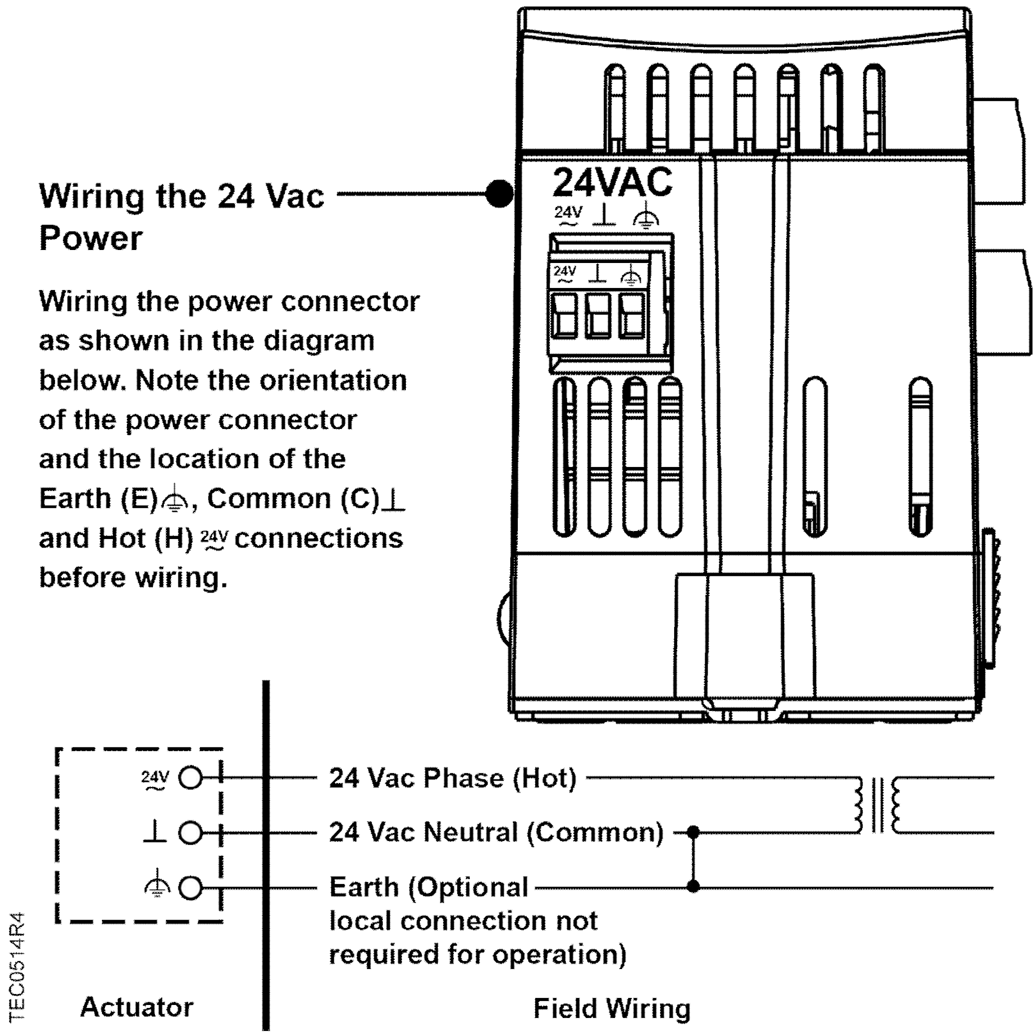


Figure 73: Power Trunk Connection to ATEC.

BACnet ATEC or N-Variant P1 ATEC (Updated Hardware Power Source Requirements.			
Product	Input Voltage	Line Frequency	Maximum Power [1,2,3]
BACnet Actuator	24 Vac	50/60 Hz	5 VA + DO loads

1) Total VA rating is dependent upon the controlled DO loads (for example, actuators, contactors, and so on.) limited to 12 VA per DO.

2) Smoke control listed ATECs are limited to 6 VA max per DO.

3) Do not control more than the nameplate rated loads for DOs of the electronic output controllers. The controller UL and CSA listing is based on the nameplate power rating.

BACnet Actuator Wiring Diagrams

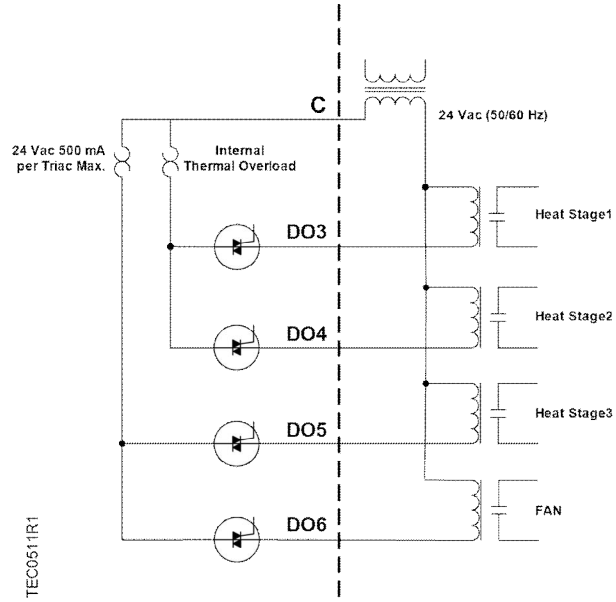


Figure 74: ATEC VAV with Electric Heat and Fan.

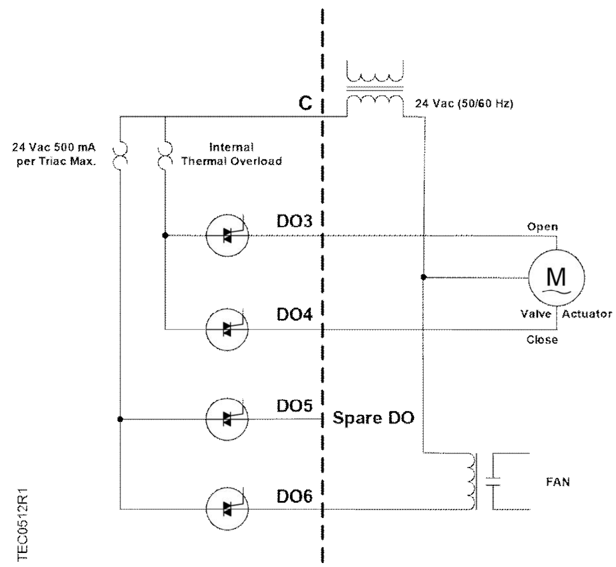


Figure 75: ATEC VAV with Hot Water Reheat, Fan and Spare DO.

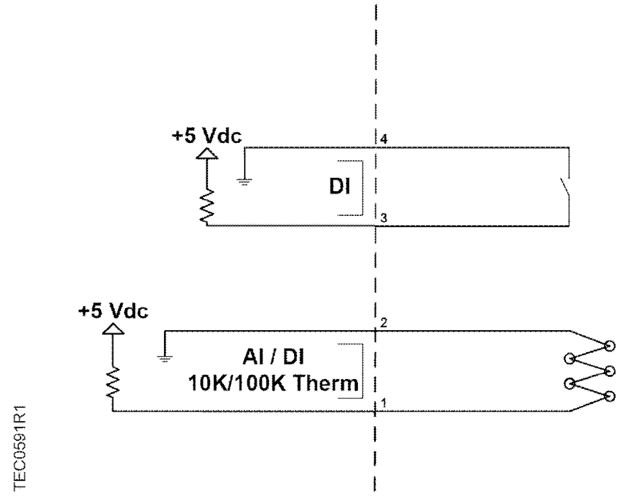


Figure 76: ATEC Wiring for DI2/AI3.

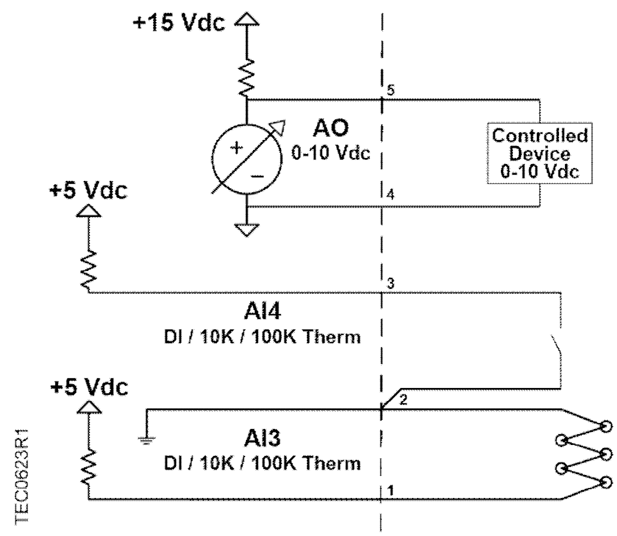


Figure 77: ATEC Wiring for A13/A14/AO.

BACnet Programmable Terminal Equipment Controllers (PTEC) and N-Variant P1 TEC (Updated Hardware)

Earth Ground Reference

The earth ground reference for all field panels and equipment controllers must be supplied using a third wire run with the AC power source providing power to that cabinet. All AC power sources must be bonded per NEC 250 unless isolation is provided between the cabinets.

For more information, see the Equipment Grounding System Requirements [→ 17] section of this manual.

BACnet PTEC or N-Variant P1 TEC (Updated Hardware) Power Source Requirements.			
Product	Input Voltage	Line Frequency	Maximum Power [1,2,3,4]
BACnet Equipment Controller (6 DO Platform)	24 Vac	50/60 Hz	3 VA + DO loads
BACnet Equipment Controller (8 DO Platform)	24 Vac	50/60 Hz	7 VA + DO loads

1) Total VA rating is dependent upon the controlled DO loads (for example, actuators, contactors, and so on) limited to 12 VA per DO.

2) Smoke control listed ATECs are limited to 6 VA maximum per DO.

3) Do not control more than the nameplate rated loads for DOs of the electronic output controllers. The controller UL and CSA listing is based on the nameplate power rating.

4) For higher VA requirements, 110 or 220 Vac requirements, separate transformers used to power the load, or DC power requirements, use an interposing 220V 4-relay module (TEC Relay Module P/N 540-147).

See the Installation Instructions for point wiring diagrams.

6 DO Platform

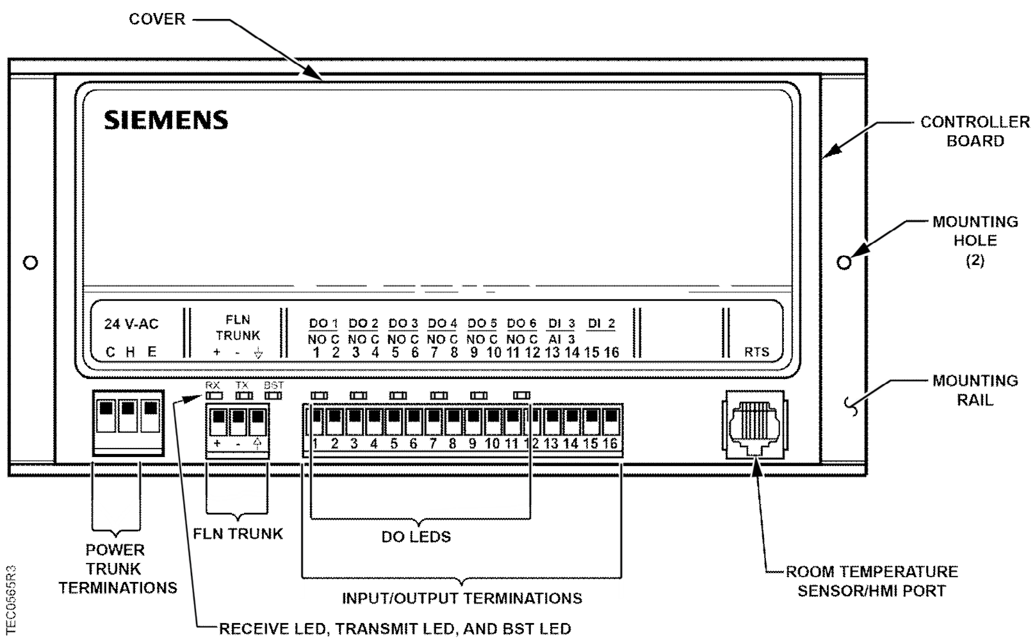


Figure 78: 6 DO Controller with 1 DI, 1 DI/AI-T.

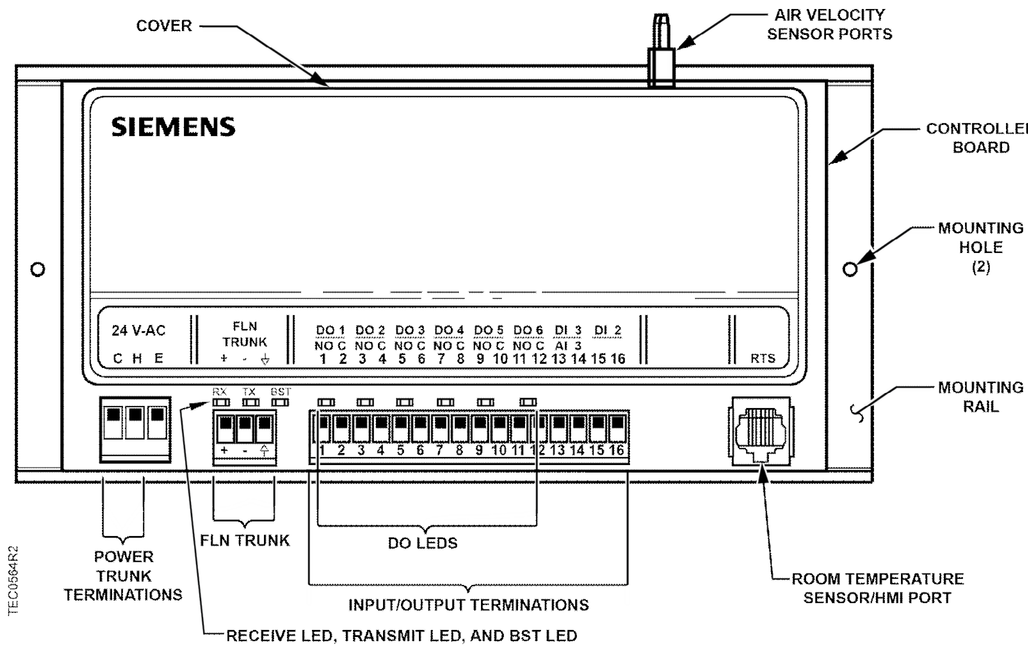


Figure 79: 6 DO Controller with 1 DI, 1 DI/AI-T, and Air Velocity Sensor.

8 DO Platform

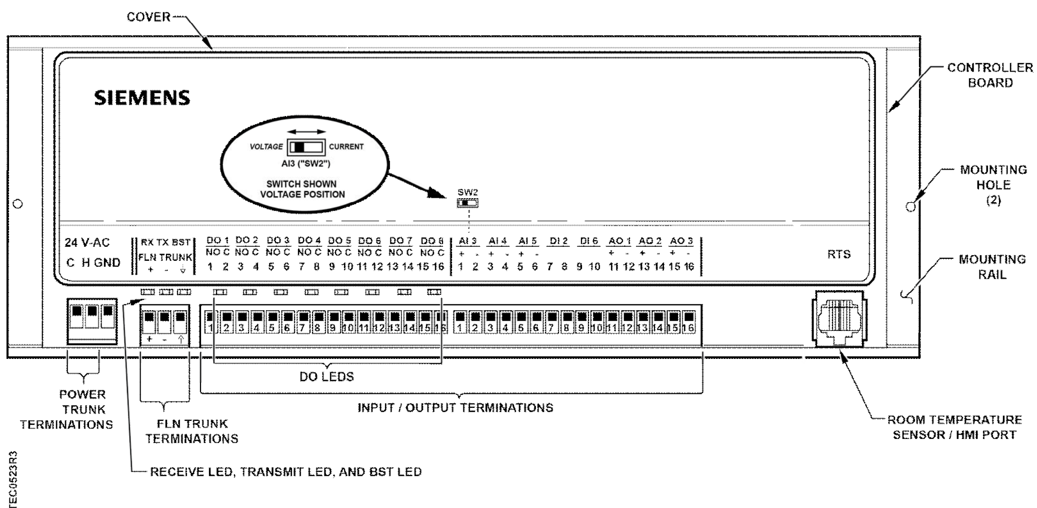


Figure 80: 8 DO Controller with 1 AI-V/I, 2 AI-T, 2 DI, and 3 AO-V.

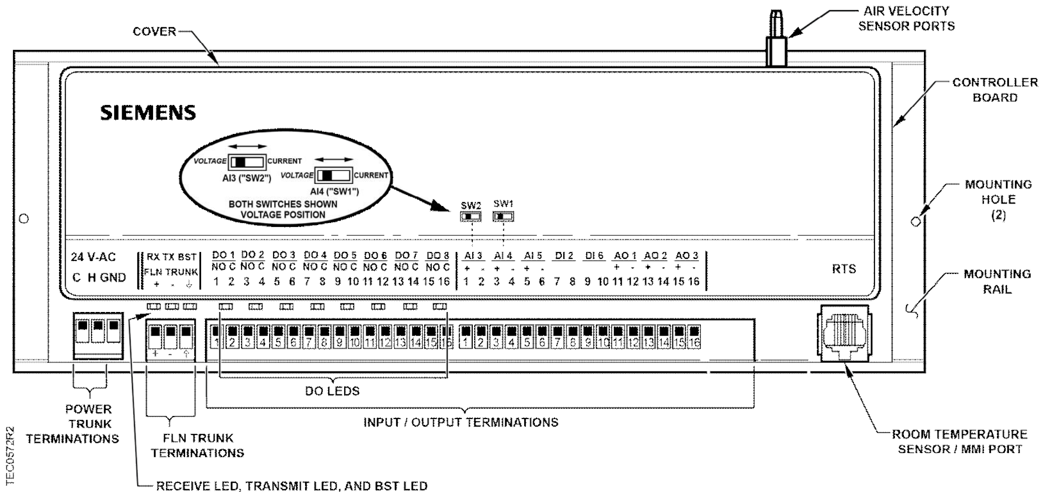


Figure 81: 8 DO Controller with 2 AI-V/I, 1A1-T, 2 DI, 3 AO-V, and 1 Air Velocity Sensor.

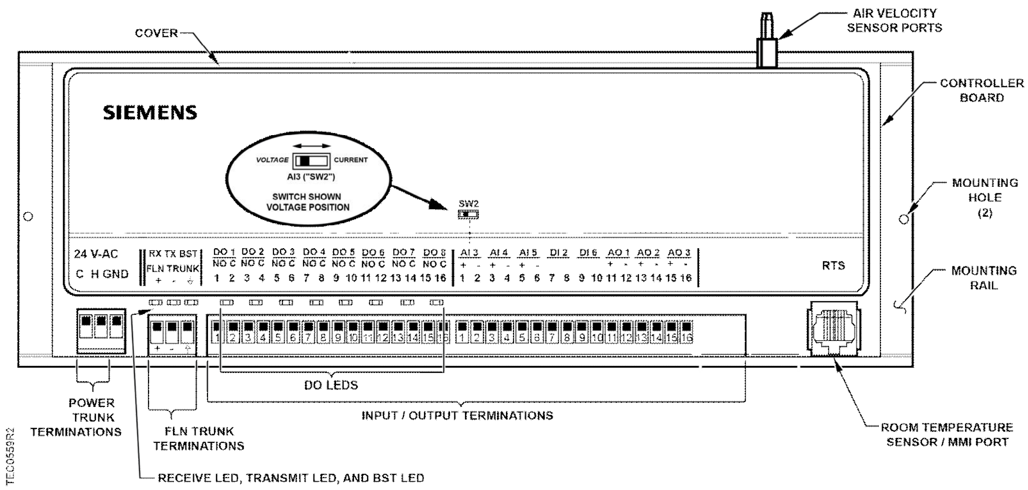


Figure 82: 8 DO Controller with 1 AI-V/I, 2AI-T, 2 DI, 3 AO-V, and 1 Air Velocity Sensor.

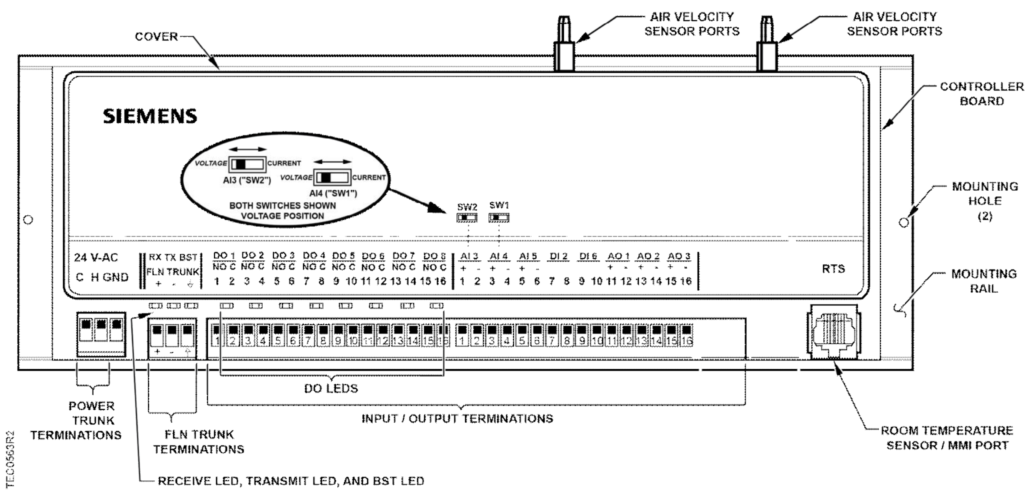


Figure 83: 8 DO Controller with 2 AI-V/I, 1 AI-T, 2 DI, 3 AO-V, and 2 Air Velocity Sensors.

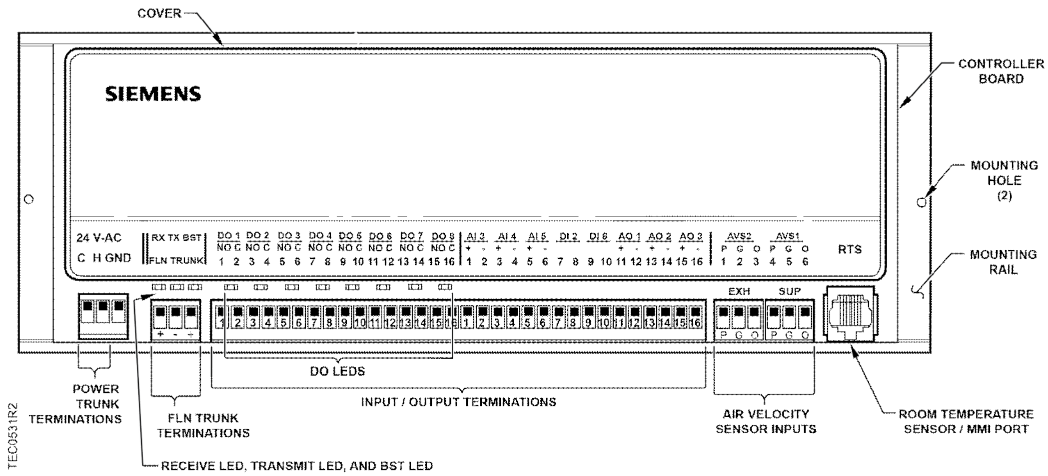


Figure 84: 8 DO Controller with 2 AI-V/I, 1AI-T, 2 DI, 3 Fast AO-V, and 2 Offboard Air Velocity Sensor Inputs.

Appendix A – Discontinued Products

The following products are no longer available for new sales; this information is for reference only.

Modular Equipment Controller (MEC) and Point Expansion Module (PXM)

Wire Type Requirements

MEC, MEC with LON, and PXM Points Wire Type Requirements.				
Circuit Type	Class	Wire Type	Maximum Distance[1]	Conduit Sharing[2]
AC Line Power (120V or greater)	1	No. 12 to No. 14 AWG THHN	See NEC	Check local codes
AC Low Voltage Power	2	No. 12 to No. 18 AWG THHN	See NEC	Check local codes
Analog Input 1K Ohm platinum RTD	2	No.18 or No.22 AWG TP or TSP[5] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)	Check local codes
Analog Input 0-10V	2	No.18 or No.22 AWG TP or TSP[5] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)	Check local codes
Analog Input 0-20 mA	2	No.18 or No.22 AWG TP or TSP[5] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)	Check local codes
Analog Output 0-10V	2	No.18 or No.22 AWG TP or TSP[5] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)	Check local codes
Analog Output 0-20 mA	2	No.18 or No.22 AWG TP or TSP[5] CM (FT4) or CMP (FT6)[3]	750 ft (230 m)	Check local codes
Analog and Digital Inputs on SCS	2	24 AWG UTP[6], solid or stranded.	328 ft (100 m)	Check local codes
Digital Input	2	No.14 to No.22 AWG. TP not required below 1 Hz. at faster pulse speeds, use TP or TSP[5]; check job specifications and local codes.	750 ft (230 m)	Check local codes
Digital Output	1, 2	No.14 to No.22 AWG. TP not required; check job specifications and local codes.	Check local codes	Check local codes
MEC Point EXP Bus[4]	2	No. 24 AWG TSP CM (FT4) or CMP (FT6)[3]	200 ft (61 m)	Check local codes

1) Wire length affects point intercept entry. Adjust intercept accordingly.

2) Conduit sharing rules: No Class 2 point wiring can share conduit with any Class 1 wiring except where local codes permit. (Both Class 1 and Class 2 wiring can be run in the field panel providing the Class 2 wire is UL listed 300V 75°C (167°F) or higher, or the Class 2 wire is NEC type CM (FT4) (75°C or higher) or CMP (FT6) (75°C or higher). NEC type CL2 and CL2P is not acceptable unless UL listed and marked 300V 75°C (167°F) or higher.

3) Twisted pair, non-jacketed, UL listed 75°C (167°F) and 300V cable can be used in place of CM (FT4) or CMP (FT6) (both must be rated 75°C or higher) cable when contained in conduit per local codes. See the *Field Purchasing Guide* for wire.

4) All point blocks wired to an MEC must be daisy-chained. The total wire length from the MEC to the last point block in the chain must be no longer than 200 ft (61 m). Unlike BLN connections, shield wires to the point blocks must be terminated at both ends.

5) Twisted Shielded Pair TSP is not required, does not affect MEC specifications, and may be substituted where otherwise specified. TSP should be used in areas of high electrical noise (for example when in proximity to VFDs and 100 kVa or larger motors). Where used, connect the shield drain wire to the MEC Shield terminals or equivalent grounding system inside enclosure.

6) Cable must be part of a Structured Cabling System (SCS).

NOTE:
UL-recognized wire (labeled with a backwards "RU") is not field-installable. Use only UL-listed wire.
For analog inputs, termination for shield is provided, if required. Termination for shield is not provided for digital inputs. For more information, see the wiring diagrams.

Power Source Requirements

Power Source Requirements for MEC.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power** [1,2]
MEC	24 Vac	50/60 Hz	35 VA
MEC with FLN	24 Vac	50/60 Hz	50 VA
L model MEC	24 Vac	50/60 Hz	50 VA
MEC Digital Point Block, 4 DI, 4 DO	24 Vac	50/60 Hz	14 VA
MEC Digital Point Block, 8 DI, 4 DO	24 Vac	50/60 Hz	18 VA
MEC Analog Point Block, 4 AI, 4 AO	24 Vac	50/60 Hz	20 VA
MEC Analog Point Block, 8 AI	24 Vac	50/60 Hz	18 VA
Point Expansion Module	24 Vac	50/60 Hz	18 VA
PX Series Service Box – 192 VA	192 VA	50/60 Hz	200 VA[3]
PX Series Service Box – 384 VA	384 VA	50/60 Hz	175 VA

1) The 24V wiring is Class 2. It draws less than 50 watts of power. AC power uses Class 1 wire.

2) An external connection is provided for power at 24 Vdc at 50 mA per termination (200 mA maximum all terminations) for

external sensors.

3) Service outlets are restricted to only continuously power network devices.

Analog Input Powered Devices

Approved sensors drawing less than 25 mA can be powered by the MEC analog input (AI) connections. Sensors requiring more power must be powered by an external source. The external source can be connected to the same AC line as the MEC power supply as long as it is only used to power low voltage devices (less than 30 volts).

Analog Output Powered Devices

The PX Series Service Box provides a 24 Vac 100 VA total power source to any auxiliary device via a two-wire connection (L, N).

Powering Options

One of the options for powering the MEC, point blocks, and 24V devices is the PX Series Service Box.

See *PX Series Service Box* in this chapter for more information.

Point Bus Wiring Restrictions

All point blocks wired to an MEC must be daisy-chained. The total wire length from the MEC to the last point block in the chain must be no longer than 200 ft (61 m).

NOTE:
Unlike BLN connections, shield wires to the point blocks must be terminated at both ends.

Multiple MECs on One Power Source

Table *Number of MECs Allowed on a Single Three-Wire Circuit* shows the number of MECs allowed on a single three-wire (ACH, an ACN, and Earth Ground) circuit, if local code permits.

Number of MECs Allowed on a Single Three-Wire Circuit.				
Circuit Breaker Size[1]	Maximum Values for Concentrated Loads		Maximum Values for Evenly Spaced Loads	
	Length[2]	MEC	Length[2]	MEC
15 amp (No.14 AWG THHN)	75 ft (22.87 m)	7/10	100 ft (30.48 m)	7/10
20 amp (No.12 AWG THHN)	115 ft (35.06 m)	7/10	130 ft (40.63 m)	7/10

1) Assumes minimum voltage of 102 Vac at circuit breaker and 5 Vac maximum voltage drop (97 Vac at loads). See Class 1 power trunk information in *the Wire Specification Tables* section of Chapter 1.

