Automation Server Family

Hardware

Reference Guide

04-15001-03-en
December 2014

Schneider Electric

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Contents

Introduction

Reference

Introduction

The Introduction part contains information on the purpose of this guide, how this guide is organized, where to find more information, and information on regulatory notices.

1 About This Guide

Topics

1.1 Purpose of This Guide

This guide provides information about the Building Operation hardware, such as Automation Servers, Power Supplies, and I/O modules. This information is intended to help you understand the different types of hardware that can be in a Building Operation system, as well as how to use the hardware.

1.2 How This Guide is Organized

This Building Operation Guide is divided into the following parts:

Introduction

The Introduction part contains information on the purpose of this guide, how this guide is organized, where to find more information, and information on regulatory notices.

Reference

The Reference part contains conceptual information, procedures, user interface descriptions and troubleshooting information. If you want more information, see WebHelp or the other Building Operation Reference Guides.

1.3 Typographical Conventions

Building Operation Guides use the following specially marked texts:

Tip

Helps you understand the benefits and capabilities of the product.

Note

Provides you with supplementary information.

Important

Alerts you to supplementary information that is essential to the completion of a task.

Caution

Alerts you to a condition that can cause loss of data.

Warning

Alerts you to a condition that can cause product damage or physical harm.

Bold texts:

User interface items, such as property names and buttons, are written in bold, for example "On the **File** menu, select **New**."

2 Additional Information

Topics

2.1 Where to Find Additional Information

All the technical Building Operation information is available online, on WebHelp.

WebHelp is a web-based help system for StruxureWare Building Operation and Automation Server Family products, the software and hardware that powers SmartStruxure solution.

By pressing F1 or clicking a Help button in the StruxureWare Building Operation software your web browser opens WebHelp with the latest, up-to-date, technical documentation.

Figure: Help in StruxureWare Building Operation

Some StruxureWare Building Operation software products give you context-sensitive help by opening a WebHelp page that explains the view or dialog box you have in focus. Some programs open up an overview page. From these pages, you can follow the links to get more detailed information.

WebHelp contains all the technical information that is in the guides, specification sheets, and installation instructions.

The WebHelp site

One of the advantages with WebHelp is that you can reach Help without having the StruxureWare Building Operation software installed on your computer. By entering the URL address help.sbo.schneider-electric.com you can access WebHelp from any computer, smartphone, or tablet connected to the internet.

Finding information

The easiest way to find information on WebHelp is to search for it.

Figure: Home page search

All technical information is gathered in one place, so you do not need to know which guide, specification sheet, or installation instruction the information is in.

Filtering the information

To narrow down the search results, you can use these filters:

- Product
- Functionality
- Information type

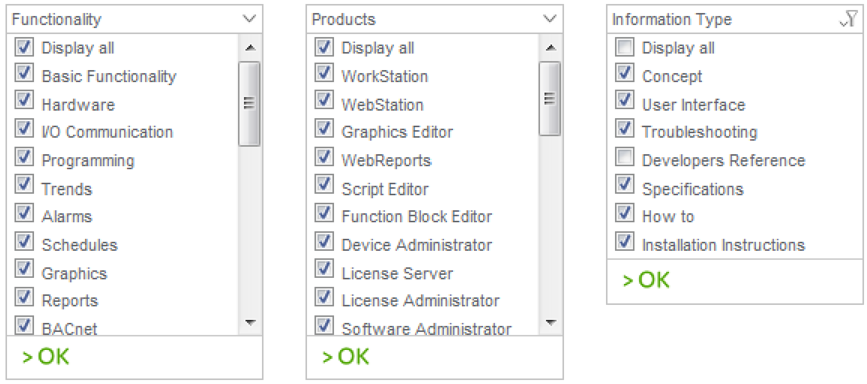


Figure: Search filters

2.2 Regulatory Notices

UL 916 Listed products for the Unites States and Canada, Open Class Energy Management Equipment.

WEEE - Directive of the European Union (EU)

This equipment and its packaging carry the waste of electrical and electronic equipment (WEEE) label, in compliance with European Union (EU) Directive 2002/96/EC, governing the disposal and recycling of electrical and electronic equipment in the European community.

CE - Compliance to European Union (EU)

2004/108/EC Electromagnetic Compatibility Directive

This equipment complies with the rules, of the Official Journal of the European Union, for governing the Self Declaration of the CE Marking for the European Union as specified in the above directive(s) per the provisions of the following standards: IEC/EN 61326-1 Product Standard, IEC/EN 61010-1 Safety Standard.

Industry Canada

ICES-003

This is a Class B digital device that meets all requirements of the Canadian Interference Causing Equipment Regulations.

N1831

C-Tick (Australian Communications Authority (ACA))

AS/NZS 3548

This equipment carries the C-Tick label and complies with EMC and radio communications regulations of the Australian Communications Authority (ACA), governing the Australian and New Zealand (AS/NZS) communities.

Federal Communications Commission

FCC Rules and Regulations CFR 47, Part 15, Class B

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference. (2) This device must accept any interference received, including interference that may cause undesired operation.

Reference

The Reference part contains conceptual information, procedures, user interface descriptions and troubleshooting information. If you want more information, see WebHelp or the other Building Operation Reference Guides.

3 Hardware

Topics

3.1 Hardware Overview

The Schneider Electric hardware devices for SmartStruxure solution include the Automation Server, PS-24V power supply, and I/O modules.

3.1.1 Device Components

Each device consists of a terminal base and an electronics module.

For more information, see section 3.2 “Device Components” on page 32.

3.1.2 Automation Server Family Devices

The Automation Server family consists of the PS-24V power supply, the Automation Server, and the I/O modules.

For more information, see section 3.3 “Automation Server Family Devices” on page 34.

3.1.3 Wiring

The wiring recommendations provide guidance regarding wiring of the I/O modules and the Automation Server.

For more information, see section 9.1 “Wiring” on page 159.

3.2 Device Components

Each device consists of a terminal base and an electronics module.

The electronics module has two handles, which have to be pulled out when removing the module from or inserting the module to the terminal base. In their inner position, the handles lock the module to the terminal base. This effectively prevents unintentional separation. Two plastic label carriers can carry labels that show field markings. Wiring connections are made at terminal blocks contained on the terminal base. The terminal screws are accessible without removing the module. Power for all devices is taken from the 24 VDC rails of the backplane that is part of the terminal base.

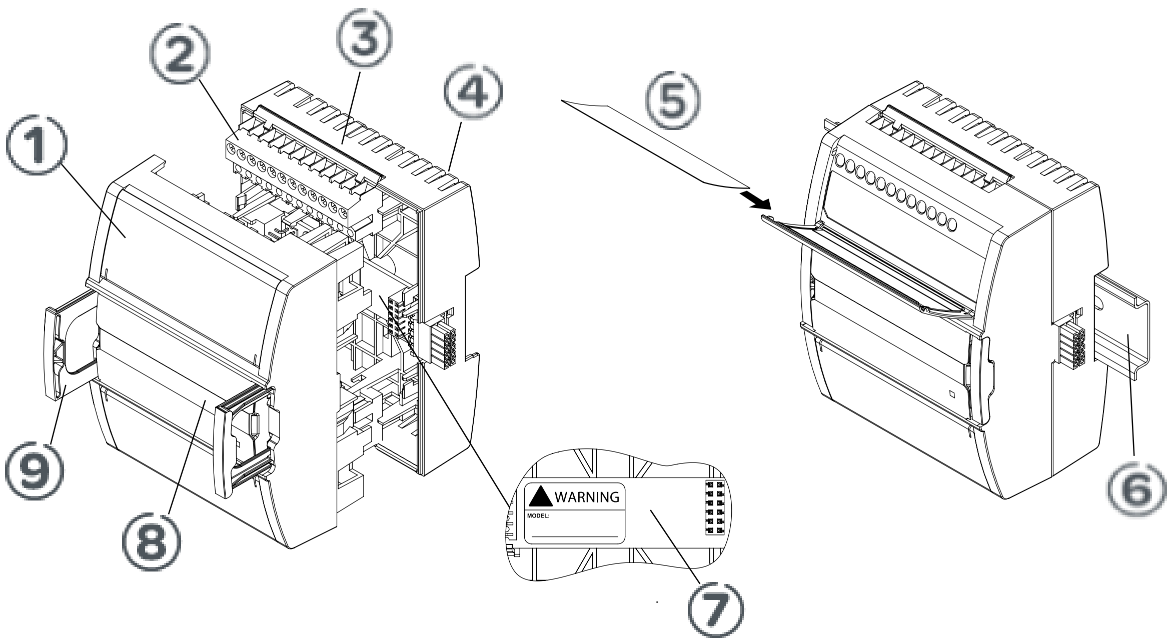


Figure: General assembly

Number	Device Parts
①	Electronics module
②	Terminal block
③	Terminal base
④	Ventilation slot
⑤	Label carrier
⑥	DIN rail
⑦	Backplane board with device label
⑧	LEDs
⑨	Handle

Number	Device Parts

3.2.1 Terminal Bases

There are three different types of terminal bases: one for power supplies (PS-24V), one for Automation Servers, and one for I/O modules.

For more information, see section 4.1 “Terminal Bases” on page 37.

3.2.2 Electronics Modules

There are three different types of electronics modules: power supplies (PS-24V), Automation Servers, and I/O modules.

For more information, see section 5.1 “Electronics Modules” on page 61.

3.3 Automation Server Family Devices

The Automation Server family consists of the PS-24V power supply, the Automation Server, and the I/O modules.

3.3.1 Power Supply PS-24V

PS-24V is the power supply for the Automation Server and its connected I/O modules. The PS-24V power supply requires an input voltage of either 24 VAC +/–20 % or 24–30 VDC.

For more information, see section 6.1.1 “” on page 69.

3.3.2 Automation Servers

An Automation Server is a Schneider Electric manufactured embedded device that generally serves as the lowest tier Building Operation server within the Building Operation product family. The Automation Server controls and supervises equipment, typically HVAC equipment. It uses I/O modules with connected field devices, such as sensors and actuators, to do that.

For more information, see section 7.1 “Automation Servers” on page 77.

3.3.3 I/O Modules

By adding a variety of I/O and power supply modules, you can use the Automation Server to tailor the Intelligent Building Management System to your unique requirements.

For more information, see section 8.1 “I/O Modules” on page 91.

4 Terminal Bases

Topics

4.1 Terminal Bases

There are three different types of terminal bases: one for power supplies (PS-24V), one for Automation Servers, and one for I/O modules.

Figure: Terminal base for I/O modules

The difference between the terminal bases for Automation Servers and I/O modules is that the terminal base for Automation Servers has one terminal block, whereas the terminal base for I/O modules has two terminal blocks. The terminal bases for Automation Servers and I/O modules have the same backplane boards, which are connecting the power bus, the address bus, and communication bus from the left bus connector to the right bus connector. A common name for these buses is the I/O bus.

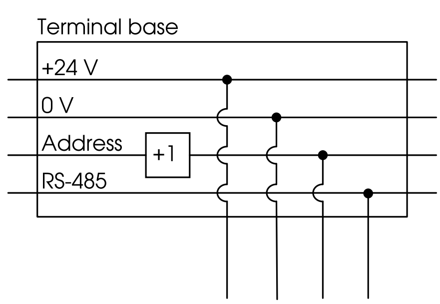


Figure: Internal configuration for the Automation Server and I/O module terminal base

The terminal base for power supplies has a different backplane board, which does not pass through the power bus input from the left connector and allows the power supply to supply only the Automation Server and I/O modules installed to the right with power. The ground connection is connected from the left bus connector to the right bus connector in all terminal bases, because it is used as a common signal ground for the address bus as well as the communication bus.

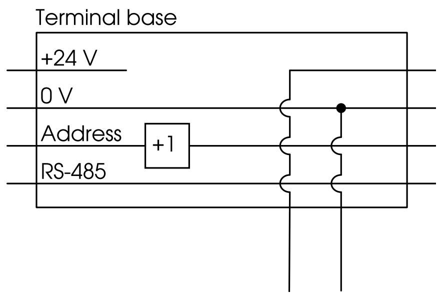


Figure: Internal configuration for the power supply terminal base

4.1.1 Backplane Board

A backplane board is mounted in the terminal base for the W1 width devices. The backplane board is equipped with two 2x5-pin bus connectors, a 2x6-pin electronics module connector, address logic circuitry, and a device label.

For more information, see section 4.2 “Backplane Board” on page 39.

4.1.2 Device Addressing

Each device can detect its order in the chain of connected devices and assigns itself an address accordingly. This auto-addressing feature is provided by the terminal base backplane.

For more information, see section 4.3 “Device Addressing” on page 42.

4.1.3 Device Installation

The devices are designed mainly for installing on DIN rails in a cabinet.

For more information, see section 4.4 “Device Installation” on page 44.

4.1.4 I/O Bus

The I/O bus is a common bus that delivers power, address information, and communication to all devices connected to the bus. The I/O bus is provided to the devices through the backplane in the terminal bases. The term I/O bus also denotes the chain of devices that are connected together.

For more information, see section 4.8 “I/O Bus” on page 52.

4.2 Backplane Board

A backplane board is mounted in the terminal base for the W1 width devices. The backplane board is equipped with two 2x5-pin bus connectors, a 2x6-pin electronics module connector, address logic circuitry, and a device label.

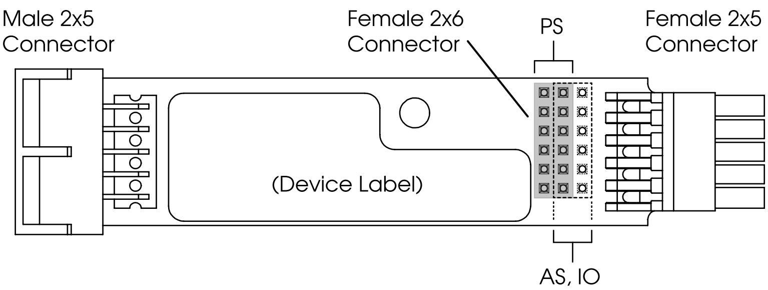


Figure: Backplane board

There are two versions of the backplane board:

- The Automation Server and I/O module version passes power through from the left to the right connector.
- The power supply version does not pass power through from the left to the right connector.

The two backplane board versions incorporate different locations of the 6x2 electronics module connector. This arrangement prevents power interference problems if one or more power supplies are unintentionally installed on terminal bases that are designed for I/O modules or Automation Servers.

4.2.1 2x5 Connectors

The right connector establishes connection with the left connector of the next terminal base when the terminal bases are connected together.

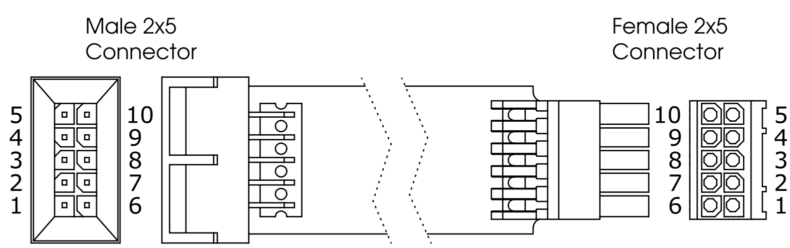


Figure: Pinout for the left and right 2x5 connectors, seen from the outside

The pins are used as follows:

Table: Backplane Connector Pin Usage

Pin number		Pin number	
5	Address bit #4 (MSB)	10	+24 V backplane power
4	Address bit #3	9	+24 V bus power

Continued

Pin number		Pin number	
3	Address bit #2	8	GND
2	Address bit #1	7	RS-485 – bus communication
1	Address bit #0	6	RS-485 + bus communication

4.2.2 6x2 Connector

The internal connector fetches or supplies power from/to the electronics module that is installed on the terminal base.

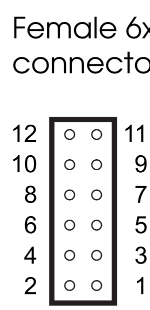


Figure: Pinout for the 6x2 connector

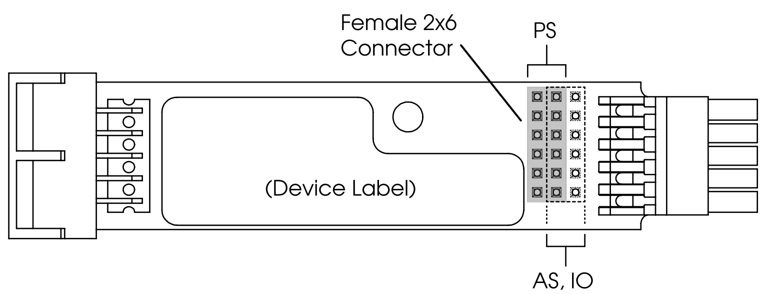


Figure: The 6x2 connector and its two positions

For the power supply, the connector resides in the left position and the pins are used as follows:

Table: MB-1X-PS: Power Supply

Pin number		Pin number	
12	+24 V power to bus	11	GND
10	+24 V power to bus	9	GND
8	+24 V backplane power	7	Address bit #3

Continued

Pin number		Pin number	
6	Address bit #4 (MSB)	5	Address bit #2
4	RS-485 – bus communication	3	Address bit #1
2	RS-485 + bus communication	1	Address bit #0

For the Automation Server and I/O modules, the connector resides in the right position and the pins are used as follows:

Table: MB-1X: Automation Server and I/O Modules

Pin number		Pin number	
12	GND	11	+24 V bus power
10	GND	9	+24 V bus power
8	Address bit #3	7	GND
6	Address bit #2	5	Address bit #4 (MSB)
4	Address bit #1	3	RS-485 – bus communication
2	Address bit #0	1	RS-485 + bus communication

4.2.3 Address Logic Circuitry

The backplane board includes circuitry that provides the electronics module that is installed on the terminal base with a 5-bit address.

The logic circuitry accepts a 5-bit address input from the device to the left and adds “1” to the input address. The incremented output address is passed to the next backplane in the device to the right. The leftmost position (slot) has the address 1.

The address circuitry on the backplane receives it power from the +24 V backplane power. This is separated from the +24 V bus power.

4.2.4 Device Label

The device label on the backplane board is used for writing down what type of electronics module is intended to be connected to the terminal base.

4.3 Device Addressing

Each device can detect its order in the chain of connected devices and assigns itself an address accordingly. This auto-addressing feature is provided by the terminal base backplane.

The backplane generates an address corresponding to the order (position) of the terminal base in the chain and passes this address through the I/O bus to the electronics module that is installed on the terminal base.

The leftmost device in the chain gets the address 1. The next device gets the address 2, and so on, up to 32. Position 1 is reserved for a power supply. Position 2 is reserved for the Automation Server. For more information, see section 4.10 “I/O Bus Restrictions” on page 54.

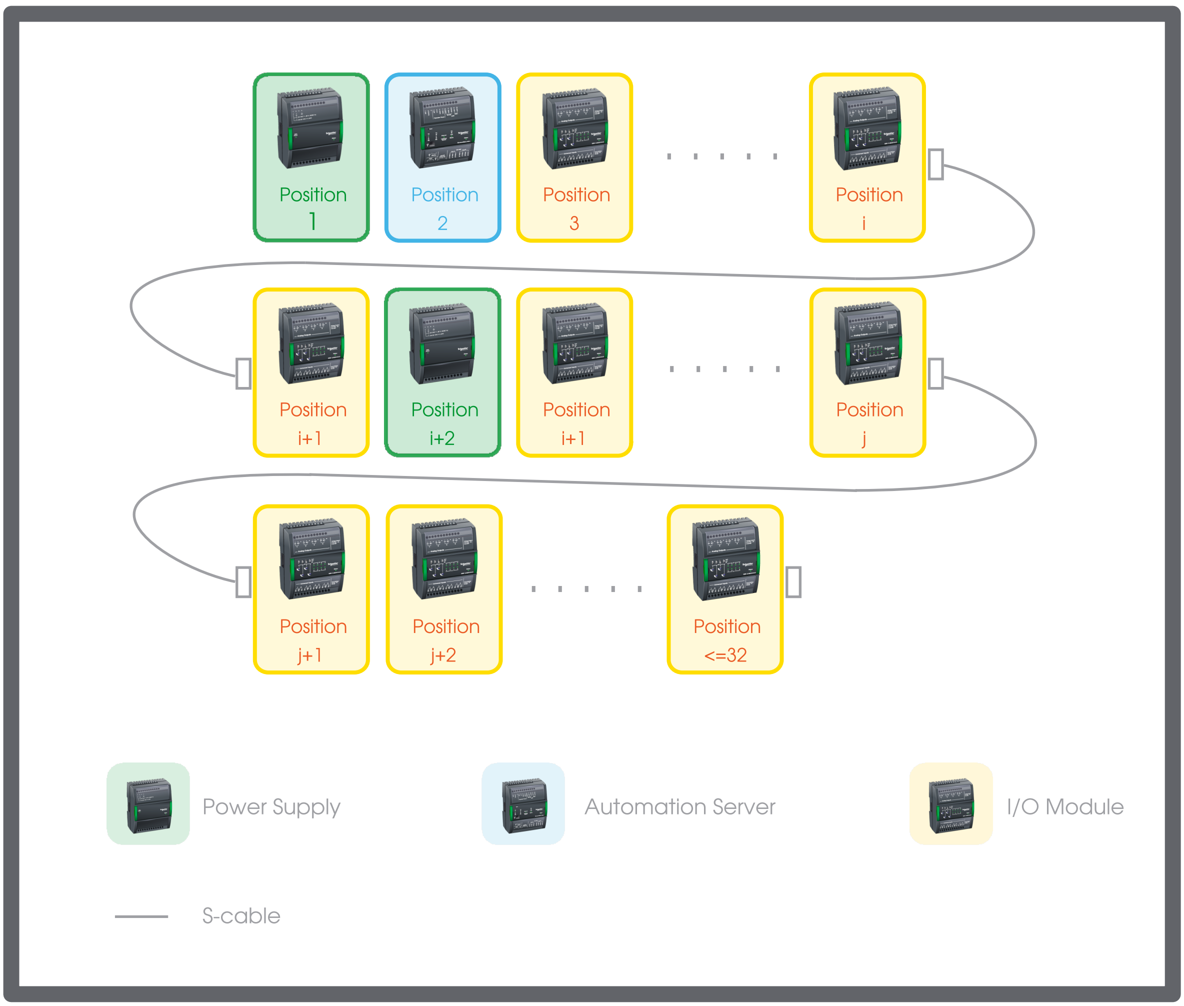


Figure: Device addressing

Although the power supply device gets an address, the PS-24V does not use it.

When you replace an electronics module, the new module automatically picks up the same address. If you remove an electronics module from its terminal base, the addresses of the following devices are not affected.

In Building Operation WorkStation, you create a logical I/O module to be associated with the physical I/O module on the I/O bus. You specify the I/O module type and name. Initially, the module ID is Null, which means that the I/O module is non-operational. You assign a module ID that is equal to the address (position) of the I/O module on the I/O bus. You can configure the module ID either when you create the logical I/O module or later. When the I/O module is plugged into the system at the intended position on the bus, Building Operation automatically associates the I/O module with the logical I/O module that has a matching module ID and type.

4.4 Device Installation

The devices are designed mainly for installing on DIN rails in a cabinet.

Consider a simple example:

Figure: System ex. 1. A Power supply, an Automation Server, and two I/O modules

Each device consists of two parts:

- Terminal base
- Electronics module

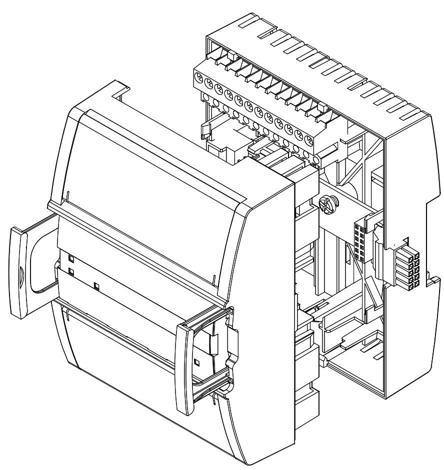


Figure: A hardware device: the electronics module and the terminal base

A separate terminal base means the terminal base can be installed and wired long before the electronics module with the application program and data is supplied.

The terminal base is usually installed on a DIN rail, but it can also be mounted directly on the wall. The electronics module is easily plugged in to the terminal base and firmly locked by pushing the handles in place.

Replacing an electronics module is done in seconds since no terminal wiring is affected.

4.4.1 DIN Rail Installation

The terminal bases are installed on the DIN rail, with the power supply terminal base to the far left.

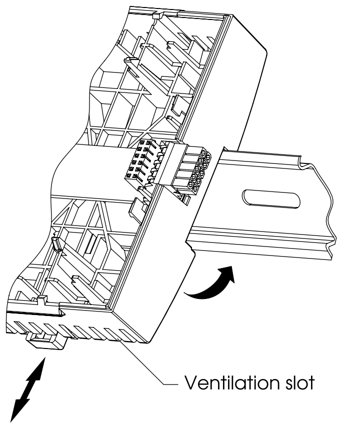


Figure: Terminal base installed on a DIN rail

Caution

For proper cooling air flow through the device, install the terminal base with its ventilation slots pointing up and down.

The terminal bases are connected to each other by sliding the terminal bases together using the built-in connectors.

To ensure that the correct electronics module is used with the correct terminal base, you must always check that the warning label on the terminal base backplane indicates which module type is to be connected. Write the intended module type, if it is not already printed, on the label.

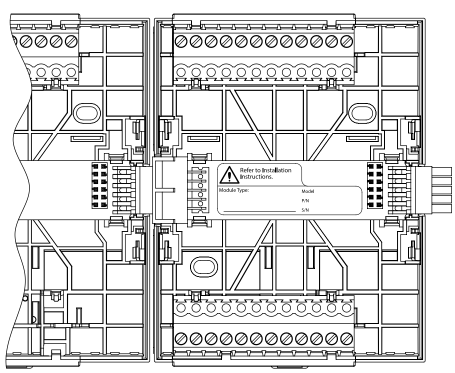


Figure: Terminal base with label for intended module type

Warning

Install only the module type that is indicated on the label on the terminal base backplane. If the label does not indicate the intended module type, consult the control panel documentation to determine the intended module type. A mismatch can cause electric shock and damage the electronics module.

To prevent the modules from sliding sideways on the DIN rail, fix an end clamp for DIN 35 tightly against the rightmost device on the rail. The end clamp is easily removed if you bend the snap lock open with a screwdriver.

Figure: End clamp for DIN 35 fixed across the DIN rail

The chain of devices can be split on multiple DIN rails (rows) by using an extension cord called S-cable. Maximum five S-cables are allowed per system. The S-cable connects the last (rightmost) device on one DIN rail with the first (leftmost) device on the next DIN rail. The complete chain of devices must remain within one cabinet for EMC reasons.

The following figure shows an example of how you can use an S-cable to connect devices that are installed on separate DIN rails in a cabinet. For proper cooling air flow through the devices, the DIN rails and the devices should be installed horizontally in the cabinet, as shown in the figure.

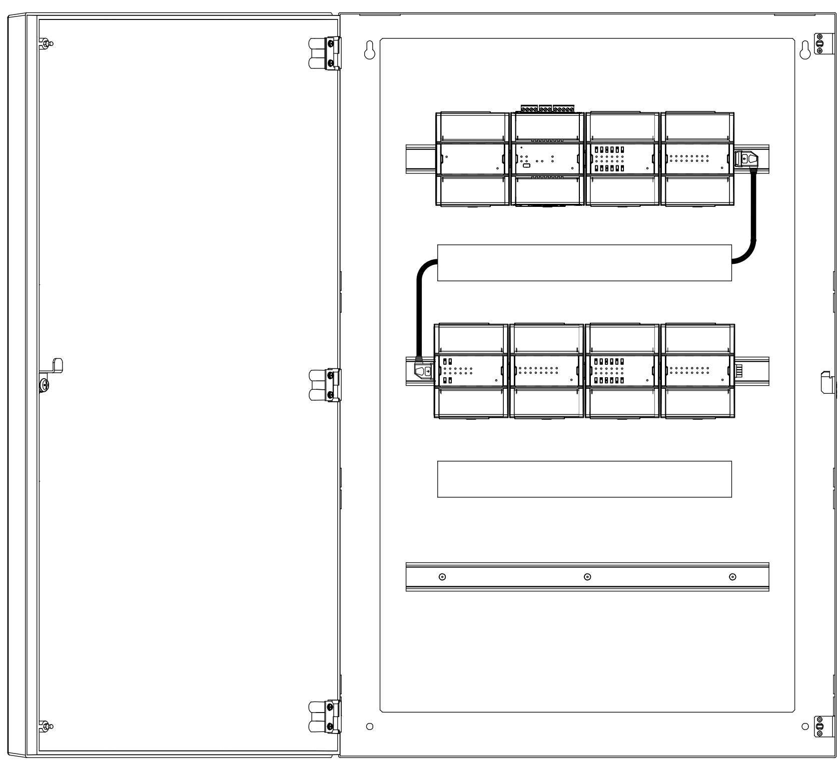


Figure: Devices installed on separate, horizontal rails and connected using an S-cable

The S-cable is available with right angle connectors and in 1.5 m (5 ft) and 0.75 m (2 ft 5 in) lengths. You can serially connect up to two S-cables to extend the length.

The following image shows the minimum space required for plugging/unplugging the S-cable from the device but also provides information on the minimum bend radius required to reduce the stress of the cable. The S-cable with straight connectors is a discontinued product, which can no longer be ordered from Schneider Electric.

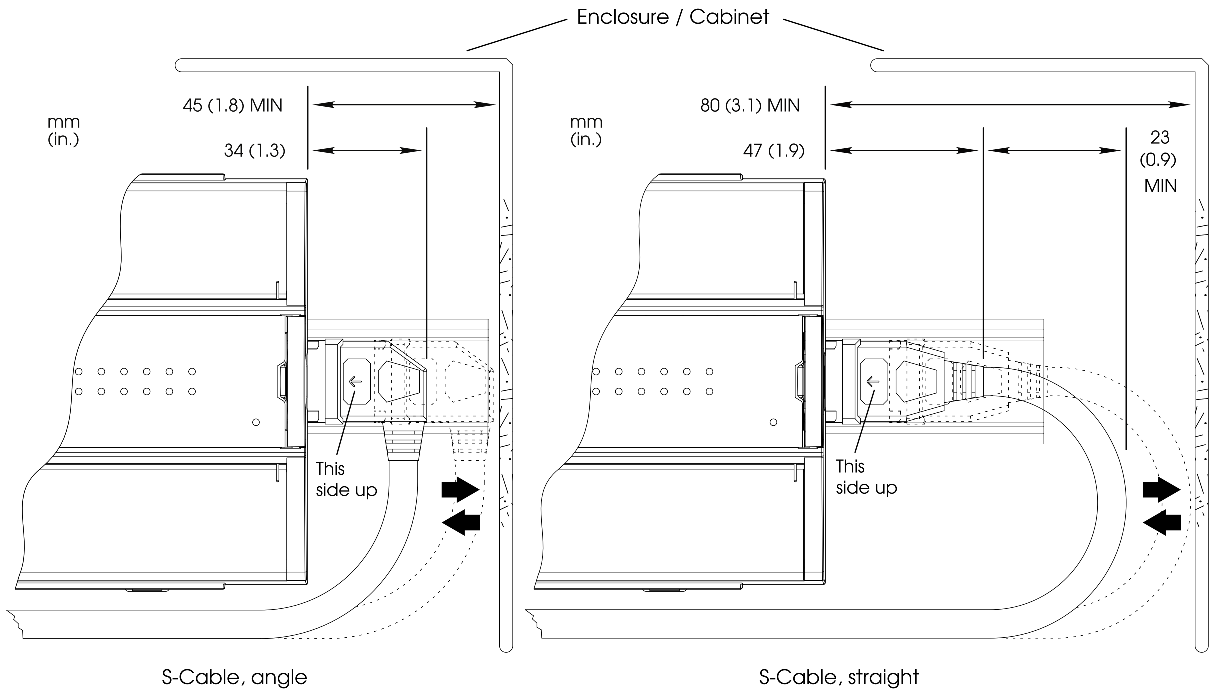


Figure: S-cable connecting devices on separate rails

4.4.2 Device Order

The order in which the devices are installed in the chain (I/O bus) is important. The devices should be installed in the following order:

- Position 1 (leftmost): Power supply (mandatory)
- Position 2: Automation Server (mandatory)
- Position 3-32: I/O modules and extra power supplies as needed based on power budget. One power supply can supply power for loads up to 30 W. For more information, see section 6.3 “Power Budget” on page 73.

Note

There is a limit of one Automation Server per I/O bus.

The rules are summarized in the following illustration.

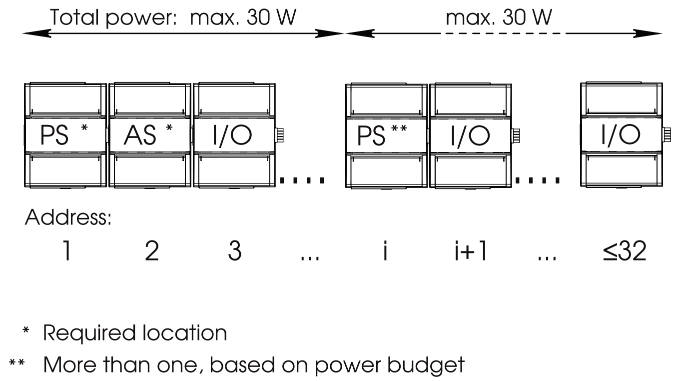


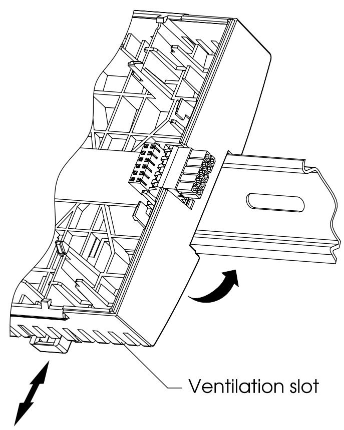
Figure: Order of devices on the I/O bus

4.5 Installing a Terminal Base on a DIN-rail

You install a terminal base on a DIN-rail prior to connecting it to its neighboring terminal bases.

To install a terminal base on a DIN-rail

1. Pull down the DIN-rail clip.



2. Hook the terminal base onto the top of the DIN-rail.
3. Push the terminal base fully onto the DIN-rail and release the DIN-rail clip.

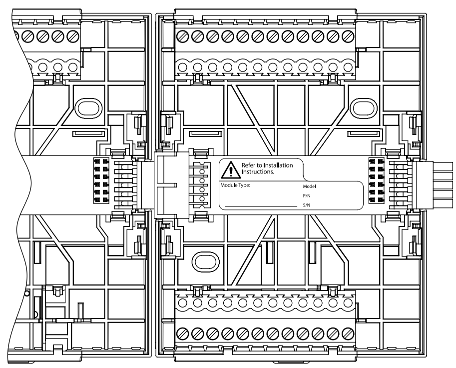
> **Caution**
>
> For proper cooling air flow through the device, install the terminal base with its ventilation slots pointing up and down.

4.6 Connecting Terminal Bases

You connect terminal bases together to provide continuity of the power supply and the address bus.

To connect terminal bases

1. Ensure that each terminal base is clipped to the DIN-rail.
2. Push each terminal base firmly against its neighbor to the left, ensuring that the power supply and address bus connector is properly mated.



3. On the backplane label of each terminal base, write the type of module to be connected to that terminal base.

> **Warning**
>
> Install only the module type that is indicated on the label on the terminal base backplane. If the label does not indicate the intended module type, consult the control panel documentation to determine the intended module type. A mismatch can cause electric shock and damage the electronics module.

You can now wire the terminal base.

4.7 Wiring a Terminal Base

You can wire a terminal base prior to installing an electronics module.

Note

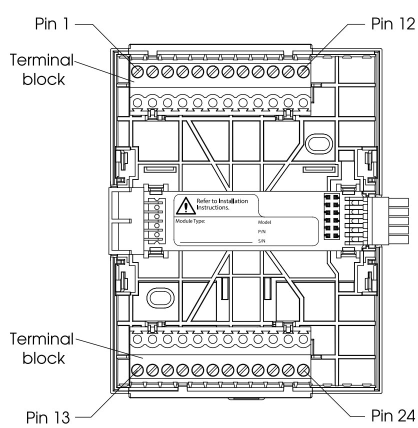
- Wiring can also be carried out after a module has been installed in its terminal base.
- Always use the recommended cables.

Warning

- Some modules or terminal bases may carry lethal voltages. Isolate the supply before wiring.

To wire a terminal base

1. To access the terminal block screws, remove the electronics module or open the clear plastic label carrier.



2. Strip back the individual wires and insert each one into its correct terminal. Fasten securely using a small flat-blade screwdriver.
3. Close the top clear plastic label carrier or refit the electronics module.

4.8 I/O Bus

The I/O bus is a common bus that delivers power, address information, and communication to all devices connected to the bus. The I/O bus is provided to the devices through the backplane in the terminal bases. The term I/O bus also denotes the chain of devices that are connected together.

4.8.1 I/O Bus Parts

The I/O bus consists of the following parts:

- Power bus
- Address bus
- Communication bus

For more information, see section 4.9 “I/O Bus Parts” on page 53.

4.8.2 I/O Bus Restrictions

The I/O bus imposes restrictions on the number of devices that can be connected to the bus and what type of devices that are allowed on certain positions.

For more information, see section 4.10 “I/O Bus Restrictions” on page 54.

4.9 I/O Bus Parts

The I/O bus consists of the following parts:

- Power bus
- Address bus
- Communication bus

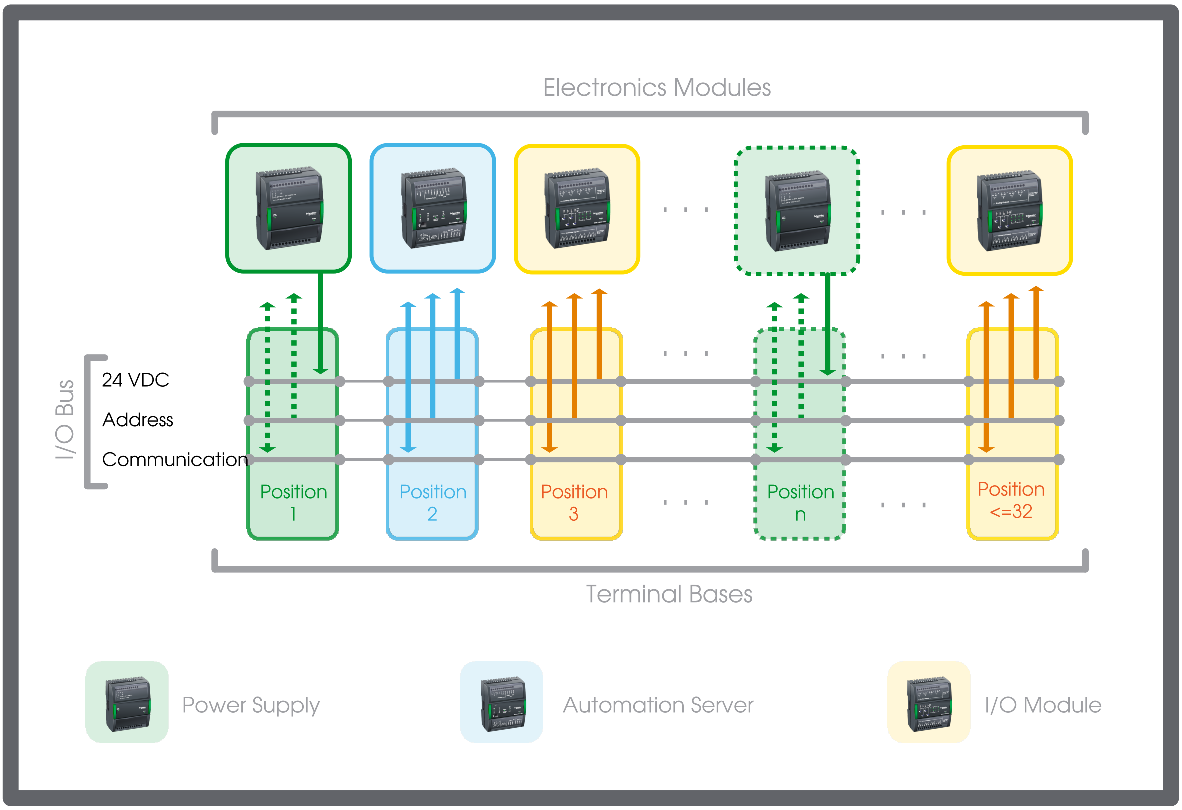


Figure: I/O bus parts

All the buses use a common ground, which is connected to the signal return paths with terminals called "RET". The signal return path is also called signal ground.

The power bus distributes 24 VDC power from the power supply to the Automation Server and I/O modules.

The address bus is used to pass the address (position) from the terminal base backplane to the electronics module that is installed on the terminal base and to the next terminal base on the I/O bus.

The communication bus enables serial (RS-485) communication between the Automation Server and the I/O modules. The Automation Server controls and supervises the communication on the communication bus. The I/O modules also monitor their communication status. When a new I/O module is configured and connected to the I/O bus, the Automation Server automatically detects the new device.

4.10 I/O Bus Restrictions

The I/O bus imposes restrictions on the number of devices that can be connected to the bus and what type of devices that are allowed on certain positions.

The following restrictions apply to the I/O bus:

- Maximum 32 devices per I/O bus
- Maximum one Automation Server per I/O bus
- Position 1 reserved for a power supply
- Position 2 reserved for the Automation Server

Note

- Even when connected by an S-cable, no more than 32 devices are allowed on the I/O bus.

4.11 Printing a Wiring List for the I/O Bus

You print an I/O wiring list for the I/O bus that describes which I/O points are associated with each I/O module. You use the printed copy of this list to help wire the I/O bus network.

Note

- You cannot print a wiring list for an I/O module with a Module ID of Null (unconfigured).
- I/O points with a channel of Null do not display on the wiring list.

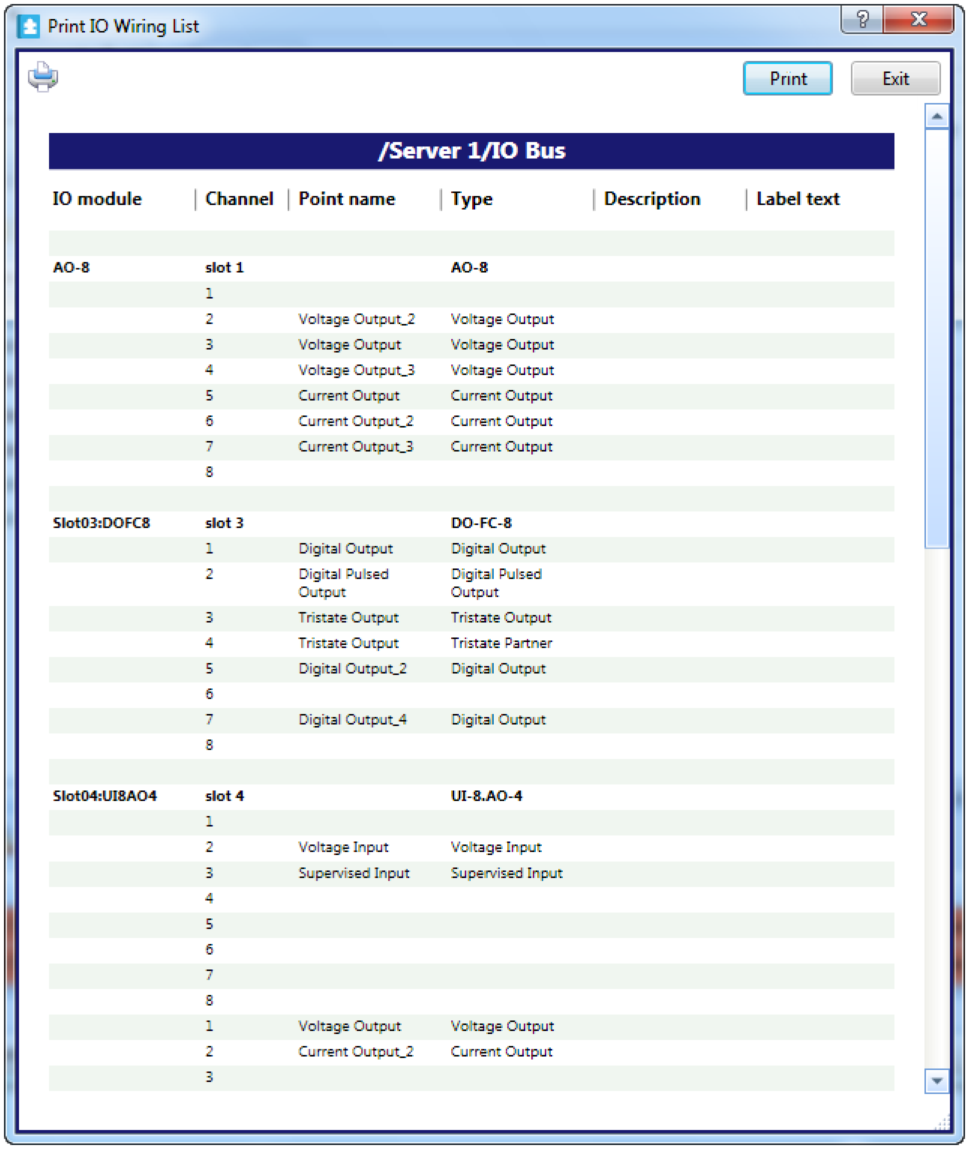
For more information, see section 4.9 “I/O Bus Parts” on page 53.

To print an I/O wiring list for the I/O bus

1. In WorkStation, in the **System Tree** pane, expand the **IO Bus**.

Continued on next page

2. Right-click **IO Bus** and then click **Print IO wiring list** to print a wiring list for the entire I/O bus.



IO module	Channel	Point name	Type	Description	Label text
AO-8	slot 1		AO-8		
	1				
	2	Voltage Output_2	Voltage Output		
	3	Voltage Output	Voltage Output		
	4	Voltage Output_3	Voltage Output		
	5	Current Output	Current Output		
	6	Current Output_2	Current Output		
	7	Current Output_3	Current Output		
	8				
Slot03:DOFC8	slot 3		DO-FC-8		
	1	Digital Output	Digital Output		
	2	Digital Pulsed Output	Digital Pulsed Output		
	3	Tristate Output	Tristate Output		
	4	Tristate Output	Tristate Partner		
	5	Digital Output_2	Digital Output		
	6				
	7	Digital Output_4	Digital Output		
	8				
Slot04:UI8AO4	slot 4		UI-8.AO-4		
	1				
	2	Voltage Input	Voltage Input		
	3	Supervised Input	Supervised Input		
	4				
	5				
	6				
	7				
	8				
	1	Voltage Output	Voltage Output		
	2	Current Output_2	Current Output		
	3				

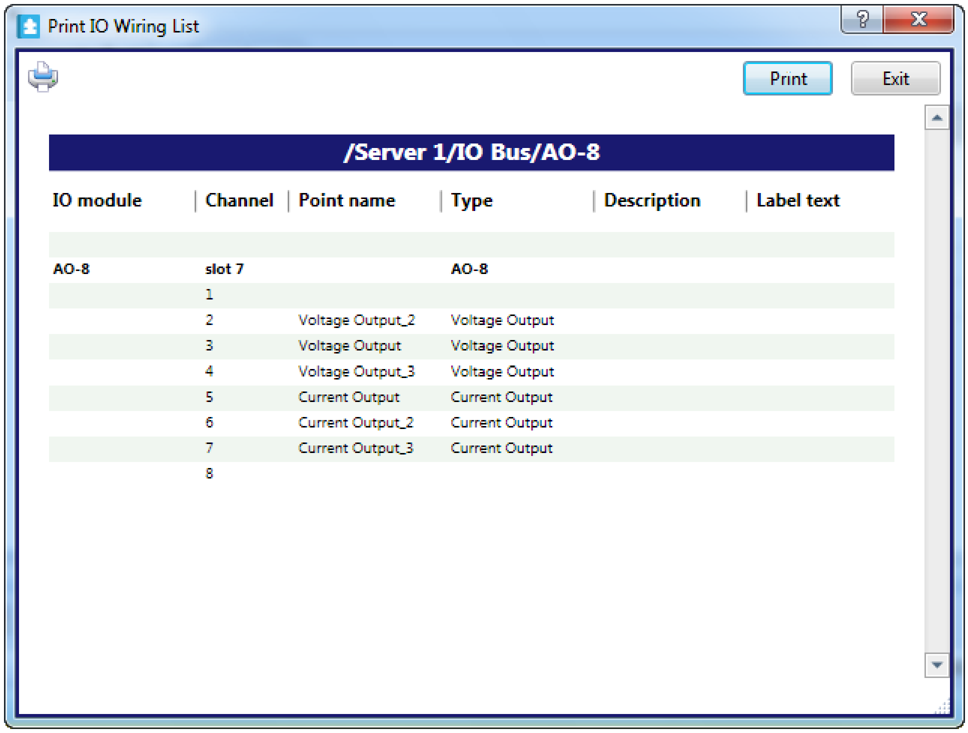
3. In the **Print IO Wiring List** dialog box, click the **Printer** icon  to print the I/O wiring list.

4. To print a wiring list for a single I/O module, right-click the selected I/O module (AO-8 in this example).

Continued on next page

5. Click **Print IO wiring list**.

   You can also select multiple I/O modules in the **List View**.



6. Click the **Printer** icon  to print the wiring list.

Observe that the complete path to the I/O module is displayed on the title bar for the I/O wiring list.

5 Electronics Module

Topics

5.1 Electronics Modules

There are three different types of electronics modules: power supplies (PS-24V), Automation Servers, and I/O modules.

5.1.1 Status LEDs

The Status LED on the front of the Automation Server, I/O modules, and PS-24V Power Supply changes color and flashes to indicate the status of the device.

For more information, see section 5.2 “Status LEDs” on page 62.

5.2 Status LEDs

The Status LED on the front of the Automation Server, I/O modules, and PS-24V Power Supply changes color and flashes to indicate the status of the device.

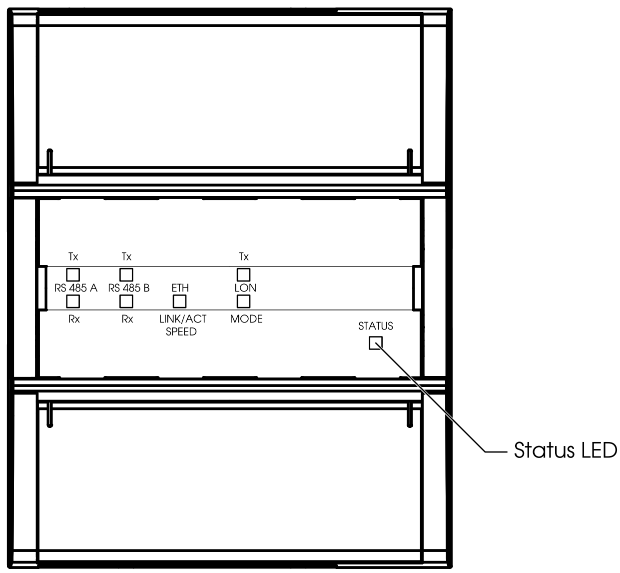


Figure: The Automation Server with the Status LED

The remaining LEDs on the front differ in number and meaning for the different devices and are explained in the sections about the specific device.

5.2.1 Automation Server Status LED

The Automation Server Status LED indicates the condition of the device according to the following table.

Table: Automation Server Status LED Patterns

LED Patterns	**Condition**
Green, constant	Normal operation, status OK
Green, flashing (~1 Hz)	Device restarting, wait
Red, constant	Fatal error - attention required
Red, flashing (~1 Hz)	Device operates, but a problem needs attention
Red/green, flashing (~1 Hz)	Firmware being downloaded, wait
Red/green, vague	Device firmware upgrade mode, wait
Red/green, vague	Reset button has been pressed for more than 8 s, meaning cold start will be made when button is released

Continued

LED Patterns	Condition
No light	No input power

5.2.2 I/O Module Status LED

The I/O Module Status LED indicates the condition of the device according to the following table.

Table: I/O Module Status LED Patterns

LED Patterns	Condition
Green, constant	Online and configured (at least one channel/point downloaded successfully)
Green, flashing (200 ms ON, 200 ms OFF)	Online and unconfigured (physical module that either matches/mismatches logical module)
Green, slow flashing (approximately every 3 s)	Low power mode (saves energy)
Red, constant	Error requiring attention (for example, the input voltage is too low)
Red, flashing (100 ms ON, 100 ms OFF)	Offline with respect to the Automation Server (both configured and unconfigured modules)
Red/Green, flashing (green 100 ms, red 100 ms)	Bootloader mode (downloading data)
No light	No input power

5.2.3 PS-24V Power Supply Status LED

The PS-24V Power Supply Status LED indicates the condition of the device according to the following table.

Table: Power Supply Status LED Patterns

LED Patterns	Condition
Green, constant	Output voltage and load OK
Red/green, flashing	Output slightly overloaded
Red, constant	Output overloaded
No light	No input power

5.3 Installing an Electronics Module on a Terminal Base

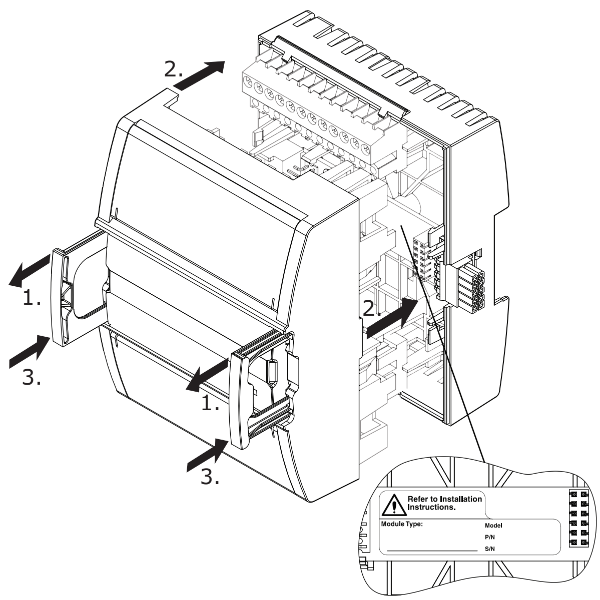
You install an electronics module directly onto the relevant terminal base, where it will connect to the power supply and address bus.

To install an electronics module on a terminal base

1. Pull out the two handles on the left and right sides of the module.
2. Plug in the module to the terminal base, ensuring that the PCB header pins align correctly with the backplane socket, and press firmly.

> **Warning**
>
> Install only the module type that is indicated on the label on the terminal base backplane. If the label does not indicate the intended module type, consult the control panel documentation to determine the intended module type. A mismatch can cause electric shock and damage the electronics module.

