BEDROCK
OPEN SECURE AUTOMATION

Bedrock™ User Manual

Contents

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Bedrock Control System Overview

Introduction

This document provides reference information for the Bedrock Control System. This includes descriptions of system hardware and software components, configuration information, communications, and installation.

Who Should Use This Manual?

This publication is designed for use by anyone responsible for planning and implementing the Bedrock Control System such as:

- Application engineers
- Control engineers
- Instrumentation technicians

The contents of this publication are for those who already have an understanding of Distributed Control Systems (DCSs) and/or Programmable Logic Controllers (PLCs), programming techniques, and communication networks.

System Components

The Bedrock Control System includes the following system components. See Appendix B, “Part Numbers” for the Bedrock Automation part numbers.

- one 5, 10, or 20-Slot Backplane Magnetic Interconnect (BMI)
- one or two Secure Power Modules (SPMs). Bedrock Automation offers two types of SPMs, the SPM.U and the SPM.24. Except where noted, “SPM” will refer to both the SPM.U and SPM.24 throughout this manual. See the “SPM (Power) Overview” chapter for details on the SPMs.
- one or two Secure Control and Communication (SCC) modules or one Secure Controller Single (SCS) module. SCC and SCS modules will be referred to as “Controllers” throughout this manual except where references to specific Controller types or features are needed for clarity. Two types of SCS Controllers are offered — the SCS.5 and SCS.10. See the “Controllers (Control)” chapter for details on SCS Controllers.
- one to twenty Secure Input Output (SIO) modules (any combination of analog, discrete, or communication modules).

SPM

A single Secure Power Module (SPM) (or a pair if redundant) is mounted to the BMI. See "SPM (Power) Overview" for information on redundant power in the Bedrock Control System.

An SPM provides inductive power through the BMI to a single Controller or redundant pair of Controllers and all the SIO modules. Either 90-240 V AC (SPM.U only) or a 24 V DC supply voltage is connected to an SPM.

An SPM provides regulated, fused, filtered 24 V DC to the Controller(s). An SPM also provides 20 high frequency, current limited, voltage sources to inductive power coils on the BMI. These coils power up to 20 SIO modules.

A dimensional diagram of an SPM.U is shown in Figure 1-1.

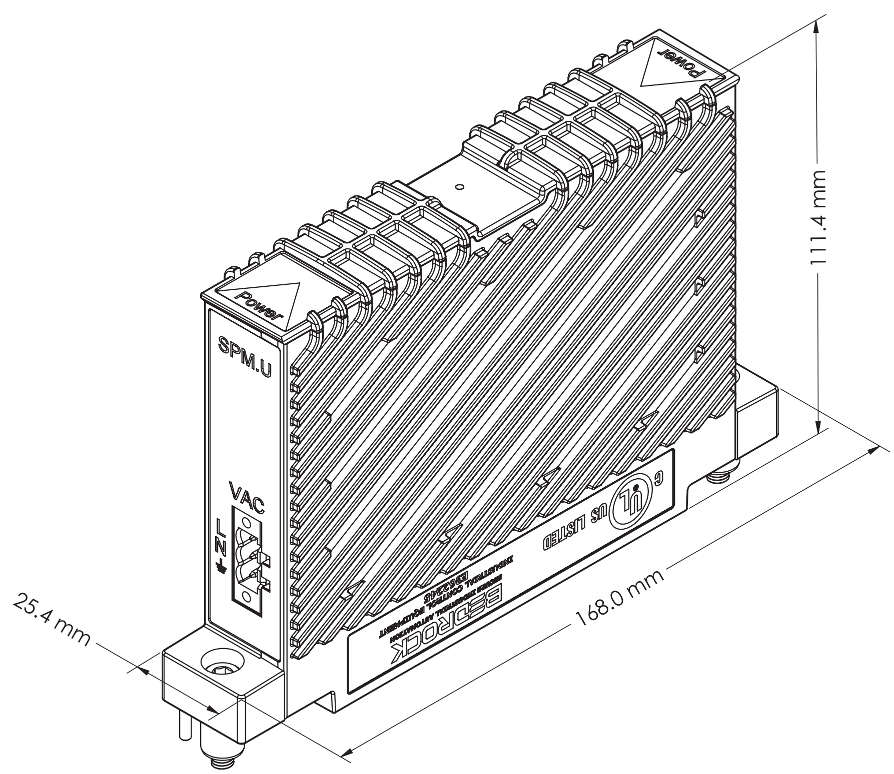


Figure 1-1 SPM.U with Dimensions

A dimensional diagram of an SPM.24 is shown in Figure 1-2.

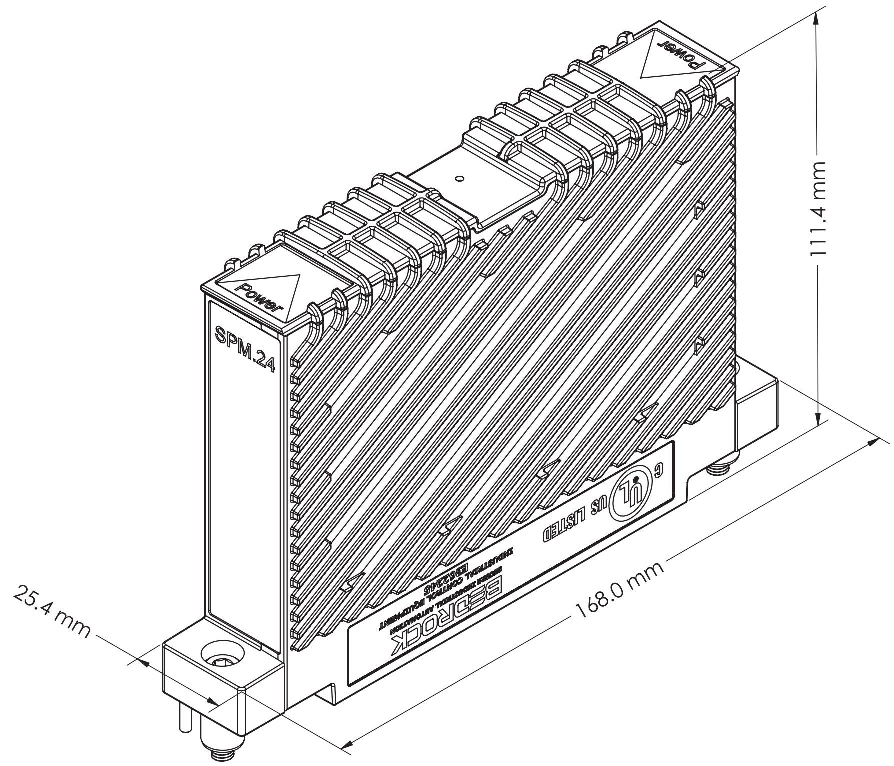


Figure 1-2 SPM.24 with Dimensions

Controllers

Bedrock Controllers provide communication and control to the system. Single or dual (if redundant) Controllers mount on the BMI. Controllers scan input modules, execute control functions and write outputs. Controllers communicate asynchronously over full-duplex buses with each SPM and SIO module in the control system.

A dimensional diagram of an SCC module is shown in Figure 1-3. Note that the figure shows two Gigabit Ethernet ports. Port A can be used to interface to a local intranet while Port B is a spare and reserved for future use. Port B may not be present on all types of Controllers. See the “Controllers (Control)” chapter for more information on Controller features and the types of Controllers available for use in Bedrock Control Systems.

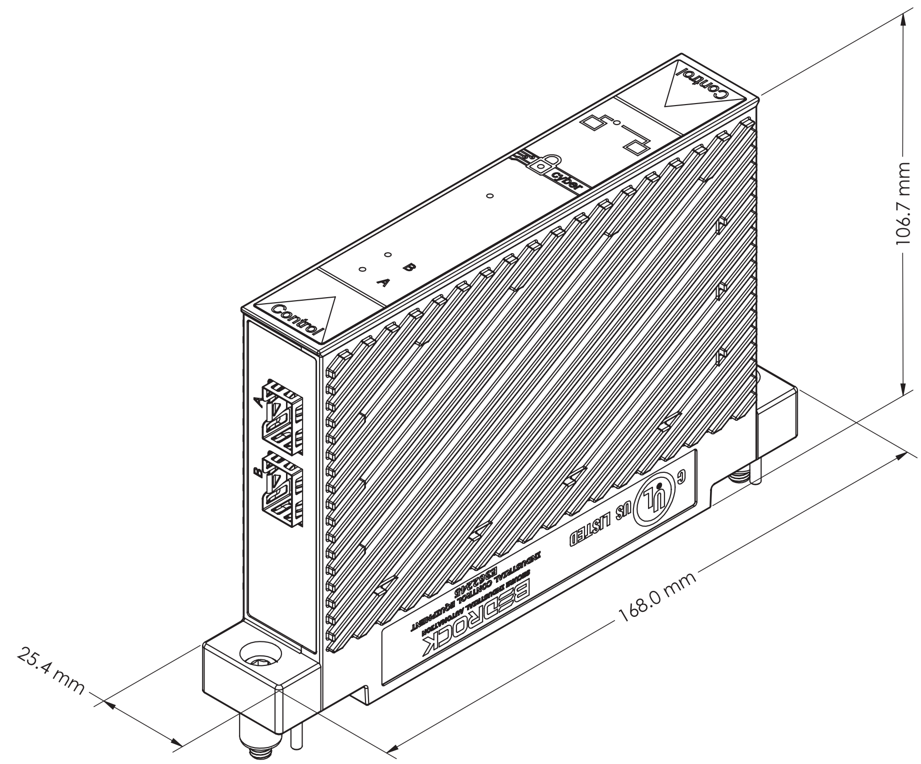


Figure 1-3 SCC with Dimensions

SIO Modules

All Secure Input Output (SIO) modules have a common physical size and communicate with Controllers via dual 10 Mb communication links. Each module indicates module status using tricolor light-emitting diodes (LEDs). Additional LEDs indicate channel status. The SIO modules are supplied redundant power from the SPM.

Analog and discrete SIO modules interface to industrial sensors and actuators through standard 20-pin pluggable connectors.

The SIO4.E communication module interfaces to industrial controllers through the appropriate communications connector using Ethernet-based protocols such as EtherNet/IP™ and Modbus® TCP.

The SIOS.5 communication module can interface to industrial controllers or other devices capable of serial communication using RS-232, RS-485, or RS-422.

A dimensional diagram of an SIO module is shown in Figure 1-4.

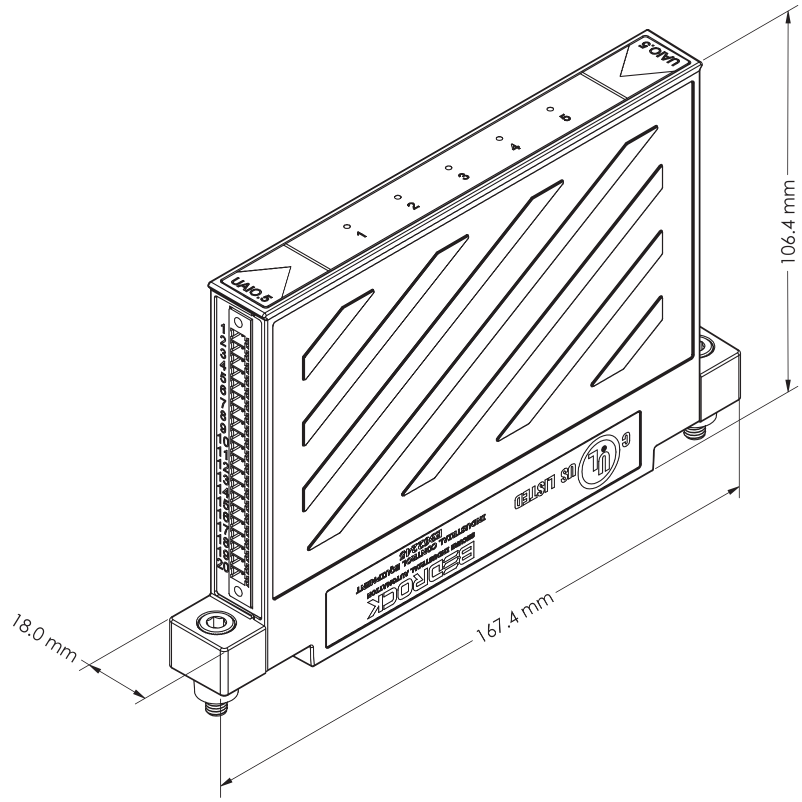


Figure 1-4 SIO Module with Dimensions

Analog SIO Module Offerings

This following are the analog SIO module offerings for the Bedrock Control System.

SIO1.5

The SIO1.5 is a five channel universal analog input/output module. The SIO1.5 power supply provides isolated power for each channel. Each channel has channel-to-channel and channel-to-ground galvanic isolation. Each channel has its own dedicated, secure processor.

The SIO1.5 can interface to the following sensor types:

Analog Inputs

- 2-wire 4-20 mA internally and externally powered loop transmitters
- 4-wire 4-20 mA externally powered loop transmitter

- mV input (±78.125 mV range)
- 3-wire and 4-wire RTDs (platinum, nickel, and copper)
- Thermocouples (J, K, B, E, N, R, S and T) complete with CJC terminal block

Analog Outputs

- 4-20 mA with read back

Open Digital Protocols

- HART Master Device supporting HART Revision 7

SIO6.20

The SIO6.20 has twenty 4-20 mA input channels. This circuit is connected to two 10-channel multiplexer (MUXES). A HART modem is also multiplexed via each of the 10-channel MUXES. The channels are isolated into two groups of ten. Each group is galvanically isolated from each other and ground.

The SIO6.20 can interface to the following sensor types:

Analog Inputs

- 2-wire 4-20 mA externally powered loop transmitters

Open Digital Protocols

- HART Master Device supporting HART Revision 7

SIOU.10

The SIOU.10 is a ten-channel, secure universal I/O module. Each channel is galvanically isolated from each other and from ground. The SIOU.10 features ten independent HART 7 modems. Each SIOU.10 channel can be independently configured to operate in one of the following modes. Channels that are not being used can be configured as a spare.

- 4-20 mA input (loop power set to 25 mA) with HART and discrete input
- 4-20 mA output with readback with HART and discrete input
- internally or externally powered discrete output with readback (excitation maximum current of 25 mA)
- NAMUR input
- 0-10 V voltage input

Discrete SIO Module Offerings

This following are the discrete SIO module offerings for the Bedrock Control System.

SIO2.10

The SIO2.10 has ten discrete AC/DC voltage monitor input channels with soft-selectable thresholds. It also has soft- selectable digital filtering. Each channel is galvanically isolated from each other and ground. Each channel can be configured to monitor AC or DC voltages up to 240 volts. See “SIO Discrete Operation” for more information on the voltage input ranges.

SIO3.10

The SIO3.10 is a ten channel discrete output module. Each channel is galvanically isolated from each other and ground. Each channel can switch AC or DC voltages up to 240 V and is electronically fused at 2.5 amps.

Each channel’s electronic fuse can be configured to latch off or auto retry during an overcurrent condition.

SIO5.10

The SIO5.10 is a ten channel high-speed discrete input module. The channels are group-isolated from ground. Each channel has a programmable threshold from 5 volts to 24 volts. Each channel can be configured for voltage monitor or contact sense using a module-supplied 24 volt wetting voltage. Each input can be set up to measure frequency up to 100 kHz using a 32-bit pulse counter. The counter will roll over when it reaches its maximum value of 4,294,967,295.

SIO7.20

The SIO7.20 has 20 discrete voltage monitor channels. The channels are galvanically isolated from each other and ground. Each channel can monitor either AC or DC voltages up to 60 V DC or 48 V AC. The SIO7.20 is:

- on at 20 V AC/DC
- off at 7 V AC/DC
- maximum input up to 60 V AC/DC.

SIO8.20

The SIO8.20 is a twenty channel discrete output module. Each channel has the following features:

- galvanically isolated from each other and ground

- discrete output with both voltage and current readback
- an electronic fuse with programmable threshold that can be configured to latch off or auto retry during an overcurrent condition.

SIO Communication Module Offerings

This following are the SIO communication module offerings for the Bedrock Control System.

SIO4.E

The SIO4.E is a five channel smart controller module that interfaces to industrial controllers through five Ethernet connectors. The following communication protocols are supported:

- EtherNet/IP
- Modbus TCP

The SIO4.E has the following features:

- five Ethernet ports - each capable of providing Power over Ethernet (PoE) to field devices
- 25 watts of power per port
- Ethernet 10/100 Mbps half/full duplex communication
- LED status indicators for module status and port status
- 23 diagnostic switch counters per port - viewable in the Bedrock IDE

SIOS.5

The SIOS.5 is a five channel serial interface module that can communicate with industrial controllers and other serial devices through five Micro-D connectors. Each channel has channel-to-channel and channel-to-ground galvanic isolation. Each channel has its own dedicated, secure processor. The following serial communication standards are supported:

- RS-232
- RS-485
- RS-422

The SIOS.5 has the following features:

- five serial ports with Micro-D connectors
- each channel has three LEDs as follows:
  - a status LED
  - a transmit activity LED and a receive activity LED
- settings for each port are independently configured in the Bedrock IDE

BMI

The BMI is a passive backplane providing mechanical support and electrical connections for Controllers, SPMs, and SIO modules. The BMI is available in three styles: 5-slot, 10-slot, and 20-slot. These are the number of SIO modules that can be accommodated. The 5-slot BMI (BMI.5) has single slots for an SPM and a Controller. The 10-slot BMI (BMI.10) and 20-slot BMI (BMI.20) have two slots to accommodate up to two SPMs and another two slots to accommodate up to two Controllers.

For more information, see “BMI” for BMI dimensions and illustrations.

System Architecture

The advanced design features of the Bedrock Control System architecture provide:

- Maximized throughput of sensor data via the Controllers, SIO modules, and the BMI
- Accurate timekeeping and coordination
- High-speed analog control loops on a cycle of up to 5 milliseconds (ms)
- A more secure and robust system through the choice of:
  - Point-to-point I/O communication
  - Real-Time Operating System (RTOS)
  - Passive BMI construction
  - Active encryption security.

A simplified block diagram showing the architecture of the Bedrock Control System is shown in Figure 1-5.