2) Conduit length from MEC to MEC.

Metal Oxide Varistors (MOVs)

For MECs, MOVs must be used across the DO terminals when connected to loads in all cabinets. MOVs are factory-installed on all DOs in MECs. See the *Controlling Transients* section in Chapter 1 for MOV part numbers.

When installing MOVs across the DO relay contacts on termination boards, keep the MOV leads as short as possible. This makes the MOV more effective in reducing spikes from field wiring or controlled devices. Remove and reinstall any MOVs with leads longer than 1 to 1-1/2 in. (25.4 mm to 38.1 mm).

Line Voltage Receptacle

V150LA20A MOVs are factory-installed on all MEC 115V service box receptacles.

MEC and PXM Wiring Diagrams

Point Type	Specifics	Diagram
Analog Input	4-20 mA, 2-wire	Figure 71
	4-20 mA, externally powered	Figure 72
	4-20 mA, 3-wire, internally powered	Figure 73
	0-10 Vdc, externally powered	Figure 74
	0-10 Vdc, internally powered	Figure 75
	1000 Ohm platinum RTD	Figure 76
Analog Output	4-20 mA	Figure 77
	0-10 Vdc	Figure 78
Digital Input	Dry contacts	Figure 79
	Pulse accumulating	Figure 80
Digital Output	Pulsed or latched	Figure 81
Universal Input		Figure 82

WARNING

All transformer or isolated power supply secondary neutrals requiring connection to earth ground must be directly connected to an approved building earth ground terminal located at the point termination module where the signal is terminated.

This is represented in the following diagrams by “E” at the earth ground symbol.

Analog Input

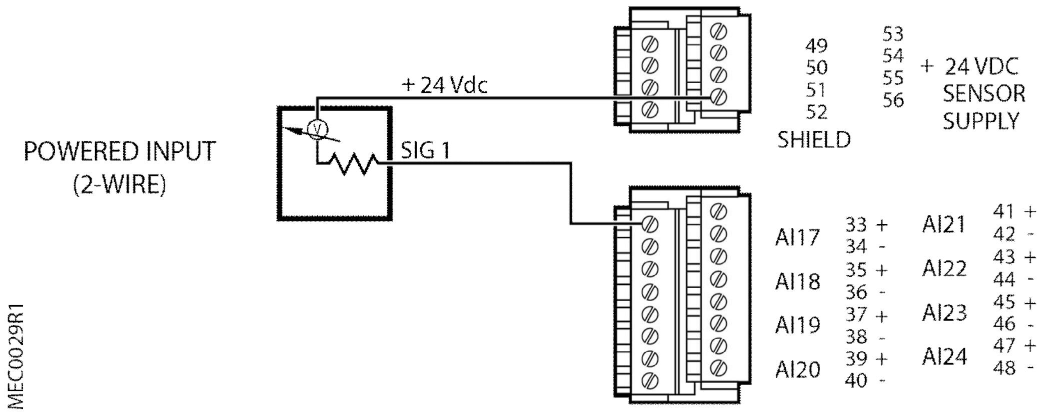


Figure 85: Figure 71. Connecting a 2-Wire Analog Input (4 to 20 mA).

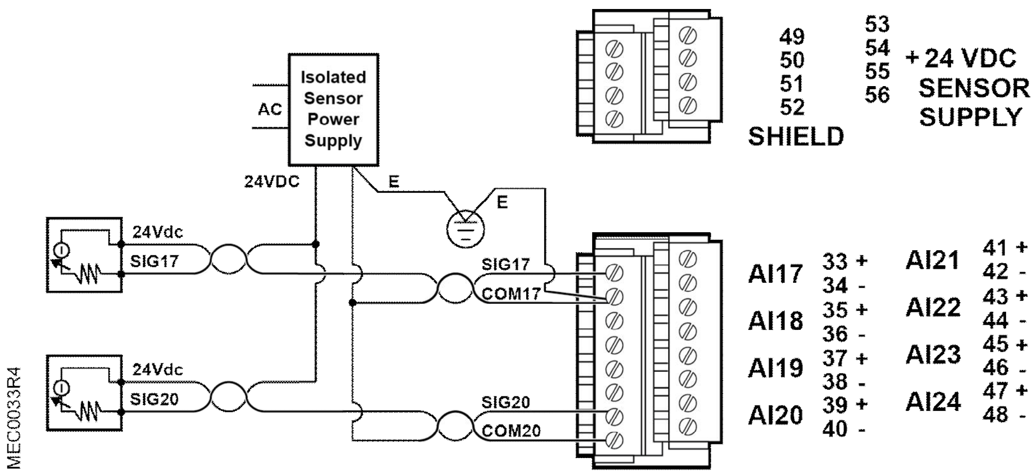


Figure 86: Figure 72. Connecting an Externally Powered Analog Input (4 to 20 mA).

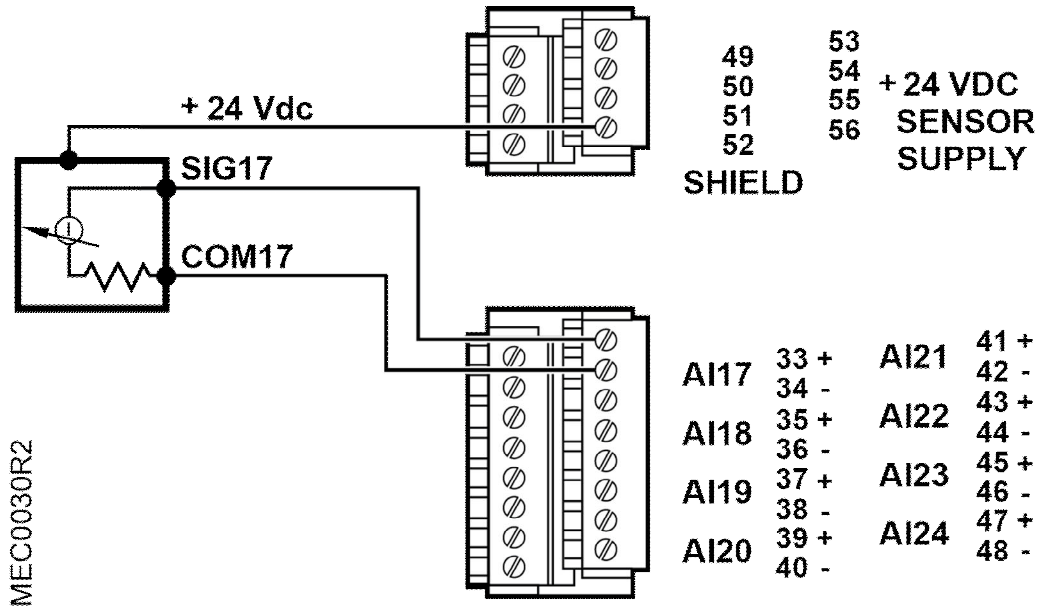


Figure 87: Figure 73. Connecting an Internally Powered 3-Wire Analog Input (4 to 20 mA).

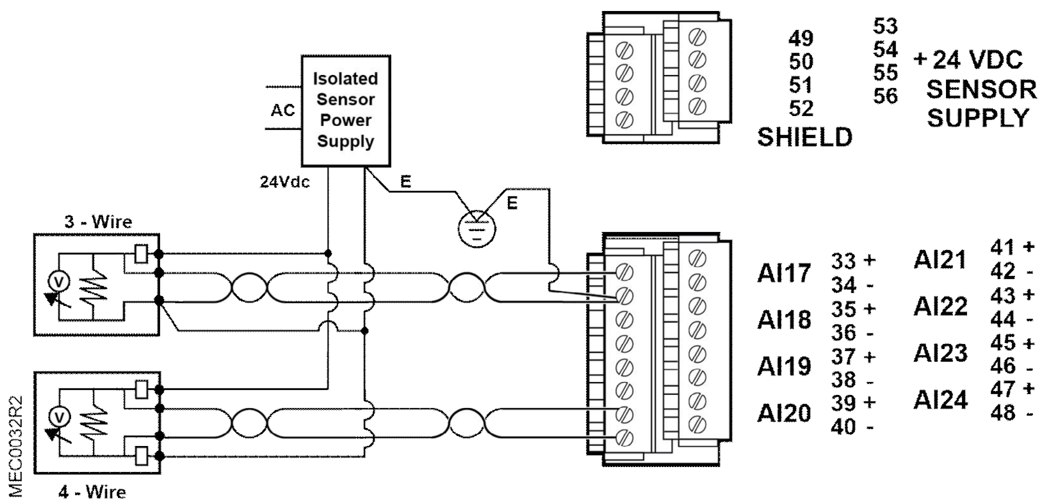


Figure 88: Figure 74. Connecting an Externally Powered Analog Input (0 to 10 Vdc).

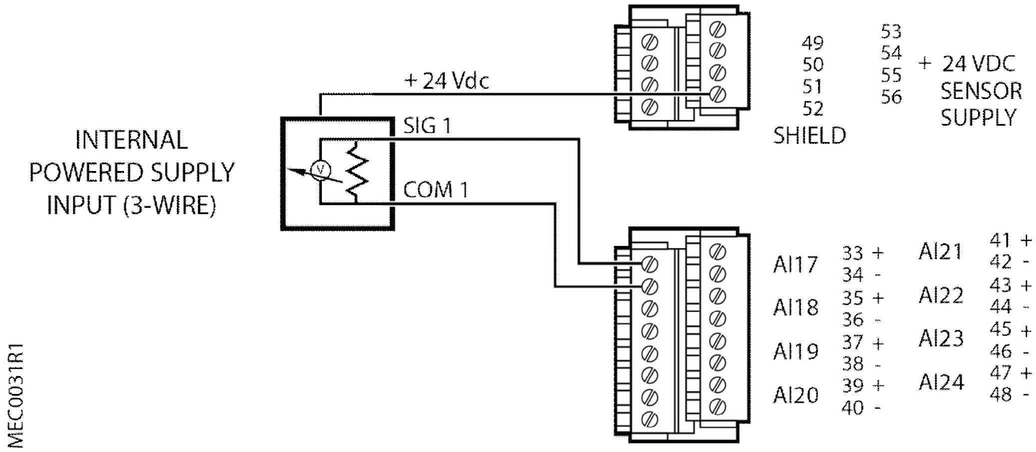


Figure 89: Figure 75. Connecting an Internally Powered Analog Input (0 to 10 Vdc).

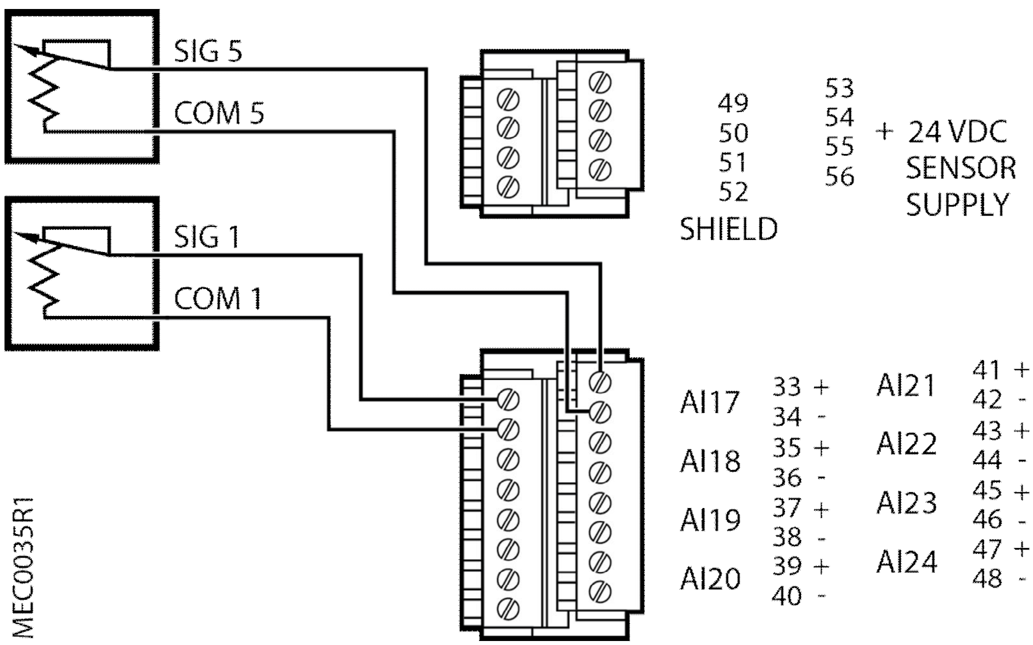


Figure 90: Figure 76. Connecting an Analog Input (1000 ohm Platinum RTD).

Analog Output

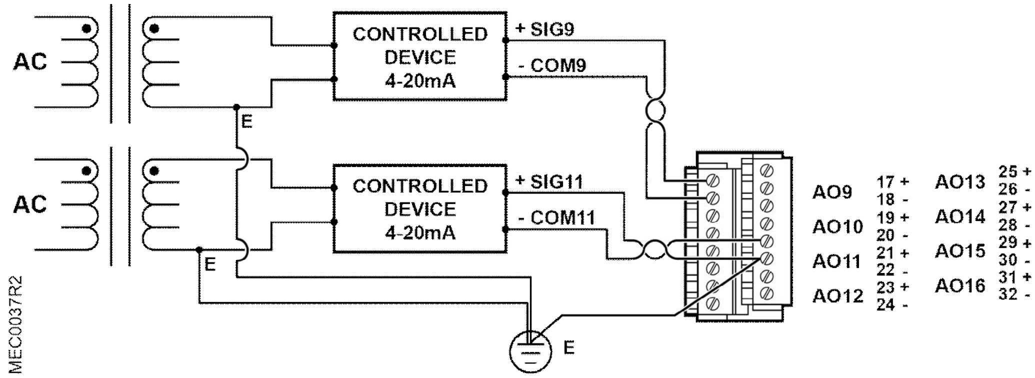


Figure 91: Figure 77. Connecting an Analog Output (4 to 20 mA).

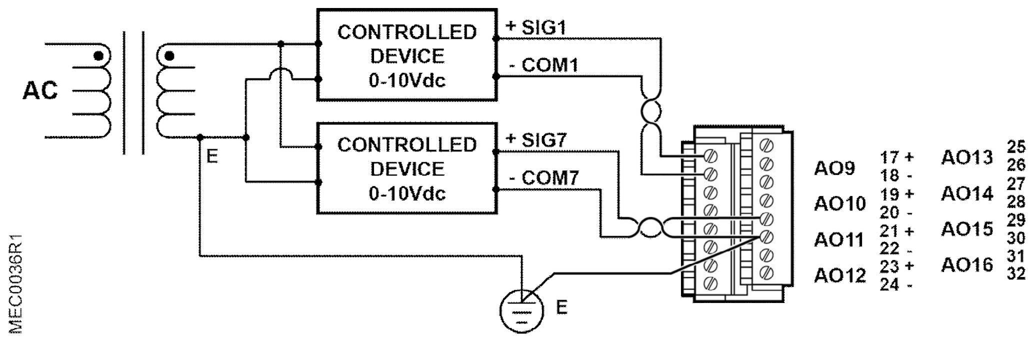


Figure 92: Figure 78. Connecting an Analog Output (0 to 10 Vdc).

Digital Input

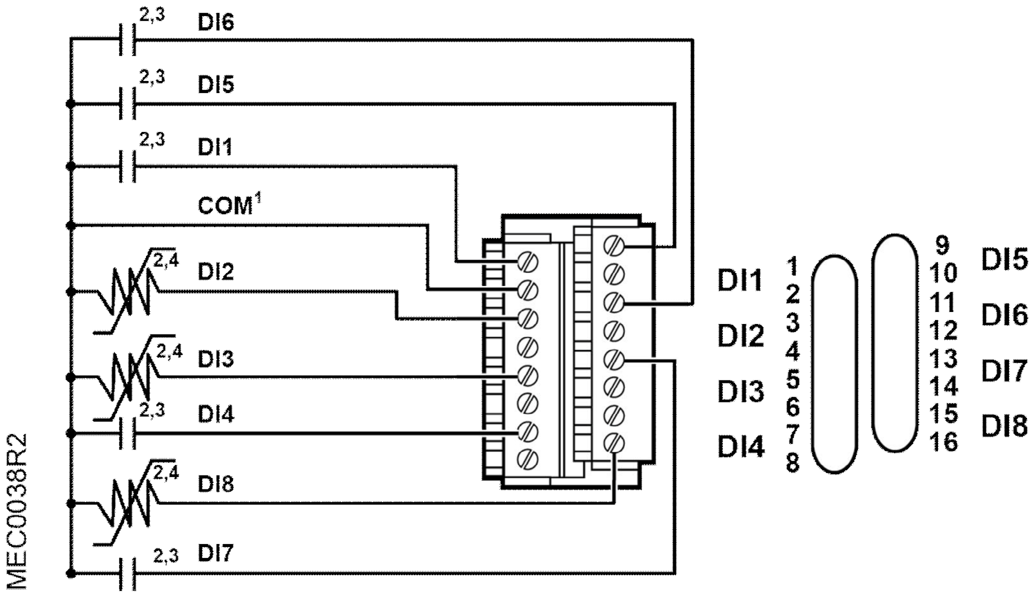


Figure 93: Figure 79. Connecting a Digital Input (Dry Contacts).

1) A single common may be used for all digital inputs.

2) Excitation equals 24 Vdc at 22 mA. Pulse rate equals 10 Hz.

3) Dry contact only. Does not require gold contacts.

4) Solid state device must be rated for 30V minimum, with RDS on less than 1K ohms and RDS off greater than 100K ohms

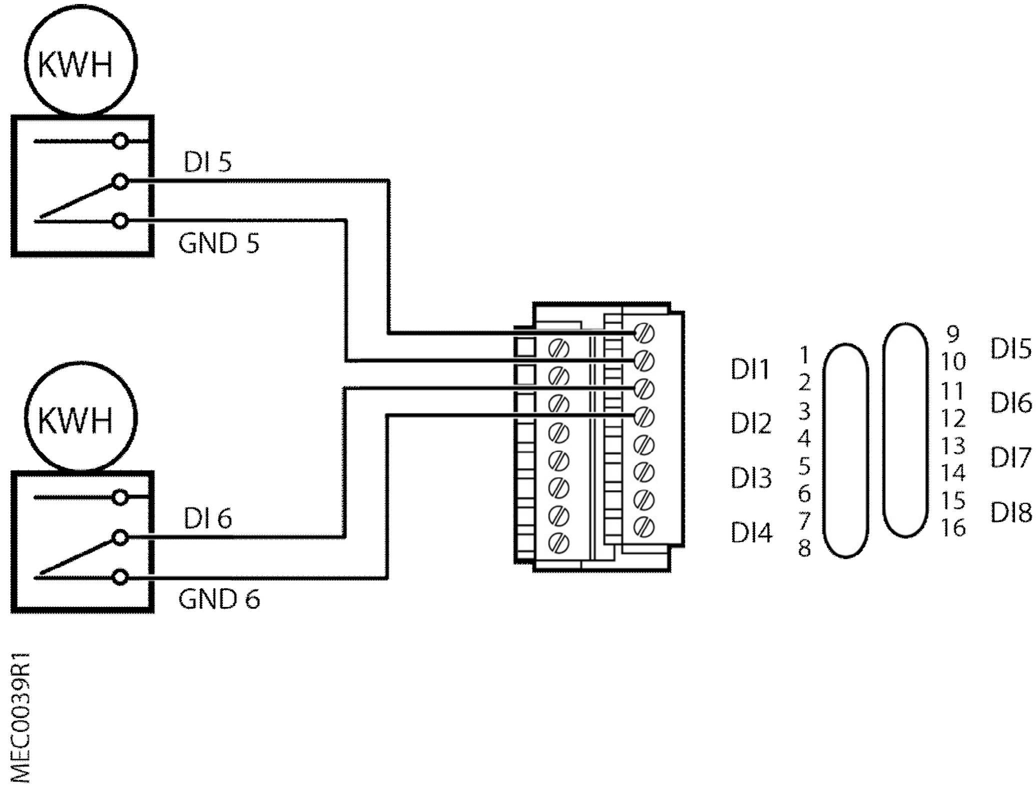


Figure 94: Figure 80. Connecting a Digital Input (Pulse Accumulating).

Digital Output

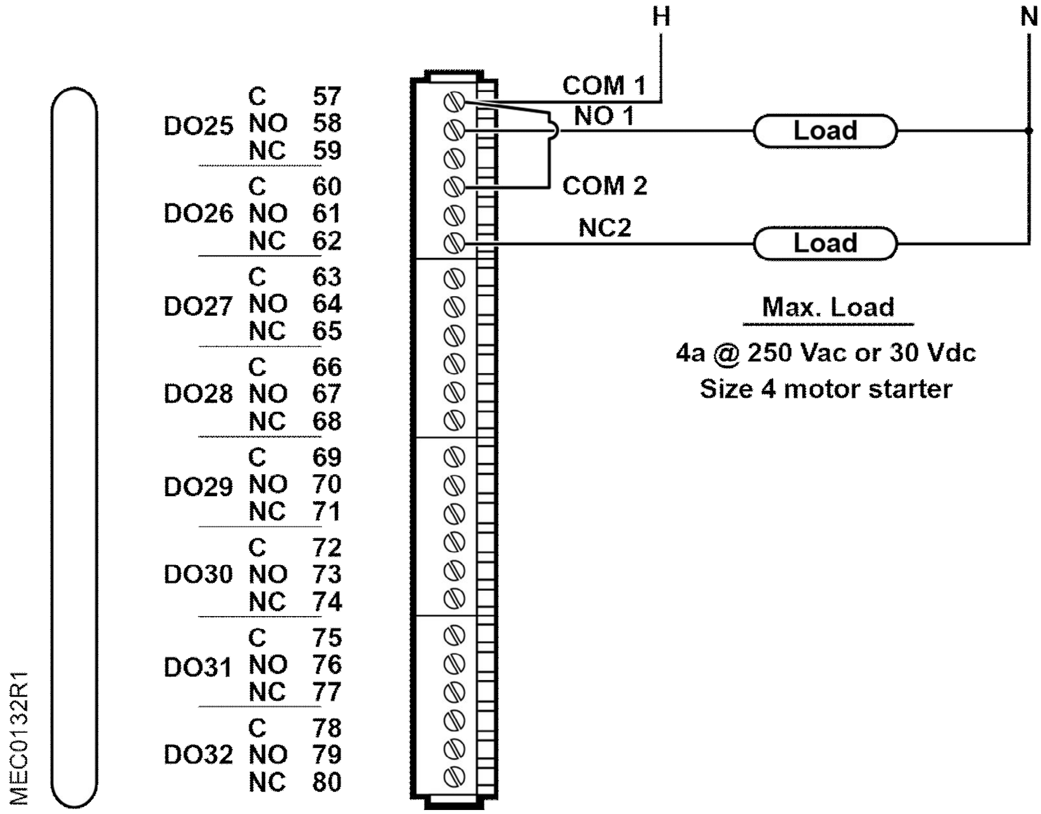


Figure 95: Figure 81. Connecting a Digital Output (Pulsed or Latched).

Universal Inputs

To use an AI as a DI, wire the device as follows:

1. Wire a 1/2-Watt, 3.3K-ohm resistor between the 24 Vdc sensor supply and the dry contact to be monitored. (See the following Figures.)
2. Wire the other side of the dry contact into the signal terminal of an AI point.
3. In parallel to the first 3.3K-ohm resistor, wire a second 3.3K-ohm resistor.
4. Set the jumper for the corresponding AI to **current**.
5. Define the point in the Firmware as an LDI.

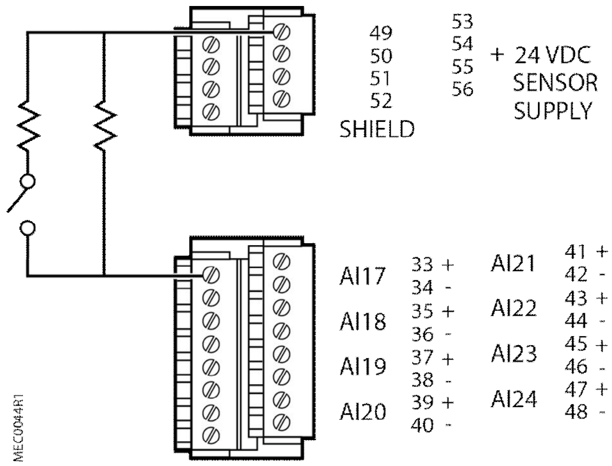


Figure 96: MEC Wiring Diagram to use an AI as a DI.

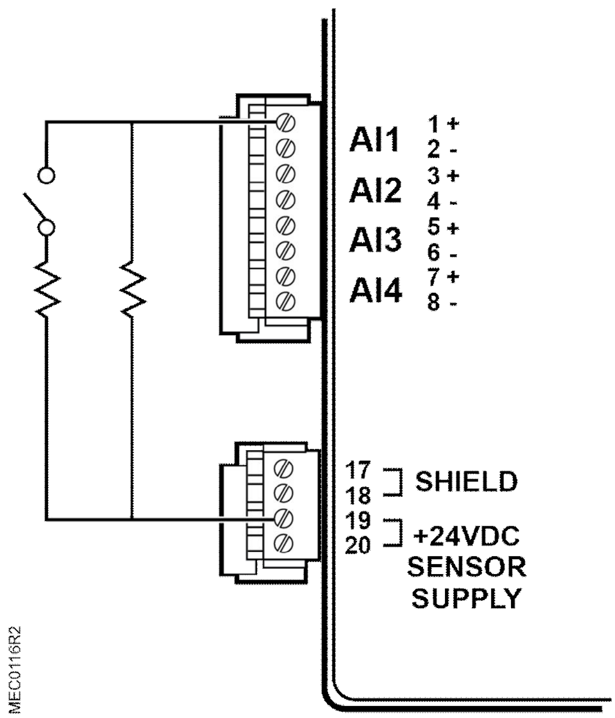


Figure 97: PXM Wiring Diagram to use an AI as a DI.

MEC Service Boxes

One of the options for powering the TX-I/O, PXC Compact, MEC, point blocks, and 24V devices is the Service Box.

	CAUTION
	Do not connect inductive loads, such as drill motors, vacuum cleaners, or compressors, to the duplex receptacle on the 115V Service Box.

Service Box Source Requirements and Outputs						
			Maximum Input		Maximum 24 Vac Output	
Service Box Type	Input Voltage	Line Frequency	Transformer	Service Outlets	Total [1]	Class [2]
115V 175VA	115 Vac	50/60 Hz	1.8A	2A2	175 VA	60 VA
230V 175VA	230 Vac	50/60 Hz	0.9A	N/A	175 VA	60 VA

1) Total 24 Vac Output Power is distributed to both Class 1 Power Limited Terminations for use inside the enclosure only and a Class 2 Termination which may be used outside the enclosure.

2) Service outlets (115 Vac only) are restricted to continuously powered network devices (0.5A) and reserved power for laptop computers (1.5A). Plan Branch circuit for an additional 2A per 115 Vac 24 Vac Service Box.

Multiple Service Boxes on One Power Source

The table *Number of MECs Allowed on a Single Three-Wire Circuit* shows the number of MECs allowed on a single three-wire (ACH, an ACN, and Earth Ground) circuit, if local code permits.

Number of MECs Allowed on a Single Three-Wire Circuit.				
Circuit Breaker Size [1]	Maximum Values for Concentrated Loads		Maximum Values for Evenly Spaced Loads	
	Length [2]	MEC	Length [2]	MEC
15 amp (No.14 AWG THHN)	75 ft (22.87 m)	7/10	100 ft (30.48 m)	7/10
20 amp (No.12 AWG THHN)	115 ft (35.06 m)	7/10	130 ft (40.63 m)	7/10

1) Assumes minimum voltage of 102 Vac at circuit breaker and 5 Vac maximum voltage drop (97 Vac at loads). See Class 1 power trunk information in the *Wire Specification Tables* section of Chapter 1.

2) Conduit length from Service Box to Service Box.

115V Version

Standard source power is 115 Vac. The high-voltage supply enters the enclosure from the top through the right-hand side conduit knockout. The source voltage of the MEC must be current limited to 20 amps or less (15 amps or less for Smoke Control), depending on the requirements of any particular installation.

Two pigtails and grounding studs are provided under the wire cover for easy connection by the electrician. The pigtails come from the factory pre-wired to the transformer through a single pole On/Off switch and circuit breaker. The duplex receptacle is not switched. MOVs (3 x 150V) are installed on input power.

Low voltage is routed from the transformer and supplies 24 Vac power at 175VA maximum. (The power source to the Service Box must be current limited to 15 amps or less.) The CTLR, POINT BLOCKS connector is rated at 100 VA. The 24V ACTUATOR connector is rated Class 2 and limited to 60 VA. A MOV (30V) is installed on 24 Vac side of transformer.