3. Push the handles in firmly to lock the module in place.



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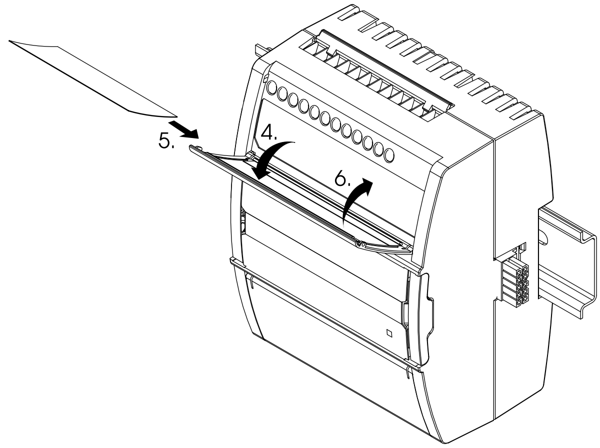
4. Open the clear plastic label carriers.



5. Write and insert the labels.
6. Close the label carriers.

You can now power up the device.

5.4 Powering Up a Device

You perform the following steps to power-up a device.

To power up

1. Check that the device is properly seated in its terminal base.
2. Check that all wiring is correct.
3. Ensure that power is supplied to the backplane.
4. After powering up, check that the Status LED is in the constant green state (can also be off briefly during each period of activity).

6 Power Supplies

Topics

6.1 Power Supply PS-24V

PS-24V is the power supply for the Automation Server and its connected I/O modules. The PS-24V power supply requires an input voltage of either 24 VAC +/–20 % or 24–30 VDC.

PS-24V is usually installed on a DIN rail in a cabinet and provides power to the succeeding devices in the chain through the terminal base backplane. A PS-24V power supply consumes one address position, even though the address is not used.

A system may contain more than one PS-24V to supply the power needed, depending on the type and number of connected devices. A power budget table can be used for proper calculations. For more information, see section 6.3 “Power Budget” on page 73.

The output voltage is 24 VDC supplied on the backplane, maximum 30 W. If the output is overloaded, the power is automatically shut down and the Status LED turns red. At an interval of a couple of seconds the power supply retries to switch on the power output. This is sometimes called ‘the hiccup mode’. For more information, see the *Power Supply Overload* topic on WebHelp.

The power supply has galvanic isolation between the primary (input power) and secondary (output power) side of the power supply.

6.1.1 Specifications

DC output

Voltage ....24 VDC

Accuracy ....+/-1 VDC

Maximum power ....30 W

AC input

Nominal voltage ....24 VAC

Operating voltage range ....+/-20 %

Frequency ....50/60 Hz

Maximum current ....2.5 A rms

Recommended transformer rating ....60 VA or higher

DC input

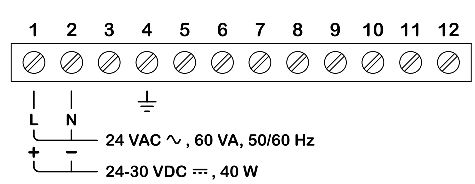
Nominal voltage ....24 to 30 VDC

Operating voltage range ....21 to 33 VDC

Maximum power consumption ....40 W

Terminals

PS-24V



6.1.2 Internal Configuration

The PS-24V power supply module does not connect to the address and communication busses in the terminal base. The AC/DC converter terminals L/+ and N/- are isolated from the circuits on the secondary side of the converter. You can wire these terminals without concern for polarity matching, but it is good practice to connect the positive supply voltage to L/+ and the negative supply voltage to N/- in order to prevent confusion.

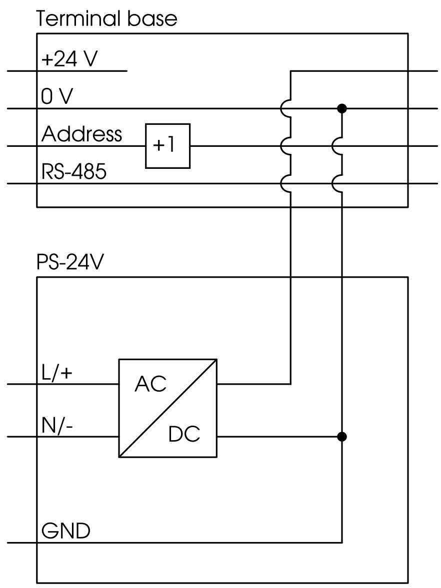


Figure: PS-24V internal configuration

The ground terminal (GND) on the PS-24V power supply is connected to signal ground, which is the same as the negative output from the power supply. The purpose of this connection is to comply with EMC directives.

6.1.3 Power Supply PS-24V LEDs

There are two LEDs on the front panel of the PS-24V. The LEDs indicate status for input and output power.

For more information, see section 6.2 “Power Supply PS-24V LEDs” on page 71.

6.1.4 Power Budget

Use the power budget to calculate the maximum number of devices that the power supply can supply. If more devices are used, additional power supplies must be added to the I/O bus.

For more information, see section 6.3 “Power Budget” on page 73.

6.2 Power Supply PS-24V LEDs

There are two LEDs on the front panel of the PS-24V. The LEDs indicate status for input and output power.

Figure: The PS-24V power supply

Table: Power Supply PS-24V LEDs

Function	Color
Main power	Green
Status	Green/red

Tha Main Power LED indicates status for input power. The Main Power LED indicates the condition according to the following table.

Table: Main Power LED Patterns

LED Patterns	Condition
Green, constant	Input power

Continued

LED Patterns	Condition
No light	No input power

The Status LED indicates status for output power. For more information, see section 5.2 “Status LEDs” on page 62.

6.3 Power Budget

Use the power budget to calculate the maximum number of devices that the power supply can supply. If more devices are used, additional power supplies must be added to the I/O bus.

The power supply delivers and output voltage of 24 VDC +/– 1 V at an output current of about 1.25 A. The power supply can supply power for loads up to 30 W. The number of devices that the power supply can supply has to be calculated based on this figure, 30 W.

To determine the number and position of the power supplies, use the following power budget table.

Table: Power Budget Table

Device	Power (W)
Automation Server (all models)	7.0
UI-16	1.8
DI-16	1.6
RTD-DI-16	1.6
DO-FA-12	1.8
DO-FA-12-H	1.8
DO-FC-8	2.2
DO-FC-8-H	2.2
AO-8	4.9
AO-8-H	4.9
AO-V-8	0.7
AO-V-8-H	0.7
UI-8-DO-FC-4	1.9
UI-8-DO-FC-4-H	1.9
UI-8-AO-4	3.2
UI-8-AO-4-H	3.2
UI-8-AO-V-4	1.0
UI-8-AO-V-4-H	1.0

7 Automation Servers

Topics

7.1 Automation Servers

An Automation Server is a Schneider Electric manufactured embedded device that generally serves as the lowest tier Building Operation server within the Building Operation product family. The Automation Server controls and supervises equipment, typically HVAC equipment. It uses I/O modules with connected field devices, such as sensors and actuators, to do that.

The Automation Server is installed with the I/O modules on DIN rails in cabinets. The Automation Server electronics module uses a W1 enclosure. Power is supplied through the terminal base backplane.

7.1.1 Supported Building Standards

The Automation Server natively communicates with three of the most popular communication protocols:

- BACnet: The Automation Server directly communicates to BACnet/IP and BACnet MS/TP networks, which provides access to b3 devices and BACnet devices.
- LonWorks: The Automation Server has a built-in FTT-10 port, which enables access to Xenta devices and LonWorks devices.
- Modbus: The Automation Server natively integrates Modbus RS-485 master and slave configurations, as well as IP client and server. This integration provides access to devices that communicate on the Modbus protocol, such as power meters, circuit breakers, and lighting controllers.

7.1.2 Memory

The Automation Server has two types of memory:

- 128 MB SDRAM (for program execution)
- 4 GB flash (for storage)

If a power failure occurs, all important variables are automatically saved to the flash memory before complete shutdown. When power returns, this data retention function ensures that the Automation Server can continue to run with the correct set of values.

7.1.3 Communication Ports

The Automation Server has the following communication ports:

- 1 Ethernet 10/100 megabit
- 2 RS-485
- 2 LonWorks (FT and RS-485)
- 2 USB host
- 1 USB device
- 1 backplane I/O bus

The following table describes the ports that are available with the Automation Server.

Table: The Automation Server Communication Ports

Communication port	Connection
Ethernet 10/100	IP, LAN/WAN, Modbus, BACnet
RS-485 COM A	Modbus, BACnet
RS-485 COM B	Modbus, BACnet
LonWorks (FT and RS-485)	LonWorks
USB host	
USB device	Automation Server Device Administrator
Backplane I/O bus	Internal power supply and I/O addressing

There are two USB host ports facing down to connect to external devices, such as telephone modems, printers, memory expansions (USB “sticks” or hard disc drives), and expansion modules. The USB device port on the front is intended for program download from a PC by means of Device Administrator. It is connected to a PC or a downstream port of a hub.

The Ethernet communication is performed over a 10/100BaseTX, 10 or 100 Mbps, twisted pair network. The network is connected to the Automation Server by an RJ45 connector.

7.1.4 Automation Server Screw Terminals

There are 12 screw terminals at the top of the Automation Server and 3+4 plugable screw terminals at the bottom.

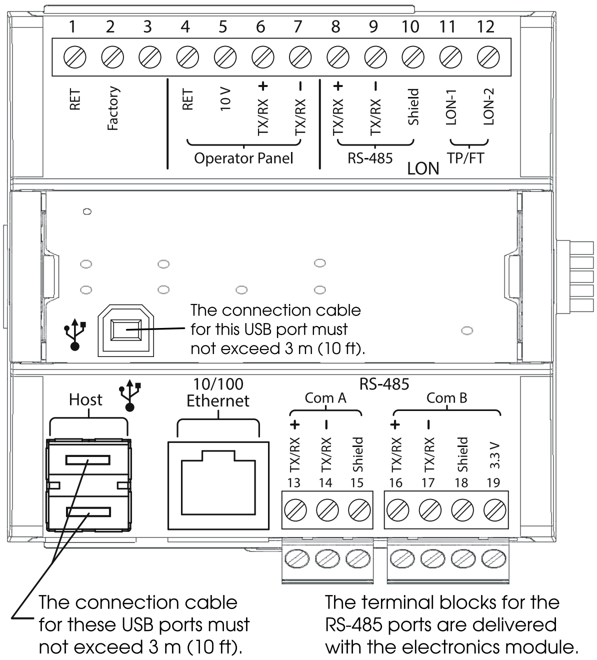


Figure: Automation Server screw terminals and other connectors

Table: Top Side Screw Terminals, Automation Server

Terminal number	**Designation**	**Usage**
1	RET	Internally connected to ground
2	FACTORY	No function
3		
OPERATOR PANEL[a]		
4	RET	Internally connected to ground
5	10 V	10 VDC max. 120 mA
6	Tx/Rx+	RS-485 communication
7	Tx/Rx-	RS-485 communication
LON		
8	Tx/Rx+	RS-485 LonWorks
9	Tx/Rx-	RS-485 LonWorks
10	Shield	Internally connected to ground
11	LON-1	TP/FT-10 Free topology LonWorks network, 78 kbps

Continued

Terminal number	Designation	Usage
12	LON-2	TP/FT-10 Free topology LonWorks network, 78 kbps

a) Operator Panels are not supported.

The screw terminals 13 to 19, intended for RS-485 communication, act as connectors to the Automation Server and are easily inserted/removed without disrupting the network. Doing so may help in isolating possible RS-485 communication problems.

Table: Bottom Side Screw Terminals, Automation Server

Terminal number	Designation	Usage
COM A		
13		RS-485 communication signals
14		RS-485 communication signals
15		Internally connected to ground
COM B		
16		RS-485 communication signals
17		RS-485 communication signals
18		Internally connected to ground
19		3.3 VDC, 100 mA output for RS-485 biasing

7.1.5 Automation Server LEDs

There are eight LEDs on the front panel of the Automation Server.

For more information, see section 7.2 “Automation Server LEDs” on page 82.

7.1.6 Automation Server Wiring

The Automation Server wiring recommendations apply to the wires and cables used for RS-485 communications, LonWorks communication, USB connection, and Ethernet connection. Always use the recommended cables and wires.

For more information, see section 9.5 “Automation Server Wiring” on page 167.

7.1.7 Reset Functions

There are several ways to reset the Automation Server using the reset button or a command from WorkStation, and in one case by short-circuiting one of the terminals.

For more information, see section 7.3 “Reset Functions” on page 85.

7.2 Automation Server LEDs

There are eight LEDs on the front panel of the Automation Server.

Figure: The Automation Server

Table: The Eight LEDs

Function	Color
RS-485 A, Tx	Yellow

Continued on next page

Continued

Function	Color
RS-485 A, Rx	Green
RS-485 B, Tx	Yellow
RS-485 B, Rx	Green
Ethernet, Link/Act/Speed	Green/Yellow
LON, Tx	Yellow
LON, Mode	Red
Status (Automation Server)	Green/Red

Note

- The ETHERNET and server STATUS indicators comprise two LEDs (green/yellow and green/red respectively) in one structure. Normally, when one LED is lit, the other is not lit and vice versa, that is, the indicator will show one color at a time.

The LEDs indicate status of the server and the ongoing communication.

The Status LED indicates the status for the device. For more information, see section 5.2 “Status LEDs” on page 62.

The RS-485 (COM A and COM B) LEDs indicate the condition of the RS-485 communication according to the following table.

Table: RS-485 LED Patterns

LED Patterns	Condition
Yellow, flashing (Tx)	Send data
Green, flashing (Rx)	Receive data

The Ethernet LED indicates the condition of the Ethernet communication according to the following table.

Table: Ethernet LED Patterns

LED Patterns	Condition
Green, flashing	10 Mbit communication
Yellow, flashing	100 Mbit communication

The LON LEDs indicate the condition of the LonWorks RS-485 communication according to the following table.

Table: LON LED Patterns

LED Patterns	Condition
Yellow, flashing (Tx)	LON communication RS-485
Red, short flash (MODE)	During start-up; otherwise for future use

7.3 Reset Functions

There are two ways to reset the Automation Server, using the reset button or a command from WorkStation.

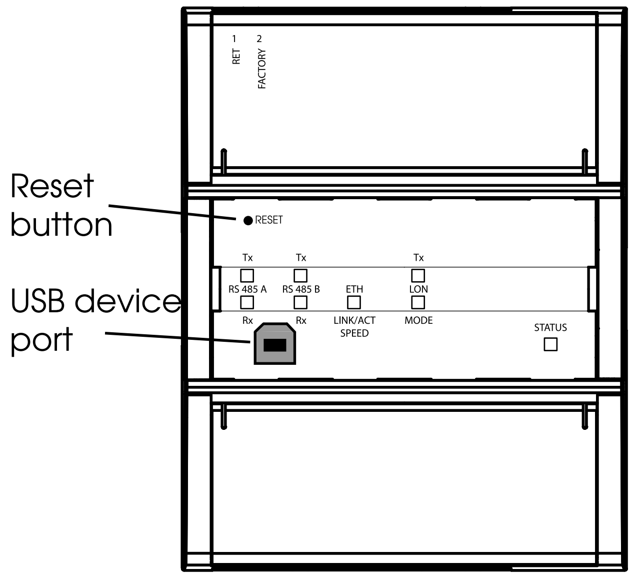


Figure: Reset button

Table: Automation Server Reset Functions

Type	Triggered by	Affected	Configuration, Historic database	IP settings
Warm start	• Short push on Reset button • Command from WorkStation • Power return	Variables according to specified retain level	Retained	Retained
Cold start	• 10 s push on Reset button • Command from WorkStation	Variables according to specified retain level	Retained	Retained
DFU mode	• 3 pushes on Reset button within 2 seconds	Automation Server can communicate with Device Administrator program		Retained

Type	Triggered by	Affected	Configuration, Historic database	IP settings

Parameters and variables that are used to define the system or contain important data in the Automation Server can be retained in a permanent memory. These parameters and variables are automatically saved in the event of power failure, or request for restart and are reloaded after startup.

You can define what kind of events that retention for the parameters and variables should apply.

7.3.1 Retain Levels for Variables

There are three retain levels for the variables:

- No: The variable is reset to the value set when the object was created.
- Warm start: The value is set back to the last value set by the user.
- Cold start: The value is set back to the last value set by either the user or the system (for instance by a program).

7.3.2 Configuration and Historic Database

A number of parameters describe the current configuration. The historic database contains information collected from different sources. Parameters and historic database are retained at both Warm and Cold start.

7.3.3 DFU Mode

The Device Firmware Upgrade mode can be used if the Automation Server does not communicate in its normal operating mode. In the DFU mode, with a PC connected to the USB device port on the Automation Server, the Device Administrator can be used to update the firmware. For more information, see section 7.4 “Resetting the Automation Server” on page 87.

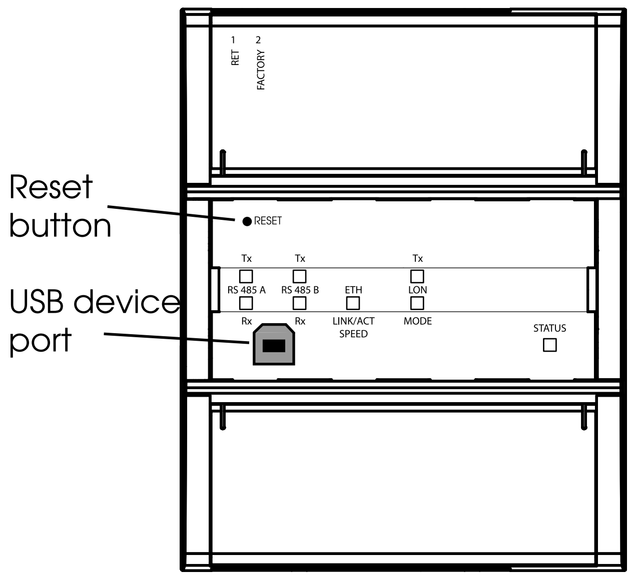
7.4 Resetting the Automation Server

If the Automation Server firmware is damaged, the Automation Server can be put in DFU (Device Firmware Upgrade) mode to be able to communicate on the USB device port.

After the reset operation and the initial boot process, the upgrade process can be started, using the USB device port. It is also possible to retrieve debug information from the device.

To reset the Automation Server

1. Start the Device Administrator. For more information, see the *Connecting to an Automation Server Using the USB Device Port* topic on WebHelp.
2. On the Automation Server, press the **Reset** button 3 times within 2 seconds.



3. Use a USB cable to connect the USB device port on the Automation Server with a USB port on the PC.
4. Ensure that the Automation Server is displayed in the list and **DFU mode** is displayed in the **Device status** column.

The Automation Server is now ready for the upgrade procedure. For more information, see the *Uploading and Upgrading an Automation Server* topic on WebHelp.

Alternatively, the Device Administrator can now be used to fetch saved debug data. For more information, see the *Getting Automation Server Debug Information* topic on WebHelp.

8 I/O Modules

Topics

8.1 I/O Modules

By adding a variety of I/O and power supply modules, you can use the Automation Server to tailor the Intelligent Building Management System to your unique requirements.

Power and communications are delivered to the Automation Server and its family of I/O modules in a common bus, thus allowing them to be plugged together without tools. This simple one-step process involves sliding the modules together using their built-in connectors.

The available I/O modules are designed to accommodate a fixed number of inputs and outputs. For example, several I/O modules, such as digital inputs, only support a single electrical type. Other modules, such as digital inputs mixed with digital outputs, support a combination of electrical types. The various modules enable you to select the right combination of points necessary for your project.

8.1.1 I/O Module LEDs

The I/O modules have the following status indicator LEDs on the front of the module:

- I/O Module Status LED
- I/O Channel Status LEDs

For more information, see section 8.2 “I/O Module LEDs” on page 93.

8.1.2 Override Switches and Potentiometers

For I/O modules with outputs, the following components on the front provide control of the output channels:

- Override switches
- Potentiometers

For more information, see section 8.3 “Override Switches and Potentiometers” on page 95.

8.1.3 External Device Connections

There are many different kinds of external devices from different vendors that can be connected to a SmartStruxure solution.

For more information, see section 9.4 “External Device Connections” on page 163.

8.1.4 Grounding and Power

It is important to perform the grounding correctly for two reasons:

- To design a safe system that is not harmed by minor connection errors.
- To design a system that works well and is resistant to EMI.

For more information, see section 9.3 “Grounding and Power” on page 161.

8.1.5 Input Modules

Input modules support a single electrical type, such as digital or universal inputs. The available input modules include the following:

- DI-16
- UI-16
- RTD-DI-16

For more information, see section 8.4 “Input Modules” on page 98.

8.1.6 Output Modules

Output modules support a number of electrical types, such as digital, tristate, and pulsed digital outputs. The available output modules include the following:

- DO-FA-12 and DO-FA-12-H
- DO-FC-8 and DO-FC-8-H
- AO-8 and AO-8-H
- AO-V-8 and AO-V-8-H

For more information, see section 8.8 “Output Modules” on page 119.

8.1.7 Mixed Modules

Mixed modules support a combination of electrical types, such as universal inputs mixed with digital outputs. The available mixed modules include the following:

- UI-8/DO-FC-4 and UI-8/DOFC-4-H
- UI-8/AO-4 and UI-8/AO-4-H
- UI-8/AO-V-4 and UI-8/AO-V-4-H

For more information, see section 8.13 “Mixed Modules” on page 130.

8.2 I/O Module LEDs

The I/O modules have the following status indicator LEDs on the front of the module:

- I/O Module Status LED
- I/O Channel Status LEDs

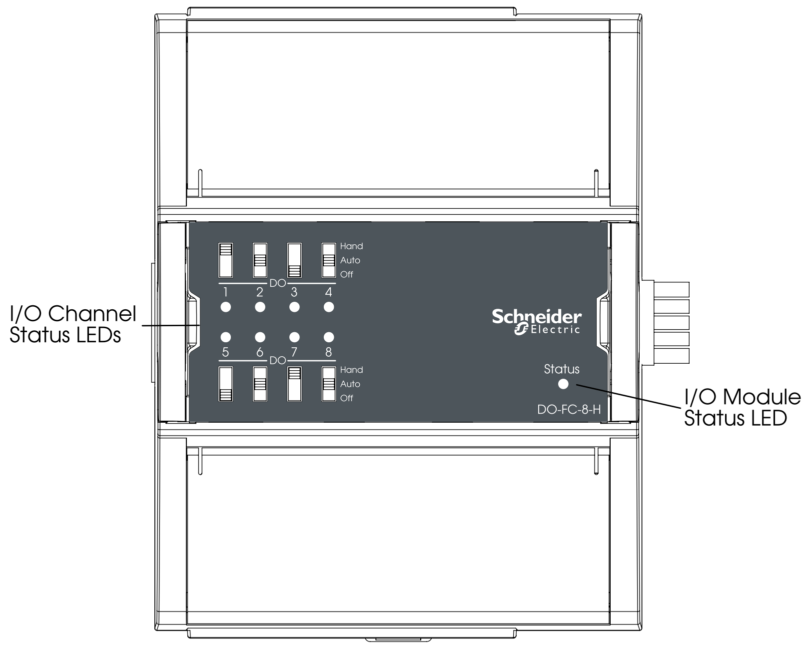


Figure: I/O module LEDs

8.2.1 I/O Module Status LED

Each I/O module contains a green/red Status LED that indicates the status of the I/O module in relationship to the Automation Server. The LED is labeled Status and is located on the lower right side of the I/O Module placard.

There are several LED patterns for the I/O module status LED. For more information, see section 5.2 “Status LEDs” on page 62.

8.2.2 I/O Channel Status LEDs

Each digital input (DI) channel, digital output (DO) channel, and Universal Input (UI) channel contains a green I/O channel status LED. This LED indicates the On/Off state of the digital input or output.

You can also configure I/O channel status LEDs as an invert, so that either a HIGH or LOW signal can turn the LED ON.

Note

- For Universal Inputs, the I/O Channel Status LED is active only if the channel is configured as a digital input or as a counter input.

8.3 Override Switches and Potentiometers

For I/O modules with outputs, the following components on the front provide control of the output channels:

- Override switches
- Potentiometers

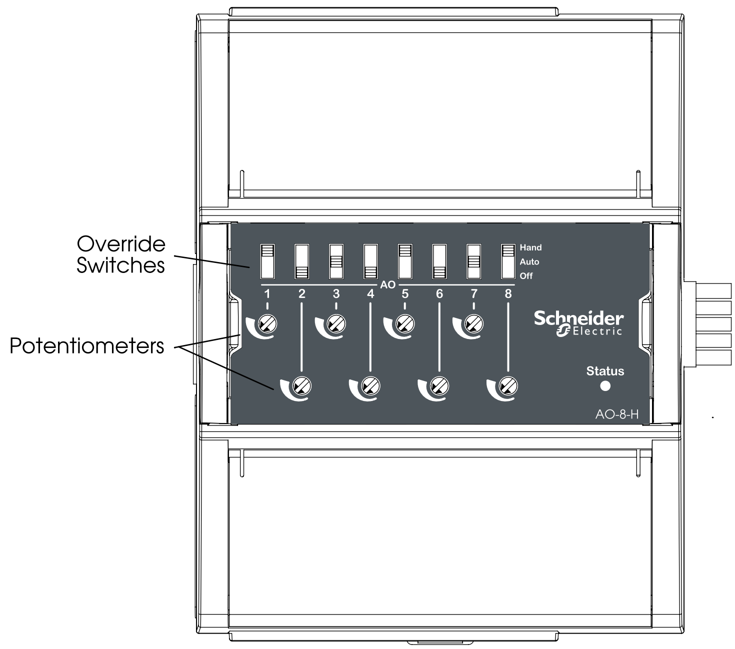


Figure: Override switches and potentiometers

8.3.1 Override Switches

I/O modules with analog or digital outputs are available with Hand-Off-Auto (HOA) override switches on the front of the I/O module. The switches provide override control of the output channels. The analog and digital output channels operate differently depending on the type of output:

- Analog outputs work in conjunction with the potentiometers to manually adjust the voltage or current output by the channel.
- Digital outputs are used with Form A or Form C relays to open and close relay contacts.

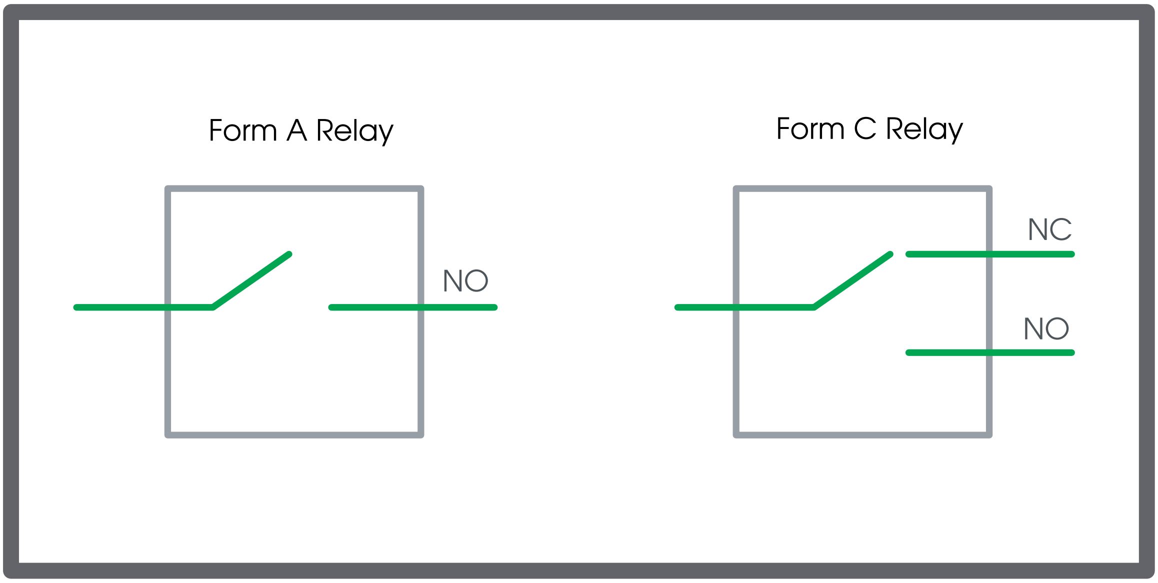


Figure: Form A and Form C relays

The output of the channel can be directed from program control or manual control. The output can be disabled as well.

The following table describes the actions associated with each position of the analog override switch.

Table: Analog Override Switch

Switch Position	**Action**
HAND	Using the potentiometer, you can manually adjust the voltage or current of the output. Programs have no effect on the output when the switch is in this position.
AUTO	Programs control the output.
OFF	The voltage or current is set to zero scale. Programs have no effect on the output when the switch is in this position.

The following table describes the actions associated with each position of the digital override switch.

Table: Digital Override Switch

Switch Position	**Action**
HAND	The output relay is energized to an ON state. Programs have no effect on the output when the switch is in this position.
AUTO	Programs control the output.
OFF	The output relay is de-energized to an OFF state. Programs have no effect on the output when the switch is in this position.

Switch Position	Action

8.3.2 Potentiometers

Each analog output channel contains a potentiometer that allows you to manually adjust the voltage or current output by the channel. These potentiometers are one-turn with a range of values from zero to full-scale.

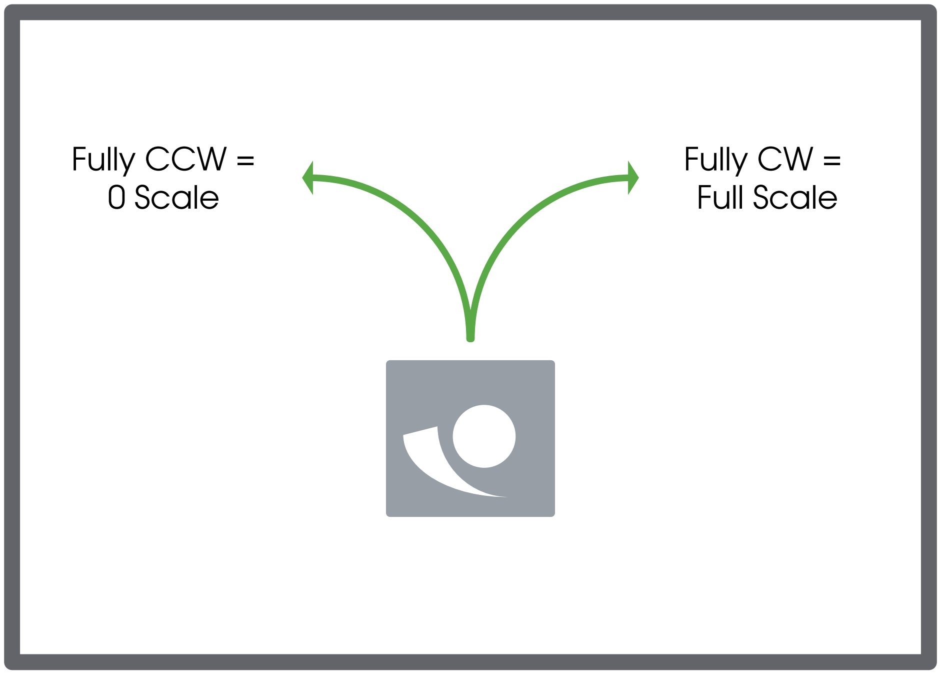


Figure: Potentiometers

The potentiometers are used in conjunction with the override switches to manually adjust the current or voltage output of the analog output channel.

8.4 Input Modules

Input modules support a single electrical type, such as digital or universal inputs. The available input modules include the following:

- DI-16
- UI-16
- RTD-DI-16

8.4.1 DI-16 I/O Module

The DI-16 I/O module is a digital input, 16-channel I/O module. You can use the DI-10 I/O module for sensing of multiple dry digital inputs in applications such as equipment status or alarm point monitoring.

The maximum counter frequency is 25 Hz on all sixteen inputs. This input type is useful in metering applications.

The following input types are supported:

- Digital input
- Dry contact, Open Collector, or Open Drain

For more information, see section 8.5.2 “” on page 102.

8.4.2 UI-16 I/O Module

UI-16 is a 16-channel universal input module with status indicators for each of the inputs. You can use this module for any mix of temperature, pressure, flow, status points, and similar inputs in a control system with a 0-10 V input range and a 12-bit A/D conversion. You can also make adjustments for various sensor types using the available pull-up resistors.

The following input types are supported:

- Dry contact closing
- Voltage 0–10 V
- Current 0–20 mA
- Thermistor– 10k Type I (Continuum), 10k Type II (I/NET), 10k Type III (Satchwell), 10k Linearized (Satchwell D?T), 10k Type IV (FD), and 10k Type V (FD w/ 11k shunt)
- Thermistor– 1.8k (Xenta)
- Thermistor– 1k (Balco)
- Thermistor- 20k (Honeywell)
- Thermistor- 2.2k (Johnson Controls)
- Supervised

For more information, see section 8.6.2 “” on page 108.

8.4.3 RTD-DI-16 I/O Module

A Resistance Temperature Detector (RTD) is a sensing element that uses the change in the resistance of a metal, such as platinum or nickel, to measure temperature. RTDs are used in scientific and industrial applications to measure temperature for kilns, gas turbine exhaust, diesel engines, and other industrial processes. Due to their accuracy and repeatability, they are typically used in industrial applications below 600° C.

In Building Operation, the RTD-DI-16 is a 16-channel I/O module with 1 return per 2 inputs. It supports the following input types:

- RTD Temperature including:
  - Pt100
  - Pt1000
  - Ni1000
  - LG-Ni1000
- RTD Resistance including:
  - 100 ohms
  - 1000 ohms
- Resistance including 0 to 1500 ohms
- Digital
- Counter

The RTD connection type is either a 2-wire or 3-wire configuration with a 3-wire RTD using 2 inputs. For more information, see section 8.7.2 “” on page 116.

8.5 DI-16 I/O Module

The DI-16 I/O module is a digital input, 16-channel I/O module. Each channel has a dedicated two-color (red and green) status LED that provides local monitoring of contact, counter, and supervised input types.

You can configure the channel status LED to display either red or green for each input state. The front panel contains both the I/O channel and module status LEDs.

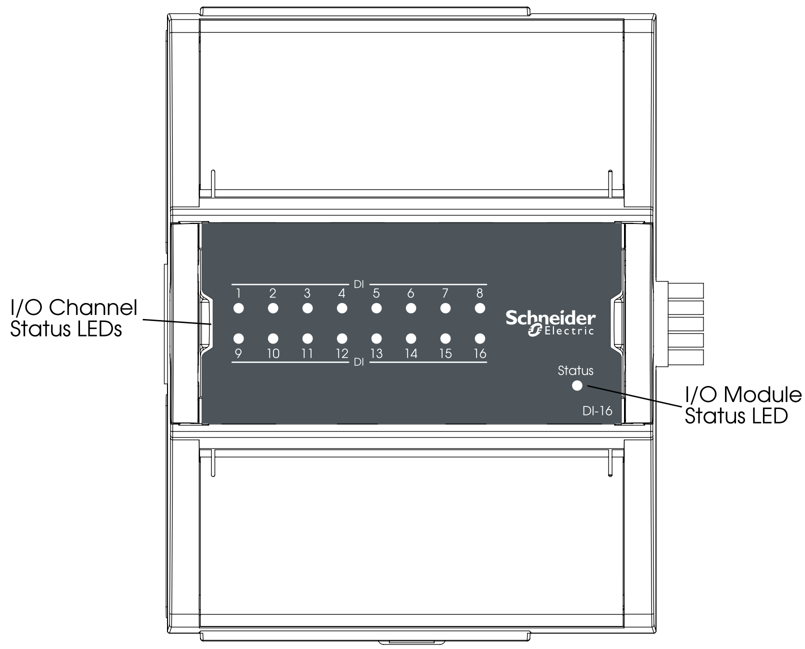


Figure: DI-16 I/O Module

8.5.1 Inputs

The inputs of the DI-16 I/O module are designed to read two different types of inputs:

- Digital
- Counter

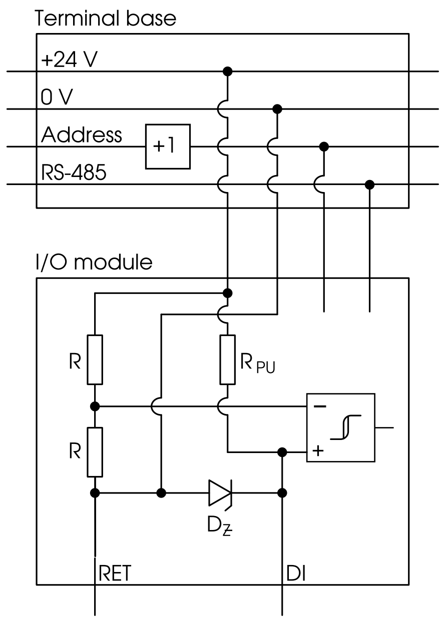


Figure: Internal configuration

Applied signals beyond the absolute maximum ratings cause over current in the protection component D_Z.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

Digital inputs

The external connection of a digital input is shown in the following figure:

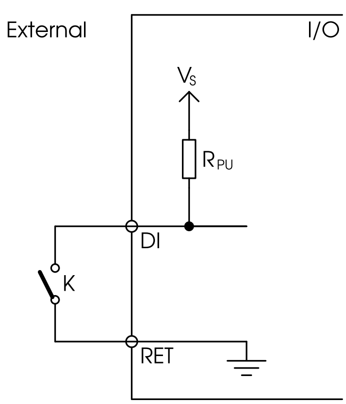


Figure: Digital input external connection

K is the monitored external switch.

V_S = 24 V

R_{PU} = 10 kohm

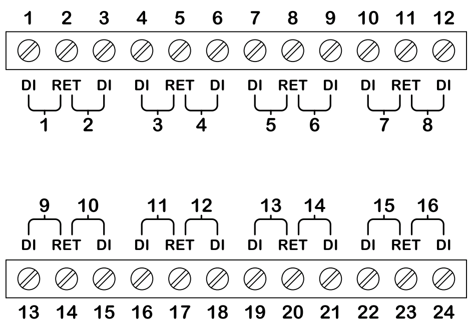
Counter inputs

A counter input utilizes the same hardware configuration as the digital input as shown in the figure above.

8.5.2 Specifications

Terminals

DI-16



All inputs

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Absolute maximum ratings ....-0.5 to +24 VDC

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Digital

Minimum pulse width ....120 ms

Counter

Minimum pulse width ....20 ms

Maximum frequency ....25 Hz

8.6 UI-16 I/O Module

The UI-16 I/O module is a universal input, 16-channel I/O module. Each channel has a dedicated status two-color LED that provides local monitoring of contact, counter, and supervised input types. The front panel shows the module status LED and the I/O channel status LEDs.

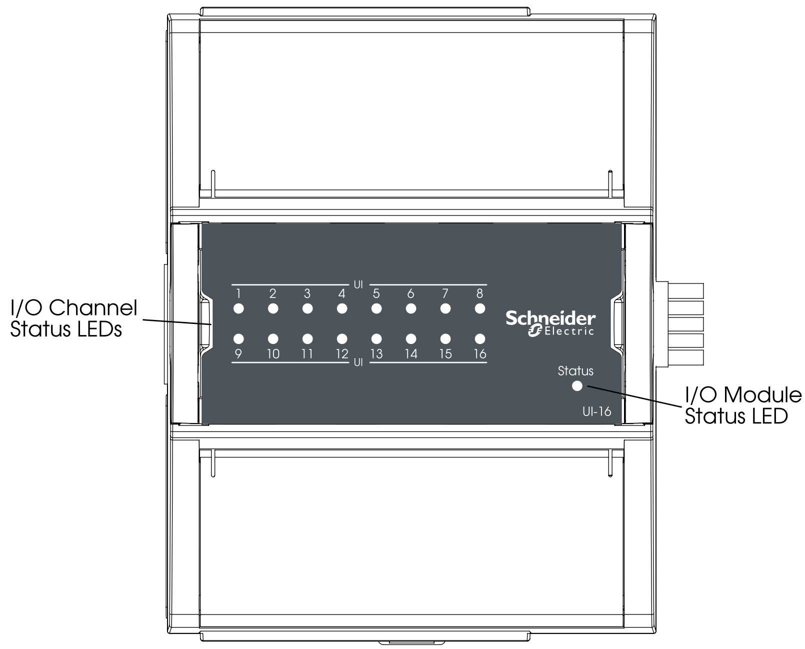


Figure: UI-16 I/O Module

8.6.1 Universal inputs

The universal inputs of the UI-16 I/O module are designed to read several different types of inputs.

Input types:

- Digital
- Counter
- Supervised
- Voltage
- Current
- Temperature
- Resistive

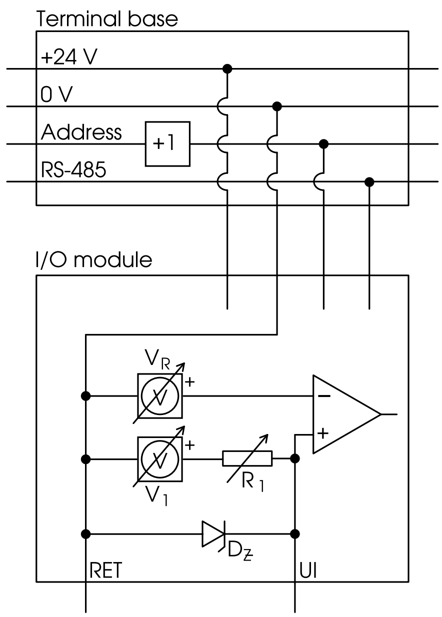


Figure: Universal input internal configuration

Applied signals beyond the absolute maximum ratings will cause over current in the protection component D_Z.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

Digital inputs

The external connection of a digital input is shown in the following figure.

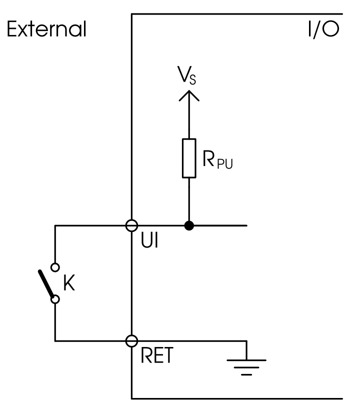


Figure: Digital input external connection

K is the monitored external switch.

V_S = 24 V

R_{PU} = 10 kohm

Counter inputs

A counter input utilizes the same hardware configuration as the digital input as shown in the figure above.

Supervised inputs

Supervised inputs are contact closing inputs supplemented with the supervision of the field wiring integrity. This supervision is a required feature in many security system applications. The supervised inputs provide the ability to detect specific forms of tampering or trouble with the wire connections to the field contacts. The supervision is achieved with a combination of 1 or 2 resistors attached to the contact in the field. The resistor combination creates continuous current flow through the field contact loop and presents a defined set of expected resistance values for each of the defined conditions. If someone is attempting to defeat the monitoring of the field contact by short circuiting the wire with a jumper or cutting the wire, the objective is to detect and indicate such a condition. The resistors need to be located at the end of the cable close to the field contact, so that the point where there is a risk that the circuit is defeated is between the resistors and the I/O module.

Three different types of supervised input connections are supported:

- Series only
- Parallel only
- Series and parallel

Each type of supervised input connection provides a different capability in regards to what form of tamper/trouble can be detected regardless of switch contact open or closed condition.

A single resistor, which is connected in series with the switch, can only detect tamper/trouble in the form of a short circuit across the wire pair. The external connection of a series only supervised input connection is shown in the following figure.

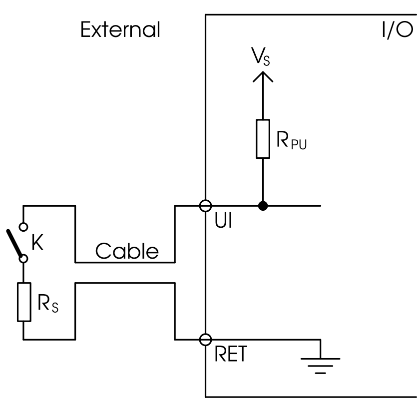


Figure: Series only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

A single resistor, which is connected in parallel with the switch, can only detect tamper/trouble in the form of an open circuit in the field wiring loop. The external connection of a parallel only supervised input connection is shown in the following figure.

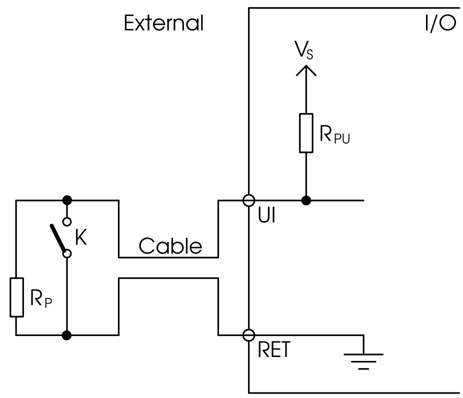


Figure: Parallel only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

Two resistors, where one is connected in series with the switch and one is connected in parallel with the switch, can detect tamper/trouble conditions in the form of both an open and a shorted circuit. The external connection of a series and parallel supervised input connection is shown in the following figure.

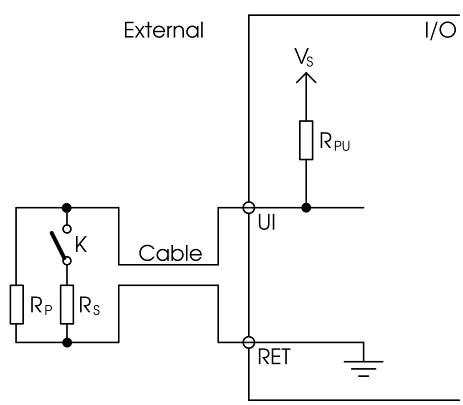


Figure: Series and parallel external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

Voltage inputs

The external connection of a voltage input is shown in the following figure.

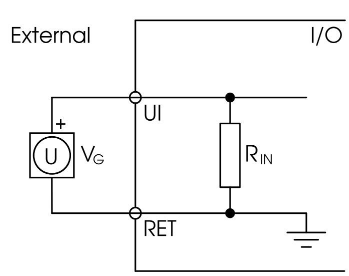


Figure: Voltage input external connection

V_G is the monitored external voltage.

R_{IN} = 100 kohm

Current inputs

The external connection of a current input is shown in the following figure.

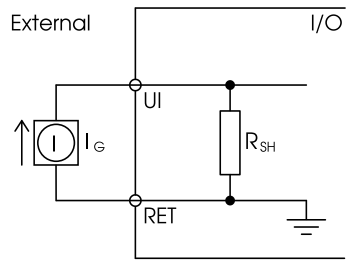


Figure: Current input external connection

I_G is the monitored external current.

R_{SH} = 47 ohm

In the internal configuration of the current input, there is a current limit circuit in order to protect the shunt resistor from over load. The input current is limited to 60 mA with a serial connected FET transistor. If this limit is reached for 0.5 s, the transistor is turned off. When 5 s has elapsed, the transistor is turned on again to make a new start attempt.

Temperature inputs

The external connection of a temperature input is shown in the following figure.

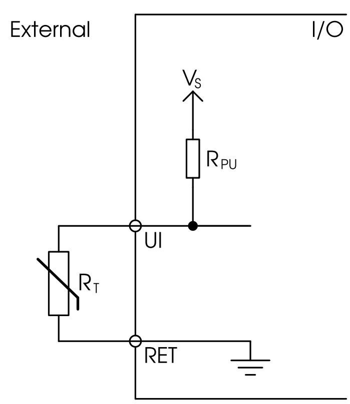


Figure: Temperature input external connection

R_T is the monitored external thermistor.

When a universal input is used as a temperature input, V_S and R_{PU} in the internal configuration of the universal input are used according to the following table.

Thermistor type	**V_s**	**R_{PU}**
20 kohm	5 V	10 kohm
10 kohm	5 V	10 kohm
2.2 kohm	1 V	1.5 kohm
1.8 kohm	1 V	1.5 kohm

Continued

Thermistor type	V_s	R_{PU}
1 kohm	1 V	1.5 kohm

The resulting voltage across the thermistor is measured and a temperature is calculated dependent on the selected thermistor type.

Resistive inputs

The external connection of a resistive input is shown in the following figure.

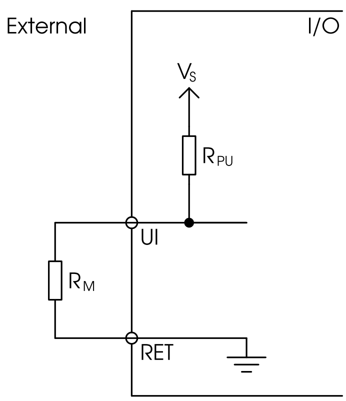


Figure: Resistive input external connection

R_M is the monitored external resistance.

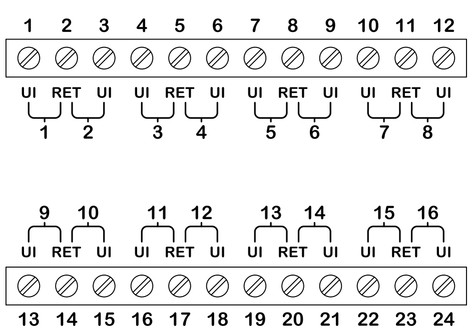
V_S = 5 V

R_{PU} = 10 kohm

8.6.2 Specifications

Universal inputs

UI-16



Absolute maximum ratings ....-0.5 to +24 VDC

Digital

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width ....120 ms

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Counter

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width ....20 ms

Maximum frequency ....25 Hz

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Supervised

5 V circuit, 1 or 2 resistors
Monitored switch combinations...Series only, parallel only, and series and parallel

Resistor range...1 to 10 kohm
For a 2-resistor configuration, each resistor is assumed to have the same value +/- 5 %

Voltage

Range..0 to 10 VDC

Accuracy ....+/-(7 mV + 0.2 % of reading)

Resolution...12 bit, 2.7 mV

Impedance...100 kohm

Reliability check ....Yes

Current

Range..0 to 20 mA

Accuracy ....+/-(0.03 mA + 0.4 % of reading)

Resolution...12 bit, 5.6 µA

Impedance ....47 ohm

Reliability check ....Yes

Resistive

10 ohm to 10 kohm accuracy ....+/-(7 + 4 x 10^{-3} x R) ohm
R = Resistance in ohm

10 to 60 kohm accuracy...+/-(4 x 10^{-3} x R + 7 x 10^{-8} x R^2) ohm
R = Resistance in ohm

Reliability check ....Yes

Temperature

Range ....-50 to +150 °C (-58 to +302 °F)

Resolution...12 bit

Reliability check ....Yes

Supported thermistors

Honeywell ....20 kohm

Type I (Continuum) ....10 kohm

Type II (I/NET)...10 kohm

Type III (Satchwell)...10 kohm

Type IV (FD).. 10 kohm

Type V (FD w/ 11k shunt)...Linearized 10 kohm

Satchwell D?T ....Linearized 10 kohm

Johnson Controls..2.2 kohm

Xenta ....1.8 kohm

Balco ....1 kohm

Thermistor accuracy

20 kohm, 10 kohm, 2.2 kohm, and 1.8 kohm....................-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)
....-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
.... 0 to 50 °C: +/-0.2 °C (32 to 122 °F: +/-0.4 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-1.5 °C (212 to 302 °F: +/-2.7 °F)

Linearized 10 kohm ....-50 to -30 °C: +/-3.0 °C (-58 to -22 °F: +/-5.4 °F)
....-30 to 0 °C: +/-1.0 °C (-22 to +32 °F: +/-1.8 °F)
.... 0 to 50 °C: +/-0.3 °C (32 to 122 °F: +/-0.5 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-2.0 °C (212 to 302 °F: +/-3.6 °F)

1 kohm ....-50 to +150 °C: +/-1.5 °C (-58 to +302° F: +/-2.7 °F)

8.7 RTD-DI-16 I/O Module

The RTD-DI-16 module is an RTD temperature, RTD resistance, digital, counter, or resistance input, 16-channel I/O module. Each channel has a dedicated two-color (red and green) status LED.

You can configure the channel status LED to display either red or green for each input state. The front panel contains both the I/O channel and module status LEDs.

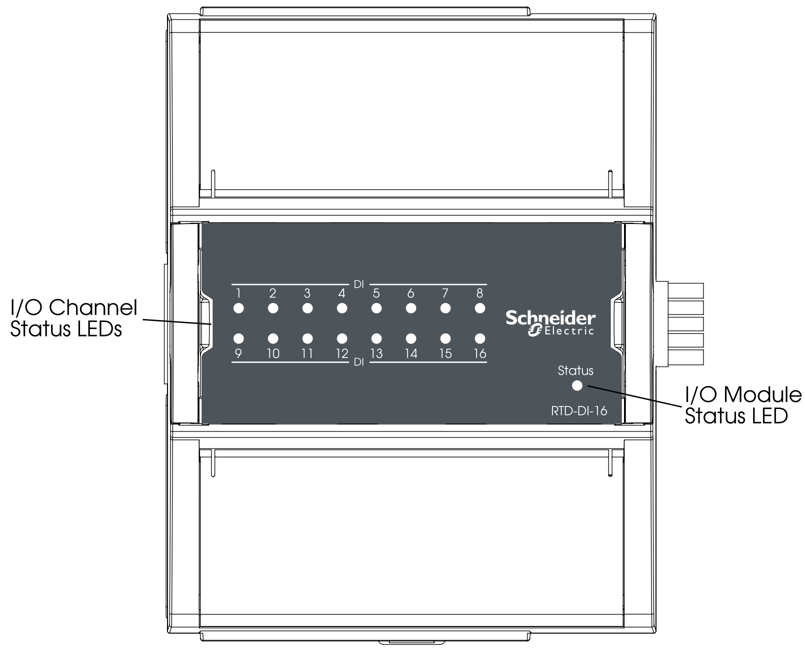


Figure: RTD-DI-16 I/O Module

8.7.1 Inputs

The inputs of the RTD-DI-16 I/O module are designed to read seven different types of inputs:

- 2-wire RTD temperature
- 3-wire RTD temperature
- 2-wire RTD resistive
- 3-wire RTD resistive
- Digital
- Counter
- Resistive

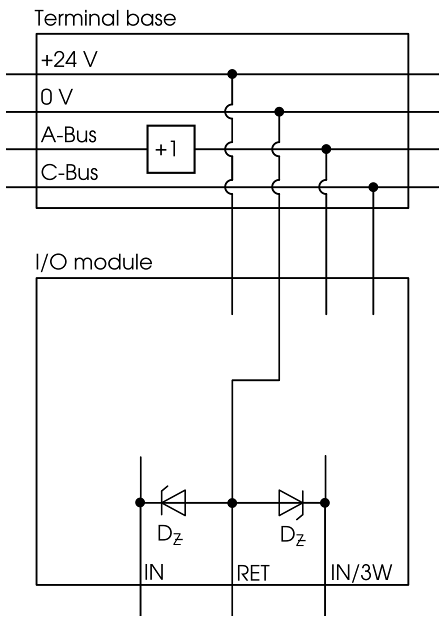


Figure: Internal configuration

Applied signals beyond the absolute maximum ratings cause over current in the protection component D_Z.

In a 2-wire configuration, the leads are connected to IN and RET or RET and IN/3W. This provides up to 16 inputs for 2-wire configurations.

In a 3-wire configuration, the leads are connected to IN, RET, and IN/3W. This provides up to 8 inputs for 3-wire configurations.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

2-wire RTD temperature inputs

The external connection of a 2-wire RTD temperature input is shown in the following figure.