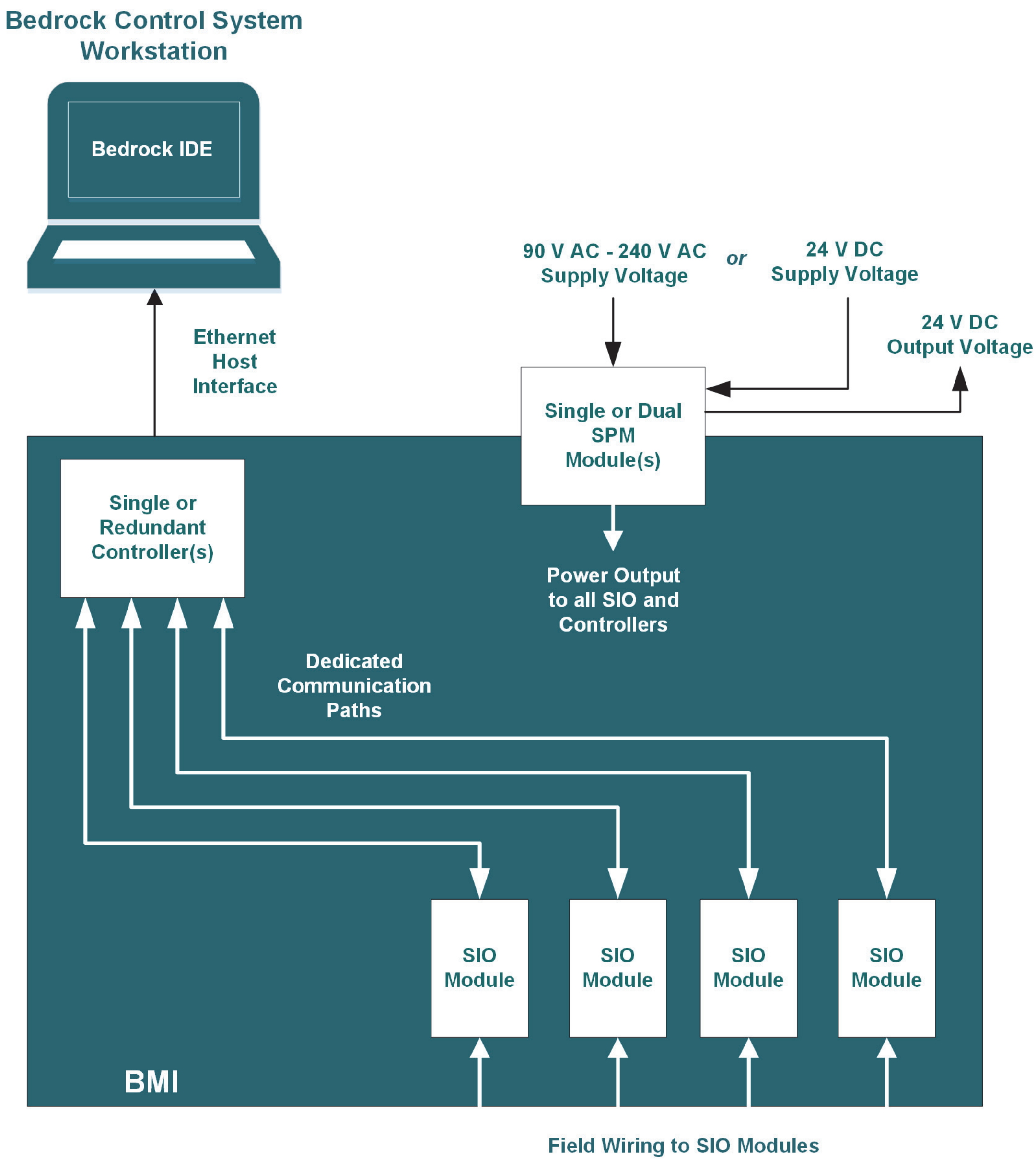


Figure 1-5 System Architecture

Basic System Configurations

The following are the five basic Bedrock Control System configurations available:

- 5-Slot Non-Redundant (single SPM, single Controller)
- 10-Slot Non-Redundant (single SPM, single Controller)
- 20-Slot Non-Redundant (single SPM, single Controller)
- 10-Slot Redundant (two SPMs, two Controllers)
- 20-Slot Redundant (two SPMs, two Controllers)

Security

Bedrock Automation provides system-wide security that includes the features listed below:

- Secure boot for the Controller and each SIO module including an encrypted and signed image
- Transport Layer Security (TLS) with X.509 certificates used on all workstation communication channels
- Certificates and cryptographic keys with a usable lifetime projected beyond the year 2030
- Image updates that are signed and encrypted and will be rejected if they fail authentication by the Controllers or SIO modules
- Device authentication between the Controllers, SIO modules, and SPMs
- Dedicated hardware cryptographic support in all modules (SIO, SPM, and Controller)
- True random number generator
- Physical tamper protection that is designed for compliance with FIPS 140-2 Level 2 (SPMs, SIO modules, and Controllers)
- Designed to meet ISASecure Level 3 for Devices
- Compliance with NIST SP800-57, *Recommendation for Key Management*
- Compliance with FIPS 186-4, *Digital Signature Standard*

Environmental

The following are the environmental conditions applicable to the Bedrock Control System.

- Operating temperature is dependent upon the BMI type and type of power supplied to a single SPM. See “Operating Temperature”.
- -40°C to +85°C storage
- 5 to 95% non-condensing humidity

Software Requirements

The following software is required for use with the Bedrock Control System.

- Bedrock Integrated Development Environment (IDE)
- Bedrock Field Device Tool (FDT) for configuration of SIO modules that support the HART Communication Protocol. See the “HART Device Configuration”chapter for more information.

Mechanical Requirements

The following are the mechanical requirements for the hardware required to use the Bedrock Control System.

Controller Ethernet Connection

Communication to the Controller is via a small form-factor pluggable (SFP) module. A Fiber Ethernet SFP Interface Module can be used with a fiber-optic cable to provide 1 Gbps Ethernet over fiber. A Copper Ethernet SFP Interface Module can be used with a Cat6 shielded copper cable to provide 10/100/100 Mbps communication with the Controller.

Bedrock Universal Cable

All field connections to SIO analog and discrete modules are done via the Bedrock Universal Cable. See “SIO Module Introduction” for information on available cable lengths.

SIO Communication Module Connections

Field connections to the SIO4.E communication module are done via standard Cat5 shielded Ethernet cables.

Field connections to the SIOS.5 communication module are done via the Bedrock SIOS.5 Serial Communication Cable.

Tools

The following tools are necessary to install the Bedrock Control System modules.

- For connection to the field terminals only: mini-precision metal handle screwdriver, non-magnetic, 0.08 blade width for the connector screws.
- 4 mm Bondhus (or equivalent) ball end hex driver for mounting modules to the BMI.

Torque

The following are the recommended torque measurements to be used when installing the Bedrock Control System.

- 8.1 N·m (6 lb·ft) (torque measurement for mounting modules to the BMI)

BMI

The BMI is a passive backplane providing mechanical support and electrical connection for the Controller, SPM, and SIO modules.

The BMI is available in three styles: a 5-slot, 10-slot, and a 20-slot. The 5-slot has a single slot for an SPM and another single slot for a Controller. A dimensional drawing of a 5-slot BMI is shown in Figure 2-1. Figure 2-2 shows the front and side view of a 5-slot BMI.

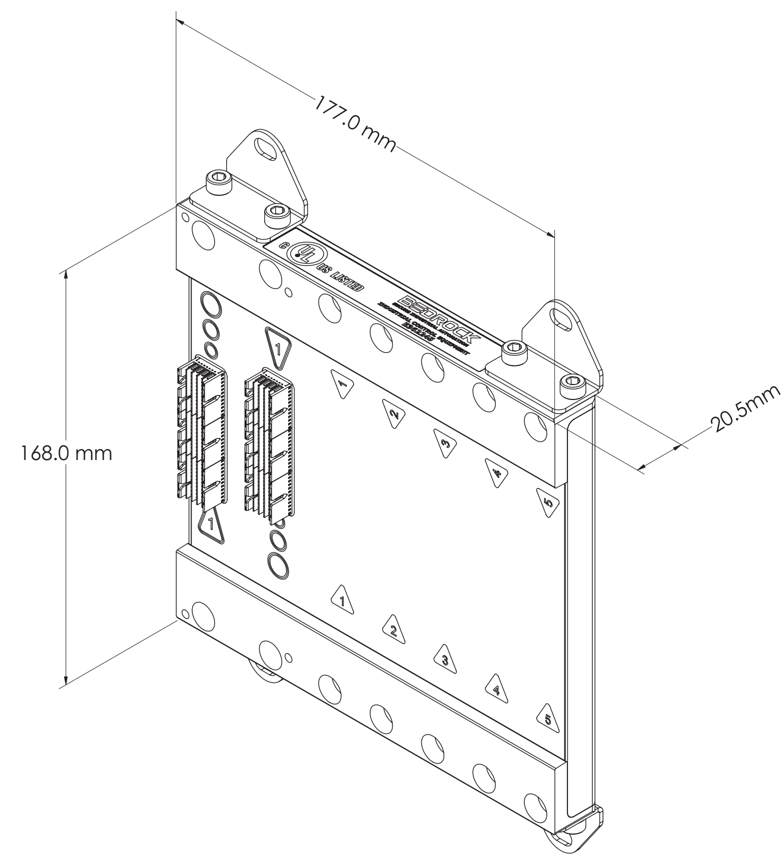


Figure 2-1 5-Slot BMI with Dimensions

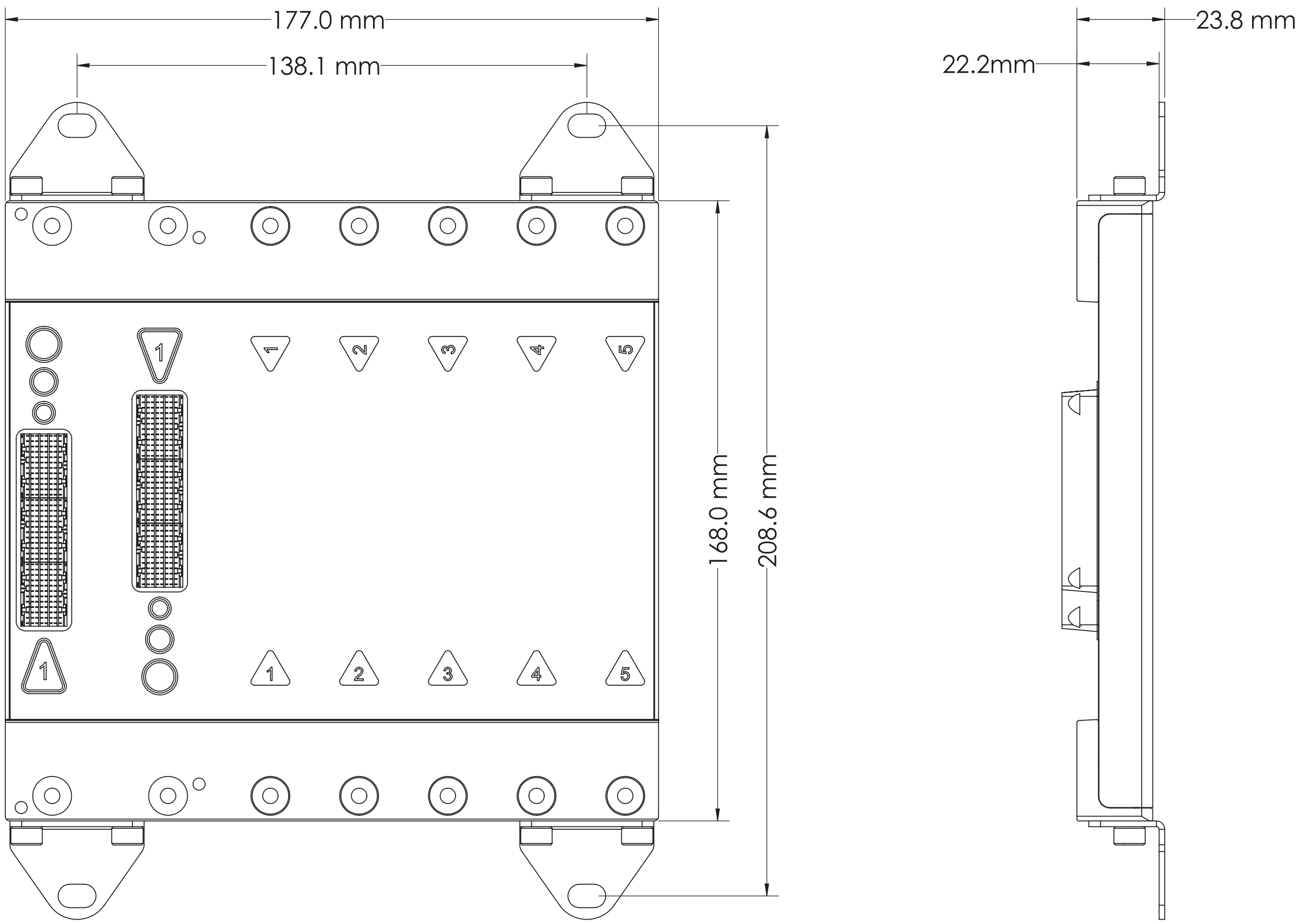


Figure 2-2 5-Slot BMI Front and Side

Both the 10-slot and 20-slot BMIs have fixed slots for redundant SPMs and Controllers. A dimensional drawing of a 10-slot BMI is shown in Figure 2-3. Figure 2-4 shows the front and side view of a 10-slot BMI.

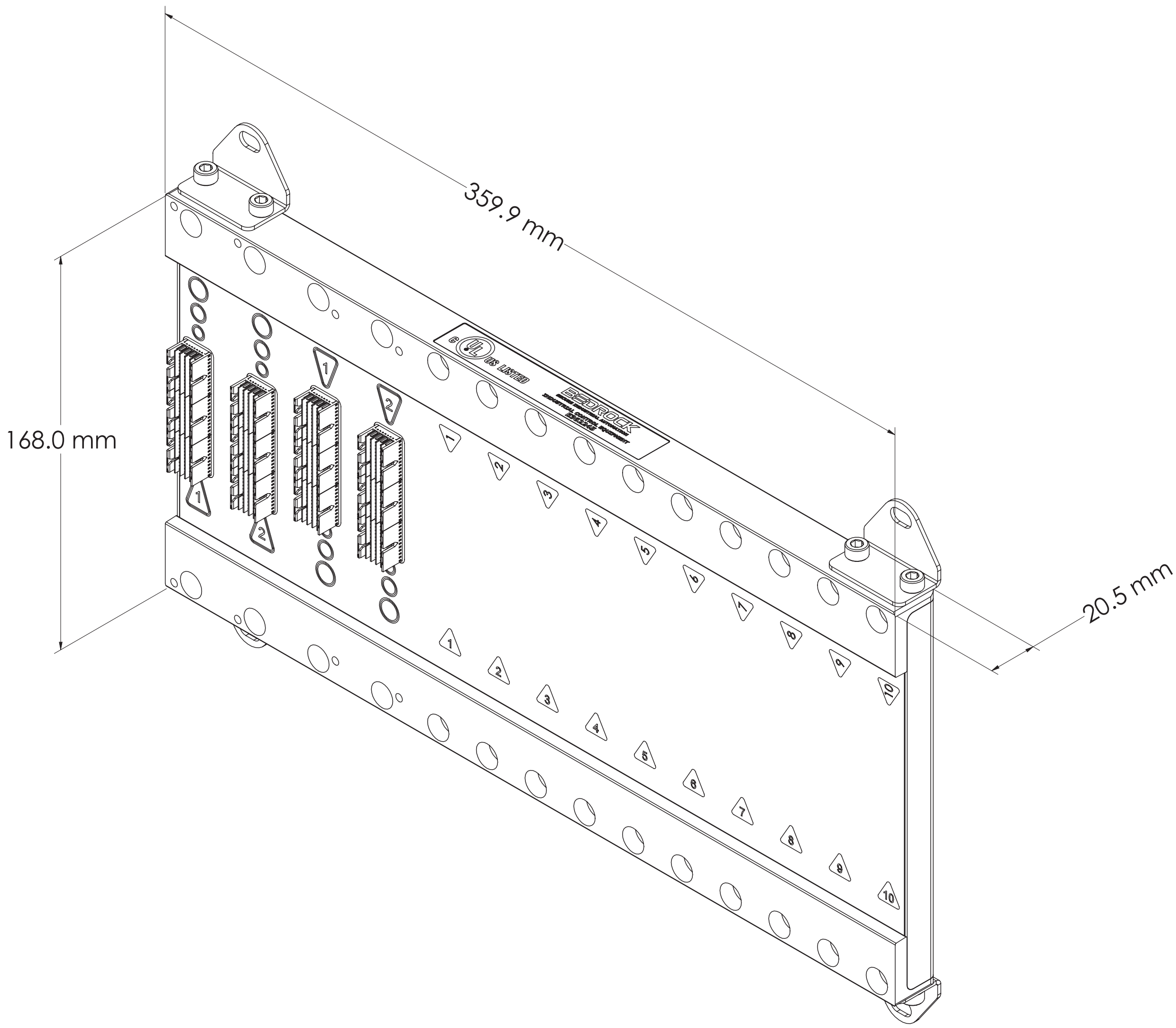


Figure 2-3 10-Slot BMI with Dimensions

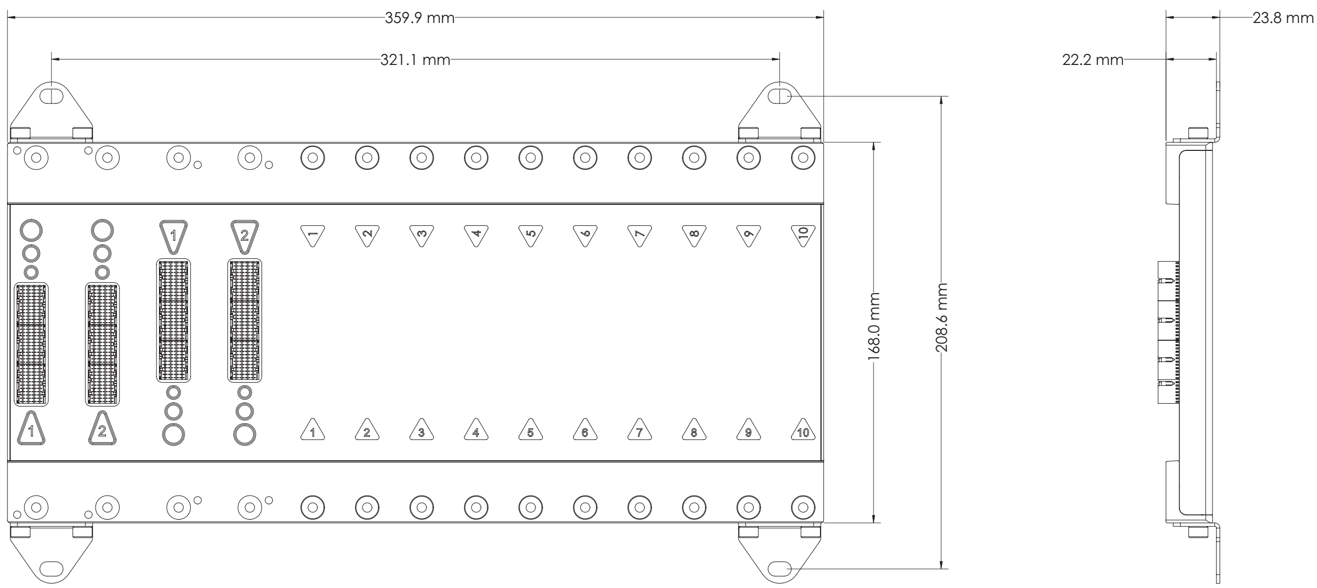


Figure 2-4 10-Slot BMI Front and Side

A dimensional drawing of a 20-slot BMI is shown in Figure 2-5. Figure 2-6 shows the front and side view of a 20-slot BMI.