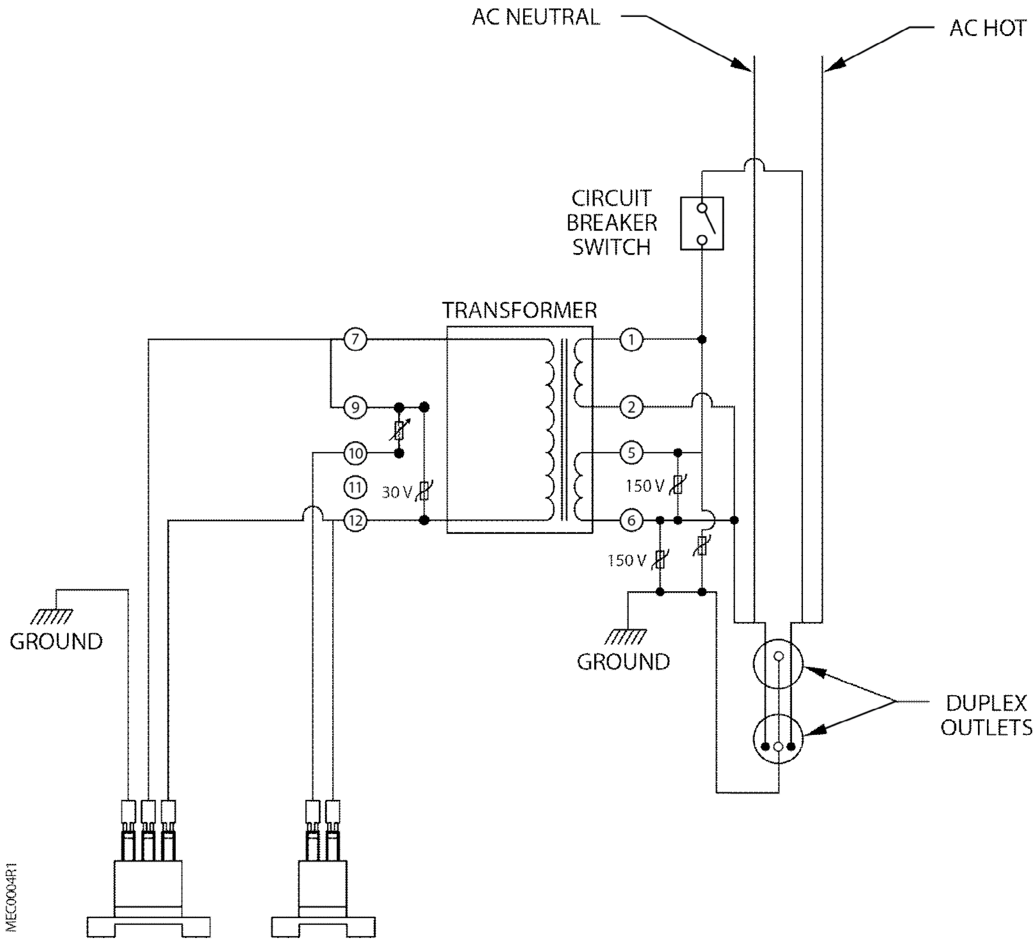


Figure 98: Wiring Diagram for 115V MEC Service Box.

	DANGER
	Possible shock hazard! The power switch disables power to the control side of the MEC only. Power remains ON at the duplex receptacle (115V version) and in the service box. Power may be present at the field devices. To avoid injury, follow proper safety precautions.

230V Version Service Box

The 230V Service Box is also available for applications where source power is 230 Vac. The high-voltage supply enters the enclosure from the top through the right-hand side conduit knockout. The source voltage of the MEC must be current limited to 10 amps or less, depending on the requirements of any particular installation.

A termination block for power and ground termination is provided on the wire cover for easy connection by the electrician. The termination block comes from the factory pre-wired to the transformer through a double pole On/Off switch and circuit breaker. MOVs (3 x 275V) are installed on input power.

Low voltage is routed from the transformer and supplies 24 Vac power at 175 VA maximum. The **CTLR, POINT BLOCKS** connector is rated at 100 VA. The **24V ACTUATOR** connector is rated Class 2 and limited to 60 VA. A MOV (30V) is installed on the 24 Vac side of the transformer.

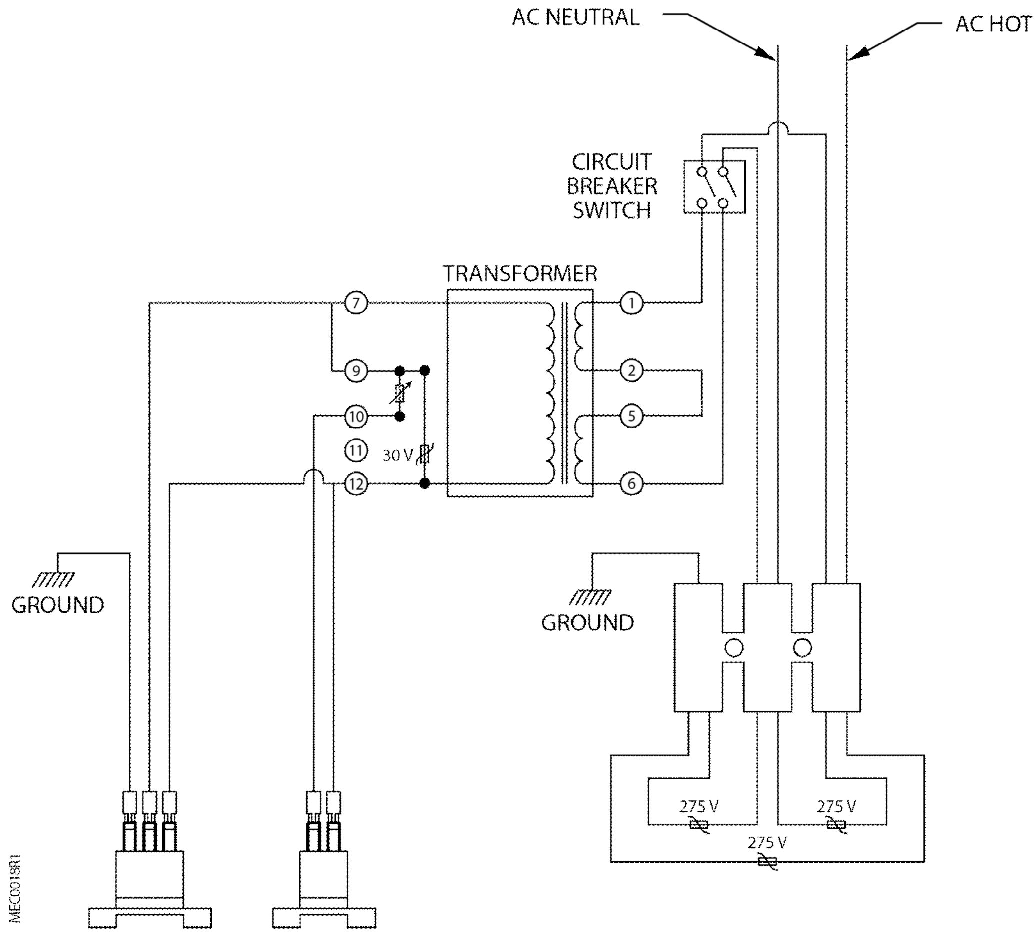


Figure 99: Wiring Diagram for 230V Service Box.

Service Box Earth Grounding Transfer 24 Vac Neutral

The service box has a floating neutral system, which when required must be connected to the building approved earth ground, as follows:

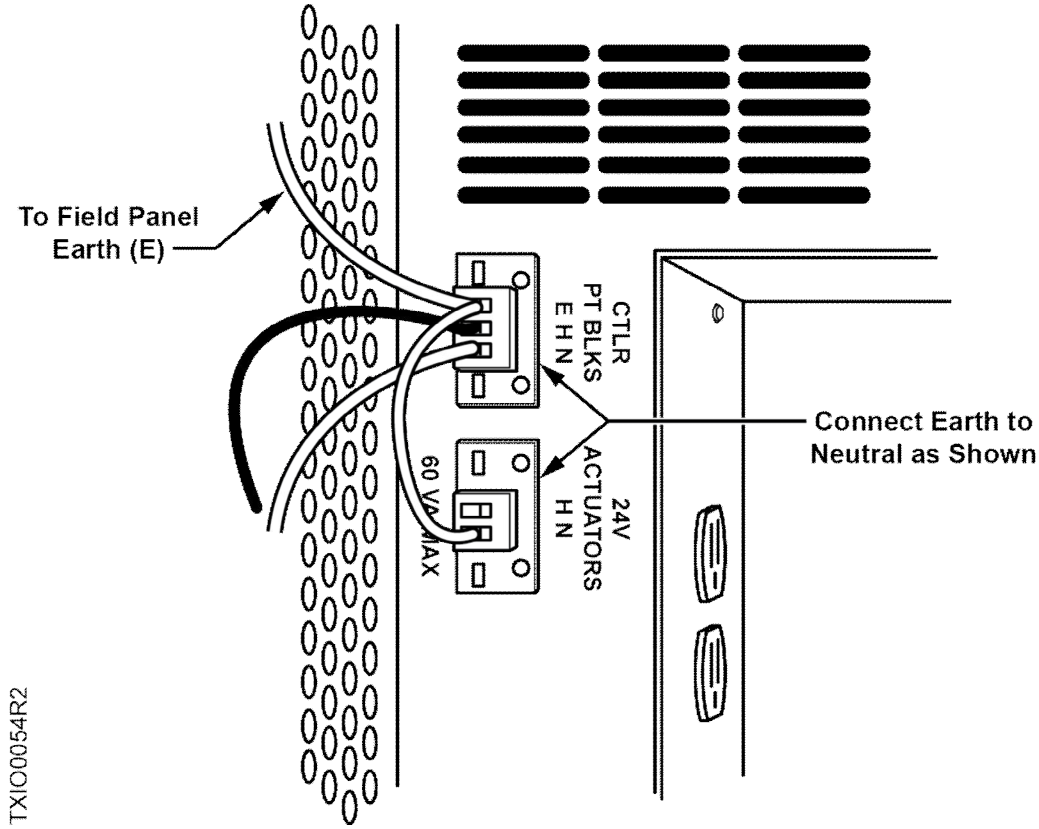


Figure 100: MEC Service Box Common Grounding.

	⚠ DANGER
	The Transformer Secondary Neutral (N) must be connected to the building approved earth ground whenever transformer primary is greater than 150 Vac.

Modular Building Controller/Remote Building Controller (MBC/RBC)

Wire Type Requirements

MBC/RBC Wire Type Requirements.				
Circuit Type	Class	Wire Type4	Maximum Distance1	Conduit Sharing2
AC Line Power	Power	No. 12 to No. 14 AWG THHN	See NEC*	Check local codes
Digital Output	1, 2	No. 14 to No. 22 AWG TP not required, check job specifications and local codes	Check local codes	Check local codes

MBC/RBC Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type[4]**	**Maximum Distance[1]**	**Conduit Sharing[2]**
Digital Input	2	No. 14 to No. 22 AWG TP not required, check job specifications and local codes	750 ft (230 m)	Check local codes
High Voltage Digital Input	1, 2	No. 14 to No. 22 AWG TP not required, check job specifications and local codes	750 ft (230 m)	Check local codes
Analog Input 1k Nickel or Platinum	2	No. 20 AWG TP or TSP[3] CM (FT4) or CMP (FT6)	750 ft (230 m)	Check local codes
Analog Input, Thermistor	2	No. 18 to No. 20 AWG TP or TSP[3] CM (FT4) or CMP (FT6)	750 ft (230 m)	Check local codes
Analog Input, 0-10V	2	No. 18 to No. 20 AWG TP or TSP[3] CM (FT4) or CMP (FT6)	750 ft (230 m)	Check local codes
Analog Input, 4-20 mA	2	No. 18 to No. 20 AWG TP or TSP[3] CM (FT4) or CMP (FT6)	750 ft (230 m)	Check local codes
Analog Output, 0-10V	2	No. 18 to No. 20 AWG TP or TSP[3] CM (FT4) or CMP (FT6)	750 ft (230 m)	Check local codes
Analog Output, 4-20 mA	2	No. 18 to No. 20 AWG TP or TSP[3] CM (FT4) or CMP (FT6)	750 ft (230 m)	Check local codes
Analog and Digital on SCS	2	24 UTP[4], solid or stranded	328 ft (100 m)	Check local codes

* National Electric Code.

1) Wire length affects point intercept entry. Adjust intercept accordingly.

2) Conduit sharing rules: No Class 2 point wiring can share conduit with any Class 1 wiring except where local codes permit. Both Class 1 and Class 2 wiring can be run in the field panel providing the Class 2 wire is UL-listed 300V 75°C (167°F) or higher, or the Class 2 wire is NEC type CM (FT4)(75°C or higher) or CMP (FT6) (75°C or higher). NEC type CL2 and CL2P is not acceptable unless also UL listed and marked 300V 75°C (167°F) or higher.).

3) Twisted Shielded Pair TSP is not required for general installation, does not affect MBC/RBC specifications, and may be substituted where otherwise specified. TSP should be used in areas of high electrical noise (for example when in proximity to VFDs and 100 kVa or larger motors). Where used, connect the shield drain wire to the grounding system inside enclosure.

4) Cable must be part of a Structured Cabling System (SCS).

NOTE:
UL-recognized wire (labeled with a backwards “RU”) is not field-installable. Use only UL-listed wire.

Power Source Requirements

Power Source Requirements for MBC/RBC			
Product	Input Voltage	Line Frequency	Maximum Power
MBC 24/40 – 115V	115Vac	50/60 Hz	200 VA[4]
MBC 24/40 – 230V	230Vac	50/60 Hz	175 VA
RBC – 115V	115Vac	50/60 Hz	150 VA[4]
RBC – 230V	230Vac	50/60 Hz	135 VA
Power Open Processor	24 Vac ±20%	50/60 Hz	6 VA
Open Processor	24 Vac ±20%	50/60 Hz	5 VA
Power Module	24 Vac ±20%	50/60 Hz	5 VA
PTM6.2P1K	24 Vac ±20%	50/60 Hz	.25 VA
PTM6.2N100K	24 Vac ±20%	50/60 Hz	.35 VA
PTM6.2U10	24 Vac ±20%	50/60 Hz	.20 VA
PTM6.2I420	24 Vac ±20%	50/60 Hz	2.2 VA
PTM6.2D20[1]	24 Vac ±20%	50/60 Hz	.75 VA
PTM6.4D20	24 Vac ±20%	50/60 Hz	3 VA
PTM6.2D250	24 Vac ±20%	50/60 Hz	.75 VA
PTM6.2C	24 Vac ±20%	50/60 Hz	.75 VA
PTM6.2Y10[2]	24 Vac ±20%	50/60 Hz	3.2 VA
PTM6.2Y10S	24 Vac ±20%	50/60 Hz	3.2 VA
PTM6.2Y10-M[3]	24 Vac ±20%	50/60 Hz	3.2 VA
PTM6.2Y10S-M	24 Vac ±20%	50/60 Hz	3.2 VA
PTM6.2Y420	24 Vac ±20%	50/60 Hz	3.5 VA
PTM6.1PSI20-M	24 Vac ±20%	50/60 Hz	2.0 VA
PTM6.2Q250	24 Vac ±20%	50/60 Hz	2.6 VA
PTM6.2Q250-M	24 Vac ±20%	50/60 Hz	2.6 VA

1) PTM6.2D20 is no longer available.

2) PTM6.2Y10 has been replaced by the PTM6.2Y10S; however, both are still in use.

3) PTM6.2Y10M has been replaced by the PTM6.2Y10S-M. Both are still in use.

4) Cable must be part of a Structured Cabling System (SCS).

Analog Input Powered Devices

Approved sensors drawing less than 50 mA can be powered by the MBC/RBC analog input (AI) connections. Sensors requiring more power must be powered by an external source. The external source can be connected to the same AC line as the MBC/RBC power supply as long as it is only used to power low voltage devices (less than 30 volts).

Analog Output Powered Devices

No analog output devices can be powered by the MBC/RBC analog outputs.

Class 1/Class 2 Separations

High voltage (and other non-Class 2) Point Termination Modules (PTMs) must be placed in the upper right module slots of the field panel. All other PTMs must be placed on either the left rail of the field panel or below the high voltage modules.

Multiple MBCs/RBCs on One Power Source

The following table shows the number of MBC/RBCs allowed on a single three-wire (ACH, an ACN, and Earth Ground) circuit if local code permits.

Number of MBCs/RBCs Allowed on a Single Three-Wire Circuit.				
Circuit Breaker Size[1]	Maximum Vales for Concentrated Loads		Maximum Values for Evenly Spaced Loads	
	Length[2]	MBC/RBC	Length[2]	MBC/RBC
15 amp (No.14 AWG THHN)	75 ft (22.87 m)	7/10	100 ft (30.48 m)	7/10
20 amp (No.12 AWG THHN)	115 ft (35.06 m)	7/10	130 ft (40.63 m)	7/10

1) Assumes minimum voltage of 102 Vac at circuit breaker and 5 Vac maximum voltage drop (97 Vac at loads). See Class 1 power trunk information in the *Wire Specification Tables* section of Chapter 1.

2) Conduit length from MBC/RBC to MBC/RBC.

Metal Oxide Varistors (MOVs)

Line Voltage Receptacle

V150LA20A MOVs are factory-installed on all MBC/RBC service box receptacles.

MBC/RBC Service Box Wiring Diagrams

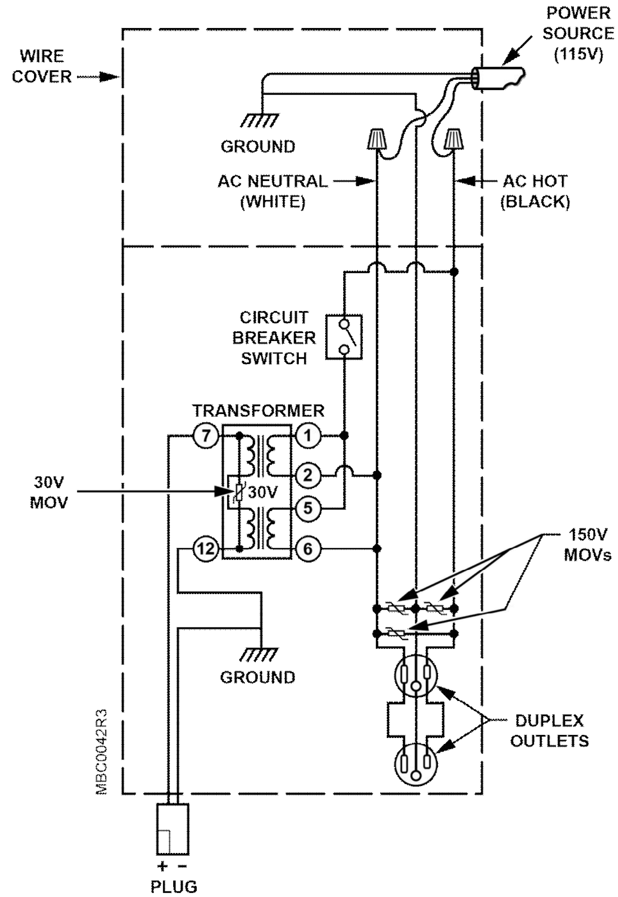


Figure 101: 115 Vac MBC/RBC Service Box Wiring Diagram.

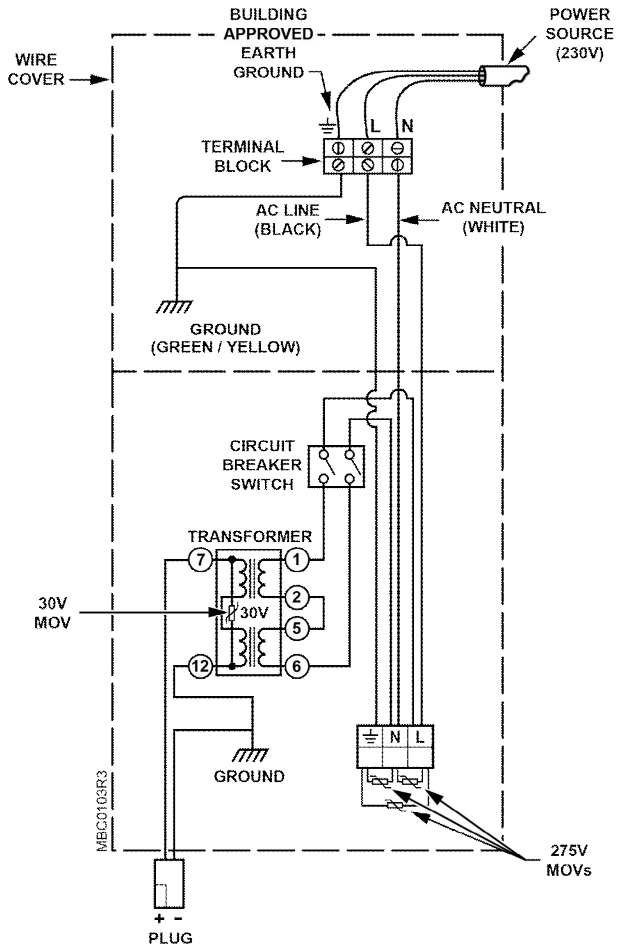


Figure 102: 230 Vac MBC/RBC Service Box Wiring Diagram.

Point Termination Modules

This section contains information on wiring Point Termination Modules (PTMs).

Metal Oxide Varistors (MOVs)

MOVs are not required for any MBC/RBC Point Termination Modules.

Wiring Point Termination Modules

The Table *PTM Wiring Diagram Reference* summarizes PTM applications. Since most PTMs can have multiple uses, the table is divided into applications and a specific wiring diagram is referenced.

To use the information in Table *PTM Wiring Diagram Reference*:

1. Determine the point type of the application.
2. Determine how that point type is used in relation to the piece of equipment you are controlling.
3. Review the table and find the appropriate PTM and corresponding wiring diagram.

Example

A wiring diagram is needed for a 100K ohm thermistor.

1. A 100K ohm thermistor is a Logical Analog Input. See the **Point Type** column in Table *PTM Wiring Diagram Reference* and locate the Logical Analog Input section.
2. Find the entry in the **Specifics** column that identifies a 100K ohm thermistor.
3. In the **PTM Qty** and **PTM Type** columns, the quantity and type of PTM recommended for use with this application are identified: one half of a 2N100K. In the **Diagram** column, the wiring diagram for the application is identified. See Figure *Connecting an Analog Input (Thermistor)*.

PTM Wiring Diagram Reference.				
Point Type	**Specifics**	**PTM Qty**	**PTM Type**	**Diagram**
Logical Analog Input 1 – AI	4-20 mA, 3-wire (externally powered)	1/2	2I420	Connecting an External Powered 3-Wire Analog Input (4 to 20 mA)
	0-10 Vdc, 3-wire (externally powered)	1/2	2U10	Connecting an External Powered 3-Wire Analog Input (0 to 10 Vdc)
	100K ohm thermistor	1/2	2N100K	Connecting an Analog Input (Thermistor)
	1000 ohm platinum RTD	1/2	2P1K	Connecting an Analog Input (1000 ohm Platinum RTD)
	Connecting to a full-featured sensor			Connecting to a Full-Featured Sensor (P/N 544-780)
Logical Analog Output 1 – AO	0-10 Vdc	1/2	2Y10	Connecting an Analog Output (0 to 10 Vdc)
	4-20 mA	1-1/2 or 1/2	2Y420 or 2Y10-M	Connecting an Analog Output (4 to 20 mA)
Logical Digital Input 1 – DI	Dry contacts, 4 points	1	4D20	Connecting a Digital Input (Dry Contacts)

PTM Wiring Diagram Reference.				
Point Type	**Specifics**	**PTM Qty**	**PTM Type**	**Diagram**
	Voltage sensing	1	2D250	Connecting a Digital Input (Voltage Sensing)
	WARNING: High and low voltage cannot be combined on the same PTM.			
Logical Pulsed Accumulator 1 – DI (Counting)	Pulse accumulating for counting pulses initiated by dry contact.	1	2C	Connecting a Digital Input (Pulse Accumulation)
Logical Digital Output 1 – DO	DO latched or pulsed	1 or 1	2Q250 or 2Q250-M	Connecting a Digital Output (Latched or Pulsed)
	WARNING: High and low voltage cannot be combined on the same PTM. A 2Q250-M PTM must have 24 Vac voltage fed into the M-Bus.			
	CAUTION: Circuits powering PTM6.2Q50-M point modules must be limited by a 15-amp (max.) circuit breaker.			
Logical FAST/SLOW/ STOP Latched Control 1 – DO (OFF/Fast) 1 – DO (OFF/SLOW) 1 – DI (Proof)	LFSSL (no proof)	1	2Q250	Connecting an LFSSL (No Proof)
	LFSSL (proof of contact)	1 1/2, or 1/4	2Q250 2D20, or 4D20	Connecting an LFSSL (Proof of Contact)
	LFSSL (proof of voltage)	1 1/2	2Q250 2D250	Connecting an LFSSL (Proof of Voltage)
Logical FAST/SLOW/STOP Pulsed Control 1 – DO (OFF) 1 – DO (FAST) 1 – DO (SLOW) 1 – DI (Proof)	LFSSP (no proof)	1-1/2	2Q250	Connecting an LFSSP (No Proof)
	LFSSP (proof of contact)	1-1/2 1/2, or 1/4	2Q250 2D20, or 4D20	Connecting an LFSSP (Proof of Contact)
	LFSSP (proof of voltage)	1-1/2 1/2	2Q250 2D250	Connecting an LFSSP (Proof of Voltage)
Logical ON/OFF/AUTO Latched Control 1 – DO (ON/OFF) 1 – DO (AUTO)	LOOAL (no proof)	1	2Q250	Connecting an LOOAL (No Proof)

PTM Wiring Diagram Reference.				
Point Type	**Specifics**	**PTM Qty**	**PTM Type**	**Diagram**
1 – DI (Proof)	LOOAL (proof of contact)	1 1, or 1/2	2Q250 2D20, or 4D20	Connecting an LOOAL (Proof of Contact)
	LOOAL (proof of voltage)	1 1/2	2Q250 2D250	Connecting an LOOAL (Proof of Voltage)
Logical ON/OFF/AUTO Pulsed Control 1 – DO (ON) 1 – DO (OFF) 1 – DO (AUTO) 1 – DI (Proof)	LOOAP (no proof)	1-1/2	2Q250	Connecting an LOOAP (No Proof)
	LOOAP (proof of contact)	1-1/2 1/2, or 1/4	2Q250 2D20, or 4D20	Connecting an LOOAP (Proof of Contact)
	LOOAP (proof of voltage)	1-1/2 1/2	2Q250 2D250	Connecting an LOOAP (Proof of Voltage)
Logical Two-State Latched 1 – DO (ON/OFF) 1 – DI (Proof)	L2SL (no proof)	1/2, or 1/2	2Q250, or 2Q250-M	Connecting an L2SL (No Proof)
	L2SL (proof of contact)	1/2, or 1/2 1/2, or 1/4	2Q250, or 2Q250-M 2D20, or 4D20	Connecting an L2SL (Proof of Contact)
	L2SL (proof of voltage)	1/2, or 1/2 1/2	2Q250, or 2Q250-M 2D250	Connecting an L2SL (Proof of Voltage)
	WARNING: High and low voltage cannot be combined on the same PTM. A 2Q250-M PTM must have 24 Vac voltage fed into the M-Bus.			
	CAUTION: Circuits powering PTM6.2Q50-M point modules must be limited by a 15-amp (max.) circuit breaker.			
Logical Two-State Pulsed 1 – DO (ON) 1 – DO (OFF) 1 – DI (Proof)	L2SP (no proof)	1	2Q250	Connecting an L2SP (No Proof)
	L2SP (proof of contact)	1 1/2, or 1/4	2Q250 2D20, or 4D20	Connecting an L2SP (Proof of Contact)
	L2SP (proof of voltage)	1 1/2	2Q250 2D250	Connecting an L2SP (Proof of Voltage)

Point Termination Module Wiring Diagrams

WARNING

All transformer or isolated power supply secondary neutrals requiring connection to earth ground must be directly connected to an approved building earth ground terminal located at the point termination module where the signal is terminated.

This is represented in the following diagrams by “E” at the earth ground symbol.

Analog Input

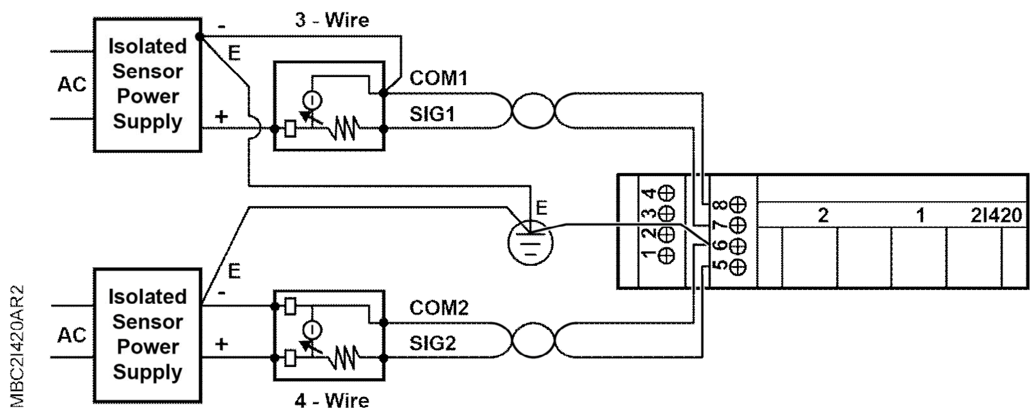


Figure 103: Connecting an External Powered 3-Wire Analog Input (4 to 20 mA).