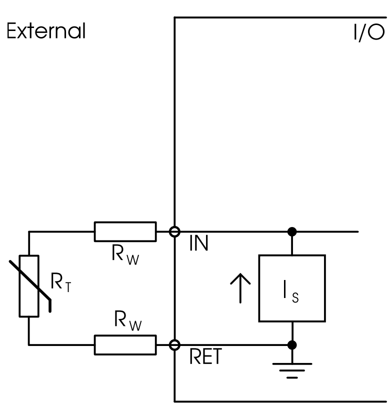


Figure: 2-wire temperature input external connection

R_T is the monitored external RTD.

R_W is the wiring resistance.

In the internal configuration of the RTD temperature input, I_S is used according to the following table.

RTD type	$\mathbf{I_s}$
Pt100	1.5 mA
Pt1000	750 µA
Ni1000	750 µA
LG-Ni1000	750 µA

The current source nominal duty cycle is 5 %.

When an input is used as a 2-wire RTD temperature input, you need to state the wiring resistance in the software.

The resulting voltage across the RTD is measured, and the temperature is calculated dependent on the selected RTD type.

3-wire RTD temperature inputs

The external connection of a 3-wire RTD temperature input is shown in the following figure.

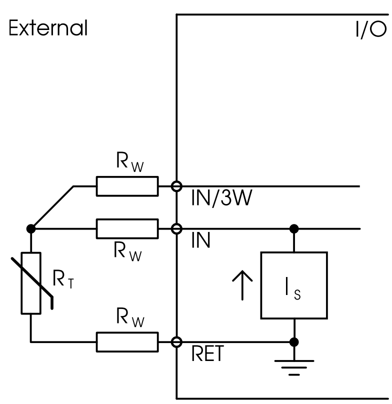


Figure: 3-wire temperature input external connection

R_T is the monitored external RTD.

R_W is the wiring resistance.

In the internal configuration of the RTD temperature input, I_S is used according to the following table.

RTD type	$\mathbf{I_s}$
Pt100	1.5 mA
Pt1000	750 µA
Ni1000	750 µA
LG-Ni1000	750 µA

RTD type	I_s

The current source nominal duty cycle is 5 %.

When an input is used as a 3-wire RTD temperature input, the module automatically compensates for the wiring resistance.

The resulting voltage across the RTD is measured, and the temperature is calculated dependent on the selected RTD type.

2-wire RTD resistive inputs

The external connection of a 2-wire RTD resistive input is shown in the following figure.

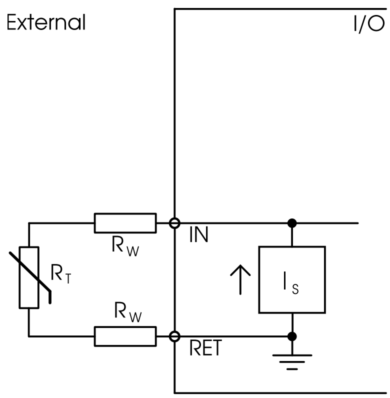


Figure: 2-wire RTD resistive input external connection

R_T is the monitored external resistance.

R_W is the wiring resistance.

In the internal configuration of the RTD resistive input, I_S is used according to the following table.

RTD type	I_s
100 ohm	1.5 mA
1000 ohm	750 µA

The current source nominal duty cycle is 5 %.

When an input is used as a 2-wire RTD resistive input, you need to state the wiring resistance in the software.

The resulting voltage across the RTD is measured, and the resistance is calculated dependent on the selected RTD type.

The RTD resistive input type is used to measure the resistance of an RTD other than the supported types. The resistance to temperature conversion must be performed in a function block or script program in the Automation Server.

3-wire RTD resistive inputs

The external connection of a 3-wire RTD resistive input is shown in the following figure.

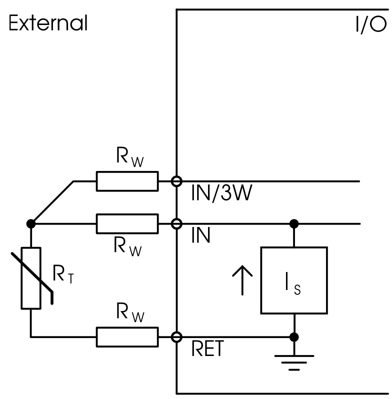


Figure: 3-wire RTD resistive input external connection

R_T is the monitored external resistance.

R_W is the wiring resistance.

In the internal configuration of the RTD resistive input, I_S is used according to the following table.

RTD type	I_s
100 ohm	1.5 mA
1000 ohm	750 µA

The current source nominal duty cycle is 5 %.

When an input is used as a 3-wire RTD resistance input, the module automatically compensates for the wiring resistance.

The resulting voltage across the RTD is measured, and the resistance is calculated dependent on the selected RTD type.

The RTD resistive input type is used to measure the resistance of an RTD other than the supported types. The resistance to temperature conversion must be performed in a function block or script program in the Automation Server.

Digital inputs

The external connection of a digital input is shown in the following figure.

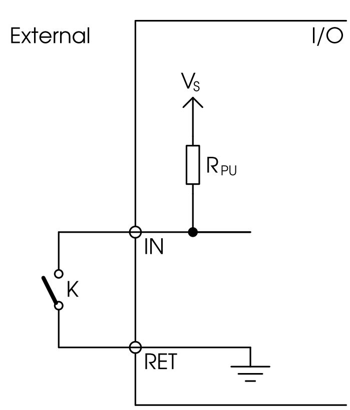


Figure: Digital input external connection

K is the monitored external switch.

V_S = 24 V

R_{PU} = 10.1 kohm

Counter inputs

A counter input utilizes the same hardware configuration as the digital input as shown in the figure above.

Resistive inputs

The external connection of a resistive input is shown in the following figure.

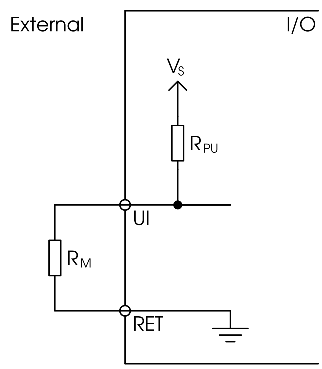


Figure: Resistive input external connection

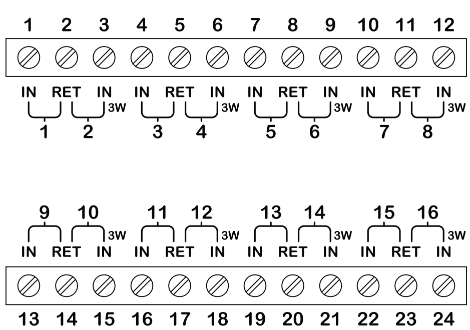
R_T is the monitored external resistance.

I_S = 100 µA

8.7.2 Specifications

Universal inputs

RTD-DI-16



Absolute maximum ratings ....-0.5 to +24 VDC

RTD temperature

Current source open circuit voltage ....4 V

Reliability check ....Yes

Supported RTDs ....Pt100, Pt1000, Ni1000, and LG-Ni1000
For more information, see the RTD resistance table.

Pt100

Range ....-50 to +150 °C (-58 to +302 °F)

Accuracy ....+/-0.5 °C (+/-0.90 °F)

Resolution ....0.03 °C (0.05°F)

Pt1000

Range .... -50 to +150 °C (-58 to +302 °F)

Accuracy .... +/-0.3 °C (+/-0.54 °F)

Resolution .... 0.03 °C (0.05 °F)

Ni1000

Range .... -50 to +150 °C (-58 to +302 °F)

Accuracy .... +/-0.2 °C (+/-0.36 °F)

Resolution .... 0.03 °C (0.05 °F)

LG-Ni1000

Range .... -50 to +150 °C (-58 to +302 °F)

Accuracy .... +/-0.2 °C (+/-0.36 °F)

Resolution .... 0.03 °C (0.05 °F)

RTD temperature wiring

Maximum wire resistance .... 20 ohm/wire (40 ohm total)

Maximum wire capacitance .... 40000 pF
The wire resistance and capacitance typically corresponds to a 200 m wire.
Shielded wires are recommended if the wiring is placed in a noisy electrical environment.

RTD resistive

Current source .... 4 V

Reliability check .... Yes

100 ohm

Range .... 50 to 220 ohm
.... Including wiring resistance

Accuracy .... $+/-(0.12 + 4 \times 10^{-4} \times R)$ ohm
R = resistance in ohm

Resolution .... 0.01 ohm

1000 ohm

Range .... 500 to 2200 ohm
.... Including wiring resistance

Accuracy .... $+/-(0.7 + 2 \times 10^{-2} \times R)$ ohm
R = resistance in ohm

Resolution .... 0.1 ohm

RTD resistive wiring

Maximum wire capacitance .... 40000 pF
Shielded wires are recommended if the wiring is placed in a noisy electrical environment.

Digital

Range .... Dry contact switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width .... 120 ms

LED polarity .... Software selectable, if the LED is activated when the input is high or low

LED color .... Red or green, software selectable

Counter

Range .... Dry contact switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width .... 20 ms

Maximum frequency .... 25 Hz

LED polarity .... Software selectable, if the LED is activated when the input is high or low

LED color .... Red or green, software selectable

Resistive

Range ....0 to 15000 ohm

Accuracy ....+/-(6 + 7 x 10^{-4} x R) ohm
R = resistance in ohm

Resolution ....1 ohm

Current source open circuit voltage ....4 V

Reliability check ....Yes

Maximum wire capacitance ....40000 pF
Shielded wires are recommended if the wiring is placed in a noisy electrical environment.

Table: RTD resistance

Temperature	Pt100 (ohm)	Pt1000 (ohm)	Ni-1000 (ohm)	LG-Ni1000 (ohm)
-50 °C (-58 °F)	80.31	803.1	742.6	790.9
-40 °C (-40 °F)	84.27	842.7	791.3	830.8
-30 °C (-22 °F)	88.22	882.2	841.5	871.7
-20 °C (-4 °F)	92.16	921.6	893.0	913.5
-10 °C (14 °F)	96.09	960.9	945.8	956.2
0 °C (32 °F)	100.00	1000.0	1000.0	1000.0
10 °C (50 °F)	103.90	1039.0	1055.5	1044.8
20 °C (68 °F)	107.79	1077.9	1112.4	1090.7
30 °C (86 °F)	111.67	1116.7	1170.6	1137.6
40 °C (104 °F)	115.54	1155.4	1230.1	1185.7
50 °C (122 °F)	119.40	1194.0	1291.1	1235.0
60 °C (140 °F)	123.24	1232.4	1353.4	1285.4
70 °C (158 °F)	127.08	1270.8	1417.2	1337.1
80 °C (176 °F)	130.90	1309.0	1482.5	1390.1
90 °C (194 °F)	134.71	1347.1	1549.3	1444.4
100 °C (212 °F)	138.51	1385.1	1617.8	1500.0
110 °C (230 °F)	142.29	1422.9	1687.9	1557.0
120 °C (248 °F)	146.07	1460.7	1759.7	1615.4
130 °C (266 °F)	149.83	1498.3	1833.3	1675.2
140 °C (284 °F)	153.58	1535.8	1908.9	1736.5
150 °C (302 °F)	157.33	1573.3	1986.3	1799.3

8.8 Output Modules

Output modules support a number of electrical types, such as digital, tristate, and pulsed digital outputs. The available output modules include the following:

- DO-FA-12 and DO-FA-12-H
- DO-FC-8 and DO-FC-8-H
- AO-8 and AO-8-H
- AO-V-8 and AO-V-8-H

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

8.8.1 DO-FA-12 and DO-FA-12-H I/O Modules

The DO-FA-12 I/O module is a digital output, Form A relay, 12-channel I/O module.

The supported output types include the following:

- Digital Form A
- Tristate

The Form-A relays in the DO-FA-12 are designed for direct load applications for up to 2A loads. For more information, see section 8.9.2 “” on page 122.

8.8.2 DO-FC-8 and DO-FC-8-H I/O Modules

The DO-FC-8 I/O module is a digital output, Form C relay, 8-channel I/O module.

The supported output types include the following:

- Digital Form C
- Tristate

The Form-C relays in the DO-FC-8 are designed for direct load applications for up to 3A loads. For more information, see section 8.10.2 “” on page 124.

8.8.3 AO-8 and AO-8-H I/O Modules

The AO-8 is an analog output, 8-channel I/O module. Each channel contains both voltage and current outputs.

The following output types are supported:

- Voltage 0–10 V; 2 mA source, -1 mA sink
- Current 0–20 mA into a termination resistor (650Ω maximum)

Since the AO-8 controls 0-10 V outputs, the module supports a wide range of devices, such as valves and actuators. You can use the AO-8 to drive 0-20 mA current signals on any of its eight channels. For more information, see section 8.11.2 “” on page 126.

8.8.4 AO-V-8 and AO-V-8-H I/O Modules

The AO-V-8 I/O module is an analog output, 8-channel I/O module that contains only voltage outputs.

The supported output type is Voltage 0–10 V; 2 mA source, -1 mA sink, so the AO-V-8 supports a wide range of devices, such as valves and actuators. For more information, see section 8.12.2 “” on page 129.

8.9 DO-FA-12 and DO-FA-12-H I/O Modules

The DO-FA-12 I/O module is a 12-channel, Form A relay, digital output I/O module.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel includes a dedicated two-color status LED that provides local monitoring of the digital outputs. You can configure the LED to display either red or green for each output state.

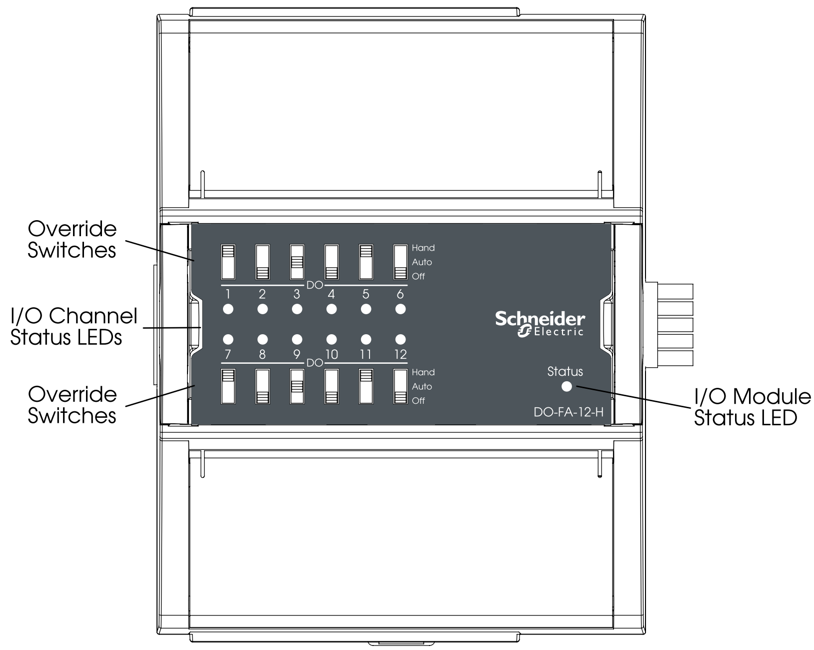


Figure: DO-FA-12-H I/O Module

8.9.1 Digital outputs

The Form A digital outputs of the DO-FA-12 and DO-FA-12-H I/O modules are closing contacts with one common terminal (C) and one normally open terminal (NO). The terminals are isolated from signal ground.

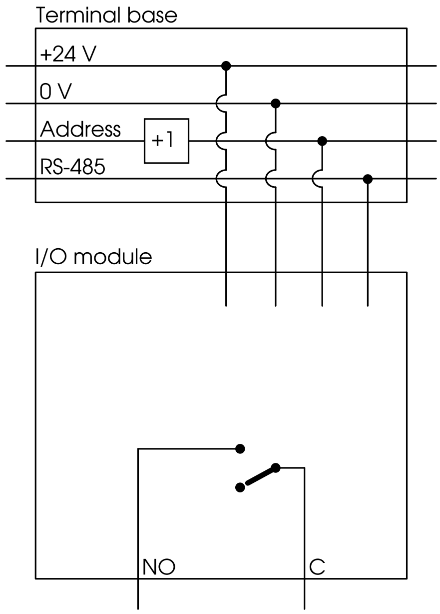


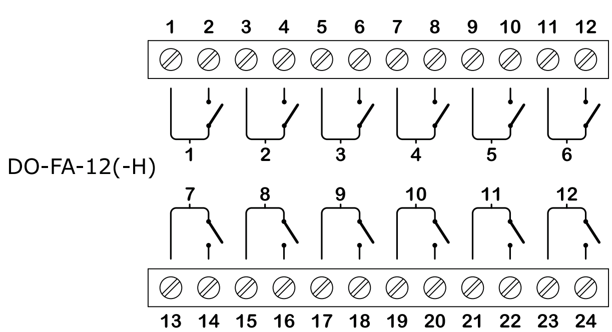
Figure: Form A digital output internal configuration

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.9.2 Specifications

Digital outputs



Contact rating ....250 VAC/30 VDC, 2 A

Switch type ....Form A Relay
....Single Pole Single Throw
....Normally Open

Isolation contact to system ground ....3000 VAC

Minimum pulse width ....100 ms

LED polarity energized relay ....On

LED polarity non-energized relay ....Off

LED color ....Green

8.10 DO-FC-8 and DO-FC-8-H I/O Modules

The DO-FC-8 I/O module is a digital output, Form C relay, 8-channel I/O module.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel includes dedicated two-color (red and green) status LEDs for local monitoring of digital outputs. You can configure these LEDs to display either red or green for each output state.

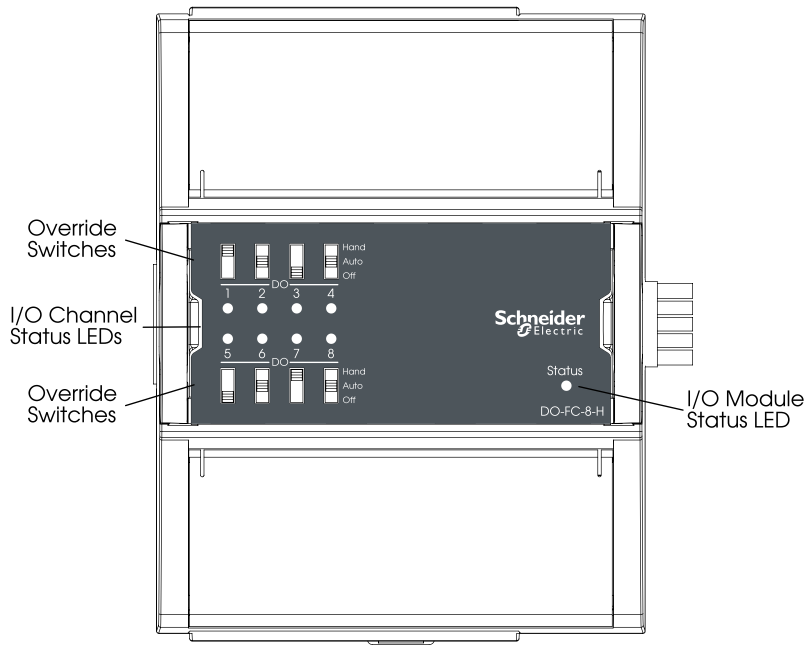


Figure: DO-FC-8-H I/O Module

8.10.1 Digital outputs

The Form C digital outputs of the DO-FC-8 and DO-FC-8-H I/O modules are switching contacts with one common terminal (C), one normally open terminal (NO), and one normally closed terminal (NC). The terminals are isolated from signal ground.

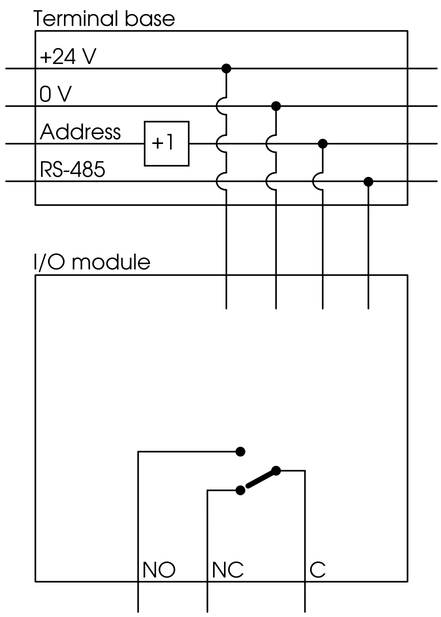


Figure: Form C digital output internal configuration

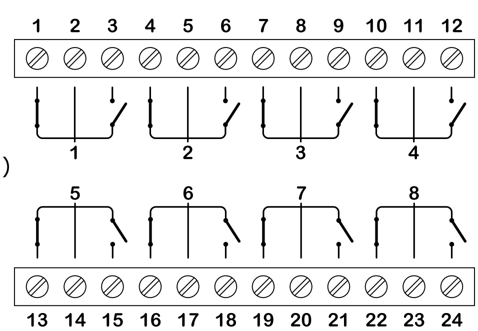
The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.10.2 Specifications

Digital outputs

DO-FC-8(-H)



Contact rating.....250 VAC/30 VDC, 3 A
Switch type.....Form C Relay
.....Single Pole Double Throw
..... Normally Open or Normally Closed
Isolation contact to system ground.....5000 VAC
Minimum pulse width .....100 ms
LED polarity energized relay .....On
LED polarity non-energized relay .....Off
LED color .....Green

8.11 AO-8 and AO-8-H I/O Modules

The AO-8 I/O module is an analog output, 8-channel I/O module.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel shows the module status LED, override switches, and adjustable potentiometers.

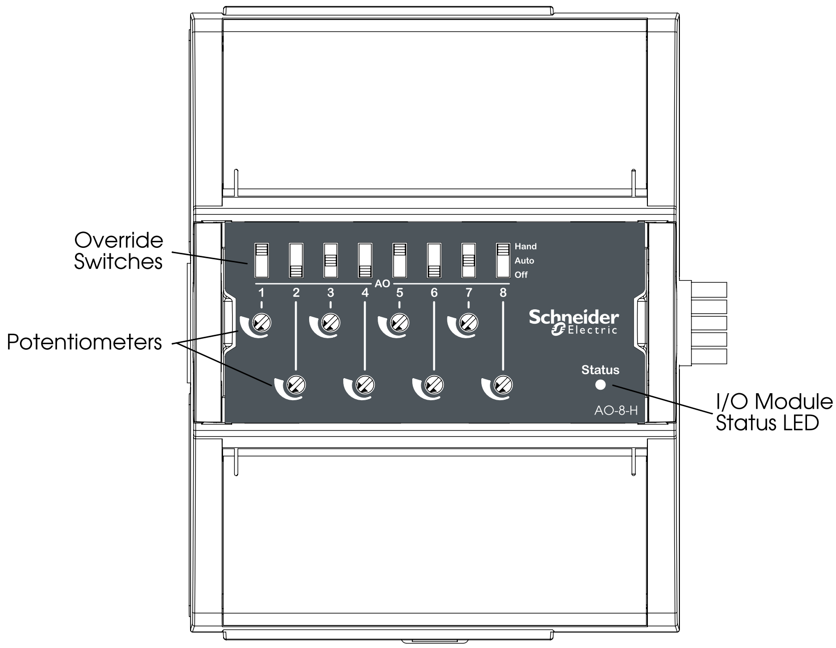


Figure: AO-8-H I/O Module

8.11.1 Analog outputs

The analog outputs of the AO-8 and AO-8-H I/O modules are designed to be used for voltage or current outputs.

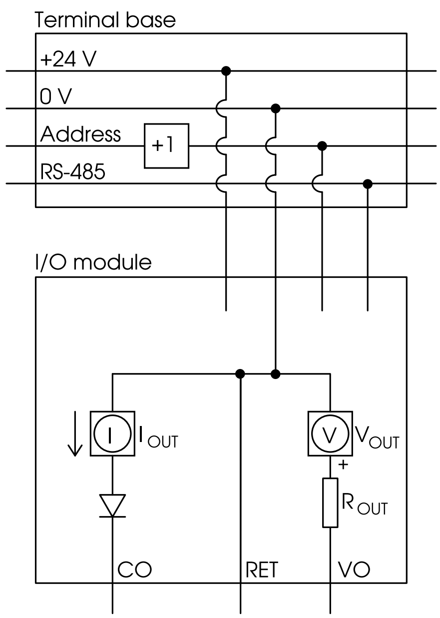


Figure: Analog output internal configuration

R_{OUT} is approximately equal to 10 ohm.

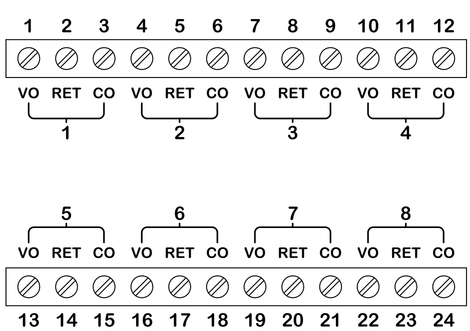
The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.11.2 Specifications

Analog outputs

AO-8(-H)



Voltage

Range....................0 to 10 VDC

Accuracy ....+/-100 mV

Resolution ....42 mV

Minimum load resistance ....5 kohm

Load range ....-1 to +2 mA

Reliability check ....Yes

Terminals....................Voltage Output (VO), Return (RET)

Current

Range....0 to 20 mA
Accuracy ....+/-0.2 mA
Resolution ....0.1 mA
Load range ....0 to 650 ohm
Reliability check ....Yes
Terminals ....Current Output (CO), Return (RET)

8.12 AO-V-8 and AO-V-8-H I/O Modules

The AO-V-8 I/O module is an analog output, 8-channel I/O module.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel shows the module status LED, override switches, and adjustable potentiometers.

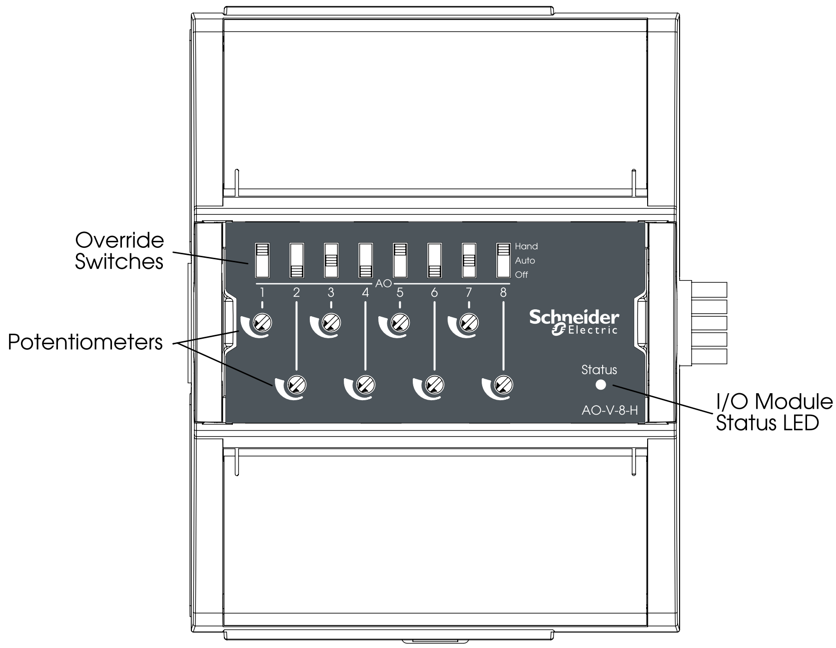


Figure: AO-V-8-H I/O Module

8.12.1 Analog outputs

The analog outputs of the AO-V-8 and AO-V-8-H I/O modules are designed to be used for voltage outputs.

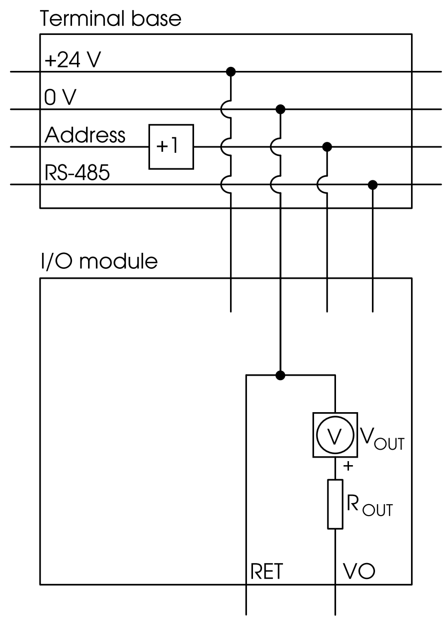


Figure: Analog output internal configuration

R_{OUT} is approximately equal to 10 ohm.

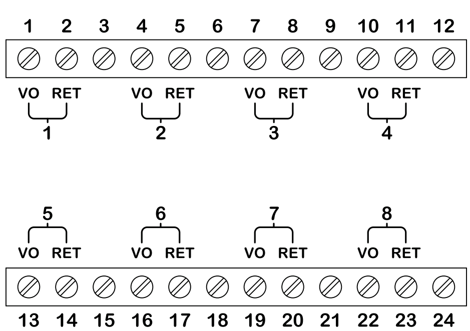
The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.12.2 Specifications

Analog outputs

AO-V-8(-H)



Voltage

Range....0 to 10 VDC

Accuracy ....+/-100 mV

Resolution ....42 mV

Minimum load resistance ....5 kohm

Load range ....-1 to +2 mA

Reliability check ....Yes

8.13 Mixed Modules

Mixed modules support a combination of electrical types, such as universal inputs mixed with digital outputs. The available mixed modules include the following:

- UI-8/DO-FC-4 and UI-8/DOFC-4-H
- UI-8/AO-4 and UI-8/AO-4-H
- UI-8/AO-V-4 and UI-8/AO-V-4-H

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

8.13.1 UI-8/DO-FC-4 and UI-8/DO-FC-4-H I/O Modules

The UI-8/DO-FC-4 module combines 8 universal inputs and 4 digital Form C relay outputs. You can use these modules when an application requires only a few points of each type.

The following input types are supported:

- Dry contact closing
- Voltage 0–10 V
- Current 0–20 mA
- Thermistor– 10k Type 1 (Continuum), 10k Type II (I/NET), 10k Type III (Satchwell), 10k Linearized (Satchwell D?T), 10k Type IV (FD), and 10k Type V (FD w/11k shunt)
- Thermistor– 1.8k (Xenta)
- Thermistor– 1k (Balco)
- Thermistor– 20k (Honeywell)
- Thermistor– 2.2k (Johnson Controls)
- Supervised
- Counter Inputs

The following output types are supported:

- Digital Form C
- Tristate

The Form-C relays in the UI-8/DO-FC-4 are designed for direct load applications for up to 3A loads. For more information, see section 8.14.4 “” on page 139.

8.13.2 UI-8/AO-4 and UI-8/AO-4-H I/O Modules

The UI-8/AO-4 is a combination I/O module, consisting of 8 universal input channels and 4 analog output channels. You can use these modules when an application requires only a few points of each type.

The following input types are supported:

- Dry contact closing
- Voltage 0-10 V
- Current 0–20 mA
- Thermistor– 10k Type 1 (Continuum), 10k Type II (I/NET), 10k Type III (Satchwell), 10k Linearized (Satchwell D?T), 10k Type IV (FD), and 10k Type V (FD w/11k shunt)
- Thermistor– 1.8k (Xenta)
- Thermistor– 1k (Balco)
- Thermistor– 20k (Honeywell)
- Thermistor– 2.2k (Johnson Controls)
- Supervised
- Counter inputs

The following output types are supported:

- Voltage 0–10 V; 2 mA source, -1 mA sink
- Current 0–20 mA into a termination resistor (650Ω maximum)

For more information, see section 8.15.4 “” on page 147.

8.13.3 UI-8/AO-V-4 and UI-8/AO-V-4-H I/O Modules

The UI-8/AO-V-4 is a combined input and output module that supports 8 universal input channels and 4 analog output channels.

The following input types are supported:

- Dry contact closing
- Voltage 0–10 V
- Current 0–20 mA
- Thermistor– 10k Type 1 (Continuum), 10k Type II (I/NET), 10k Type III (Satchwell), 10k Linearized (Satchwell D?T), 10k Type IV (FD), and 10k Type V (FD w/11k shunt)
- Thermistor– 1.8k (Xenta)
- Thermistor– 1k (Balco)
- Thermistor– 20k (Honeywell)
- Thermistor– 2.2k (Johnson Controls)
- Supervised

The supported output type is Voltage 0–10 V; 2 mA source, -1 mA sink. For more information, see section 8.16.4 “” on page 156.

8.14 UI-8/DO-FC-4 and UI-8/DO-FC-4-H I/O Modules

The UI-8/DO-FC-4 module combines 8 universal inputs and 4 digital Form C relay outputs.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel includes a dedicated two-color (red and green) status LED for local monitoring of digital inputs and outputs. You can configure the LED to display either red or green for each input or output state.

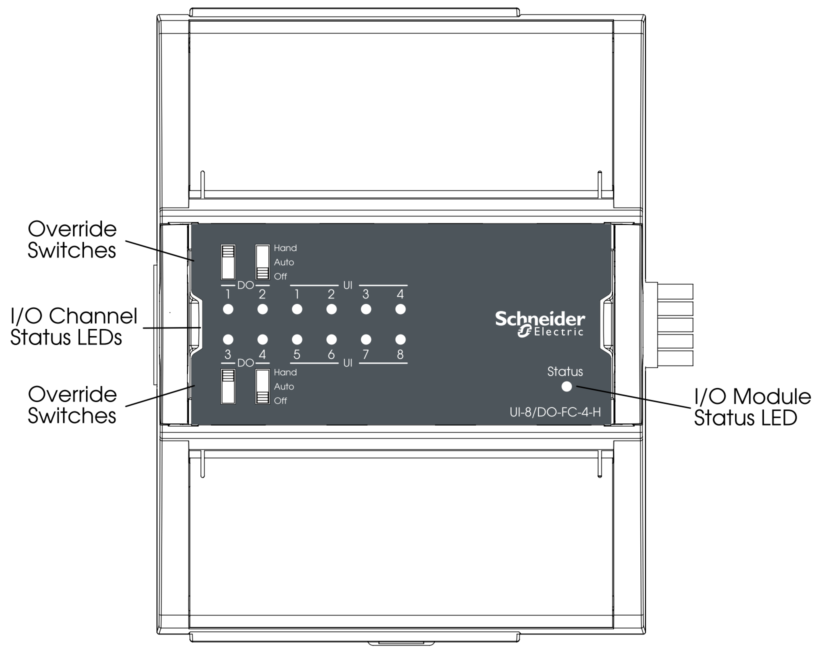


Figure: UI-8/DO-FC-4-H I/O Module

8.14.1 Universal inputs

The universal inputs of the UI-8/DO-FC-4 and UI-8/DO-FC-4-H I/O modules are designed to read several different types of inputs.

Input types:

- Digital
- Counter
- Supervised
- Voltage
- Current
- Temperature

- Resistive

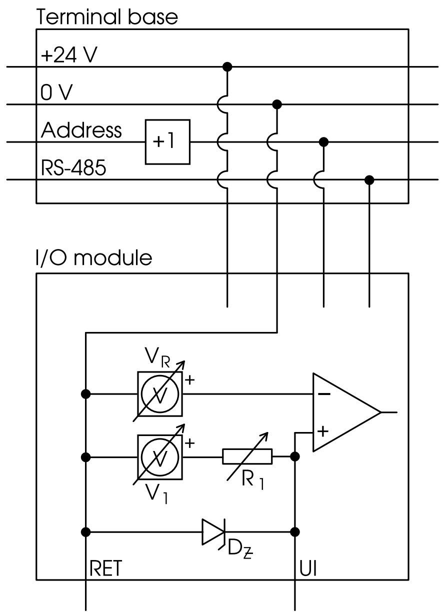


Figure: Universal input internal configuration

Applied signals beyond the absolute maximum ratings will cause over current in the protection component D_Z.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

Digital inputs

The external connection of a digital input is shown in the following figure.

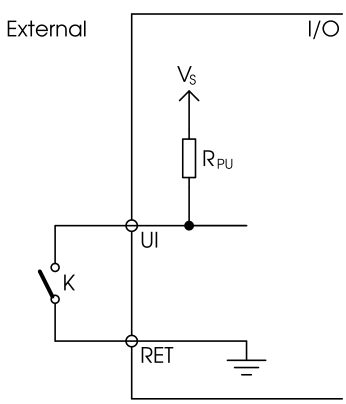


Figure: Digital input external connection

K is the monitored external switch.

V_S = 24 V

R_{PU} = 10 kohm

Counter inputs

A counter input utilizes the same hardware configuration as the digital input as shown in the figure above.

Supervised inputs

Supervised inputs are contact closing inputs supplemented with the supervision of the field wiring integrity. This supervision is a required feature in many security system applications. The supervised inputs provide the ability to detect specific forms of tampering or trouble with the wire connections to the field contacts. The supervision is achieved with a combination of 1 or 2 resistors attached to the contact in the field. The resistor combination creates continuous current flow through the field contact loop and presents a defined set of expected resistance values for each of the defined conditions. If someone is attempting to defeat the monitoring of the field contact by short circuiting the wire with a jumper or cutting the wire, the objective is to detect and indicate such a condition. The resistors need to be located at the end of the cable close to the field contact, so that the point where there is a risk that the circuit is defeated is between the resistors and the I/O module.

Three different types of supervised input connections are supported:

- Series only
- Parallel only
- Series and parallel

Each type of supervised input connection provides a different capability in regards to what form of tamper/trouble can be detected regardless of switch contact open or closed condition.

A single resistor, which is connected in series with the switch, can only detect tamper/trouble in the form of a short circuit across the wire pair. The external connection of a series only supervised input connection is shown in the following figure.

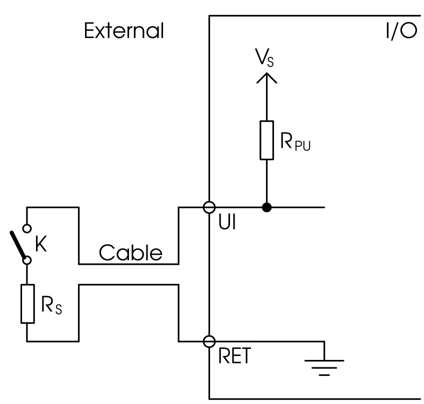


Figure: Series only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

A single resistor, which is connected in parallel with the switch, can only detect tamper/trouble in the form of an open circuit in the field wiring loop. The external connection of a parallel only supervised input connection is shown in the following figure.

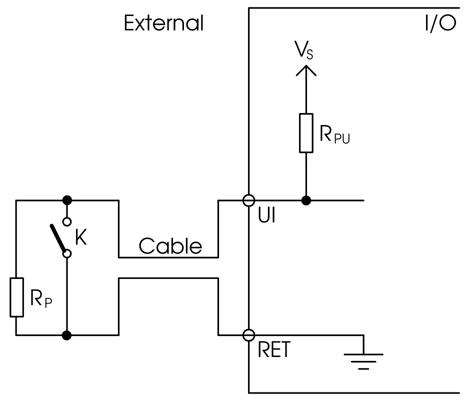


Figure: Parallel only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

Two resistors, where one is connected in series with the switch and one is connected in parallel with the switch, can detect tamper/trouble conditions in the form of both an open and a shorted circuit. The external connection of a series and parallel supervised input connection is shown in the following figure.

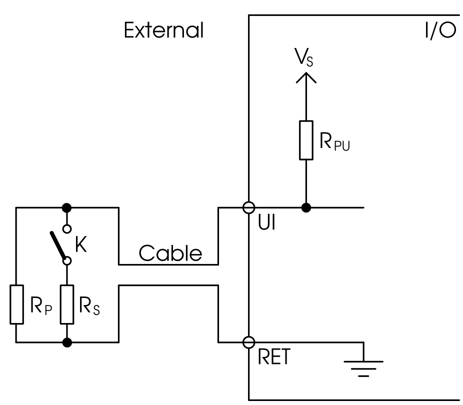


Figure: Series and parallel external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

Voltage inputs

The external connection of a voltage input is shown in the following figure.

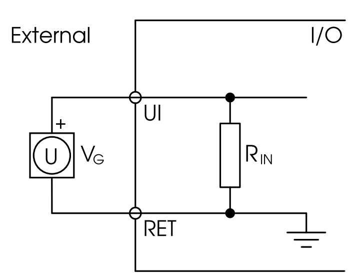


Figure: Voltage input external connection

V_G is the monitored external voltage.

R_{IN} = 100 kohm

Current inputs

The external connection of a current input is shown in the following figure.

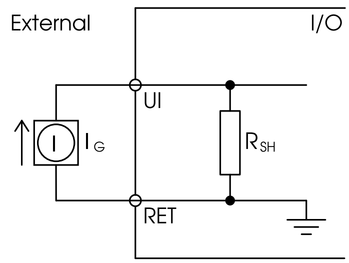


Figure: Current input external connection

I_G is the monitored external current.

R_{SH} = 47 ohm

In the internal configuration of the current input, there is a current limit circuit in order to protect the shunt resistor from over load. The input current is limited to 60 mA with a serial connected FET transistor. If this limit is reached for 0.5 s, the transistor is turned off. When 5 s has elapsed, the transistor is turned on again to make a new start attempt.

Temperature inputs

The external connection of a temperature input is shown in the following figure.

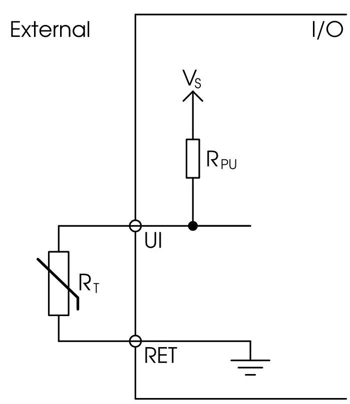


Figure: Temperature input external connection

R_T is the monitored external thermistor.

When a universal input is used as a temperature input, V_S and R_{PU} in the internal configuration of the universal input are used according to the following table.

Thermistor type	**V_s**	**R_{PU}**
20 kohm	5 V	10 kohm
10 kohm	5 V	10 kohm
2.2 kohm	1 V	1.5 kohm
1.8 kohm	1 V	1.5 kohm

Continued

Thermistor type	**V_s**	**R_{PU}**
1 kohm	1 V	1.5 kohm

The resulting voltage across the thermistor is measured and a temperature is calculated dependent on the selected thermistor type.

Resistive inputs

The external connection of a resistive input is shown in the following figure.

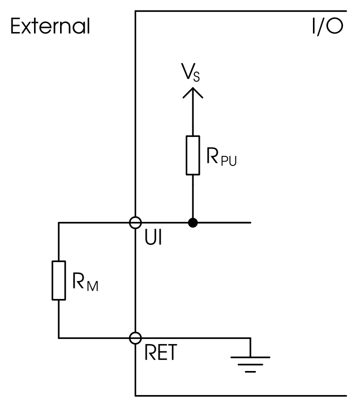


Figure: Resistive input external connection

R_M is the monitored external resistance.

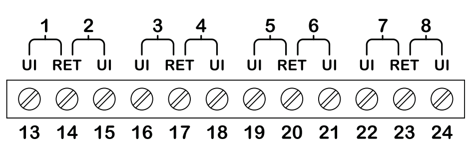
V_S = 5 V

R_{PU} = 10 kohm

8.14.2 Specifications

Universal inputs

UI-8/
DO-FC-4(-H)



Absolute maximum ratings ....-0.5 to +24 VDC

Digital

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width ....120 ms

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Counter

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width ....20 ms

Maximum frequency ....25 Hz

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Supervised

5 V circuit, 1 or 2 resistors
Monitored switch combinations..Series only, parallel only, and series and parallel

Resistor range..1 to 10 kohm
For a 2-resistor configuration, each resistor is assumed to have the same value +/- 5 %

Voltage

Range..0 to 10 VDC

Accuracy ....+/-(7 mV + 0.2 % of reading)

Resolution..12 bit, 2.7 mV

Impedance..100 kohm

Reliability check ....Yes

Current

Range..0 to 20 mA

Accuracy ....+/-(0.03 mA + 0.4 % of reading)

Resolution..12 bit, 5.6 µA

Impedance ....47 ohm

Reliability check ....Yes

Resistive

10 ohm to 10 kohm accuracy ....$+/-(7 + 4 \times 10^{-3} \times R)$ ohm
R = Resistance in ohm

10 to 60 kohm accuracy...$+/-(4 \times 10^{-3} \times R + 7 \times 10^{-8} \times R^2)$ ohm
R = Resistance in ohm

Reliability check ....Yes

Temperature

Range ....-50 to +150 °C (-58 to +302 °F)

Resolution..12 bit

Reliability check ....Yes

Supported thermistors

Honeywell ....20 kohm

Type I (Continuum) ....10 kohm

Type II (I/NET)..10 kohm

Type III (Satchwell)..10 kohm

Type IV (FD).. 10 kohm

Type V (FD w/ 11k shunt)...Linearized 10 kohm

Satchwell D?T ....Linearized 10 kohm

Johnson Controls ....2.2 kohm

Xenta ....1.8 kohm

Balco ....1 kohm

Thermistor accuracy

20 kohm, 10 kohm, 2.2 kohm, and 1.8 kohm...................-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)
....-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
.... 0 to 50 °C: +/-0.2 °C (32 to 122 °F: +/-0.4 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-1.5 °C (212 to 302 °F: +/-2.7 °F)

Linearized 10 kohm ....-50 to -30 °C: +/-3.0 °C (-58 to -22 °F: +/-5.4 °F)
....-30 to 0 °C: +/-1.0 °C (-22 to +32 °F: +/-1.8 °F)
.... 0 to 50 °C: +/-0.3 °C (32 to 122 °F: +/-0.5 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-2.0 °C (212 to 302 °F: +/-3.6 °F)

1 kohm ....-50 to +150 °C: +/-1.5 °C (-58 to +302° F: +/-2.7 °F)

8.14.3 Digital outputs

The Form C digital outputs of the UI-8/DO-FC-4 and UI-8/DO-FC-4-H I/O modules are switching contacts with one common terminal (C), one normally open terminal (NO), and one normally closed terminal (NC). The terminals are isolated from signal ground.

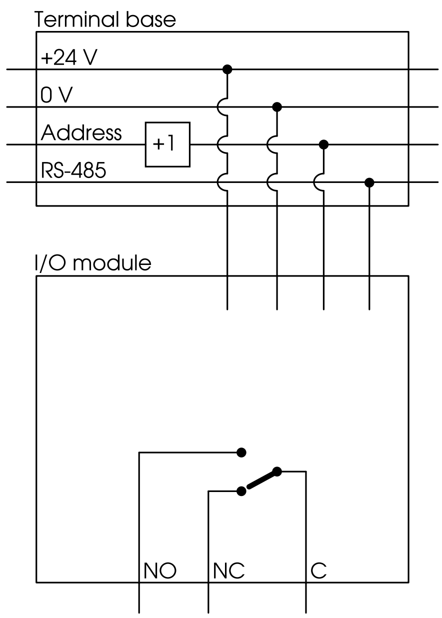


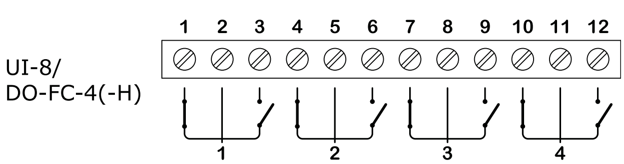
Figure: Form C digital output internal configuration

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.14.4 Specifications

Digital outputs



Contact rating....................250 VAC/30 VDC, 3 A

Switch type....................Form C Relay
....................Single Pole Double Throw
.... Normally Open or Normally Closed

Isolation contact to system ground....................5000 VAC

Minimum pulse width ....100 ms

LED polarity energized relay ....On

LED polarity non-energized relay ....Off

LED color ....Green

8.15 UI-8/AO-4 and UI-8/AO-4-H I/O Modules

The UI-8/AO-4 module combines 8 universal inputs and 4 analog outputs.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel includes a dedicated two-color (red and green) status LED for local monitoring of contact, counter, and supervised input types. You can configure the LED to display either red or green for each input or output state.

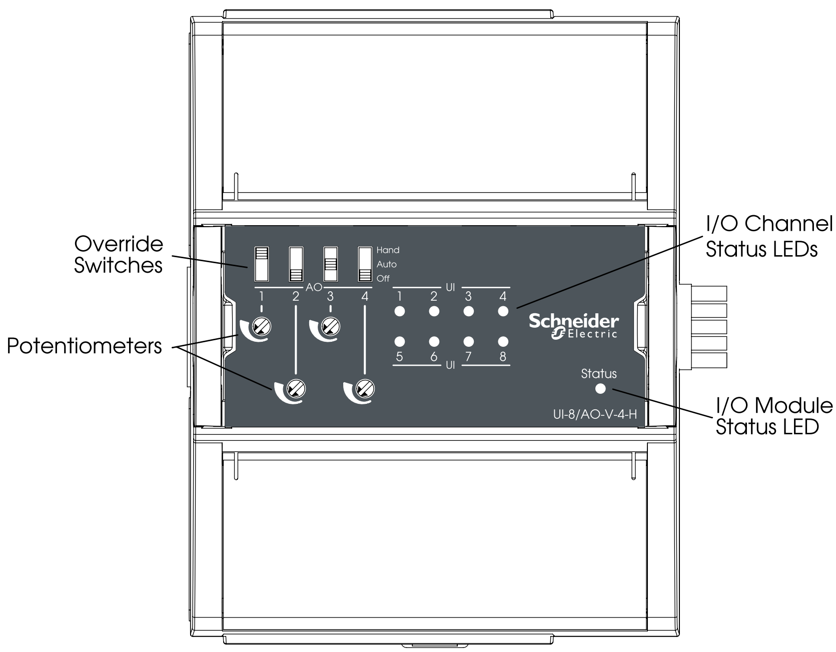


Figure: Ui-8/AO-V-4-H I/O Module

8.15.1 Universal inputs

The universal inputs of the UI-8/AO-4 and UI-8/AO-4-H I/O modules are designed to read several different types of inputs.

Input types:

- Digital
- Counter
- Supervised
- Voltage
- Current
- Temperature
- Resistive

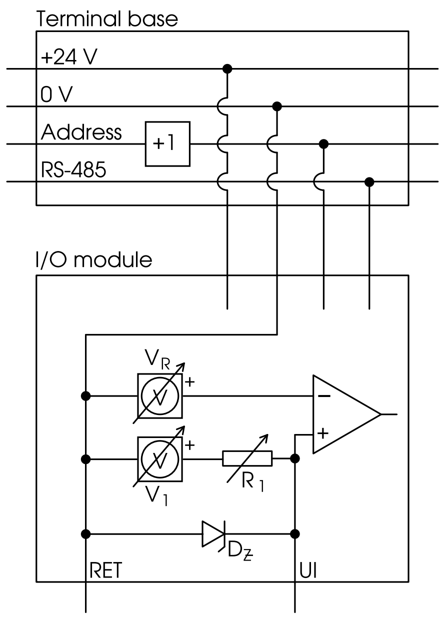


Figure: Universal input internal configuration

Applied signals beyond the absolute maximum ratings will cause over current in the protection component D_Z.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

Digital inputs

The external connection of a digital input is shown in the following figure.

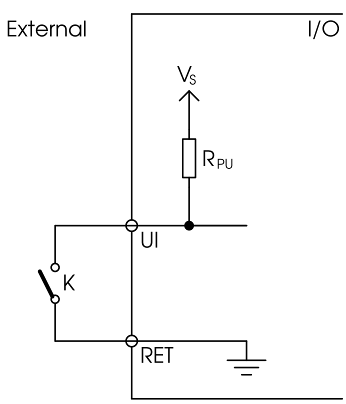


Figure: Digital input external connection

K is the monitored external switch.

V_S = 24 V

R_{PU} = 10 kohm

Counter inputs

A counter input utilizes the same hardware configuration as the digital input as shown in the figure above.

Supervised inputs

Supervised inputs are contact closing inputs supplemented with the supervision of the field wiring integrity. This supervision is a required feature in many security system applications. The supervised inputs provide the ability to detect specific forms of tampering or trouble with the wire connections to the field contacts. The supervision is achieved with a combination of 1 or 2 resistors attached to the contact in the field. The resistor combination creates continuous current flow through the field contact loop and presents a defined set of expected resistance values for each of the defined conditions. If someone is attempting to defeat the monitoring of the field contact by short circuiting the wire with a jumper or cutting the wire, the objective is to detect and indicate such a condition. The resistors need to be located at the end of the cable close to the field contact, so that the point where there is a risk that the circuit is defeated is between the resistors and the I/O module.

Three different types of supervised input connections are supported:

- Series only
- Parallel only
- Series and parallel

Each type of supervised input connection provides a different capability in regards to what form of tamper/trouble can be detected regardless of switch contact open or closed condition.

A single resistor, which is connected in series with the switch, can only detect tamper/trouble in the form of a short circuit across the wire pair. The external connection of a series only supervised input connection is shown in the following figure.

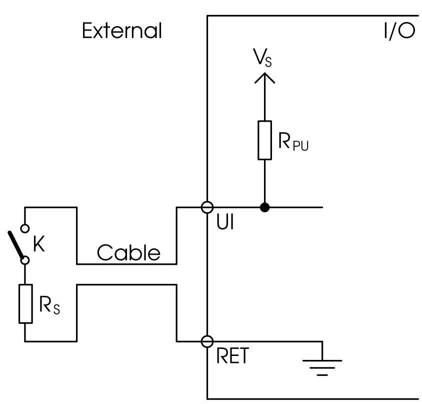


Figure: Series only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

A single resistor, which is connected in parallel with the switch, can only detect tamper/trouble in the form of an open circuit in the field wiring loop. The external connection of a parallel only supervised input connection is shown in the following figure.

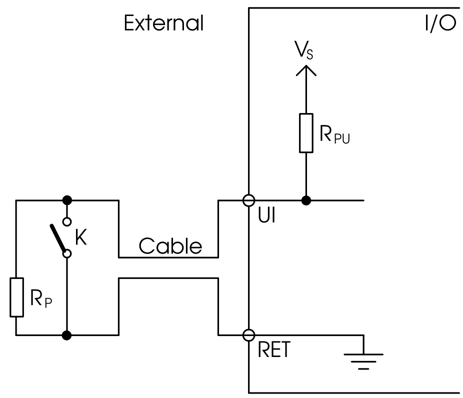


Figure: Parallel only external connection

K is the monitored external switch.

$V_S = 5$ V

$R_{PU} = 10$ kohm

Two resistors, where one is connected in series with the switch and one is connected in parallel with the switch, can detect tamper/trouble conditions in the form of both an open and a shorted circuit. The external connection of a series and parallel supervised input connection is shown in the following figure.

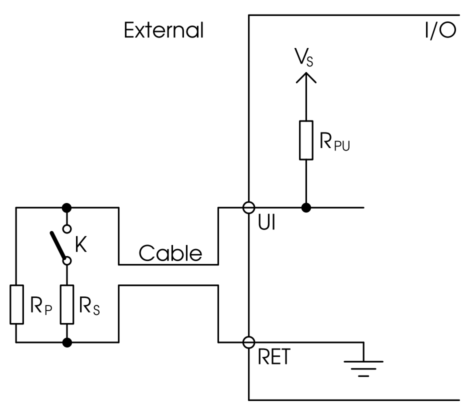


Figure: Series and parallel external connection

K is the monitored external switch.