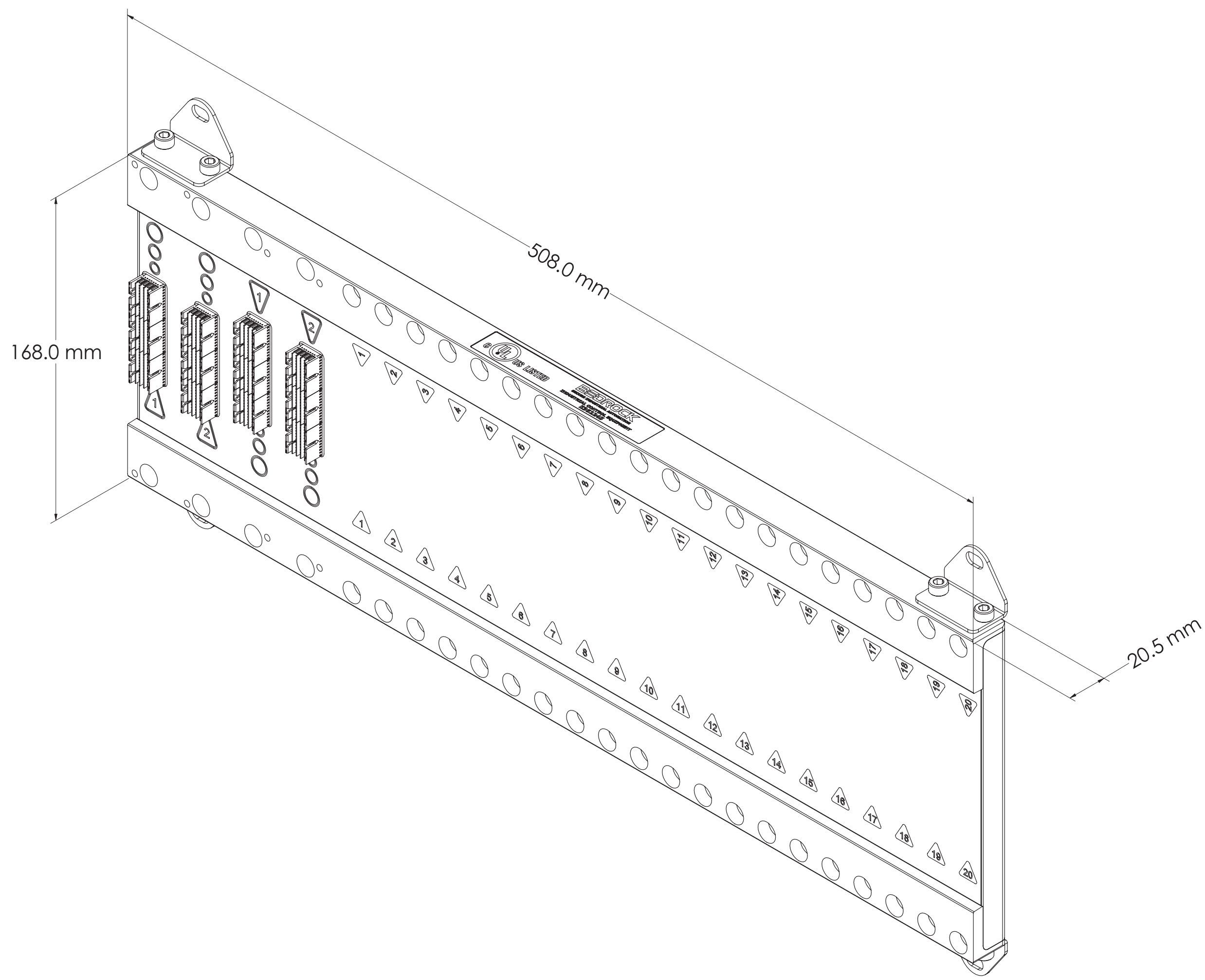


Figure 2-5 20-Slot BMI with Dimensions

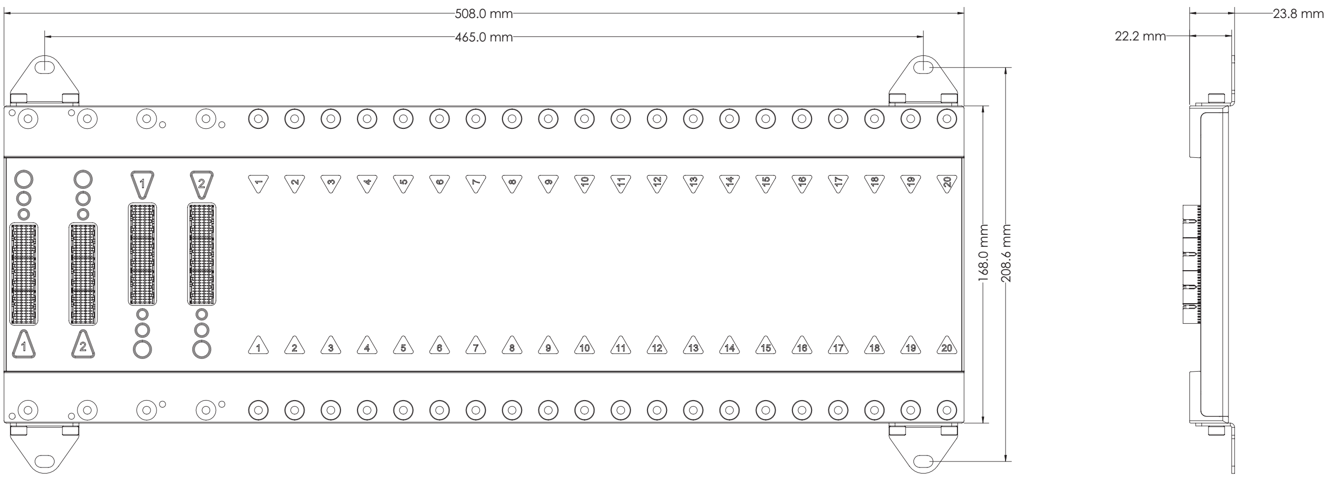


Figure 2-6 20-Slot BMI Front and Side

Any combination of SIO modules install in the slots of the BMIs shown in the above illustrations.

See the “Hardware Installation” chapter for information on BMI installation.

SPM (Power) Overview

Introduction

The Secure Power Module (SPM) provides power to the Backplane Magnetic Interconnect (BMI) to inductively power the SIO modules. It also provides power to the Controllers. To provide redundant power, a pair of SPM modules may be affixed to a ten-slot BMI (BMI.10) or twenty-slot BMI (BMI.20). A single SPM can be affixed to any BMI (BMI.5, BMI.10, or BMI.20).

SPM Offerings

Bedrock Automation offers the Secure Power Modules that are summarized below. Additional detail is provided in the remainder of this chapter.

SPM.U

The SPM.U has a universal AC power input and two DC power inputs. A 24 V DC output is also provided. A block diagram of the SPM.U is shown in Figure 3-1.

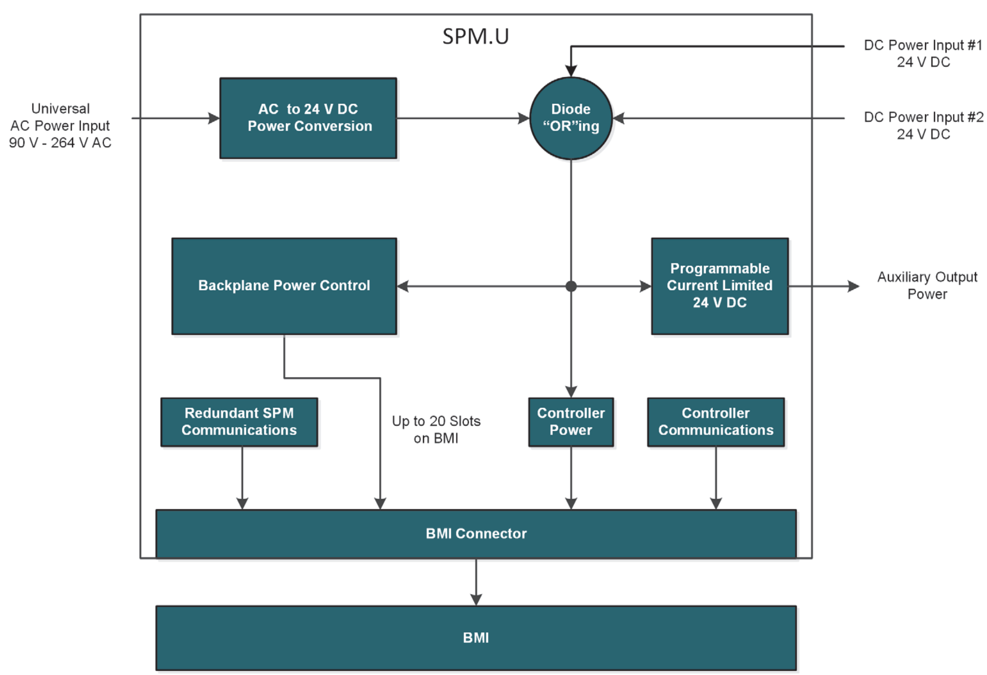


Figure 3-1 SPM.U Block Diagram

SPM.24

The SPM.24 features two DC power inputs and a 24 V DC output. A block diagram of the SPM.24 is shown in Figure 3-2.

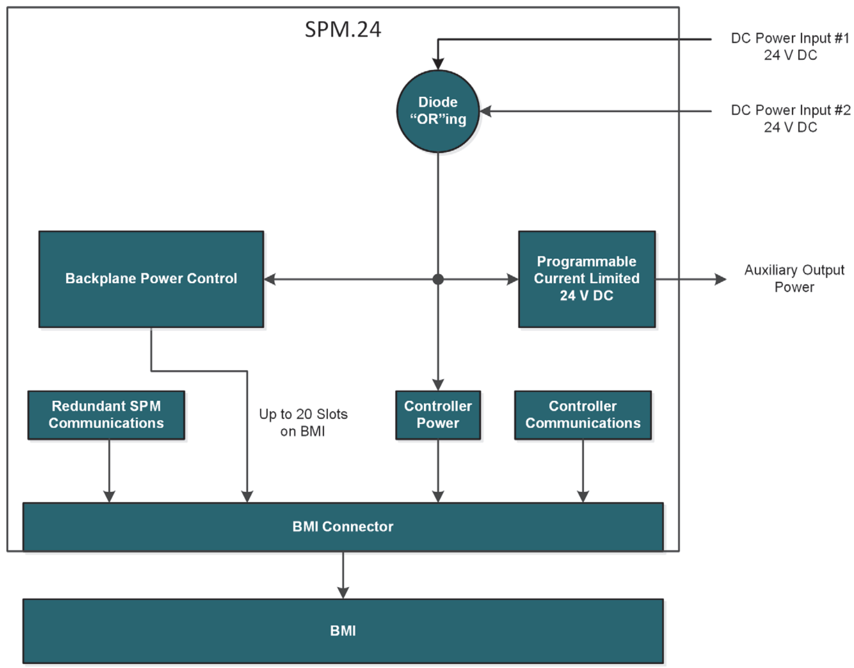


Figure 3-2 SPM.24 Block Diagram

Redundant Power

A second SPM can be added to a BMI.10 or BMI.20 to provide redundant power to the Controller and SIO modules on the BMI. This will allow the modules on the BMI to remain powered in the event that one of the SPMs becomes faulted. On a BMI with redundant SPMs, power from each SPM is shared among the SIO modules on the BMI. Each SPM monitors the other SPM by using its interlink connection via the BMI. If one SPM determines that the other SPM is faulted, the healthy SPM will power all the Controller and SIO modules on the BMI.

Fault information is indicated by the status LED on the SPMs (see Table G-1) and recorded by the system logging function (see "System Logging"). See the Bedrock IDE online help for information on saving log information to a text file.

See "SPM Configuration" later in this chapter for information on configuration of SPMs in the Bedrock IDE.

Physical Dimensions

The physical dimensions of an SPM are shown from the side of an SPM.U with the VAC connector in Figure 3-3 and from the side with the DC connectors in Figure 3-4. The dimensions are the same for an SPM.24. However, the SPM.24 does not have a VAC connector.

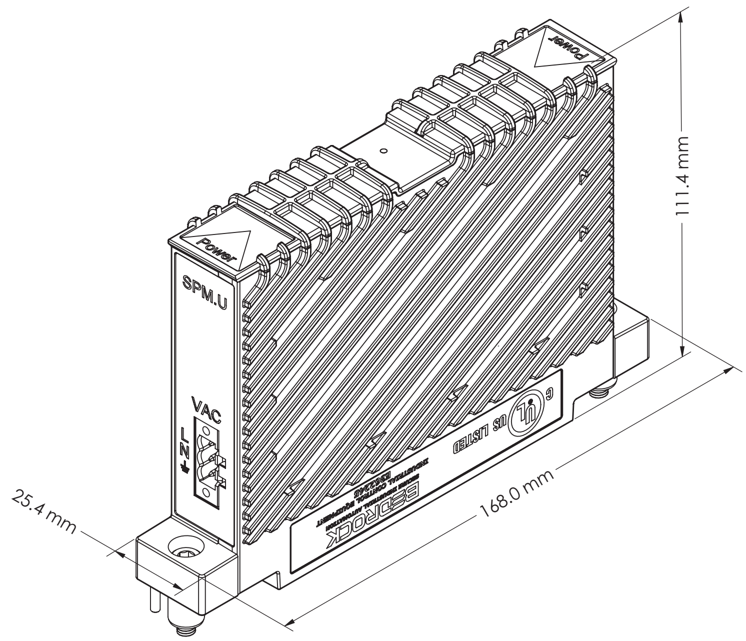


Figure 3-3 SPM.U with View of VAC Connector

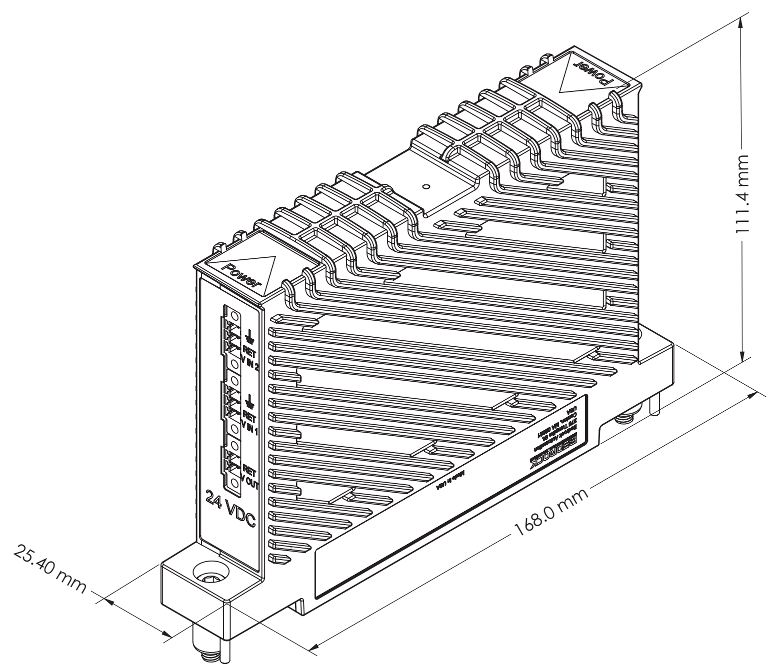


Figure 3-4 SPM.U with View of DC Connector

SPM Power Input

Power is provided to the SPM either by one of its two DC power inputs or, in the case of the SPM.U, by the universal AC power input. Any combination of the three power inputs can be used to run the SPM.U. One or two DC power inputs can be used to run the SPM.24. See Table 3-1 for the SPM power input specifications. An SPM (or both SPM modules, if redundant) can power the Controller(s) and all of the SIO modules. UL has designated the SPMs as a low voltage, limited current (LVLC) source. UL recommends using a UL Listed Class 2 power supply for the DC inputs.

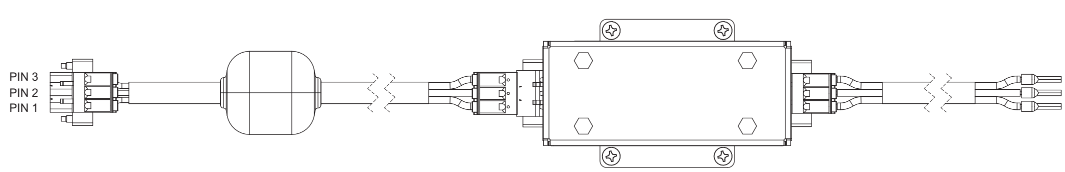
When using redundant SPM modules, the two SPM modules will share the load. The DC power inputs to each SPM are diode “OR”ed. The power source that provides the highest voltage will power the system.

Table 3-1 SPM Power Input Requirements

	Minimum	Maximum
AC Mains Input (SPM.U only)		
Input Voltage	90 V rms	240 V rms
Frequency	47 Hz	63 Hz
Input Power		170 W
24 V DC Input (SPM.U and SPM.24)		
Input Voltage*	22.8 V	25.2 V
Input Power		160 W
*24 V DC is the typical input voltage		

SPM AC Power Input (SPM.U Only)

Bedrock Automation provides the AC Line Filter Assembly for providing AC power to the SPM.U. The AC Line Filter Assembly *must* be used when providing AC power to the SPM.U. The AC Line Filter Assembly is shown in Figure 3-5. The assembly includes a power cable and an AC line filter that is needed to meet FCC and CE requirements. The AC line filter has no effect on the efficiency of the SPM.U. See the “Hardware Installation” chapter for information on mounting the AC Line Filter Assembly.



PIN NO.	COLOR	FUNCTON
PIN 3	GREEN	GROUND
PIN 2	WHITE	NEUTRAL
PIN 1	BLACK	LINE

Figure 3-5 AC Line Filter Assembly (SPM.U Only)

The AC line filter with its dimensions is shown in Figure 3-6.

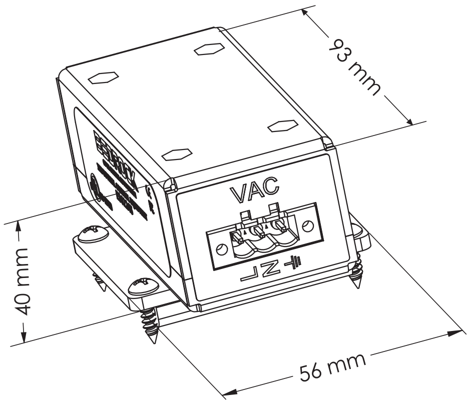
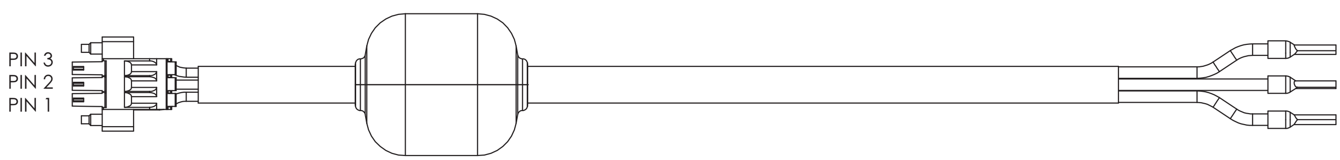


Figure 3-6 AC Line Filter with Dimensions

SPM DC Power Input

Bedrock Automation provides the SPM DC Input Power Cable for providing DC power to the SPM.U and SPM.24.

The SPM DC Input Power Cable is shown in Figure 3-7.



PIN NO.	COLOR	FUNCTION
PIN 3	GREEN	GROUND
PIN 2	BLACK	RETURN
PIN 1	RED	VOLTAGE IN

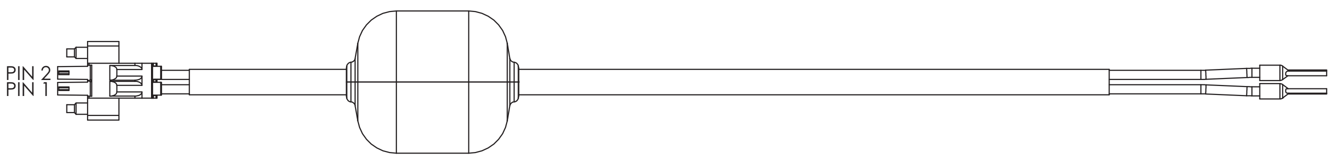
Figure 3-7 SPM DC Input Power Cable

SPM Power Output

This section applies to both the SPM.U and the SPM.24.

The SPM provides the customer with a 24 V DC output for use as an output voltage. The auxiliary power output may be used to provide power for field circuits. The maximum current that can be drawn by the output voltage is programmable in the Bedrock Integrated Development Environment (IDE) and is adjusted based on the system configuration. The auxiliary power output can range from zero to 120 watts. The current is monitored so that if an overcurrent situation occurs, the SPM will shutdown the output power. The current limiter of the SPM will shut off the current and auto-retry every 50 milliseconds. This will occur indefinitely and will result in the reporting of current and voltage values of zero in the SPM details window of the System Monitor. The System Monitor is accessed via the Status tab in the Device window of the Bedrock IDE. Refer to the Bedrock IDE online help for more information.

Bedrock Automation provides the Output Power Cable (reference "Wetting Cable" for ordering) for providing output power from the SPM. The Output Power Cable is shown in Figure 3-8.



PIN NO.	COLOR	FUNCTION
PIN 2	BLACK	RETURN
PIN 1	RED	VOLTAGE OUT

Figure 3-8 Output Power Cable

SPM Power Requirements

This section contains information that can be used for calculating the amount of power that must be supplied to the SPM. This calculation is a function of the type of power source, the number of modules on the BMI, and the SPM auxiliary power output.