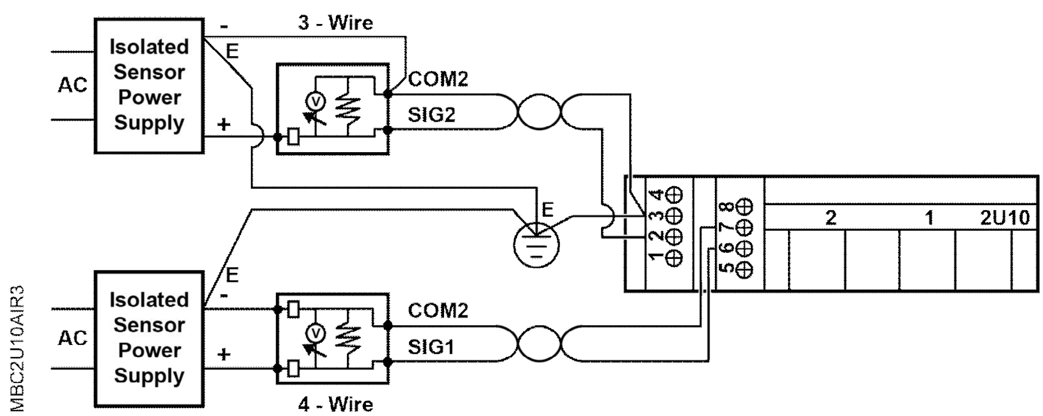


Figure 104: Connecting an External Powered 3-Wire Analog Input (0 to 10 Vdc).

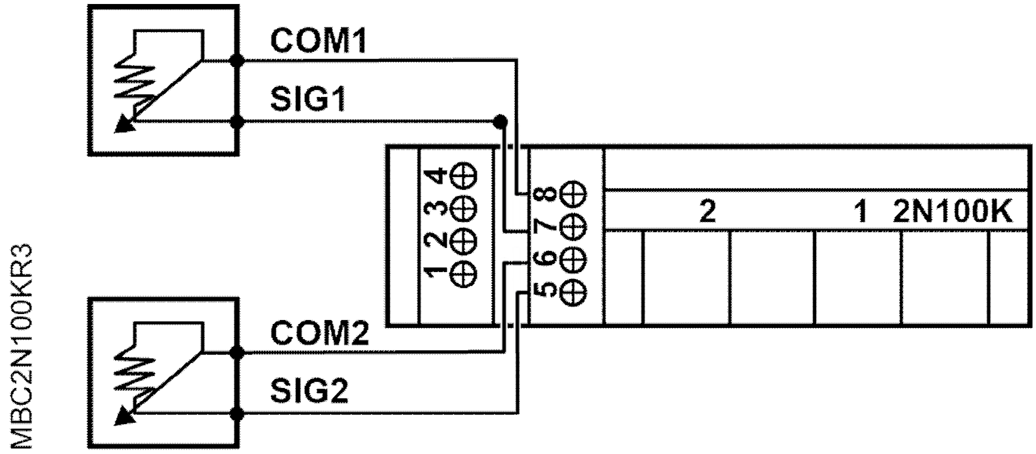


Figure 105: Connecting an Analog Input (Thermistor).

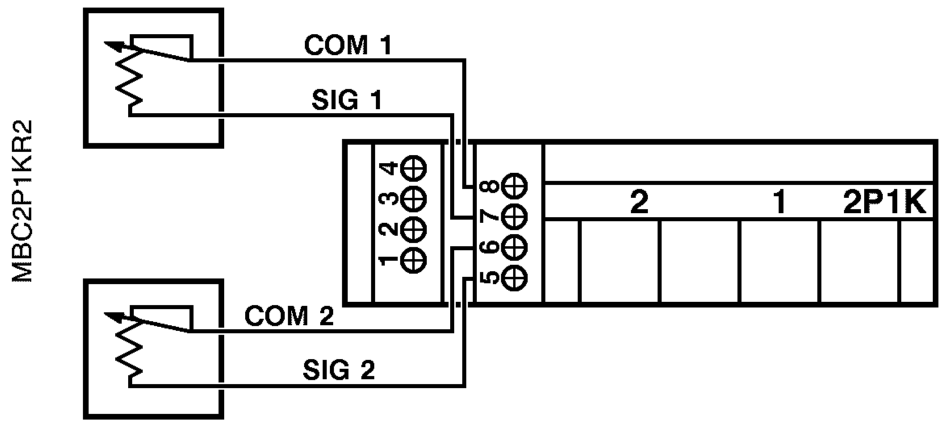


Figure 106: Connecting an Analog Input (1000 ohm Platinum RTD).

Full-Featured Sensor

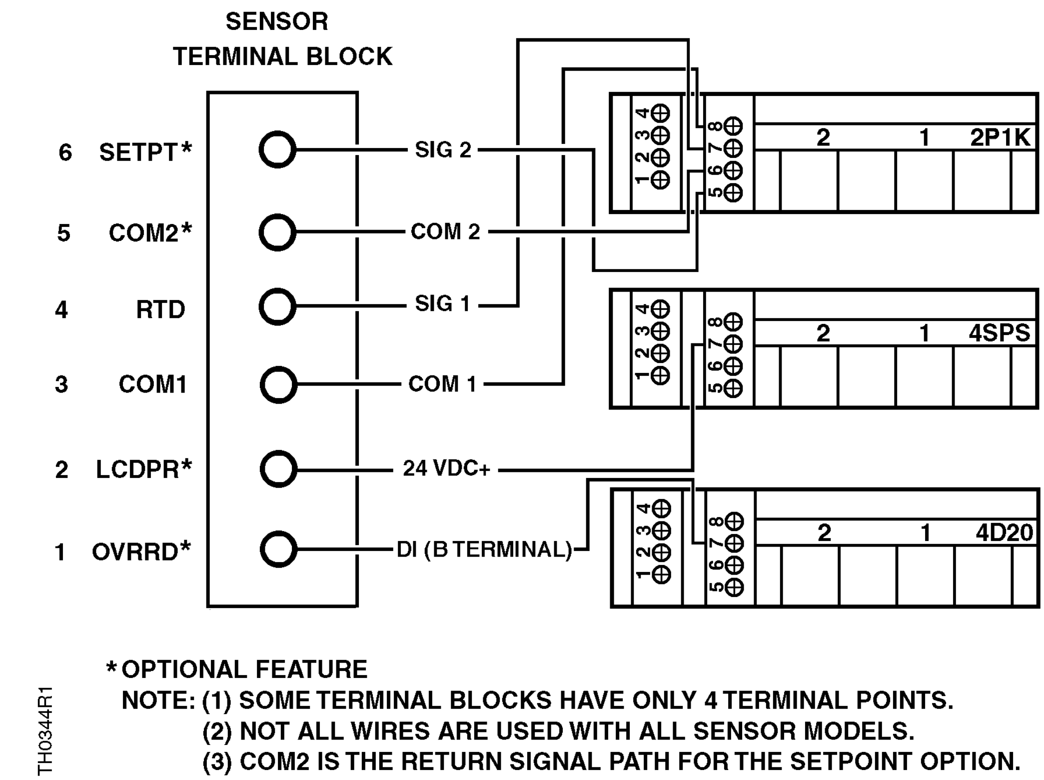


Figure 107: Connecting to a Full-Featured Sensor (P/N 544-780).

Analog Output

	WARNING
	Some I/O module terminal blocks are labeled with a 24 Vac power requirement designation. The 24 Vac supply is not intended for use to power external devices (for example transducers). If this 24 Vac is used to power external devices, the operational capabilities of other modules in the MBC/RBC can be affected.

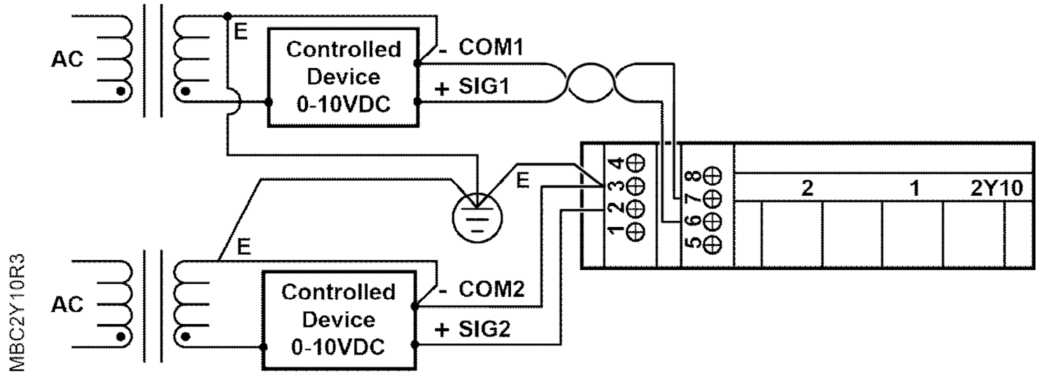


Figure 108: Connecting an Analog Output (0 to 10 Vdc).

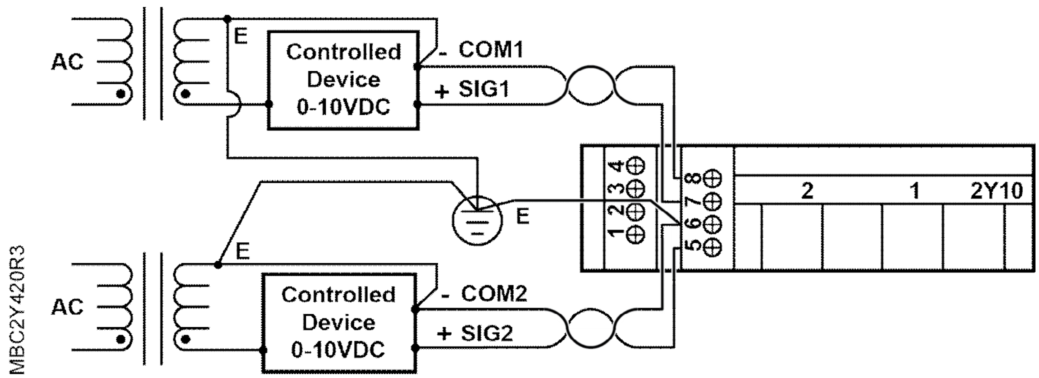


Figure 109: Connecting an Analog Output (4 to 20 mA).

Digital Input

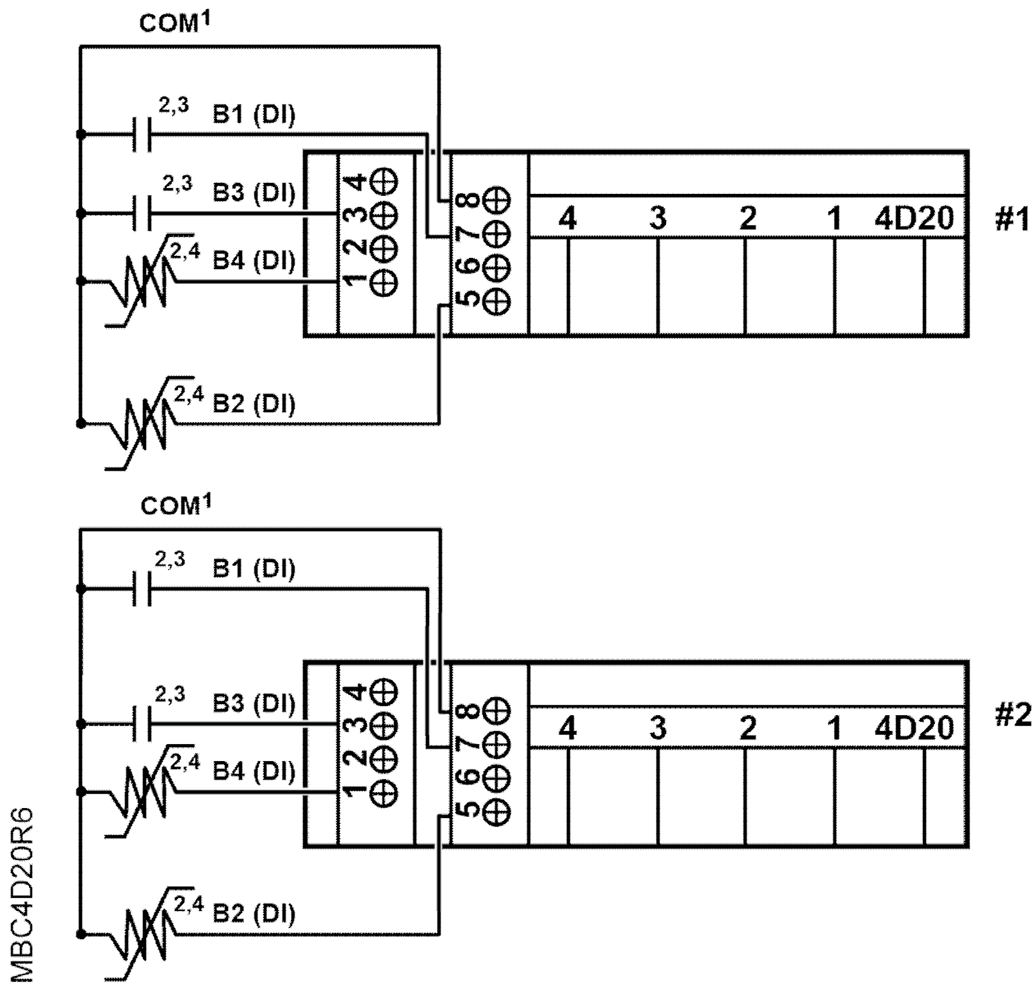


Figure 110: Connecting a Digital Input (Dry Contacts).

1. A single common may be used for all digital inputs on the same point termination module.
2. Excitation equals 22 Vdc at 8 mA. Pulse rate equals 25 Hz.
3. Dry contact only. Does not require gold contacts.
4. Solid state device must be rated for 30V minimum, with RDS on less than 200 ohms and RDS off greater than 50K ohms.

	WARNING
	High and low voltage cannot be combined on the same PTM.

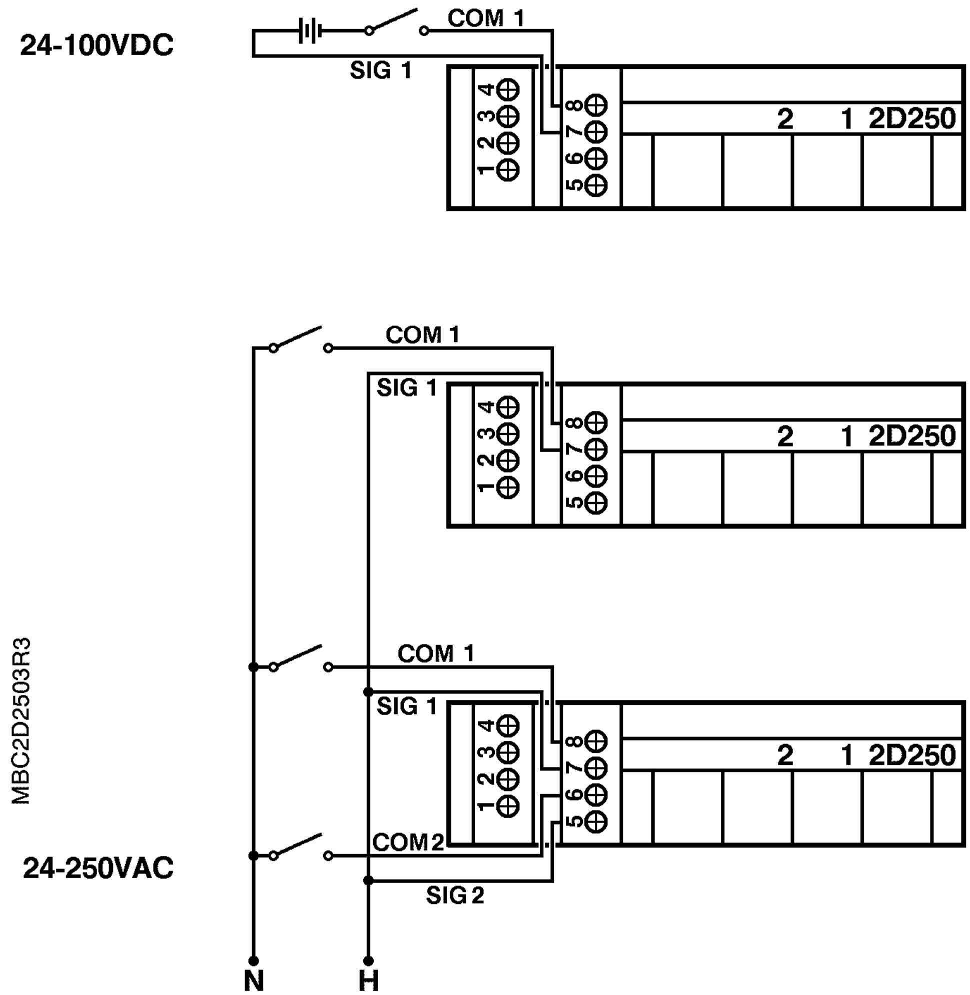


Figure 111: Connecting a Digital Input (Voltage Sensing).

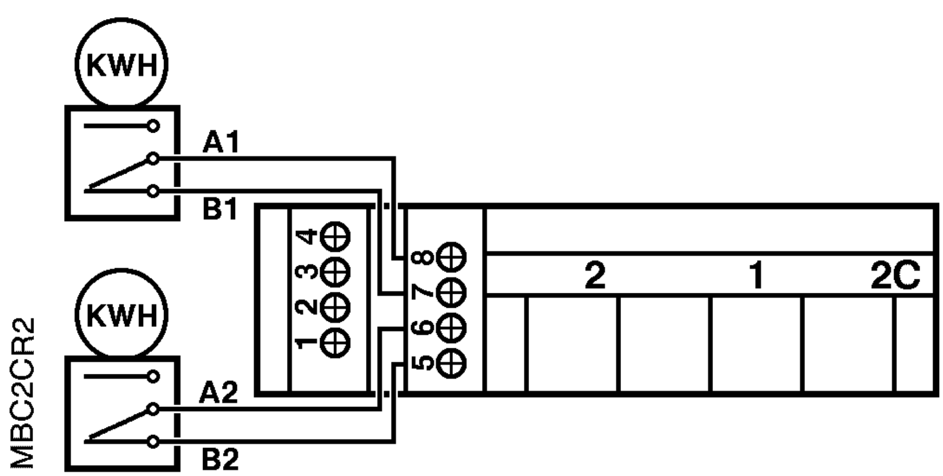


Figure 112: Connecting a Digital Input (Pulse Accumulating).

Digital Output

	WARNING
	- High and low voltage cannot be combined on the same PTM. - A 2Q250-M PTM must have 24 Vac voltage fed into the M-Bus. - Circuits powering a PTM6.2Q250-M must be limited by a 15-amp (max.) circuit breaker.

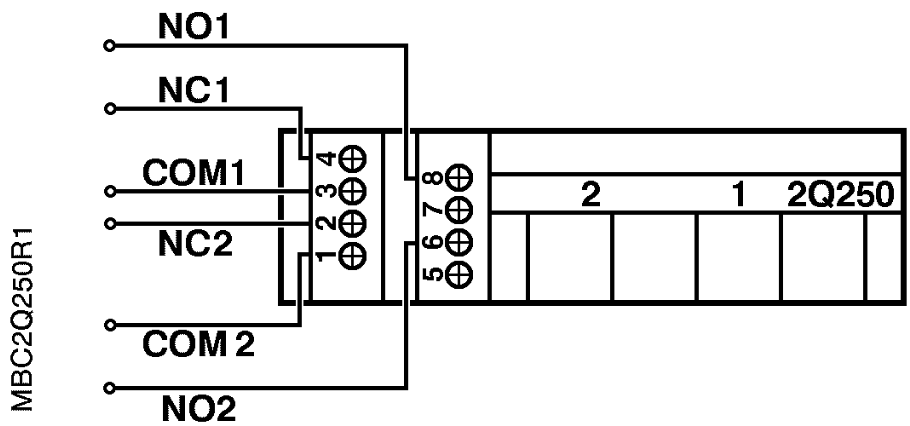


Figure 113: Connecting a Digital Output (Latched or Pulsed).

LFSSL (Logical FAST/SLOW/STOP Latched)

	WARNING
	For points defined as LFSSL, DO NOT use the PTM6.2Q250-M.

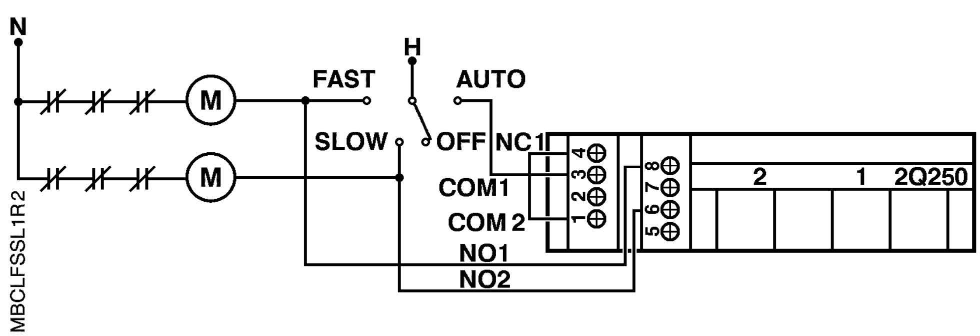


Figure 114: Connecting an LFSSL (No Proof).

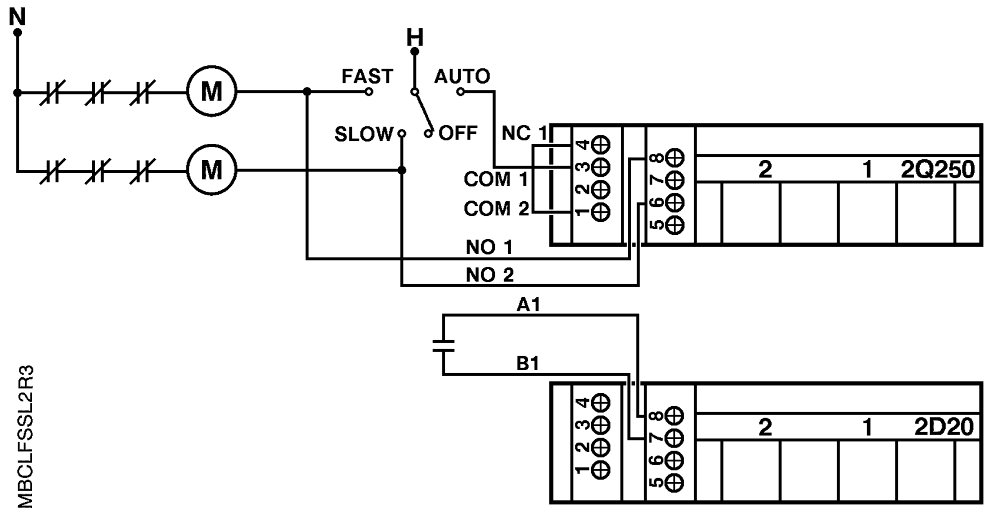


Figure 115: Connecting an LFSSL (Proof of Contact).

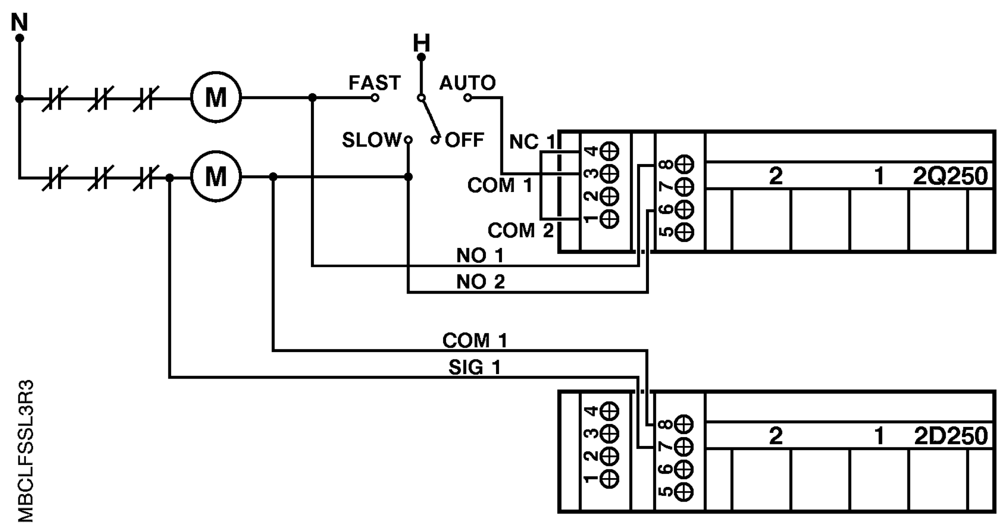


Figure 116: Connecting an LFSSL (Proof of Voltage).

LFSSP (Logical FAST/SLOW/STOP Pulsed)

	WARNING
	For points defined as LFSSP, DO NOT use the PTM6.2Q250-M.

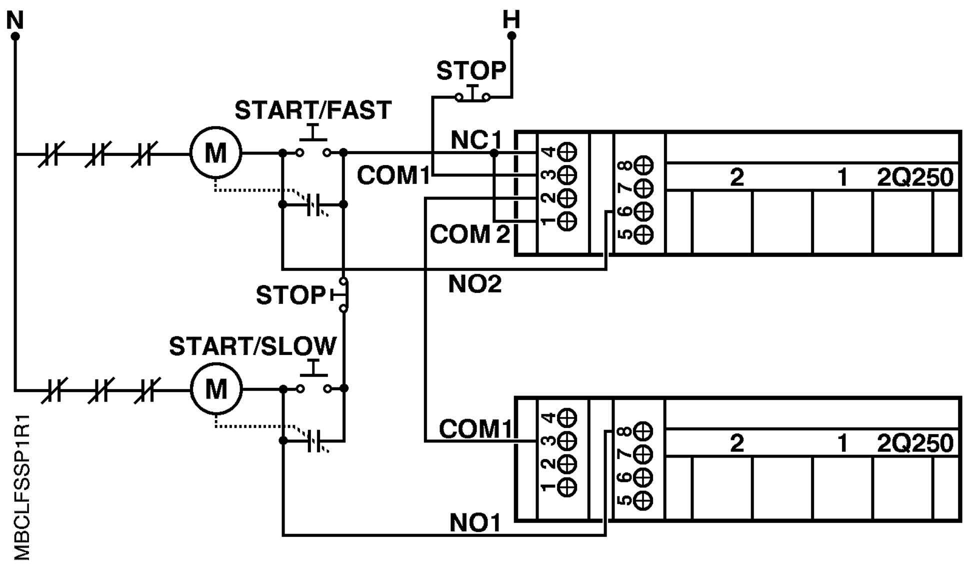


Figure 117: Connecting an LFSSP (No Proof).

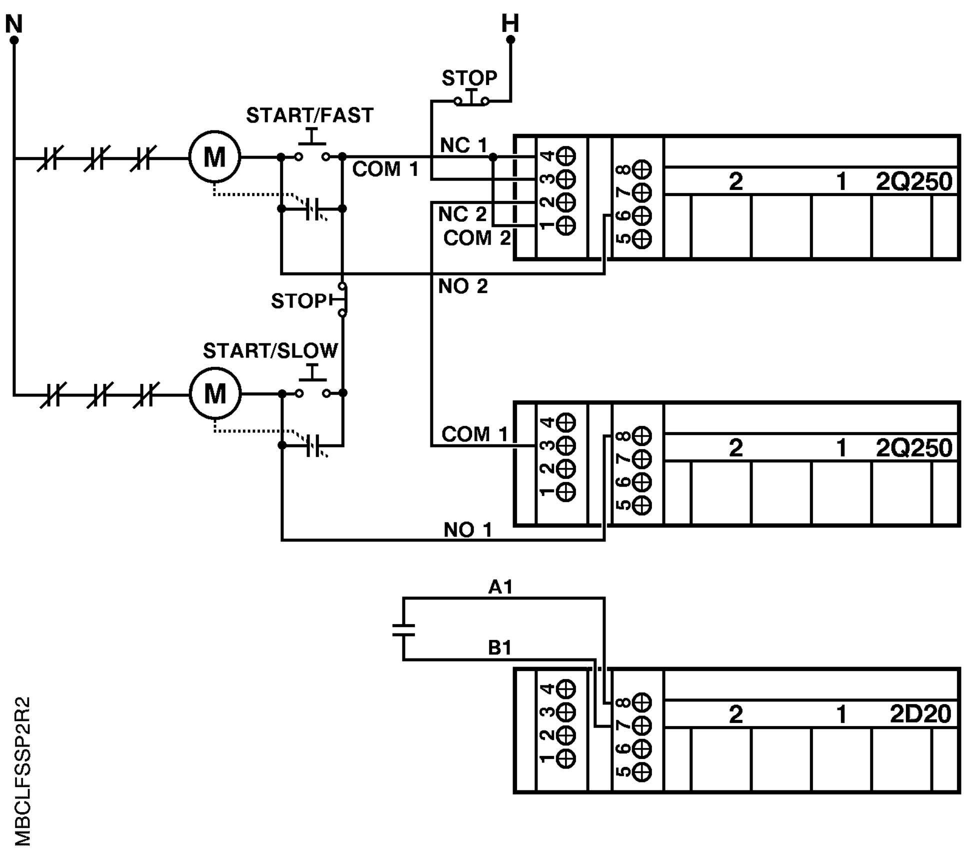


Figure 118: Connecting an LFSSP (Proof of Contact).