$V_S = 5$ V

$R_{PU} = 10$ kohm

Voltage inputs

The external connection of a voltage input is shown in the following figure.

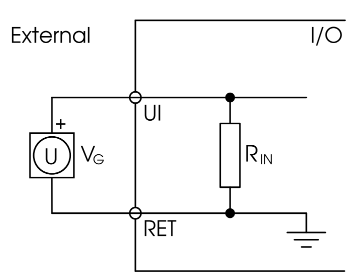


Figure: Voltage input external connection

V_G is the monitored external voltage.

R_{IN} = 100 kohm

Current inputs

The external connection of a current input is shown in the following figure.

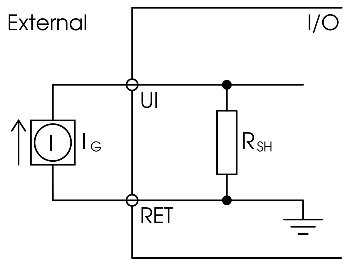


Figure: Current input external connection

I_G is the monitored external current.

R_{SH} = 47 ohm

In the internal configuration of the current input, there is a current limit circuit in order to protect the shunt resistor from over load. The input current is limited to 60 mA with a serial connected FET transistor. If this limit is reached for 0.5 s, the transistor is turned off. When 5 s has elapsed, the transistor is turned on again to make a new start attempt.

Temperature inputs

The external connection of a temperature input is shown in the following figure.

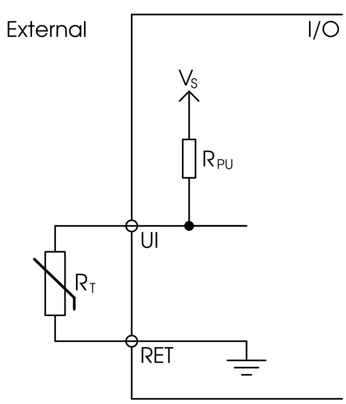


Figure: Temperature input external connection

R_T is the monitored external thermistor.

When a universal input is used as a temperature input, V_S and R_{PU} in the internal configuration of the universal input are used according to the following table.

Thermistor type	V_S	R_{PU}
20 kohm	5 V	10 kohm
10 kohm	5 V	10 kohm
2.2 kohm	1 V	1.5 kohm
1.8 kohm	1 V	1.5 kohm

Continued

Thermistor type	V_s	R_{PU}
1 kohm	1 V	1.5 kohm

The resulting voltage across the thermistor is measured and a temperature is calculated dependent on the selected thermistor type.

Resistive inputs

The external connection of a resistive input is shown in the following figure.

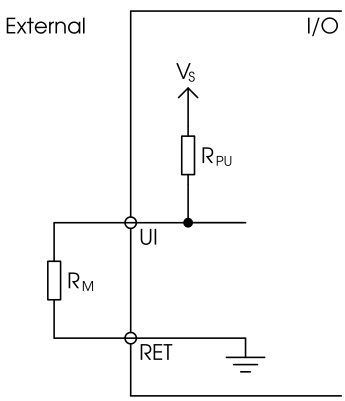


Figure: Resistive input external connection

R_M is the monitored external resistance.

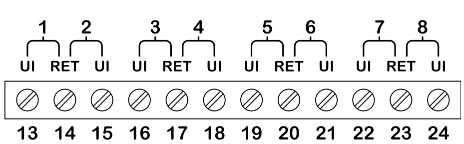
V_S = 5 V

R_{PU} = 10 kohm

8.15.2 Specifications

Universal inputs

UI-8/
AO-4(-H)



Absolute maximum ratings .... -0.5 to +24 VDC

Digital

Range .... Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width .... 120 ms

LED polarity .... Software selectable, if the LED is activated when the input is high or low

LED color .... Red or green, software selectable

Counter

Range .... Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width .... 20 ms

Maximum frequency .... 25 Hz

LED polarity .... Software selectable, if the LED is activated when the input is high or low

LED color .... Red or green, software selectable

Supervised

5 V circuit, 1 or 2 resistors
Monitored switch combinations..Series only, parallel only, and series and parallel

Resistor range..1 to 10 kohm
For a 2-resistor configuration, each resistor is assumed to have the same value +/- 5 %

Voltage

Range...0 to 10 VDC

Accuracy ....+/-(7 mV + 0.2 % of reading)

Resolution..12 bit, 2.7 mV

Impedance...100 kohm

Reliability check ....Yes

Current

Range...0 to 20 mA

Accuracy ....+/-(0.03 mA + 0.4 % of reading)

Resolution..12 bit, 5.6 µA

Impedance ....47 ohm

Reliability check ....Yes

Resistive

10 ohm to 10 kohm accuracy ....+/-($7 + 4 \times 10^{-3} \times R$) ohm
R = Resistance in ohm

10 to 60 kohm accuracy...+/-($4 \times 10^{-3} \times R + 7 \times 10^{-8} \times R^2$) ohm
R = Resistance in ohm

Reliability check ....Yes

Temperature

Range ....-50 to +150 °C (-58 to +302 °F)

Resolution..12 bit

Reliability check ....Yes

Supported thermistors

Honeywell ....20 kohm

Type I (Continuum) ....10 kohm

Type II (I/NET)..10 kohm

Type III (Satchwell)...10 kohm

Type IV (FD).. 10 kohm

Type V (FD w/ 11k shunt)...Linearized 10 kohm

Satchwell D?T ....Linearized 10 kohm

Johnson Controls...2.2 kohm

Xenta ....1.8 kohm

Balco ....1 kohm

Thermistor accuracy

20 kohm, 10 kohm, 2.2 kohm, and 1.8 kohm...................-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)
....-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
.... 0 to 50 °C: +/-0.2 °C (32 to 122 °F: +/-0.4 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-1.5 °C (212 to 302 °F: +/-2.7 °F)

Linearized 10 kohm ....-50 to -30 °C: +/-3.0 °C (-58 to -22 °F: +/-5.4 °F)
....-30 to 0 °C: +/-1.0 °C (-22 to +32 °F: +/-1.8 °F)
.... 0 to 50 °C: +/-0.3 °C (32 to 122 °F: +/-0.5 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-2.0 °C (212 to 302 °F: +/-3.6 °F)

1 kohm ....-50 to +150 °C: +/-1.5 °C (-58 to +302° F: +/-2.7 °F)

8.15.3 Analog outputs

The analog outputs of the UI-8/AO-4 and UI-8/AO-4-H I/O modules are designed to be used for voltage or current outputs.

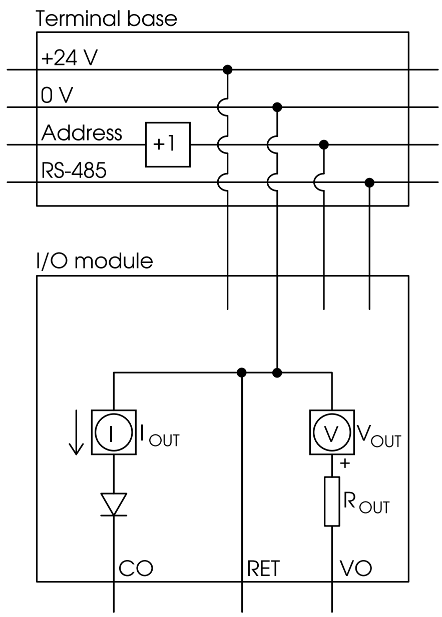


Figure: Analog output internal configuration

R_{OUT} is approximately equal to 10 ohm.

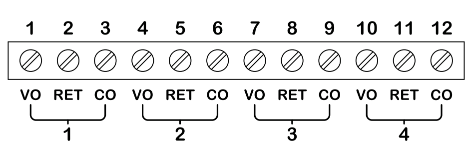
The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.15.4 Specifications

Analog outputs

UI-8/
AO-4(-H)



Voltage

Range.......0 to 10 VDC

Accuracy ....+/-100 mV

Resolution ....42 mV

Minimum load resistance ....5 kohm

Load range ....-1 to +2 mA

Reliability check ....Yes

Terminals.......Voltage Output (VO), Return (RET)

Current

Range.......0 to 20 mA

Accuracy .... +/-0.2 mA

Resolution .... 0.1 mA

Load range .... 0 to 650 ohm

Reliability check .... Yes

Terminals .... Current Output (CO), Return (RET)

8.16 UI-8/AO-V-4 and UI-8/AO-V-4-H I/O Modules

The UI-8/AO-4 and UI-8/AO-V-4 modules combine 8 universal inputs and 4 analog outputs.

Note

Module names with an -H indicate the presence of Hand-Off-Auto override switches.

The front panel includes a dedicated two-color (red and green) status LED for local monitoring of contact, counter, and supervised input types. You can configure the LED to display either red or green for each input or output state.

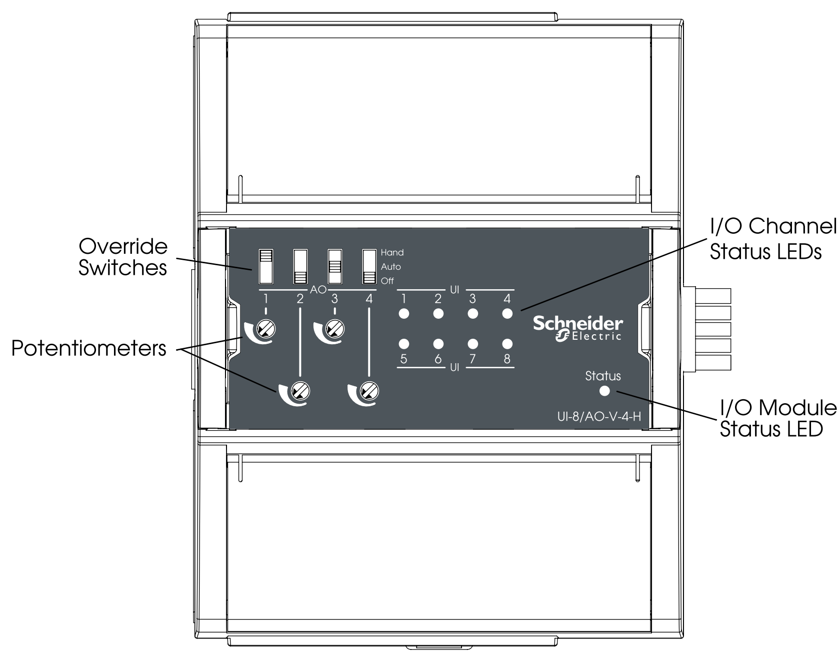


Figure: Ui-8/AO-V-4-H I/O Module

8.16.1 Universal inputs

The universal inputs of the UI-8/AO-V-4 and UI-8/AO-V-4-H I/O modules are designed to read several different types of inputs.

Input types:

- Digital
- Counter
- Supervised
- Voltage
- Current
- Temperature

- Resistive

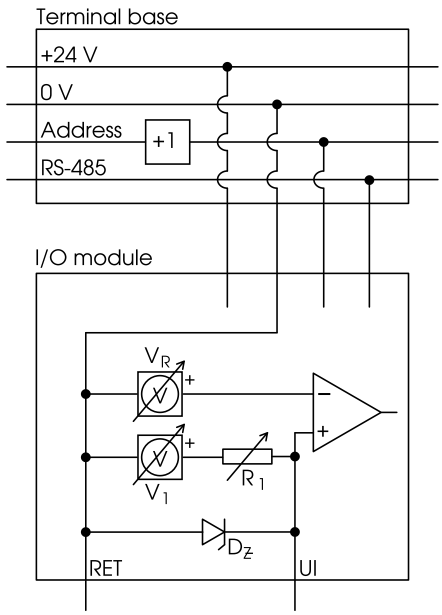


Figure: Universal input internal configuration

Applied signals beyond the absolute maximum ratings will cause over current in the protection component D_Z.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

Digital inputs

The external connection of a digital input is shown in the following figure.

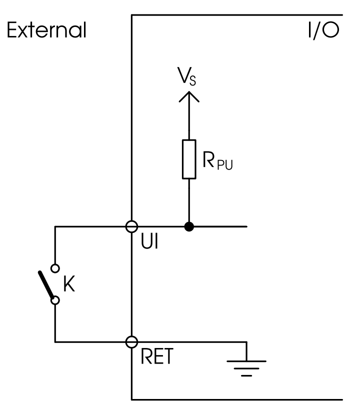


Figure: Digital input external connection

K is the monitored external switch.

V_S = 24 V

R_{PU} = 10 kohm

Counter inputs

A counter input utilizes the same hardware configuration as the digital input as shown in the figure above.

Supervised inputs

Supervised inputs are contact closing inputs supplemented with the supervision of the field wiring integrity. This supervision is a required feature in many security system applications. The supervised inputs provide the ability to detect specific forms of tampering or trouble with the wire connections to the field contacts. The supervision is achieved with a combination of 1 or 2 resistors attached to the contact in the field. The resistor combination creates continuous current flow through the field contact loop and presents a defined set of expected resistance values for each of the defined conditions. If someone is attempting to defeat the monitoring of the field contact by short circuiting the wire with a jumper or cutting the wire, the objective is to detect and indicate such a condition. The resistors need to be located at the end of the cable close to the field contact, so that the point where there is a risk that the circuit is defeated is between the resistors and the I/O module.

Three different types of supervised input connections are supported:

- Series only
- Parallel only
- Series and parallel

Each type of supervised input connection provides a different capability in regards to what form of tamper/trouble can be detected regardless of switch contact open or closed condition.

A single resistor, which is connected in series with the switch, can only detect tamper/trouble in the form of a short circuit across the wire pair. The external connection of a series only supervised input connection is shown in the following figure.

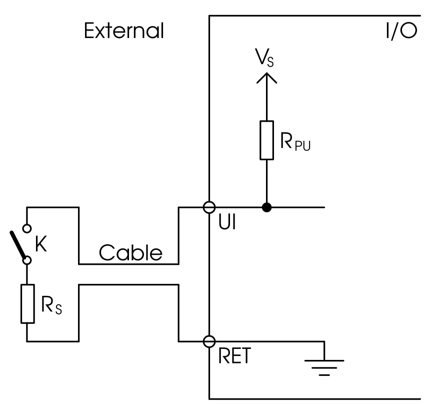


Figure: Series only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

A single resistor, which is connected in parallel with the switch, can only detect tamper/trouble in the form of an open circuit in the field wiring loop. The external connection of a parallel only supervised input connection is shown in the following figure.

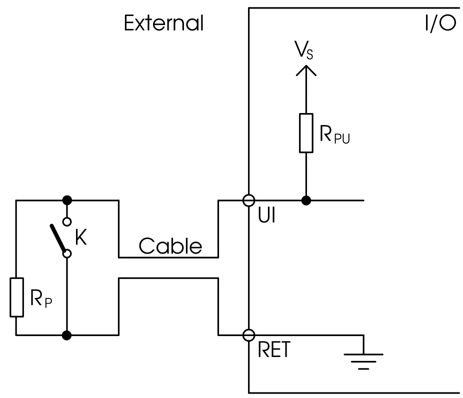


Figure: Parallel only external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

Two resistors, where one is connected in series with the switch and one is connected in parallel with the switch, can detect tamper/trouble conditions in the form of both an open and a shorted circuit. The external connection of a series and parallel supervised input connection is shown in the following figure.

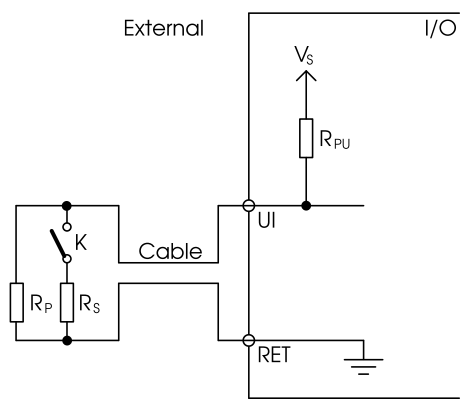


Figure: Series and parallel external connection

K is the monitored external switch.

V_S = 5 V

R_{PU} = 10 kohm

Voltage inputs

The external connection of a voltage input is shown in the following figure.

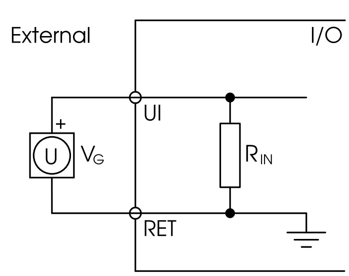


Figure: Voltage input external connection

V_G is the monitored external voltage.

R_{IN} = 100 kohm

Current inputs

The external connection of a current input is shown in the following figure.

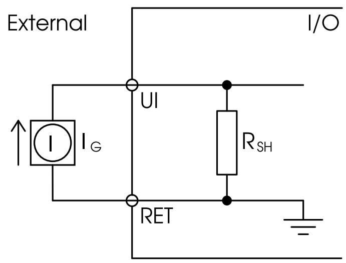


Figure: Current input external connection

I_G is the monitored external current.

R_{SH} = 47 ohm

In the internal configuration of the current input, there is a current limit circuit in order to protect the shunt resistor from over load. The input current is limited to 60 mA with a serial connected FET transistor. If this limit is reached for 0.5 s, the transistor is turned off. When 5 s has elapsed, the transistor is turned on again to make a new start attempt.

Temperature inputs

The external connection of a temperature input is shown in the following figure.

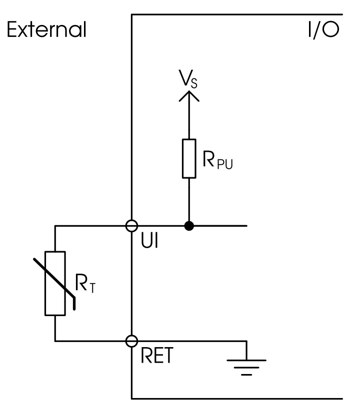


Figure: Temperature input external connection

R_T is the monitored external thermistor.

When a universal input is used as a temperature input, V_S and R_{PU} in the internal configuration of the universal input are used according to the following table.

Thermistor type	V_s	R_{PU}
20 kohm	5 V	10 kohm
10 kohm	5 V	10 kohm
2.2 kohm	1 V	1.5 kohm
1.8 kohm	1 V	1.5 kohm

Continued

Thermistor type	**V_s**	**R_{PU}**
1 kohm	1 V	1.5 kohm

The resulting voltage across the thermistor is measured and a temperature is calculated dependent on the selected thermistor type.

Resistive inputs

The external connection of a resistive input is shown in the following figure.

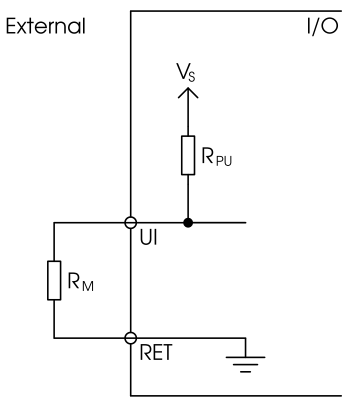


Figure: Resistive input external connection

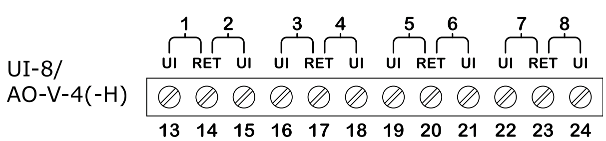
R_M is the monitored external resistance.

V_S = 5 V

R_{PU} = 10 kohm

8.16.2 Specifications

Universal inputs



Absolute maximum ratings ....-0.5 to +24 VDC

Digital

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width ....120 ms

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Counter

Range ....Dry contract switch closure or open collector/open drain, 24 VDC, 2.4 mA

Minimum pulse width ....20 ms

Maximum frequency ....25 Hz

LED polarity ....Software selectable, if the LED is activated when the input is high or low

LED color ....Red or green, software selectable

Supervised

5 V circuit, 1 or 2 resistors
Monitored switch combinations..Series only, parallel only, and series and parallel

Resistor range..1 to 10 kohm
For a 2-resistor configuration, each resistor is assumed to have the same value +/- 5 %

Voltage

Range...0 to 10 VDC

Accuracy ....+/-(7 mV + 0.2 % of reading)

Resolution..12 bit, 2.7 mV

Impedance...100 kohm

Reliability check ....Yes

Current

Range...0 to 20 mA

Accuracy ....+/-(0.03 mA + 0.4 % of reading)

Resolution..12 bit, 5.6 µA

Impedance ....47 ohm

Reliability check ....Yes

Resistive

10 ohm to 10 kohm accuracy ....+/-(7 + 4 x 10^{-3} x R) ohm
R = Resistance in ohm

10 to 60 kohm accuracy...+/-(4 x 10^{-3} x R + 7 x 10^{-8} x R^2) ohm
R = Resistance in ohm

Reliability check ....Yes

Temperature

Range ....-50 to +150 °C (-58 to +302 °F)

Resolution...12 bit

Reliability check ....Yes

Supported thermistors

Honeywell ....20 kohm

Type I (Continuum) ....10 kohm

Type II (I/NET)..10 kohm

Type III (Satchwell)...10 kohm

Type IV (FD).. 10 kohm

Type V (FD w/ 11k shunt)...Linearized 10 kohm

Satchwell D?T ....Linearized 10 kohm

Johnson Controls...2.2 kohm

Xenta ....1.8 kohm

Balco ....1 kohm

Thermistor accuracy

20 kohm, 10 kohm, 2.2 kohm, and 1.8 kohm....................-50 to -30 °C: +/-1.5 °C (-58 to -22 °F: +/-2.7 °F)
....-30 to 0 °C: +/-0.5 °C (-22 to +32 °F: +/-0.9 °F)
.... 0 to 50 °C: +/-0.2 °C (32 to 122 °F: +/-0.4 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-1.5 °C (212 to 302 °F: +/-2.7 °F)

Linearized 10 kohm ....-50 to -30 °C: +/-3.0 °C (-58 to -22 °F: +/-5.4 °F)
....-30 to 0 °C: +/-1.0 °C (-22 to +32 °F: +/-1.8 °F)
.... 0 to 50 °C: +/-0.3 °C (32 to 122 °F: +/-0.5 °F)
.... 50 to 100 °C: +/-0.5 °C (122 to 212 °F: +/-0.9 °F)
.... 100 to 150 °C: +/-2.0 °C (212 to 302 °F: +/-3.6 °F)

1 kohm ....-50 to +150 °C: +/-1.5 °C (-58 to +302° F: +/-2.7 °F)

8.16.3 Analog outputs

The analog outputs of the UI-8/AO-V-4 and UI-8/AO-V-4-H I/O modules are designed to be used for voltage outputs.

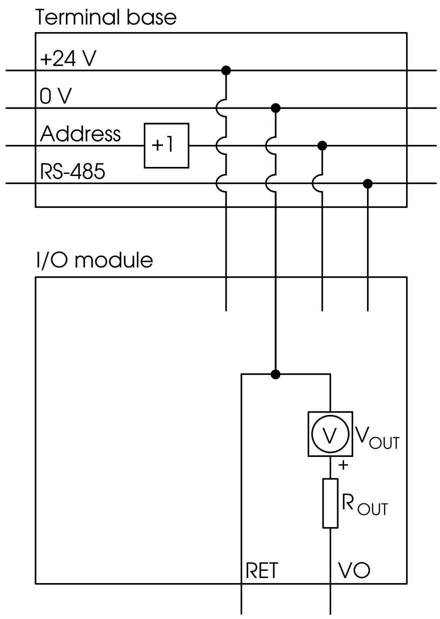


Figure: Analog output internal configuration

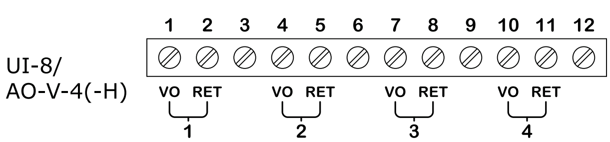
R_{OUT} is approximately equal to 10 ohm.

The I/O bus in the terminal base provides the I/O module with power and an address.

The address value in the I/O bus is increased by one for each terminal base. The I/O bus also enables RS-485 communication between the I/O module and the Automation Server.

8.16.4 Specifications

Analog outputs



Voltage

Range...0 to 10 VDC

Accuracy ....+/-100 mV

Resolution ....42 mV

Minimum load resistance ....5 kohm

Load range ....-1 to +2 mA

Reliability check ....Yes

9 Wiring

Topics

9.1 Wiring

The wiring recommendations provide guidance regarding wiring of the I/O modules and the Automation Server.

9.1.1 I/O Module Wiring

The I/O module wiring recommendations provide guidance on what type of wires should be used for the different I/O modules (including the RTD-DI-16 module), how to perform grounding, and how to connect different external devices to the I/O modules. Always use the recommended cables and wires.

For more information, see section 9.2 “I/O Module Wiring” on page 160.

9.1.2 Automation Server Wiring

The Automation Server wiring recommendations apply to the wires and cables used for RS-485 communications, LonWorks communication, USB connection, and Ethernet connection. Always use the recommended cables and wires.

For more information, see section 9.5 “Automation Server Wiring” on page 167.

9.2 I/O Module Wiring

The I/O module wiring recommendations provide guidance on what type of wires should be used for the different I/O modules (including the RTD-DI-16 module), how to perform grounding, and how to connect different external devices to the I/O modules. Always use the recommended cables and wires.

Most of the wiring is made to the terminal base, and can be done before the electronics module is fitted.

Warning

Isolate the supply before wiring. Some modules or terminal bases may carry lethal voltages.

9.2.1 Shielded Wires

For digital I/O modules, you can use shielded or unshielded wire. Unshielded wires are usually sufficient.

For analog I/O modules, you can use shielded or unshielded wire. Shielded wires are recommended if the wiring is placed in a noisy electrical environment. Connect the shield to ground only at the I/O module end.

9.2.2 RTD Wiring

For RTD-DI-16 I/O modules that have an external connection of an RTD temperature input, an RTD resistive input, or a resistive input, shielded wires are recommended if the wiring is placed in a noisy electrical environment.

9.2.3 Grounding and Power

It is important to perform the grounding correctly for two reasons:

- To design a safe system that is not harmed by minor connection errors.
- To design a system that works well and is resistant to EMI.

For more information, see section 9.3 “Grounding and Power” on page 161.

9.2.4 External Device Connections

There are many different kinds of external devices from different vendors that can be connected to a SmartStruxure solution.

For more information, see section 9.4 “External Device Connections” on page 163.

9.3 Grounding and Power

It is important to perform the grounding correctly for two reasons:

- To design a safe system that is not harmed by minor connection errors.
- To design a system that works well and is resistant to EMI.

Use the following recommendations to design a good working system:

- It is preferable to have single signal ground rail long enough to cover all signal ground connections. If several ground rails are used, connect them in a tree configuration with wires of at least 4 mm^2 copper areas. This corresponds to AWG 12.
- Connect at least one RET pin from every module to the signal ground rail (SGR) using a 1.3 mm^2 (16 AWG) or larger wire.
- Connect the root of the signal ground tree to ground.
- Connect the signal output (Y-terminals) from external devices such as transmitters to the UI-inputs. For non-isolated devices, connect the signal common from the transmitter to the SGR in the panel. For isolated devices, connect the signal common from the transmitter to the RET pin on the same module as the UI-input.
- Connect the signal input (X-terminals) of external devices such as actuators to the AO-outputs. For non-isolated devices, connect the signal common from the actuator to the SGR in the panel. For isolated devices, connect the signal common from the actuator to the RET pin on the same module as the AO-output.
- Connect the G0 (Power Ground/Common) of external devices such as actuators and transmitters to the SGR in the panel.
- Connect thermistors to the UI-input and corresponding RET terminal on the same UI module.
- One or several 24 V power transformers can be used to supply the system.
- Different loads are connected to different fuses in order to limit short circuit currents, but it is important to keep in mind that some of the signal ground wires will carry the sum of all load currents.
- The current limited power source used to power the PS-24V units should be different from the current limited source used to supply the field devices.
- For UL listing compliance (Class 2 power), the fuses (circuit breakers) must be rated not more than 4A. For other regions, not requiring UL compliance, fuses (circuit breakers) may be rated up to 6A.
- For UL compliance a UL Class 2 (100 VA or less) transformer may be used instead of the fuse/breaker limited transformer arrangement shown.
- All field devices connected to an I/O module should be powered from a single current limited source. Avoid intermixing multiple 4A or 6A power sources on a single I/O module.

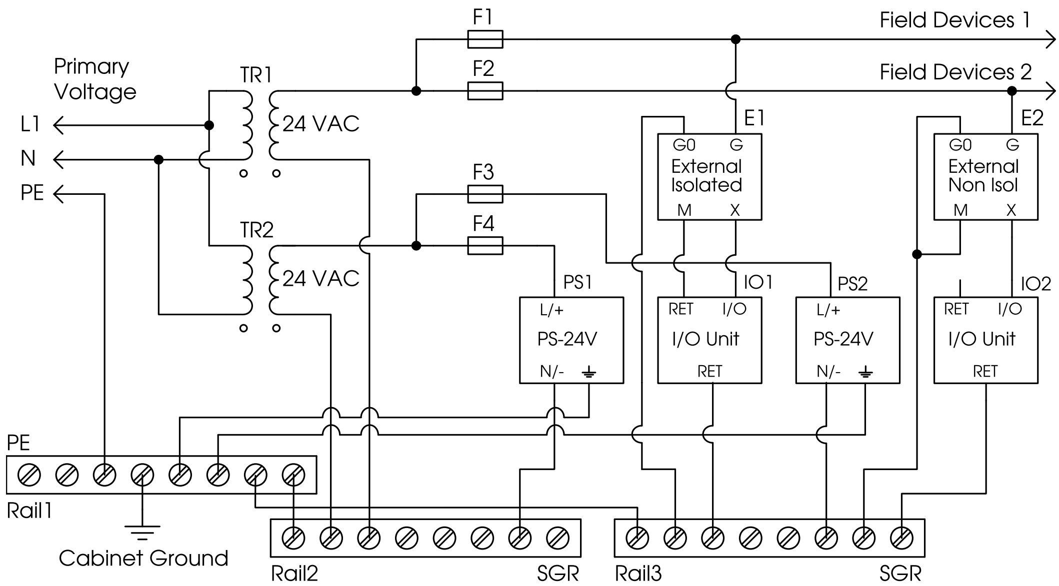


Figure: System configuration

9.4 External Device Connections

There are many different kinds of external devices from different vendors that can be connected to a SmartStruxure solution.

It is important to know how different external devices co-operate with the devices in the SmartStruxure solution, so we present some different principles for those external devices here. As a rule of thumb, try to avoid direct connections between RET and G0 (Ground) if possible in the field (external to the control panel). As discussed below, one RET pin on each I/O module should be wired to a signal ground rail (SGR) in the control panel using 16AWG (1.3 mm²) or larger wire.

9.4.1 Thermistors

Thermistors are connected directly between a UI input and the corresponding RET.

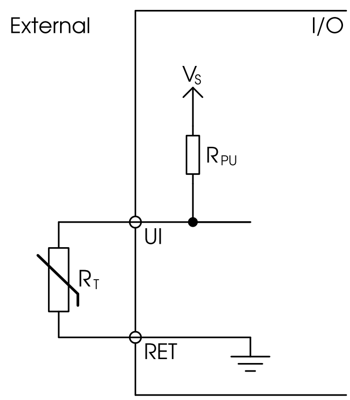


Figure: Temperature input

9.4.2 Contacts

Digital inputs are controlled by contact closings to RET. The digital inputs are normally quite immune to disturbance signals, so they can also detect contact closings directly to the signal ground rail. Even though RET is connected to the signal ground rail, there might be a small voltage difference that could impact results on analog inputs. Such small voltage differences are not enough to impact digital inputs though.

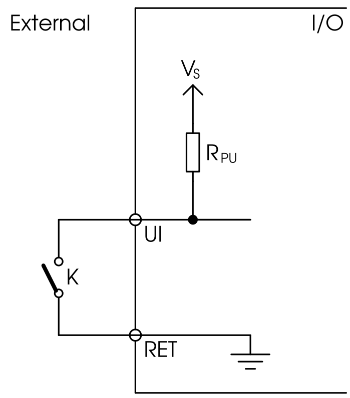


Figure: Digital input

9.4.3 Actuators

Actuators are divided into two types: isolated and non-isolated control voltage actuators. The non-isolated actuators are more commonly used. The two actuator types work mostly in the same way, but the non-isolated actuators have the signal ground M internally connected to power ground G0. In some cases, they have only three terminals with one common terminal for M and G0.

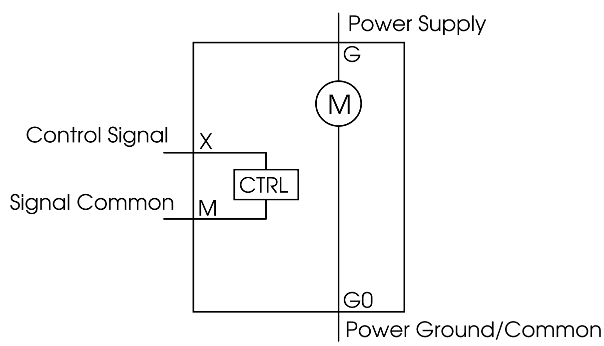


Figure: Isolated actuator

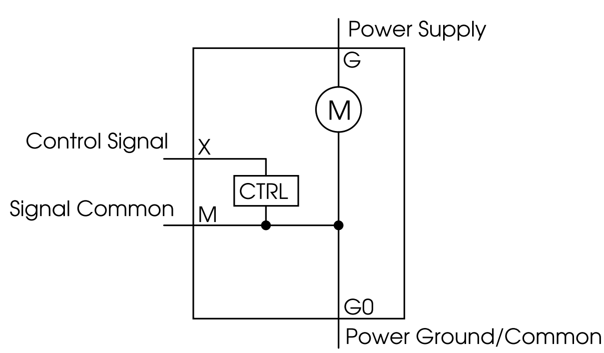


Figure: Non-isolated actuator

Non-isolated actuators can be more sensitive to different kinds of disturbances, and it is sometimes easier to design a more stable system using isolated actuators. When the system uses a non-isolated actuator, care must be taken in properly wiring the neutral wire back to the supply neutral for each actuator rather than daisy chaining to prevent large voltage drops that can affect input signal accuracy.

Some actuator control signal inputs may be designed with a high impedance differential input which prevents AC/DC supply currents from being shared in the signal return path. Such actuators are as good as isolated actuators with respect to disturbances and ground currents, so they can be connected as isolated actuators.

The disturbance can be of two kinds: AC disturbance causing the actuator to move quickly back and forth, and DC disturbance causing an offset. Both AC and DC issues occur as a result of currents in the connection from M to RET.

The DC issue is a less severe problem because a DC error can be compensated by the control loop as long as it is quite small. If the DC error is big, the actuator may not be able to turn off or on completely. Normally the actuator starts to open when the control voltage is a few hundred millivolt, so a DC offset of 100 mV is probably not an issue.

The AC issue can be a more severe problem. If an AC disturbance is added to the control signal, the actuator will start to travel back and forth and its dependability may be affected.

If it is unknown whether an actuator is isolated or non-isolated, it should be treated as non-isolated.

9.4.4 Transmitters

Transmitters are used to convert signals from sensors that cannot be connected directly to an I/O module. Transmitters are divided into two types: isolated and non-isolated transmitters.

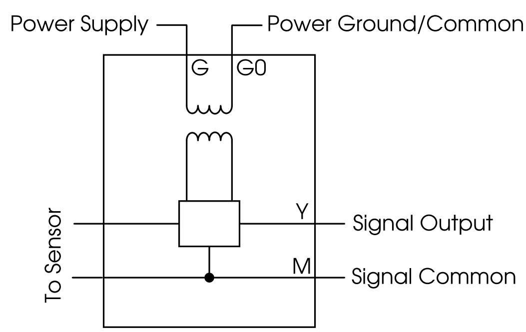


Figure: Isolated transmitter

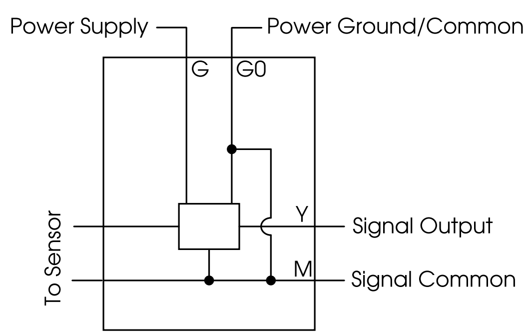


Figure: Non-isolated transmitter

When the system uses a non-isolated transmitter, AC and DC bias issues may occur.

The DC error from a voltage transmitter can never be compensated for by a loop. So, a DC current in the M conductor will cause a DC error in the reading value if the current and the resistance are large enough to cause a non-negligible voltage drop, thus creating an error. An AC voltage drop caused by an AC current in the conductor between M and RET will result in unstable measurements.

Selecting isolated transmitters will solve the AC and DC bias issues, but the issues can also be limited by good system design. For more information, see section 9.3 “Grounding and Power” on page 161.

In isolated transmitters, the sensors are normally not isolated from the M conductor, they are only isolated from the power supply of the transmitter. This is not an issue, since the sensors are not connected to anything but the transmitters.

Transmitters may have differential outputs. Transmitters with differential outputs can be connected as isolated external devices.

If it is unknown whether a transmitter is isolated or non-isolated, it should be treated as a non-isolated transmitter.

The use of current (4-20 mA) transmitters (instead of voltage output) will avoid error from DC voltage drop in the common M to RET return wiring and will assist in reducing signal reading instability from AC current in the return path.

9.4.5 Loads Such as Relays

All loads such as relays are connected to digital output modules with outputs isolated from the signal ground. No special care must be taken with respect to grounding in this case.

9.5 Automation Server Wiring

The Automation Server wiring recommendations apply to the wires and cables used for RS-485 communications, LonWorks communication, USB connection, and Ethernet connection. Always use the recommended cables and wires.

The LonWorks wiring is made to the terminal base and can be done before the electronics module is fitted. The connections for RS-485 communications, Ethernet, and USB are made to the electronics module.

Warning

Isolate the supply before wiring. Some modules or terminal bases may carry lethal voltages.

9.5.1 RS-485 Communications

The information in this section provides recommendations for the RS-485 interface port configuration between the Automation Server and RS-485 network devices. This information is intended to supplement existing guides for the Automation Server and for the various RS-485 network devices.

For more information, see section 10.1 “RS-485 Communications” on page 173.

9.5.2 LonWorks Communications

Twisted pair cables should be used between the FTT-10 interface on the Automation Server terminal base and the TP/FT-10 LonWorks network. The cables should conform to the standard EN 50173-1.

9.5.3 USB Connections

Standard USB cables should be used for connection to the USB host and device ports on the Automation Server electronics module. The recommended maximum cable length is 3 m (10 ft).

9.5.4 Ethernet Connections

Category 5 twisted pair cables with RJ-45 connector should be used for connection to the Ethernet 10/100 port(s) on the Automation Server electronics module. The recommended maximum cable length is 100 m (330 ft).

10 RS-485 Communications

Topics

10.1 RS-485 Communications

The information in this section provides recommendations for the RS-485 interface port configuration between the Automation Server and RS-485 network devices. This information is intended to supplement existing guides for the Automation Server and for the various RS-485 network devices.

The guidelines focus on the arrangement of the electrical interface to the RS-485 port in regard to biasing, termination, cable selection, cable length, and cable routing. There are also guidelines presented for maximum unit load (node count) and common mode voltage tolerance.

The guidelines are available through a collection of application notes. Most of the application notes target specific product families such as the b3 BACnet devices, MNB BACnet devices, Legrand power meters, and Viconics VT/VZ/SE 7xxx series devices. There is also an application note directed toward generic RS-485 network devices.

10.1.1 Generic RS-485 Network Devices

This application note provides recommendations for the RS-485 interface port configuration between the Automation Server and generic RS-485 network devices (Modbus or MS/TP). This information is intended to supplement the instructions you receive with the various RS-485 network devices. These guidelines focus on the arrangement of the electrical interface to the RS-485 port in regards to biasing, termination, cable selection, cable lengths, and cable routing. The guidelines on maximum unit load (node count) and common mode voltage tolerance are associated with Automation Servers with serial number of TD133954000 and later.

For more information, see section 10.2 “Generic RS-485 Network Devices” on page 175.

10.1.2 b3 BACnet Devices

This application note provides recommendations and guidelines for the configuration of RS-485 communications between the Automation Server and b3 BACnet devices. This information is intended to supplement the existing configuration documents, such as the “b3 BACnet and b4920 Controller Technical Reference (30-3001-862)”. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths, and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance is associated with the Automation Servers with serial number of TD133954000 and later.

For more information, see section 10.18 “b3 BACnet Devices” on page 216.

10.1.3 MNB BACnet Devices

This application note provides recommendations for the configuration of RS-485 communications between the Automation Server and MNB BACnet devices. This information is intended to supplement the existing configuration documents such as the “TAC I/A Series MicroNet BACnet Wiring and Networking Practices Guide (F-

27360-3)”. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance is associated with the Automation Servers with serial number of TD133954000 and later.

For more information, see section 10.22 “MNB BACnet Devices” on page 223.

10.1.4 Legrand Power Meters

This application note provides recommendations and guidelines for the configuration of RS-485 Modbus communications between the Automation Server and Legrand power meters. The recommendations are based on an investigation of Legrand meter models 04677, 04680, 04684, and 14669. The investigation was used to discover isolation and unit load characteristics along with requirements of the RS-485 transceiver for external failsafe biasing on the RS-485 network and to test communications operation with the meters under recommended configurations. This information is intended to supplement the product information provided with the Legrand meters. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance is associated with the Automation Servers with serial number of TD133954000 and later.

For more information, see section 10.34 “Legrand Power Meters” on page 252.

10.1.5 Viconics VT/VZ/SE 7xxx Series Devices

This application note provides recommendations for the configuration of RS-485 communications between the Automation Server and Viconics room controllers. The recommendations are associated with the Viconics VT/VZ/SE 7xxx series thermostats / room controllers configured with the Viconics plug-on MS/TP network adapter. This information is intended to supplement the instructions you receive with the various RS-485 network devices. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths, and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance are associated with the Automation Servers with serial number of TD133954000 and later.

For more information, see section 10.45 “Viconics VT/VZ/SE 7xxx Series Devices” on page 278.

10.2 Generic RS-485 Network Devices

This application note provides recommendations for the RS-485 interface port configuration between the Automation Server and generic RS-485 network devices (Modbus or MS/TP). This information is intended to supplement the instructions you receive with the various RS-485 network devices. These guidelines focus on the arrangement of the electrical interface to the RS-485 port in regards to biasing, termination, cable selection, cable lengths, and cable routing. The guidelines on maximum unit load (node count) and common mode voltage tolerance are associated with Automation Servers with serial number of TD133954000 and later.

Figure: RS-485 interface between the Automation Server and a generic RS-485 network device

The recommendations listed here deal only with the electrical load characteristics. The node count limits are related to the electrical interface, termination, biasing and cable characteristics. The usable node limit may be lower as a function of individual product configurations, resources or performance limits. The existing manuals, installation instructions, and guidelines for the various RS-485 network device products must be referenced to establish the initial system configuration and capacity objectives. This document is intended to supplement the existing product documentation. The recommendations here can only maintain or reduce the product documented node capacity (on a single bus) and/or the length of the bus. The various product described capacities and distances can frequently operate acceptably. However, some product described capacities and distances may encounter environment and cabling characteristics where a reduction of tolerance shows up. The intention here is to adjust the configuration recommendations to consider other influences on the network load and length with the objective of operating within the margins defined by the TIA-485A standard and the transceiver manufacturers.

10.2.1 Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices

To make appropriate recommendations, it is necessary to first collect some information about the intended configuration. The worksheet contains questions, which identify some specific attributes that affect the proposed configuration. Review the installation guide and manuals for the products to be connected to the RS-485 port on the Automation Server. Use the product manuals along with your project details to answer the questions in the worksheet.

For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178.

10.2.2 Configuration Selection for Generic RS-485 Network Devices

Use the answers from the worksheet together with these flowcharts to determine the recommended RS-485 bus configuration for your generic RS-485 devices.

For more information, see section 10.4 “Configuration Selection for Generic RS-485 Network Devices” on page 180.

10.2.3 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

For more information, see section 10.14 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (MNB and Generic RS-485 Devices)” on page 209.

10.2.4 Expanded Unit Load with Network of Isolated Devices Only

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. It is recommended that a maximum load extension should be 16UL (50% overload) giving a total expanded unit load limit of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network and Automation Server leaves 24UL available for the devices. With the example device load of 0.18UL each, it is suggested that the isolated bus arrangement could support the full collection of up to 127 devices.

For more information, see section 10.15 “Expanded Unit Load with Network of Isolated Devices Only (MNB and Generic RS-485 Devices)” on page 211.

10.2.5 Cable Routing

The RS-485 network cable should be routed in a continuous daisy chain bus configuration. There should not be any stub connections, stars or ring configurations. The bussed cable should pass through each node to be connected with no splits or branches in the cable network.

For more information, see section 10.16 “Cable Routing” on page 212.

10.2.6 Cable Selection

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

For more information, see section 10.17 “Cable Selection” on page 213.

10.3 Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices

To make appropriate recommendations, it is necessary to first collect some information about the intended configuration. The worksheet contains questions, which identify some specific attributes that affect the proposed configuration. Review the installation guide and manuals for the products to be connected to the RS-485 port on the Automation Server. Use the product manuals along with your project details to answer the questions in the worksheet.

After answering the questions on this worksheet, work through the configuration selection flowcharts based on your answers. The flowcharts use your worksheet answers to provide you with a recommended configuration. For more information, see section 10.4 “Configuration Selection for Generic RS-485 Network Devices” on page 180.

Q1 Failsafe Receiver

Does the product use an RS-485 transceiver with integrated idle-state failsafe receiver?

Integrated failsafe refers to a receiver that will provide the logic 1 level output when presented with any voltage of 0 V or above from an idle and terminated bus. This does not refer to transceivers with what is called open wire failsafe. Those transceivers represent an earlier class of devices that simply provided a small current pull-up and pull-down in the chip. That integrated bias will not withstand DC termination and the resulting near 0V level would again produce indeterminate output. You must assume a basic transceiver and answer No to this question (Q1) if the failsafe function cannot be confirmed as a feature of the transceiver being used. This will be the case with many third-party RS-485 devices.

This is a very beneficial feature and worthy of pursuing confirmed answers. This feature avoids the requirement for strong bias and the additional restrictions on node count and distance.

If you have a mixture of devices connected to the Automation Server and any of these do not have a failsafe receiver, answer No here. You must treat the entire bus as a basic RS-485 and operate the bus with the basic rules and restrictions.

Q2 Data Transmission Speed

What data transmission speed will be used for the RS-485 bus?

This will normally be one of the following selections: 9600, 19200, 38400, 57600, or 76800 bps.

Data rates of 19200 bps and lower offer better immunity to transmission line effects and allow flexibility with the bias and termination options to avoid some of the guideline restrictions they inject.

Q3 Distance

What is the objective on maximum length of the RS-485 bus?

Q4 Isolated Interface

Does the device provide an isolated RS-485 interface?

Most product installation guides will make reference to the feature of isolated RS-485 interface if the product contains such a feature. It may be called galvanic isolation.

Q5 Published Unit Load Value

What is the published unit load rating for the RS-485 device to be installed?

Many times this unit load rating is not provided and instead the guide will simply identify the maximum number of devices that can be attached to a single copper segment (without repeaters). Divide 32 by the listed maximum node count to determine the implied unit load rating.

Many product guides do not include the unit load impact from local bias resistors supplied within the product. While the local bias resistors are typically considered weak (high resistance) bias sources with little impact, they actually can have a significant contribution when used in conjunction with fractional unit load transceivers (such as 1/4UL and 1/8UL). The following question (Q6) uses a resistance measurement to determine the actual unit load presented by a sample device. This will frequently show a higher unit load value than the published number. It is recommended that you should use the higher UL of the two UL values (published or measured).

Q6a Measured Resistance

With no electrical connections to the product, what is the measured resistance between the RS-485 low-side (-) signal and the communications common?

On a standard non-isolated product, the communications common will typically be the recommended ground connection on the product.

On an isolated RS-485 product, the common will typically be a third terminal on the RS-485 interface, for example, REF, COMMON, SHLD, RETURN.

Q6b Measured/Calculated Unit Load Value

What is the measured/calculated unit load of the device?

Calculate the measured unit load by dividing 12,000 by the measured resistance in ohm (from Q6a).

Example: On a sample b3865V controller, the resistance measured between COM- (terminal 17) and the Ground connection (terminal 11) is 35,760 ohm (12,000 / 35,760 = 0.336 UL).

Enter that calculated result as answer for Q6b.

For the proposed configurations, it is recommended that you use the larger of the two unit load values (Q5 or Q6b).

10.4 Configuration Selection for Generic RS-485 Network Devices

Use the answers from the worksheet together with these flowcharts to determine the recommended RS-485 bus configuration for your generic RS-485 devices.

10.4.1 Flowcharts

Use Flowchart 1 below as a starting point for the selection of a recommended configuration.

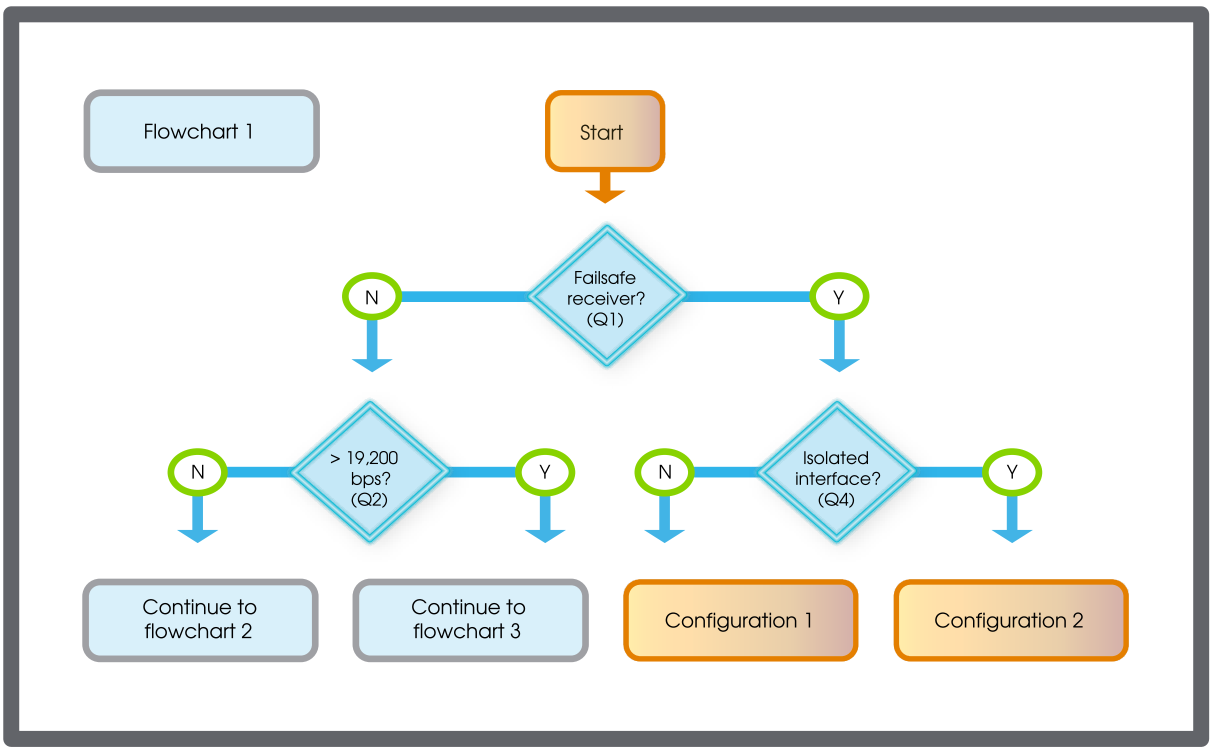


Figure: Flowchart 1

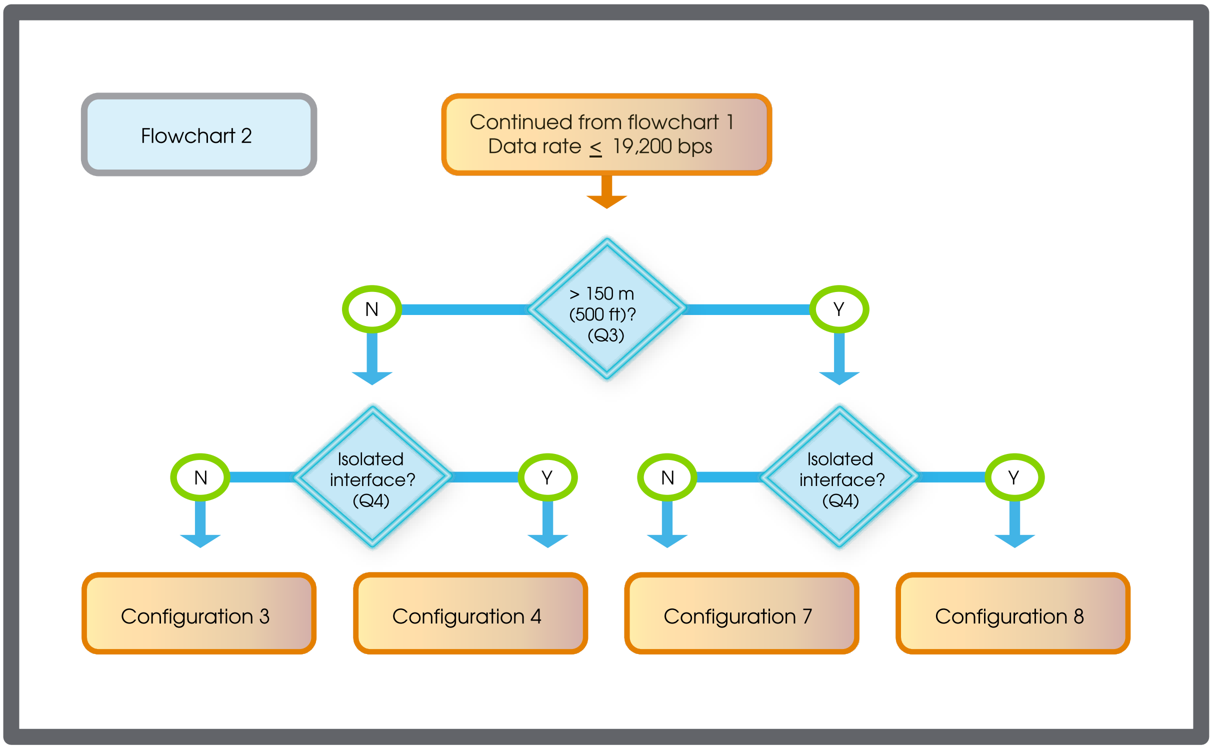


Figure: Flowchart 2 – no failsafe receivers and the data rate is 19,200 bps or less

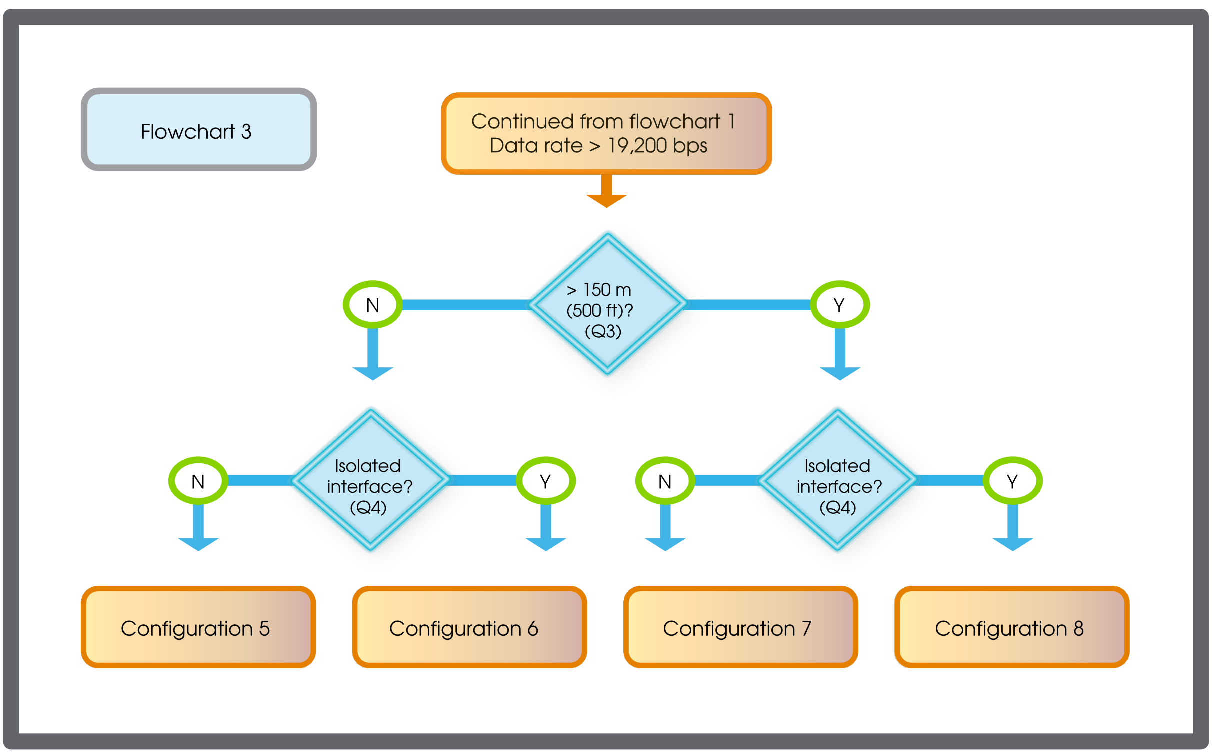


Figure: Flowchart 3 – no failsafe receivers and the data rate is greater than 19,200 bps

10.4.2 Generic RS-485 Network Device Configuration 1

This configuration is recommended if the following conditions apply to the RS-485 network devices to be connected to the Automation Server RS-485 port:

- All RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.