The requirement for the amount of power to be supplied to the SPM can be calculated as follows:

$$pwr\_in = spm\_load + auxiliary\_power + pwr\_spm$$

where `spm_load` is the sum of the maximum power required by all the SIO and Controllers mounted on the BMI. There may be an additional load from the SPM auxiliary output power (up to 120 watts). The maximum power requirements for the Controller and SIO module types are listed in Table 3-2.

Note that it is not recommended to use auxiliary power on a fully loaded BMI.20.

Table 3-2 Controller and SIO Maximum Power Requirements

Module Type	Max. Power (Watts)
SCC Controller	7.0
SCS.5 Controller	6.0
SCS.10 Controller	6.0
SIO1.5	9.5
SIO2.10	2.5
SIO3.10	5.5
SIO4.E	4.0
SIO5.10	4.5
SIO6.20	3.5
SIO7.20	1.5
SIO8.20	4.0
SIOS.5	4.0
SIOU.10	9.0

The `pwr_spm` value to be used in calculating `pwr_in` can be found in Table 3-3. For DC operation, this is a fixed value. For AC operation, the SPM power requirement is dependent upon the load power range, i.e., the sum of the power requirements of the modules used in calculating `spm_load` plus the auxiliary power output.

Table 3-3 SPM Power Requirements

Power Source Type	Load Power Range (Watts)	Max. Power (Watts)
DC Operation	0-160	5
AC Operation (SPM.U)	0-30	12
AC Operation (SPM.U)	30-80	15
AC Operation (SPM.U)	80-170	20

For example, the calculation shown below is for a configuration consisting of a BMI.5 being supplied with AC power and populated with one SCC Controller, two SIO1.5 modules, one SIO3.10, one SIO5.10, and one SIO6.20. The example includes 10 watts of SPM auxiliary power being supplied to field circuits. The 15 watt `pwr_spm` value is from Table 3-3 after `spm_load` is calculated (sum of the values in parenthesis) and added to the auxiliary power output (10 watts).

pwr_in = (7.0+9.5+9.5+5.5+4.5+3.5)+15 + 10

SPM Wiring

Two three-pin power connectors allow the customer to provide 24 V DC to the SPM. Each of the three-pin mating connectors is wired to a 24 V DC source. UL recommends using a UL Listed Class2 power supply. A pair of screws on each connector allow the connectors to be securely fastened to the module. Labels and functions of the three-pin power connectors are listed in Table 3-4 (pin 3 is the top pin).

Table 3-4 24 V DC Connector Pin Out

Input # / Pin #	Label	Function
Input 2 / Pin 3	⏚	Safety ground for system
Input 2 / Pin 2	RET	24 V return
Input 2 / Pin 1	V IN 2	24 V input #2
Input 1 / Pin 3	⏚	Safety ground for system
Input 1 / Pin 2	RET	24 V return
Input 1 / Pin 1	V IN 1	24 V input #1

The output voltage connector pin outs are shown in Table 3-5.

Table 3-5 Output Voltage Connector Pin Out

Pin #	Label	Function
2	RET	24 V return
1	24VDC	24 V output

The following applies to the SPM.U only.

A separate three-pin connector, labeled "VAC", allows the customer to provide the AC mains power to the SPM.U. This three-pin connector is keyed differently than the three-pin mating connectors that plug into the 24 V DC connector. This prevents the VAC connector from being plugged into the 24 V DC connector. The VAC pin outs are shown in Table 3-6.

Table 3-6 VAC Connector Pin Out (SPM.U Only)

Pin #	Label	Function
1	L	Line 1
2	N	Neutral / Line 2
3	⏚	Safety ground for system

SPM Configuration

The Bedrock IDE provides the ability to configure the SPM functionality that is described below. Figure 3-9 shows the parameters that are displayed on the BMI_x tabs in the Bedrock IDE. Table 3-7 provides a summary of the parameters.

Parameter	Type	Value	Default Value	Unit	Description
Power Polling Map	DWORD	1023			Bit pattern of slots to be polled when power polling mode is "Use Polling Map"
Poll Slot 1	BOOL	On	On		Polling Map State for the Slot
Poll Slot 2	BOOL	On	On		Polling Map State for the Slot
Poll Slot 3	BOOL	On	On		Polling Map State for the Slot
Poll Slot 4	BOOL	On	On		Polling Map State for the Slot
Poll Slot 5	BOOL	On	On		Polling Map State for the Slot
Poll Slot 6	BOOL	On	On		Polling Map State for the Slot
Poll Slot 7	BOOL	On	On		Polling Map State for the Slot
Poll Slot 8	BOOL	On	On		Polling Map State for the Slot
Poll Slot 9	BOOL	On	On		Polling Map State for the Slot
Poll Slot 10	BOOL	On	On		Polling Map State for the Slot
Power Polling Mode	Enumeration of BYTE	All On	All On		Select how SIO slots on the BMI will be powered by the SPM
SPM Output Current Low Threshold	REAL	1.0	1.0		Low threshold for SPM output
SPM Output Current High Threshold	REAL	23.0	23.0		High threshold for SPM output
SPM Output Current Limit	REAL	1.0	1.0		SPM will turn off if output exceeds this limit
Redundant SPM Present	BOOL	FALSE	FALSE		Indicates that a redundant SPM is present on the backplane

Figure 3-9 SPM Configuration Parameters (BMI.10 Shown)

Table 3-7 SPM Configurable Parameters

Parameter Name	Description
Power Polling Map	Specifies which SIO slots the SPM will attempt to power. Only used when Power Polling Mode is set to “Use Polling Map”.

Table 3-7 SPM Configurable Parameters

Parameter Name	Description
Power Polling Mode	Specifies how SIO slots on the BMI will be powered by the SPM. Possible values are: All On: SPM will attempt to power all SIO modules Use Polling Map: SPM will attempt to power SIO modules specified by Power Polling Map Use SIO Config: SPM will attempt to power SIO modules that have been configured in the Device Pane of the Bedrock IDE.
SPM Output Current Low Threshold	Low threshold for SPM output current. If the output current falls below this value, an SPM power fault will occur.
SPM Output Current High Threshold	High threshold for SPM output current. If the output current goes above this value, an SPM power fault will occur.
SPM Output Current Limit	SPM will shut off if the output current exceeds this value.
Redundant SPM Present	Enables power sharing. Not applicable for an SPM on a BMI.5.

SPM Status Indicators

The SPM has a single LED used as a status indicator. See Appendix G, "SPM and SIO Blink Code Summary" for more details.

Communication with the Controller

The data collected by the SPM is sent via Black Fabric to the Controller. SPM data sent to the Controller includes:

- SPM state and status information
- SPM diagnostic counter information related to Black Fabric messages
- Output voltage information.

For more details on the SPM information sent to the Controller, see "Power Supplies - SPMs" in the System Monitor section of the Bedrock IDE online help.

Controllers (Control)

Introduction

Bedrock Controllers provide communication and control to the system. Single or dual (if redundant) Controllers mount on the Backplane Magnetic Interconnect (BMI). The Controllers provide the operating system, network communications, redundancy (SCC only), provisions for hardware configuration, and management of system operations. The Controller scans input modules, executes control functions and writes outputs. It also provides control and system status information to upper Ethernet systems.

Controller Offerings

Bedrock Automation offers the Controllers described in this section.

SCC Controllers

Secure Control and Communication (SCC) Controllers support up to twenty SIO modules, provide a second Ethernet port (for future use), and offer Controller redundancy. Redundant power is also supported.

SCS Controllers

Secure Controller Single (SCS) Controllers are available in the two models described below. Redundant Controllers are not supported by either model.

- SCS.10 Controllers support up to ten SIO modules.
- SCS.5 Controllers support up to five SIO modules.
- Redundant power is supported for SCS Controllers when mounted on a BMI.10 or BMI.20.

Controller Comparison

All Controllers share the features and functionality described in this chapter except where noted. Differences between the different Controller types are listed in Table 4-1. Feature descriptions follow the table.

Table 4-1 Bedrock Controller Comparison

Feature/Function	SCC	SCS.10	SCS.5
SIO Modules Supported	20	10	5
Redundant Controller Support	Yes	No	No
Gigabit Ethernet Ports	2	1	1
RAM	512 MB	512 MB	256 MB
SD Flash	32 GB	32 GB	8 GB

Controllers with Customer-specific OPC UA Security Keys

Bedrock Automation provides customers with the option of ordering Controllers with OPC UA certificates for increased security. The OPC UA certificates are standard X.509 certificates with required OPC UA fields and must be issued by the Bedrock Certificate Authority. Customer-specific security certificates can be added to Controllers already in the field using the Bedrock Upgrade Utility. The OPC UA communication protocol is required for application software to securely communicate with Controllers using customer-specific security certificates. As a result, the Bedrock IDE and any additional OPC UA client software must also be updated with the appropriate security certificates.

An OPC UA server certificate is required to be loaded onto any Controllers that are being upgraded. A separate client certificate is required for any OPC UA client software to be able to connect to a Controller that is configured with customer-specific security certificates. OPC UA client certificates are specific to each OPC UA client application.

Contact Bedrock Automation for guidance on upgrading Controllers and configuring software with customer-specific security certificates. For Controllers, you will need to provide the Controller name or IPv4 address. Controller names must start with a letter and contain only letters and numbers without dashes or underscores. Any changes to information that is embedded in the certificate, e.g., Controller name or IPv4 address, will require a new OPC UA server certificate.

Part numbers for ordering the firmware upgrade for customer-specific security certificates for Controllers are listed in Table B-1.

See the Bedrock IDE online help for information on the Bedrock Upgrade Utility.

Secure Boot Software

This software component manages power on startup. It is responsible for initializing the hardware and starting the operating system.

MRAM and Data Persistence

All Bedrock Controllers have 8 kB of magnetoresistive RAM (MRAM) available. This allows control programs to have access to persistent or retained variables. These two types of variables are declared in Program Organization Units (POUs) in the Bedrock IDE and provide data persistence as follows:

- *Persistent* variables are restored after cold resets, warm resets, or program downloads. They are cleared using the Reset Origin function in the Bedrock IDE.
- *Retain* variables are restored after a warm reset. They are cleared using the Reset Origin function in the Bedrock IDE.

Refer to the Bedrock IDE online help for information on how to implement persistent and retained variables in your application.

Note that an application program in the Bedrock IDE must have its task interval set to 5 ms or greater to ensure that the MRAM is correctly updated during each control cycle.

Note

Note that for SCC Controllers, ensure that the module revision number is rev. G or greater. Earlier SCC Controllers do not contain the MRAM needed to support persistent data. The figure below shows the location of the module revision number on the Controller label.

Alternatively, the log file for an SCC Controller will indicate if MRAM is present in the Controller. Search for the string “MRAM found”.

Figure 4-1 Controller Label with Module Revision Number

IP Stack

The Controller uses a dual-mode IPv4/IPv6 stack.

I/O Support

The platform manages all communications with the Secure Input/Output (SIO) modules. It provides for I/O scanning in real-time, monitoring and managing SIO module health, and SIO module configuration.

Ethernet Communication

The Controller Ethernet communication is designed to interface to a local intranet through Port A on the Controller (Port B on the SCC is a spare and reserved for future use). It consists of a single 1 Gbit Ethernet channel. The system uses a small form-factor pluggable (SFP) interface module (fiber or copper). It has the following characteristics.

- 1 Gbit fiber or 10/100/1000 Mbps copper interface
- IEEE-1588 time synchronization

OPC UA

The Controller software uses the OPC Unified Architecture communication protocol for connectivity to external devices, HMIs, and SCADA systems.

For more information about OPC UA, visit the OPC foundation website at:

https://opcfoundation.org/

Redundancy

Controller Redundancy is supported by SCC Controllers only.

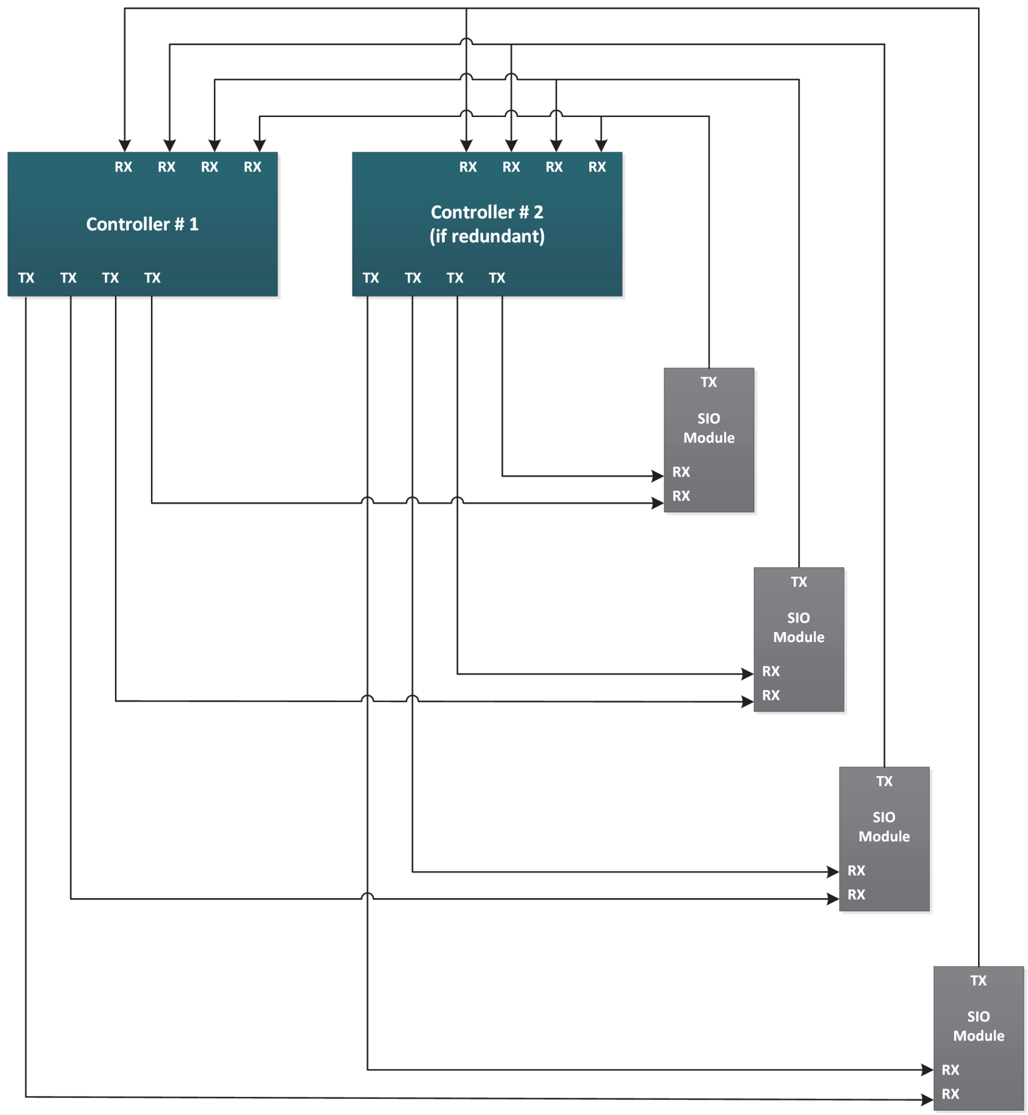
The Bedrock Control System allows for the configuration of redundant SCC Controllers on 10-slot or 20-slot BMIs in order to provide continuous system availability during system maintenance or in the case of a faulted Controller.

See “Controller Redundancy” for more information on the operation and configuration of redundant Bedrock Controllers.

Black Fabric Communication

The Black Fabric™ communication consists of galvanically isolated, full-duplex communication channels. Two channels are dedicated to the SPM modules while the remaining channels are dedicated to SIO modules. The number of channels available for I/O is dependent upon the Controller type (see Table 4-1).

Each SIO module has the connections to a Controller as shown in Figure 4-2. Each SIO module has a dedicated full-duplex four-wire bus connecting the Controllers and SIO modules. This allows a Controller to receive SIO data directly into its registers.



Note: Only four SIO modules are shown but the total can be 20

Figure 4-2 SIO Modules to Controllers Communication Architecture

Controller LEDs

Bedrock Controllers feature LEDs that provide information on status, authentication and security, Ethernet activity, and interlink activity. See “Monitoring and Troubleshooting” for more information on Controller LEDs.

Controller Configuration

This section provides information needed to configure Controllers in a Bedrock Control System.

Prerequisite

Install the BMI, a Secure Power Module (SPM) and the Controller to be configured. See “Hardware Installation” for details.

System Configuration

Prior to configuring the Controller, define the control strategy for your system, including what type of I/O modules are needed, how many of each type of module is needed, network communications, IPv4 address definition, etc.

Since SCS.10 Controllers have ten Black Fabric channels available for I/O, only configuration with a BMI.5 or BMI.10 is supported. If a BMI.10 is used, an SCS.10 can be configured with redundant power.

SCS.5 Controllers may only be configured with a BMI.5. Five Black Fabric channels are available for I/O. Redundant power is not supported with a BMI.5.

Application Programming

Application programming is done using the Bedrock IDE development environment. See the Bedrock IDE online help for more information.

Controller Redundancy

Overview

Controller Redundancy is supported by SCC Controllers only.

The primary objective of Controller Redundancy is to provide continuous system availability. The system uses an Active Controller and a Passive Controller that communicate via a proprietary interlink via the BMI. If a fault is detected on the Active Controller, control is transferred to the Passive Controller. The Passive Controller then becomes the Active Controller. The ability to replace a faulted Controller and install a new Passive Controller without interfering with the new Active Controller provides continuous operation of the system.

The result is fast failover with minimal impact on control behavior. In this context, “fast” is a function of the control cycle time. The minimum control cycle for a redundant SCC Controller is 10 milliseconds (3 milliseconds for a Standalone Controller). The maximum fault recovery time is two control cycles.

The platform provides a high priority executive task that manages reaction to fault conditions and controls startup, shutdown, removal, and replacement of Controllers. This task, in conjunction with the corresponding task in the partner Controller, if present, executes the state logic required to manage redundancy and assign Controller roles. Based on the state information, it takes the actions required to accomplish needed state transitions. Examples include shutting down a faulty Controller, bringing up a pair on power up, and replacing a Passive Controller while the system is active.

The platform also provides fault detection and status monitoring using diagnostics, watchdog timers, and related mechanisms. This includes the ability to execute periodic control cycle diagnostics and perform a high-speed data transfer. This allows the system to update the data in the Passive Controller during the control cycle.

Redundant Operation

During redundant operation, a Controller is normally in the role of an Active Controller or a Passive Controller. Additionally, each Controller transitions through a set of redundancy states that are determined by the Bedrock Control System. The redundancy states and current Controller role are used in determining if there needs to be a state change. The Controller roles and redundancy states are described below.

Note that if both Controllers in a redundant configuration are equally qualified to be the Active Controller, the Controller in slot two will be designated as the Active Controller.

When the control system determines which Controller is the Passive Controller, the OPC UA port to the Passive Controller is intentionally disabled so that HMI and SCADA systems only communicate with the Active Controller. The Bedrock IDE will still be able to communicate with both redundant Controllers.

Controller Roles

The Controller roles in a redundant system are described below.

Standalone Controller

In a redundant system, a Controller's role is Standalone immediately after a power on reset. The Controller's role will remain Standalone until the Controller is able to successfully transition through the Discovery and Authentication states described below. At that point, the Controller's role will become either Active Controller or Passive Controller.

In a non-redundant system or in a redundant system with a faulted Controller, a Controller's role will also be Standalone. A Standalone Controller performs the control tasks described below for the Active Controller.

Active Controller

The Active Controller performs all control tasks with the Passive Controller and sends data to local and remote SIO modules. The Active Controller is the Controller that is "in control", i.e., it is running control applications and driving the SIO modules. If an Active Controller is unable to do this, then a role switch will occur.

Passive Controller

When the control system determines which Controller is the Active Controller and the Controllers are synchronized, the other Controller is designated to be the Passive Controller. The Passive Controller periodically updates status information with the Active Controller so that system health may be determined. The Passive Controller operates in parallel with the Active Controller but does not communicate with the SIO modules.