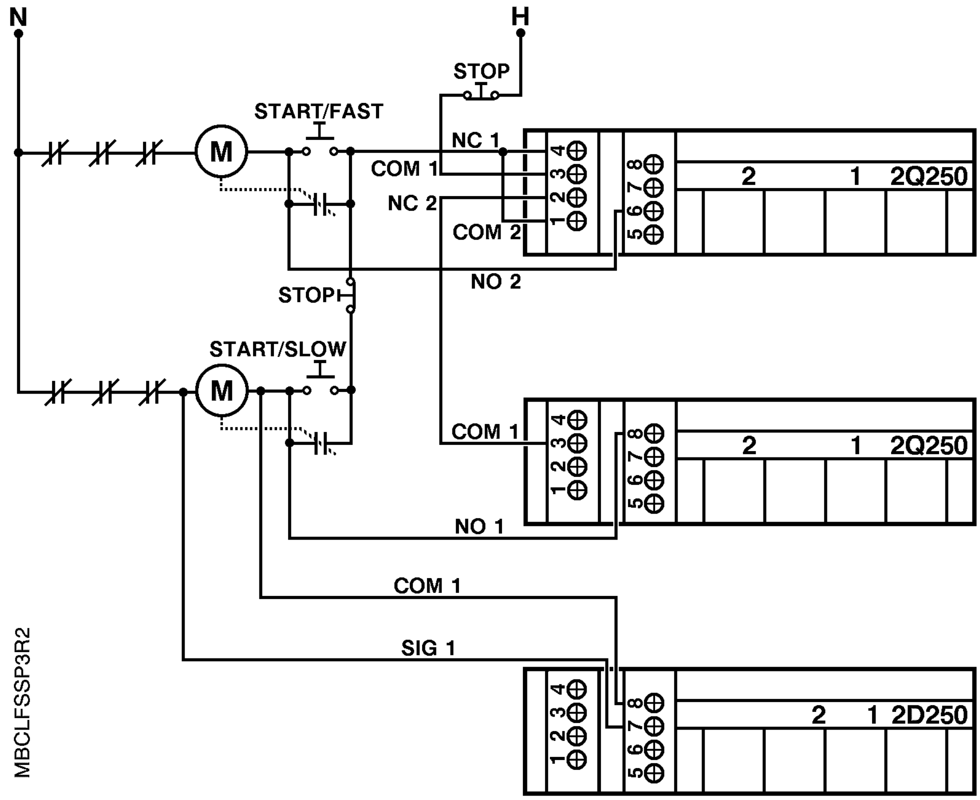


Figure 119: Connecting an LFSSP (Proof of Voltage).

LOOAL (Logical ON/OFF/AUTO Latched)

	**WARNING**
	For points defined as LOOAL, DO NOT use the PTM6.2Q250-M.

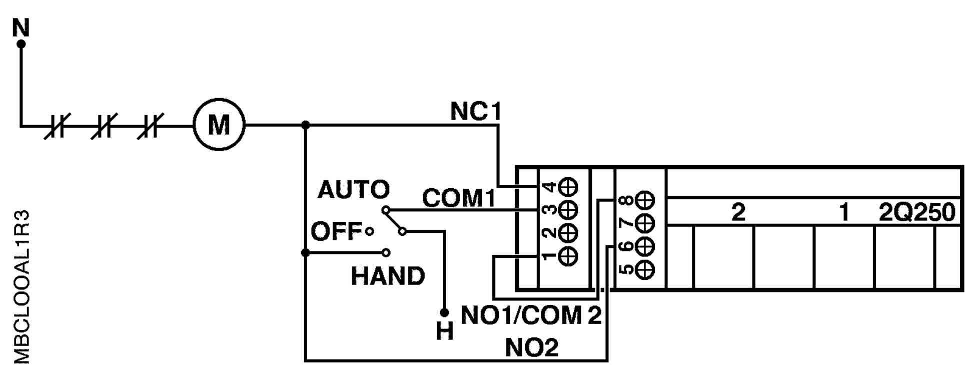


Figure 120: Connecting an LOOAL (No Proof).

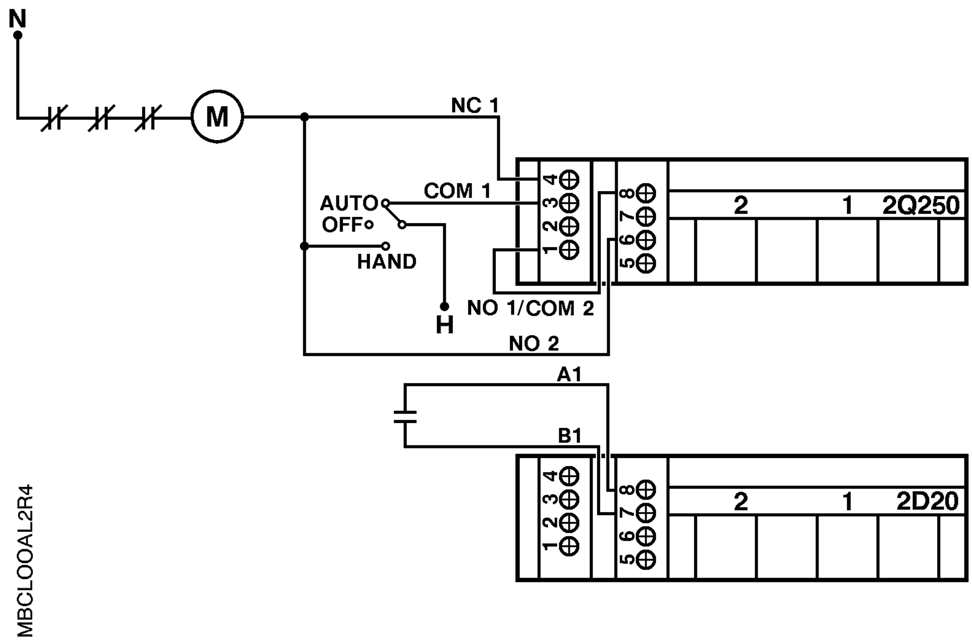


Figure 121: Connecting an LOOAL (Proof of Contact).

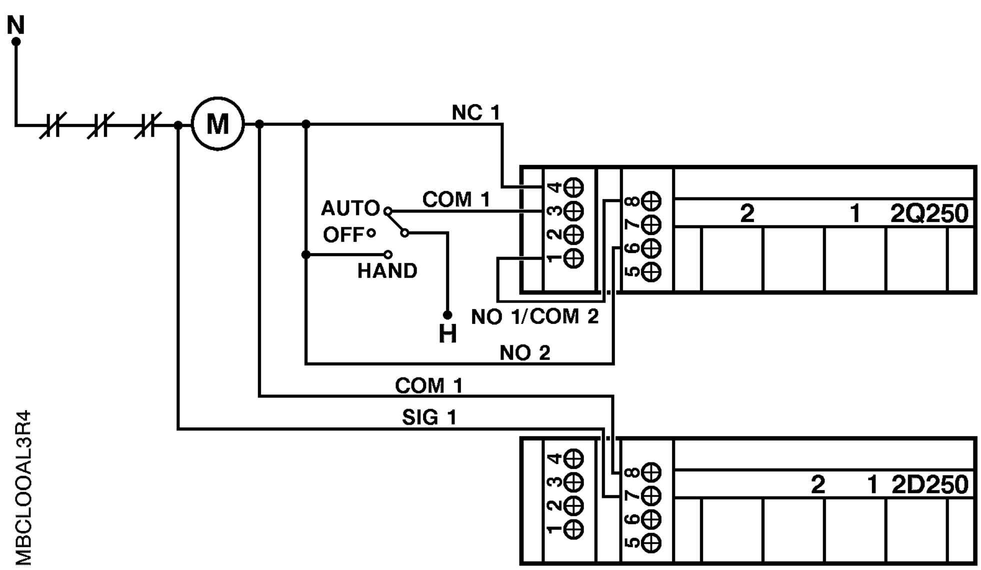


Figure 122: Connecting an LOOAL (Proof of Voltage).

LOOAP (Logical ON/OFF/AUTO Pulsed)

	WARNING
	For points defined as LOOAP, DO NOT use the PTM6.2Q250-M.

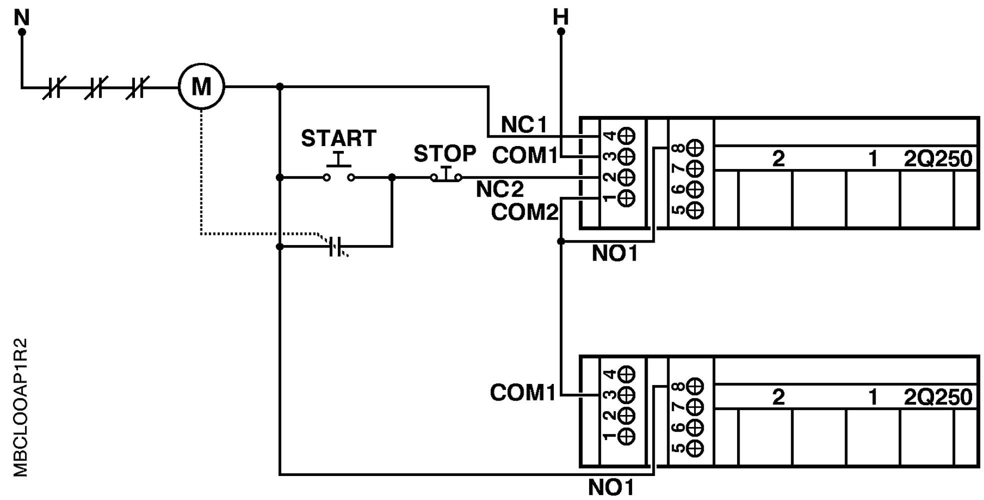


Figure 123: Connecting an LOOAP (No Proof).

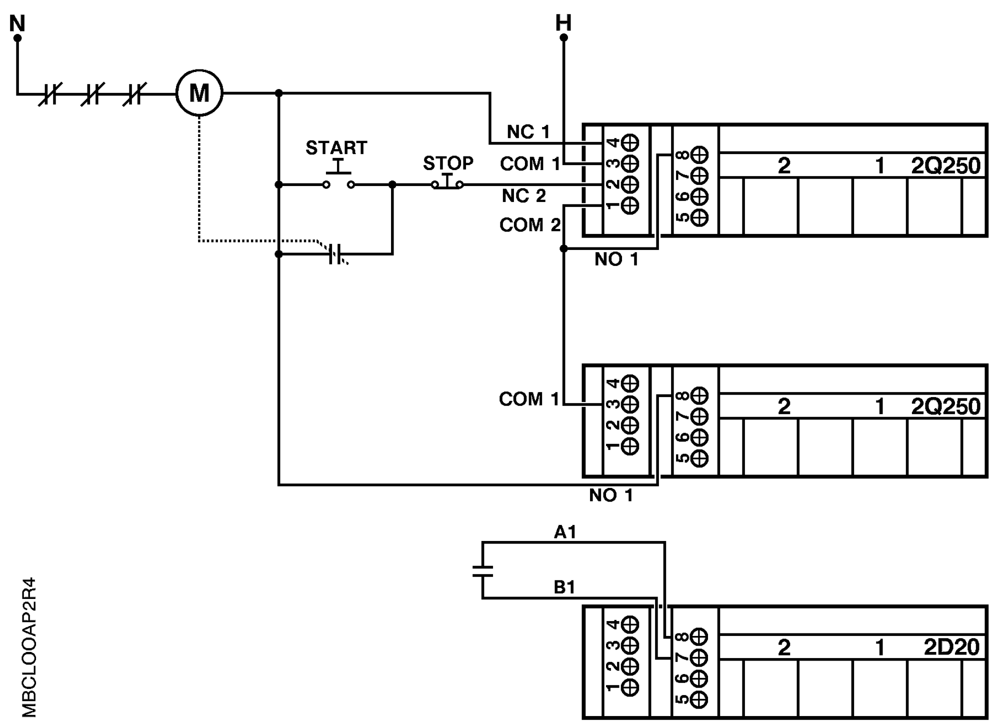


Figure 124: Connecting an LOOAP (Proof of Contact).

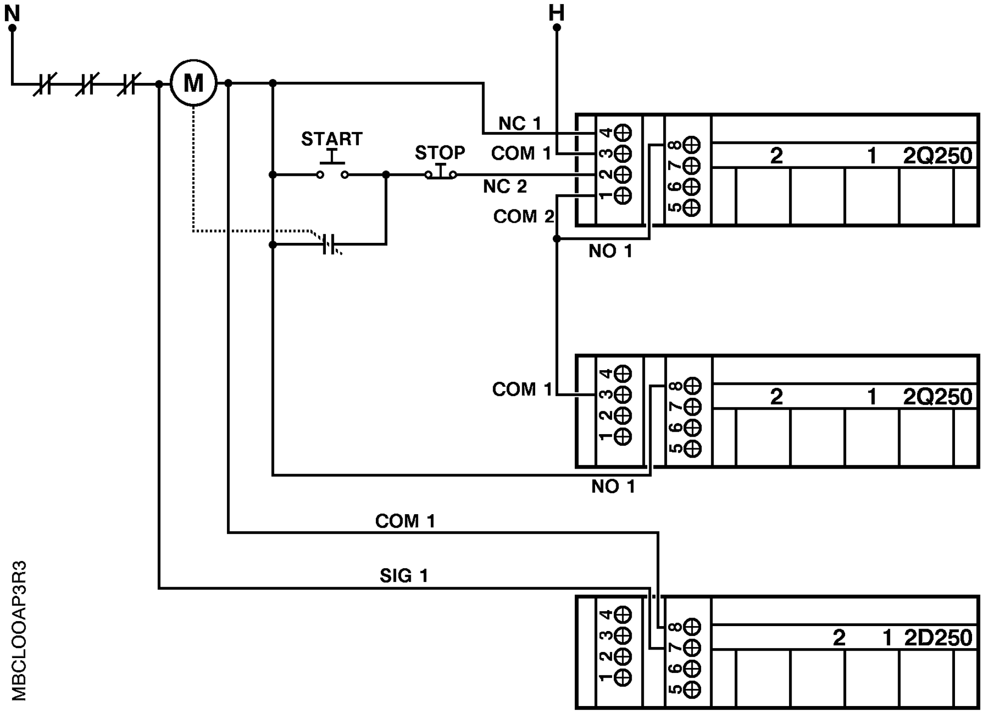


Figure 125: Connecting an LOOAP (Proof of Voltage).

L2SL (Logical Two State Latched)

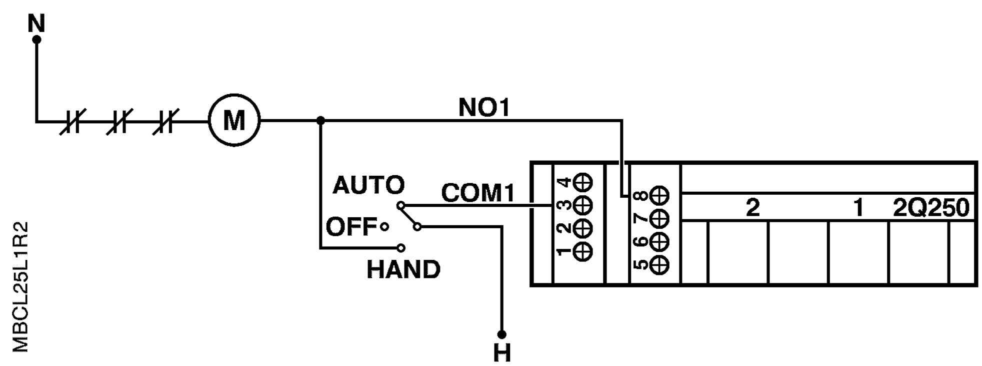


Figure 126: Connecting an L2SL (No Proof).

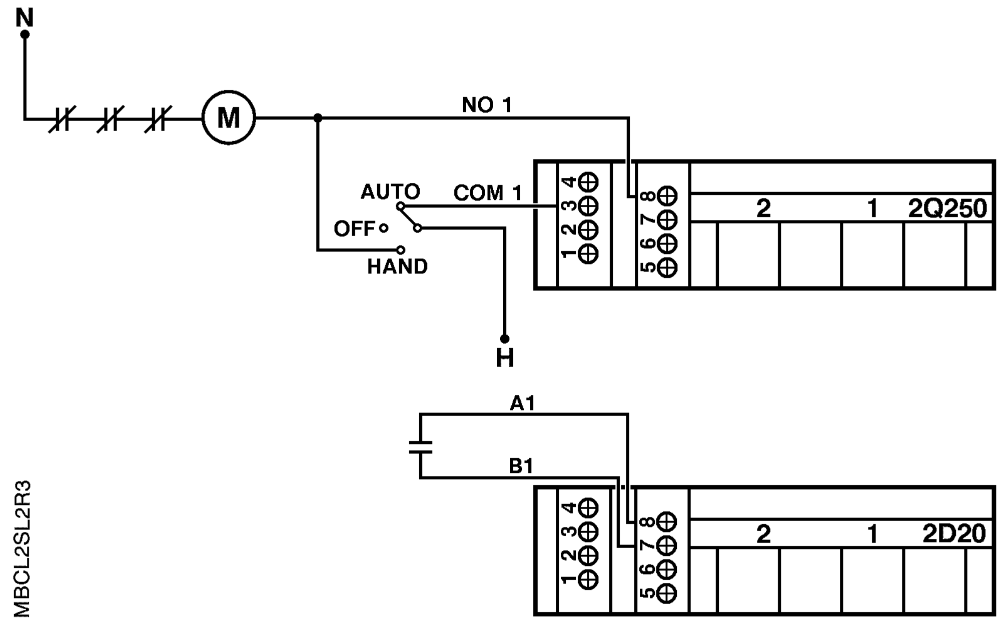


Figure 127: Connecting an L2SL (Proof of Contact).

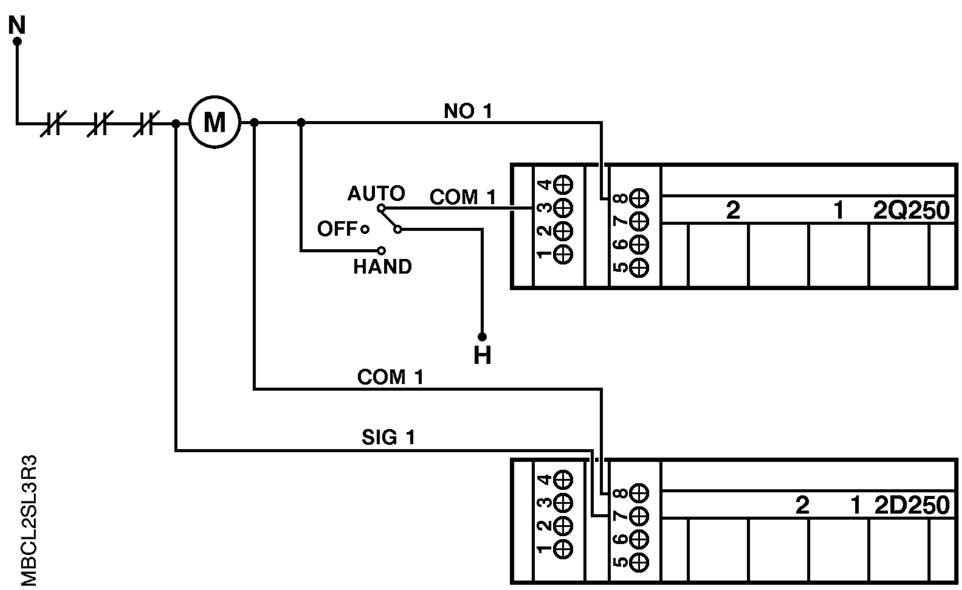


Figure 128: Connecting an L2SL (Proof of Voltage).

L2SP (Logical Two State Pulsed)

	WARNING
	- For points defined as L2SP, DO NOT use the PTM6.2Q250-M. - High and low voltage cannot be combined on the same PTM.

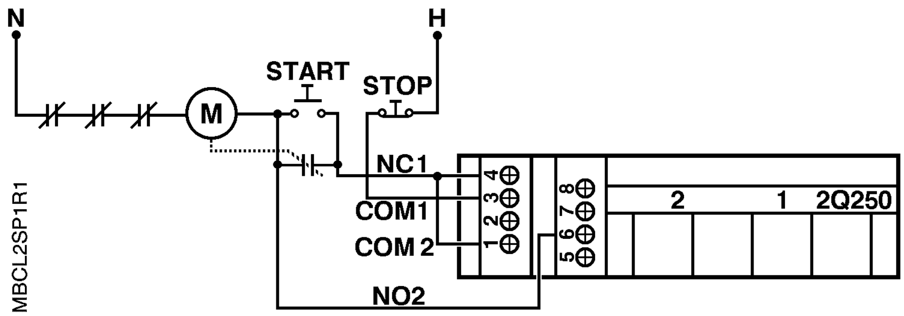


Figure 129: Connecting an L2SP (No Proof).

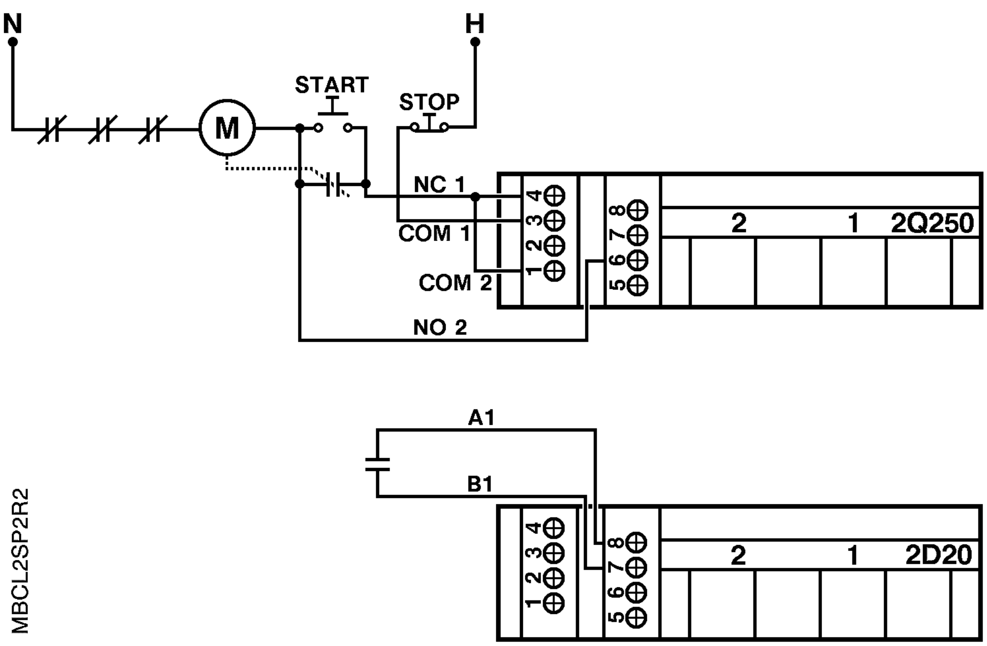


Figure 130: Connecting an L2SP (Proof of Contact).

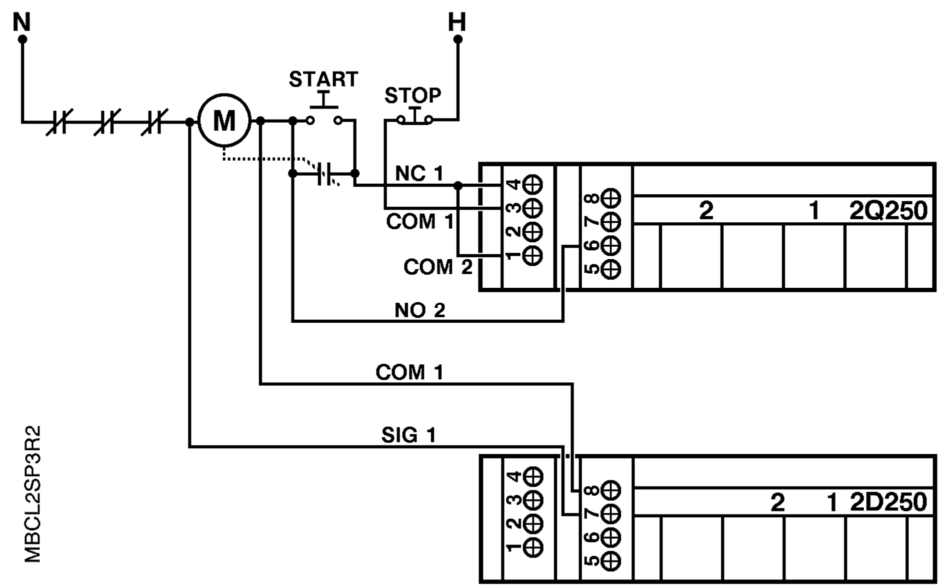


Figure 131: Connecting an L2SP (Proof of Voltage).

FLN Controller

Wire Type Requirements

FLN Controller Wire Type Requirements.				
Circuit Type	Class	Wire Type	Distance	Conduit Sharing[1]
AC Line Power	Power	No. 12 to No. 14 THHN	See NEC	Check local codes

1) Conduit sharing rules: No Class 2 point wiring can share conduit with any Class 1 wiring except as noted for Digital Inputs where local codes permit.

NOTE:
UL-recognized wire (labeled with a backwards “RU”) is not field-installable. Use only UL-listed wire.

Power Source Requirements

Power Source Requirements for FLN Controller.			
Product	Input Voltage	Line Frequency	Maximum Power
FLN Controller – 115V	115 Vac	50/60 Hz	12 VA[1]
FLN Controller – 230V	230 Vac	50/60 Hz	12 VA[1]

1) Service outlets are restricted to continuously power network devices only.

Point Wiring Restrictions

Wire specified in the *BLN, FLN (P1), and Point Expansion Trunk* table in Chapter 1 can be used at any trunk speed.

Metal Oxide Varistors (MOVs)

Line Voltage Receptacle

MOVs are factory-installed on all FLN Controller receptacles.

Stand-alone Control Unit (SCU)

NOTE:
The SCU is no longer available for new sales. Information in this section is for reference only.

Wire Type Requirements

SCU Wire Type Requirements.				
Circuit Type	Class	Wire Type	Distance	Conduit Sharing[1]
AC Line Power	Power	No.12 to No.14 THHN	See NEC	Check local codes
Digital Output	1, 2	Check local codes	Check local codes	Check local codes
Digital Input	2	No.18 to No.22 TP 2 CL2, CL2P, CM (FT4), or CMP (FT6)	750 ft (230 m)	Class 1 and 2 (Check local codes)
Analog Input (4 to 10 mA, Thermistor, Voltage)	2	No.18 to No.22 TP 2 CL2, CL2P, CM (FT4), or CMP (FT6)	750 ft (230 m)	Class 2 only
Analog Output	2	No.18 to No.22 TP 2 CL2, CL2P, CM (FT4), or CMP	750 ft	Class 2 only

SCU Wire Type Requirements.				
Circuit Type	Class	Wire Type	Distance	Conduit Sharing[1]
(4 to 10 mA or Voltage)		(FT6)	(230 m)	

1) Conduit sharing rules: No Class 2 point wiring can share conduit with any Class 1 wiring except as noted for Digital Inputs and where local codes permit.

2) Twisted pair, non-jacketed, rated 75°C and 300V cable can be used in place of CL2, CL2P, CM (FT4), or CMP (FT6) cable when contained in conduit per local codes. Both CM and CMP must be rated 75°C or higher. See the F*ield Purchasing Guide* for wire.

NOTE:
UL-recognized wire (labeled with a backwards "RU") is not field-installable. Use only UL-listed wire.

Power Source Requirements

Power Source Requirements.			
Product	Input Voltage	Line Frequency	Maximum Power
SCU – 115V	115 Vac	50/60 Hz	135 VA[1]
SCU – 230V	230 Vac	50/60 Hz	135 VA[1]

1) Service outlets are restricted to only continuously power network devices.

Analog Input Powered Devices

Approved sensors drawing less than 50 mA can be powered by the SCU analog input (AI) connections. Sensors requiring more power must be powered by an external source. The external source can be connected to the same AC line as the SCU power supply as long as it is only used to power low voltage devices (less than 30 volts).

Analog Output Powered Devices

No analog output devices can be powered by the SCU analog outputs.

Point Wiring Restrictions

SCU specifications are the same as MBC/RBC specifications with the exception that CL2P or CL2 wire can be used because it is separated from Class 1 wiring in the field panel by physical barriers.

For No.18 to No.22 AWG used at 4800 bps and lower, BLN and FLN wiring specifications allow a minimum of six twists per foot. At 9600 bps and higher, use wire specifications provided in Table *BLN, FLN (P1), and Point Expansion Trunk* in Chapter 1. Wire specified in this table can be used at any trunk speed.

Digital Output (DO) Wiring—SCU Specific

UL and CSA listing requires the following:

- The DO wiring shield must be installed in the field panels for which they are supplied.
- The DO wiring must enter the SCUs as shown.

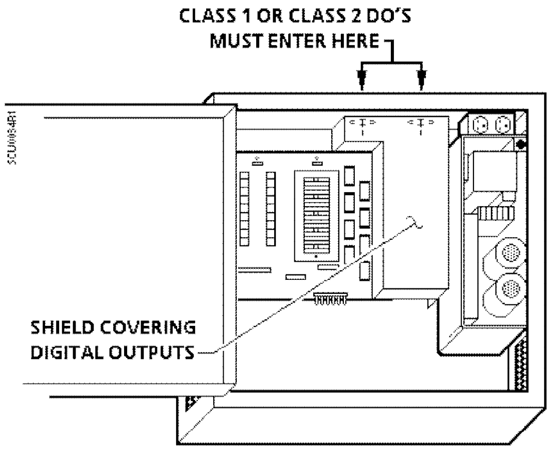


Figure 132: DO Wiring Entry Locations for the SCU.

Multiple SCUs on One Power Source

Table *Number of SCUs Allowed on a Single Three-Wire Circuit* shows the number of SCUs allowed on a single three-wire (ACH, an ACN, and earth ground) circuit if local code permits.