For more information, see section 10.5 “Generic RS-485 Network Device Configuration 1” on page 185.

10.4.3 Generic RS-485 Network Device Configuration 2

This configuration is recommended if the following conditions apply to the RS-485 network devices to be connected to the Automation Server RS-485 port:

- All RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.

For more information, see section 10.6 “Generic RS-485 Network Device Configuration 2” on page 187.

10.4.4 Generic RS-485 Network Device Configuration 3

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is 19,200 bps or lower.
- The maximum network cable length required is 150 m (500 ft) or less.

For more information, see section 10.7 “Generic RS-485 Network Device Configuration 3” on page 189.

10.4.5 Generic RS-485 Network Device Configuration 4

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is 19,200 bps or lower.
- The maximum network cable length required is 150 m (500 ft) or less.

For more information, see section 10.8 “Generic RS-485 Network Device Configuration 4” on page 192.

10.4.6 Generic RS-485 Network Device Configuration 5

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is greater than 19,200 bps.
- The maximum network cable length required is:
  - 150 m (500 ft) or less with 24 AWG (0.20 mm^2) or
  - 240 m (800 ft) or less with 22 AWG (0.33 mm^2).

For more information, see section 10.9 “Generic RS-485 Network Device Configuration 5” on page 195.

10.4.7 Generic RS-485 Network Device Configuration 6

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is greater than 19,200 bps.
- The maximum network cable length required is:
  - 150 m (500 ft) or less with 24 AWG (0.20 mm^2) or
  - 240 m (800 ft) or less with 22 AWG (0.33 mm^2).

For more information, see section 10.10 “Generic RS-485 Network Device Configuration 6” on page 198.

10.4.8 Generic RS-485 Network Device Configuration 7

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.
- The maximum network cable length required is:
  - greater than 150 m (500 ft) with 24 AWG (0.20 mm^2) or

  - greater than 240 m (800 ft) with 22 AWG (0.33 mm^2).

For more information, see section 10.11 “Generic RS-485 Network Device Configuration 7” on page 201.

10.4.9 Generic RS-485 Network Device Configuration 8

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.
- The maximum network cable length required is:
  - greater than 150 m (500 ft) with 24 AWG (0.20 mm^2) or
  - greater than 240 m (800 ft) with 22 AWG (0.33 mm^2).

For more information, see section 10.12 “Generic RS-485 Network Device Configuration 8” on page 204.

10.4.10 Power Supply Selection for Generic RS-485 Network Device Configuration 7 and 8

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

For more information, see section 10.13 “Power Supply Selection for Generic RS-485 Network Device Configuration 7 and 8” on page 207.

10.5 Generic RS-485 Network Device Configuration 1

This configuration is recommended if the following conditions apply to the RS-485 network devices to be connected to the Automation Server RS-485 port:

- All RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.

If all the devices being connected to the Automation Server RS-485 port provide failsafe receivers, the configuration becomes very simple and no node or distance reductions are called for. The failsafe receivers can typically operate with no added bias resistors.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is usually the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm^2) to 18 AWG (1.62 mm^2) wire.

If the network has a mix of isolated and non-isolated devices, the shield terminal or communications ground terminal of the isolated devices should be connected to the shield. Refer to the device specific instructions.

The shield drain wires are simply connected together at each device, allowing the shield to continue on past the devices for the full length of the bus.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

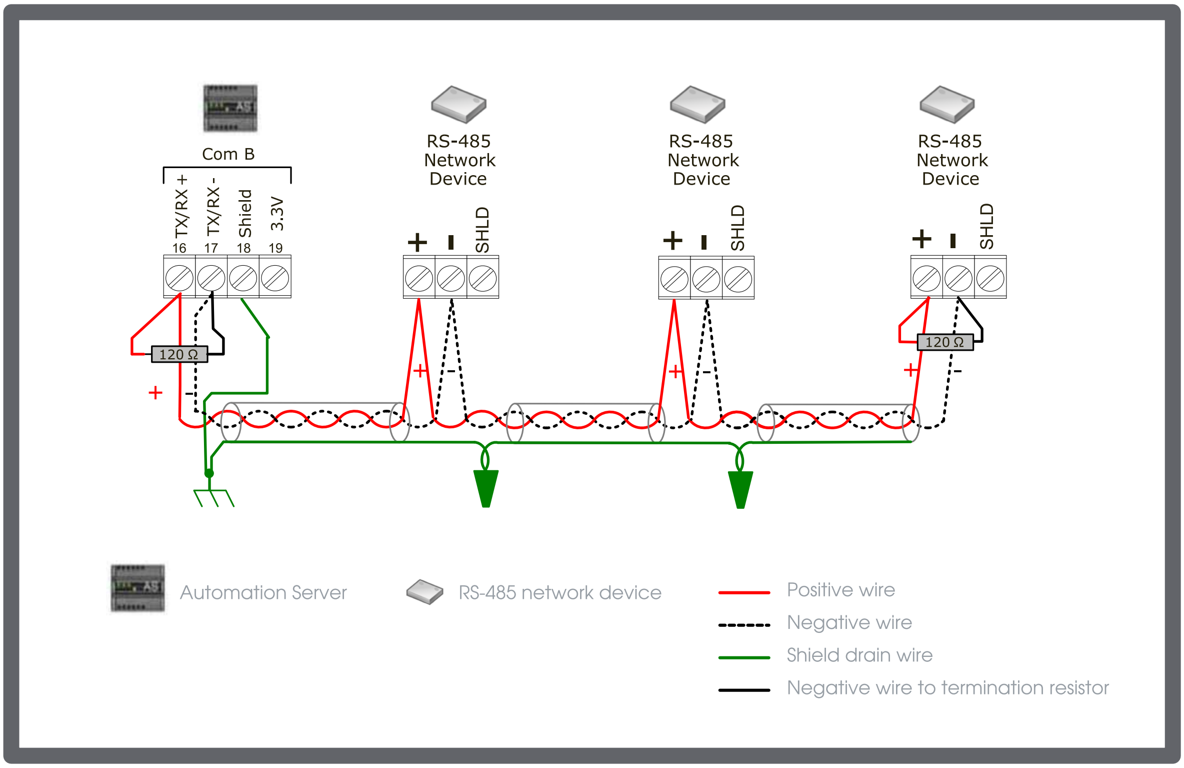


Figure: RS-485 generic device configuration 1 – terminated bus, no bias required, non-isolated interfaces

The unit load rating will determine the recommended maximum number of nodes you should install on this copper segment. Select the higher unit load value between answers Q5 and Q6B. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide 32 by the UL value (from Q5 or Q6b). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 is 0.25 and the answer to Q6b is 0.32, use the value 0.32. Calculate the maximum recommended node count as 32 / 0.32 = 100 nodes. It is recommended that you use the calculated 100 node maximum limit instead of the 128 node value suggested by the 0.25UL published UL load rating. It is likely that the node has added bias resistors that are not considered in the 0.25 published value.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

For this terminated configuration with no biasing, the maximum cable length may extend to the full standard length of 1200 m (4000 ft).

10.6 Generic RS-485 Network Device Configuration 2

This configuration is recommended if the following conditions apply to the RS-485 network devices to be connected to the Automation Server RS-485 port:

- All RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.

If all the devices being connected to the Automation Server RS-485 port provide failsafe receivers, the configuration becomes very simple and no node or distance reductions are called for. The failsafe receivers can typically operate with no added bias resistors.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm²) to 18 AWG (1.62 mm²) wire.

The shield drain wires from two cable segments are both connected to the RS-485 common/reference terminal at each device.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

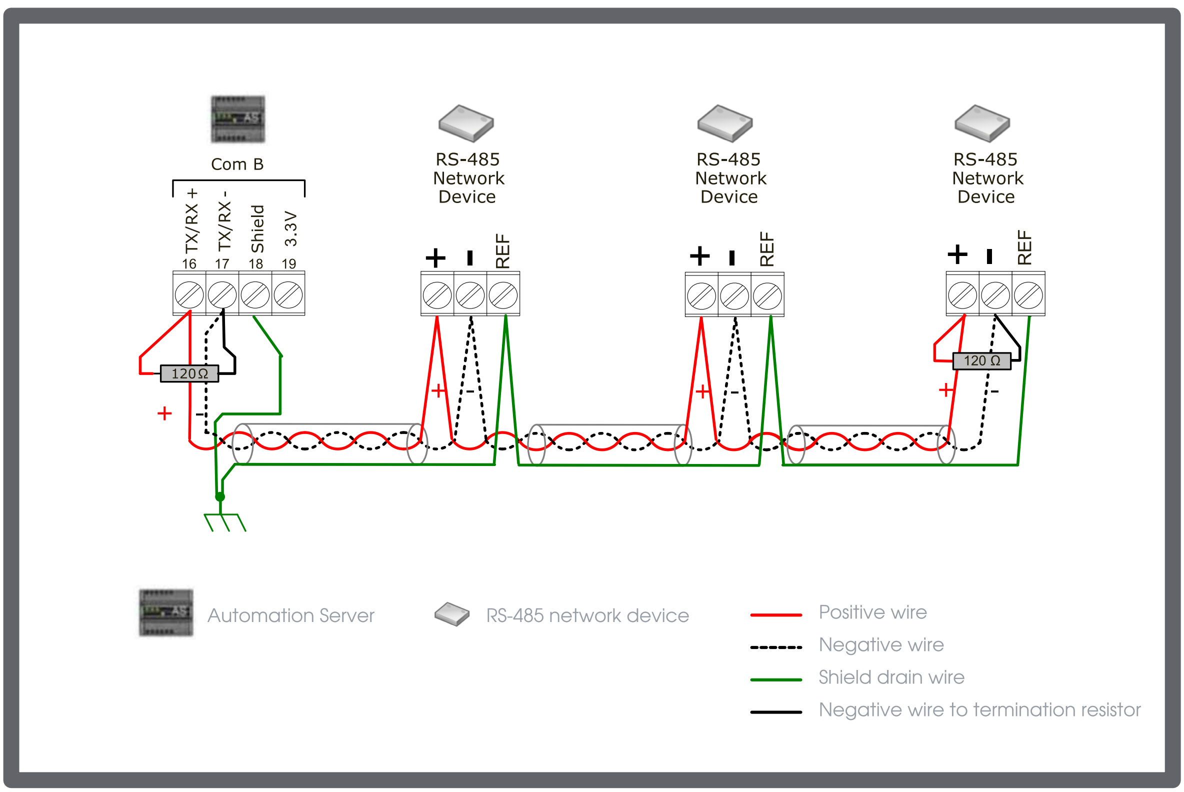


Figure: RS-485 generic device configuration 2 – terminated bus, no bias required, isolated interfaces

The unit load rating will determine the recommended maximum number of nodes you should install on this copper segment. Select the higher unit load value between answers Q5 and Q6B. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide 32 by the UL value (from Q5 or Q6b). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 is 0.25 and the answer to Q6b is 0.32, use the value 0.32. Calculate the maximum recommended node count as 32 / 0.32 = 100 nodes. It is recommended that you use the calculated 100 node maximum limit instead of the 128 node value suggested by the 0.25UL published UL load rating. It is likely that the node has added bias resistors that are not considered in the 0.25 published value.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

For this terminated configuration with no biasing, the maximum cable length may extend to the full standard length of 1200 m (4000 ft).

10.7 Generic RS-485 Network Device Configuration 3

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is 19,200 bps or lower.
- The maximum network cable length required is 150 m (500 ft) or less.

For data rates of 19,200 bps or lower, and network lengths of 150 m (500 ft) or less, it is suggested that termination can be omitted. Omission of termination avoids the requirement to add strong (low resistance) network bias. Such bias imposes reductions on the node capacity and also reduces cable length (if bias is applied from a single end).

Connect 3300 ohm resistor from + line to 3.3 V. Connect 3300 ohm resistor from - line to Ground (Shield).

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is usually the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm^2) to 18 AWG (1.62 mm^2) wire.

If the network has a mix of isolated and non-isolated devices, the shield terminal or communications ground terminal of the isolated devices should be connected to the shield. Refer to the device specific instructions.

The shield drain wires are simply connected together at each device, allowing the shield to continue on past the devices for the full length of the bus.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

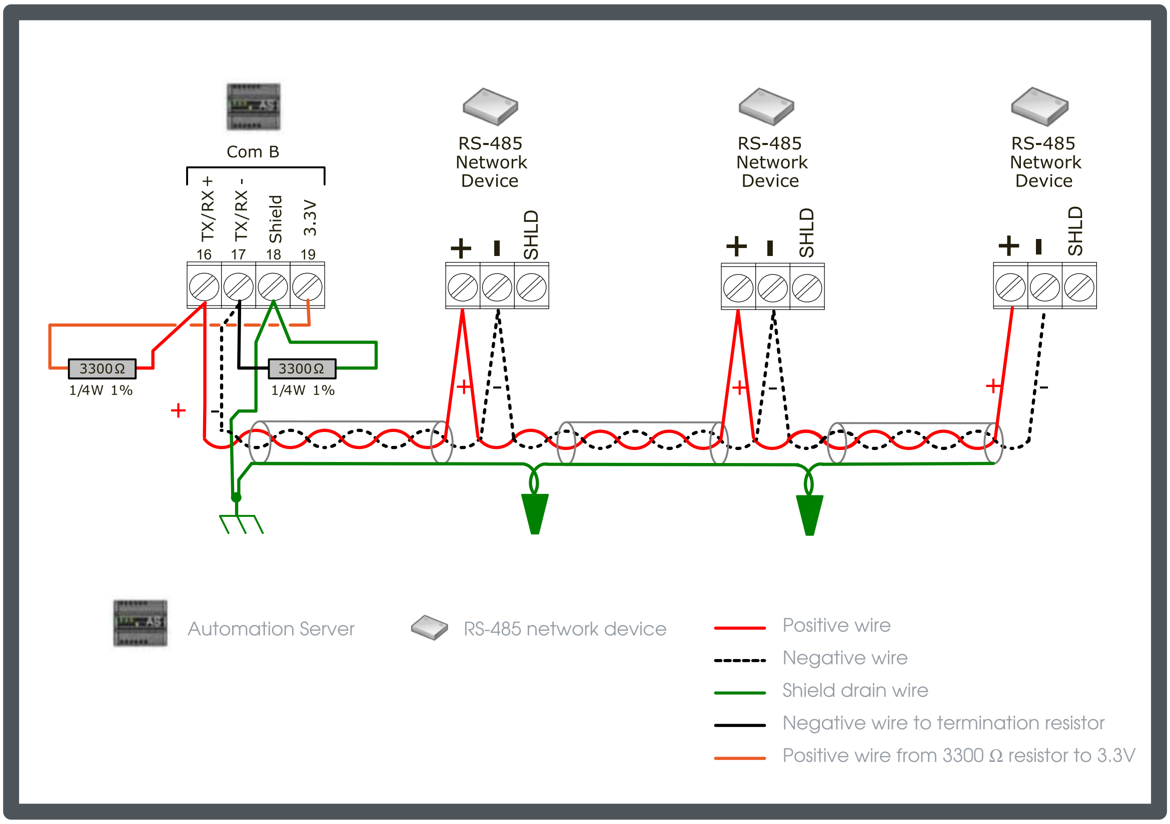


Figure: Generic RS-485 network device configuration 3 – non-terminated bus, 3300 ohm bias, non-isolated interfaces

The unit load rating of the network product will determine the recommended maximum number of nodes you should install on this copper segment. The standard unit load budget for an RS-485 segment is 32UL.

We must determine the UL node budget available after subtracting the load imposed by the bias resistors and the Automation Server. The recommended 3300 bias resistors present a unit load of 3.6 (12,000 / 3,300). The Automation Server adds 0.5UL.

For a bus with non-isolated interfaces, the remaining node budget is: 32 - 3.6 - 0.5 = 27.9UL

For the network device load, select the higher unit load value between answers Q5 and Q6b. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide the node budget value by the device UL value (Q5 or Q6b, whichever is greater). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 was 0.25 and the answer to Q6b was 0.32, use the value 0.32.

For non-isolated interfaces, the maximum node count is: 27.9 / 0.32 = 87 nodes

In this unterminated configuration with a 3300 ohm bias, the extra 3.6UL unit load (when combined with a full 32UL load of network devices) presents only a minimal impact on the reduction of CMV. For more information, see section 10.14 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (MNB and Generic RS-485 Devices)” on page 209.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.8 Generic RS-485 Network Device Configuration 4

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is 19,200 bps or lower.
- The maximum network cable length required is 150 m (500 ft) or less.

For data rates of 19,200 bps or lower, and network lengths of 150 m (500 ft) or less, it is suggested that termination can be omitted. Omission of termination avoids the requirement to add strong (low resistance) network bias. Such bias imposes reductions on the node capacity and also reduces cable length (if bias is applied from a single end).

Connect 3300 ohm resistor from + line to 3.3 V. Connect 3300 ohm resistor from - line to Ground (Shield).

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm^2) to 18 AWG (1.62 mm^2) wire.

The shield drain wires from two cable segments are both connected to the RS-485 common/reference terminal at each device.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

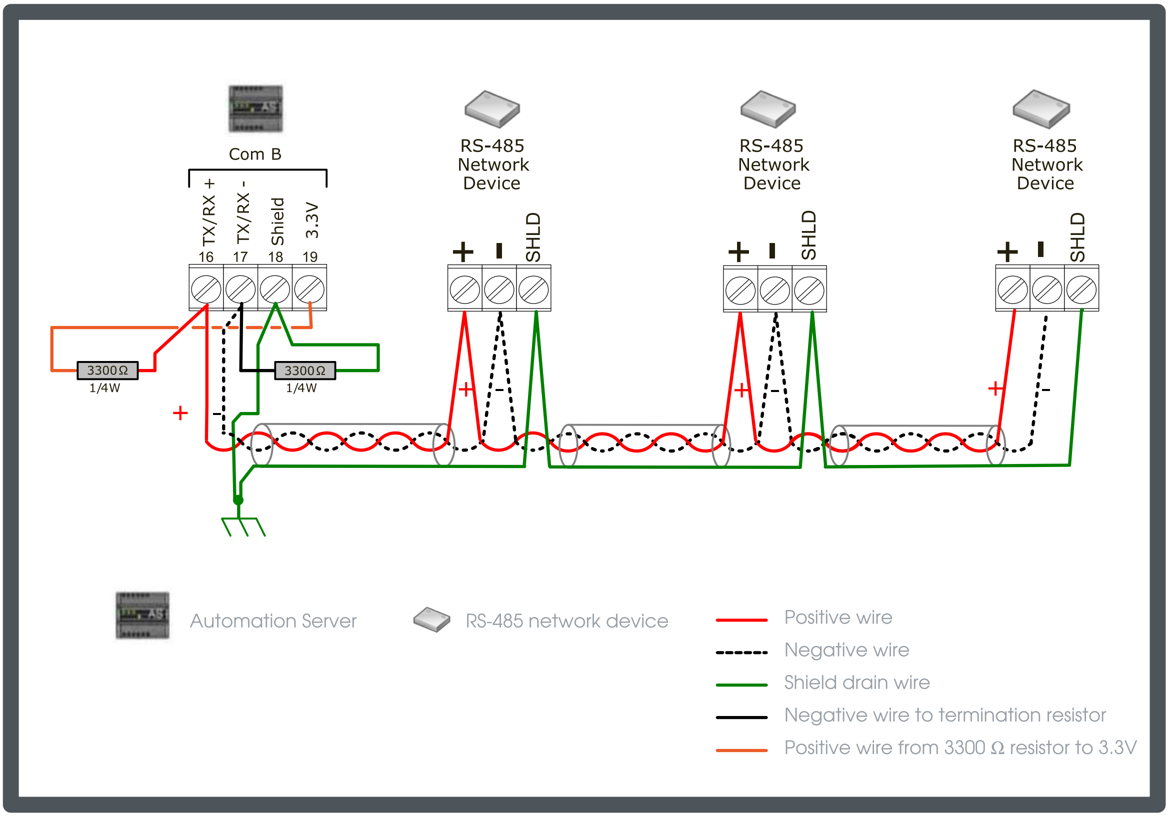


Figure: Generic RS-485 network device configuration 4 – non-terminated bus, 3300 ohm bias, isolated interfaces

The unit load rating of the network product will determine the recommended maximum number of nodes you should install on this copper segment. The standard unit load budget for an RS-485 segment is 32UL. If all devices on the bus segment are isolated RS-485 interfaces (except the Automation Server), it is recommended that we can boost the starting budget to 48UL. This extra UL capacity is related to fact that the isolated interfaces provide an avoidance of Common Mode Voltage. For more information, see section 10.15 “Expanded Unit Load with Network of Isolated Devices Only (MNB and Generic RS-485 Devices)” on page 211.

We must determine the UL node budget available after subtracting the load imposed by the bias resistors and the Automation Server. The recommended 3300 bias resistors present a unit load of 3.6 (12,000 / 3,300). The Automation Server adds 0.5UL.

For a bus with all isolated interfaces, the remaining node budget is: 48 - 3.6 - 0.5 = 43.9UL

For the network device load, select the higher unit load value between answers Q5 and Q6b. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide the node budget value by the device UL value (Q5 or Q6b, whichever is greater). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 was 0.25 and the answer to Q6b was 0.32, use the value 0.32.

For all isolated interfaces, the maximum node count is: 43.9 / 0.32 = 137 nodes

In this unterminated configuration with a 3300 ohm bias, the extra 3.6UL unit load (when combined with a full 32UL load of network devices) presents only a minimal impact on the reduction of CMV. For more information, see section 10.14 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (MNB and Generic RS-485 Devices)” on page 209.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.9 Generic RS-485 Network Device Configuration 5

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is greater than 19,200 bps.
- The maximum network cable length required is:
  - 150 m (500 ft) or less with 24 AWG (0.20 mm²) or
  - 240 m (800 ft) or less with 22 AWG (0.33 mm²).

The third condition indicates that network termination is needed. The first condition indicates the termination will cause a need for strong bias.

A strong external resistor bias (low resistance pull-up and pull-down) is required to create a minimum +200 mV level (plus noise margin) across the data+ and data- conductors for the full length of the bus when the network is idle (in between all packets). The low resistance bias is needed to overcome the voltage drop created by the wire resistance and current pulled by the termination resistors. This is referenced as failsafe bias and is required because the transceiver is of the earlier type with no integrated failsafe receiver function.

With the first and third conditions defined, there are two bias configuration options to choose from. The choice relates to simplicity of the arrangement and the maximum cable length needed (the fourth condition). This configuration uses single end-point biasing. Dual end-point biasing is required to support cable lengths up to 1200 m (4000 ft). For more information, see section 10.11 “Generic RS-485 Network Device Configuration 7” on page 201.

This configuration uses the 3.3 V supply output from the Automation Server to generate bias on the bus from the single location where the Automation Server is located (typically at the head end of the bus). An alternate termination resistance value of 180 ohm is recommended with the current Automation Server. The bias voltage on the server is 3.3 V and 180 ohm termination allows the minimum failsafe voltage to be created (approximately the same voltage as created with 120 ohm and 5 V bias supply).

Connect 510 ohm resistor from + line to 3.3 V. Connect 510 ohm resistor from - line to Ground (Shield).

Connect 180 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 180 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is usually the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm²) to 18 AWG (1.62 mm²) wire.

If the network has a mix of isolated and non-isolated devices, the shield terminal or communications ground terminal of the isolated devices should be connected to the shield. Refer to the device specific instructions.

The shield drain wires are simply connected together at each device, allowing the shield to continue on past the devices for the full length of the bus.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

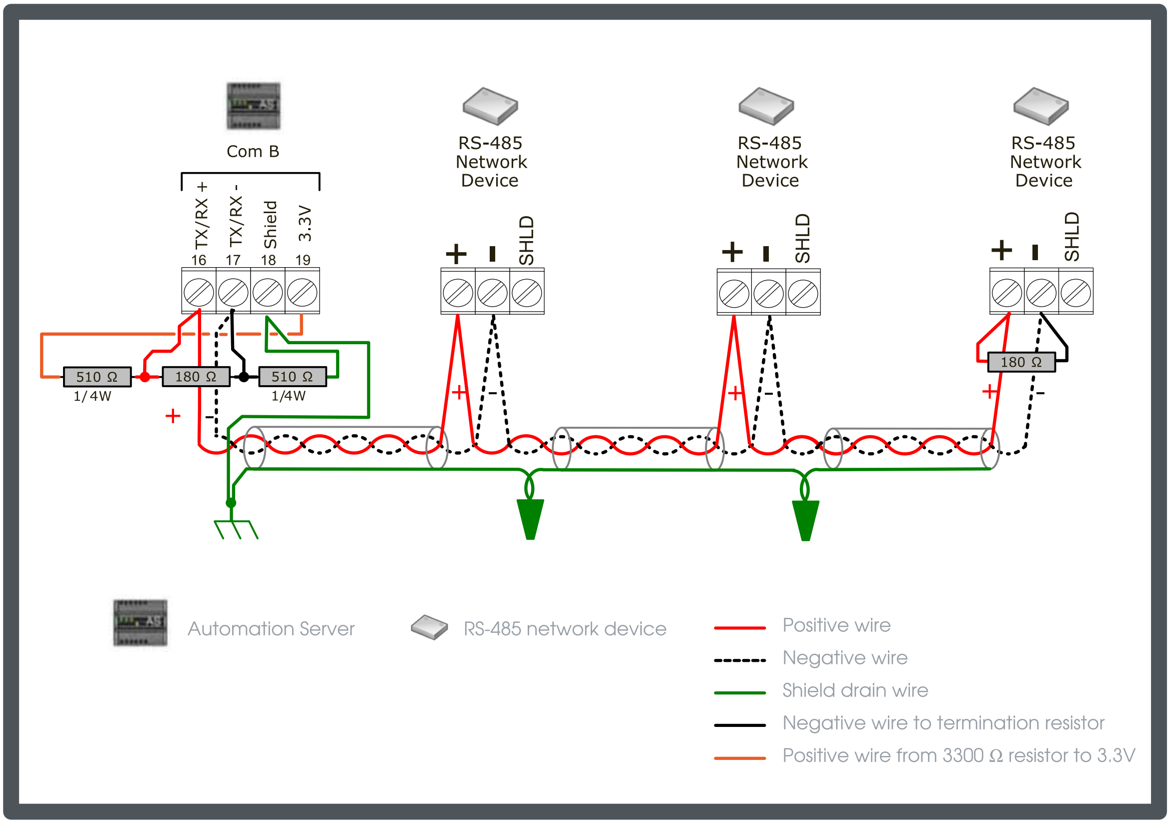


Figure: Generic RS-485 network device configuration 5 – 180 ohm terminated bus, single end-point 510 ohm bias, non-isolated interfaces

The addition of termination resistors to a network requiring failsafe bias resistors creates a continuous current flow through the network in the idle condition. The result is a voltage divider network where the termination resistors create a voltage drop in the bias resistors and network wiring. The bus biasing from the single point presents cable length limitations based on wire size as seen in the following table. This table indicates the wire lengths where the starting (head end) bias voltage created by the 510 ohm resistors will have dropped to the minimum voltage level due to the wire resistance.

Table: Recommended Maximum Cable Lengths and Associated Wire Sizes

Maximum Length	**Wire Size**
150 m (500 ft)	24 AWG (0.20 mm²)
240 m (800 ft)	22 AWG (0.33 mm²)

The recommended node count for the configuration shown in the figure above is determined using the following process.

The unit load rating of the individual network devices along with the remaining available unit load budget will determine the recommended maximum number of nodes you should install on this copper segment. The total unit load budget specified in the RS-485 standard for all components connected to a bus segment (communicating devices and bias resistors) is 32UL.

We must determine the UL node budget available after subtracting the load imposed by the bias resistors and the Automation Server. The single end-point bias configuration presents a unit load of 23.5UL (12,000 / 510 = 23.5). The Automation Server adds 0.5UL.

For a bus with non-isolated interfaces, the remaining node budget is: 32 - 23.5 - 0.5 = 8UL

We must divide our node budget by the device load value to determine node count. For the network device load, select the higher unit load value between answers Q5 and Q6b. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide the node budget value by the device UL value (Q5 or Q6b, whichever is greater). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 was 0.25 and the answer to Q6b was 0.32, use the value 0.32.

For a network with any non-isolated devices, the maximum node count is: 8 / 0.32 = 25 nodes

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.10 Generic RS-485 Network Device Configuration 6

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.
- The maximum data rate required is greater than 19,200 bps.
- The maximum network cable length required is:
  - 150 m (500 ft) or less with 24 AWG (0.20 mm^2) or
  - 240 m (800 ft) or less with 22 AWG (0.33 mm^2).

The third condition indicates that network termination is needed. The first condition indicates the termination will cause a need for strong bias.

A strong external resistor bias (low resistance pull-up and pull-down) is required to create a minimum +200 mV level (plus noise margin) across the data+ and data- conductors for the full length of the bus when the network is idle (in between all packets). The low resistance bias is needed to overcome the voltage drop created by the wire resistance and current pulled by the termination resistors. This is referenced as failsafe bias and is required because the transceiver is of the earlier type with no integrated failsafe receiver function.

With the first and third conditions defined, there are two bias configuration options to choose from. The choice relates to simplicity of the arrangement and the maximum cable length needed (the fourth condition). This configuration uses single end-point biasing. Dual end-point biasing is required to support cable lengths up to 1200 m (4000 ft). For more information, see section 10.12 “Generic RS-485 Network Device Configuration 8” on page 204.

This configuration uses the 3.3 V supply output from the Automation Server to generate bias on the bus from the single location where the Automation Server is located (typically at the head end of the bus). An alternate termination resistance value of 180 ohm is recommended with the current Automation Server. The bias voltage on the server is 3.3 V and 180 ohm termination allows the minimum failsafe voltage to be created (approximately the same voltage as created with 120 ohm and 5 V bias supply).

Connect 510 ohm resistor from + line to 3.3 V. Connect 510 ohm resistor from - line to Ground (Shield).

Connect 180 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 180 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm^2) to 18 AWG (1.62 mm^2) wire.

The shield drain wires from two cable segments are both connected to the RS-485 common/reference terminal at each device.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

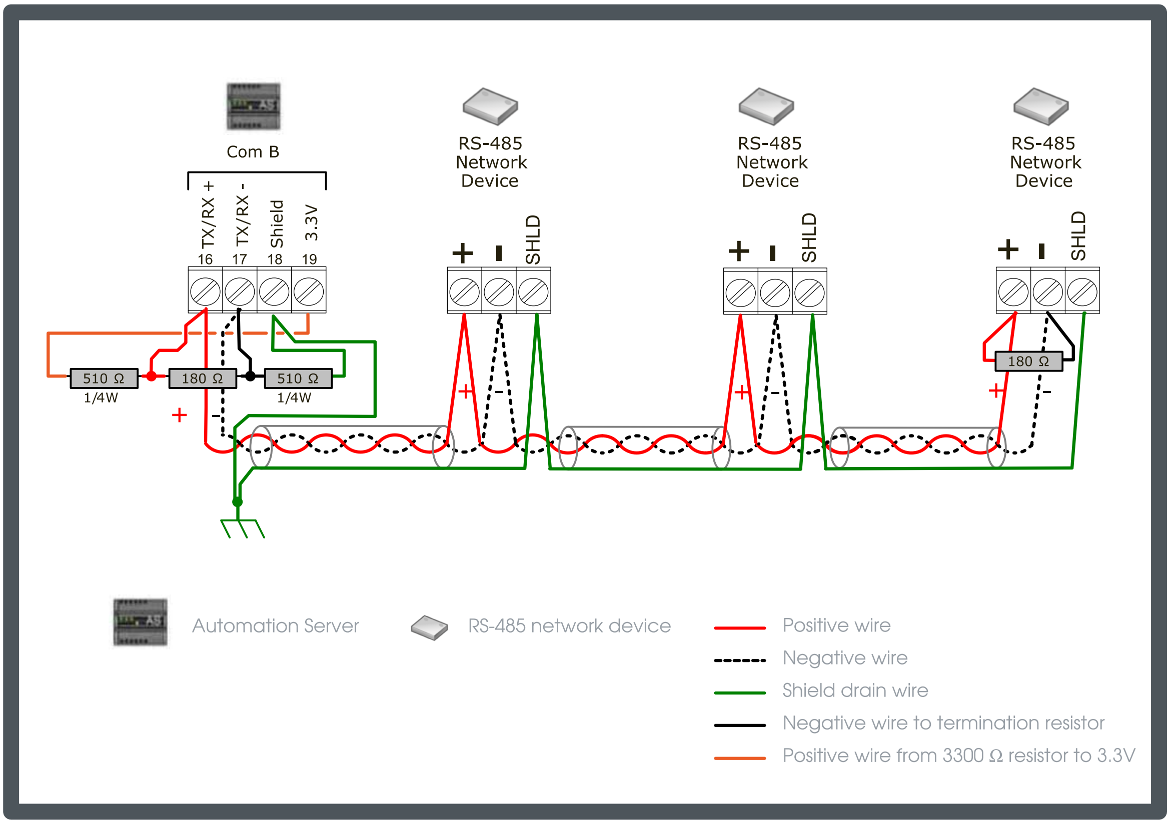


Figure: Generic RS-485 network device configuration 6 – 180 ohm terminated bus, single end-point 510 ohm bias, isolated interfaces

The addition of termination resistors to a network requiring failsafe bias resistors creates a continuous current flow through the network in the idle condition. The result is a voltage divider network where the termination resistors create a voltage drop in the bias resistors and network wiring. The bus biasing from the single point presents cable length limitations based on wire size as seen in the following table. This table indicates the wire lengths where the starting (head end) bias voltage created by the 510 ohm resistors will have dropped to the minimum voltage level due to the wire resistance.

Table: Recommended Maximum Cable Lengths and Associated Wire Sizes

Maximum Length	**Wire Size**
150 m (500 ft)	24 AWG (0.20 mm²)
240 m (800 ft)	22 AWG (0.33 mm²)

The recommended node count for the configuration shown in the figure above is determined using the following process.

The unit load rating of the individual network devices along with the remaining available unit load budget will determine the recommended maximum number of nodes you should install on this copper segment. The total unit load budget specified in the RS-485 standard for all components connected to a bus segment (communicating devices and bias resistors) is 32UL. If all devices on the bus segment have isolated RS-485 interfaces (excluding the Automation Server), it is recommended that we can boost the basic budget limit of 32UL up to 48UL. This extra 16UL (50%) capacity allowance is related to fact that the isolated interfaces provide an avoidance of Common Mode Voltage. For more information, see section 10.15 “Expanded Unit Load with Network of Isolated Devices Only (MNB and Generic RS-485 Devices)” on page 211.

We must determine the UL node budget available after subtracting the load imposed by the bias resistors and the Automation Server. The single end-point bias configuration presents a unit load of 23.5UL (12,000 / 510 = 23.5). The Automation Server adds 0.5UL.

For a bus with all isolated interfaces, the remaining node budget is: 48 - 23.5 - 0.5 = 24UL

We must divide our node budget by the device load value to determine node count. For the network device load, select the higher unit load value between answers Q5 and Q6b. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide the node budget value by the device UL value (Q5 or Q6b, whichever is greater). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 was 0.25 and the answer to Q6b was 0.32, use the value 0.32.

For a network with all isolated devices, the maximum node count is: 24 / 0.32 = 75 nodes

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.11 Generic RS-485 Network Device Configuration 7

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- Not all RS-485 network devices have isolated RS-485 interfaces.
- The maximum network cable length required is:
  - greater than 150 m (500 ft) with 24 AWG (0.20 mm^2) or
  - greater than 240 m (800 ft) with 22 AWG (0.33 mm^2).

The first and third conditions above together require the use of dual end-point biasing. Dual end-point bias applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. The recommended power supplies are discussed separately. For more information, see section 10.13 “Power Supply Selection for Generic RS-485 Network Device Configuration 7 and 8” on page 207. Instead of a single pair of 510 ohm resistors, the dual end-point scheme uses a pair of 1000 ohm resistances at each end. The dual end-point bias is the best technique for avoiding the drop in the bias voltage over extended cable lengths as you move away from the bias connection location. By applying the bias at the same two locations where the termination is located, the arrangement maintains an equal bias across the complete length of the cable.

The recommended location for the separate supply bias is at the two extreme ends of the network cable, but the bias voltage remains effective with a 60 m (200 ft) tolerance on the cable length from the end. This configuration supports the preferred termination resistor values of 120 ohm with one positioned at each end of the cable. The unit load imposed by the dual end-point bias is 24UL (12,000 / (1,000 / 2) = 24).

Connect 5 V DC power supply to the RS-485 bus pair through two 1000 ohm resistors at the head end of the cable. Connect 5 V DC power supply to the RS-485 bus pair through two 1000 ohm resistors at the tail end of the cable.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is usually the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm^2) to 18 AWG (1.62 mm^2) wire.

If the network has a mix of isolated and non-isolated devices, the shield terminal or communications ground terminal of the isolated devices should be connected to the shield. Refer to the device specific instructions.

The shield drain wires are simply connected together at each device, allowing the shield to continue on past the devices for the full length of the bus.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

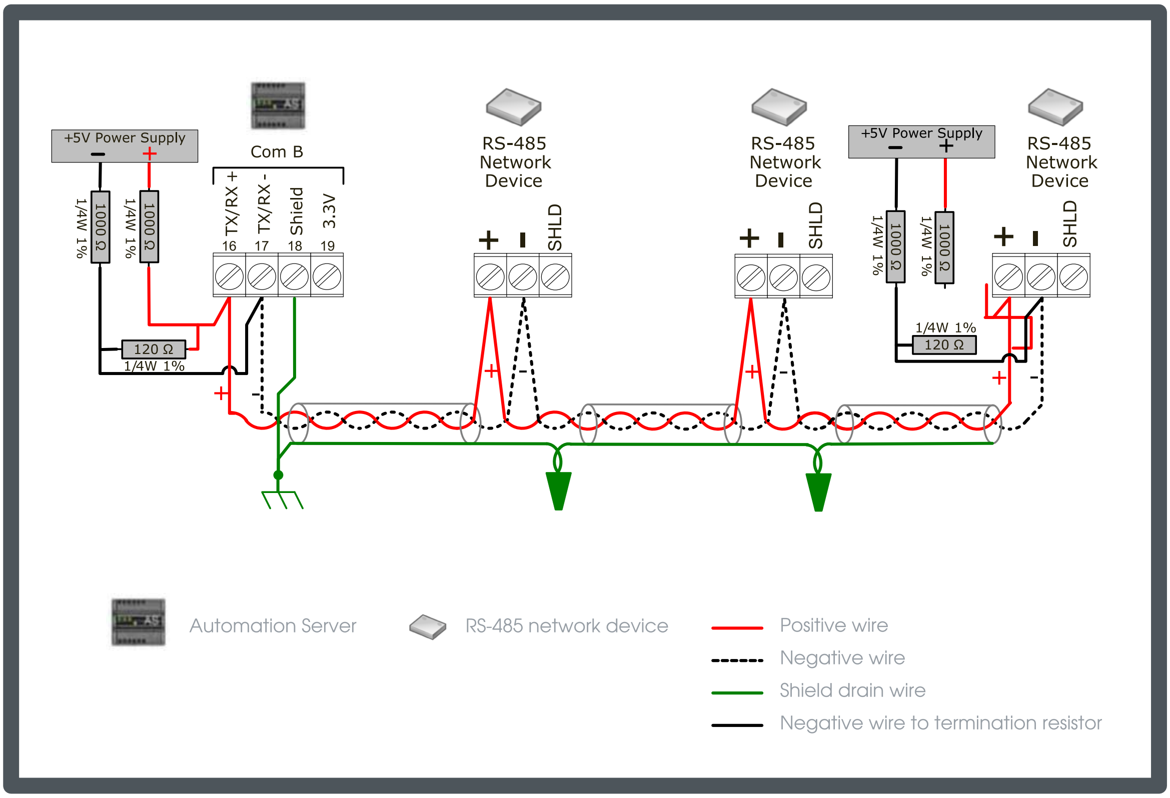


Figure: Generic RS-485 network device configuration 7 – 120 ohm terminated bus, dual end-point 1000 ohm bias, non-isolated interfaces

The configuration shown in the figure above supports the maximum cable length of 1200 m (4000 ft).

The recommended node count for the configuration shown in the figure above is determined using the following process.

The unit load rating of the individual network devices along with the remaining available unit load budget will determine the recommended maximum number of nodes you should install on this copper segment. The total unit load budget specified in the RS-485 standard for all components connected to a bus segment (communicating devices and bias resistors) is 32UL.

We must determine the UL node budget available after subtracting the load imposed by the bias resistors and the Automation Server. The dual end-point bias configuration presents a unit load of 24UL (12,000 / (1,000 / 2) = 24). The Automation Server adds 0.5UL.

For a bus with non-isolated interfaces, the remaining node budget is: 32 - 24 - 0.5 = 7.5UL

We must divide our node budget by the device load value to determine node count. For the network device load, select the higher unit load value between answers Q5 and Q6b. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide the node budget value by the device UL value (Q5 or Q6b, whichever is greater). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 was 0.25 and the answer to Q6b was 0.32, use the value 0.32.

For a network with any non-isolated devices, the maximum node count is: 7.5 / 0.32 = 23.4 nodes

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.12 Generic RS-485 Network Device Configuration 8

This configuration is recommended if the following conditions apply to the RS-485 network and the devices to be connected to the Automation Server RS-485 port:

- Not all RS-485 network devices have failsafe receivers.
- All RS-485 network devices have isolated RS-485 interfaces.
- The maximum network cable length required is:
  - greater than 150 m (500 ft) with 24 AWG (0.20 mm^2) or
  - greater than 240 m (800 ft) with 22 AWG (0.33 mm^2).

The first and third conditions above together require the use of dual end-point biasing. Dual end-point bias applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. The recommended power supplies are discussed separately. For more information, see section 10.13 “Power Supply Selection for Generic RS-485 Network Device Configuration 7 and 8” on page 207. Instead of a single pair of 510 ohm resistors, the dual end-point scheme uses a pair of 1000 ohm resistances at each end. The dual end-point bias is the best technique for avoiding the drop in the bias voltage over extended cable lengths as you move away from the bias connection location. By applying the bias at the same two locations where the termination is located, the arrangement maintains an equal bias across the complete length of the cable.

The recommended location for the separate supply bias is at the two extreme ends of the network cable, but the bias voltage remains effective with a 60 m (200 ft) tolerance on the cable length from the end. This configuration supports the preferred termination resistor values of 120 ohm with one positioned at each end of the cable. The unit load imposed by the dual end-point bias is 24UL (12,000 / (1,000 / 2) = 24).

Connect 5 V DC power supply to the RS-485 bus pair through two 1000 ohm resistors at the head end of the cable. Connect 5 V DC power supply to the RS-485 bus pair through two 1000 ohm resistors at the tail end of the cable.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. Connect terminal 18 on the Automation Server to the ground rail in the panel using a 12 AWG (3.31 mm^2) to 18 AWG (1.62 mm^2) wire.

The shield drain wires from two cable segments are both connected to the RS-485 common/reference terminal at each device.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

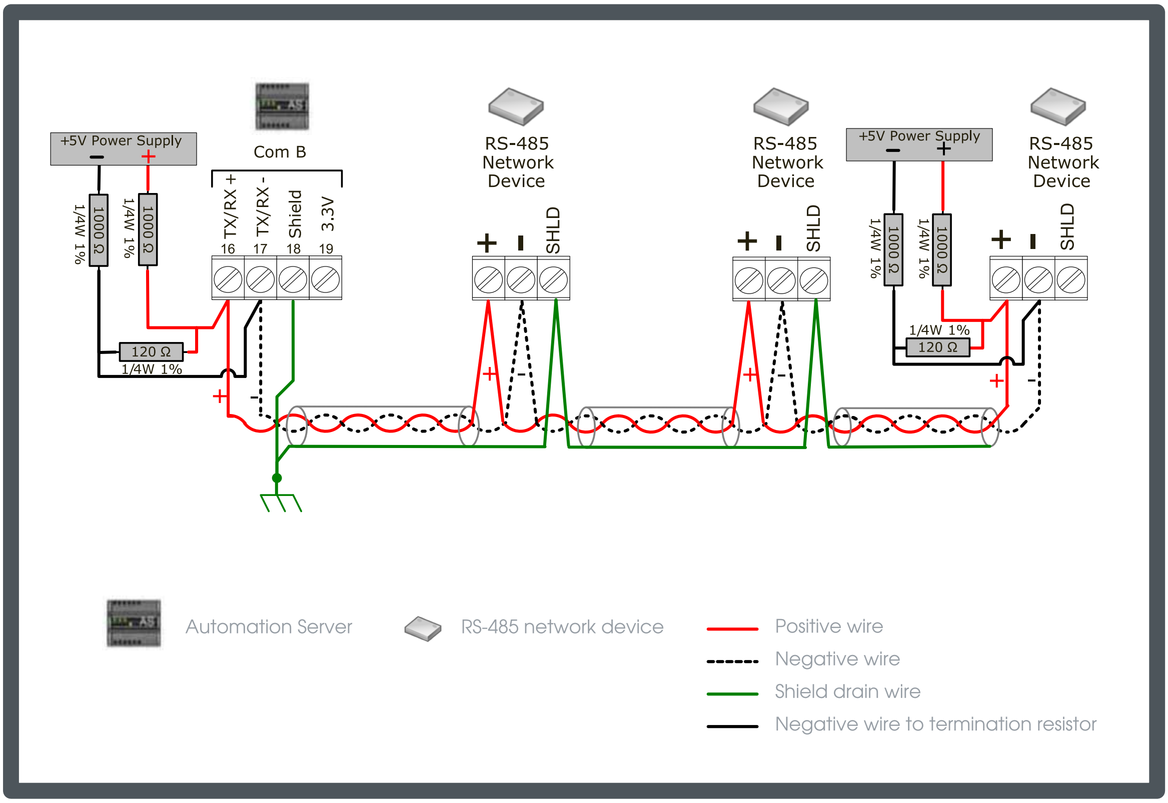


Figure: Generic RS-485 network device configuration 8 – 120 ohm terminated bus, dual end-point 1000 ohm bias, isolated interfaces

The configuration shown in the figure above supports the maximum cable length of 1200 m (4000 ft).

The recommended node count for the configuration shown in the figure above is determined using the following process.

The unit load rating of the individual network devices along with the remaining available unit load budget will determine the recommended maximum number of nodes you should install on this copper segment. The total unit load budget specified in the RS-485 standard for all components connected to a bus segment (communicating devices and bias resistors) is 32UL. If all devices on the bus segment have isolated RS-485 interfaces (excluding the Automation Server), it is recommended that we can boost the basic budget limit of 32UL up to 48UL. This extra 16UL (50%) capacity allowance is related to fact that the isolated interfaces provide an avoidance of Common Mode Voltage. For more information, see section 10.15 “Expanded Unit Load with Network of Isolated Devices Only (MNB and Generic RS-485 Devices)” on page 211.

We must determine the UL node budget available after subtracting the load imposed by the bias resistors and the Automation Server. The dual end-point bias configuration presents a unit load of 24UL (12,000 / (1,000 / 2) = 24). The Automation Server adds 0.5UL.

For a bus with all isolated interfaces, the remaining node budget is: 48 - 24 - 0.5 = 23.5UL

We must divide our node budget by the device load value to determine node count. For the network device load, select the higher unit load value between answers Q5 and Q6b. For more information, see section 10.3 “Worksheet for Configuration of RS-485 Bus with Generic RS-485 Devices” on page 178. Divide the node budget value by the device UL value (Q5 or Q6b, whichever is greater). The result is the maximum recommended node count in regards to bus loading.

Example: If the answer to Q5 was 0.25 and the answer to Q6b was 0.32, use the value 0.32.

For a network with all isolated devices, the maximum node count is: 23.5 / 0.32 = 73.4 nodes

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.13 Power Supply Selection for Generic RS-485 Network Device Configuration 7 and 8

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

Table: Recommended Supply Specifications

Characteristics	**Recommendations**
Type	5 V DC output isolated from local ground or equipment connections
Output Voltage	5.00 V DC +/- 5% (or better)
Maximum Output Current	0.1 A to 1.5 A (0.5 W to 7.5 W) Any model in this popular range
Minimum Output Current	Operates/regulates down to 0 current (no load required)
Maximum Output Ripple/Noise	150 mV_{pp} (or less)
Safety/EMC Agency Approvals	Applicable approvals for country of application

Frequently, the most convenient power source for the 5 V DC bias supply will be the 24 V AC typically powering the various RS-485 device products. A couple options for the 24 V AC to Isolated 5 V DC power supply would include the models PS-200-3-A-3-L and PS-200-3-A-3-N from Mamac Systems and the model DCP-524 from Kele. Another isolated 5 V supply option with a smaller package/footprint and lower cost would be the combination of the Altronix model VR1TM5 regulator and the small (20 VA) Veris Industries X020ADA 24 V AC to 24 V AC isolation transformer. The figure below shows the Veris/Altronix configuration.

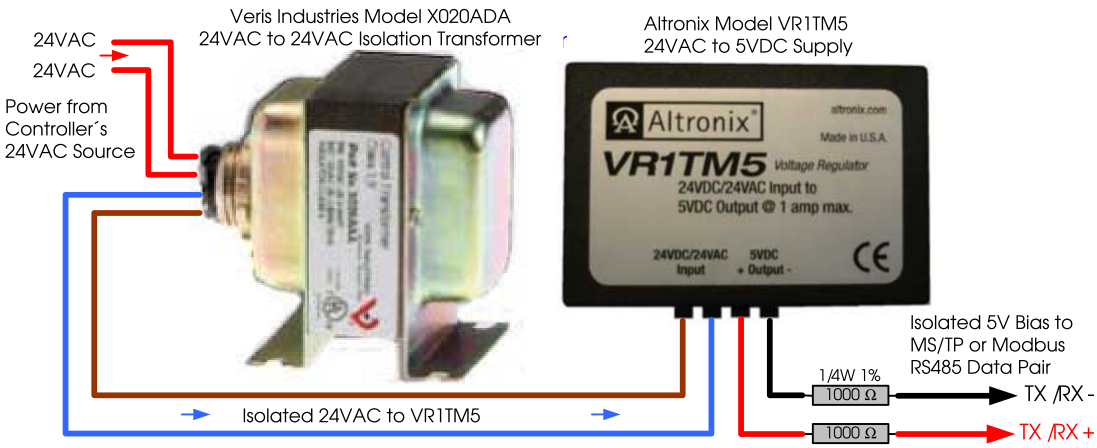


Figure: Isolated 5 V DC power supply using Veris X020ADA and Altronix VR1TM5

Other manufacturers/models of 24VAC/24VAC isolation transformers can be substituted to accommodate preferred package, size, local availability, and approvals.

If the use of 115/230 V AC line voltage for the + 5 V DC supply is preferred, the Veris X020ADA transformer can be replaced with a common 115 V/24 V or 230 V/24 V transformer. This can be a separate transformer of the same type used to power the 24 V AC devices. However, the transformer size used for this application can be as small as you have available. In this application, the VR1TM5 presents a load of less than 1 VA. The transformer output used to power the VR1TM5 should not be connected to any other device.

10.14 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (MNB and Generic RS-485 Devices)

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

The TIA-485A standard does not accommodate any special allowance or exclusion for the addition of bias resistors. If you add load to the data lines (for whatever purpose), it is part of the common mode load and must be considered in the calculation of unit load on the network. Just as 375 ohm equals 32UL, 510 ohm resistance equals 23.5UL.

The accumulation of RS-485 node counts in excess of the standard defined limit of 32UL does not alone create a violation prompting immediate inoperability. The primary performance parameter affected by network load is the ability of the RS-485 transmitter to output the minimum specified signal level of 1.5 V. Reduction in output signal level starts with the addition of the first load connected and reduces further as additional load is added. The 32UL boundary is simply the standardized guaranteed specification limit where the manufacturers guarantee the signal level will not have reduced below 1.5 V. As mentioned above, the 1.5 V signal output is guaranteed not only with a 32UL load, but also with an elevated common mode voltage (CMV of -7 V to +12 V). As the network exceeds the 32UL limit, the tolerance for this CMV will decay. The following graph from the TIA-TSB-89-A standards document shows the expected reduction in CMV as a function of unit load on the bus.