Redundancy States

SCC Controllers transition through the following redundancy states.

System Initialization

The System Initialization state is entered upon power on reset. It is the only way to enter this state. During System Initialization, local certificates are validated and startup diagnostics (SUDs) are performed. If any validation or diagnostic fails, the Controller transitions to the Faulted state. Otherwise, the Controller transitions to the Discovery state.

Discovery

The Discovery state is entered upon successful completion of SUDs and certificate validation. The Discovery state is used to detect the presence of another Controller. An acknowledgment must be received from the other Controller for successful discovery. State transitions from the Discovery state are summarized in Table 5-1.

Table 5-1 Transitions from Discovery State

Discovery Result	Next Redundancy State
Success	Authentication
No Link	Running Standalone
Link present but no acknowledgment	Faulted

Authentication

In the Authentication state, the redundant pair of Controllers use Bedrock and X.509 customer certificates to perform mutual authentication. The initial authentication uses Bedrock certificates. If that authentication is successful, then a second authentication is performed using the X.509 customer certificates.

If both authentications are successful, then the Controllers enter either the Running Active state or the Running Passive state as determined by the Controller firmware. If both Controllers are equally qualified to be the Active Controller, then the Controller in slot two will assume that role.

If either authentication fails and one of the Controllers was already running, that Controller will enter the Running Standalone state and the other Controller will enter the Faulted state. If there was an authentication failure while both Controllers were powering up, then the Controller in slot two will enter the Running Standalone state and the Controller in slot one will enter the Faulted state.

Running Standalone

A Standalone Controller periodically executes the following tasks:

1. Poll the interlink for the presence of another Controller. If another Controller is detected, then transition to the Discovery state.
2. Update the diagnostic counters (remain in Running Standalone state).

Running Active

An Active Controller periodically executes the following tasks:

1. Poll the interlink for a loss of link. If the link is lost, then transition to the Running Standalone state.

2. Update the diagnostic counters (remain in Running Active state).
3. Exchange diagnostic counters with the Passive Controller. If it is determined that the Passive Controller is fault-free and the Active Controller is not, then trigger a role switch, i.e., the Active Controller transitions to the Running Passive state and the Passive Controller transitions to the Running Active state.
4. Determine if a role switch was requested from the Bedrock IDE. If so, switch roles as described in the previous step.

Running Passive

A Passive Controller periodically executes the following tasks:

1. Poll the interlink for a loss of link. If the link is lost, then transition to the Faulted state.
2. Update the diagnostic counters (remain in the Running Passive state).
3. Exchange diagnostic counters with the Active Controller. If it is determined that the Passive Controller is fault-free and the Active Controller is not, then trigger a role switch as described in the description of the Running Active state.
4. Determine if a role switch was requested from the Bedrock IDE. If so, switch roles.

Faulted (While Running Active or Running Passive)

The Faulted state is entered when a fault is detected in one of the running states. Faults may be caused by one of the fault conditions listed in Table 5-2.

Table 5-2 Controller Faults During Running Roles

Fault	Description	Action
Loss of interlink connection	Failed interlink connection	The faulted Controller will be in the Faulted state. The other Controller will be in the Running Standalone state.
Excessive ECC faults	The number of ECC faults exceeded ten in a one second period.	The faulted Controller will be in the Faulted state. The other Controller will be in the Running Standalone state.
Ethernet communication faults	Loss of link or more than ten CRC errors in a one second period	The faulted Controller will be in the Faulted state. The other Controller will be in the Running Standalone state.

Table 5-2 Controller Faults During Running Roles

Fault	Description	Action
Black Fabric faults	More than ten frame or CRC errors in a one second period	The faulted Controller will be in the Faulted state. The other Controller will be in the Running Standalone state.
Black Fabric dropped/lost packets	Black Fabric has dropped more than ten packets in a one second period.	Swap roles only if the other Controller is not dropping packets.
Redundant power loss	One of the SPMs supplying the Controller is not functioning.	Swap roles only if the other Controller still has redundant power.
Excessive interlink CRC or frame errors	The interlink experienced more than ten CRC or frame errors in a one second period.	Put one Controller into the Faulted state. Turn off interlink. The other Controller will be in the Running Standalone state.
Watchdog Timeout	The watchdog timer has expired.	The faulted Controller will be in the Faulted state. The other Controller will be in the Running Standalone state.

Faulted (During Controller Initialization)

The Faulted state can also be entered when a fault is detected before a Controller's role is determined. The actions taken in this state depend on what state the Controller was in when the fault occurred. Table 5-3 lists the states where a fault may occur and the action taken to correct the fault.

Table 5-3 Controller Faults During Controller Initialization

Fault	Action
System Initialization	If system initialization fails, the interlink is disabled and the control application is not loaded. If a hardware fault is the cause, the Controller will display a blink code.
Authentication	If an authentication failure occurs while both Controllers are booting, the Controller in slot two will become the Active Controller. The Controller in slot one will disable its interlink and go offline. The Bedrock Upgrade Utility should be run.

State Transition Diagram

Figure 5-1 shows the state transitions for Bedrock Controllers in a redundant system configuration.

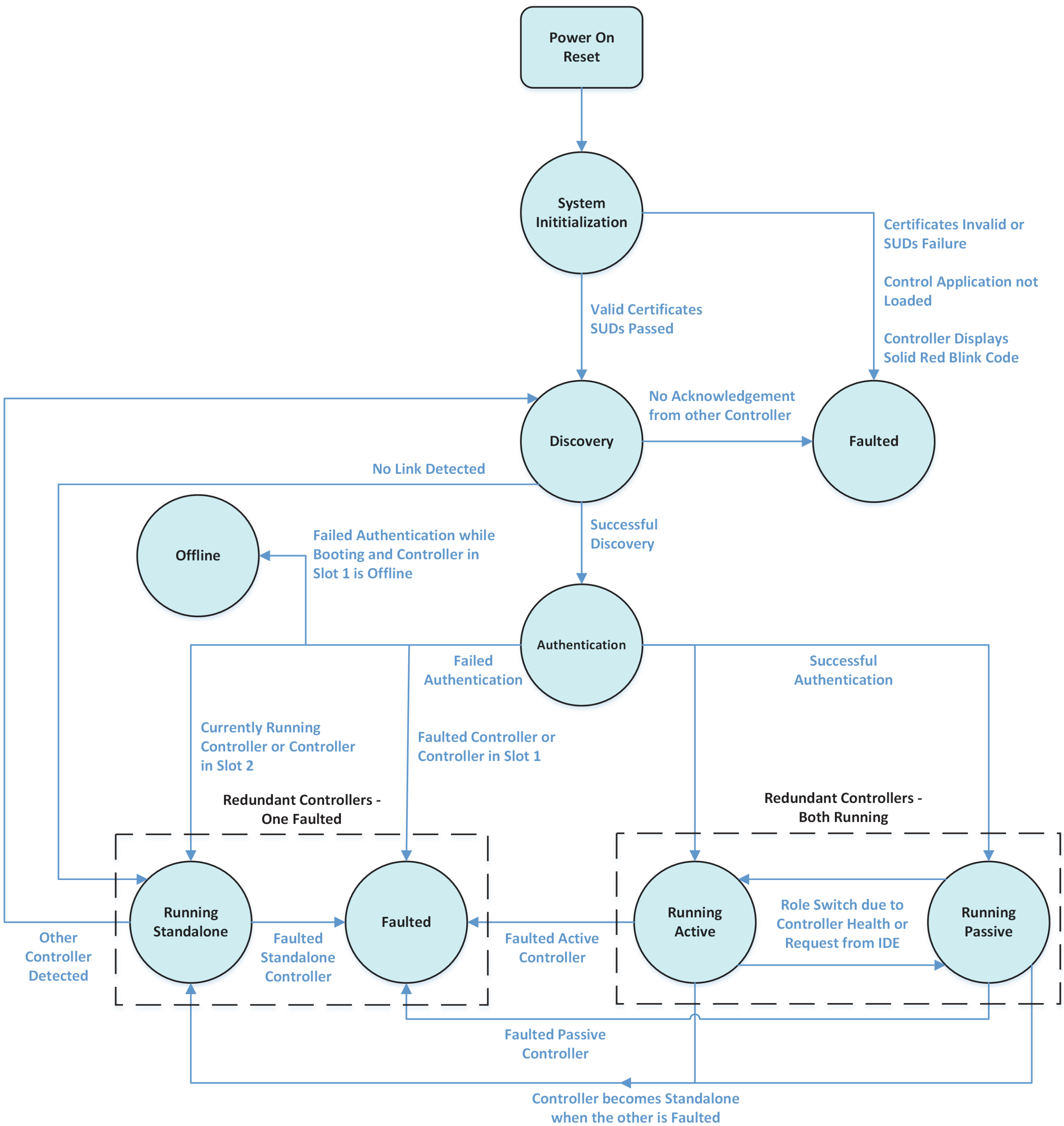


Figure 5-1 Controller States in a Redundant Configuration

Configuration of Redundant Controllers

The Bedrock IDE is used for configuration of redundant Controllers. The following sections describe how to setup a redundant configuration as well as performing tasks related to managing a redundant configuration such as switching Controller roles, updating control programs, and replacing faulted Controllers.

Important

Initial configuration of redundant Controllers must be completed without any control code running as described below in Configuration. To replace a faulted Controller, see “Replacing Faulted Controllers in a Redundant System”. The new Controller must be configured on a separate BMI before being added to the target BMI.

Placing two Controllers on the same BMI with mismatched configurations is not supported and may cause unpredictable behavior.

Note

Note that in a system with redundant SCC Controllers, each Controller must have the same version of firmware. Configuration of mismatched versions of firmware is not supported. See the Bedrock IDE online help for information on upgrading Controllers using the Bedrock Upgrade Utility.

Configuration

The following steps describe how to use the Bedrock IDE to configure redundant Controllers for the Bedrock Control System. These steps assume basic familiarity with the Bedrock IDE, e.g., the ability to create a project with a Standalone Controller. See the Bedrock IDE online help for more information. Note that Controller Redundancy is only supported for SCC Controllers.

Create a project with redundant Controllers in the Bedrock IDE as follows:

1. Create or open a project with a single Controller. Make sure that the project includes a control program and control task.
2. In the Devices pane of the Bedrock IDE, right-click the Application node as shown in Figure 5-2. Select “Add Object…” and then “Redundancy Configuration”.

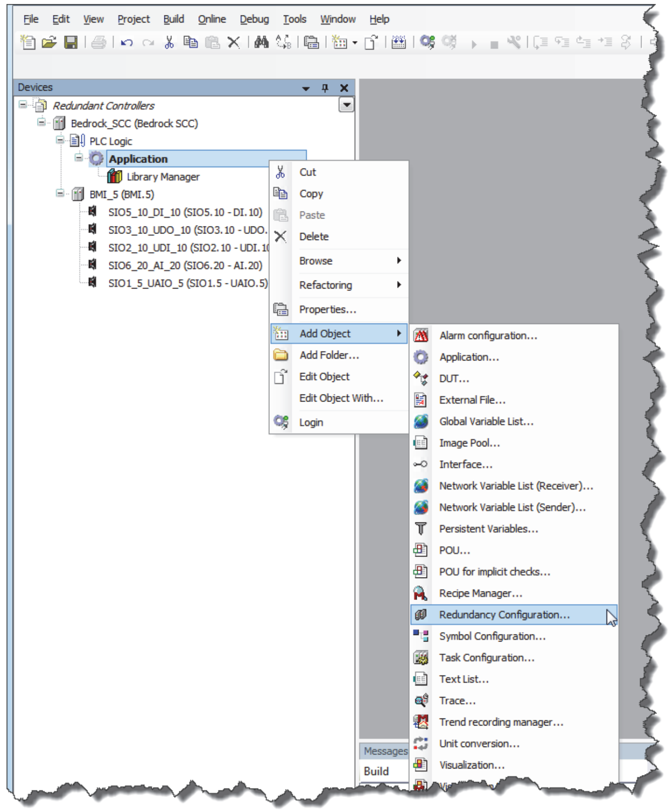


Figure 5-2 Select Redundancy Configuration

3. In the Add Redundancy Configuration Window, select the Add Button (Figure 5-3).

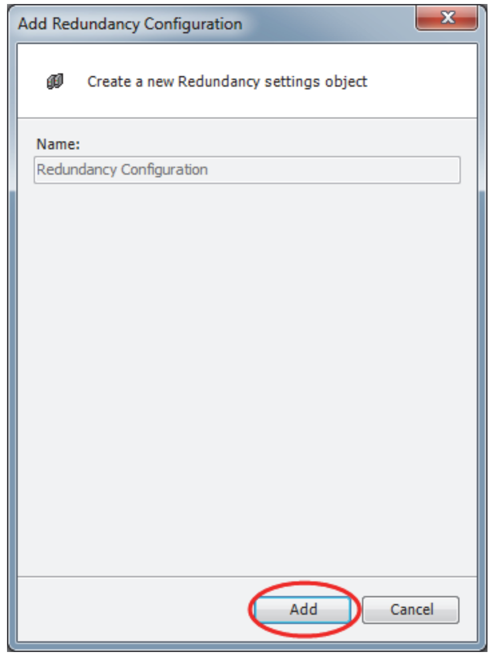


Figure 5-3 Add Button Selection

4. Verify that the Redundancy Configuration tab is displayed (Figure 5-4). Note that there is now a Redundancy Configuration node in the Devices pane. There is also a Redundancy State tab with a figure that depicts a redundant pair of Controllers. Each Controller (PLC) has its own set of buttons for managing the redundant pair.

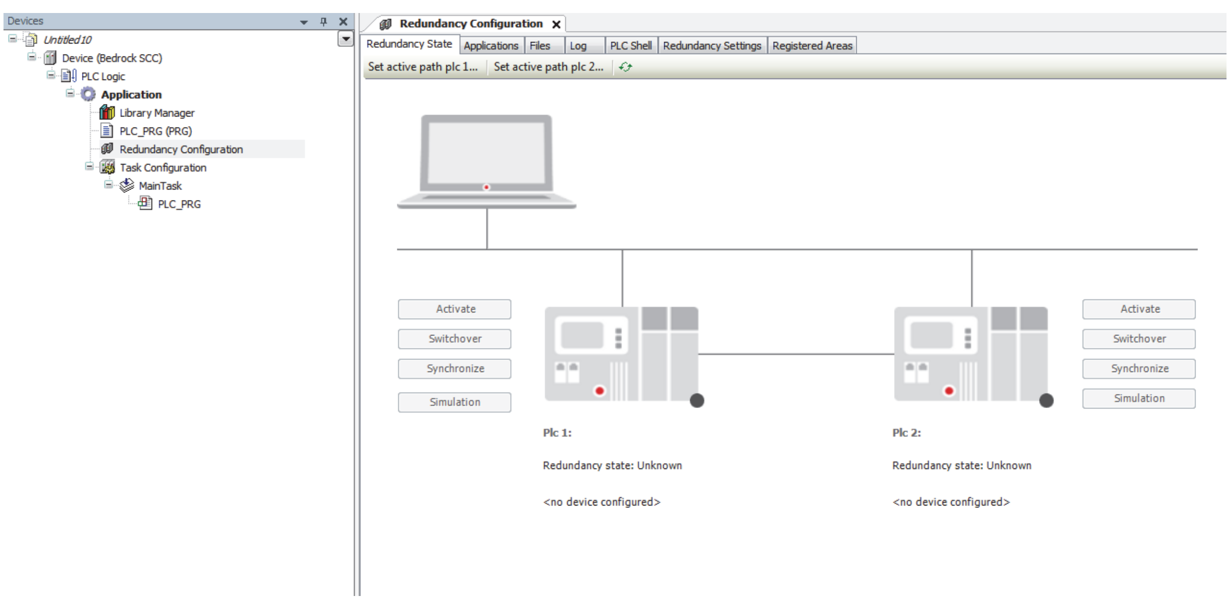


Figure 5-4 Redundancy Configuration Tab

5. On the Redundancy State tab (Figure 5-4), select the button labeled "Set active path plc 1…" to display the Device tab (Figure 5-5).

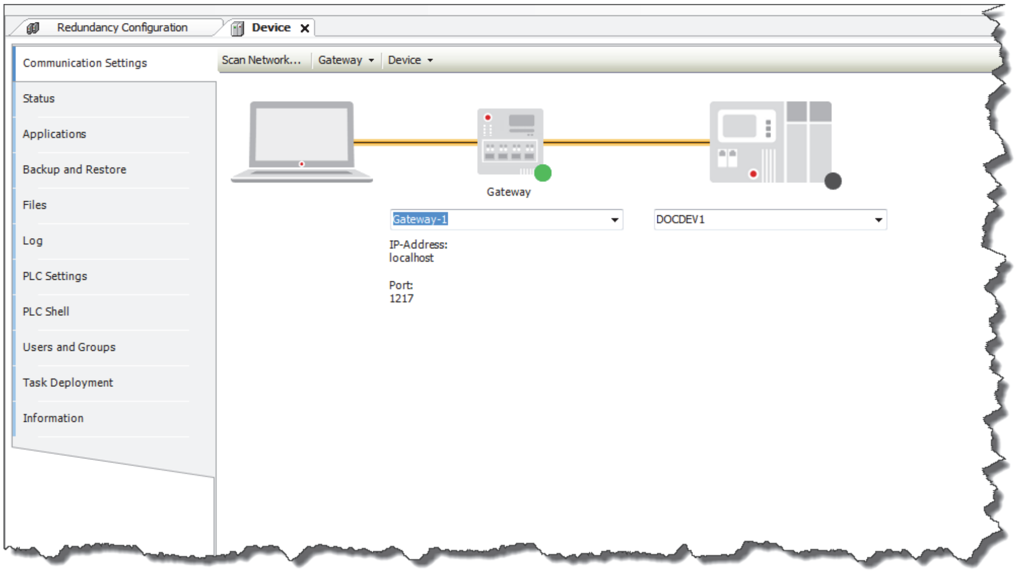


Figure 5-5 Device Tab

6. On the Device tab, select "Scan Network…"
7. In the Select Device window, select the SCC Controller that is in slot 1 of the BMI. Select OK. This will display Controller Information under the PLC graphic.
8. Select the Redundancy Configuration tab.
9. Select the button labeled "Set active path plc 2…".
10. Select the SCC Controller that is in slot 2 of the BMI. Select OK. This will display Controller Information under the PLC 2 graphic.
11. Select the Redundancy Settings tab.
12. Select the Common tab. The Common tab is shown in Figure 5-6.