Number of SCUs Allowed on a Single Three-Wire Circuit.				
Circuit Breaker Size[1]	Maximum Vales for Concentrated Loads		Maximum Values for Evenly Spaced Loads	
	Length[2]	SCU	Length[2]	SCU
15 amp (No.14 AWG THHN)	75 ft (22.87 m)	7/10	100 ft (30.48 m)	7/10
20 amp (No.12 AWG THHN)	115 ft (35.06 m)	7/10	130 ft (40.63 m)	7/10

1) Assumes minimum voltage of 102 Vac at circuit breaker and 5 Vac maximum voltage drop (97 Vac at loads). See Class 1 power trunk information in the *Wire Specification Tables* section of Chapter 1.

2) Conduit length from MBC/MEC/RBC/SCU to MBC/MEC/RBC/SCU.

Metal Oxide Varistors (MOVs)

For SCUs, MOVs must be used across the DO terminals when connected to loads in all cabinets. MOVs are factory-installed on all DOs in SCUs. See the Controlling Transients [→ 24] section in Chapter 1 for MOV part numbers.

When installing MOVs across the DO relay contacts on termination boards, keeping MOV leads as short as possible makes the MOV more effective at reducing spikes from field wiring or controlled devices. Remove and reinstall any MOVs with leads longer than 1 to 1-1/2 inches (25.4 mm to 38.1 mm).

Line Voltage Receptacle

MOVs are factory installed in the line voltage receptacle of Rev. 8 and later SCU enclosures.

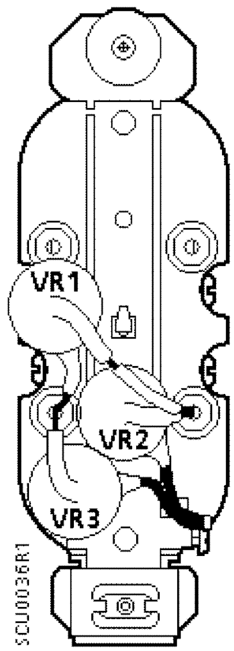


Figure 133: SCU Receptacle with MOVs.

Digital Outputs

SCUs with Rev. 7 or earlier termination boards do not contain factory-installed MOVs. These must be field installed.

SCUs with Revisions 8 through 16 termination boards have one MOV installed across the NO contacts. One additional MOV is required when using the normally closed (NC) contacts.

SCUs with Rev. 17 or later termination boards have two MOVs installed per point. No additional MOVs are required.

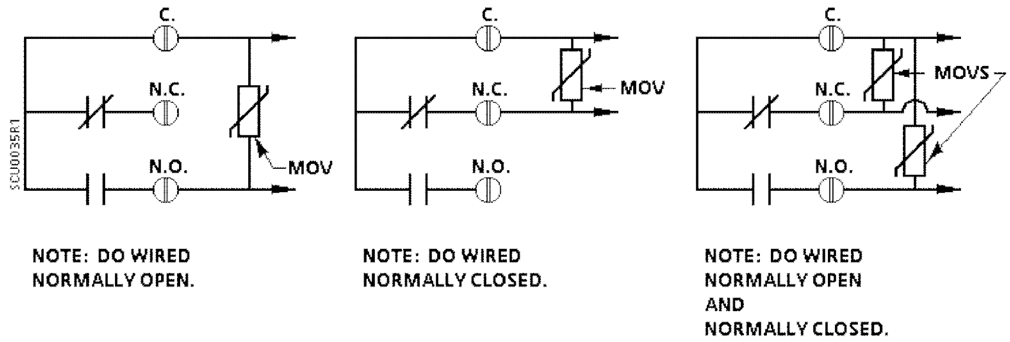


Figure 134: Field Installed MOVs.

Network Devices

NOTE:
The TI and IPMDA are no longer available for new sales. Information in this section is for reference only.

Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power**
TI	115/230 Vac	50/60 Hz	10 VA
IPMDA	115/230 Vac	50/60 Hz	25 VA

Multi-Point Unit/Digital Point Unit (MPU/DPU)

NOTE:
The DPU and MPU are no longer available for new sales. Information in this section is for reference only.

Wire Type Requirements

MPU and DPU Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance**	**Conduit Sharing[1]**
AC line power (to field panel)	Power	No.12 to No.14, No.12 THHN	Check local codes	Check local codes
Digital Output	1	Check local codes	Check local codes	Check local codes
Digital Output	2	Check local codes	Check local codes	Check local codes

MPU and DPU Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance**	**Conduit Sharing**[1]
Digital Input (MPU and DPU)	2	No.18 to No.22 TP	750 ft (230 m)	Class 1 and 2 (check local codes)
Analog Input (MPU) Thermistors	2	No.18 to No.22 TP	100 ft (30.5 m)	Class 1 and 2 (check local codes)
MPU Power Trunk	2	No.14 THHN OR No.14 TP	180 ft (55 m)[2]	Class 1 and 2 (check local codes)

1) Conduit sharing rules were determined through EMI and shared conduit testing. These rules indicate wiring methods that have no adverse affect on the proper operation of the equipment, but do not necessarily indicate compliance with local codes.

2) Distances depend on transformer location. Install 100 VA transformers near the most convenient line voltage sources to minimize line voltage wiring costs. Use one 100 VA transformer for every eight MPUs. (180 ft using 14 AWG wires is worst case).

Power Source Requirements

The MPU can be powered in two ways:

- Individual transformer using a transformer rated for Class 2 service.
- Power trunk. For more information, see the *Power Trunk Guidelines* in the *Wiring* chapter.

CAUTION

The phase of all devices on a power trunk must be identical.

Phase differences can destroy equipment. Any relays, EPs, or contactors sharing power must be clamped with MOVs at their locations.

MPU/DPU Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power**
MPU	24 Vac	50/60 Hz	30 VA
DPU – 115V	115 Vac	50/60 Hz	50 VA[1]
DPU – 230V	230 Vac	50/60 Hz	50 VA[1]

1) Service outlets are restricted to only continuously power network devices.

MPU Grounding

MPUs connected to a power trunk with the optional ground wire should have the ground wire connected to the field panel ground lug in each field panel.

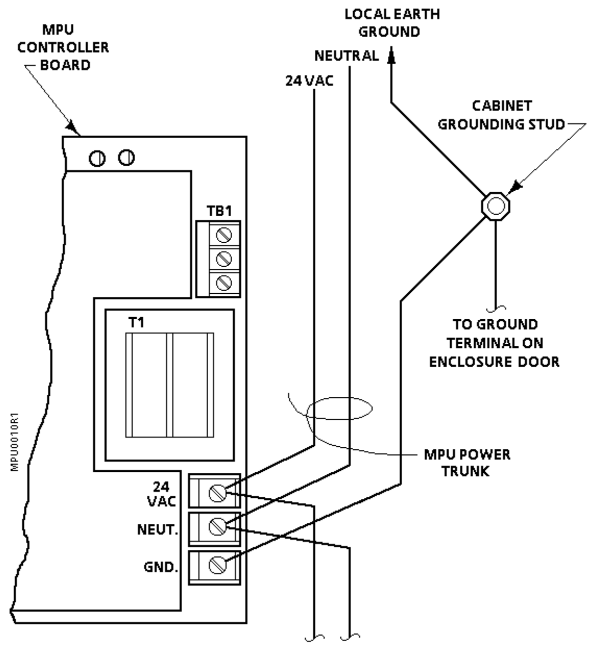


Figure 135: AC Earth Ground for MPU Connected to a Power Trunk.

Metal Oxide Varistors (MOVs)

Metal Oxide Varistors (MOVs) must be used across the DO terminals when connected to loads. MOVs are factory-installed in all FLN products.

When installing MOVs across the DO relay contacts on termination boards, keeping the MOV leads as short as possible makes the MOV more effective at reducing spikes from field wiring or controlled devices. Remove and reinstall any MOVs with leads longer than 1 in. (2.5 cm). See C*ontrolling Transients* section in Chapter 1 for MOV part numbers.

Line Voltage Receptacle

MOVs are factory-installed in the line voltage receptacle of Rev. 6 and later MPU enclosures and Rev. 8 and later DPU enclosures.

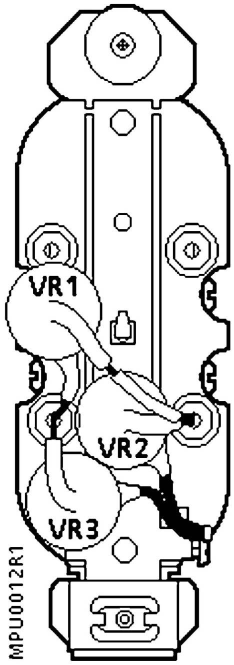


Figure 136: MPU/DPU Receptacle with MOVs.

Digital Outputs

MPUs and DPUs shipped before March 1, 1989 contain one factory-installed snubber on each DO point on the termination board. The snubber can be placed across the normally open (NO) or normally closed (NC) terminals by means of a jumper. A second MOV must be field installed when both the NO and NC terminals of a DO point are being used.

No additional MOVs are required on DO points on MPUs or DPUs shipped after March 1, 1989.

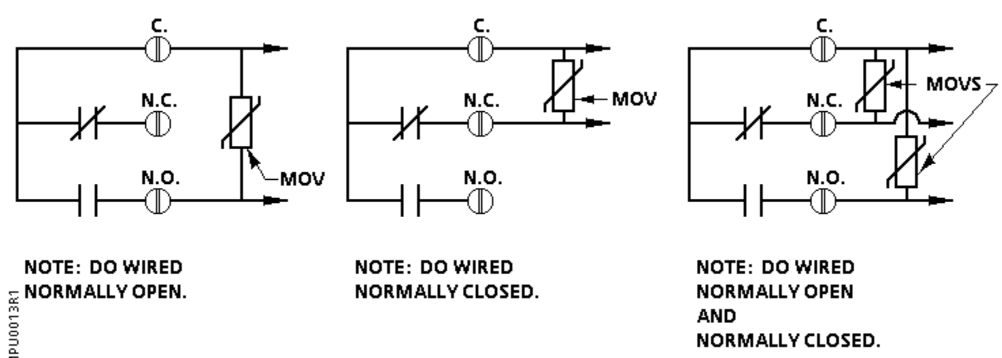


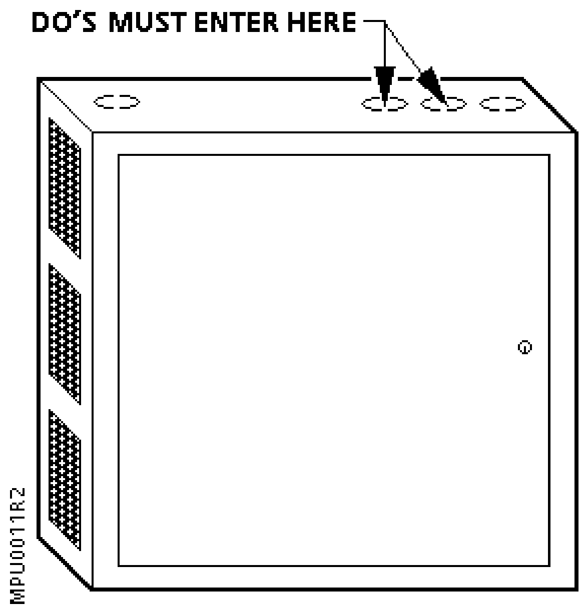
Figure 137: Field Installed MOVs.

Digital Output (DO) Wiring

Table *MPU and DPU Wire Type Requirements* provides DO wire run lengths for points wired to equipment controllers.

UL and CSA listing requires the following:

- The DO wiring shield must be installed in the cabinets for which they are supplied.
- DO wiring must enter the MPUs and DPUs as shown.



DO Entry Locations for MPU and DPU.

Terminal Equipment Controller—Pneumatic Output, Low Voltage

NOTE:
The Pneumatic TEC is no longer available for new sales. Information in this section is for reference only.

When placing the low voltage, (24 Vac Class 2), pneumatic output Terminal Equipment Controllers on a power trunk, use the nameplate power rating for calculating the maximum number of devices that can be placed on a Class 2 power trunk. The nameplate power rating takes into account a controller power factor of less than unity.

Terminal Equipment Controllers—Pneumatic Output

Do not control more than the nameplate rated loads for the DOs of the pneumatic output controllers. The controller UL and CSA listing is based on the nameplate power rating.

The separate FAN output (Form A dry contact) on the Unit Vent Controllers is rated at 1/3 H.P. at 115 or at 230 Vac. The digital output, which is part of the large wiring harness, switches the incoming power to the controller. This cable can contain up to 230 Vac depending on controller input voltage. The 115 and 230 Vac controllers use a molded cord for this output. Exceeding the nameplate power on this output can damage the controller circuit board.

Pneumatic Output Controller

The power source for the high voltage Unit Vent Controller should be obtained after the fuse in the unit ventilator. By obtaining the power for the controller after the fuse, you can ensure that the controller is powered down whenever the fuse opens or is removed.

TEC Power Source Requirements.			
Product	Input Voltage	Line Frequency	Maximum Power
Terminal Equipment Controller—Pneumatic Output, Low Voltage	24 Vac	50/60 Hz	12 VA + damper output
Terminal Equipment Controller—Pneumatic Output, High Voltage	115 Vac	50/60 Hz	7 VA + damper output
Terminal Equipment Controller—Pneumatic Output, High Voltage	230 Vac	50/60 Hz	7 VA + damper output

1) Service outlets are restricted to only continuously power network devices.

Pneumatic Output Wire Type Requirements.				
Circuit Type	Class	Wire Type (AWG)	Distance[2]	Conduit Sharing[1]
Input Power (Low voltage controllers)	2	Check local codes	Check local codes	Check local codes
Input Power (Unit Vent Controller—115/230V)	1	Check local codes	Check local codes	Check local codes
Damper Output (Low voltage controllers)	2	Check local codes	Check local codes	Check local codes
Damper Output (Unit Vent Controller—115/230V)	1	Check local codes	Check local codes	Check local codes
Digital Inputs	2	No. 18 to No. 22 TP	100 ft (30 m)	Class 1 and 2 Check local codes
Analog Inputs	2	No. 18 to No. 22 TP	100 ft (30 m)	Class 1 and 2 Check local codes
Room Temperature Sensor	2	Pre-terminated 3 TP No. 24	100 ft (30 m)	Class 2

1) Conduit sharing rules were determined through EMI and shared conduit testing. These rules indicate wiring methods that have no adverse affect on the proper operation of the equipment, but do not necessarily indicate compliance with local codes.

2) Check local codes concerning wire gauge and distance to extend the 3-foot pre-determined “Fan Output” cable. The 3-foot cable is No. 18 AWG.

LonMark® Terminal Equipment Controller (LTEC)

Wire Type Requirements

NOTE:
Follow local codes regarding wire gauge and length.

LonWorks® FLN Wire Type Requirements.		
Wire Type	Maximum Total Wire Length*	Maximum Node-to-Node Length
22 AWG 1 pair, stranded, unshielded or shielded, Level IV per NEMA standards	1640 ft (500 m)	1312 ft (400 m)

* Maximum trunk length can be extended by 1640 ft (500 m) with a two-port repeater or by two additional 1640 ft (500 m) segments with a three-port repeater.

LTEC Recommended Wire Gauges.		
Connection Type	Class	Recommendation
24 Vac input	2	3 wire, 16 AWG to 12 AWG cable
Network connection	2	22 AWG TP, Level IV[1]
LTEC Room Temperature Sensor	2	Pre-terminated1, plenum-rated, 3-pair cable[2]
Application Inputs	2	20–22 AWG TP
Analog outputs	2	20–22 AWG TP
Digital outputs	2	16–20 AWG per local code and current/length voltage drop requirements

1) Level IV cable per NEMA standards (not equivalent to EIA/TIA Level 4 cable).

2) Available in fixed lengths of 25, 50, and 100 feet (7.6, 15.2, and 30.5 m).

LTEC Inputs and Outputs.	
Specification	Details
Application inputs	100K Ω thermistor/0 to 10 Vdc, 4 to 20 mA, or dry contact
Room sensor input	10K Ω thermistor
Digital outputs	Triac (max. 500 mA at 24 Vac)
Analog outputs	0 to 10 Vdc (max. 12.5 mA)

LTEC Room Temperature Sensor Specifications.	
Specification	**Details**
Resistance value (sensor)	10K Ω thermistor @ 77°F (25°C)
Output signals • Room temperature • Set point • Occupancy (bypass button)	 • Changing resistance • Changing resistance • Digital
Installation	100 ft (30.5 m) maximum cable length 3 pr. 24 AWG, NEC Class 2

Power Source Requirements

Transformer Requirements and Recommended Voltages

The base rating of the controller and the sum of the sensor, actuators, and relays connected dictates the VA rating.

CAUTION

The LTEC Digital Outputs (DOs) control 24 Vac only. The maximum rating is 12 VA for each DO. Use an interposing 24 Vac relay for any of the following:

- VA requirements higher than the maximum
- 110 to 220 Vac or higher
- Control load requires DC power
- Separate transformers used to power the load
- Need for dry contacts

CAUTION

The neutral side of the 24 Vac power transformer for the TEC **must** be tied to earth at the source of the 24 Vac and only at this point.

LTEC Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power**
LTEC	24 Vac	50/60 Hz	5 VA plus loads

Load Limits

Allowable loads for the LTEC are 24 Vac devices (actuators, interposing relays, motor contactor control coils, solenoids, lamps or indicators) rated at 12 VA or less for each termination set. If the load exceeds 12 VA @ 24 Vac, an interposing relay must be used.

	CAUTION
	The entire digital output load on a single LTEC must not exceed 95 VA.

Power for the loads is obtained from the same terminals that supply power to the LTEC. If fusing is required, 3/4 amp slow blow fuses are recommended per digital output. The entire LTEC and its loads must be powered from a 24 Vac line fused at 4 amps (100 VA) or less.

NOTE:
The LTEC uses triacs to control digital output loads. The triacs are rated at 500 mA at 24 Vac for a power rating of 12 VA for each termination set.

LTEC Wiring Diagrams

Each application set has a default input/output-wiring configuration shown in the wiring diagrams. All input and output physical connections are pre-configured per application. See the installation instructions for application-specific wiring diagrams.

The wiring diagrams are shown using the full point controllers (shaded terminals). Reduced point controllers should be used when the additional input/output points are not required.

Points shown as optional on the wiring diagrams are pre-configured I/O points. In some instances, some configuration parameters will need to be modified to use these points.

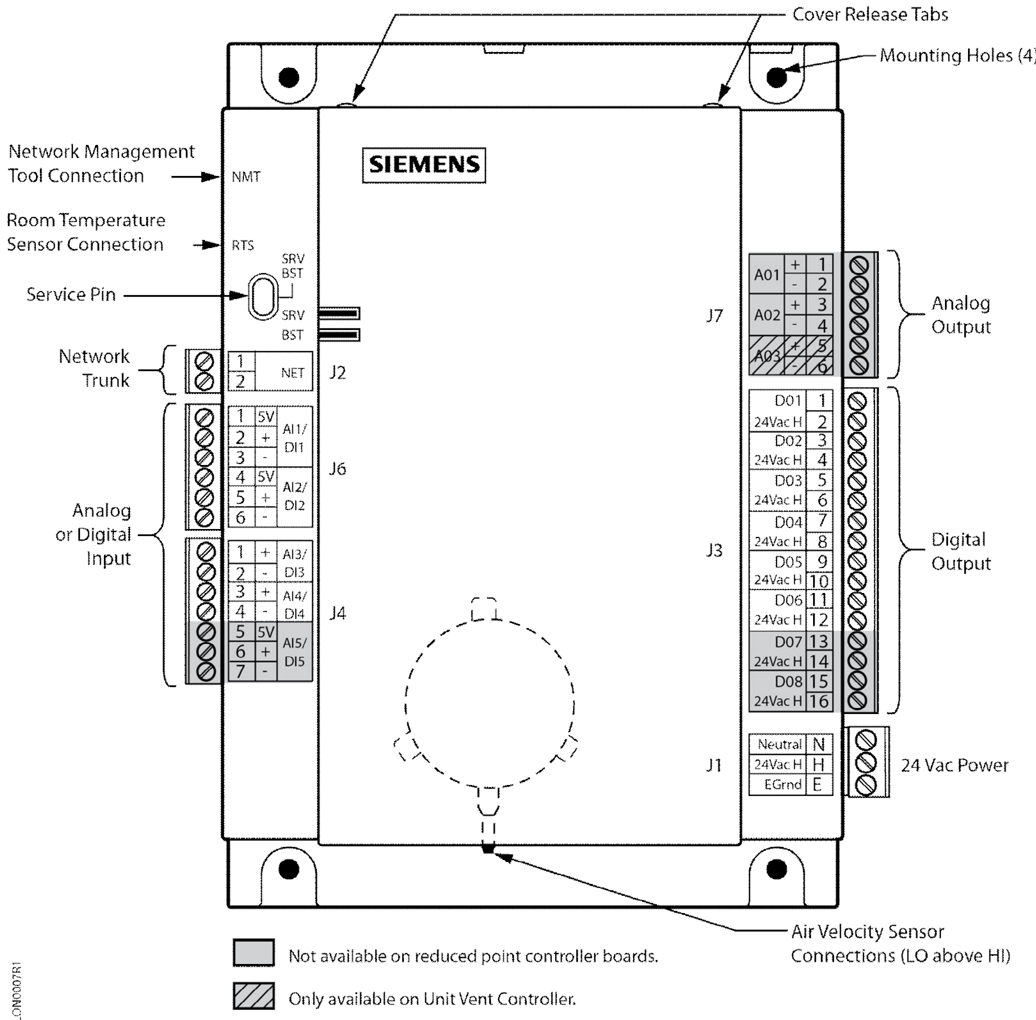
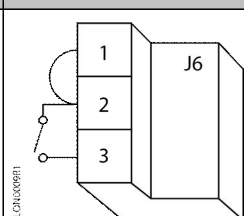
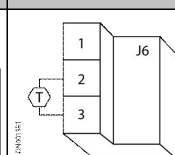
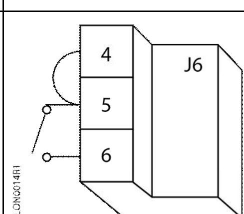
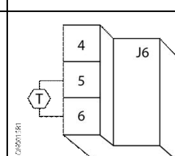
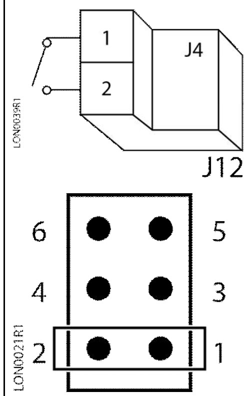
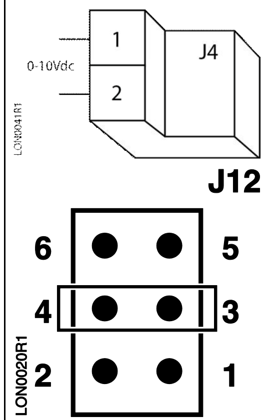
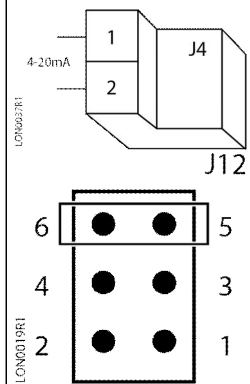
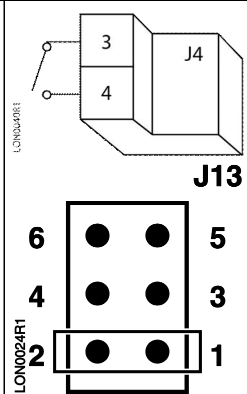
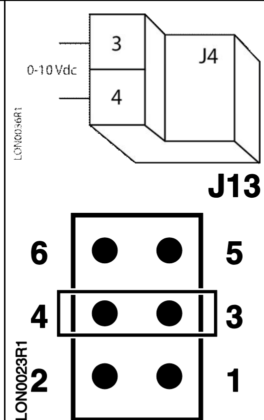
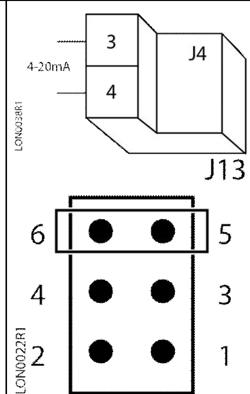
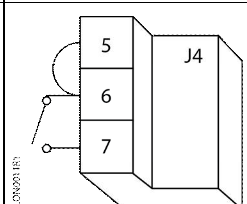
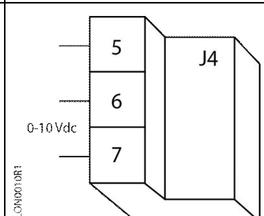
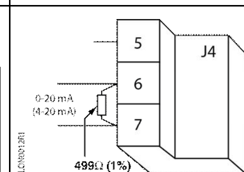


Figure 138: LTEC Wiring Designations.

Input Configuration and Jumper Settings.				
	Digital input	100K Thermistor	0-10 Vdc input	0-20 / 4-20 mA input
AI/DI 1			Not available	Not available
AI/DI 2			Not available	Not available

Input Configuration and Jumper Settings.				
	Digital input	100K Thermistor	0-10 Vdc input	0-20 / 4-20 mA input
AI/DI 3	 internal jumper	Not available	 internal jumper	 internal jumper
AI/DI 4	 internal jumper	Not available	 internal jumper	 internal jumper
AI/DI 5		Not available		

1) Resistor, 499 Ω 1%, part number (587-152) for AI 5 current input (0-20 mA).

2) See *LTEC Internal Jumper Location* figure for physical location of internal jumpers and external terminal block connections.

3) The location of physical inputs must match a specific application wiring diagram; see *Installation Instructions*.

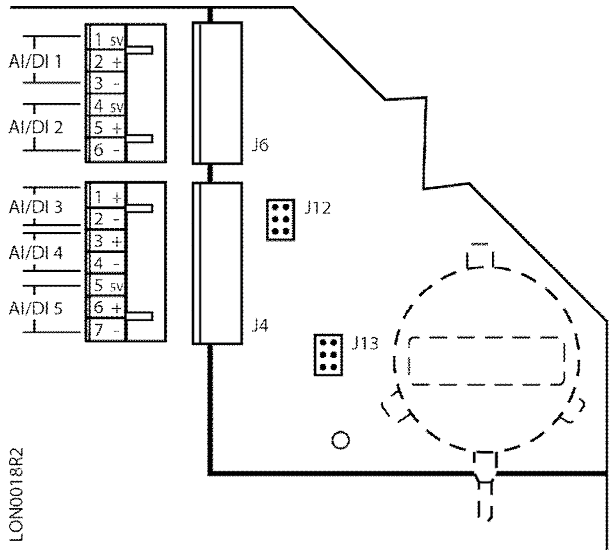


Figure 139: LTEC Internal Jumper Location.

LTEC Network Wiring

The LTEC can be wired using a free topology configuration. The LTEC communicates on the LonTalk network at 78K bps.

Terminals 1 and 2 on J2 are reserved for the network connection.

NOTE:
The connection is not polarity sensitive.

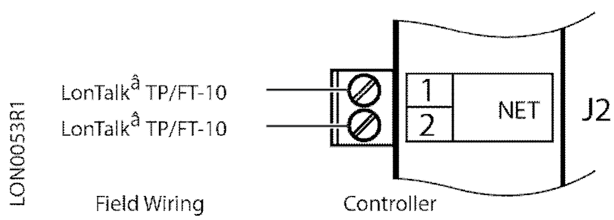


Figure 140: Network to LTEC Connection.

LTEC Power Wiring

The following terminations are reserved for the power connection to the LTEC:

- N (Neutral)
- H (Hot)
- E (Earth)

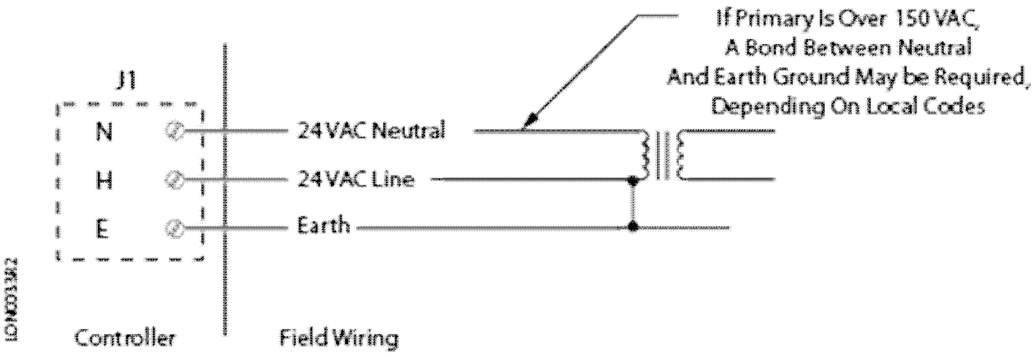


Figure 141: Power Connection to LTEC.

100K Ohm Thermistor Input

100K Ω thermistor inputs can be wired to the LTEC inputs AI 1/DI 1 or AI 2/DI 2 on terminal block J6.

NOTE:
The following figure illustrates a 100K Ω thermistor input connecting to input terminals J6-2 and J6-3, which correspond to termination set AI 1/DI 1.