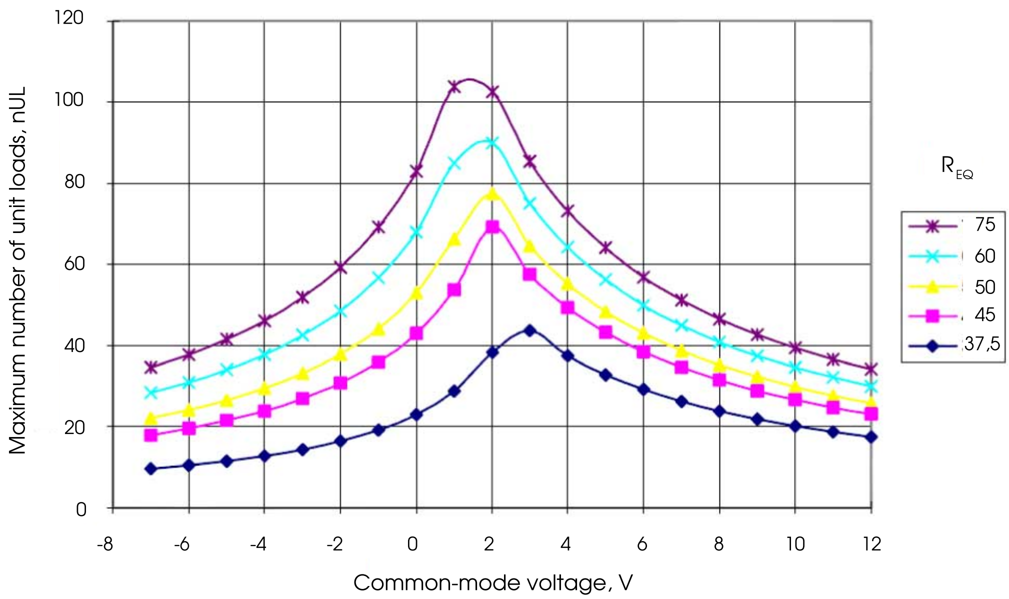


Figure: Maximum number of unit loads versus common-mode voltage and REQ (From TIA TSB-89-A 485 application guidelines

The REQ legend in the figure above refers to the resulting parallel load resistance of two termination resistors. The common 120 ohm termination produces 60 ohm and is shown by the REQ=60 cyan colored line. The cyan line indicates a standard UL load limit of 32 with a CMV between -7 V and +12 V. Extra current is required from the transmitter to overcome the common mode voltage seen through the common mode load impedance (unit load). As node count elevates, the tolerance for CMV pulls in as seen in the graph.

For example, if we take the 24UL of the bias network and add a collection of 127 nodes with each rated at 0.18UL, we would have a total network load of 47UL. From the figure above, you can see that the specified minimum -7 V CMV will be reduced to around -2.5 V and the normal +12 V will reduce to about +6.5 V. When operating in a situation where CMV is avoided, the reduction in transceiver CMV performance can be better tolerated. An isolated RS-485 bus configuration (such as with the MNB BACnet devices) allows the nodes to be insulated from local ground voltage differences which are a main source of sustained CMV on the bus. The isolated bus allows each of the transmitters to move up/down to the idle voltage of the bus.

10.15 Expanded Unit Load with Network of Isolated Devices Only (MNB and Generic RS-485 Devices)

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. It is recommended that a maximum load extension should be 16UL (50% overload) giving a total expanded unit load limit of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network and Automation Server leaves 24UL available for the devices. With the example device load of 0.18UL each, it is suggested that the isolated bus arrangement could support the full collection of up to 127 devices.

The extra unit load accommodation is unique to the isolated interface configuration. The configuration is operating with a single non-isolated node (the Automation Server) which acts as the single point reference for the CMV of the network pair as imposed by the bias arrangement. If this configuration of isolated device nodes is intermixed with any other products that are not isolated, the configuration rules on the network node count must fall back to the limits produced with the standard 32UL maximum total unit load.

If the standard specified unit load limit of 32 is applied, the node count calculation is as follows:

- Subtracting 24UL from the starting budget of 32 gives a node budget of 8UL.
- Each of the example devices (with isolated RS-485 interfaces) presents a RS-485 network load of 0.18UL.
- The calculated node count that consumes the remainder of the budget is: 8UL / 0.18UL = 44 nodes.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.16 Cable Routing

The RS-485 network cable should be routed in a continuous daisy chain bus configuration. There should not be any stub connections, stars or ring configurations. The bussed cable should pass through each node to be connected with no splits or branches in the cable network.

The network configuration diagrams below (with red Xs) show undesirable arrangements of the connected copper cabling. Repeaters can be used to achieve the star, distributed star (backbone with clusters), and stubs off of the backbone. The repeater separates the cable and each side (or each port on a multi-port repeater) starts a new wire segment. This avoids the effect of stub or cluster/lump capacitance from distorting the data on the backbone. No more than two repeaters should separate any two nodes on the network. This means after you use a repeater to drop a branch leg off the backbone at multiple locations, you cannot add another repeater on any branch. The additional repeater would create a three repeater string to one or more nodes on the network.

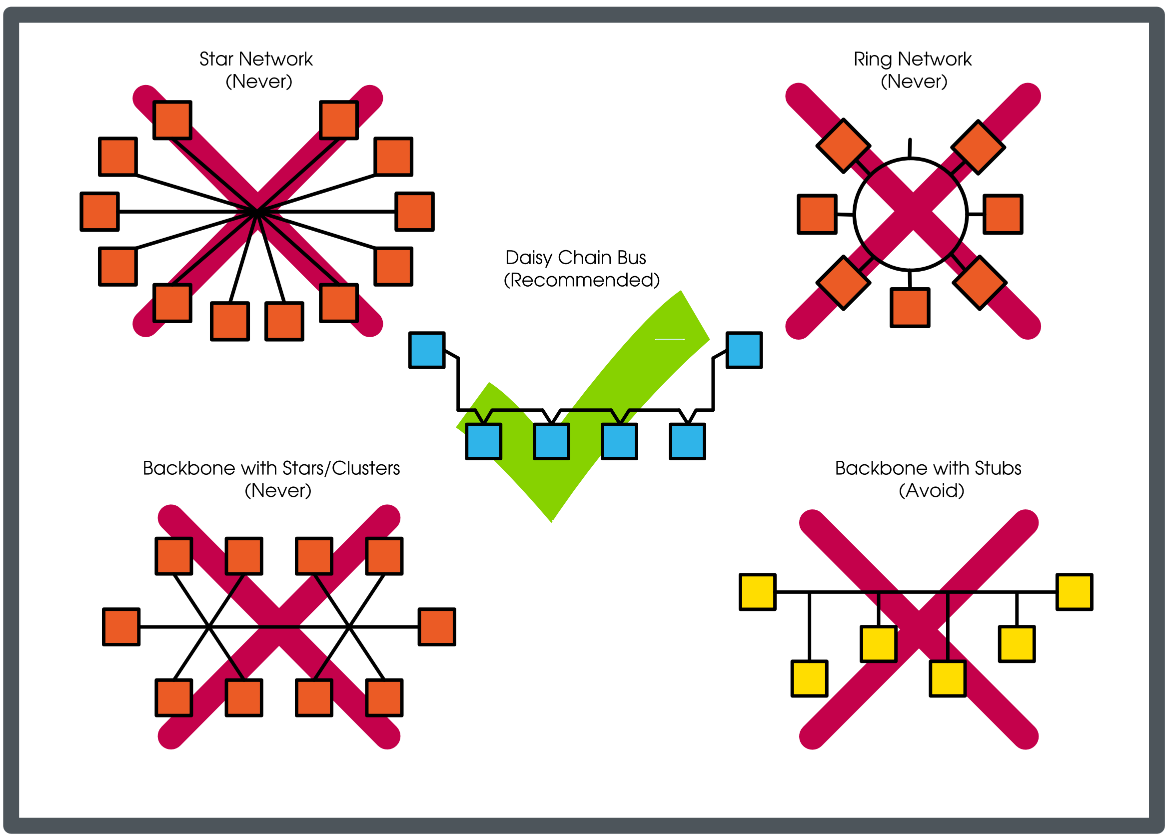


Figure: Bus routing configurations to avoid

10.17 Cable Selection

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

With RS-485, two conductors are used to pass the differential data (A+ and B- signals) from one node to the next. To maintain the balanced characteristics between the two wires, the cable must provide twisted pairs and be specified for data communications. As the twisted pair passes along side other cables and equipment in the facility, there are a multitude of noise sources, radiated EMI and electromagnetic fields that will impose noise on to the twisted pair cable.

The shield does not provide any form of total protection. The shield inhibits a significant portion of high frequency radiated noise, but other fields may simply pass through. As long as the twisted pair of wires remains balanced, the noise will be imposed on the two wires equally. An imbalance of impedance to ground of the differential pair determines in part the susceptibility of the network to interference, regardless of it being inductive or capacitive coupled. When balanced, a noise appearing equally on both wires is called common mode noise. The RS-485 receiver only looks at the differential voltage seen between the two conductors and ignores the common mode noise. This is true up to the common mode voltage limits of the transceiver, which should be a minimum range of -7 V to +12 V. A reduction in this range, such as from fully exhausting transmitter CMV support with excess unit load, can make the bus susceptible to induced common mode noise.

The balanced performance of the cable requires more than just the twisted pair characteristics, although it is definitely the most important. The twisted pair cable can become unbalanced when encountering discontinuities in the capacitance between the two wires, or the capacitance from conductor to shield, or the impedance of the wires. This makes it important to select quality cable specified for RS-485 data communications. The cable supplier must provide cable specification that includes all of the characteristics seen in the table below. The recommended specification for these characteristics is also listed. These will provide the best results. You should avoid a cable where the manufacturer/supplier cannot provide the full cable specifications.

Table: Recommended Cable Characteristics

Characteristics	**Recommendations**
Type	Shielded Twisted Pair Low Capacitance
Twisted Wire Size	22 AWG to 24 AWG (0.33 mm^2 to 0.20 mm^2)
Impedance	120 ohm
Capacitance (wire to shield)	<82 pF/m (<25 pF/ft)
Capacitance (wire to wire)	<46 pF/m (<14 pF/ft)
Maximum Length	1200 m (4000 ft) depending on termination and bias restrictions

Characteristics	**Recommendations**

Table: Recommended Twisted Pair Cables

Manufacturer	Model	Size	Pairs	Imp.	Cap1[a]	Cap2[b]	Vel	Plenum
Belden	3105A	22 AWG Str (0.33 mm²)	1	120 ohm	36.1 pF/m (11 pF/ft)	68.6 pF/m (20.9 pF/ft)	78%	
Belden	3107A	22 AWG Str (0.33 mm²)	2	120 ohm	36.1 pF/m (11 pF/ft)	68.6 pF/m (20.9 pF/ft)	78%	
Belden	9841	24 AWG Str (0.20 mm²)	1	120 ohm	42.0 pF/m (12.8 pF/ft)	75.5 pF/m (23 pF/ft)	66%	
Belden	9842	24 AWG Str (0.20 mm²)	2	120 ohm	42.0 pF/m (12.8 pF/ft)	75.5 pF/m (23 pF/ft)	66%	
Belden	82841	24 AWG Str (0.20 mm²)	1	120 ohm	39.4 pF/m (12 pF/ft)	72.2 pF/m (22 pF/ft)	76%	Y
Belden	82842	24 AWG Str (0.20 mm²)	2	120 ohm	39.4 pF/m (12 pF/ft)	72.2 pF/m (22 pF/ft)	76%	Y
Belden	89841	24 AWG Str (0.20 mm²)	1	120 ohm	39.4 pF/m (12 pF/ft)	72.2 pF/m (22 pF/ft)	76%	Y
Belden	89842	24 AWG Str (0.20 mm²)	2	120 ohm	39.4 pF/m (12 pF/ft)	72.2 pF/m (22 pF/ft)	76%	Y
Alpha Wire	6453	22 AWG Str (0.33 mm²)	1	120 ohm	36.0 pF/m (11 pF/ft)	68.6 pF/m (20.9 pF/ft)	78%	
Alpha Wire	6455	22 AWG Str (0.33 mm²)	2	120 ohm	36.0 pF/m (11 pF/ft)	68.6 pF/m (20.9 pF/ft)	78%	

Continued

Manufacturer	Model	Size	Pairs	Imp.	Cap1[a]	Cap2[b]	Vel	Plenum
Alpha Wire	6412	24 AWG Str (0.20 mm^2)	1	120 ohm	42.0 pF/m (12.8 pF/ft)	75.5 pF/m (23 pF/ft)		
Alpha Wire	6413	24 AWG Str (0.20 mm^2)	2	120 ohm	42.0 pF/m (12.8 pF/ft)	75.5 pF/m (23 pF/ft)		
General Cable	C0841A	24 AWG Str (0.20 mm^2)	1	120 ohm	46.6 pF/m (14.2 pF/ft)	84.0 pF/m (25.6 pF/ft)	66%	
General Cable	C0842A	24 AWG Str (0.20 mm^2)	2	120 ohm	37.4 pF/m (11.4 pF/ft)	67.3 pF/m (20.5 pF/ft)	66%	

a) Cap1 = Capacitance between the two conductors of the pair(s)
b) Cap2 = Capacitance from each signal conductor to shield

10.18 b3 BACnet Devices

This application note provides recommendations and guidelines for the configuration of RS-485 communications between the Automation Server and b3 BACnet devices. This information is intended to supplement the existing configuration documents, such as the “b3 BACnet and b4920 Controller Technical Reference (30-3001-862)”. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths, and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance is associated with the Automation Servers with serial number of TD133954000 and later.

10.18.1 General b3 BACnet Device Properties

The b3 BACnet devices provide a RS-485 transceiver with unit load rating of 0.125. With consideration only for the transceiver unit load, the 0.125 unit load rating would indicate up to 256 units (32/0.125) could be attached to a single RS-485 network wire segment. The b3 BACnet devices include an on-board bias resistor of 47 kohm on the A+ and B- bus signals. This 47 kohm resistance presents an additional unit load of 0.255 that makes each of the devices have an aggregate unit load of 0.38.

For more information, see section 10.19 “General b3 BACnet Device Properties” on page 218.

10.18.2 Automation Server to b3 BACnet Device Configuration

The Automation Server configuration for the b3 BACnet devices is simply the addition of a 120 ohm (1/4W 1%) termination resistor across the A+ and B- signal pair, if the Automation Server is located at the end of the bus.

For more information, see section 10.20 “Automation Server to b3 BACnet Device Configuration” on page 219.

10.18.3 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

For more information, see section 10.21 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (b3 BACnet Devices)” on page 221.

10.18.4 Cable Routing

The RS-485 network cable should be routed in a continuous daisy chain bus configuration. There should not be any stub connections, stars or ring configurations. The bussed cable should pass through each node to be connected with no splits or branches in the cable network.

For more information, see section 10.16 “Cable Routing” on page 212.

10.18.5 Cable Selection

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

For more information, see section 10.17 “Cable Selection” on page 213.

10.19 General b3 BACnet Device Properties

The b3 BACnet devices provide a RS-485 transceiver with unit load rating of 0.125. With consideration only for the transceiver unit load, the 0.125 unit load rating would indicate up to 256 units (32/0.125) could be attached to a single RS-485 network wire segment. The b3 BACnet devices include an on-board bias resistor of 47 kohm on the A+ and B- bus signals. This 47 kohm resistance presents an additional unit load of 0.255 that makes each of the devices have an aggregate unit load of 0.38.

The transceiver used in the b3 BACnet devices includes an integrated failsafe receiver function. This means network biasing resistors are not typically required on the RS-485 bus to ensure the idle state of the bus is kept at a minimum level. This integrated failsafe feature allows avoidance of the additional unit load caused by bias resistor network discussed in other application notes.

The RS-485 circuitry on the b3 BACnet devices is not an isolated interface. The RS-485 network depends on the local device ground potentials being within the -7V to +12V common mode voltage (CMV) range of the RS-485 transceivers. The RS-485 interface provided by the b3 BACnet devices has the interface attributes according to the table below.

Table: Interface attributes of the b3 BACnet devices

Transceiver	Transceiver Unit Load	Transceiver Failsafe	Adapter Circuit Bias	Circuit Bias Load	Total Unit Load	Isolated 485 Bus
Multiple Parts	0.125	Yes	47 kohm	0.255	0.38	No

The typical MS/TP data rates of 38.4 kbps or 76.8 kbps used with the b3 BACnet devices make the installation of End Of Line (EOL) resistor termination necessary. Because the b3 BACnet devices do not require network bias, there is no negative effect from termination (such as need for strong bias and its unit load impact). The 120 ohm termination is recommended regardless of the data rate used.

When it is found necessary to combine one or more b3 BACnet family devices on the same MS/TP bus segment with MS/TP devices that use isolated RS-485 interfaces (that require network bias), you should evaluate the impact such combination can have on the recommended node counts for the two products. Isolated RS-485 interface products have a tolerance for Common Mode Voltage that allows them to have an expanded unit load budget within our recommendations (48UL instead of 32UL). When the isolated interface product needs bias, the expanded budget is more than consumed by the load. The addition of any non-isolated devices to the bus (with exception of the Automation Server) nullifies the recommended budget expansion returning the recommended limit to 32UL. Review the load status of the isolated products to determine if they can tolerate the standard 32UL budget.

For more information, see section 10.2 “Generic RS-485 Network Devices” on page 175.

For more information, see section 10.22 “MNB BACnet Devices” on page 223.

10.20 Automation Server to b3 BACnet Device Configuration

The Automation Server configuration for the b3 BACnet devices is simply the addition of a 120 ohm (1/4W 1%) termination resistor across the A+ and B- signal pair, if the Automation Server is located at the end of the bus.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. The shield drain wires from the two cable segments are both connected to the SHLD terminal at each b3 BACnet device.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

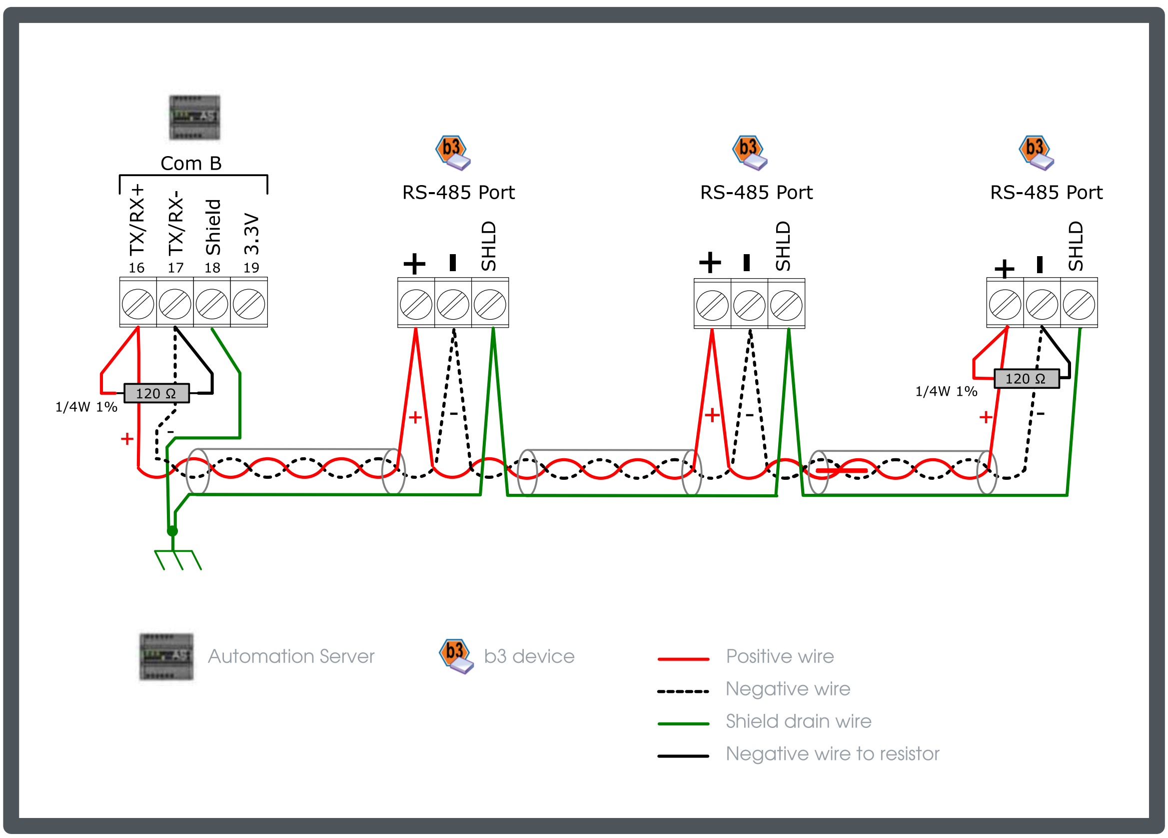


Figure: Configuration of Automation Server to b3 BACnet devices

The b3 BACnet configuration supports the full recommended maximum cable length of 1200 m (4000 ft). The network does not encounter distance reductions and/or alternate configurations typical of networks requiring the addition of failsafe bias circuits.

In some instances, the installation of the network in a high electrical noise environment or use of substandard cable may prompt differential noise levels on the bus sufficient to exceed the integrated failsafe noise immunity level of the transceiver. In such a situation, the addition of a weak bias such as 3300 ohm pull-up (A+ to 3.3V) and 3300 ohm pull-down (B- to Shield/Ground) may be appropriate. This will not typically be required. The observation of receive LED blinking on a device when the network is known to be inactive would be an indication of an idle state noise condition where some added bias can be helpful. The addition of 3300 ohm bias would add 3.6UL to the unit load.

The TIA-485A standard specifies a maximum network load of 32UL (Unit Loads). From the TIA-485A budget of 32UL, we must subtract the Unit Load (0.5UL) of the Automation Server transceiver to calculate the node count:

- Subtracting 0.5UL from the starting budget of 32 gives a node budget of 31.5UL.
- Each of the b3 BACnet devices present a RS-485 network load of 0.38UL.
- The calculated b3 BACnet node count that consumes the remainder of the budget is 31.5UL / 0.38UL = 82 nodes.

10.21 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (b3 BACnet Devices)

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

The TIA-485A standard does not accommodate any special allowance or exclusion for the addition of bias resistors. If you add load to the data lines (for whatever purpose), it is part of the common mode load and must be considered in the calculation of unit load on the network.

The accumulation of RS-485 node counts in excess of the standard defined limit of 32UL does not alone create a violation prompting immediate inoperability. The primary performance parameter affected by network load is the ability of the RS-485 transmitter to output the minimum specified signal level of 1.5 V. Reduction in output signal level starts with the addition of the first load connected and reduces further as additional load is added. The 32UL boundary is simply the standardized guaranteed specification limit where the manufacturers guarantee the signal level will not have reduced below 1.5 V. As mentioned above, the 1.5 V signal output is guaranteed not only with a 32UL load, but also with an elevated common mode voltage (CMV of -7 V to +12 V). As the network exceeds the 32UL limit, the tolerance for this CMV will decay. The following graph from the TIA-TSB-89-A standards document shows the expected reduction in CMV as a function of unit load on the bus.

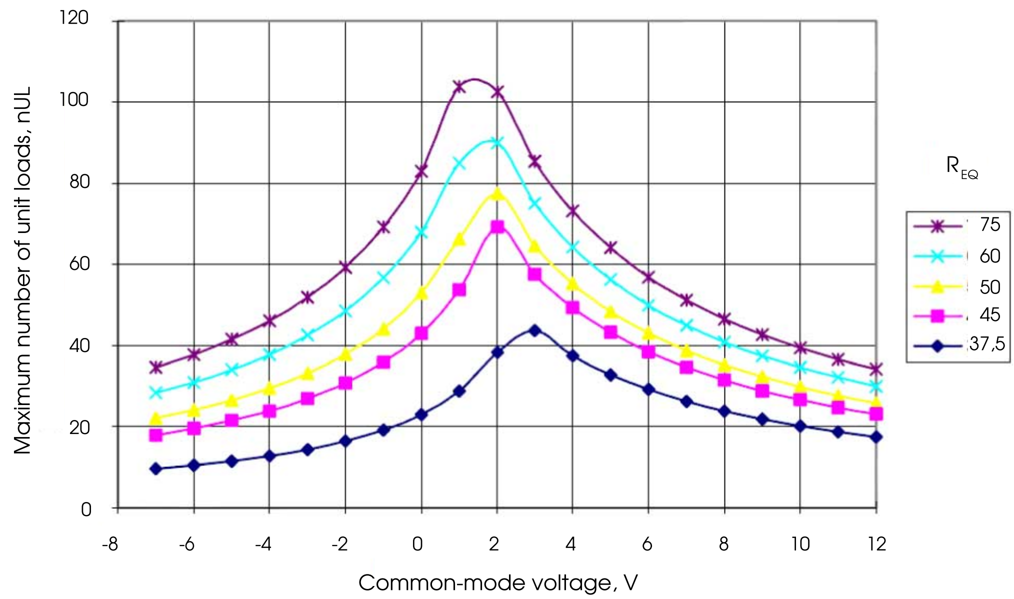


Figure: Maximum number of unit loads versus common-mode voltage an REQ (From TIA TSB-89-A 485 Application Guidelines)

The REQ legend in the figure above refers to the resulting parallel load resistance of two termination resistors. The common 120 ohm termination produces 60 ohm and is shown by the REQ=60 cyan colored line. The cyan line indicates a standard UL load limit of 32 with a CMV between -7 V and +12 V. Extra current is required from the transmitter to overcome the common mode voltage seen through the common mode load impedance (unit load). As node count elevates, the tolerance for CMV pulls in as seen in the graph.

For example, if we add the collective unit load for 127 b3 BACnet devices (0.38UL each) along with an Automation Server (0.5UL) we have a total bus unit load of 49UL. From the figure above you can see that the specified minimum -7 V CMV will be reduced to around -3 V and the normal +12 V CMV will reduce to about +6 V.

On a non-isolated RS-485 network, the CMV tolerance of the network is a much more critical performance parameter. Reduction of the CMV tolerance to levels less than the standard -7 V to +12 V range is not recommended. The maximum recommended b3 BACnet device node count of 82 maintains the CMV range.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.22 MNB BACnet Devices

This application note provides recommendations for the configuration of RS-485 communications between the Automation Server and MNB BACnet devices. This information is intended to supplement the existing configuration documents such as the “TAC I/A Series MicroNet BACnet Wiring and Networking Practices Guide (F-27360-3)”. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance is associated with the Automation Servers with serial number of TD133954000 and later.

10.22.1 General MNB BACnet Device Properties

MNB BACnet devices use an RS-485 transceiver that provides integrated galvanic isolation (NVE IL3286E). This transceiver has an RS-485 unit load rating of 0.125. With consideration only for the transceiver unit load, the 0.125 unit load rating would indicate up to 256 units (32/0.125) could be attached to a single RS-485 network wire segment. The MNB devices include an on-board weak bias resistor of 220 kohm on the A+ and B- bus signals. This 220 kohm resistance presents a very small additional unit load of 0.055 making each of the devices have an aggregate unit load of 0.18. This is a little better (lower) than the 0.25UL listed in “TAC I/A Series MicroNet BACnet Wiring and Networking Practices Guide (F-27360-3)”.

For more information, see section 10.23 “General MNB BACnet Device Properties” on page 226.

10.22.2 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

For more information, see section 10.14 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (MNB and Generic RS-485 Devices)” on page 209.

10.22.3 Expanded Unit Load with Network of Isolated Devices Only

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. It is recommended that a maximum load extension should be 16UL (50% overload) giving a total expanded unit load limit of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network and Automation Server leaves 24UL available for the devices. With the example device load of 0.18UL each, it is suggested that the isolated bus arrangement could support the full collection of up to 127 devices.

For more information, see section 10.15 “Expanded Unit Load with Network of Isolated Devices Only (MNB and Generic RS-485 Devices)” on page 211.

10.22.4 MNB Configurations

The recommendations include five different configuration options to choose from with differences in performance and/or resources required.

For more information, see section 10.24 “MNB Configurations” on page 227.

10.22.5 Cable Routing

The RS-485 network cable should be routed in a continuous daisy chain bus configuration. There should not be any stub connections, stars or ring configurations. The bussed cable should pass through each node to be connected with no splits or branches in the cable network.

For more information, see section 10.16 “Cable Routing” on page 212.

10.22.6 Cable Selection

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

For more information, see section 10.17 “Cable Selection” on page 213.

10.22.7 Existing MNB Systems Transition

Many times the application of the SmartStruxure system will deal with existing MNB systems. In many of those instances, the existing MNB system installation may not be consistent with the network cable recommendations (For more information, see section 10.17 “Cable Selection” on page 213.). When dealing with an existing earlier installed system that has been operating for an extended period with no signs of problems, there will be an expectation that such a system can be effectively adapted to the SmartStruxure system with the Automation Server picking up the existing MS/TP buses.

For more information, see section 10.32 “Existing MNB Systems Transition” on page 248.

10.22.8 Network Check-Up (Examination and Monitoring)

When migrating an older system to a newer architecture or enhanced application environment, there is the possibility the existing system will encounter closer examinations, be expected to perform in a more detailed coordination with the larger system or be exercised in a more visible performance-sensitive manner by new applications. While an existing system may be considered stable and error free, the existing observations can sometimes be limited to the visibility offered by the earlier system. Communications problems can exist but go unnoticed (or masked) due by low level protocol retries. The typical MS/TP communications protocol setup for example can mask severe levels of communications errors with the retries not providing visibility of the issue until new dependencies on command/request latency reveals notable delays.

For more information, see section 10.33 “Network Check-Up (Examination and Monitoring)” on page 251.

10.23 General MNB BACnet Device Properties

MNB BACnet devices use an RS-485 transceiver that provides integrated galvanic isolation (NVE IL3286E). This transceiver has an RS-485 unit load rating of 0.125. With consideration only for the transceiver unit load, the 0.125 unit load rating would indicate up to 256 units (32/0.125) could be attached to a single RS-485 network wire segment. The MNB devices include an on-board weak bias resistor of 220 kohm on the A+ and B- bus signals. This 220 kohm resistance presents a very small additional unit load of 0.055 making each of the devices have an aggregate unit load of 0.18. This is a little better (lower) than the 0.25UL listed in “TAC I/A Series MicroNet BACnet Wiring and Networking Practices Guide (F-27360-3)”.

The transceiver used in the MNB devices does not include an integrated failsafe receiver function. This means network biasing resistors are required on the RS-485 bus to insure the idle state of the bus is kept at a minimum of +200 mV (target bias value +225 mV or higher for a noise buffer). The biasing of the network has been a jumper selectable feature provided by several of the head-end I/A series devices or routers in the family. The MNB-300, MNB-1000, and I/A Series Network Controllers included the jumper enabled bias. If one or more of these devices are present on the bus, one of these could continue to provide the network bias function.

The device bias capability mentioned above provides the jumper selected ability to connect 510 ohm pull-up resistor on the MSTP+ data line and 510 ohm pull-down resistor on the MSTP- line. The bias provided by the legacy device (Configurations 1 and 5) and the bias from separate supply (Configuration 2) delivers 5 V and supports an EOL termination resistor value of 120 ohm. For more information, see section 10.24 “MNB Configurations” on page 227.

Configurations 1 and 2 provide dual end-point bias supporting the maximum 1200 m (4000 ft) network length. Configurations 4 and 5 provide the common single end-point bias which is simpler to implement and supports a shorter network length, but frequently covers the distances required in the HVAC applications.

The RS-485 circuitry on the MNB devices provides an isolated interface. The circuit common used by the RS-485 transceiver is isolated from the local ground potential. This isolated common created by the isolated DC power supply on the adapter is presented on the terminal labeled SHLD on the three position network terminal block.

In addition to the A+ and B- twisted pair signal conductors, the shield drain wire in the RS-485 cable is also bussed in a daisy chain arrangement from each device to the next. The shield conductor provides an isolated reference/common for all MNB devices to use with their isolated RS-485 interfaces. The RS-485 interface provided by the MNB devices has the following interface attributes, as shown in the table below.

Table: Interface Attributes of the MNB BACnet Devices

Transceiver	Transceiver Unit Load	Transceiver Failsafe	Adapter Circuit Bias	Circuit Bias Load	Total Unit Load	Isolated RS-485 Bus
NVE IL3286E	0.125	No	220 kohm	0.055	0.18	Yes

The typical MS/TP data rates of 38.4 kbps or 76.8 kbps used with the MNB devices make the installation of EOL resistor termination necessary.

10.24 MNB Configurations

The recommendations include five different configuration options to choose from with differences in performance and/or resources required.

10.24.1 MNB Configuration 1: Dual End-point Bias (MNB Source)

Dual end-point bias applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. Instead of a single pair of 510 ohm resistors, the dual end scheme uses a pair of 1020 ohm resistors at each end. The dual end-point is the best technique for avoiding the drop in the bias voltage over extended cable lengths as you move away from the bias connection location. By applying the bias at the same location as the termination, the arrangement maintains an equal bias across the complete length of the cable. This technique avoids the positional sensitivity of Configuration 3 in locating the middle point of the network and provides a superior bias reliability. For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237. This Configuration 1 differs from Configuration 2 only in the use of MNB-300 or MNB-1000 devices to provide the bias supply source. For more information, see section 10.26 “MNB Configuration 2: Dual End-point Bias (External Supply Source)” on page 234.

For more information, see section 10.25 “MNB Configuration 1: Dual End-point Bias (MNB Source)” on page 230.

10.24.2 MNB Configuration 2: Dual End-point Bias (External Supply Source)

When MNB-300 or MNB-1000 devices are not available within 60 m (200 ft) of the end of the cable, the dual end-point bias configuration can still be deployed as seen here in Configuration 2 using separate external 5 V DC power supplies. For more information, see section 10.28 “Power Supply Selection for MNB Configuration 2 and 3” on page 240. This configuration applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. The same as Configuration 1, this arrangement provides the best performance on systems where bias is needed. For more information, see section 10.25 “MNB Configuration 1: Dual End-point Bias (MNB Source)” on page 230. The dual end-point avoids the drop in the bias voltage seen with the single end-point bias arrangements. By applying the bias at the same location as the termination, the arrangement maintains an equal bias across the complete length of the cable. This technique does not encounter the positional sensitivity of Configuration 3 in locating the middle point of the network. For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237.

For more information, see section 10.26 “MNB Configuration 2: Dual End-point Bias (External Supply Source)” on page 234.

10.24.3 MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)

Mid-point bias refers to the technique of using a separate 5 V DC power supply (For more information, see section 10.28 “Power Supply Selection for MNB Configuration 2 and 3” on page 240.) and locating it at the middle of the total network cable length. This technique takes advantage of the maximum DC differential resistance at the center to maximize the bias voltage applied from through the typical pair of 510 ohm resistors from the bias supply source. The higher bias voltage level now applied in the center can extend up to 600 m (2000 ft) in both directions from the center using 24 AWG (0.20 mm^2) size cable (or larger). As an alternative to the separate supply, if a bias-capable MNB device is positioned at the middle point in the network, its bias option can be used to achieve mid-point bias and render the longer network support. This relocation of the bias source from the typical end of the bus position to the middle of the cable length facilitates a large increase in cable length raising the total cable from 150 m (500 ft) recommended maximum (for single end bias) to a length of 1200 m (4000 ft) for the mid-point bias.

For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237.

10.24.4 Power Supply Selection for MNB Configuration 2 and 3

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

For more information, see section 10.28 “Power Supply Selection for MNB Configuration 2 and 3” on page 240.

10.24.5 MNB Configuration 4: Single End-point Bias (Automation Server Provided Source)

This configuration applies to the situation where existing legacy MNB devices with bias capability (MNB-300 or MNB-1000) are not available on the network segment, and it is preferred not to add external supplies.

For more information, see section 10.29 “MNB Configuration 4: Single End-point Bias (Automation Server Provided Source)” on page 242.

10.24.6 MNB Configuration 5: Single End-point Bias (MNB Device Provided Source)

This configuration applies to the situation where a legacy MNB device with bias capability is part of the network and can be used to supply the required network bias. In this configuration, no bias resistors are required on the Automation Server. The 510 ohm bias of an MNB device can be used in place of external resistors on the Automation Server. This configuration allows the termination resistance of 120 ohm to be applied due to the +5 V bias supply of the MNB device.

For more information, see section 10.30 “MNB Configuration 5: Single End-point Bias (MNB Device Provided Source)” on page 244.

10.24.7 MS/TP Data and Shield Connections

The cable shield drain wire is connected to each MNB device to provide a ground reference to the isolated RS-485 interface in each of the MNB devices. This shield connection on each MNB device is not a local ground connection. The shield drain wire from the MS/TP bus cable must only connect to the specific terminal designated to receive the shield for the MS/TP bus. The terminal label/text reference varies a little in the device documentation between the MNB devices. In all cases, it will be a third screw terminal in a set of three on a terminal block identified for MS/TP communications.

For more information, see section 10.31 “MS/TP Data and Shield Connections” on page 247.

10.25 MNB Configuration 1: Dual End-point Bias (MNB Source)

Dual end-point bias applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. Instead of a single pair of 510 ohm resistors, the dual end scheme uses a pair of 1020 ohm resistors at each end. The dual end-point is the best technique for avoiding the drop in the bias voltage over extended cable lengths as you move away from the bias connection location. By applying the bias at the same location as the termination, the arrangement maintains an equal bias across the complete length of the cable. This technique avoids the positional sensitivity of Configuration 3 in locating the middle point of the network and provides a superior bias reliability. For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237. This Configuration 1 differs from Configuration 2 only in the use of MNB-300 or MNB-1000 devices to provide the bias supply source. For more information, see section 10.26 “MNB Configuration 2: Dual End-point Bias (External Supply Source)” on page 234.

This configuration is recommended only if you have an MNB-300 or MNB-1000 device located at the two ends of the MS/TP network bus, or within 60 m (200 ft) of the end of the cable. If the MNB devices are not at the exact end of the cable, the EOL termination jumper selection must not be used on the MNB device. Only the biasing pin header/connector position will be used, and the EOL 120 ohm termination resistor must be attached across the + and – bus pair on the device positioned at the actual end of the cable. Using this configuration with MNB devices positioned farther back on the network (>60 m or 200 ft) will compromise the consistent level of bias supplied to the network with the nodes at the ends falling below target thresholds.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. The shield drain wires from the two cable segments are both connected to the SHLD terminal at each MNB BACnet device.

Use only the terminal block designated for MS/TP communications for Shield connection.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

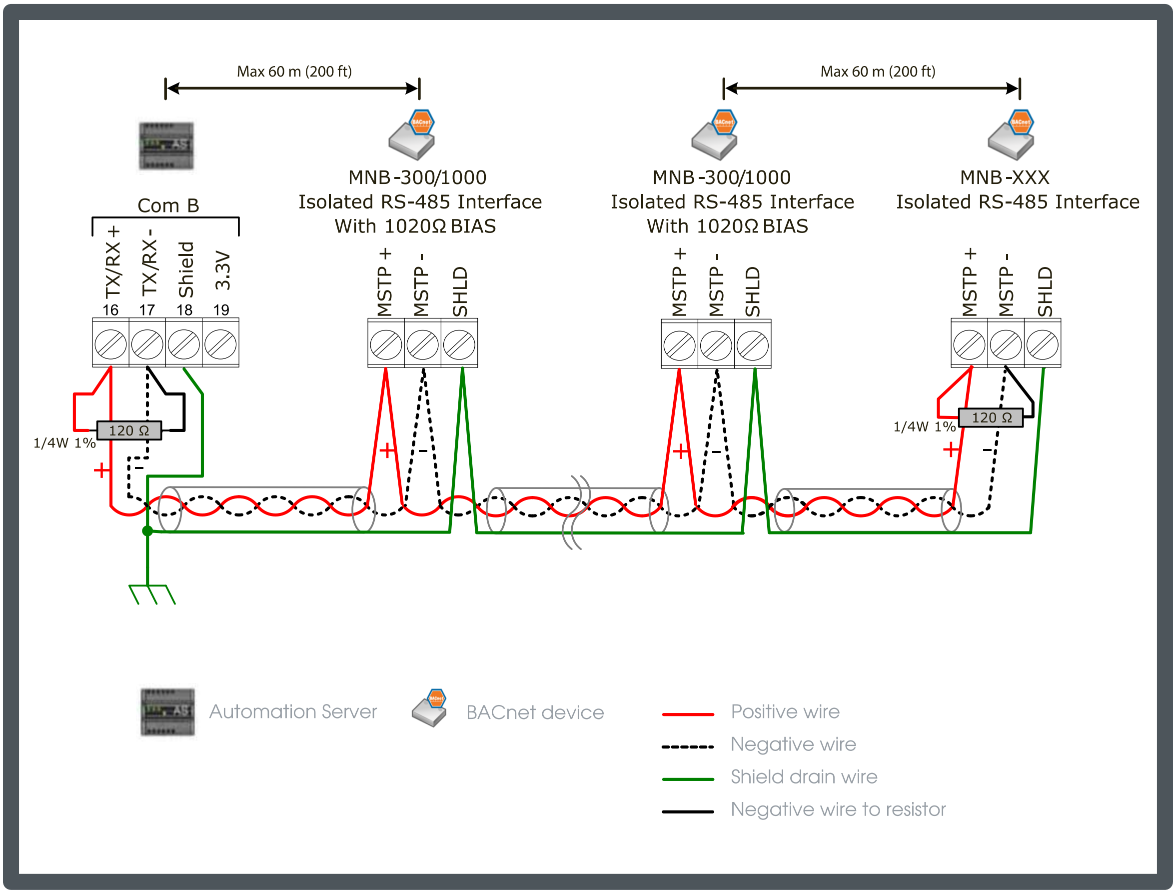


Figure: MNB configuration 1 – dual end-point network bias (MNB source supply)

Note

If an MNB-300 or MNB-1000 device is positioned at the end of the bus, the termination option jumper on the device may be enabled, instead of attaching a 120 ohm resistor on the terminal block. This also applies to the head end of the bus if a MNB-300 or MNB-1000 device is positioned there instead of a typical Automation Server.

The recommended maximum cable length is 1200 m (4000 ft), if using a 24 AWG (0.20 mm²) or larger cable.

The preferred location for the bias is at the two extreme ends of the network cable, but the bias voltage remains effective with a 60 m (200 ft) tolerance on the cable length from the end. This configuration supports the preferred termination resistor values of 120 ohm with one positioned at each end of the cable. The unit load imposed by the dual end-point bias is 23.5UL (12,000 / 510).

The two MNB-300 or MNB-1000 devices being used to provide the dual end-point bias must be configured with plug-on 510 ohm resistors instead of the typical plug-on shorting connector. The plug-on resistors are available in packages of 50 with a part number of MNBBIAS-510-50. Two of the plug-on resistors are attached to each of the two MNB devices. This arrangement creates a 1020 ohm bias from each end, instead of the single end 510 ohm bias with its shorter distance limits.

On the MNB-300 device, remove any existing plug-on shunt connectors from pin header positions P202 and P203. Press a plug-on 510 ohm resistor onto the EN (enable) position of pin headers P202 and P203. This is the top two pins on those two headers as seen in the following diagram.

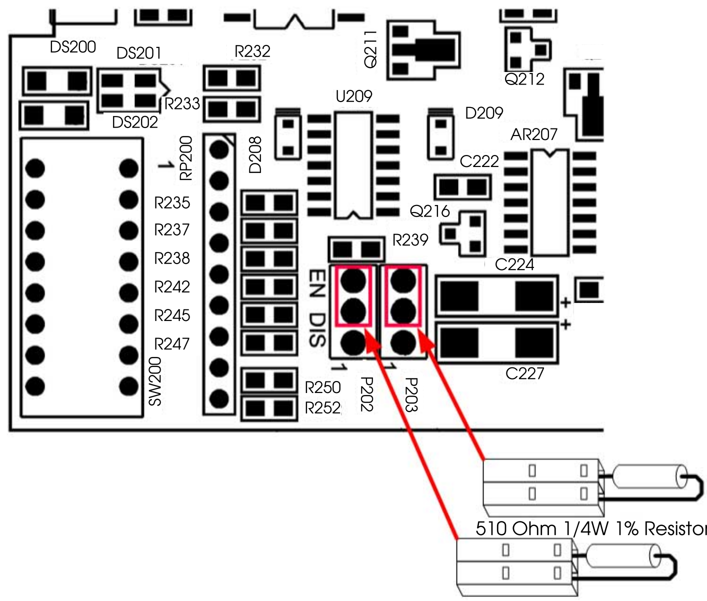


Figure: Bias resistor addition on MNB-300

On the MNB-1000 device, remove any existing plug-on shunt connectors from pin header positions P102 and P105. Press a plug-on 510 ohm resistor onto the EN (enable) position of pin headers P102 and P105. This is the right-hand two pins on those two headers as seen in the following diagram.

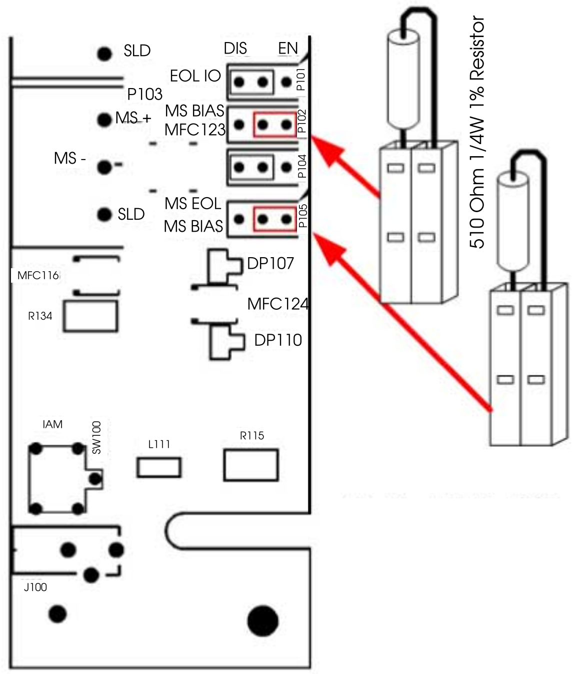


Figure: Bias resistor addition on MNB-1000

10.26 MNB Configuration 2: Dual End-point Bias (External Supply Source)

When MNB-300 or MNB-1000 devices are not available within 60 m (200 ft) of the end of the cable, the dual end-point bias configuration can still be deployed as seen here in Configuration 2 using separate external 5 V DC power supplies. For more information, see section 10.28 “Power Supply Selection for MNB Configuration 2 and 3” on page 240. This configuration applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. The same as Configuration 1, this arrangement provides the best performance on systems where bias is needed. For more information, see section 10.25 “MNB Configuration 1: Dual End-point Bias (MNB Source)” on page 230. The dual end-point avoids the drop in the bias voltage seen with the single end-point bias arrangements. By applying the bias at the same location as the termination, the arrangement maintains an equal bias across the complete length of the cable. This technique does not encounter the positional sensitivity of Configuration 3 in locating the middle point of the network. For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237.

Connect 5 V DC power supply to the MS/TP bus pair through two 1000 ohm resistors at the head end of the cable. Connect 5 V DC power supply to the MS/TP bus pair through two 1000 ohm resistors at the tail end of the cable.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground only at the head end of the network (typically at the Automation Server). The shield drain wire from the cable segments are both connected to the SHLD terminal at each MNB BACnet device.

Use only the terminal block designated for MS/TP communications for Shield connection.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

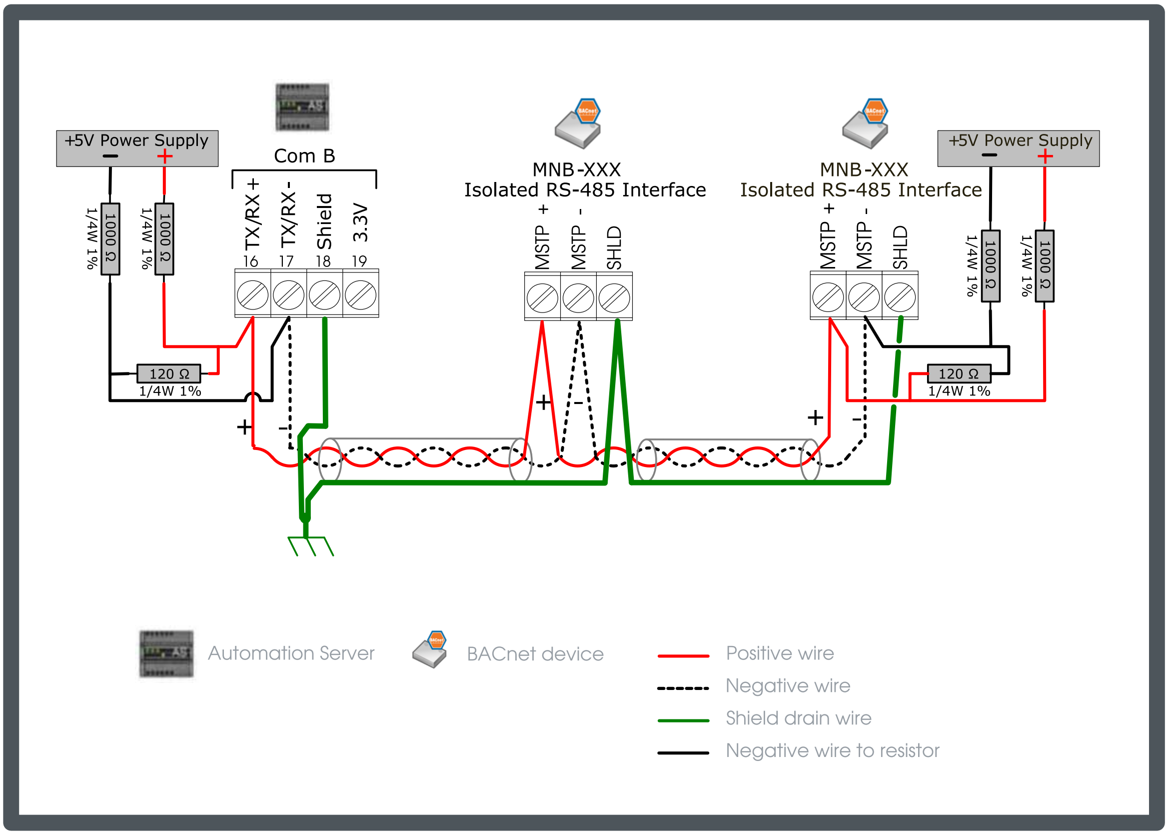


Figure: MNB configuration 2 – dual end-point network bias (separate external power supplies)

Note

If an MNB-300 or MNB-1000 device is positioned at the end of the bus, the termination option jumper on the device may be enabled, instead of attaching a 120 ohm resistor on the terminal block. This also applies to the head end of the bus if a MNB-300 or MNB-1000 device is positioned there instead of a typical Automation Server.

The recommended maximum cable length is 1200 m (4000 ft), if using a 24 AWG (0.20 mm²) or larger cable.

Note

You can combine Configuration 1 and 2. For example, if an MNB-300 device is located at the far end (within 60 m or 200 ft), the MNB device at the far end can be used for bias as instructed in Configuration 1 and the separate external supply can be applied to only the head end. Both the MNB device and the separate power supply are sufficiently equivalent.

For more information, see section 10.25 “MNB Configuration 1: Dual End-point Bias (MNB Source)” on page 230.

The recommended location for the separate supply bias is at the two extreme ends of the network cable, but the bias voltage remains effective with a 60 m (200 ft) tolerance on the cable length from the end. This configuration supports the preferred termination resistor values of 120 ohm with one positioned at each end of the cable. The unit load imposed by the dual end-point bias is slightly higher with 24UL (12,000 / (1,000 / 2) = 24) instead of 23.5UL (12,000 / 510).

10.27 MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)

Mid-point bias refers to the technique of using a separate 5 V DC power supply (For more information, see section 10.28 “Power Supply Selection for MNB Configuration 2 and 3” on page 240.) and locating it at the middle of the total network cable length. This technique takes advantage of the maximum DC differential resistance at the center to maximize the bias voltage applied from through the typical pair of 510 ohm resistors from the bias supply source. The higher bias voltage level now applied in the center can extend up to 600 m (2000 ft) in both directions from the center using 24 AWG (0.20 mm^2) size cable (or larger). As an alternative to the separate supply, if a bias-capable MNB device is positioned at the middle point in the network, its bias option can be used to achieve mid-point bias and render the longer network support. This relocation of the bias source from the typical end of the bus position to the middle of the cable length facilitates a large increase in cable length raising the total cable from 150 m (500 ft) recommended maximum (for single end bias) to a length of 1200 m (4000 ft) for the mid-point bias.

Position a 5 V DC power supply at the middle of the total MS/TP network length. Connect the supply to the MS/TP bus pair through two 510 ohm resistors. Alternatively, an MNB device with bias capability positioned in the middle of the network can be used to achieve the mid-point bias.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground only at the head end of the network (typically at the Automation Server). The shield drain wires from the cable segments are both connected to the SHLD terminal at each MNB BACnet device.

Use only the terminal block designated for MS/TP communications for Shield connections.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

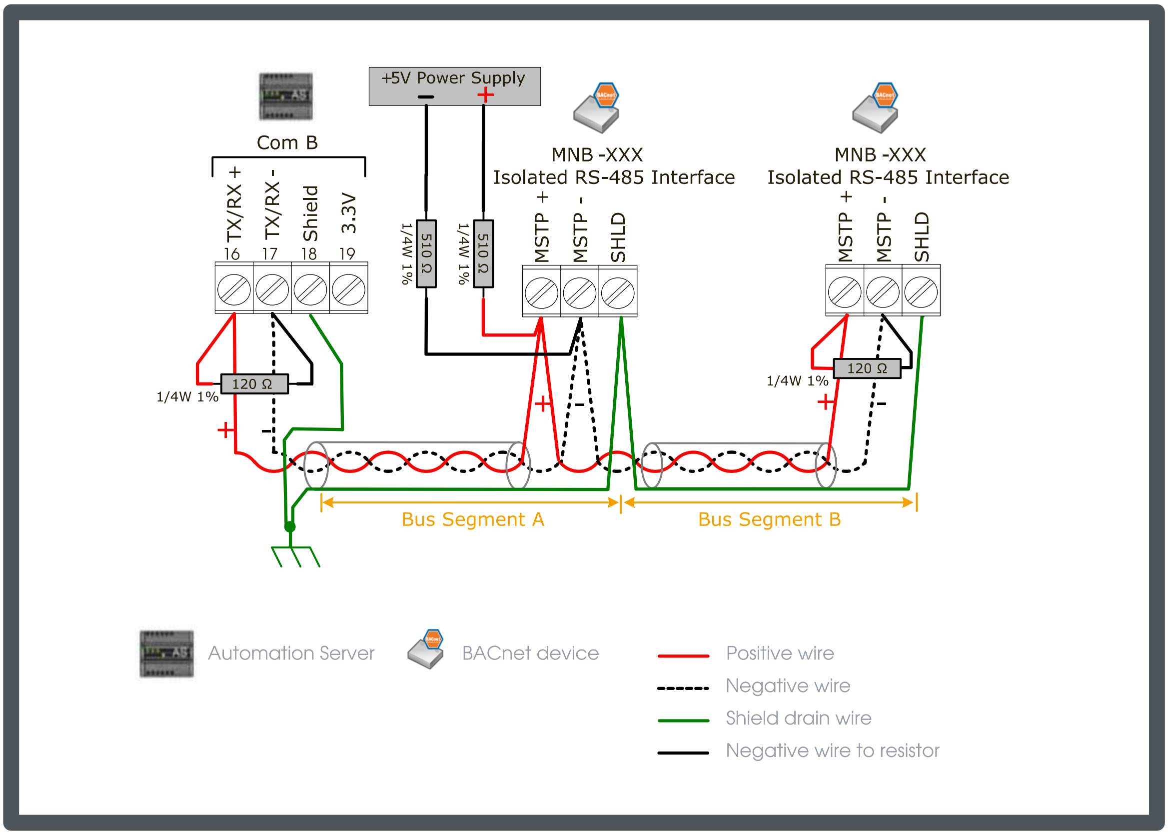


Figure: MNB configuration 3 – mid-point network bias

Note

If an MNB-300 or MNB-1000 device is positioned at the end of the bus, the termination option jumper on the device may be enabled, instead of attaching a 120 ohm resistor on the terminal block. This also applies to the head end of the bus if a MNB-300 or MNB-1000 device is positioned there instead of a typical Automation Server.