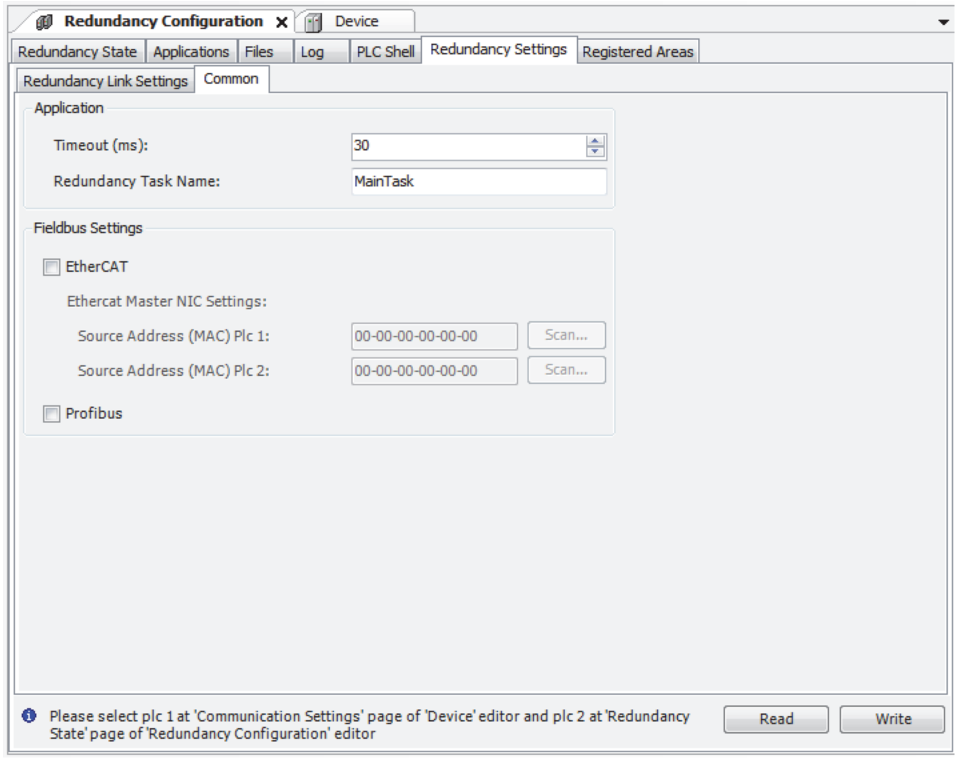


Figure 5-6 Common Tab

13. Enter the Redundancy Task Name. The Redundancy Task Name must be the same as the task name under the Task Configuration node in the Devices pane (e.g., “MainTask” in Figure 5-4).
14. Select the Write button. This will write the redundancy configuration to both SCC Controllers. The green progress bar in the lower right corner of the screen will show the progress of the write operation.
15. Select the Login button on the Bedrock IDE toolbar.
16. When prompted to download the application, select “Yes”. This will download the application only to PLC 1 (in slot 1).
17. Power cycle both SCC Controllers. When the boot process is complete, the status LED on the SCC Controller in slot 1 should be green and the status LED on the SCC Controller in slot 2 should be blue.
18. On the Redundancy State tab, select the Refresh button.
The Redundancy State for PLC 1 should be Active and display a green indicator. The Redundancy State for PLC 2 should be Passive and display a gray indicator.

The SCC Controllers should now be running as redundant Controllers.

During redundant operation, the control system will intentionally disable the OPC UA port to the Passive Controller so that HMI and SCADA systems only communicate with the Active Controller. The Bedrock IDE will still be able to communicate with both redundant Controllers.

Switching Controller Roles

In a redundant configuration, Controller roles can be switched as follows:

1. Ensure that the buttons on the Redundancy State tab are active by selecting the Refresh button.
2. Select the Switchover button for the Active Controller.

   The Redundancy State values will be reversed from their previous values.

   The status LEDs on the Controllers will change. The LED for the Active Controller will be green. The LED for the Passive Controller will be blue.

Stopping Control Programs

Perform the following steps to gracefully stop a control program on a redundant pair of Controllers.

1. Verify that PLC 1 is active. If PLC 2 is active, perform a switchover as described above.
2. Ensure that the buttons on the Redundancy State tab are active by selecting the Refresh button.
3. Select the Simulation button corresponding to the Passive Controller (PLC 2).

   The Controllers will change states. PLC 2 will transition to the Simulation state and PLC 1 will transition to the Standalone state.
4. Select the Login button on toolbar.
5. Select the Stop button on toolbar to stop the control program on the Standalone Controller (PLC 1).

Updating Control Programs

The following shows how to load new control programs on the Active Controller and then synchronize the Active and Passive Controllers.

1. Verify that PLC 1 is active.
2. Ensure that PLC 2 is in the Simulation state. If necessary, follow the procedure in the previous section. PLC 1 should be in the Standalone state.
3. Login to PLC 1 and download a new control program.
4. Select the Run button on the toolbar.

5. Select the Synchronize button corresponding to the Controller that is in the Simulation state.

Replacing Faulted Controllers in a Redundant System

This section describes how to replace a faulted Controller in a redundant system with a new Controller. Before placing the new Controller in the BMI that will be running the redundant configuration, place the new Controller in a separate BMI and ensure that the new Controller has the same configuration as the faulted Controller being replaced by verifying the following are correct:

- Controller name
- Controller IPv4 address
- firmware version

Perform the following steps:

1. Configure the Controller with the correct redundancy settings.
2. Select the Write button on the Redundancy Settings tab. A message will be displayed that the system was unable to write to a second PLC.
3. Plug the new Controller into the BMI that will host the redundant configuration.

Upgrading Firmware in Redundant Controllers

This section provides two methods for upgrading the firmware in a pair of redundant SCC Controllers. Note that some firmware releases may require a different sequence for updating the modules. Check the Errata List for a specific release before updating.

The first method describes how to upgrade the firmware while leaving both Controllers in the BMI.

1. Verify that PLC 1 is the Active Controller and PLC 2 is the Passive Controller.
2. Stop the control program on both Controllers using the process described in Stopping Control Programs. Note that the SCC Controllers should never be updated while running control code.
3. Perform the following actions on PLC 1:
    a. Upgrade the Boot New image on PLC 1.
    b. Wait for PLC 1 to reboot.
    c. Upgrade the Controller Application image on PLC 1.
    d. Wait for PLC 1 to reboot.
    e. Upgrade the Controller Boot Gold image on PLC 1.

f. Wait for PLC 1 to reboot.

g. Upgrade the Controller Bootloader image on PLC 1.

4. Perform the following actions on PLC 2:
    a. Upgrade the Controller Application image on PLC 2.
    b. Wait for PLC 2 to reboot.
    c. Upgrade the Controller Boot Gold image on PLC 2.
    d. Wait for PLC 2 to reboot.
    e. Upgrade the Controller Bootloader image on PLC 2.
    f. Wait for PLC 2 to reboot.
    g. Upgrade the Boot New image on PLC 2.

The second method can be used to perform full upgrades of each Controller individually followed by redundant configuration.

1. Verify that PLC 1is the Active Controller and PLC 2 is the Passive Controller.
2. Remove PLC 1 from the BMI.
3. Fully update PLC 2 in the BMI according to the standard upgrade instructions for a Standalone SCC Controller.
4. Remove PLC 2 and insert PLC 1 into its original slot in the BMI.
5. Fully update PLC 1 in the BMI according to the standard upgrade instructions for a Standalone SCC Controller.
6. Insert PLC 2 into its original slot in the BMI.
7. Configure the Controllers as a redundant pair according to the procedures provided in the beginning of this chapter.

SIO Module Introduction

Overview

The Secure Input/Output (SIO) modules provide the interface between field sensors, actuators, and the Bedrock Control System. SIO modules come in three basic types: analog, discrete, and communication modules. This section provides general information regarding SIO modules while later sections will provide more detailed information that is specific to each type of SIO module.

SIO modules are secured to the Backplane Magnetic Interconnect (BMI), which provides power and communication back to the Controller.

The Secure Power Module (SPM) provides power through the BMI to all the SIO modules. The BMI 10-slot and BMI 20- slot have provisions for redundant SPMs and Controllers.

Analog Modules

Bedrock Control System analog SIO modules are interface modules that convert analog signals to digital values for inputs and convert digital values to analog signals for outputs. These signals are processed by Bedrock Controllers for use in control system implementation.

Discrete Modules

Discrete input modules convert signals from user devices to the appropriate logic level for use within the processor. Typical input devices include:

- proximity switches
- limit switches
- selector switches
- float switches
- push button switches

Discrete output modules control the ON/OFF status of user devices. Typical output devices include:

- motor starters
- solenoids
- indicators

Communication Modules

SIO communication modules are designed to operate in industrial control environments for the purpose of providing a network or serial interface to smart devices.

Common Features

This section describes features that are shared by all SIO modules.

Physical Size

All SIO modules are the same size. Module dimensions are shown in millimeters in Figure 6-1.

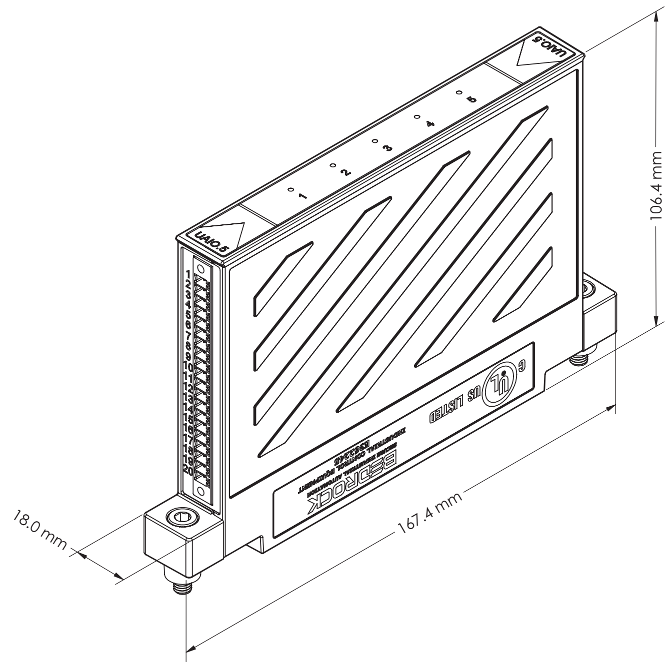


Figure 6-1 SIO Module Dimensions

Cables

All field connections to analog and discrete SIO modules are done via the Bedrock Universal Cable. The Bedrock Universal Cable is available in three fixed lengths as well as a custom length as follows:

- 1 meter
- 3 meters
- 5 meters
- the custom length cable is available in increments of one meter up to a maximum length of 30 meters.

Note

A Phoenix Contact 20-pin connector (Phoenix Contact P/N 1847301) is available for use in cases where the Bedrock Universal Cable is not being used with analog and discrete SIO modules.

Field connections to the SIO4.E communication module are done via standard Cat5 shielded Ethernet cables.

Field connections to the SIOS.5 communication module are done via the Bedrock SIOS.5 Serial Communication Cable.

Part numbers are listed in Appendix B, “Part Numbers”.

Configurable Software

All SIO modules are configured using the Bedrock IDE development and engineering software. Refer to the Bedrock IDE software on the Bedrock Control System workstation for more information.

The Bedrock Field Device Tool (FDT) is available for configuring SIO modules and smart field devices that support the HART Communication Protocol. See the “HART Device Configuration” chapter for more information.

Module Identification and Status Information

On the top of each SIO module is a label identifying the module, e.g., SIO5.10. On the side of each module is a label with a serial number and legacy information. All SIO modules have at least one tricolor LED to indicate module status. Some SIO modules have yellow channel status indicator LEDs. See individual SIO module descriptions and “Monitoring and Troubleshooting” in Chapter 12 for details.

SIO Communication to Controllers via Black Fabric

All SIO modules communicate with Controllers using the proprietary Black Fabric™ communication protocol. The protocol offers the following features:

- Full duplex communication
- Dedicated per slot communication between Controllers and SIO modules

See “Black Fabric Communication” in Chapter 4 for more details regarding SIO communication with Controllers.

SIO Analog Operation

The SIO Analog Operation section contains information relative to the operation of the analog input and output SIO modules.

Universal Analog Module (SIO1.5 - UAIO.5)

Introduction

The SIO1.5 is a five channel universal analog input/output module. The SIO1.5 power supply provides isolated power for each channel. Each channel has channel-to-channel and channel-to-ground galvanic isolation. The input types that the SIO1.5 can interface to are described in the "Bedrock Control System Overview".

Data Format

The data to and from the SIO1.5 to the Controller is 32-bit floating-point IEEE-754 format. The units depend on the sensor input type as shown in Table 7-1.

Table 7-1 SIO1.5 Data Format

Input Type	Units of Measure
4-20	mA
mV	mV
Thermocouple	°C
Thermocouple	°F
RTD	°C
RTD	°F
RTD	Ω

Software Configurable Options

The Bedrock IDE provides the ability to configure the following SIO1.5 features:

- 4-20 mA input with readback
- mV
- thermocouple or RTD type
- line frequencies
- conversion rates
- loop power source - internally powered or externally powered
- fail-safe mode

Parameters for the SIO1.5 that are configurable in the Bedrock IDE are shown in Figure 7-1 and summarized in Table 7-2.

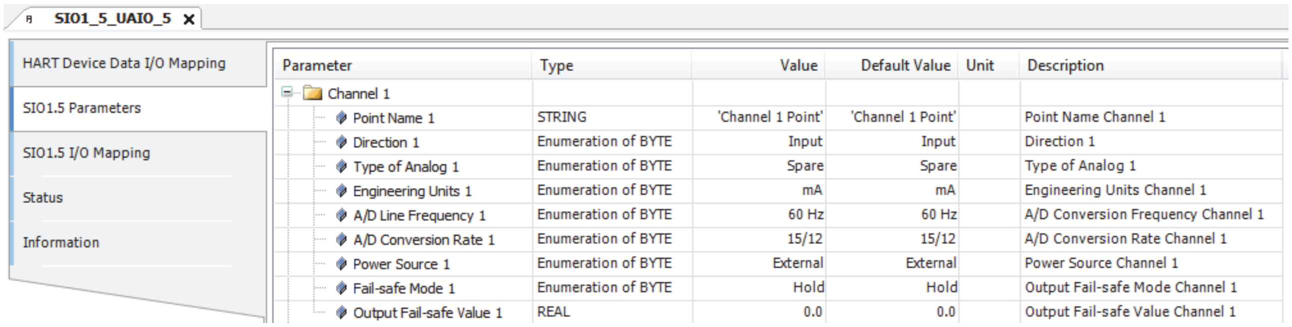


Figure 7-1 SIO1.5 Parameters in the Bedrock IDE

Table 7-2 SIO1.5 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Direction	Input or output
Type of Analog	Type of input sensor
Engineering Units	Input sensor units of measure
A/D Line Frequency	50 Hz or 60 Hz
A/D Conversion Rate	A/D Sampling rate. Each menu selection has a pair of values for 60 Hz and 50 Hz, respectively.
Power Source	Internal – power supplied by the SIO1.5 External – power received by the SIO1.5
Fail-safe Mode	Used in event of communication failure with the Controller. Fail-safe – Module output is set to a default fail-safe value. Hold – Module output is held at the current level
Output Fail-safe Value	Default fail-safe value if there is a communication failure with the Controller and Fail-safe mode is set to “Fail-safe”

Additional detail pertaining to SIO1.5 configuration parameters appears below.

SIO1.5 Input Options and Sensor Types

Table 7-3 lists the type of input sensors and the input range of those sensors available on the SIO1.5.

Table 7-3 SIO1.5 Input Sensor Types and Ranges

Sensor Type	Actual Input Range	Temp Range
4-20 mA with HART	1-24 mA	NA
4-20 mA without HART	1-24 mA	NA
Millivolt	±78.125 mV	NA
Thermocouple Type J	±78.125 mV	-210 - 760 °C
Thermocouple Type K	±78.125 mV	-200 - 500 °C
Thermocouple Type B	±78.125 mV	0 - 820 °C
Thermocouple Type E	±78.125 mV	-200 - 1000 °C
Thermocouple Type N	±78.125 mV	-200 - 1300 °C
Thermocouple Type R	±78.125 mV	-50 - 1200 °C
Thermocouple Type S	±78.125 mV	-50 - 1200 °C
Thermocouple Type T	±78.125 mV	-200 - 400 °C
3 or 4-wire RTD - Pt100 (USA and Europe)	0 to 450 Ω	-200 - 850 °C
3 or 4-wire RTD - Cu10	18 to 146 Ω	-200 - 120 °C
3 or 4-wire RTD - Ni120	0 to 450 Ω	-200 - 850 °C

Line Frequency Options

Line frequency options are configurable to accommodate different locales. The supported line frequency options for the SIO1.5 are:

- 50 Hz
- 60 Hz

Analog to Digital Sampling Rates

The analog to digital converter sampling rates and resolutions available for the SIO1.5 in the Bedrock IDE are shown in Table 7-4. The sampling rates available are dependent on the line frequency and are measured in samples per second (SPS).

Table 7-4 SIO1.5 A/D Sampling Rates and Resolutions

Sampling Rate (SPS) at 50 Hz Line Frequency	Sampling Rate (SPS) at 60 Hz Line Frequency	Resolution in Bits
8	10	20
12	15	20
25	30	20
50	60	19
100	120	19

Controller Update Rate

The Controller update rate for the SIO1.5 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

Power Source / RTD Excitation

4-20 mA Power Source Internal/External - The SIO1.5 can supply loop power to 2-wire transmitters, receive 4-20 mA signals from 4-wire transmitters, and provide 0.5 mA excitation for RTDs.

Over Range Detection

If the analog input or output circuitry detects out of range values, it sets the corresponding flags and clamps the values. See Table 7-5. These values are visible in the Bedrock IDE.

Table 7-5 SIO1.5 Over Range Flags

Value Type	Value	Channel Status Value
Input	clamped at 3.5 mA	0x0040 64 (decimal)
Input	clamped at 24.0 mA	0x0010 16 (decimal) If the input exceeds 24.9 mA, bit 2 will also be set, indicating that the ADC has become saturated. In this case, the status value will be as follows: 0x0014 20 (decimal)
Output	clamped at 3.0 mA	0x0044 68 (decimal)
Output	clamped at 24.0 mA	0x0014 20 (decimal)

Fail-safe Output Feature

The SIO1.5 has a fail-safe output feature that protects the module in the event of communication failure with the Controller. The fail-safe mode configuration parameter specifies if the output of the module will be set to a default fail-safe value or held at the current level. The fail-safe mode and the default fail-safe value are set using the Bedrock IDE. The fail-safe output feature is configured separately for each channel on the SIO1.5. The communication failure timeout value applies to the module and not individual channels. For information on configuring the fail-safe output feature, refer to the Bedrock IDE.

HART Revision 7

The SIO1.5 can communicate to smart field devices using the HART Communication Protocol. The module is a HART master device and supports HART Revision 7 software. See the “HART Device Configuration” chapter for information on configuration of HART devices in the Bedrock Control System.

Thermocouple Sense

The SIO1.5 has thermocouple break detection. It is checked by the SIO1.5 every 150 samples. If a break is detected, the module status LED for the appropriate channel will indicate a thermocouple integrity warning (eight green blinks) and set bit 2 (0x0004) of the status word in the Bedrock IDE.

Temperature Units

Temperature units can be set to degrees Celsius or degrees Fahrenheit.

Cold Junction Compensation

For channels configured for a thermocouple, a CJC unit must be installed in the channel. See Figure C-5 in Appendix C, "Wiring Diagrams and Pin Out Information" for details.

Accuracy Specifications

The SIO1.5 is accurate within ±0.015% of full-scale at 23°C. The CJC unit is accurate within ±0.8°C. The temperature coefficient of the SIO1.5 is 45 ppm /°C.

Simplified Circuit Diagram

Figure 7-2 shows a simplified circuit diagram of the SIO1.5.