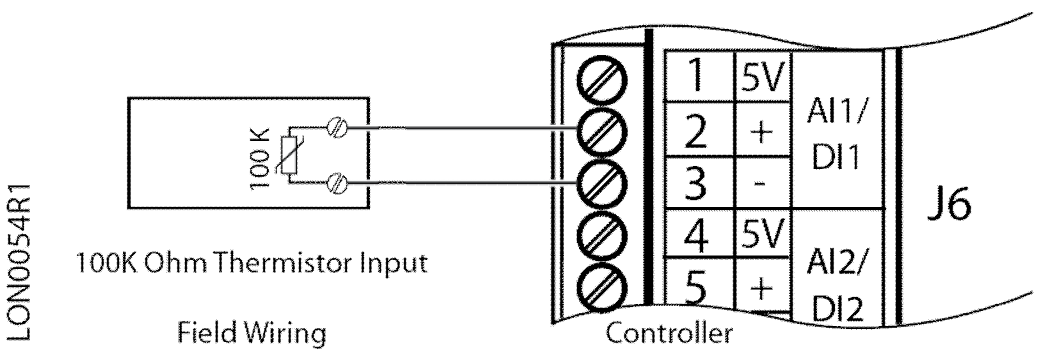


Figure 142: 100K Ω Thermistor Input Connection to the LTEC.

100K Ω Thermistor Input Wiring Details.			
Termination Set	Terminal Numbers		Internal Jumper
	Signal +	Common –	
AI 1/DI 1	J6-2	J6-3	N/A
AI 2/DI 2	J6-5	J6-6	N/A

Digital Input

AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5

Digital inputs can be wired to the LTEC inputs AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5 on terminal block J4 or J6 (Figure 132). An external jumper provides a 5 Vdc source to be used for sensing dry contacts.

AI 3/DI 3 or AI 4/DI 4

Digital inputs can be wired to the LTEC inputs AI 3/DI 3 or AI 4/DI 4 on terminal block J6 (Figure 133). For these inputs, use the internal jumper blocks, J12 and J13 respectively, and configure them as shown in Table *Digital Input Wiring Details*.

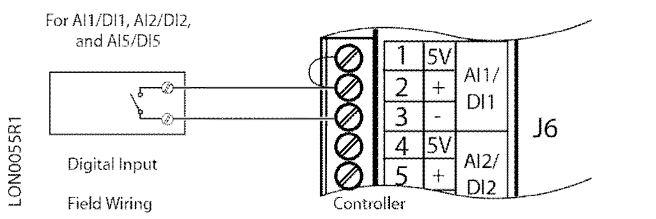


Figure 132. Digital Input Connection to LTEC Inputs AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5.

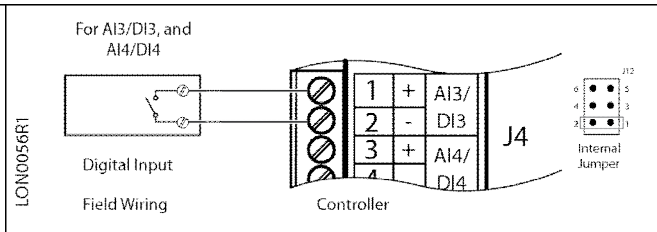
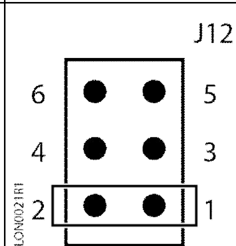
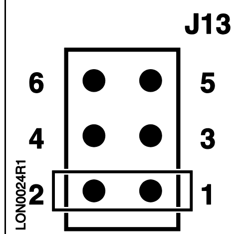


Figure 133. Digital Input Connection to LTEC Inputs AI 3/DI 3 or AI 4/DI 4.

NOTE:
Figure 132 illustrates a digital input connecting to input terminals J6-2 and J6-3, which correspond to termination set AI 1/DI 1. Figure 133 illustrates a digital input connecting to input terminals J4-1 and J4-2, which correspond to termination set AI 3/DI 3.

Digital Input Wiring Details.				
Termination Set	Terminal Numbers			Internal Jumper
	DI (Voltage Source) +5	Signal +	Common –	
AI 1/DI 1	J6-1	J6-2	J6-3	N/A
AI 2/DI 2	J6-4	J6-5	J6-6	N/A
AI 3/DI 3	N/A	J4-1	J4-2	

Digital Input Wiring Details.				
Termination Set	Terminal Numbers			Internal Jumper
	DI (Voltage Source) +5	Signal +	Common –	
AI 4/DI 4	N/A	J4-3	J4-4	
AI 5/DI 5*	J4-5	J4-6	J4-7	N/A

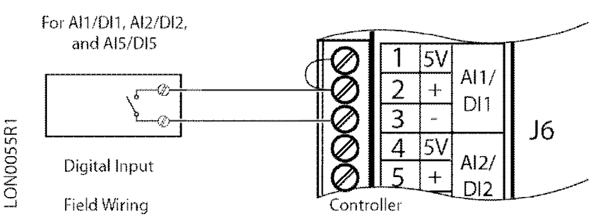
* Available on full point controller only.

AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5

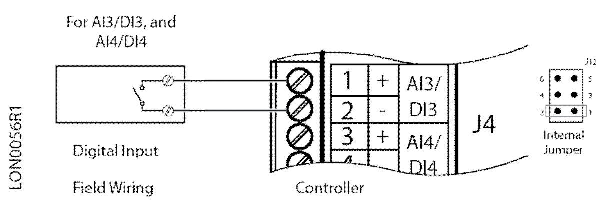
Digital inputs can be wired to the LTEC inputs AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5 on terminal block J4 or J6. An external jumper provides a 5 Vdc source to be used for sensing dry contacts.

AI 3/DI 3 or AI 4/DI 4

Digital inputs can be wired to the LTEC inputs AI 3/DI 3 or AI 4/DI 4 on terminal block J6 (Figure *Digital Input Connection to LTEC Inputs AI 3/DI 3 or AI 4/DI 4*). For these inputs, use the internal jumper blocks, J12 and J13 respectively, and configure them as shown in Table *Digital Input Wiring Details*.

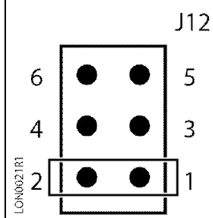
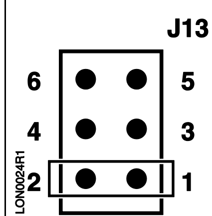


Digital Input Connection to LTEC Inputs AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5.



Digital Input Connection to LTEC Inputs AI 3/DI 3 or AI 4/DI 4.

NOTE:
Figure *Digital Input Connection to LTEC Inputs AI 1/DI 1, AI 2/DI 2, or AI 5/DI 5* illustrates a digital input connecting to input terminals J6-2 and J6-3, which correspond to termination set AI 1/DI 1. Figure *Digital Input Connection to LTEC Inputs AI 3/DI 3 or AI 4/DI 4* illustrates a digital input connecting to input terminals J4-1 and J4-2, which correspond to termination set AI 3/DI 3.

Digital Input Wiring Details.				
Termination Set	Terminal Number			Internal Jumper
	DI (Voltage Source) +5	Signal +	Common –	
AI1/DI1	J6-1	J6-2	J6-3	N/A
AI2/DI2	J6-4	J6-5	J6-6	N/A
AI3/DI3	N/A	J4-1	J4-2	
AI4/DI4	N/A	J4-3	J4-4	
AI5/DI5*	J4-5	J4-6	J4-7	N/A

*Available on full point controller only.

Analog Input (Voltage)

Analog inputs (voltage) can be wired to the LTEC inputs AI 3/DI 3 through AI 5/DI 5 on terminal block J4 (Figure 134). For AI 5/DI 5, connect directly to J4-6 and J4-7; no jumpers are required (Figure 135).

NOTE:
Figure 134 illustrates an analog input (voltage) connecting to input terminals J4-1 and J4-2, which correspond to termination set AI 3/DI 3.

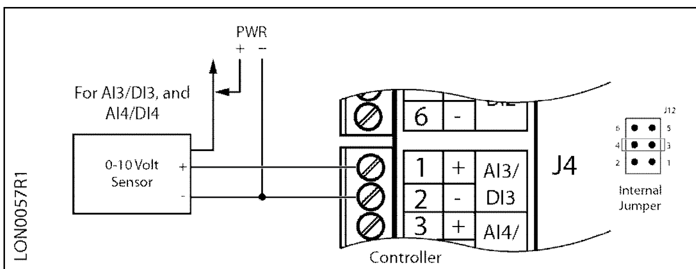


Figure 134. Analog Input (Voltage) Connection to LTEC Inputs AI 3/DI 3 and AI 4/DI 4.

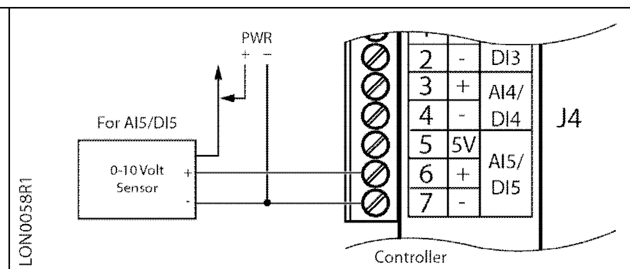
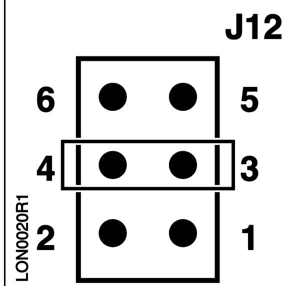
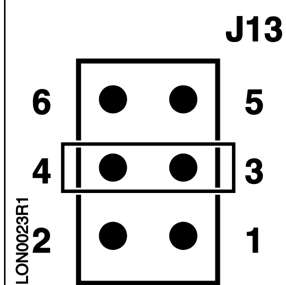


Figure 135. Analog Input (Voltage) Connection to LTEC Input AI 5/DI 5.

Analog Input (Voltage) Wiring Details.			
Termination Set	Terminal Numbers		Internal Jumper
	Signal +	Common –	
AI 3/DI 3	J4-1	J4-2	
AI 4/DI4	J4-3	J4-4	
AI 5/DI 5*	J4-6	J4-7	N/A

* Available on full point controller only.

Analog Input (Current)

Analog inputs (4-20 mA current) can be wired to the LTEC inputs AI 3/DI 3 through AI 5/DI 5 on terminal block J4. For AI 3/DI 3 and AI 4/DI 4, use the internal jumper block for current input as shown in Figure 136. For AI 5/DI 5, use an external resistor as shown in Figure 137.

NOTE:
Figure 136 illustrates an analog input (current) connecting to input terminals J4-1 and J4-2, which correspond to termination set AI 3/DI 3.

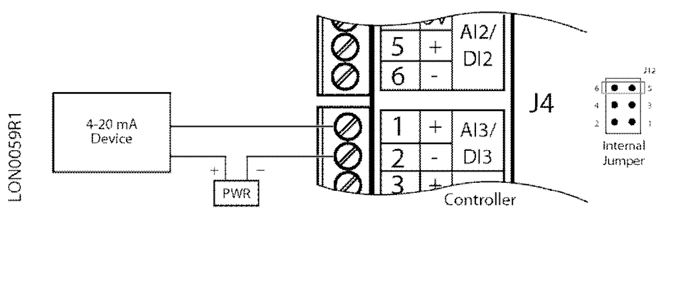
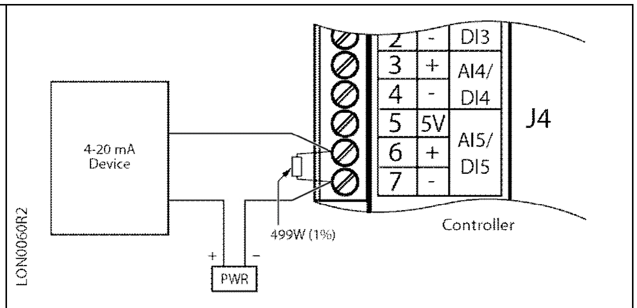
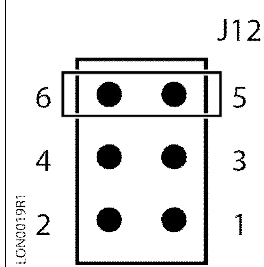
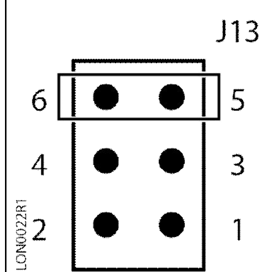
	

Figure 136. Analog Input (Current) Connection to LTEC Input AI3/DI3 or AI 4/DI 4.	Figure 137. Analog Input (Current) Connection to LTEC Input AI 5/DI 5.

Analog Input (Current) Wiring Details.			
Termination Set	Terminal Numbers		Internal Jumper
	Signal +	Common –	
AI 3/DI 3	J4-1	J4-2	
AI 4/DI 4	J4-3	J4-4	
AI 5/DI 5*	J4-6	J4-7	N/A1

1) Use external 499Ω 1% resistor across terminal 6-7.

* Available on full point controller only.

Digital Output—ON/OFF

ON/OFF digital outputs can be wired to the LTEC outputs DO1 through DO 8 on terminal block J3.

NOTE:
Figure *Digital Output (ON/OFF) Connection to the LTEC* illustrates an ON/OFF digital output connecting to output terminals J3-1 and J3-2, which correspond to termination set DO 1.

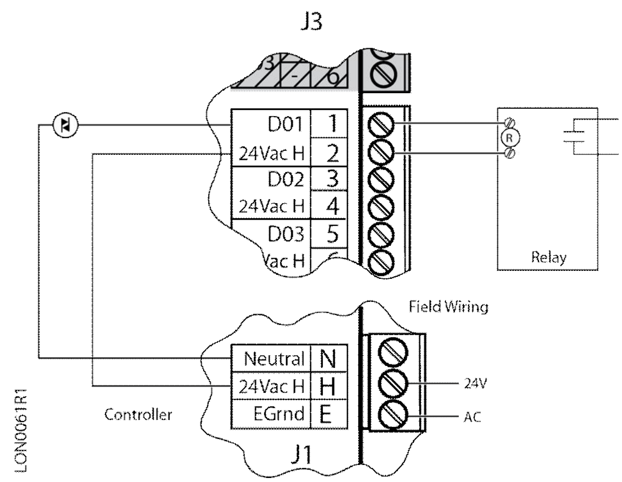


Figure 143: Digital Output (ON/OFF) Connection to the LTEC.

Digital Output—ON/OFF Wiring Details.		
Termination Set	Terminal Numbers	
	Triac Control Output	24V Sources
DO 1	J3-1	J3-2
DO 2	J3-3	J3-4
DO 3	J3-5	J3-6
DO 4	J3-7	J3-8
DO 5	J3-9	J3-10
DO 6	J3-11	J3-12
DO 7*	J3-13	J3-14
DO 8*	J3-15	J3-16

* Available on full point controller only.

3-Position Floating Motor

A 3-position floating motor can be wired to two sets of consecutive terminations on the LTEC outputs DO 1 through DO 8. Use terminal block J3.

NOTE:
Figure *3-Position Floating Motor Connection to the LTEC* illustrates a 3-position floating motor connecting to output terminals J3-1, J3-2, J3-3, and J3-4, which correspond to termination set DO 1 and DO 2.

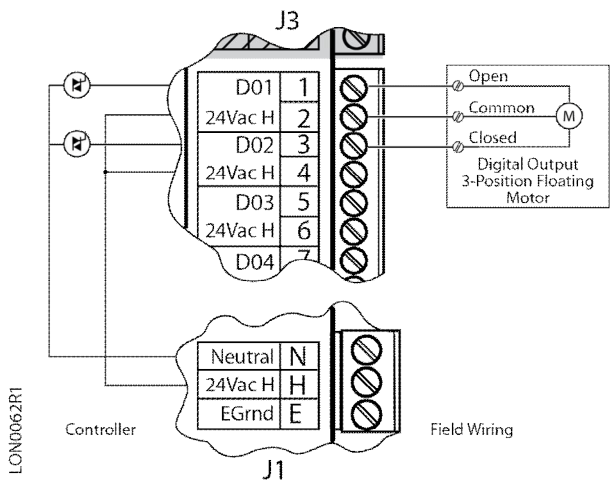


Figure 144: 3-Position Floating Motor Connection to the LTEC.

NOTE:
The outputs of the 3-position floating motor must be wired across two sets of consecutive terminal blocks (that is, DO 1 to DO 2, DO 2 to DO 3, DO 3 to DO 4, and so on).

Digital Output—3 Position Floating Motor Wiring Details.		
Termination Set	Terminal Numbers	
	Triac Control Output	24V Sources
DO 1	J3-1	J3-2
DO 2	J3-3	J3-4
DO 3	J3-5	J3-6
DO 4	J3-7	J3-8
DO 5	J3-9	J3-10
DO 6	J3-11	J3-12

Digital Output—3 Position Floating Motor Wiring Details.		
Termination Set	Terminal Numbers	
	Triac Control Output	24V Sources
DO 7*	J3-13	J3-14
DO 8*	J3-15	J3-16

* Available on full point controller only.

Lighting Contactor—Maintained

A single lighting contactor or interface relay, or a single point that drives multiple lighting contactors can be wired to the LTEC outputs DO 1 through DO 8 on terminal block J3.

NOTE:
Figure *Lighting Contractor–Maintained Connection to the LTEC* illustrates a lighting contactor or interface relay connecting to output terminals J3-15 and J3-16, which correspond to termination set DO 8.

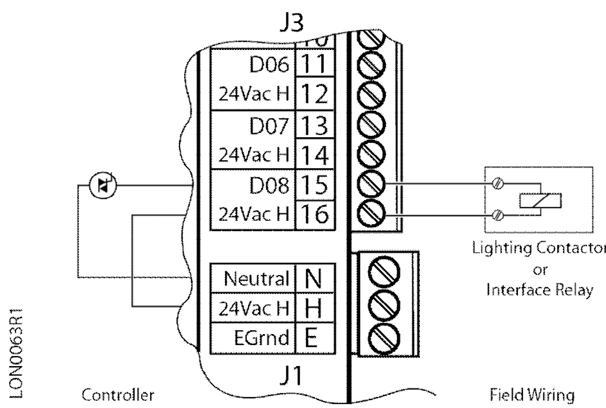


Figure 145: Lighting Contactor—Maintained Connection to the LTEC.

Lighting Contactor—Maintained Wiring Details.		
Termination Set	Terminal Numbers	
	Triac Control Output	24V Sources
DO 1	J3-1	J3-2
DO 2	J3-3	J3-4
DO 3	J3-5	J3-6
DO 4	J3-7	J3-8

Lighting Contactor—Maintained Wiring Details.		
Termination Set	Terminal Numbers	
	Triac Control Output	24V Sources
DO 5	J3-9	J3-10
DO 6	J3-11	J3-12
DO 7*	J3-13	J3-14
DO 8*	J3-15	J3-16

* Available on full point controller only.

Lighting Contactor—Pulsed (Latching)

A pulsed (momentary) lighting contactor can be wired to the LTEC outputs DO 1 through DO 8 on terminal block J3. Pulsed lighting contactors are controlled by two consecutive outputs: one output to pulse and latch the lights on and the other to pulse and latch the lights off. The lighting contactors can connect to any consecutive pair of termination sets between DO 1 and DO 8 (that is, DO 1 to DO 2, DO 2 to DO 3, DO 3 to DO 4, and so on).

NOTE:
Figure *Lighting Contractor—Pulsed Connection to the LTEC* illustrates the pulsed lighting contactor connecting to output terminals J3-13, J3-14, J3-15, and J3-16, which correspond to termination sets DO 7 and DO 8.

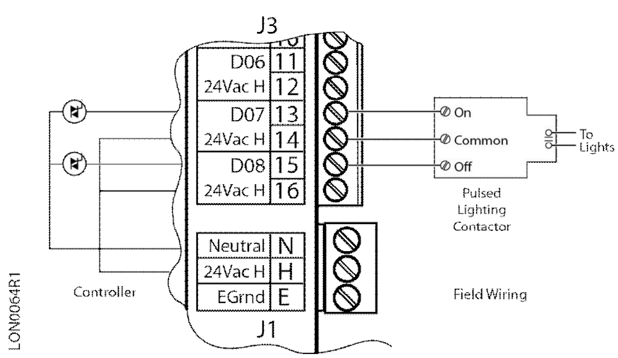


Figure 146: Lighting Contactor—Pulsed Connection to the LTEC.

Lighting Contactor—Pulsed Wiring Details.		
Termination Set	Terminal Numbers	
	Triac Control Output	24V Sources
DO 1	J3-1	J3-2
DO 2	J3-3	J3-4
DO 3	J3-5	J3-6
DO 4	J3-7	J3-8
DO 5	J3-9	J3-10
DO 6	J3-11	J3-12
DO 7*	J3-13	J3-14
DO 8*	J3-15	J3-16

* Available on full point controller only.

Analog Output (0-10 Vdc)

An analog output (0-10 Vdc) can be wired to the LTEC outputs AO 1 or AO 2 on all controllers and to AO 1 through AO 3 on Unit Ventilator Controllers. Use terminal block J7 (Figure *Analog Output (0-10 Vdc) Connection to the LTEC*).

NOTE:
Figure *Analog Output (0-10 Vdc) Connection to the LTEC* illustrates an analog output (0-10 Vdc) connecting to output terminals J7-3 and J7-4, which correspond to termination set AO 2.

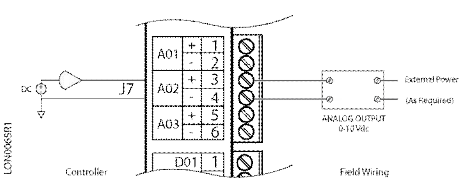


Figure 147: Analog Output (0-10 Vdc) Connection to the LTEC.

Locally-powered Actuator Connections

Local actuators, where the actuator and the LTEC share one transformer, can be wired to LTEC outputs AO 1, AO 2, or AO 3 on terminal block J7 (Figure *Locally-powered Actuator Connection to the LTEC*).

NOTE:
Figure *Locally-powered Actuator Connection to the LTEC* illustrates the actuator connecting to output terminals J7-3 and J7-4, which correspond to termination set AO 2.

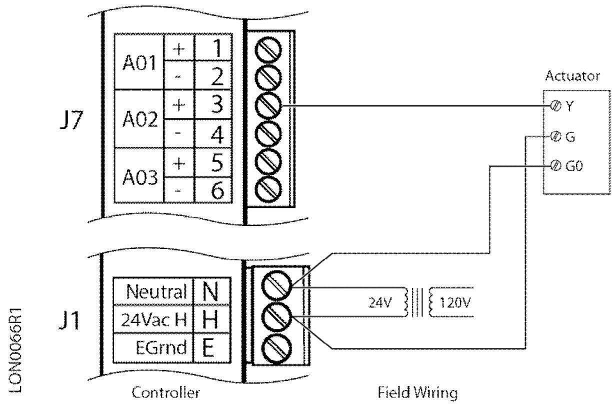


Figure 148: Locally-powered Actuator Connection to the LTEC.

Remotely-powered Actuator Connections

Remote actuators, where the actuator and the LTEC are served by separate transformers, can be wired to LTEC outputs AO 1, AO 2, or AO 3 on terminal block J7 (Figure *Remotely-powered Actuator Connection to the LTEC*).

NOTE:
Figure *Remotely-powered Actuator Connection to the LTEC* illustrates the actuator connecting to output terminals J7-3 and J7-4, which correspond to termination set AO 2.

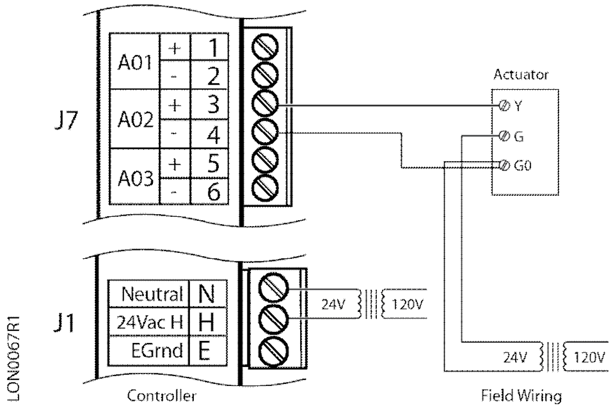


Figure 149: Remotely-powered Actuator Connection to the LTEC.

Analog Output (0-10 Vdc) Wiring Details.		
Termination Set	Terminal Numbers	
	Signal Out	Common
AO 1*	J7-1	J7-2
AO 2*	J7-3	J7-4
AO 3* (only available on Unit Ventilator controllers)	J7-5	J7-6

*Available on full point controller only.

Terminal Control Unit (TCU)

NOTE:
The TCU is no longer available for new sales. Information in this section is for reference only.

Wire Type Requirements

TCU Wire Type Requirements.				
Circuit Type	Class	Wire Type (AWG)	Distance[2]	Conduit Sharing[1]
AC line power (to field panel)	Power	No. 12 to No. 14, No. 12 THHN	Check local codes	Check local codes
Digital Output	1	Check local codes	Check local codes	Check local codes

TCU Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance[2]**	**Conduit Sharing[1]**
Digital Output	2	Check local codes	Check local codes	Check local codes
Line Volt Relay Module; 5-conductor cable to module	2	No. 22 5-conductor cable	150 ft (46 m)	Class 1 and 2 (check local codes)
Digital Input	2	No. 22 5-conductor cable	150 ft (46 m)	Class 1 and 2 (check local codes)
Analog Input Thermistors	2	No. 22 5-conductor cable	100 ft (30.5 m)	Class 1 and 2 (check local codes)
Actuator Output	2	No. 22 5-conductor cable	150 ft (46 m)	Class 1 and 2 (check local codes)
Power Trunk	2	No. 14 THHN or No. 14 TP	180 ft (55 m)[2]	Class 1 and 2 (check local codes)

1) Conduit sharing rules were determined through EMI and shared conduit testing. These rules indicate wiring methods that have no adverse affect on the proper operation of the equipment, but do not necessarily indicate compliance with local codes.

2) Distances depend on transformer location. Install 100 VA transformers near the most convenient line voltage sources to minimize line voltage wiring costs. Use one 100 VA transformer for every eight MPUs. (180 ft using 14 AWG wires is worst case).

Power Source Requirements

TCUs can be powered in three ways. Correct sizing and fusing must be maintained for each of these powering techniques:

- Individual transformer using a transformer rated for Class 2 service.
- Power trunk. For more information, see the *Power Trunk Guidelines* in Chapter 1.
- Low voltage source of the device the controller is controlling (for example, fan powered boxes, electric room heat, fan coils, and heat pumps).

CAUTION

The phase of all devices on a power trunk must be identical.

Phase differences can destroy equipment. Any relays, EPs, or contactors sharing power must be clamped with MOVs at their locations.

TCU Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power**
TCU	24 Vac	50/60 Hz	14 – 22.7 VA[1]

1) Dependent on application.

Digital Output (DO) Wiring

Table *MPU and DPU Wire Requirements* provides DO wire run lengths for points wired to Terminal Control Units.

UL and CSA listing requires the DO wiring shield be installed in the cabinets for which they are supplied.

Grounding

A ground lug is provided on TCUs, if required due to local codes or for RF grounding reasons.

Metal Oxide Varistors (MOVs)

Metal Oxide Varistors (MOVs) must be used across the DO terminals when connected to loads. MOVs are factory-installed in all FLN products.

When installing MOVs across the DO relay contacts on termination boards, keeping the MOV leads as short as possible makes the MOV more effective at reducing spikes from field wiring or controlled devices. Remove and reinstall any MOVs with leads longer than 1 in. (2.5 cm). See the *Controlling Transients* section in Chapter 1 for MOV part numbers.

Line Voltage Relay Module

Low voltage MOVs can be required if severe noise problems arise. A jumper is provided to allow you to position the snubber across either the normally open (NO) or normally closed (NC) contacts.

Unitary Controller (UC)

NOTE:
The Unitary Controller (UC) is no longer available for new sales. Information in this section is for reference only.

Wire Type Requirements

Unitary Controller Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance**	**Conduit Sharing[1]**
Input Power	2	Check local codes	Check local codes	Check local codes
Analog Input—RTD	2	No. 18 to No. 22TP	750 ft (228 m)	Class 2
Analog Input—0-20 mA or 0-10 Vdc	2	No. 18 to No. 22 TP	750 ft (228 m)	Class 2
Analog Output—0-12 Vdc or 0-20 mA	2	No. 18 to No. 22 TP	750 ft (228 m)	Check local codes
Digital Input	2	No. 18 to No. 22 TP	750 ft (228 m)	Class 1 and 2 Check local codes

Unitary Controller Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance**	**Conduit Sharing[1]**
Digital Output	1	No. 18 to No. 22 TP	Check local codes	Check local codes
Digital Output	2	Check local codes	Check local codes	Check local codes

1) Conduit sharing rules were determined through EMI and shared conduit testing. These rules indicate wiring methods that have no adverse affect on the proper operation of the equipment, but do not necessarily indicate compliance with local codes.

Power Source Requirements

UCs can be powered in three ways:

- Individual transformer using a transformer rated for Class 2 service.
- Power trunk. For more information, see the *Power Trunk Guidelines*.
- Low voltage source of a device that the UC is controlling (for example, electric-pneumatic transducer, and so on).

CAUTION

The phase of all devices on a power trunk must be identical.

Phase differences can destroy equipment. Any relays, EPs, or contactors sharing power must be clamped with MOVs at their locations.

UC Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power**
Unitary Controller	24 Vac	50/60 Hz	15.0 VA[1]

1) For standard UC package.

Digital Output (DO) Wiring

Table *Unitary Controller Wire Type Requirements* provides DO wire run lengths for points wired to Unitary Controllers.

UL and CSA listing requires the DO wiring shield be installed in the cabinets for which they are supplied.