Note

If an MNB-300 or MNB-1000 is used to provide the single point bias, the standard plug-on shunt connectors are used to achieve the bias. The plug-on resistor (MNB-BIAS-510) is only used in Configuration 1.

The recommended maximum cable length is 1200 m (4000 ft), if using a 24 AWG (0.20 mm²) or larger cable.

The mid-point location selected for the bias should be within ±60 m (±200 ft) of true middle of the cable length. In other words, the mid-point bias divides the network bus in two segments (named A and B in the above figure), which should be approximately equal. The remote end bias voltage will drop significantly as the bias location moves away from network center. With termination resistors in place, a DC ohm measurement with a DVM can be used to determine cable length. From the location targeted for the mid-point bias, the near equivalent resistance in the two directions can be verified. A 60 m (200 ft) length of 24 AWG (0.20 mm²) cable would present a loop resistance of approximately 10.3 ohm. The two measurements should not have a difference greater than that amount.

Note

The resistance measurement verification technique described above requires all nodes connected on the bus to be in a power off condition.

This configuration supports the preferred End Of Line (EOL) termination resistance value of 120 ohm. The 120 ohm termination resistors must be positioned on the two ends of the network. The unit load imposed by the mid-point bias is the same as for Configuration 1, 2, 4 and 5, and the discussion on node count calculation is the same. For more information, see section 10.24 “MNB Configurations” on page 227.

Important

Configurations 1 or 2 are preferred over Configuration 3 due to the need for Configuration 3 to maintain a length balance on either side of the bias location. Later network revisions can easily disrupt the bias performance by either adding or reducing cable length on either side of the bias location (without performing the same change on the other side). This presents a counter-intuitive result from later work on the system. A person would typically think that no harm could be encountered by reducing the length of a network. In most cases, the system will probably continue to operate, but the noise margin will have been reduced by less than specified bias now presented to a collection of devices. Such scenarios offer a tendency to go unnoticed and show up later as communications anomalies possibly thought to be related to later actions that should not have such impact, but are sufficient to compromise a situation that now is forgotten.

For more information, see section 10.25 “MNB Configuration 1: Dual End-point Bias (MNB Source)” on page 230.

For more information, see section 10.26 “MNB Configuration 2: Dual End-point Bias (External Supply Source)” on page 234.

10.28 Power Supply Selection for MNB Configuration 2 and 3

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

Table: Recommended Supply Specifications

Characteristics	**Recommendations**
Type	5 V DC output isolated from local ground or equipment connections
Output Voltage	5.00 V DC +/- 5% (or better)
Maximum Output Current	0.1 A to 1.5 A (0.5 W to 7.5 W) Any model in this popular range
Minimum Output Current	Operates/regulates down to 0 current (no load required)
Maximum Output Ripple/Noise	150 mV_{pp} (or less)
Safety/EMC Agency Approvals	Applicable approvals for country of application

Frequently, the most convenient power source for the 5 V DC bias supply will be the 24 V AC typically powering the various RS-485 device products. A couple options for the 24 V AC to Isolated 5 V DC power supply would include the models PS-200-3-A-3-L and PS-200-3-A-3-N from Mamac Systems and the model DCP-524 from Kele. Another isolated 5 V supply option with a smaller package/footprint and lower cost would be the combination of the Altronix model VR1TM5 regulator and the small (20 VA) Veris Industries X020ADA 24 V AC to 24 V AC isolation transformer. The figure below shows the Veris/Altronix configuration.

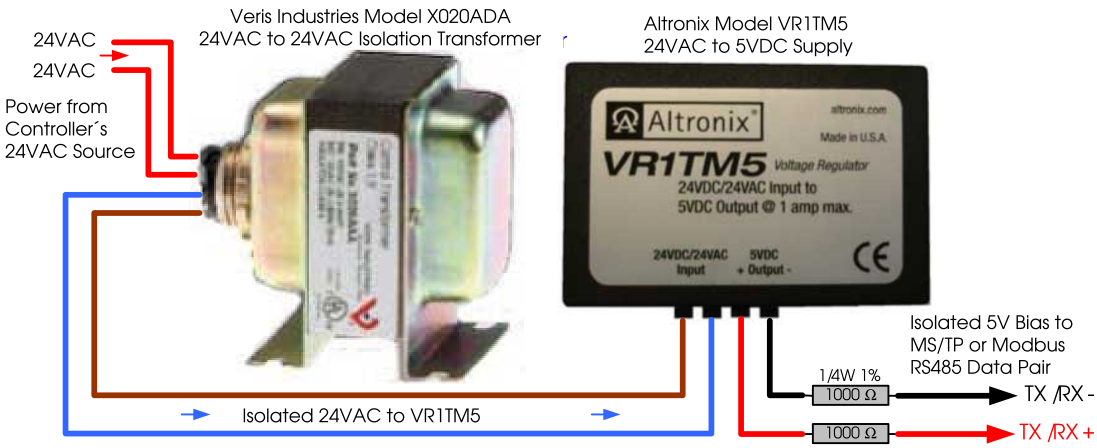


Figure: Isolated 5 V DC power supply using Veris X020ADA and Altronix VR1TM5

The 1000 ohm resistors shown in the figure above represent the application in Configuration 2 showing dual end-point bias. For more information, see section 10.26 “MNB Configuration 2: Dual End-point Bias (External Supply Source)” on page 234. For single mid-point biasing such as configuration 3, the values would be 510 ohm. For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237.

Other manufacturers/models of 24VAC/24VAC isolation transformers can be substituted to accommodate preferred package, size, local availability, and approvals.

If the use of 115/230 V AC line voltage for the + 5 V DC supply is preferred, the Veris X020ADA transformer can be replaced with a common 115 V/24 V or 230 V/24 V transformer. This can be a separate transformer of the same type used to power the 24 V AC devices. However, the transformer size used for this application can be as small as you have available. In this application, the VR1TM5 presents a load of less than 1 VA. The transformer output used to power the VR1TM5 should not be connected to any other device.

10.29 MNB Configuration 4: Single End-point Bias (Automation Server Provided Source)

This configuration applies to the situation where existing legacy MNB devices with bias capability (MNB-300 or MNB-1000) are not available on the network segment, and it is preferred not to add external supplies.

The Automation Server should be configured with bias resistors (510 ohm) to allow termination to be applied to each end of the network containing the MNB devices. With a 3.3 V bias voltage supply provided by the Automation Server, this configuration requires the use of 180 ohm termination resistors on the two ends (instead of preferred 120 ohm). The 180 ohm terminators allow minimum bias voltage specified by the transceivers in the MNB device to be achieved over the reduced cables lengths designated below.

The requirement for bias resistors to maintain an idle state voltage greater than 200 mV, and the bus current created by the termination resistors, presents a limitation on the compliant wire length due to idle state voltage drop in the wire. Unlike networks that do not require bias and the dual end-point bias configurations, when delivering the bias from a single end, the wire size will have a significant effect on the network distance over which the bias level can travel and maintain compliance. This is due to the voltage divider network setup by the wire resistance and the termination resistance. The bias is inducing a continuous DC current flow of about 5 mA and this current induces a continuous escalating voltage drop as you move down the cable away from the bias location toward the far end termination where the worst case bias voltage will be seen. See table below for recommended wire sizes and maximum distance.

Connect 510 ohm resistor from + line to 3.3 V. Connect 510 ohm resistor from - line to Shield.

Connect 180 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 180 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire directly to earth ground at the head end of the network (typically to ground rail in panel with the Automation Server). This is the only direct ground connection of the shield for the complete segment. The shield drain wire from the two cable segments are both connected to the SHLD terminal at each MNB BACnet device.

Use only the terminal block designated for MS/TP communications for Shield connection.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

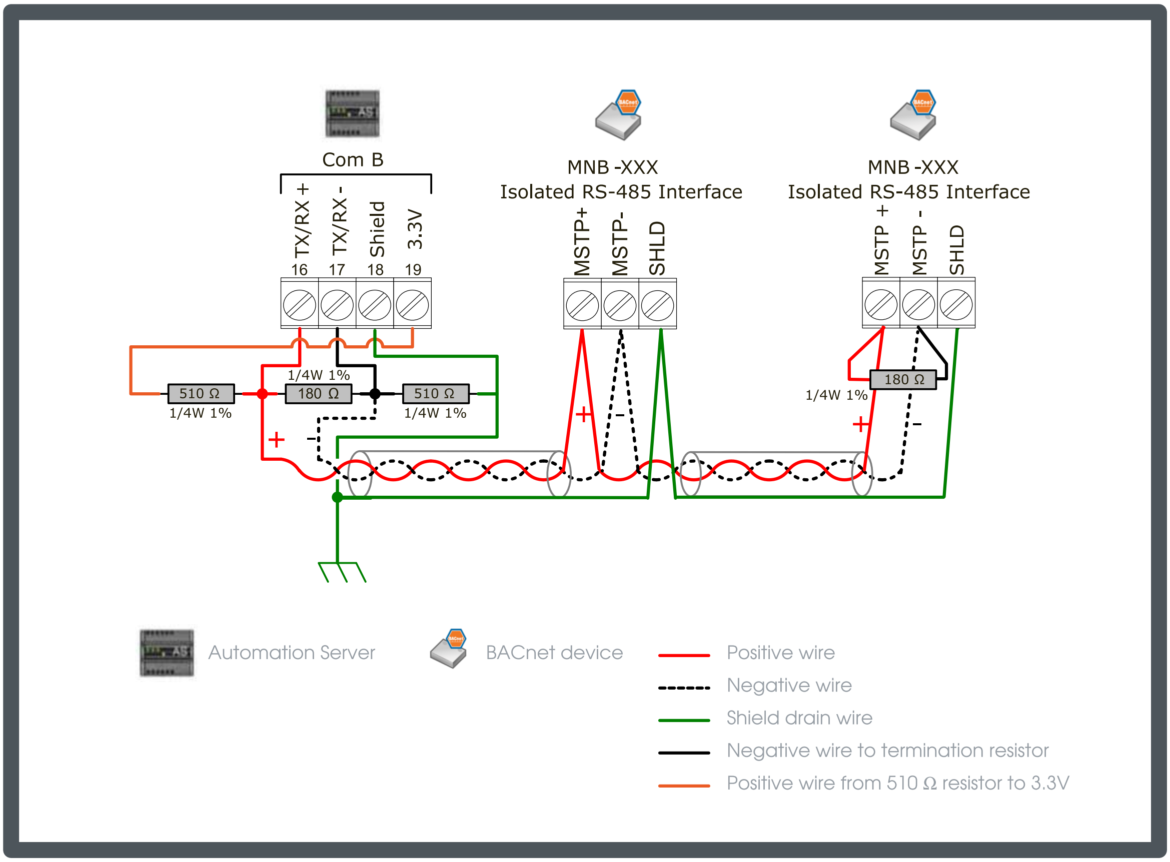


Figure: MNB configuration 4 – single end-point bias (Automation Server provided source)

The recommended maximum cable length and associated wire sizes are listed in the following table. These wire size and lengths are selected to maintain the minimum idle state voltage at the far terminated end of the network (away from the head end of the bus where the bias is attached).

Table: Recommended Maximum Cable Lengths and Associated Wire Sizes

Maximum Length	**Wire Size**
150 m (500 ft)	24 AWG (0.20 mm²)
240 m (800 ft)	22 AWG (0.33 mm²)

10.30 MNB Configuration 5: Single End-point Bias (MNB Device Provided Source)

This configuration applies to the situation where a legacy MNB device with bias capability is part of the network and can be used to supply the required network bias. In this configuration, no bias resistors are required on the Automation Server. The 510 ohm bias of an MNB device can be used in place of external resistors on the Automation Server. This configuration allows the termination resistance of 120 ohm to be applied due to the +5 V bias supply of the MNB device.

The 120 ohm termination resistors are placed on the two ends of the network, regardless of the physical location of the MNB device supplying the network bias. The low resistance bias configurations add common mode load on the RS-485 network. The common mode load (Unit Load) of the bias network must be added with the accumulated unit load of the collection of MNB devices to identify the total unit load on the bus.

This configuration differs from Configuration 4 only in the 5 V level being used for the bias (from the MNB device source) and the 120 ohm termination supported. For more information, see section 10.29 “MNB Configuration 4: Single End-point Bias (Automation Server Provided Source)” on page 242. The MNB-300 or MNB-1000 device providing the bias can be located anywhere on the bus. The typical end of bus scenario is assumed here which presents the same reduced cable lengths as for Configuration 4. The 120 ohm termination selection on the MNB device can only be used if the device is positioned on the end of the bus. If the MNB bias location is positioned specifically in the middle of the cable length, the improved cable lengths of Configuration 3 can be considered. For more information, see section 10.27 “MNB Configuration 3: Mid-point Bias (External Supply or MNB Device)” on page 237.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only direct ground connection of the shield for the complete segment. The shield drain wire from the two cable segments are both connected to the SHLD terminal at each MNB BACnet device.

Use only the terminal block designated for MS/TP communications for Shield connection.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

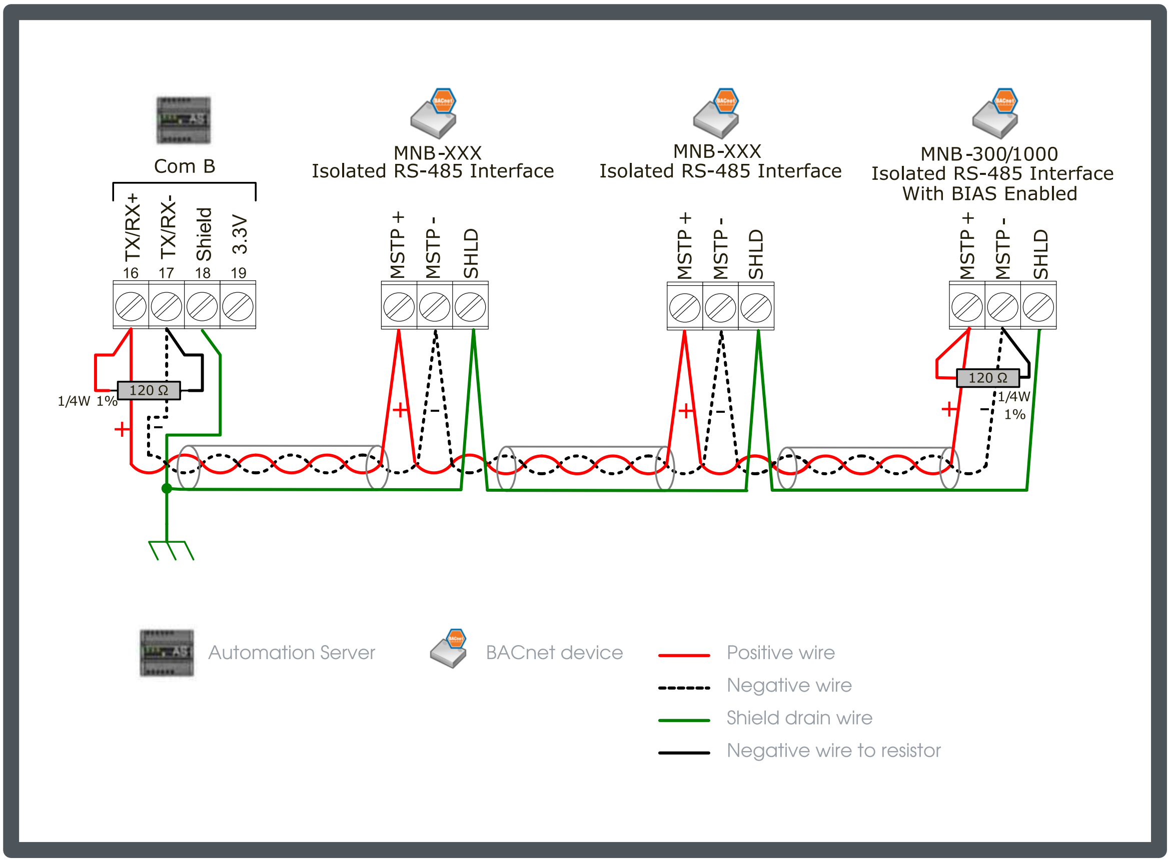


Figure: MNB configuration 5 – single end-point bias (MNB provided source)

Note

If an MNB-300 or MNB-1000 device is positioned at the end of the bus, the termination option jumper on the device may be enabled, instead of attaching a 120 ohm resistor on the terminal block. This also applies to the head end of the bus if a MNB-300 or MNB-1000 device is positioned there instead of a typical Automation Server.

Note

If an MNB-300 or MNB-1000 is used to provide the single point bias, the standard plug-on shunt connectors are used to achieve the bias. The plug-on resistor (MNB-BIAS-510) is only used in Configuration 1.

The recommended maximum cable length and associated wire sizes are listed in the following table. These wire size and lengths are selected to maintain the minimum idle state voltage at the far terminated end of the network (away from the head end of the bus where the bias is attached).

Table: Recommended Maximum Cable Lengths and Associated Wire Sizes

Maximum Length	Wire Size
150 m (500 ft)	24 AWG (0.20 mm²)

Continued

Maximum Length	Wire Size
240 m (800 ft)	22 AWG (0.33 mm^2)

10.31 MS/TP Data and Shield Connections

The cable shield drain wire is connected to each MNB device to provide a ground reference to the isolated RS-485 interface in each of the MNB devices. This shield connection on each MNB device is not a local ground connection. The shield drain wire from the MS/TP bus cable must only connect to the specific terminal designated to receive the shield for the MS/TP bus. The terminal label/text reference varies a little in the device documentation between the MNB devices. In all cases, it will be a third screw terminal in a set of three on a terminal block identified for MS/TP communications.

The sequence of MSTP+, MSTP-, and Shield terminals are different from that presented in the generic MNB configuration diagrams. For more information, see section 10.24 “MNB Configurations” on page 227. Be sure to observe the signal name instructions for each of the specific products in their respective installation guides.

Table: Terminal Numbers and References for Different MNB BACnet Devices

MNB Device	**Terminal Block Reference**	**MSTP+ Terminal Number**	**MSTP- Terminal Number**	**Shield Terminal Number**	**Shield Label Reference**
MNB-70	TB1	3	2	1	SHLD
MNB-V1 / MNB-V2	TB1	3	2	1	SHLD
MNB-300	P102	1	2	3	SLD
MNB-1000	P103	1	2	3	SLD

Important

There are two shield connection terminals on the MNB-1000 device. Both are referenced as SLD in the product data. The terminal block identified as P102 (BACnet Network Communications) is the connection serving the MS/TP bus and only the SLD terminal on this terminal block should be used to connect the shield from the MS/TP cable. The other SLD terminal is adjacent on terminal block TB101 and is used only for separate I/O RS-485 Bus. This is also an isolated ground reference connection, but it is a different isolated ground from the MS/TP bus.

10.32 Existing MNB Systems Transition

Many times the application of the SmartStruxure system will deal with existing MNB systems. In many of those instances, the existing MNB system installation may not be consistent with the network cable recommendations (For more information, see section 10.17 “Cable Selection” on page 213.). When dealing with an existing earlier installed system that has been operating for an extended period with no signs of problems, there will be an expectation that such a system can be effectively adapted to the SmartStruxure system with the Automation Server picking up the existing MS/TP buses.

These expectations need to be examined for two perspectives:

- The MS/TP bus device loading on the Automation Server needs to be compared with the Architectural Guidelines associated with the version SmartStruxure being deployed. For more information, see the *Architectural Guidelines 1.5* topic on WebHelp. The performance expectations associated with MS/TP bus loading as it related to Architectural Guidelines recommended node count limits lies outside the domain of the discussion here.
- The compliance of the existing physical network installation with recommendations should be examined to make the best judgment if the installation should be considered suitable for expansion in cable lengths or node counts. Performing a network check-up is recommended. For more information, see section 10.33 “Network Check-Up (Examination and Monitoring)” on page 251.

The “TAC I/A Series MicroNet BACnet Wiring and Networking Practices Guide (F-27360-3)” included these MS/TP wiring specifications. Wiring for an MS/TP EIA-485 (formerly RS-485) network shall meet the following specifications:

- Use shielded twisted-pair cable with characteristic impedance between 100 and 130 ohm.
- Distributed capacitance between conductors shall be less than 49 pF/m (15 pF/ft).
- Distributed capacitance between the conductors and the shield shall be less than 98 pF/m (30 pF/ft).
- Foil or braided shields are acceptable.
- The maximum recommended length of an MS/TP segment is 1200 m (4000 ft) using the cables in the table below.

In the following table, cable information is presented for comparison and discussion.

Table: Recommended BACnet MS/TP Cable Types

Baud Rate	**No. of Devices**[a]	**Cable**	**AWG (mm^2)**	**Plenum-Rate**[b]	**Cond-Cond Capacitance**[c]	**Cond-Shield Capacitance**[c]	**Cond. DC Resistance**	**Oper. Temp.**
19,200 or Less	32 Devices or Less	Belden 8641	24 (0.205)	No	73 pF/m (22.0 pF/ft)	140 pF/m (42.0 pF/ft)	82 ohm/km (25 ohm/1000 ft)	-20 to +80 °C (-4 to +176 °F)

Continued

Baud Rate	No. of Devices[a]	Cable	AWG (mm²)	Plenum-Rate[b]	Cond-Cond Capacitance[c]	Cond-Shield Capacitance[c]	Cond. DC Resistance	Oper. Temp.
19,200 or Less	32 Devices or Less	Belden 82641	24 (0.205)	Yes	103 pF/m (31.0 pF/ft)	197 pF/m (59.0 pF/ft)	79 ohm/km (24 ohm/1000 ft)	-0 to +60 °C (+32 to +140 °F)
19,200 or Less	32 Devices or Less	Belden 82502	24 (0.205)	Yes	83 pF/m (25.0 pF/ft)	150 pF/m (45.0 pF/ft)	79 ohm/km (24 ohm/1000 ft)	-0 to +60 °C (+32 to +140 °F)
76,800 or Less	128 Devices or Less	Connect-Air W241P-2000F	24 (0.205)	Yes	38 pF/m (11.4 pF/ft)	N/A	89 ohm/km (27 ohm/1000 ft)	+150 °C max. (+302 °F max.)
76,800 or Less	128 Devices or Less	Connect-Air W241P-2000S	24 (0.205)	Yes	38 pF/m (11.4 pF/ft)	N/A	89 ohm/km (27 ohm/1000 ft)	+150 °C max. (+302 °F max.)
76,800 or Less	128 Devices or Less	Belden 89841	24 (0.205)	Yes	40 pF/m (12.0 pF/ft)	73 pF/m (22.0 pF/ft)	79 ohm/km (24 ohm/1000 ft)	-70 to +200 °C (-94 to +392 °F)

a) The length of a wiring segment must be 1200 m (4000 ft) or less.
b) Use plenum-rated cable for operating temperatures less than -20 °C (-4 °F).
c) Capacitance at 1 kHz.

Recommended cables are listed in a separate table. For more information, see section 10.17 “Cable Selection” on page 213.

The table above is extracted from “TAC I/A Series MicroNet BACnet Wiring and Networking Practices Guide (F-27360-3)”. The first three cables in that guide represent a relaxed recommendation for lower performance cable on slower and shorter (reduced node count) systems. Going forward we have a higher incidence of merging multiple products on a MS/TP bus and use of these lower performance cables is no longer recommended.

When encountering systems constructed using any of the cables in the first set of three (8641, 82641, 82502) or other cables with equal or less performance (higher capacitance or unspecified capacitance or impedance), it is recommended that the network composition be maintained as-is with only the required transitions to connect with an Automation Server positioned in place of the previous head-end device at the same location. If expansion on the bus segment is needed, it is recommended that you stay within the reduced speed and capacity/size restriction described in table above. It is also suggested that a network check-up should be used to judge if any expansion should be performed.

Of the lower three cables in table above, the Belden 89841 is a fully compliant and recommended cable. For more information, see section 10.17 “Cable Selection” on page 213. The other two cables in the bottom set of three in table above are the Connect-Air models W241P-2000F and W241P-2000S. These are later introductions that offered a lower cost cable while providing low capacitance specifications and a plenum rating. The W241P-2000S is described as an older model cable from Connect-Air that is now rarely used and carries a much higher price than its successor model W241P-2000F. The table above dose not show the wire to shield capacitance values or the impedance. The latest Connect-Air specification for the W241P-2000F cable is shown in the following table.

Table: Specification for the Connect-Air W241P-2000F Cable

Parameter	**Value**
Capacitance Wire to Wire	42 pF/m (12.5 pF/ft) +/- 10%
Capacitance Wire to Shield	78 pF/m (23.8 pF/ft) +/- 10%
Impedance	100 ohm +/- 10%
Velocity of Propagation	80% nominal
DC Resistance	76.8 ohm/km at 20°C (23.4 ohm/1000 ft at 68 °F)

The recommended cable list indicates preference for 120 ohm cable. For more information, see section 10.17 “Cable Selection” on page 213. This is the cable impedance recommended in the RS-485 standard and specified in the data for all of the RS-485 transceivers. The use of 100 ohm cable is a common practice thought to be directly related to the lower price and availability of several cable candidates. The use of 100 ohm is not optimum in regards to transmitter loading, noise immunity, and signal quality, but the diversion from the specified criteria is considered relatively small. The RS-485 interfaces have proven to be very robust and this is one of the areas where deviations from the standard frequently occur. The use of 120 ohm cable is recommended and may deserve more attention when expecting to operate over long distances (>600 m or 2000 ft) or environments of high noise induction.

It is commonly understood that data transmission cable should typically be terminated by a resistance equal to the characteristic impedance of the cable. The recommendations for Configuration 4 deviate from that guideline when suggesting the alternative termination resistance of 180 ohm when using 3.3 V bias source from the Automation Server. For more information, see section 10.29 “MNB Configuration 4: Single End-point Bias (Automation Server Provided Source)” on page 242. The recommended configurations using 120 ohm termination are described as preferable, but the 180 ohm is an acceptable compromise for Configuration 4. A second deviation would relate to the use of 100 ohm cable. If 100 ohm impedance cable is used, it is recommended that the EOL termination resistance stay with the 120 ohm value as seen on the diagrams for Configurations 1, 2, 3, and 5. The use of a 100 ohm termination would reduce the idle line bias levels on the bus and further increase the load on the RS-485 transmitters.

10.33 Network Check-Up (Examination and Monitoring)

When migrating an older system to a newer architecture or enhanced application environment, there is the possibility the existing system will encounter closer examinations, be expected to perform in a more detailed coordination with the larger system or be exercised in a more visible performance-sensitive manner by new applications. While an existing system may be considered stable and error free, the existing observations can sometimes be limited to the visibility offered by the earlier system. Communications problems can exist but go unnoticed (or masked) due by low level protocol retries. The typical MS/TP communications protocol setup for example can mask severe levels of communications errors with the retries not providing visibility of the issue until new dependencies on command/request latency reveals notable delays.

It is recommended that existing system MS/TP segments be examined with a BACnet communications analysis tool prior to disrupting the operation of the existing system. The objective is to capture some snapshots of the various network segments in the existing system. You can easily attach such monitoring tool to an operating MS/TP network and capture statistics on the operation of the network for an appropriate period of time. This offers visibility into the actual performance and stability of the network targeted for migration to the new system hierarchy. An indication of high error statistics may prompt a decision for diagnostic effort on the existing network prior to the system migration, or an understanding that investigative effort will play a role in the system transition. Alternatively, the insight into actual system performance may simply be used as an indication that performance expectations for specific network segments of the system may need to be moderated. In any case, it avoids a common post-update conclusion that the problems with the system upgrade were solely a product of the new system products or installation practices.

One easily available tool is the MS/TP data capture utility known as MSTPcap. The primary purpose of the MSTPcap utility is a tool to capture BACnet MS/TP communications traffic by listening to the bus and packaging the captured traffic into data packets in a PCAP file format suitable for feeding into another tool called Wireshark. Wireshark is another very useful tool for the detailed analysis of network communications on a variety of systems. The later versions of Wireshark now include the support for decoding BACnet protocol layers.

The Schneider Electric Lessons Learned article LL#5367 provides guidance on use of the MSTPcap program for performing a network checkup.
http://buildingskb.schneider-electric.com/view.php?AID=5637

10.34 Legrand Power Meters

This application note provides recommendations and guidelines for the configuration of RS-485 Modbus communications between the Automation Server and Legrand power meters. The recommendations are based on an investigation of Legrand meter models 04677, 04680, 04684, and 14669. The investigation was used to discover isolation and unit load characteristics along with requirements of the RS-485 transceiver for external failsafe biasing on the RS-485 network and to test communications operation with the meters under recommended configurations. This information is intended to supplement the product information provided with the Legrand meters. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance is associated with the Automation Servers with serial number of TD133954000 and later.

10.34.1 General Legrand Power Meter Properties

An important difference between the Legrand meters is that models 04677, 04680, and 04684 use transceivers with integrated failsafe receivers, whereas the model 14669 uses a transceiver with no integrated failsafe function.

For more information, see section 10.35 “General Legrand Power Meter Properties” on page 254.

10.34.2 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

For more information, see section 10.36 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (Legrand Power Meters)” on page 255.

10.34.3 Expanded Unit Load with Network of Isolated Devices Only

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. With a network comprised exclusively of isolated interfaces connected to the Automation Server, the standard unit load budget of 32UL can be increased by 50% to have an expanded budget of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network resistors and the load of the Automation Server leaves 24UL available for the nodes to be connected on the bus. With the example device load of 1.32UL each, the expanded budget of 48UL supports 18 nodes (meters) on the bus.

For more information, see section 10.37 “Expanded Unit Load with Network of Isolated Devices Only (Legrand Power Meters)” on page 257.

10.34.4 Legrand Configurations

The recommendations include four different configuration options to choose from with differences in performance and/or resources required.

For more information, see section 10.38 “Legrand Configurations” on page 258.

10.34.5 Cable Routing

The RS-485 network cable should be routed in a continuous daisy chain bus configuration. There should not be any stub connections, stars or ring configurations. The bussed cable should pass through each node to be connected with no splits or branches in the cable network.

For more information, see section 10.16 “Cable Routing” on page 212.

10.34.6 Cable Selection

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

For more information, see section 10.44 “Cable Selection (Legrand Power Meters)” on page 276.

10.35 General Legrand Power Meter Properties

An important difference between the Legrand meters is that models 04677, 04680, and 04684 use transceivers with integrated failsafe receivers, whereas the model 14669 uses a transceiver with no integrated failsafe function.

Review of the RS-485 interface provided by the Legrand meters yields the following interface attributes:

Table: Interface Attributes of the Legrand Power Meters

Legrand Model	Transceiver	Transceiver Unit Load	Transceiver Failsafe	Meter Circuit Bias	Circuit Bias Load	Total Unit Load	Isolated RS-485 Bus
04677	Exar SP4082	0.125	Yes	10 kohm	1.200	1.325	Yes
04680	TI SN65HVD3082	0.125	Yes	10 kohm	1.200	1.325	Yes
04684	TI SN65HVD3082	0.125	Yes	10 kohm	1.200	1.325	Yes
14669[a]	Exar SP485E	1.000	No	16 kohm[b]	0.750[b]	1.750	Yes

a) The RS-485 interface on the model 14669 is provided by the model 14673 plug-in option module.
b) The 16 kohm network bias occurs with 14673 switches 1 and 2 in the OFF position, which is recommended. Placing these two switches in the ON position changes the bias to 8 kohm (1.5UL) and places a 120 ohm termination resistance across the network pair.

The provision of failsafe transceivers in the Legrand models 04677, 04680, and 04684 is a very beneficial feature. This type of transceiver with integrated failsafe receiver allows recommendation for a terminated bus without the negative limitation imposed with external bias resistors required to support termination. Configuration 1 supports these three meter models. For more information, see section 10.38 “Legrand Configurations” on page 258.

The model 14669 uses an older transceiver with no integrated failsafe feature and rated for a full 1UL unit. This 1UL coupled with the internal bias resistance pushes the unit load of the model 14669 to a very high value of 1.75UL. This means each 14669 meter consumes almost two of the available 32 unit loads. Without the failsafe feature, the use of one of the alternate configuration options (2, 3, or 4) will be required. These configurations provide the required bias for the model 14669, but have the side effect of reduced node count and/or distance. For more information, see section 10.38 “Legrand Configurations” on page 258.

The models 04677, 04680, and 04684 can be used in any of the four configurations. If the network consists of only the models 04677, 04680, and/or 04684, Configuration 1 offers the best performance. If a single model 14669 is included on the network bus, the bus must use Configuration 2, 3, or 4 and follow the associated guidelines. For more information, see section 10.38 “Legrand Configurations” on page 258.

10.36 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (Legrand Power Meters)

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

The TIA-485A standard does not accommodate any special allowance or exclusion for the addition of bias resistors. If you add load to the data lines (for whatever purpose), it is part of the common mode load and must be considered in the calculation of unit load on the network. Just as 375 ohm equals 32UL, 510 ohm resistance equals 23.5UL.

The accumulation of RS-485 node counts in excess of the standard defined limit of 32UL does not alone create a violation prompting immediate inoperability. The primary performance parameter affected by network load is the ability of the RS-485 transmitter to output the minimum specified signal level of 1.5 V. Reduction in output signal level starts with the addition of the first load connected and reduces further as additional load is added. The 32UL boundary is simply the standardized guaranteed specification limit where the manufacturers guarantee the signal level will not have reduced below 1.5 V. As mentioned above, the 1.5 V signal output is guaranteed not only with a 32UL load, but also with an elevated common mode voltage (CMV of -7 V to +12 V). As the network exceeds the 32UL limit, the tolerance for this CMV will decay. The following graph from the TIA-TSB-89-A standards document shows the expected reduction in CMV as a function of unit load on the bus.

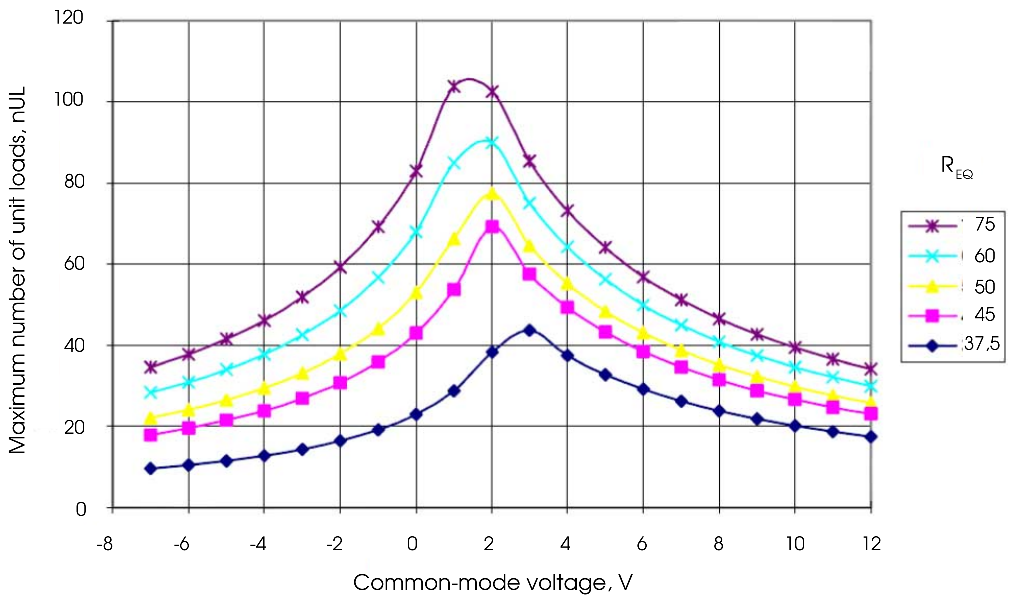


Figure: Maximum number of unit loads versus common-mode voltage and REQ (From TIA TSB-89A 485 Application Guidelines)

The REQ legend in the figure above refers to the resulting parallel load resistance of two termination resistors. The common 120 ohm termination produces 60 ohm and is shown by the REQ=60 cyan colored line. The cyan line indicates a standard UL load limit of 32 with a CMV between -7 V and +12 V. Extra current is required from the transmitter to overcome the common mode voltage seen through the common mode load impedance (unit load). As node count elevates, the tolerance for CMV pulls in as seen in the graph.

For example, if we take the 24UL of the bias network seen in Configuration 3 (For more information, see section 10.41 “Legrand Configuration 3: Terminated Bus with Single End-point Bias” on page 268.) and add a collection of 32 meter nodes each rated at 1.325UL, we would have a total network load of 66.4UL (24 + 42.4UL). In this 32 node configuration, the bus is loaded to 207% of the standard RS-485 32UL load limit, From the graph above you can see that the specified minimum -7 V CMV is expected to be reduced to 0 V and the normal +12 V will pull back to about +3.5 V. Operation of the network with a unit load twice the standard specified maximum load of 32UL is not recommended. When operating in a situation where CMV is avoided, the reduction in transceiver CMV performance can be better tolerated. An isolated RS-485 bus configuration (such as with the Legrand meters) allows the nodes to be insulated from local ground voltage differences which are a main source of sustained CMV on the bus. The isolated bus allows each of the transmitters to move up and down to the idle voltage of the bus.

10.37 Expanded Unit Load with Network of Isolated Devices Only (Legrand Power Meters)

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. With a network comprised exclusively of isolated interfaces connected to the Automation Server, the standard unit load budget of 32UL can be increased by 50% to have an expanded budget of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network resistors and the load of the Automation Server leaves 24UL available for the nodes to be connected on the bus. With the example device load of 1.32UL each, the expanded budget of 48UL supports 18 nodes (meters) on the bus.

The excess unit load accommodation is unique to the isolated interface configuration. Excluding the Automation Server, if a device with a non-isolated RS-485 interface is connected to the bus, then the complete network must fall back to comply with the RS-485 standard specified maximum budget of 32UL.

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

10.38 Legrand Configurations

The recommendations include four different configuration options to choose from with differences in performance and/or resources required.

10.38.1 Legrand Configuration 1: Terminated Bus with No Bias Requirement

This configuration is recommended when using any combination of Legrand meter models 04677, 04680, and 04684. The configuration does not apply to the model 14669. The configuration uses 120 ohm End Of Line (EOL) termination resistors and requires no extra biasing.

For more information, see section 10.39 “Legrand Configuration 1: Terminated Bus with No Bias Requirement” on page 262.

10.38.2 Legrand Configuration 2: Unterminated Bus with Minimal Bias

This configuration uses no bus termination, which means reduced data rates and cable lengths. The configuration applies to any combination of Legrand meter models 04677, 04680, 04684, or 14669.

For more information, see section 10.40 “Legrand Configuration 2: Unterminated Bus with Minimal Bias” on page 265.

10.38.3 Legrand Configuration 3: Terminated Bus with Single End-point Bias

A third configuration option is available where low resistance bias is added to the Automation Server to allow termination to be applied on a network containing one or more model 14669 meters. The configuration applies to any combination of Legrand models 04677, 04680, 04684, or 14669. With a 3.3 V bias voltage supply, the configuration can support 180 ohm termination resistors on the two ends (instead of the typical 120 ohm resistors) and achieve the minimum bias voltage required by the transceiver in the model 14669.

For more information, see section 10.41 “Legrand Configuration 3: Terminated Bus with Single End-point Bias” on page 268.

10.38.4 Legrand Configuration 4: Terminated Bus with Dual End-point Bias

A fourth configuration option is targeted at recovering the full 1200 m (4000 ft) capability of the RS-485 network while accommodating the standard 120 ohm End Of Line (EOL) terminations for better high speed data quality. This technique applies two small 5 V supplied to bias the network from each end. Biasing the network from both ends completely eliminates the dropping failsafe bias voltage as the cable length extends toward the remote terminator. This configuration option can be used for any combination of Legrand models 04677, 04680, 04684, or 14669.

For more information, see section 10.42 “Legrand Configuration 4: Terminated Bus with Dual End-point Bias” on page 271.

10.38.5 Power Supply Selection for Legrand Configuration 4

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

For more information, see section 10.43 “Power Supply Selection for Legrand Configuration 4” on page 274.

10.38.6 Configuration Summary

The four configuration options described above are summarized in the following table.

Table: Summary of the Legrand Configuration Options

Configuration	Description	Max Cable Length	Max Data Rate	Max Node Count, All Isolated, for 04677, 04680, 04684	Max Node Count, All Isolated, for 14669	Max Node Count, Any Non-isolated, for 04677, 04680, 04684	Max Node Count, Any Non-isolated, for 14669	Comments
1	Terminated – 120 ohm With no bias requirement	1200 m (4000 ft)	76,800 bps	35.8	Not supported	23.7	Not supported	Best performance and simplest configuration, but not applicable to the model 14669.
2	Unterminated With minimal bias	150 m (500 ft)	19,200 bps	33	25	20.9	15.7	Useful for lower data speed over shorter distances in low noise environment.
3	Terminated – 180 ohm With single end-point bias	150 m (500 ft)	76,800 bps	18.1	13.7	6	4.5	Common configuration that supports full data speed over shorter distances covering many application needs.

Continued

Configuration	Description	Max Cable Length	Max Data Rate	Max Node Count, All Isolated, for 04677, 04680, 04684	Max Node Count, All Isolated, for 14669	Max Node Count, Any Non-isolated, for 04677, 04680, 04684	Max Node Count, Any Non-isolated, for 14669	Comments
4	Terminated – 120 ohm With dual end-point bias	1200 m (4000 ft)	76,800 bps	17.7	13.4	5.6	4.2	Supports long length and maximum data rates with all four models. Node count reduced due to bias requirements.

10.39 Legrand Configuration 1: Terminated Bus with No Bias Requirement

This configuration is recommended when using any combination of Legrand meter models 04677, 04680, and 04684. The configuration does not apply to the model 14669. The configuration uses 120 ohm End Of Line (EOL) termination resistors and requires no extra biasing.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the two RS-485 common wire pair and the shield to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for these conductors. The shield drain wire from the cable segments are twisted together and passed by each node.

Both conductors of the second twisted pair cable are used to connect RS-485 Common on the meters.

Use only twisted pair bus cable specified for use with RS-485 (for example, Belden 9842 or equivalent). For more information, see section 10.44 “Cable Selection (Legrand Power Meters)” on page 276.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

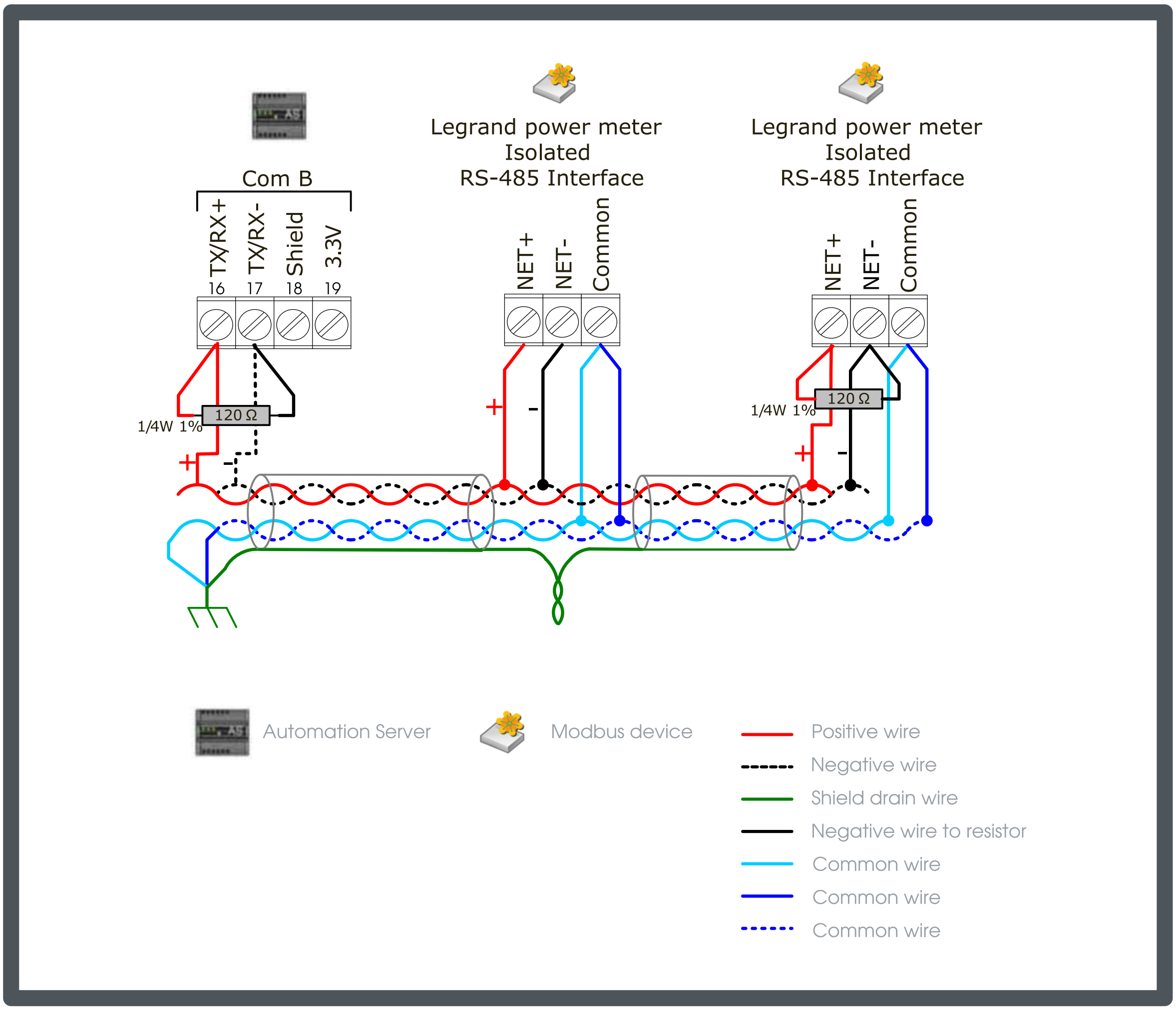


Figure: Legrand configuration 1 – terminated bus with no bias requirement (for models 04677, 04680, or 04684)

In this configuration, the failsafe feature of the transceivers allows the full RS-485 cable length to be supported with 24 AWG (0.20 mm^2) wire size without the node count and length reductions associated with failsafe bias load seen with Configuration 2, 3, and 4. For more information, see section 10.38 “Legrand Configurations” on page 258.

With products such as these three models using integrated failsafe transceivers, the addition of extra bias would typically only be applicable to system conditions prompting high levels of differential noise. In a well balanced cable system the differential noise is expected to be below 50 mV. With no added bias, the Automation Server will accommodate noise of approximately 130 mV_{pp} or more. Additional biasing will typically not be needed. In a system with Legrand meters, significant additional biasing is being supplied internal to the meters. This is what elevates the Total Unit Load values. For more information, see section 10.35 “General Legrand Power Meter Properties” on page 254. For example, with 10 Legrand meters, the equivalent of a 1 kohm bias is accumulated on the bus. This alone increases the idle state line voltage by an additional 200 mV and presents an additional 12UL of load.

Each of the models 04677, 04680, and 04684 presents an RS-485 network load of 1.32UL. The Automation Server has a network load of 0.5UL. To determine the number of nodes (meters) the bus will support, we first determine the remaining available unit load capacity after subtracting the base load of the Automation Server. This configuration does not require bias which would present a large reduction.

For networks connecting only with Legrand meters, the initial unit load budget is 48UL. For networks with one or more other Modbus devices that are not isolated, the initial unit load budget is 32UL. Subtracting the Automation Server load of 0.5UL, we have a remaining capacity of 47.5UL (all isolated) or 31.5UL (mixed).

For isolated network, the calculated maximum node count is 47.5 / 1.325 = 35.8 nodes (meters).

For mixed network, the calculated maximum node count is 31.5 / 1.325 = 23.7 nodes (meters).

10.40 Legrand Configuration 2: Unterminated Bus with Minimal Bias

This configuration uses no bus termination, which means reduced data rates and cable lengths. The configuration applies to any combination of Legrand meter models 04677, 04680, 04684, or 14669.

When using any combination of Legrand models that include the model 14669 (with the 14673 RS-485 optional plug-in), Configuration 1 cannot be used. For more information, see section 10.39 “Legrand Configuration 1: Terminated Bus with No Bias Requirement” on page 262. The transceiver in the 14673 module requires a minimum of +200 mV idle line voltage (plus 25-50 mV for noise margin) to insure a known idle state data output when no transmitters are active. Bias resistors must be added to the bus to pull the + and – lines apart. To minimize load on the bus (lowering node count), higher resistance values are preferred. However, a high resistance bias will not work if bus termination must be applied. Configuration 2 omits the use of termination. With data rates of 19,200 bps and lower, and cable lengths of less than 150 m (500 ft), the reflections from an unterminated bus can be tolerated. Without the 120 ohm resistors at the ends of the bus, the differential signal voltage will expand to wider level allowing higher noise immunity during the idle state.

Connect 3300 ohm resistor from + line to 3.3 V. Connect 3300 ohm resistor from - line to Ground (Shield).

Connect the two RS-485 common wire pair and the shield to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for these conductors. The shield drain wire from the cable segments are twisted together and passed by each node.

Both conductors of the second twisted pair cable are used to connect RS-485 Common on the meters.

Use only twisted pair bus cable specified for use with RS-485 (for example, Belden 9842 or equivalent). For more information, see section 10.44 “Cable Selection (Legrand Power Meters)” on page 276.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

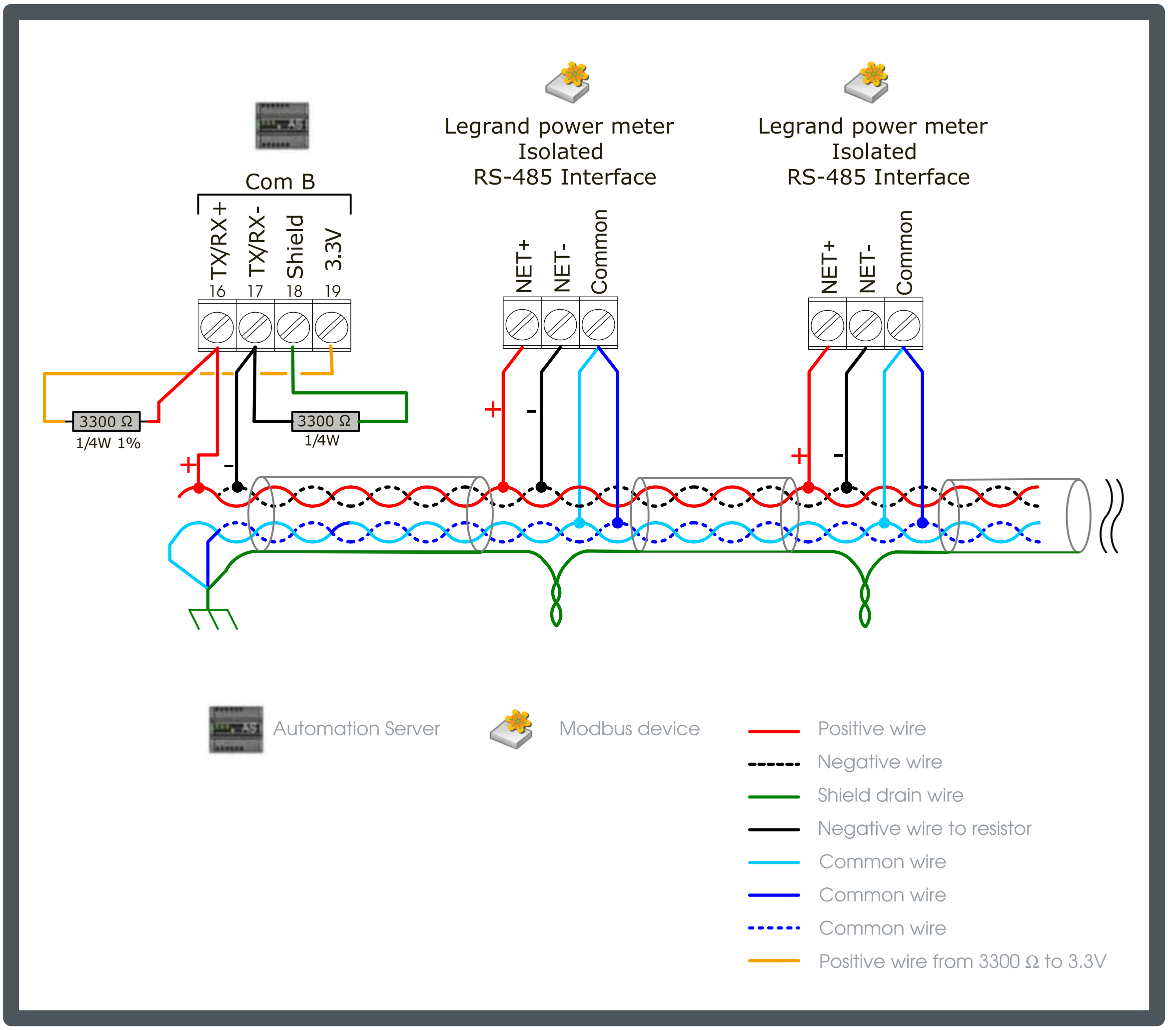


Figure: Legrand configuration 2 – unterminated bus with minimal bias (for models 04677, 04680, 04684, or 14669)

In Configuration 2, the Automation Server is connected with 3.3 kohm failsafe bias resistors. These resistors pull the + and – data lines apart during an idle bus period. Without the termination resistors, this configuration will easily achieve the minimum +225 mV level for the full length of the bus. The 3.3 kohm bias serves to override the faulty bias influence from a Legrand meter when one or more of the meters lose power while they are still connected to the bus. The TIA-485A specification on transceivers requires that they do not place any additional load on the bus when they lose power. The addition of bias resistors within individual RS-485 network products compromises that insulation from power loss affects. Lower bias resistance values generate higher levels of bias current and produce more ill effect from a power down situation.