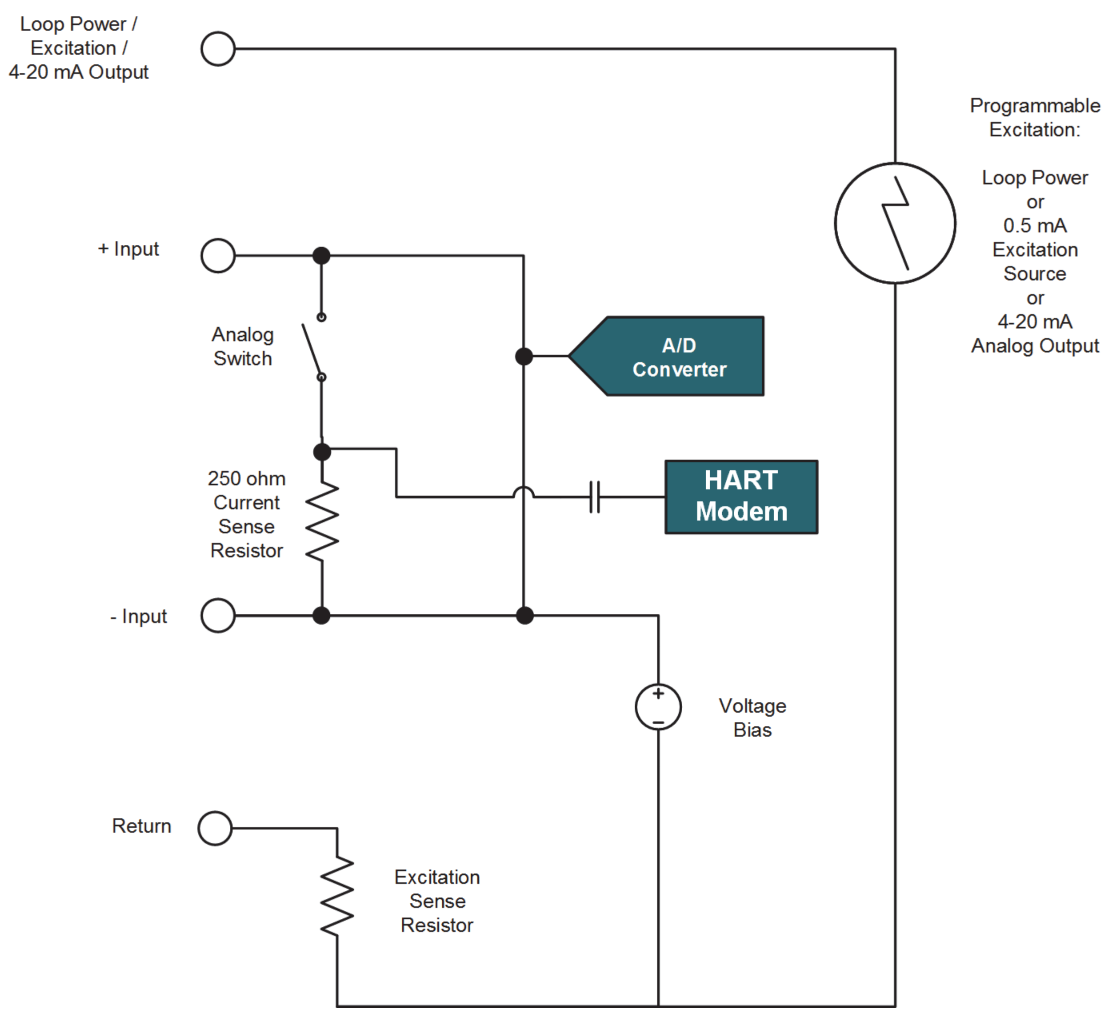


Figure 7-2 SI01.5 Simplified Circuit Diagram

Wiring the Module

See Appendix C, "Wiring Diagrams and Pin Out Information"for wiring information for the SIO1.5.

Module Fault and Status Indication

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIO1.5.

Analog 4-20 mA Input Module (SIO6.20 - AI.20)

Introduction

The SIO6.20 is a 20-channel 4-20 mA input module with HART. The channels are group isolated (two groups of ten channels).

Group Isolation

The SIO6.20 is a group isolated module. Each group of channels (1-10 and 11-20) share a common current path to the DC loop power supply. In order to prevent ground loops, a suitable current isolation module should be used to interface the SIO6.20 to 4-wire 4-20 mA transmitters.

Software Configurable Options

Parameters for the SIO6.20 that are configurable in the Bedrock IDE are shown in Figure 7-3 and summarized in Table 7-6.

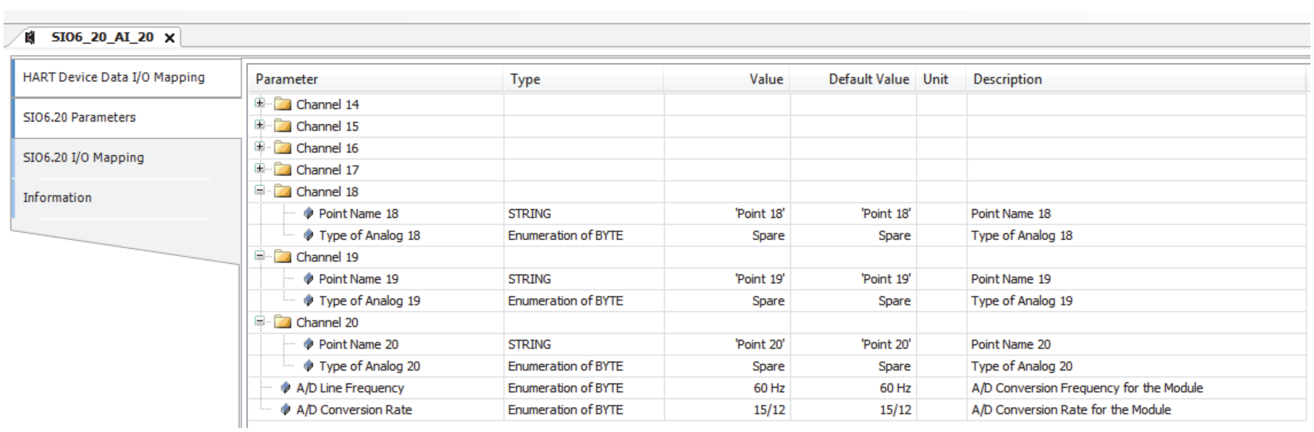


Figure 7-3 SIO6.20 Parameters in the Bedrock IDE

Table 7-6 SIO6.20 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Type of Analog	Type of input sensor
A/D Line Frequency	50 Hz or 60 Hz. Applies to the module.
A/D Conversion Rate	A/D Sampling rate. Each menu selection has a pair of values for 60 Hz and 50 Hz, respectively. Applies to the module.

Additional detail pertaining to operation of SIO6.20 modules and configuration parameters appears below.

Input Options

The input options available for the SIO6.20 are shown in Table 7-7.

Table 7-7 Input Options for SIO6.20

Option	Range	Actual
Input	4-20 mA	3.25 - 24 mA
Input	HART	HART

Line Frequency Options

Line frequency options are configurable to accommodate different locales. The supported line frequency options for the SIO6.20 are:

- 50 Hz
- 60 Hz

SIO6.20 Analog to Digital Sampling Rates

The analog to digital converter sampling rates for the SIO6.20 available in the Bedrock IDE are shown in Table 7-8. The sampling rates available are dependent on the line frequency and are measured in samples per second (SPS).

Table 7-8 SIO6.20 A/D Sampling Rates and Resolutions

Sampling Rate (SPS) at 50 Hz Line Frequency	Sampling Rate (SPS) at 60 Hz Line Frequency	Resolution in Bits
8	10	20
12	15	20
25	30	20
50	60	19
100	120	19

Channel (Point) Update Rate

The SIO6.20 multiplexes two analog to digital converters among 20 channels. One ADC is used for channels 1-10 and the other ADC is used for channels 11-20. The channel update rate for the SIO6.20 is configured by the sampling rate.

Use the following formula to calculate the channel update rate in milliseconds for any single channel:

channel_update_rate = (1000/sr) * NCC

sr = configured sampling rate
NCC = number of configured channels (1-10) for the ADC

Channels configured as “spare” are skipped during a scan and do not affect the update rate.

Controller Update Rate

The Controller update rate for the SIO6.20 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

Under/Over Range Detection

If the ADC senses input values outside the ranges stated in Table 7-9, it sets the corresponding status bit(s). These values are visible in the Bedrock IDE.

Table 7-9 SIO6.20 Over Range Flags

Value Type	Value	Channel Status Values
Input	clamped at 3.5 mA	0x0040 64 (decimal)
Input	clamped at 24.0 mA	0x0010 16 (decimal) If the input exceeds 24.9 mA, bit 2 will also be set, indicating that the ADC has become saturated. In this case, the status value will be as follows: 0x0014 20 (decimal)

HART Revision7

The SIO6.20 can communicate to smart field devices using the HART Communication Protocol. The module is a HART master device and supports HART Revision 7 software. See the “HART Device Configuration” chapter for information on configuration of HART devices in the Bedrock Control System.

Accuracy Specifications

The SIO6.20 is accurate within ±0.015% of full-scale at 23°C. The temperature coefficient is 45 ppm/°C.

Simplified Circuit Diagram

Figure 7-4 shows a simplified circuit diagram of one of the groups of ten channels on the SIO6.20.

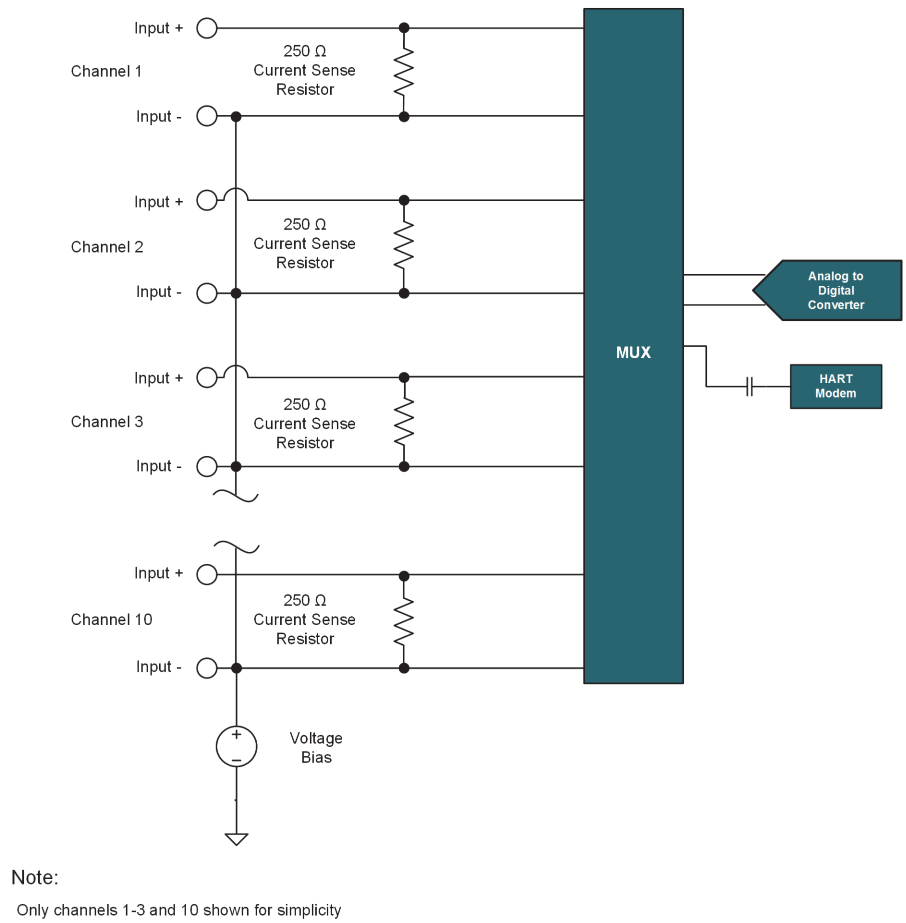


Figure 7-4 SI06.20 Input Channel

Wiring the Module

See Appendix C, “Wiring Diagrams and Pin Out Information” for wiring information for the SIO6.20.

Module Fault and Status Indication

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIO6.20.

Universal Input / Output Module (SIOU.10 - UIO.10)

Introduction

The SIOU.10 is a ten channel universal secure input/output module. Each channel has channel-to-channel and channel-to-ground galvanic isolation. Each channel on the SIOU.10 can be independently configured to operate in one of five modes. Depending upon the mode selected, SIOU.10 channels can interface to analog inputs and outputs with HART, discrete inputs and outputs, or NAMUR outputs. The available operating modes are discussed in the next section.

Operating Modes

Each SIOU.10 channel can be configured to operate in one of the modes listed below. The operating mode is selected using the Bedrock IDE.

- 4-20 mA input (loop power set to 25 mA) with HART and discrete input
- 4-20 mA output with readback with HART and discrete input
- 4-20 mA input (loop power set to 25 mA) and discrete input
- 4-20 mA output with readback and discrete input
- internally or externally powered discrete output with readback (excitation maximum current of 25 mA)
- NAMUR input
- 0-10 V voltage input

SIOU.10 channels may also be set to “Spare” in the Bedrock IDE for configurations where a channel is not being used.

Note the following regarding the SIOU.10 operating modes:

- When using 4-20 mA inputs or outputs with HART and a high frequency discrete input (greater than 500 Hz), separate channels should be used for HART and discrete input operation. Lower frequency discrete inputs can be configured to use the same channel with HART.
- When configured for 4-20 mA outputs, the read-back value shown in the Bedrock IDE will not change unless there is a connected load.
- Discrete outputs can be used to read back current up to 1 amp.

Simplified Circuit Diagram

Figure 7-5 shows a simplified circuit diagram of the SIOU.10.

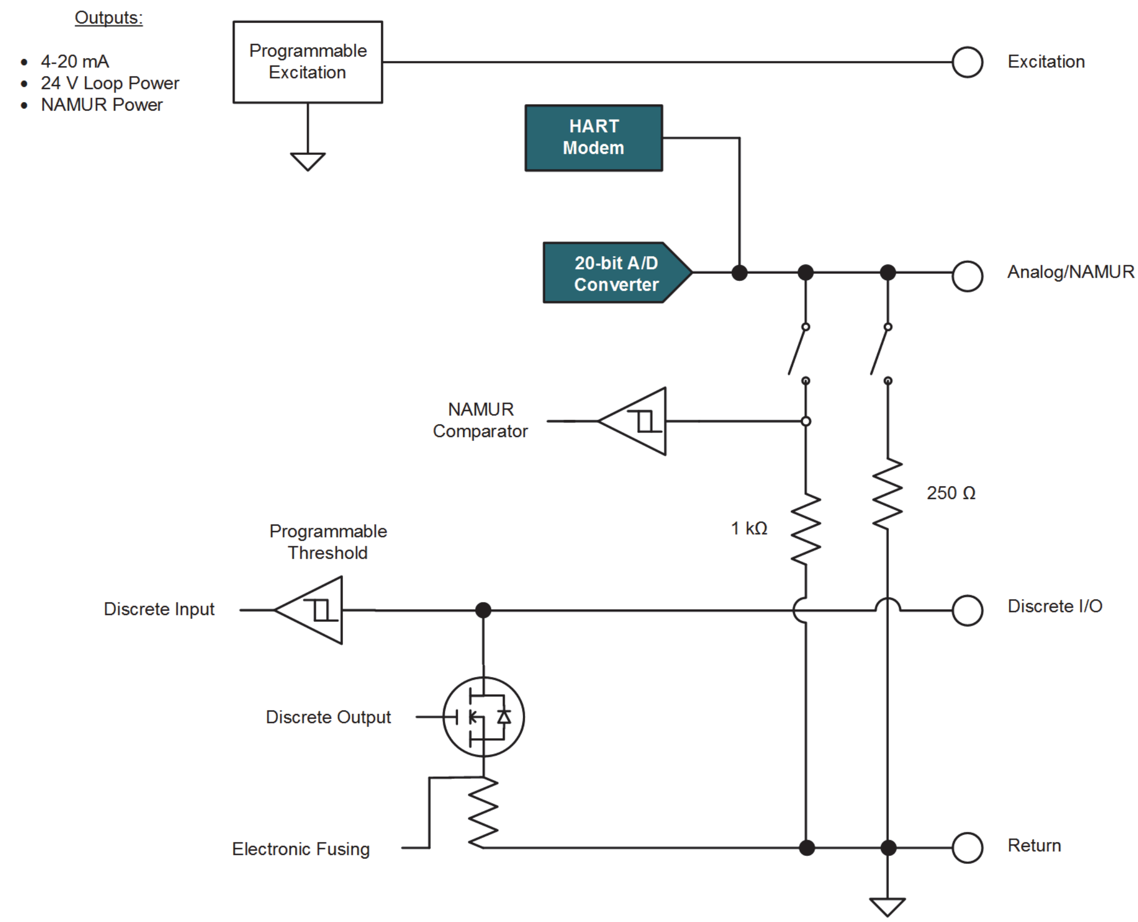


Figure 7-5 SIOU.10 Simplified Circuit Diagram

Analog Data Format

The analog data to and from the SIOU.10 to the Controller is 32-bit floating-point IEEE-754 format.

Analog Accuracy Specifications

See Table D-5 for information on the following SIOU.10 analog accuracy specifications:

- analog input accuracy for 4-20 mA inputs
- analog input accuracy for 10 V inputs (0-10 V)
- analog output accuracy
- temperature coefficient

HART Revision 7

The SIOU.10 can communicate to smart field devices using the HART Communication Protocol. The module is a HART master device and supports HART Revision 7 software. See the “HART Device Configuration” chapter for information on configuration of HART devices in the Bedrock Control System.

Discrete Output Switches

The output switch consists of a high-powered MOSFET capable of switching up to 1 amp at 30 V DC.

Electronic Fusing

When configured for discrete output, a channel can utilize an electronic fuse that will disable the channel if the current exceeds a programmable threshold up to 1 amp. Each channel’s electronic fuse can be configured to latch off or auto retry during an overcurrent condition. When the channel has been latched off, the channel must be disabled (turned off) to clear the fault condition. Channel faults can be detected in the Bedrock IDE by the XOR of the expected binary output value and the actual output value. A non-zero result of the XOR operation indicates a fault.

Discrete Outputs

When an SIOU.10 channel is configured to operate as a discrete output, the discrete output can be externally sourced or internally sourced. Internally sourced discrete outputs are ideal for driving solid state relays. A circuit diagram for an externally sourced discrete output is shown in Figure 7-6. A circuit diagram for an internally sourced discrete output is shown in Figure 7-7.

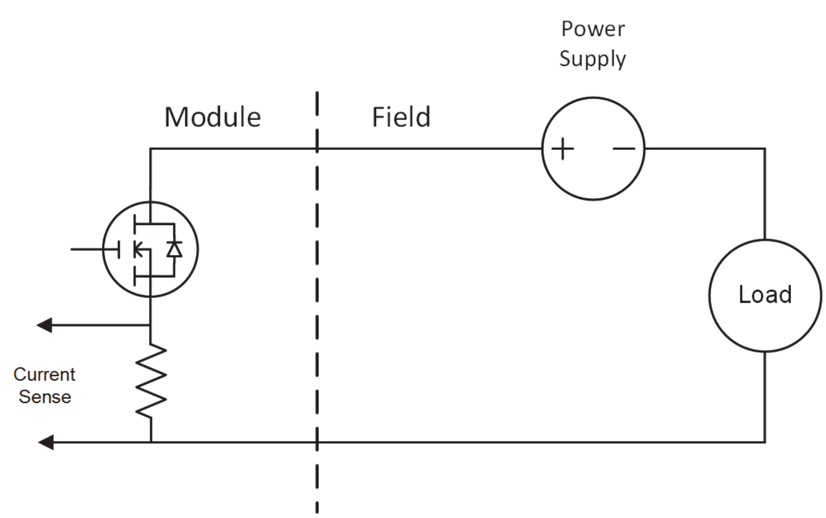


Figure 7-6 Externally Sourced Discrete Output

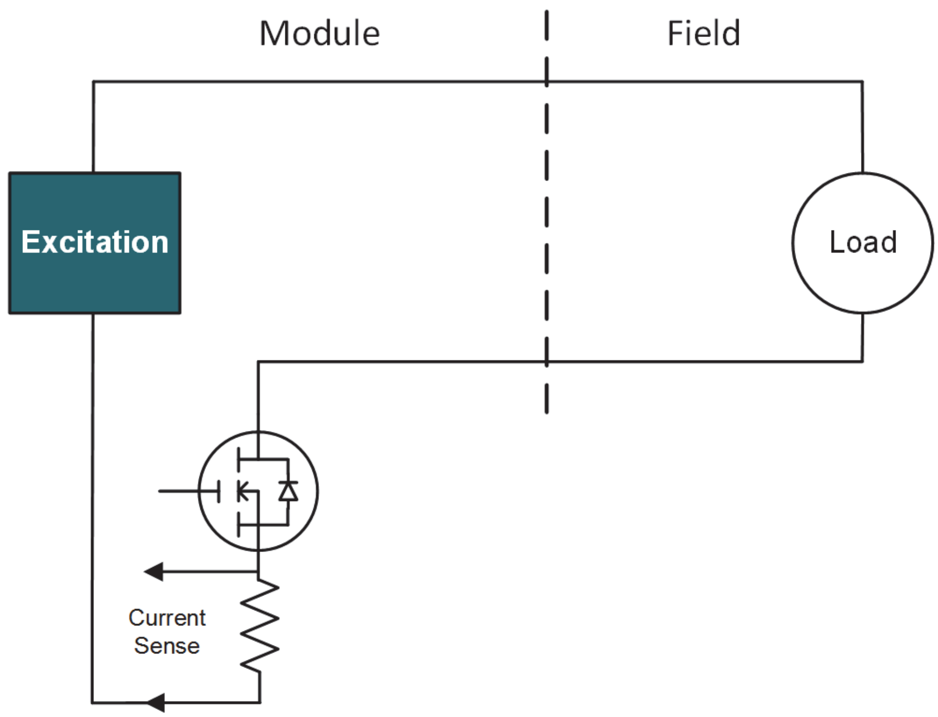


Figure 7-7 Internally Sourced Discrete Output

Discrete Output Accuracy

The discrete output current measurement is accurate to within 1.5% of full scale.