Metal Oxide Varistors (MOVs)

Metal Oxide Varistors (MOVs) must be used across the DO terminals when connected to loads. MOVs are factory-installed in all FLN products.

When installing MOVs across the DO relay contacts on termination boards, keeping the MOV leads as short as possible makes the MOV more effective at reducing spikes from field wiring or controlled devices. Remove and reinstall any MOVs with leads longer than 1 in. (2.5 cm). See the *Controlling Transients* section in Chapter 1 for MOV part numbers.

Terminal Equipment Controllers (APOGEE Legacy Controllers)

Wire Type Requirements

TEC Wire Type Requirements.				
Circuit Type	**Class**	**Wire Type (AWG)**	**Distance**	**Conduit Sharing[1]**
Input Power	2	Check local codes	Check local codes	Class 2
Digital Output	2	Check local codes	150 ft (46 m)	Class 2
Analog Output	2	Check local codes	150 ft (46 m)	Class 2
Digital Inputs	2	No. 18 to No. 22 TP	150 ft (46 m)	Class 2
Analog Inputs	2	No. 18 to No. 22 TP	100 ft (30 m)	Class 2
Room Temperature Sensor	2	Pre-terminated 3 TP	100 ft (30 m)	Class 2

1) Conduit sharing rules were determined through EMI and shared conduit testing. These rules indicate wiring methods that have no adverse effect on the proper operation of the equipment, but do not necessarily indicate compliance with local codes.

Power Source Requirements

TECs can be powered in three ways. Correct sizing and fusing must be maintained for each of these powering techniques:

- Individual transformer using a transformer rated for Class 2 service.
- Power trunk. For more information, see *Power Trunk Guidelines* in Chapter 1 Wiring Requirements.
- Low voltage source of the device the controller is controlling (for example, fan powered boxes, electric room heat, fan coils, and heat pumps).

CAUTION

The phase of all devices on a power trunk must be identical.

Phase differences can destroy equipment. Any relays, EPs, or contactors sharing power must be clamped with MOVs at their locations.

	CAUTION
	The neutral side of the 24 Vac power transformer for the TEC **must** be tied to earth at the source of the 24 Vac and only at this point.

N Variant TEC (Updated Hardware) Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power** [1]
Terminal Equipment Controller—Electronic Output (6 DO Platform)	24 Vac	50/60 Hz	3 VA + 12 VA max per DO
Terminal Equipment Controller—Electronic Output (8 DO Platform)	24 Vac	50/60 Hz	7 VA + 12 VA max per DO

TEC (Legacy Hardware) Power Source Requirements.			
Product	**Input Voltage**	**Line Frequency**	**Maximum Power** [1]
Terminal Equipment Controller—Electronic Output (6 DO Platform)	24 Vac	50/60 Hz	10 VA + 12 VA max per DO
Terminal Equipment Controller—Electronic Output (8 DO Platform)	24 Vac	50/60 Hz	10 VA + 12 VA max per DO

1)	Total VA rating is dependent upon the controlled DO loads (for example, actuators, contactors, and so on).
2)	Smoke control listed TECs are limited to 6 VA max per DO.

Terminal Equipment Controllers (TEC) (Legacy Hardware)

6 DO Platform

TEC

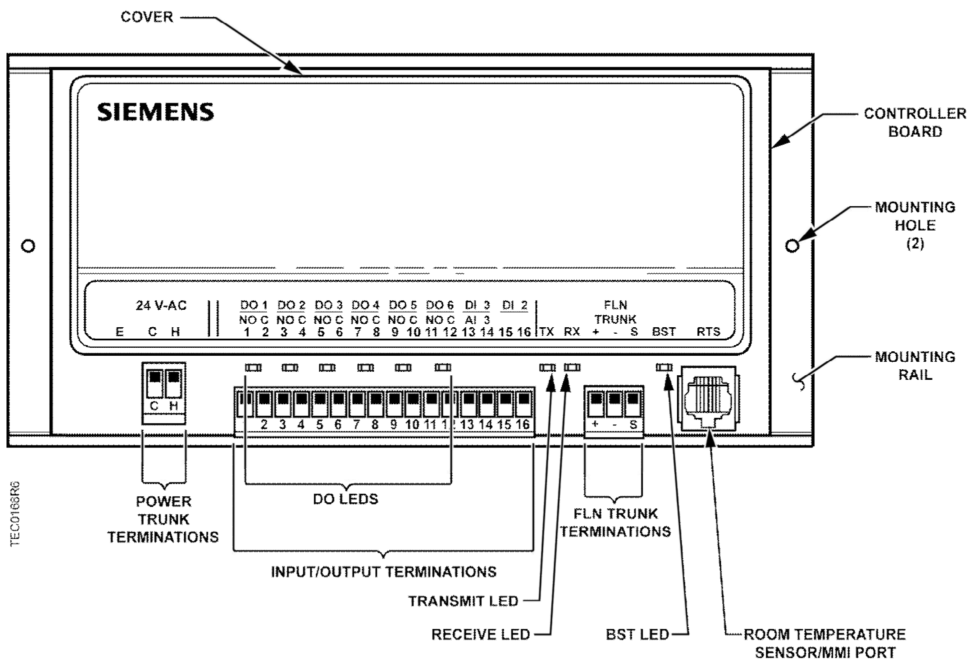


Figure 150: 6 DO Controller.

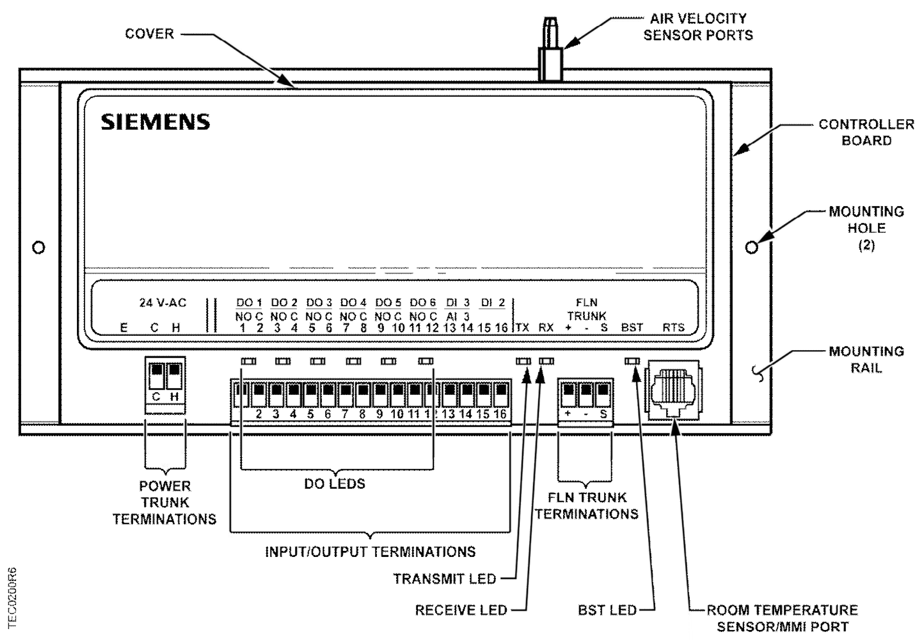


Figure 151: 6 DO Controller with Air Velocity Sensor.

8 DO Platform

TEC

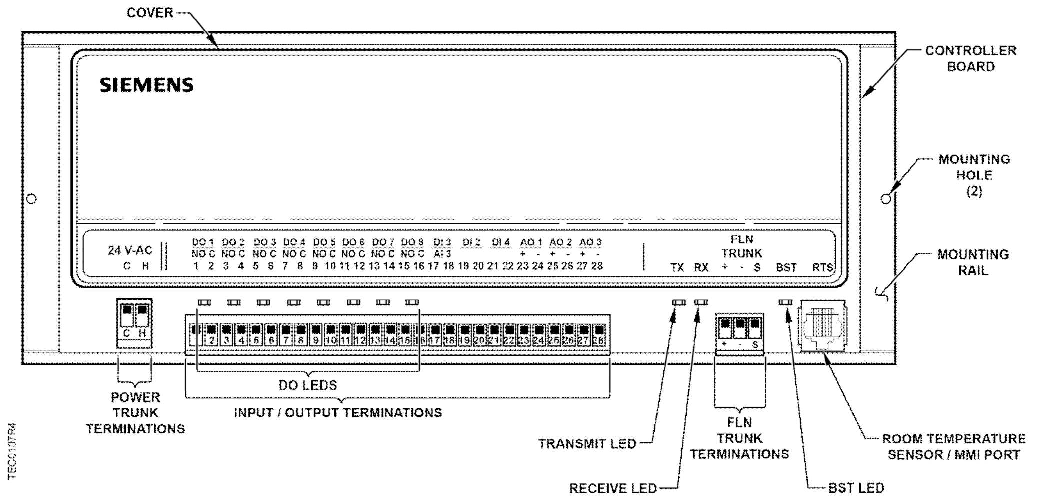


Figure 152: 8 DO Controller.

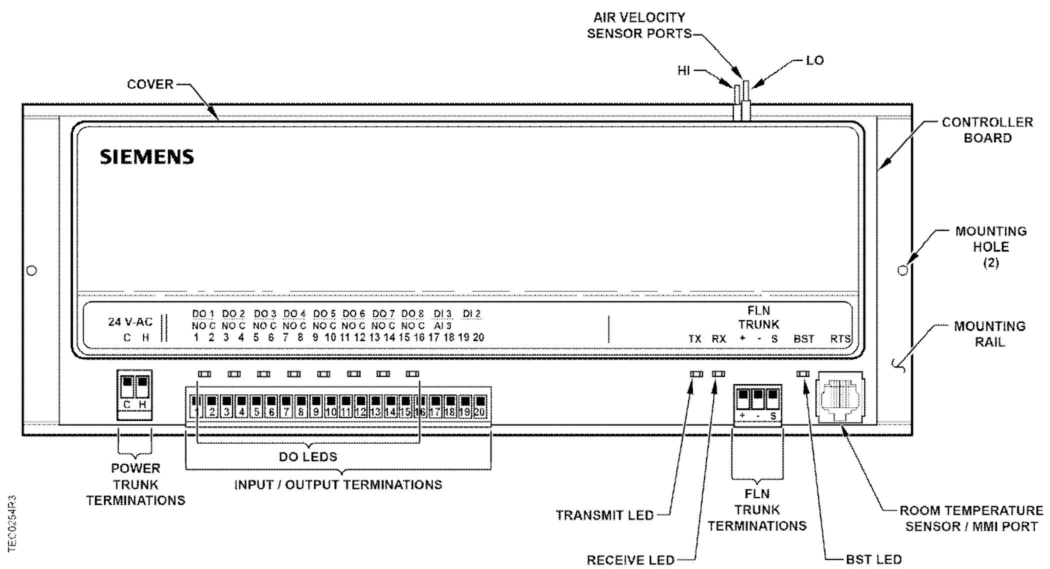


Figure 153: 8 DO Controller with Air Velocity Sensor.

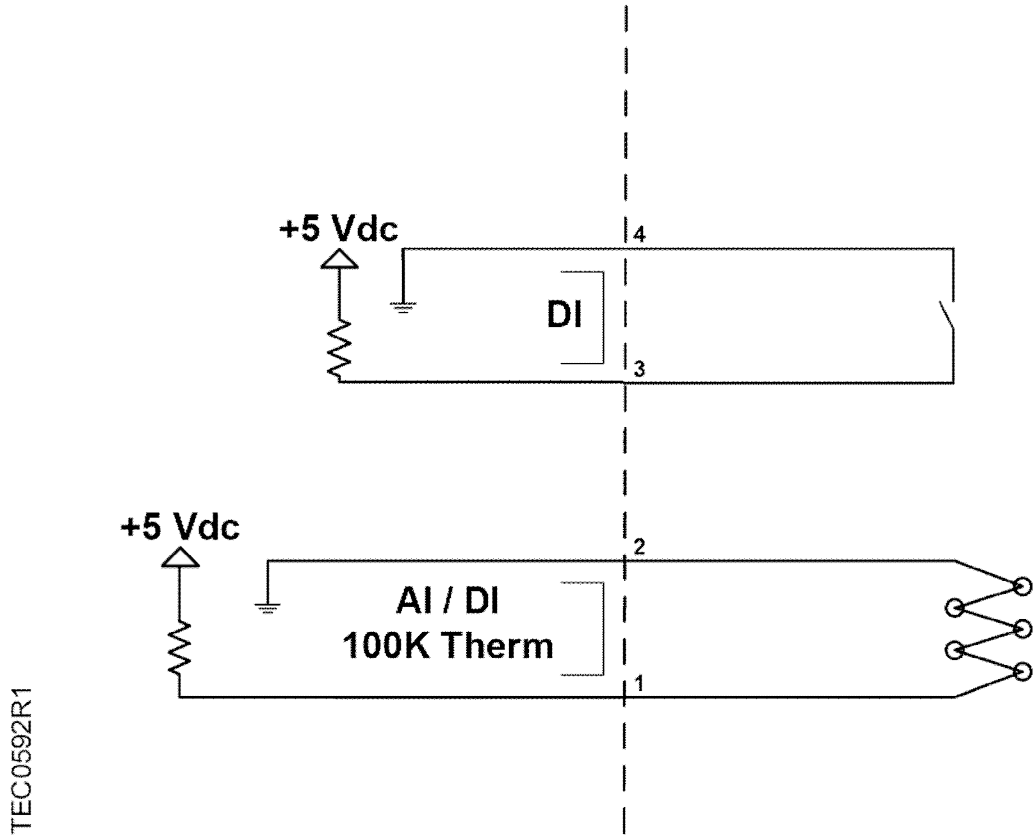


Figure 154: ATEC Wiring for AI/DI.

Wiring DI Common (pin 4) t 10K/100K selectable thermistor – 8 Vdc (pin 2) incorrectly, will cause the actuator to shut down. No damage will occur. When the wiring is corrected, the actuator will resume operation.

Digital Output (DO) Wiring

The Wire Type Requirements [→ 220] provides DO wire run lengths for points wired to TECs.

UL and CSA listing requires the DO wiring shield be installed in the cabinets for which they are supplied.

NOTE:
See the Installation Instructions for point wiring diagrams.

Terminal Equipment Controllers - Pneumatic Output

Do not control more than the nameplate rated loads for the DOs of the pneumatic output controllers. The controller UL and CSA listing is based on the nameplate power rating.

The Terminal Equipment Controller – Pneumatic Output controls 24 Vac loads only. The maximum rating is 12 VA for each DO. For higher VA requirements, 110 or 220

Vac requirements, separate transformers used to power the load, or DC power requirements, use an interposing 220 V 4-relay module (TEC Relay Module P/N 540-147).

BACnet Terminal Equipment Controllers (BTEC) (Legacy Hardware)

6 DO Platform

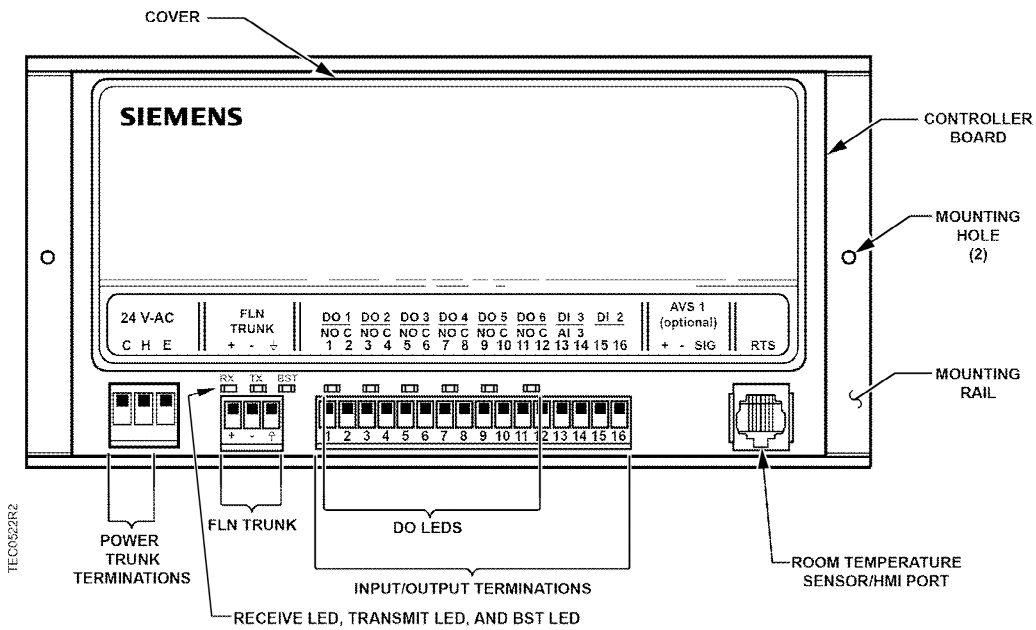


Figure 155: 6 DO Controller.

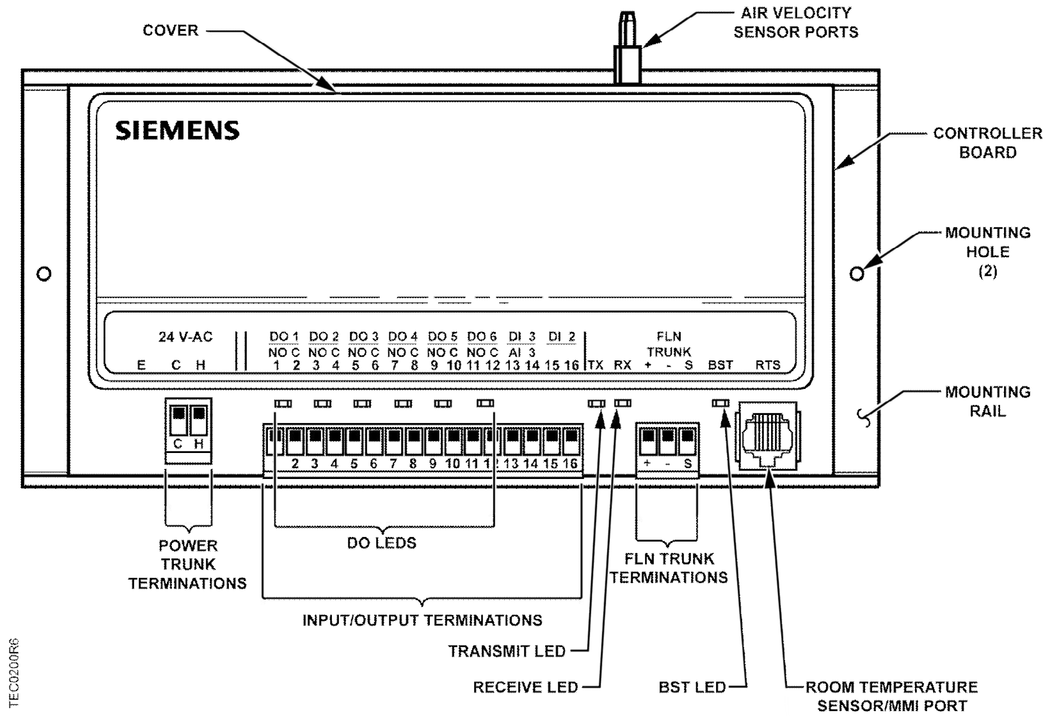


Figure 156: 6 DO Controller with Air Velocity Sensor.

8 DO Platform

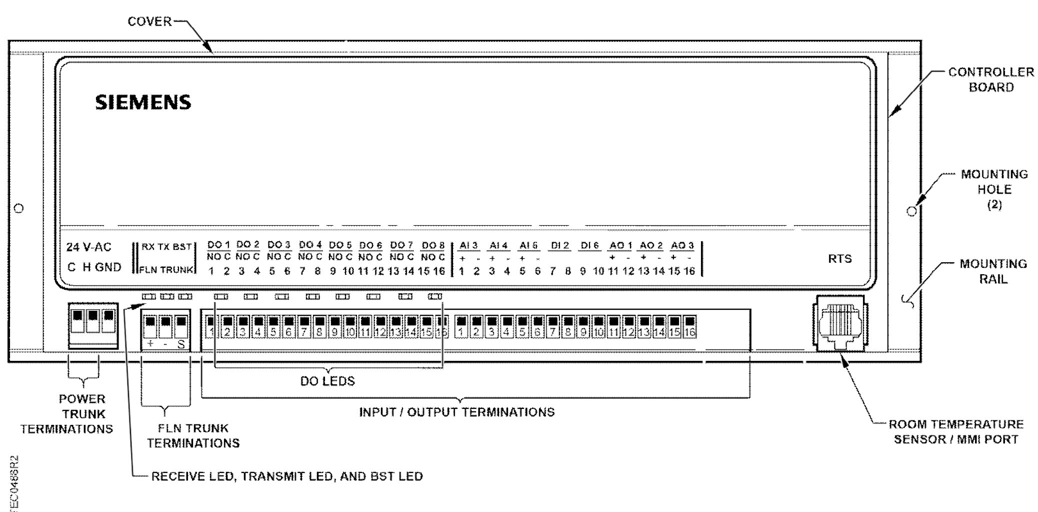


Figure 157: 8 DO Controller.

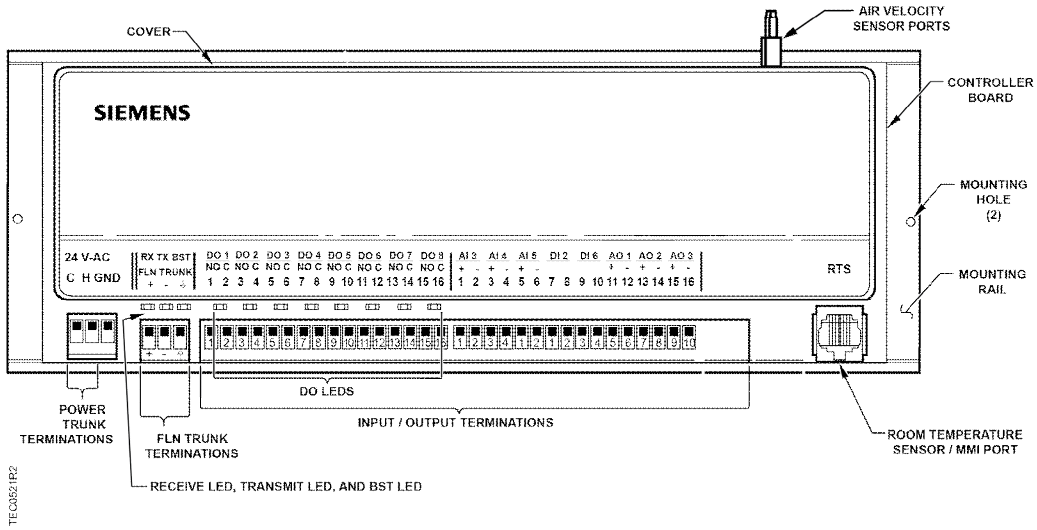


Figure 158: 8 DO Controller with Air Velocity Sensor.

Glossary

The glossary contains terms and acronyms that are used in this manual.

ACH

Alternating Current Hot.

ACN

Alternating Current Neutral.

AEM/AEM100/AEM200

Devices that allow APOGEE field panel networks to communicate with the Insight workstation across an Ethernet network. The APOGEE Ethernet Microserver (AEM) operates on a 10Base-T connection, but can also be routed across low speed networks (for example, across Frame Relay). The AEM100 supports auto-sensing 10Base-T and 100Base-TX Ethernet communication. The AEM200 adds a second serial port, allowing HMI access without disconnecting from the Insight network.

Alarm Indicating Circuit (AIC)

Used in Protective Signaling Systems (that is, fire alarm systems) to connect to alarm devices (horns, speakers, flashing lights, and so on).

ANSI

American National Standards Institute

Automation Level Network (ALN)

Field panel (Protocol 2, Ethernet, or BACnet/IP) network consisting of PXC Modular Series, PXC Compact Series, MECs, MBCs, RBCs, and FLN Controllers. BACnet/IP ALNs may also contain Insight BACnet/IP-capable workstations and third-party BACnet devices. The Automation Level Network (ALN) and Building Level Network (BLN) are identical.

BACnet

ASHRAE Building Automation and Control Networking protocol that allows computerized equipment performing various functions to exchange information, regardless of the building service the equipment performs.

Class 1 Circuit

Remote control and signaling circuits not exceeding 600 Vac and having no power limitation. Normally used for controlling equipment such as fans or pumps through starters.

Class 2 Circuit

Power limited circuits not exceeding a power level of 100 VA (that is, 24 Vac × 4 amps = 96 VA).

Class 3 Circuit

Circuits of relatively low power but of higher voltage than Class 2 (such as 120 volts and up to 1 amp). This is not a common application.

Class 2 Power Source, Inherently Limited

An inherently limited Class 2 power source has some form of current-limiting characteristic designed into the product. Sources of this type are often protected by a current-limiting impedance or embedded fusible link, but other methods are also used. As long as the current limiting is an integral part of the power supply, it will fall into this category. Because of this built-in current-limiting characteristic, a circuit powered by this type of source needs no further protection to qualify as a Class 2 circuit.

Class 2 Power Source, Not Inherently Limited

A Class 2 source that is not inherently limited does not have built-in current limiting protection. At the time of installation, a current-limiting device must be installed between the source and the loads. The most common current limiting device for this application is a single fuse or integral transformer circuit breaker, which must be sized so that the power available to the loads does not exceed 100 VA.

EIA

Electronic Industries Association.

Electromagnetic Interference (EMI)

Electrical noise induced in process wiring by electric or magnetic fields created by power wiring, other process wiring, or electrical equipment.

Field Level Network (FLN)

Data communications link that passes information between an FLN device or devices and an Automation Level Network (ALN) device.

IEEE

Institute of Electrical and Electronic Engineers.

IEEE Standard 802.3

Explains the basic functioning of the CSMA/CD (Carrier Sense Multiple Access with Collision Detection) packet network with an exclusive focus on the ISO/IEC (International Organization of Standardization and the International Electrotechnical Commission).

Initiating Device Circuit (IDC)

Used in Protective Signaling Systems (that is, fire alarm and security systems) to monitor alarm or supervisory sensing devices (manual stations, smoke detectors, valve tamper switches, and so on).

Interoperability

Process that ensures that multiple nodes (from the same or different manufacturers) can be integrated into a single network (LonWorks ® FLN) without custom development.

Lay

Axial distance required for one cabled conductor to complete one revolution about the axis around which it is cabled (for example, a cable lay of 2 inches (50.8 mm) is equivalent to six twists per foot).

LonMark

The LonMark Interoperability Consortium is an industry group whose purpose is to make recommendations to Echelon Corporation on interoperability issues. Issues include standardization of Network Variable types, Configuration Property Types, and Object Definitions. The logo indicates that the product is LonWorks® interoperable.

LonWorks

An open networking technology platform for interoperable control networks. The generic term for Echelon’s line of networking products.

Management Level Network (MLN)

Communications connection between individual Insight workstations in an APOGEE building control system.

National Electrical Code (NEC)

Code of standards issued by the National Fire Protection Association (NFPA) for “...safeguarding of persons and property from hazards arising from the use of electricity.”

Node

Single Neuron 3120 or 3150 Chip in a LON® product.

Plenum Cable

Specially jacketed cabling (flame resistant and low smoke properties) for use without conduit in air plenums where local code permits.

PXC Compact

The PXC Compact is a series of high-performance, Direct Digital Control (DDC), programmable controllers. The controllers operate stand-alone or networked to perform complex control, monitoring, and energy management functions without relying on a higher-level processor. The Compact series communicates with an Insight workstation and other APOGEE or pre-APOGEE field panels on a peer-to-peer Automation Level Network (ALN).

PXC Modular

The PXC Modular is a global hardware platform. It has installation flexibility, a capability for large point counts, and supports FLN devices. The Modular series communicates with an Insight workstation and other APOGEE or pre-APOGEE field panels on a peer-to-peer Automation Level Network (ALN), and with TX-I/O modules directly through the TX-I/O self-forming bus.

Signaling Line Circuit (SLC)

Used in a Protective Signaling System (that is, fire or security) to carry multiple signals. Typically, the communication channel (trunk) between a central monitoring station and remote units at an APOGEE Automation System.

Snubber

Series resistor capacitor suppression network designed to control the maximum voltage spike across a circuit.

Structured Cabling

Wiring system conforming to industry standards and practices for use by voice and data communication networks. Refers to cable, both copper and fiber optic, and associated hardware including telecommunications closets.

Sub-system

One or more LON nodes working together and being managed by a single network management tool.

System

One or more independently managed LON sub-systems working together.

THHN

Flame retardant, heat resistant, thermoplastic covered wire.

TIA

Telecommunications Industry Association

TX-I/O

TX-I/O™ is a line of I/O modules with associated power and communication modules for use within the APOGEE Automation System.

TX-I/O Modules

TX-I/O Modules provide I/O points for the APOGEE Automation System based upon TX-I/O Technology. TX-I/O Technology provides flexibility of point types, tremendous flexibility of signal types and support for manual operation.

Shielded Twisted Pair (STP)

Stranded or solid wire twisted into pairs. Shielding is individually wrapped around each twisted pair or around all twisted pairs contained in the sheath.

Unshielded Twisted Pair (UTP)

Stranded or solid wire twisted into pairs. Multiple twisted pairs may be contained in the same sheath.

Virtual AEM (VAEM)

Firmware emulation of an APOGEE Ethernet Microserver (AEM). See *AEM/AEM100/AEM200* in this Glossary.

Index

Issued by
Siemens Industry, Inc.
Building Technologies Division
1000 Deerfield Pkwy
Buffalo Grove IL 60089
Tel. +1 847-215-1000

Document ID 125-3002 125-3002(MA)
Edition 2017-05-04