Each of the models 04677, 04680, and 04684 presents an RS-485 network load of 1.32UL, and the model 14669 has a network load of 1.75UL. The Automation Server has a network load of 0.5UL. To determine the number of nodes (meters) the bus will support, we first determine the remaining available unit load capacity after subtracting the base load of the Automation Server, and the load produced by the bias resistors.

For networks connecting only with Legrand meters, the initial unit load budget is 48UL. For networks with one or more other Modbus devices that are not isolated, the initial unit load budget is 32UL. The Automation Server has a unit load of 0.5UL. The 3.3 kohm bias gives a unit load of 3.63UL (12,000 / 3,300). Subtracting these two loads from the initial budget gives a remaining capacity of 43.8UL (all isolated) or 27.8UL (mixed).

For isolated network, the calculated maximum node count is:

- For models 04677, 04680, and 04684: 43.8 / 1.325 = 33 nodes (meters)
- For model 14669: 43.8 / 1.75 = 25 nodes (meters)

For mixed network, the calculated maximum node count is:

- For models 04677, 04680, and 04684: 27.8 / 1.325 = 20.9 nodes (meters)
- For model 14669: 27.8 / 1.75 = 15.7 nodes (meters)

You can accommodate the load from a mixed combination of model 14669 meters and the others by simply summing their individual Total Unit Load values. For more information, see section 10.35 “General Legrand Power Meter Properties” on page 254. The maximum recommended limit is reached when that sum reaches 43.8 (for all isolated) or 27.87UL (for mixed network).

10.41 Legrand Configuration 3: Terminated Bus with Single End-point Bias

A third configuration option is available where low resistance bias is added to the Automation Server to allow termination to be applied on a network containing one or more model 14669 meters. The configuration applies to any combination of Legrand models 04677, 04680, 04684, or 14669. With a 3.3 V bias voltage supply, the configuration can support 180 ohm termination resistors on the two ends (instead of the typical 120 ohm resistors) and achieve the minimum bias voltage required by the transceiver in the model 14669.

Low resistance bias configurations (with 3.3 V or 5 V) have significant added common mode load on the network. The common mode load is a function of the bias resistor values and not the voltage. Maintaining the minimum +225 mV idle voltage on a terminated bus being biased from one end limits the network to shorter distances (for a specific wire gauge). This limitation is caused by the voltage divider network setup by the wire resistance and the termination resistance at the far end. Larger wire can be used to reach longer distances. See table below. Another option to achieve long distances is to bias the network from two ends, according to Configuration 4. For more information, see section 10.42 “Legrand Configuration 4: Terminated Bus with Dual End-point Bias” on page 271.

Connect 510 ohm resistor from + line to 3.3 V. Connect 510 ohm resistor from - line to Ground (Shield).

Connect 180 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 180 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the two RS-485 common wire pair and the shield to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for these conductors. The shield drain wire from the cable segments are twisted together and passed by each node.

Both conductors of the second twisted pair cable are used to connect RS-485 Common on the meters.

Use only twisted pair bus cable specified for use with RS-485 (for example, Belden 9842 or equivalent). For more information, see section 10.44 “Cable Selection (Legrand Power Meters)” on page 276.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

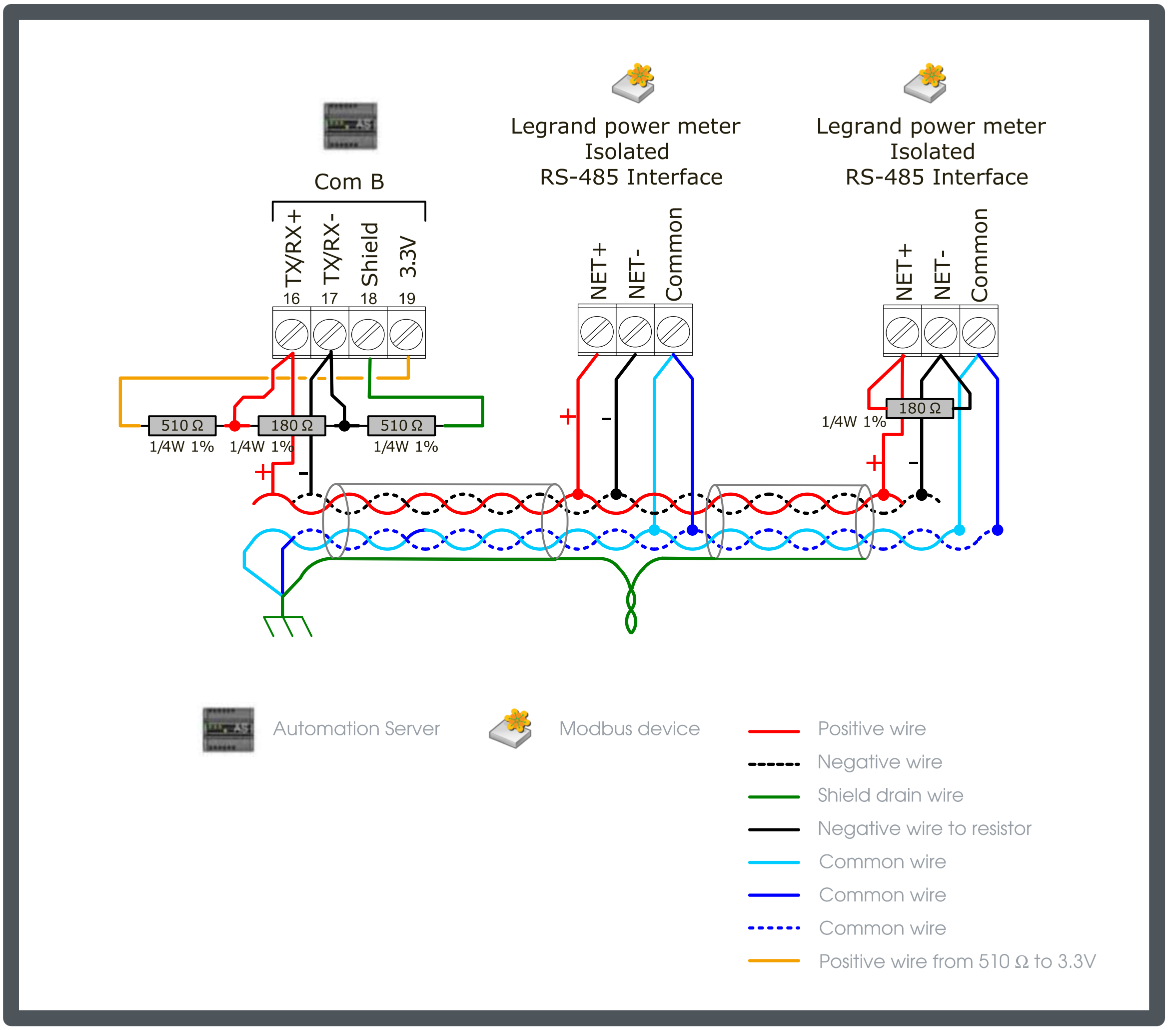


Figure: Legrand configuration 3 – terminated bus with single end-point bias (for models 04677, 04680, 04684, or 14669)

The recommended maximum cable length and associated wire sizes are listed in the following table. These wire size and lengths are selected to achieve compliant idle state voltage at the far end of the network.

Table: Recommended Maximum Cable Lengths and Associated Wire Sizes

Maximum Length	**Wire Size**
150 m (500 ft)	24 AWG (0.20 mm²)
240 m (800 ft)	22 AWG (0.33 mm²)

Each of the models 04677, 04680, and 04684 presents an RS-485 network load of 1.32UL, and the model 14669 has a network load of 1.75UL. The Automation Server has a network load of 0.5UL. To determine the number of nodes (meters) the bus will support, we first determine the remaining available unit load capacity after subtracting the base load of the Automation Server, and the load produced by the bias resistors.

For networks connecting only with Legrand meters, the initial unit load budget is 48UL. For networks with one or more other Modbus devices that are not isolated, the initial unit load budget is 32UL. The Automation Server has a unit load of 0.5UL. The 510 ohm bias gives a unit load of 23.5UL (12,000 / 510). Subtracting these two loads from the initial budget gives a remaining capacity of 24UL (all isolated) or 8UL (mixed).

For isolated network, the calculated maximum node count is:

- For models 04677, 04680, and 04684: 24 / 1.325 = 18.1 nodes (meters)
- For model 14669: 24 / 1.75 = 13.7 nodes (meters)

For mixed network, the calculated maximum node count is:

- For models 04677, 04680, and 04684: 8 / 1.325 = 6 nodes (meters)
- For model 14669: 8 / 1.75 = 4.5 nodes (meters)

You can accommodate the load from a mixed combination of model 14669 meters and the others by simply summing their individual Total Unit Load values. For more information, see section 10.35 “General Legrand Power Meter Properties” on page 254. The maximum recommended limit is reached when that sum reaches 24UL (for all isolated) or 8UL (for mixed network).

10.42 Legrand Configuration 4: Terminated Bus with Dual End-point Bias

A fourth configuration option is targeted at recovering the full 1200 m (4000 ft) capability of the RS-485 network while accommodating the standard 120 ohm End Of Line (EOL) terminations for better high speed data quality. This technique applies two small 5 V supplied to bias the network from each end. Biasing the network from both ends completely eliminates the dropping failsafe bias voltage as the cable length extends toward the remote terminator. This configuration option can be used for any combination of Legrand models 04677, 04680, 04684, or 14669.

With dual end-point bias, a strong and constant bias level is present over the complete length of the bus. The dual end-point bias uses a pair of 1000 ohm resistors at each end. This combined parallel resistance of 500 ohm still encounters the significant unit load reduction as with Configuration 3, but now supports the RS-485 maximum 1200 m (4000 ft) network length. For more information, see section 10.41 “Legrand Configuration 3: Terminated Bus with Single End-point Bias” on page 268.

Connect 5 V DC power supply to the RS-485 bus pair through two 1000 ohm resistors at the head end of the cable. Connect 5 V DC power supply to the RS-485 bus pair through two 1000 ohm resistors at the tail end of the cable.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the two RS-485 common wire pair and the shield to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for these conductors. The shield drain wire from the cable segments are twisted together and passed by each node.

Both conductors of the second twisted pair cable are used to connect RS-485 Common on the meters.

Use only twisted pair bus cable specified for use with RS-485 (for example, Belden 9842 or equivalent). For more information, see section 10.44 “Cable Selection (Legrand Power Meters)” on page 276.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

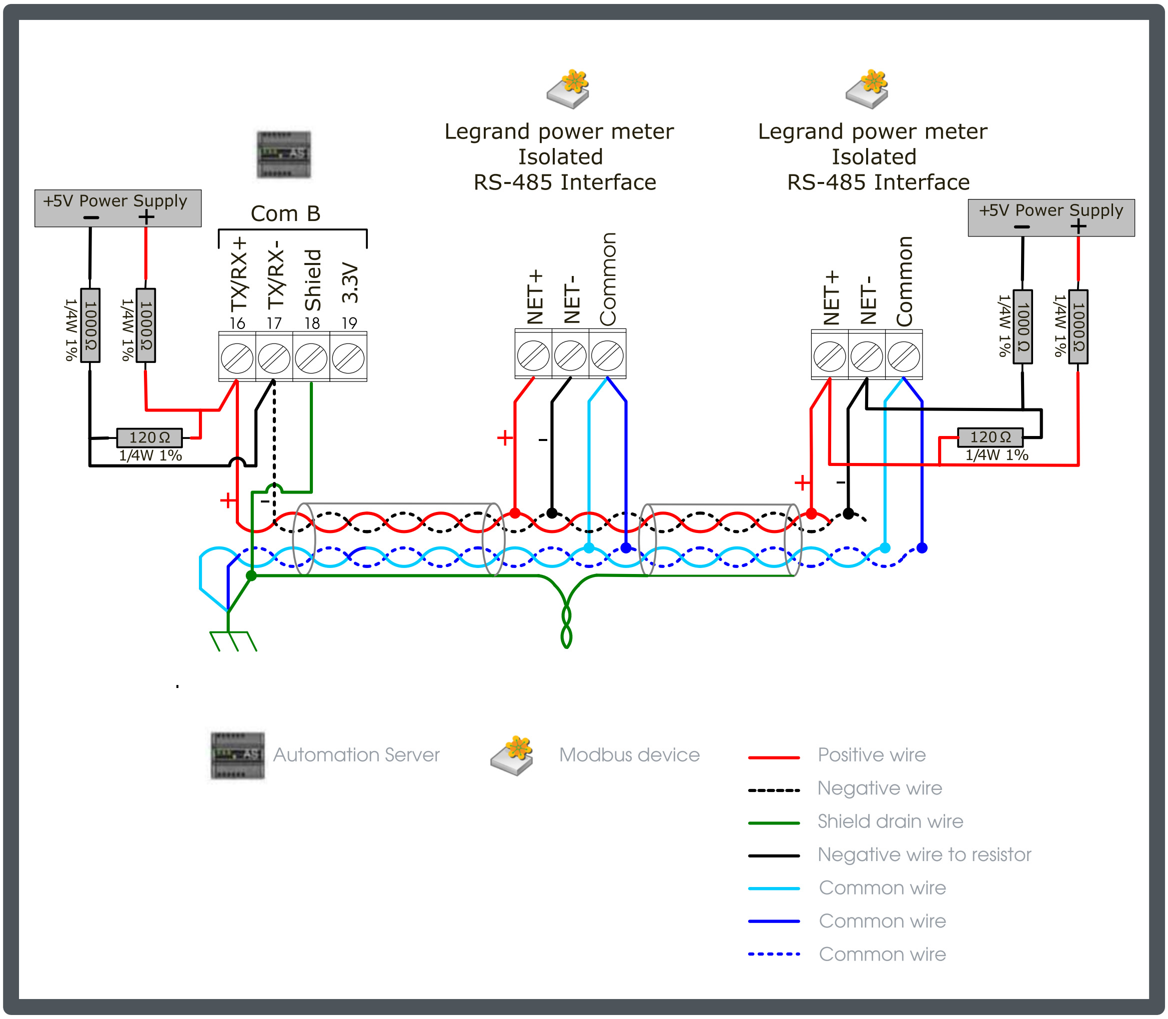


Figure: Legrand configuration 4 – terminated bus with dual end-point bias (for models 04677, 04680, 04684, or 14669)

Each of the models 04677, 04680, and 04684 presents an RS-485 network load of 1.32UL, and the model 14669 has a network load of 1.75UL. The Automation Server has a network load of 0.5UL. To determine the number of nodes (meters) the bus will support, we first determine the remaining available unit load capacity after subtracting the base load of the Automation Server, and the load produced by the bias resistors.

For networks connecting only with Legrand meters, the initial unit load budget is 48UL. For networks with one or more other Modbus devices that are not isolated, the initial unit load budget is 32UL. The Automation Server has a unit load of 0.5UL. The dual 1000 ohm bias gives a unit load of 24UL (12,000 / 500). Subtracting these two loads from the initial budget gives a remaining capacity of 23.5UL (all isolated) or 7.5UL (mixed).

For isolated network, the calculated maximum node count is:

- For models 04677, 04680, and 04684: 23.5 / 1.325 = 17.7 nodes (meters)
- For model 14669: 23.5 / 1.75 = 13.4 nodes (meters)

For mixed network, the calculated maximum node count is:

- For models 04677, 04680, and 04684: 7.5 / 1.325 = 5.6 nodes (meters)

- For model 14669: 7.5 / 1.75 = 4.2 nodes (meters)

You can accommodate the load from a mixed combination of model 14669 meters and the others by simply summing their individual Total Unit Load values. For more information, see section 10.35 “General Legrand Power Meter Properties” on page 254. The maximum recommended limit is reached when that sum reaches 23.5UL (for all isolated) or 7.5UL (for mixed network).

10.43 Power Supply Selection for Legrand Configuration 4

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

Table: Recommended Supply Specifications

Characteristics	**Recommendations**
Type	5 V DC output isolated from local ground or equipment connections
Output Voltage	5.00 V DC +/- 5% (or better)
Maximum Output Current	0.1 A to 1.5 A (0.5 W to 7.5 W) Any model in this popular range
Minimum Output Current	Operates/regulates down to 0 current (no load required)
Maximum Output Ripple/Noise	150 mV_{pp} (or less)
Safety/EMC Agency Approvals	Applicable approvals for country of application

Frequently, the most convenient power source for the 5 V DC bias supply will be the 24 V AC typically powering the various RS-485 device products. A couple options for the 24 V AC to Isolated 5 V DC power supply would include the models PS-200-3-A-3-L and PS-200-3-A-3-N from Mamac Systems and the model DCP-524 from Kele. Another isolated 5 V supply option with a smaller package/footprint and lower cost would be the combination of the Altronix model VR1TM5 regulator and the small (20 VA) Veris Industries X020ADA 24 V AC to 24 V AC isolation transformer. The figure below shows the Veris/Altronix configuration.

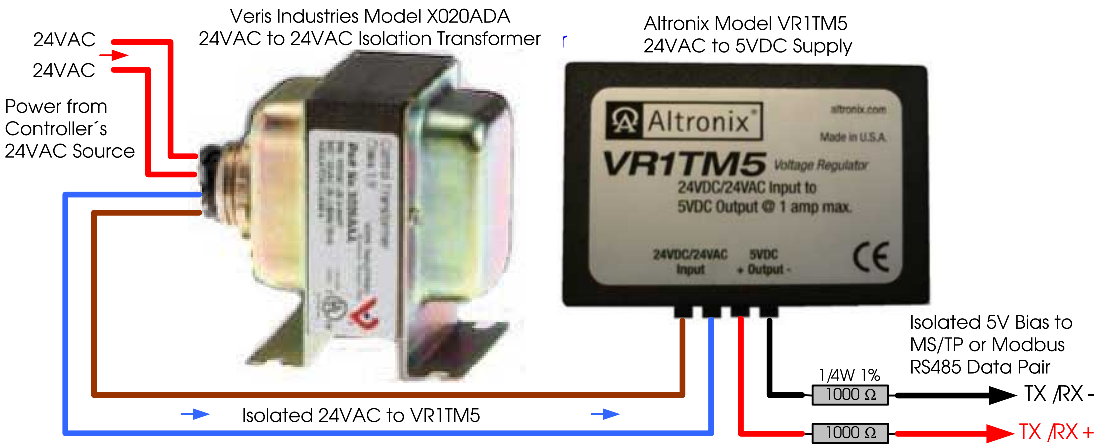


Figure: Isolated 5 V DC power supply using Veris X020ADA and Altronix VR1TM5

Other manufacturers/models of 24VAC/24VAC isolation transformers can be substituted to accommodate preferred package, size, local availability, and approvals.

If the use of 115/230 V AC line voltage for the + 5 V DC supply is preferred, the Veris X020ADA transformer can be replaced with a common 115 V/24 V or 230 V/24 V transformer. This can be a separate transformer of the same type used to power the 24 V AC devices. However, the transformer size used for this application can be as small as you have available. In this application, the VR1TM5 presents a load of less than 1 VA. The transformer output used to power the VR1TM5 should not be connected to any other device.

10.44 Cable Selection (Legrand Power Meters)

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

With RS-485, two conductors are used to pass the differential data (A+ and B- signals) from one node to the next. To maintain the balanced characteristics between the two wires, the cable must provide twisted pairs and be specified for data communications. As the twisted pair passes along side other cables and equipment in the facility, there are a multitude of noise sources, radiated EMI and electromagnetic fields that will impose noise on to the twisted pair cable.

The shield does not provide any form of total protection. The shield inhibits a significant portion of high frequency radiated noise, but other fields may simply pass through. As long as the twisted pair of wires remains balanced, the noise will be imposed on the two wires equally. An imbalance of impedance to ground of the differential pair determines in part the susceptibility of the network to interference, regardless of it being inductive or capacitive coupled. When balanced, a noise appearing equally on both wires is called common mode noise. The RS-485 receiver only looks at the differential voltage seen between the two conductors and ignores the common mode noise. This is true up to the common mode voltage limits of the transceiver, which should be a minimum range of -7 V to +12 V. A reduction in this range, such as from fully exhausting transmitter CMV support with excess unit load, can make the bus susceptible to induced common mode noise.

The balanced performance of the cable requires more than just the twisted pair characteristics, although it is definitely the most important. The twisted pair cable can become unbalanced when encountering discontinuities in the capacitance between the two wires, or the capacitance from conductor to shield, or the impedance of the wires. This makes it important to select quality cable specified for RS-485 data communications. The cable supplier must provide cable specification that includes all of the characteristics seen in the table below. The recommended specification for these characteristics is also listed. These will provide the best results. You should avoid a cable where the manufacturer/supplier cannot provide the full cable specifications.

Important

Multi-conductor cable with a twist of the conductors under the jacket in not twisted pair cable. Such a casual twist of the wire bundle is a characteristic on most cables. Such cable has no balanced pair characteristics.

Table: Recommended Cable Characteristics

Characteristics	**Recommendations**
Type	Shielded Twisted Pair Low Capacitance
Twisted Wire Size	22 AWG to 24 AWG (0.33 mm² to 0.20 mm²)
Impedance	120 ohm
Capacitance (wire to shield)	<82 pF/m (<25 pF/ft)
Capacitance (wire to wire)	<46 pF/m (<14 pF/ft)

Continued

Characteristics	Recommendations
Maximum Length	1200 m (4000 ft) depending on termination and bias restrictions

Manufacturer	Model	Size	Pairs	Imp.	Cap1[a]	Cap2[b]	Vel	Plenum
Belden	3107A	22 AWG Str (0.33 mm²)	2	120 ohm	36.1 pF/m (11 pF/ft)	68.6 pF/m (20.9 pF/ft)	78%	
Belden	9842	24 AWG Str (0.20 mm²)	2	120 ohm	42.0 pF/m (12.8 pF/ft)	75.5 pF/m (23 pF/ft)	66%	
Belden	82842	24 AWG Str (0.20 mm²)	2	120 ohm	39.4 pF/m (12 pF/ft)	72.2 pF/m (22 pF/ft)	76%	Y
Belden	89842	24 AWG Str (0.20 mm²)	2	120 ohm	39.4 pF/m (12 pF/ft)	72.2 pF/m (22 pF/ft)	76%	Y
Alpha Wire	6455	22 AWG Str (0.33 mm²)	2	120 ohm	36.1 pF/m (11 pF/ft)	68.6 pF/m (20.9 pF/ft)	78%	
Alpha Wire	6413	24 AWG Str (0.20 mm²)	2	120 ohm	42.0 pF/m (12.8 pF/ft)	75.5 pF/m (23 pF/ft)		
General Cable	C0842A	24 AWG Str (0.20 mm²)	2	120 ohm	37.4 pF/m (11.4 pF/ft)	67.3 pF/m (20.5 pF/ft)	66%	

a) Cap1 = Capacitance between the two conductors of the pair(s)
b) Cap2 = Capacitance from each signal conductor to shield

All cables recommended for Legrand are two pair cables. This allocates one twisted pair for data and one twisted pair for use in providing a large gauge shielded RS-485 return conductor from the isolated commons on all of the Legrand meters. This scheme is consistent with the recommendations detailed in the Legrand communications guide. The Legrand guide recommends the use of Belden 9842 cable (or equivalent twisted pair cable).

10.45 Viconics VT/VZ/SE 7xxx Series Devices

This application note provides recommendations for the configuration of RS-485 communications between the Automation Server and Viconics room controllers. The recommendations are associated with the Viconics VT/VZ/SE 7xxx series thermostats / room controllers configured with the Viconics plug-on MS/TP network adapter. This information is intended to supplement the instructions you receive with the various RS-485 network devices. The guidelines here focus on the arrangement of the electrical interface to the Automation Server RS-485 port in regards to biasing, termination, cable selection, cable lengths, and cable routing. The guidelines presented here on the topic of maximum unit load (node count) and common mode voltage tolerance are associated with the Automation Servers with serial number of TD133954000 and later.

The general wiring of the BACnet MS/TP adapter is described in the following Viconics documents:

- BACnet Integration Manual ITG-VT(R) 72_73-BAC-E11 (028-6009 R11, 2012-02-07)
- BACnet Integration Manual ITG-VT76xx-PIR-BAC-E02 (028-6015 R2, 2011-01-23)
- BACnet Integration Manual ITG-VZ7xxx-BAC-E04 (028-6011 R4, 2012-05-31)
- BACnet Zoning System Application Guide VBZS_Rel2_Application_Guide-E04 (2012-01-10)

10.45.1 General Viconics VT/VZ7xxx Device Properties

The RS-485 transceiver encountered on the Viconics MS/TP adapters reviewed was the STM ST485C. This transceiver alone has a RS-485 unit load rating of 0.5. With consideration only for the transceiver unit load, the 0.5 unit load rating would indicate up to 64 units transceivers could be attached to a single RS-485 network wire segment. This is the unit load and node limit described in Viconics' documents. The network adapter includes an on-board weak bias resistor of 100 kohm on the A+ and B- bus signals. This added 100 kohm resistance presents an additional unit load of 0.12UL making each of the controllers have an aggregate unit load of 0.62. This is the value that should be used in totaling the network load.

For more information, see section 10.46 “General Viconics VT/VZ7xxx Device Properties” on page 281.

10.45.2 Automation Server to VT/VZ7xxx Configurations

The recommendations include two different configuration options to choose from with differences in performance and/or resources required.

For more information, see section 10.47 “Automation Server to VT/VZ7xxx Configurations” on page 284.

10.45.3 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

For more information, see section 10.51 “Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (Viconics VT/VZ7xxx Devices)” on page 292.

10.45.4 Expanded Unit Load with Network of Isolated Devices Only

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. It is recommended that a maximum load extension should be 16UL (that is, 50% overload) giving a total expanded unit load limit of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network and Automation Server leaves 24UL available for the sensors/controllers. With the example device load of 0.62UL each, it is suggested that the isolated bus arrangement could support the full collection of up to 38 sensors.

For more information, see section 10.52 “Expanded Unit Load with Network of Isolated Devices Only (Viconics VT/VZ7xxx Devices)” on page 294.

10.45.5 Cable Routing

The RS-485 network cable should be routed in a continuous daisy chain bus configuration. There should not be any stub connections, stars or ring configurations. The bussed cable should pass through each node to be connected with no splits or branches in the cable network.

For more information, see section 10.16 “Cable Routing” on page 212.

10.45.6 Cable Selection

This is one of the most important selections having significant impact on the performance and reliability of the RS-485 network being installed. An incorrect cable selection can be difficult and expensive to reverse. The decision should not be made on previous examples of seeing some alternate non-compliant cable work.

For more information, see section 10.17 “Cable Selection” on page 213.

10.46 General Viconics VT/VZ7xxx Device Properties

The RS-485 transceiver encountered on the Viconics MS/TP adapters reviewed was the STM ST485C. This transceiver alone has a RS-485 unit load rating of 0.5. With consideration only for the transceiver unit load, the 0.5 unit load rating would indicate up to 64 units transceivers could be attached to a single RS-485 network wire segment. This is the unit load and node limit described in Viconics' documents. The network adapter includes an on-board weak bias resistor of 100 kohm on the A+ and B- bus signals. This added 100 kohm resistance presents an additional unit load of 0.12UL making each of the controllers have an aggregate unit load of 0.62. This is the value that should be used in totaling the network load.

Figure: Viconics BACnet MS/TP network adapter board

The transceiver used on the network adapter does not include an integrated failsafe receiver function. This means network biasing resistors are required on the RS-485 bus to insure the idle state of the bus is kept at a minimum of +200 mV (plus a noise buffer such as 25 to 50 mV). The recommended configuration of bias resistors are not discussed in Viconics' documents with the exception of a single line entry in the table referenced as Summary of Specifications for a Viconics' EIA-485 Network.

Table: Excerpt from Summary of Specifications for a Viconics' EIA-485 Network

Parameter	**Details**
Network Bias Resistors	510 ohm per wire (maximum of two sets per segment)

A 510 ohm pull-up resistor on the RS-485 A+ line and a 510 ohm pull-down resistor on the B- line is consistent with the typical recommendations when strong biasing is required. A strong (low resistance) bias is required due to the recommendation for bus termination resistors. The Viconics specification summary mentions a maximum of two sets per segment. The connection of two instances of 510 ohm is not recommended, due to loading issues. The single 510 ohm bias has significant negative affect with 24UL unit load consumption. Two sets would consume 150% of standard unit load capacity without adding the first controller. Dual end biasing with a higher resistance is a recommended option.

The RS-485 circuitry on the network adapter is found to provide an isolated interface. The DC common used by the RS-485 transceiver is isolated from the local ground potential. This isolated DC common created by the isolated DC power supply on the adapter is presented on the terminal labeled REF on the three-position terminal block provided on the edge of the adapter board.

In accordance with the specific instructions in Viconics' documents, the REF terminal is not connected in the field. It is left OPEN and does not connect with the cable or the local environment. This creates the situation where the local isolated common is left to float to the common mode voltage level influenced by the combined median voltage levels of the two differential RS-485 data signals (A+ and B-). Viconics' documents contains the following instructions:

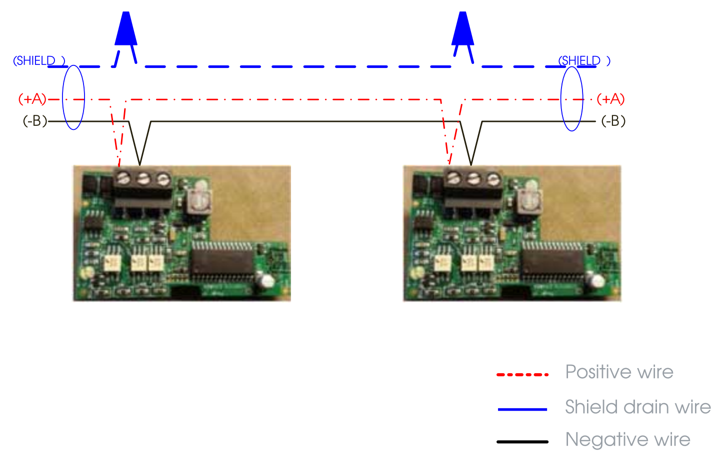


Figure: Viconics balanced pair and shield connections

Important

The REF terminal should never be used to wire shields. The two shields from each feed of the network connection to a thermostat should be wired together in the back of the thermostat and properly protected to prevent any accidental connection to the ground.

Review of the RS-485 interface provided on the network adapter yields the following interface attributes:

Table: Interface Attributes of the Network Adapter

Transceiver	Transceiver Unit Load	Transceiver Failsafe	Adapter Circuit Bias	Circuit Bias Load	Total Unit Load	Isolated RS-485 Bus
STM ST485C	0.500	No	100 kohm	0.120	0.620	Yes

Transceiver	Transceiver Unit Load	Transceiver Failsafe	Adapter Circuit Bias	Circuit Bias Load	Total Unit Load	Isolated RS-485 Bus

Viconics recommends a data rate of 38.4 kbps for most systems and notes that the 76.8 kbps data rate is available for large networks (80+ devices). These rates call for the recommended use of End Of Line (EOL) resistor termination.

10.47 Automation Server to VT/VZ7xxx Configurations

The recommendations include two different configuration options to choose from with differences in performance and/or resources required.

10.47.1 VT/VZ7xxx Configuration 1: Single End-point Bias (Automation Server Provided Source)

This configuration is the simplest to arrange and supports bus lengths out to 150 m (500 ft) on 24 AWG (0.20 mm²). The Automation Server should be configured with two 510 ohm bias resistors. One connecting the + data line to 3.3 V and the other connecting the – data line to the common (Shield) terminal. The bias is required to support the transceivers in the VT/VZ nodes and the termination of the bus. With a 3.3 V bias voltage supply provided by the Automation Server, the configuration can support 180 ohm termination resistors on the two ends (instead of the typical 120 ohm). This will achieve the minimum idle line bias voltage of +200 mV required by the transceivers. Low resistance bias configurations (with 3.3 V or 5 V supplies) add significant common mode load on the RS-485 network. The common mode load (Unit Load) of the bias network must be summed with the accumulated unit load of the collection of VT/VZ thermostats/controllers to identify the total unit load on the bus.

For more information, see section 10.48 “VT/VZ7xxx Configuration 1: Single End-point Bias (Automation Server Provided Source)” on page 286.

10.47.2 VT/VZ7xxx Configuration 2: Dual End-point Bias (External Supply Source)

Dual end-point bias applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. Instead of a single pair of 510 ohm resistors, the dual end scheme uses a pair of 1020 ohm resistors at each end. The dual end-point is the best technique for avoiding the drop in the bias voltage over extended cable lengths as you move away from the bias connection location. By applying bias at the two termination points, the arrangement maintains an equal bias across the complete length of the cable.

For more information, see section 10.49 “VT/VZ7xxx Configuration 2: Dual End-point Bias (External Supply Source)” on page 288.

10.47.3 Power Supply Selection for VT/VZ7xxx Configuration 2

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

For more information, see section 10.50 “Power Supply Selection for VT/VZ7xxx Configuration 2” on page 290.

10.48 VT/VZ7xxx Configuration 1: Single End-point Bias (Automation Server Provided Source)

This configuration is the simplest to arrange and supports bus lengths out to 150 m (500 ft) on 24 AWG (0.20 mm^2). The Automation Server should be configured with two 510 ohm bias resistors. One connecting the + data line to 3.3 V and the other connecting the – data line to the common (Shield) terminal. The bias is required to support the transceivers in the VT/VZ nodes and the termination of the bus. With a 3.3 V bias voltage supply provided by the Automation Server, the configuration can support 180 ohm termination resistors on the two ends (instead of the typical 120 ohm). This will achieve the minimum idle line bias voltage of +200 mV required by the transceivers. Low resistance bias configurations (with 3.3 V or 5 V supplies) add significant common mode load on the RS-485 network. The common mode load (Unit Load) of the bias network must be summed with the accumulated unit load of the collection of VT/VZ thermostats/controllers to identify the total unit load on the bus.

The requirement for bias resistors to maintain an idle state voltage greater than 200 mV also presents a limitation on the wire length due to idle state voltage drop produced by the wire resistance. The restricted length is due to the voltage divider network setup by the wire resistance and the termination resistance at the far end. See table below for recommended wire sizes and maximum distance. Configuration 2 offers a superior alternative option if long cable lengths are needed. For more information, see section 10.49 “VT/VZ7xxx Configuration 2: Dual End-point Bias (External Supply Source)” on page 288.

Connect 510 ohm resistor from + line to 3.3 V. Connect 510 ohm resistor from - line to Ground (Shield).

Connect 180 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 180 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground terminal rail in the panel with the Automation Server. This is the only ground connection of the shield for the complete cable segment. The shield drain wire from the cable segments are twisted together and passed by each node.

Use only twisted pair bus cable specified for use with RS-485 (for example, Belden 9841 or equivalent). For more information, see section 10.17 “Cable Selection” on page 213.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A. When failsafe bias resistors are required on the Com A network, the 3.3 V pull-up voltage is obtained from the Com B terminal group (terminal 19).

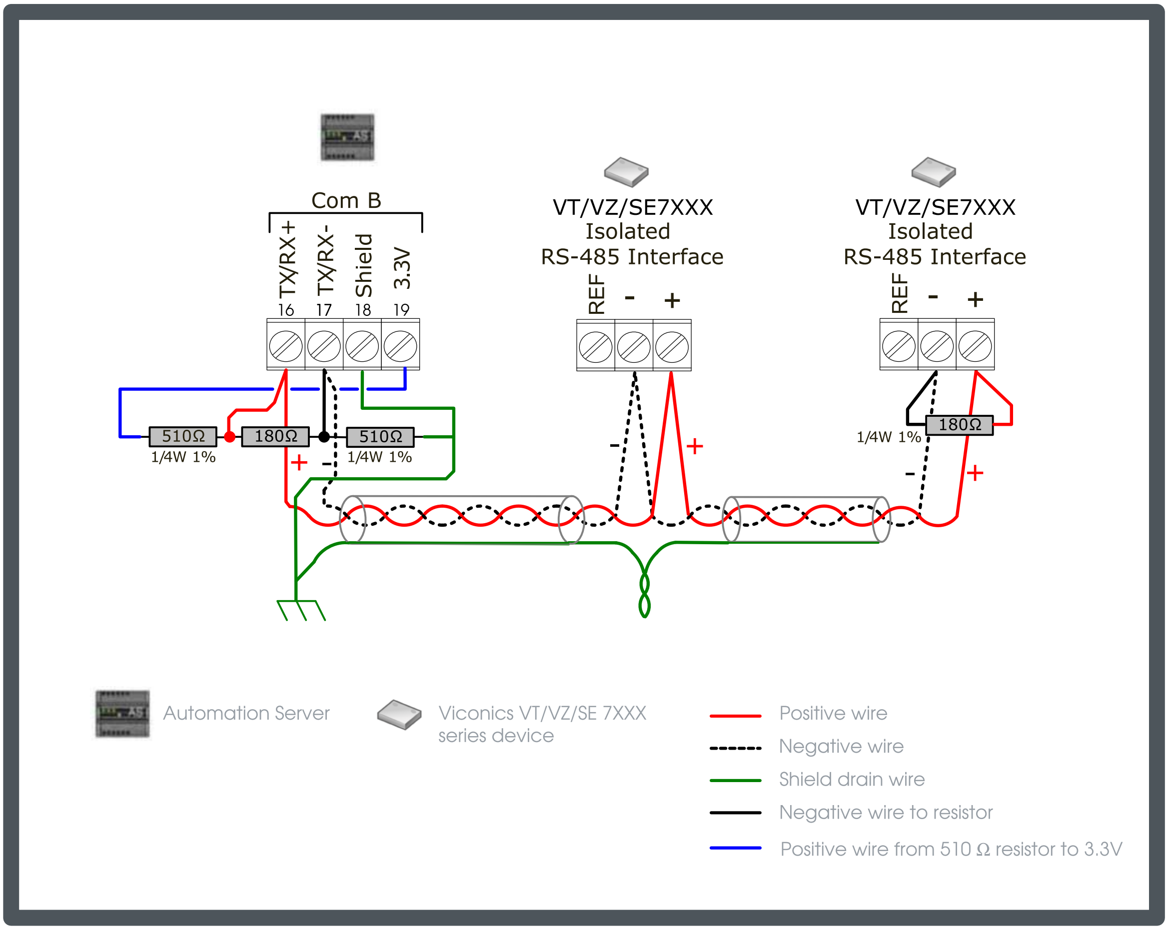


Figure: VT/VZ7xxx configuration 1 – single end-point bias (Automation Server provided source)

The recommended maximum cable length and associated wire sizes are listed in the following table. These wire size and lengths are selected to maintain the minimum idle state voltage at the far terminated end of the network (away from the Automation Server where the bias is provided).

Table: Recommended Maximum Cable Lengths and Associated Wire Sizes

Maximum Length	**Wire Size**
150 m (500 ft)	24 AWG (0.20 mm²)
240 m (800 ft)	22 AWG (0.33 mm²)

The maximum sensor/node count is 38 (using only the VT/VT7xxx devices). The node count reduces if mixed network with non-isolated devices (such as b3 BACnet devices). Node count discussions and other limiting factors are described separately. For more information, see section 10.52 “Expanded Unit Load with Network of Isolated Devices Only (Viconics VT/VZ7xxx Devices)” on page 294.

10.49 VT/VZ7xxx Configuration 2: Dual End-point Bias (External Supply Source)

Dual end-point bias applies a separate 5 V DC supply at each end of the network to generate the RS-485 bias. Instead of a single pair of 510 ohm resistors, the dual end scheme uses a pair of 1020 ohm resistors at each end. The dual end-point is the best technique for avoiding the drop in the bias voltage over extended cable lengths as you move away from the bias connection location. By applying bias at the two termination points, the arrangement maintains an equal bias across the complete length of the cable.

Connect 5 V DC power supply to the MS/TP bus pair through two 1000 ohm resistors at the head end of the cable. Connect 5 V DC power supply to the MS/TP bus pair through two 1000 ohm resistors at the tail end of the cable.

Connect 120 ohm resistor across the + and - data lines at the head end of the bus (typically at the Automation Server). Connect 120 ohm resistor across the + and - data lines on the last node at the far end of the bus.

Connect the shield drain wire to earth ground only at the head end of the network (typically at the Automation Server). The shield drain wire from the cable segments are twisted together and passed by each node.

Use only twisted pair bus cable specified for use with RS-485 (for example, Belden 9841 or equivalent). For more information, see section 10.17 “Cable Selection” on page 213.

The example diagram below shows the RS-485 Com B connections on the Automation Server. The guidelines apply the same to Com A.

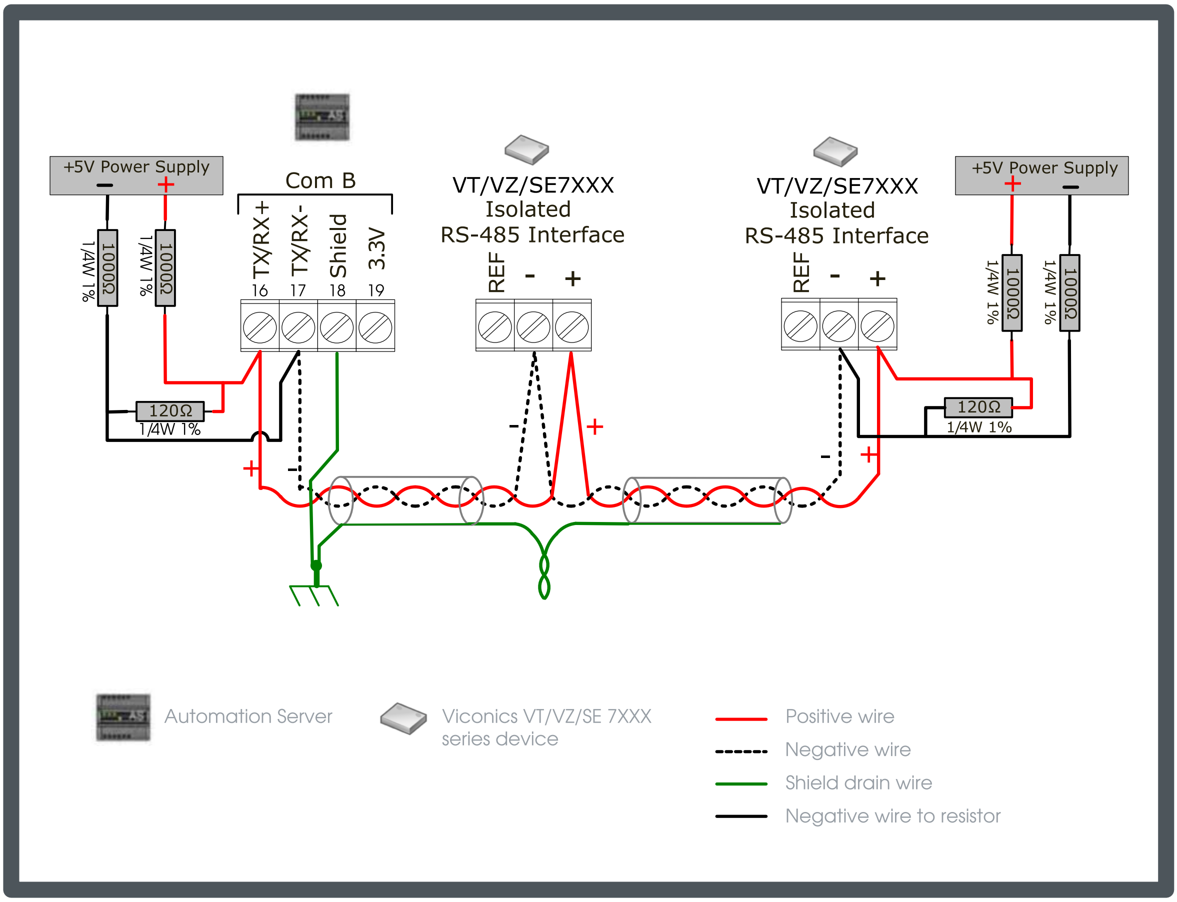


Figure: VT/VZ7xxx configuration 2 – dual end-point bias (external supply source)

The recommended maximum cable length is 1200 m (4000 ft), if using a 24 AWG (0.20 mm²) or larger cable.

The maximum sensor/node count is 38 (using only the VT/VT7xxx devices). The node count reduces if mixed network with non-isolated devices (such as b3 BACnet devices). Node count discussions and other limiting factors are described separately. For more information, see section 10.52 "Expanded Unit Load with Network of Isolated Devices Only (Viconics VT/VZ7xxx Devices)" on page 294.

The recommended location for the bias is at the two extreme ends of the network cable, but the bias voltage remains effective with a 60 m (200 ft) tolerance on the cable length from the end. This configuration supports the preferred termination resistor values of 120 ohm with one positioned at each end of the cable. The unit load imposed by the dual end-point bias is 24UL (12,000 / (1,000 / 2)).

10.50 Power Supply Selection for VT/VZ7xxx Configuration 2

The power required from the 5 V DC supply for the bias circuit is extremely small (approximately 5 mA) so just about any small isolated 5 V DC supply will have more than necessary power rating. A low noise power supply with an output isolated from local ground is recommended to minimize the injection of differential noise onto the bus.

Table: Recommended Supply Specifications

Characteristics	**Recommendations**
Type	5 V DC output isolated from local ground or equipment connections
Output Voltage	5.00 V DC +/- 5% (or better)
Maximum Output Current	0.1 A to 1.5 A (0.5 W to 7.5 W) Any model in this popular range
Minimum Output Current	Operates/regulates down to 0 current (no load required)
Maximum Output Ripple/Noise	150 mV_{pp} (or less)
Safety/EMC Agency Approvals	Applicable approvals for country of application

Frequently, the most convenient power source for the 5 V DC bias supply will be the 24 V AC typically powering the various RS-485 device products. A couple options for the 24 V AC to Isolated 5 V DC power supply would include the models PS-200-3-A-3-L and PS-200-3-A-3-N from Mamac Systems and the model DCP-524 from Kele. Another isolated 5 V supply option with a smaller package/footprint and lower cost would be the combination of the Altronix model VR1TM5 regulator and the small (20 VA) Veris Industries X020ADA 24 V AC to 24 V AC isolation transformer. The figure below shows the Veris/Altronix configuration.

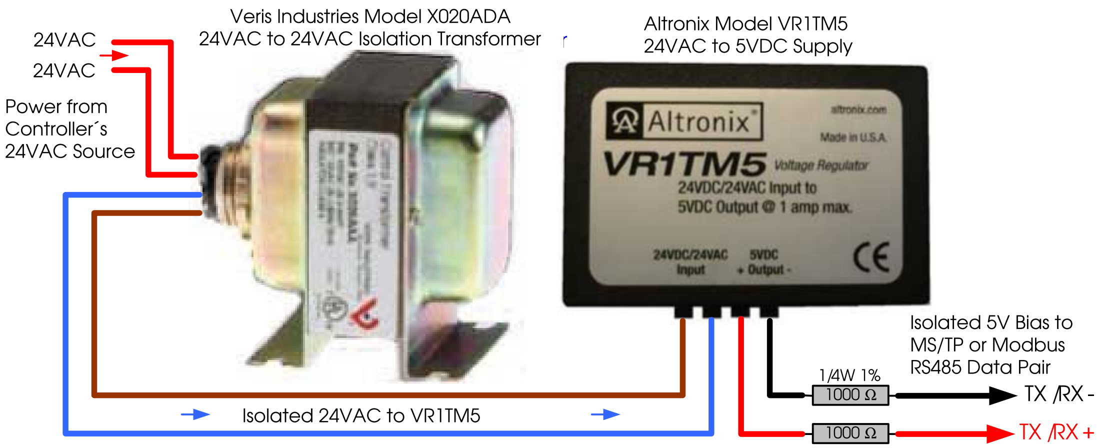


Figure: Isolated 5 V DC power supply using Veris X020ADA and Altronix VR1TM5

Other manufacturers/models of 24VAC/24VAC isolation transformers can be substituted to accommodate preferred package, size, local availability, and approvals.

If the use of 115/230 V AC line voltage for the + 5 V DC supply is preferred, the Veris X020ADA transformer can be replaced with a common 115 V/24 V or 230 V/24 V transformer. This can be a separate transformer of the same type used to power the 24 V AC devices. However, the transformer size used for this application can be as small as you have available. In this application, the VR1TM5 presents a load of less than 1 VA. The transformer output used to power the VR1TM5 should not be connected to any other device.

10.51 Unit Load Definition, Maximum Network Load and Affects of Excess Unit Load (Viconics VT/VZ7xxx Devices)

According to the TIA-485A standard, a single unit load is equivalent to a 12 kohm impedance attached to the + and – data lines (connected to ground or supply). A 1/8UL transceiver would have an impedance of 96 kohm. The TIA-485A defined total network load limit of 32UL is based on a common mode load resistance of 375 ohm connecting both the + and – data lines to ground (or CMV source). The standard requires the RS-485 drivers be capable of driving a network load of 32UL along with a Common-Mode Voltage (CMV) difference of -7 V to +12 V and produce a guaranteed minimum of 1.5 V transmit signal level. Such a full UL load with severe CMV conditions exhausts the maximum drive current of 60 mA provided by all standard RS-485 drivers. The specified minimum of 375 ohm resistance for the common mode load is the resulting resistance seen when 32 transceivers with 12 kohm input impedance are placed in parallel (12,000 / 375 = 32).

The TIA-485A standard does not accommodate any special allowance or exclusion for the addition of bias resistors. If you add load to the data lines (for whatever purpose), it is part of the common mode load and must be considered in the calculation of unit load on the network. Just as 375 ohm equals 32UL, 510 ohm resistance equals 23.5UL.

The accumulation of RS-485 node counts in excess of the standard defined limit of 32UL does not alone create a violation prompting immediate inoperability. The primary performance parameter affected by network load is the ability of the RS-485 transmitter to output the minimum specified signal level of 1.5 V. Reduction in output signal level starts with the addition of the first load connected and reduces further as additional load is added. The 32UL boundary is simply the standardized guaranteed specification limit where the manufacturers guarantee the signal level will not have reduced below 1.5 V. As mentioned above, the 1.5 V signal output is guaranteed not only with a 32UL load, but also with an elevated common mode voltage (CMV of -7 V to +12 V). As the network exceeds the 32UL limit, the tolerance for this CMV will decay. The following graph from the TIA-TSB-89-A standards document shows the expected reduction in CMV as a function of unit load on the bus.

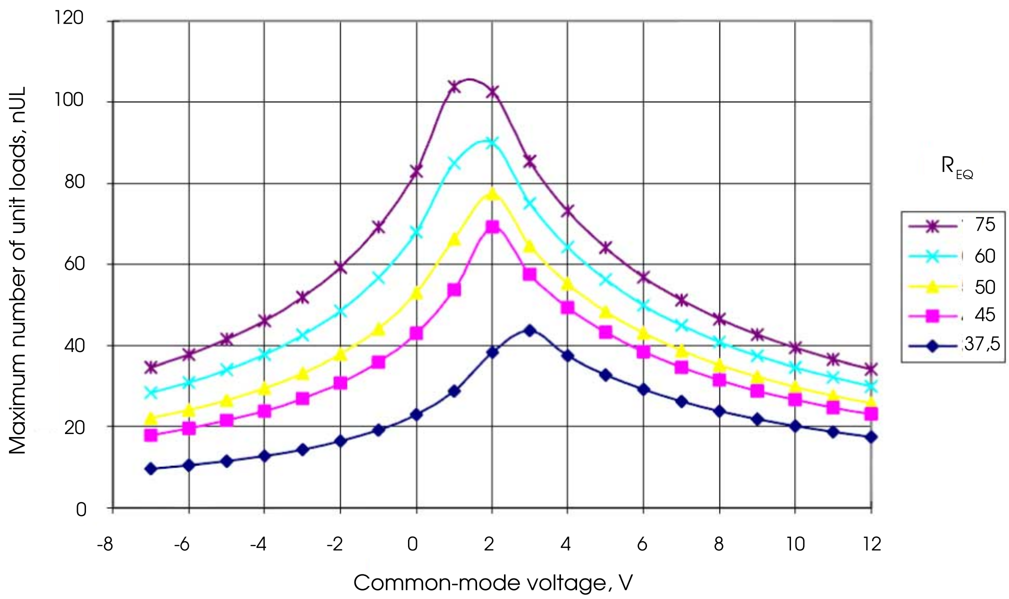


Figure: Maximum number of unit loads versus common-mode voltage and REQ (From TIA TSB-89A 485 Application Guidelines)

The REQ legend in the figure above refers to the resulting parallel load resistance of two termination resistors. The common 120 ohm termination produces 60 ohm and is shown by the REQ=60 cyan colored line. The cyan line indicates a standard UL load limit of 32 with a CMV between -7 V and +12 V. Extra current is required from the transmitter to overcome the common mode voltage seen through the common mode load impedance (unit load). As node count elevates, the tolerance for CMV pulls in as seen in the graph.

For example, if we accumulate the unit load from a collection of 63 RS-485 controller nodes each presenting a 0.62UL load, then we would have a device load of 39.06UL. When we add that to the 24UL of the 510 ohm bias network with the Automation Server, we now have a total network load of 63.06UL. In a configuration with 63 VT7000 devices we would have a load almost twice (197%) the standard recommended load limit of 32UL. From the figure above you can see that the specified minimum -7 V CMV will be expected to reduce to 0 V and the normal +12 V CMV support will reduce to about +3.5 V. All CMV reserve drive capacity has been completely exhausted. When operating in a situation where CMV is avoided, the reduction in transceiver CMV performance can be better tolerated. An isolated RS-485 bus configuration (such as with the VT7xxx sensors) allows the nodes to be insulated from local ground voltage differences which are a main source of sustained CMV on the bus. The isolated bus allows each of the transmitters to move up/down to the idle voltage of the bus.

10.52 Expanded Unit Load with Network of Isolated Devices Only (Viconics VT/VZ7xxx Devices)

If the network is comprised exclusively of devices with isolated RS-485 interfaces with the only exception being the Automation Server, it is recommended that the maximum unit load limit can be stretched higher. It is recommended that a maximum load extension should be 16UL (that is, 50% overload) giving a total expanded unit load limit of 48UL. Using a maximum network load of 48UL and subtracting the 24UL for the bias network and Automation Server leaves 24UL available for the sensors/controllers. With the example device load of 0.62UL each, it is suggested that the isolated bus arrangement could support the full collection of up to 38 sensors.

The extra unit load accommodation is unique to the isolated interface configuration. The configuration is operating with a single non-isolated node (the Automation Server) which acts as the single point reference for the CMV of the network pair as imposed by the bias arrangement. If this configuration of isolated device nodes is intermixed with any other products that are not isolated, the configuration rules on the network node count must fall back to the limits produced with the standard 32UL maximum total unit load.

If the standard specified unit load limit of 32 is applied, the node count calculation is as follows:

- Subtracting 24UL from the starting budget of 32 gives a node budget of 8UL.
- Each of the Viconics sensors presents a RS-485 network load of 0.62UL.
- The calculated VT7xxx node count that consumes the remainder of the budget is: 8UL / 0.62UL = 12.9 nodes

Important

The recommended limits on RS-485 bus node counts discussed here pertain to hardware bias and unit load considerations only. The recommended maximum node count may be further limited based on system version.

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04-15001-03-en
December 2014