Recommended Practices

The following are recommended practices for use of the SIOU.10:

- External fusing is recommended for all discrete outputs.
- External surge protection is required across the load for inductive loads greater than 60 mH. A suppression circuit for DC loads is shown in Figure 7-8.

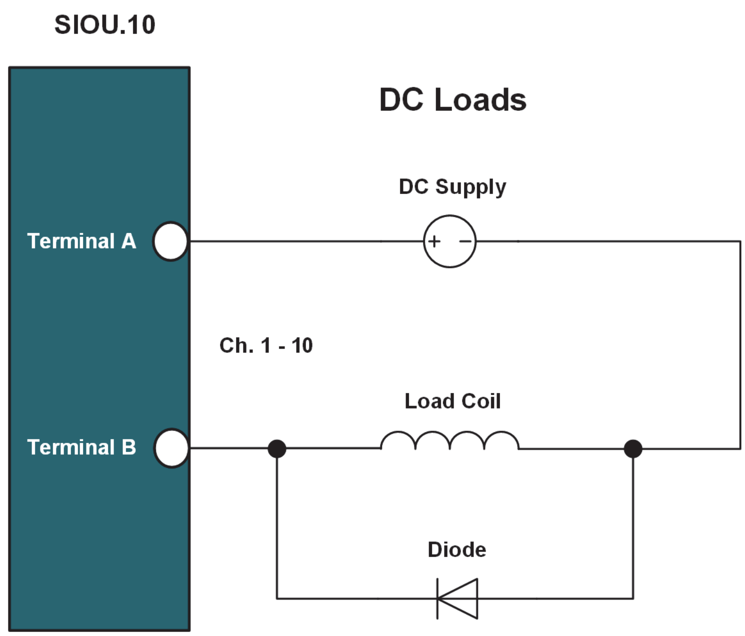


Figure 7-8 SIOU.10 Diode Suppression Circuit with DC Load

Frequency Measurement / Pulse Accumulation

Each discrete input channel is configurable for discrete on/off detection or the channel can be used for frequency measurement up to 100 kHz. Each channel can also be used for pulse accumulation. Up to 4 billion pulses can be captured. Pulses are captured on falling edges. Autoranging handles switching between frequency measurement and pulse accumulation.

NAMUR Input

The SIOU.10 can be configured to interface to a NAMUR output. A NAMUR output provides a low-level current to the SIOU.10 which will use the current level to determine if the signal represents an on or off condition or a sensor failure. NAMUR inputs are typically used in hazardous environments. See Table D-10 for NAMUR input specifications. Use the Mode parameter in the Bedrock IDE to configure the SIOU.10 for NAMUR input.

0-10 V Voltage Input

The SIOU.10 can be configured to accept a 0-10 V analog input. This configuration is set using the Mode parameter in the Bedrock IDE.

Software Configurable Options

Parameters for the SIOU.10 that are configurable in the Bedrock IDE are shown in Figure 7-9 and summarized in Table 7-10.

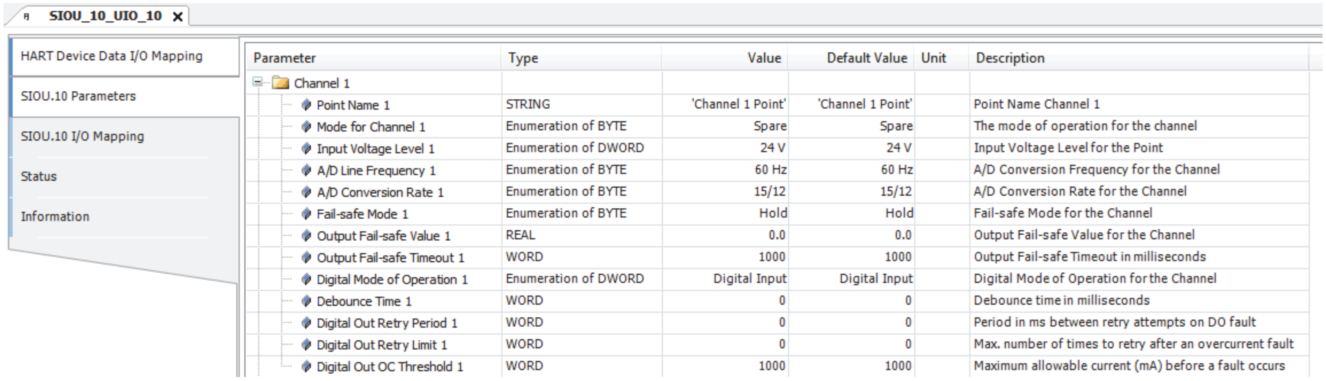


Figure 7-9 SIOU.10 Parameters in the Bedrock IDE

Table 7-10 SIOU.10 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Mode for Channel	Operating mode for the channel. See "Operating Modes" for a list of the SIOU.10 operating modes.
Input Voltage Level	Input voltage level for the module. The on and off thresholds are shown in Table 7-11 ***For modes supporting discrete input***
A/D Line Frequency	50 Hz or 60 Hz ***For mode supporting analog input***
A/D Conversion Rate	A/D Sampling rate. Each menu selection has a pair of values for 60 Hz and 50 Hz, respectively. ***For mode supporting analog input***
Fail-safe Mode	Used in event of communication failure with the Controller. Fail-safe – Module output is set to a default fail-safe value. Hold – Module output is held at the current level ***For modes supporting analog output or discrete output***
Output Fail-safe Value	Default fail-safe value if there is a communication failure with the Controller and Fail-safe mode is set to "Fail-safe" ***For modes supporting analog output or discrete output***
Output Fail-safe Timeout	Fail-safe timeout period in milliseconds. Configured for each SIOU.10 channel. ***For modes supporting analog output or discrete output***
Digital Mode of Operation	Mode of operation for discrete inputs and NAMUR inputs - Digital Input, Counter, or Frequency ***For modes supporting discrete input or NAMUR input***

Table 7-10 SIOU.10 Configurable Parameters

Parameter Name	Description
Debounce Time	Number of milliseconds (1-255) used for debounce filtering Set to zero for no debounce filtering ***For modes supporting discrete input or NAMUR input***
Digital Out Retry Period	Number of milliseconds (3-255) between retries in an overcurrent situation. This parameter is ignored if Digital Out Retry Limit is zero. ***For mode supporting discrete output***
Digital Out Retry Limit	Number of retries (up to 255) in an overcurrent situation. If set to zero, the channel stays latched off ***For mode supporting discrete output***
Digital Out OC Threshold	Maximum allowable current before a fault occurs. Specified in milliamps. ***For mode supporting discrete output***

Additional detail pertaining to SIOU.10 configuration parameters appears below.

Voltage Input Levels and Thresholds

Table 7-11 shows the input voltage levels that are selectable in the Bedrock IDE along with the corresponding thresholds for on and off voltage levels for each setting.

Table 7-11 SIOU.10 Input Voltage Settings and Thresholds

Input Voltage Setting	Off Voltage	On Voltage
5 V DC	2 V	4 V
12 V DC	6 V	8 V
24 V DC	12 V	14 V

SIOU.10 Input Options and Sensor Types

Table 7-12 lists the type of input sensors and the input range of those sensors available on the SIOU.10.

Table 7-12 SIOU.10 Input Sensor Types and Ranges

Sensor Type	Actual Input Range
4-20 mA	3.25-22 mA
0-10 V	0.1-12 V

Line Frequency Options

Line frequency options are configurable to accommodate different locales. The supported line frequency options for the SIOU.10 are:

- 50 Hz
- 60 Hz

Analog to Digital Sampling Rates

The analog to digital converter sampling rates and resolutions available for the SIOU.10 in the Bedrock IDE are shown in Table 7-13. The sampling rates available are dependent on the line frequency and are measured in samples per second (SPS).

Table 7-13 SIOU.10 A/D Sampling Rates and Resolutions

Sampling Rate (SPS) at 50 Hz Line Frequency	Sampling Rate (SPS) at 60 Hz Line Frequency	Resolution in Bits
8	10	20
12	15	20
25	30	20
50	60	19
100	120	19

Controller Update Rate

The Controller update rate for the SIOU.10 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

Over Range Detection

If the analog input or output circuitry detects out of range values, it sets the corresponding flags and clamps the values. See Table 7-14. These values are visible in the Bedrock IDE.

Table 7-14 SIOU.10 Over Range Flags

Value Type	Value	Channel Status Value
Input	clamped at 3.5 mA	0x0040 64 (decimal)
Input	clamped at 24.0 mA	0x0010 16 (decimal) If the input exceeds 24.9 mA, bit 2 will also be set, indicating that the ADC has become saturated. In this case, the status value will be as follows: 0x0014 20 (decimal)
Output	clamped at 3.0 mA	0x0044 68 (decimal)
Output	clamped at 24.0 mA	0x0014 20 (decimal)

Fail-safe Output Feature

The SIOU.10 has a fail-safe output feature that protects the module in the event of communication failure with the Controller. If no communication is received from the Controller within the configured fail-safe timeout period and the fail-safe mode configuration parameter is set to “Fail-safe”, the output for each channel will be set to either a configured fail-safe value or held at the current level.

The fail-safe mode, default output fail-safe value, and fail-safe timeout period are set using the Bedrock IDE. All fail-safe parameters are configured separately for each channel on the SIOU.10.

Digital Mode of Operation

The SIOU.10 can be configured for one of the digital modes of operation listed in Table 7-15. These settings are applicable when the SIOU.10 operating mode is configured for one of the discrete input modes or for NAMUR input. The recommended digital mode of operation is affected by the input frequency. The table shows the recommended modes for the listed input frequencies.

Table 7-15 SIOU.10 Recommended Modes of Operation

Input Frequency	Recommended Digital Mode of Operation	Description
< 100 Hz	Digital Input	standard digital input with a debounce filter
> 100 Hz	Counter	high-speed counter
> 100 Hz	Frequency	frequency measurement

Note that regardless of the mode selected, the digital, counter, and frequency values will all update in the Bedrock IDE. The most accurate value will be the one corresponding to the selected mode.

Debounce Filter

The SIOU.10 has a programmable debounce filter. The debounce filter can be set to values of 0-255 milliseconds. If the filter is set to zero milliseconds, no debounce filtering will occur. A non-zero value specifies the number of milliseconds used for debounce filtering. See Figure 8-2 for a timing diagram for the debounce filter.

Overcurrent Retry

After an overcurrent situation occurs in discrete output mode, each channel can either stay latched off or back-off and retry. Use the Bedrock IDE to specify the overcurrent threshold (maximum current allowed before a fault occurs), number of retries, and time period between retries. A channel will stay latched off if the retry limit is set to zero.

The overcurrent response time is three milliseconds.

Wiring the Module

See Appendix C, “Wiring Diagrams and Pin Out Information”for wiring information for the SIOU.10.

Module Fault and Status Indication

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIOU.10.

SIO Discrete Operation

The SIO Discrete Operation chapter contains information relative to the operation of the discrete input and output SIO modules.

Universal Discrete Input Module (SIO2.10 - UDI.10)

Introduction

The SIO2.10 is a 10-channel discrete input module. Each channel is configured for AC or DC inputs. DC inputs can be turned on by negative or positive DC voltages. The on and off thresholds are software configurable. Each channel is galvanically isolated from each other and ground.

Software Configurable Options

Parameters for the SIO2.10 that are configurable in the Bedrock IDE are shown in Figure 8-1 and summarized in Table 8-1.

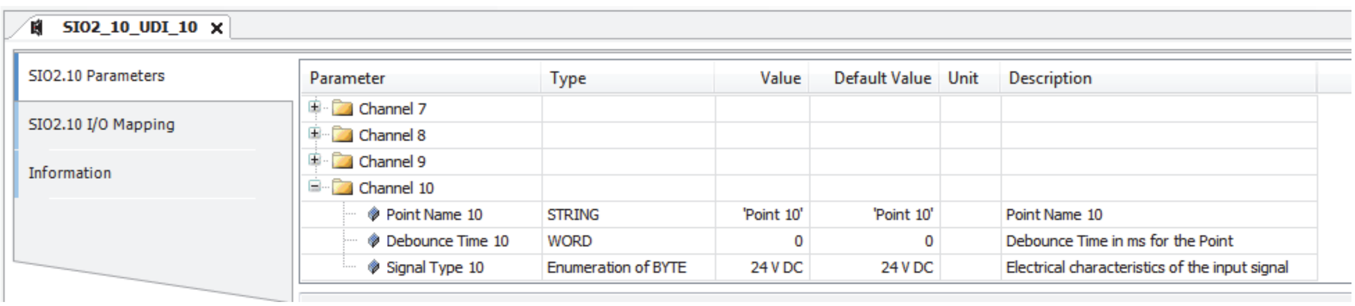


Figure 8-1 SIO2.10 Parameters in the Bedrock IDE

Table 8-1 SIO2.10 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Debounce Time	Number of milliseconds (1-255) used for debounce filtering Set to zero for no debounce filtering
Signal Type	AC or DC input range for the SIO2.10

Additional detail pertaining to SIO2.10 configuration parameters appears below.

Debounce Filter

The SIO2.10 has a programmable debounce filter. The debounce filter can be set to values of 0-255 milliseconds. If the filter is set to zero milliseconds, no debounce filtering will occur. A non-zero value specifies the number of milliseconds used for debounce filtering. A timing diagram for the debounce filter is shown in Figure 8-2.

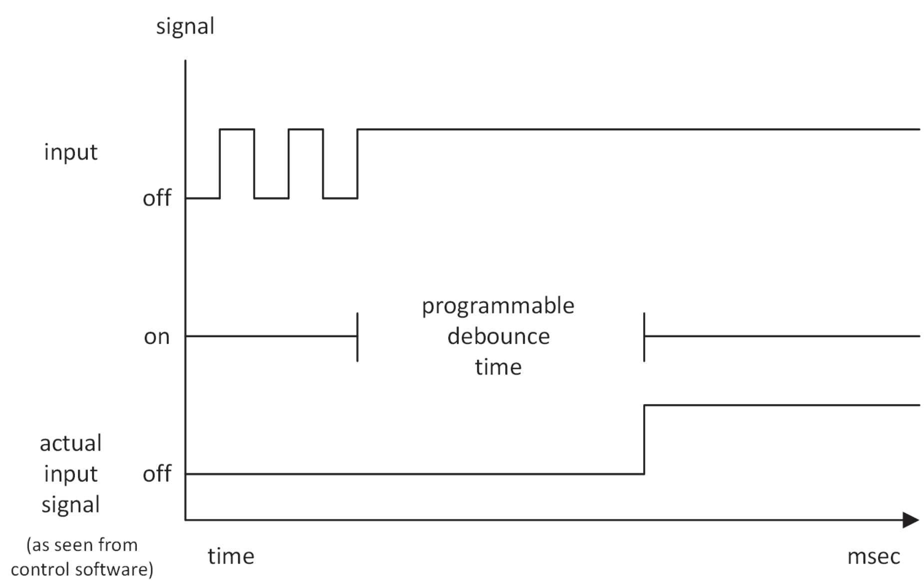


Figure 8-2 Debounce Filter Timing Diagram

Voltage Input Range

The voltage input ranges for the SIO2.10 are shown in Table 8-2.

Table 8-2 SIO2.10 Voltage Input Ranges

AC Inputs	DC Inputs
24 V AC	24 V DC
48 V AC	48 V DC
120 V AC	120 V DC
240 V AC	240 V DC

Controller Update Rate

The Controller update rate for the SIO2.10 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

Simplified Input Circuit

Figure 8-3 shows a simplified circuit diagram of the SIO2.10.

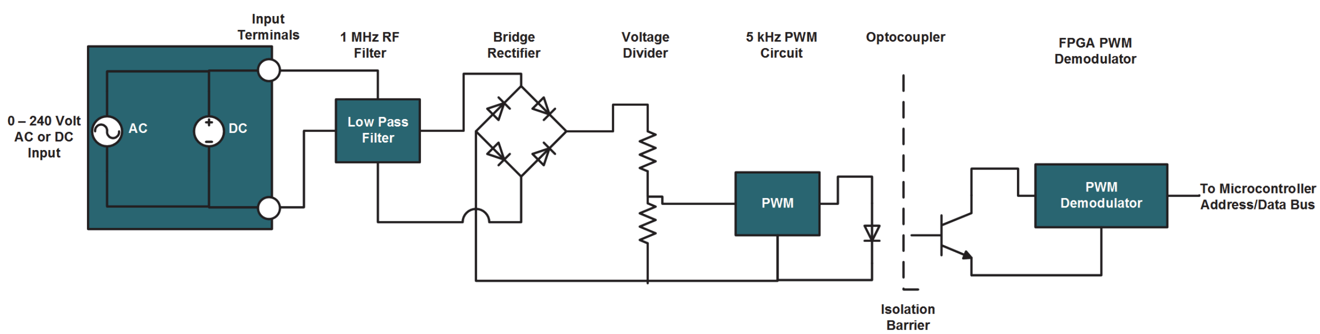


Figure 8-3 SIO2.10 Simplified Input Circuit

Wiring the Module

See Appendix C, “Wiring Diagrams and Pin Out Information” for wiring information for the SIO2.10.

Module Fault and Status Indication

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIO2.10.

Universal Discrete Output Module (SIO3.10 - UDO.10)

Introduction

The SIO3.10 is a 10-channel discrete output module. Each channel is galvanically isolated from each other and ground. The SIO3.10 can accept both positive and negative DC voltages.

Output Switches

The output switch consists of a pair of high-power MOSFETs capable of switching up to 1.66 amps at 240 V AC or DC.

Electronic Fusing

Each channel has an electronic fuse that disables the channel if the current is 2.5 amps or greater. Each channel's electronic fuse can be configured to latch off or auto retry during an overcurrent condition. When the channel has been latched off, the channel must be disabled (turned off) to clear the fault condition. Channel faults can be detected in the Bedrock IDE by the XOR of the expected output value and actual output value. A non-zero result of XOR operation indicates a fault.

Software Configurable Features

The following are SIO3.10 features that are configurable using the Bedrock IDE.

Overcurrent Retry

After an overcurrent situation occurs, each channel can either stay latched off or back-off and retry. The Bedrock IDE uses the following parameters for configuration of back-off and retry. See Table 8-3 for parameter descriptions.

- Digital Out Retry Limit
- Digital Out Retry Period

The overcurrent response time is one millisecond.

Fail-safe Output Feature

The SIO3.10 has a fail-safe output feature that allows the user to specify the module's output values in the event of a communication failure with the Controller. If no communication is received from the Controller within the configured timeout period, the output of each channel on the SIO3.10 will be set to either a configured fail-safe value or held at the current level. The Bedrock IDE uses the following parameters for configuration of the fail-safe output feature. See Table 8-3 for parameter descriptions.

- Fail-safe Mode
- Fail-safe Value
- Fail-safe Timeout

The fail-safe mode and fail-safe value are configured separately for each channel. The communication failure timeout value applies to the module and not the individual channels.

Controller Update Rate

The Controller update rate for the SIO3.10 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

SIO3.10 IDE Parameters

Bedrock IDE parameters for overcurrent retry and fail-safe output are shown in Figure 8-4 and summarized in Table 8-3. All parameters are configured separately for each channel on the SIO3.10 except where noted.

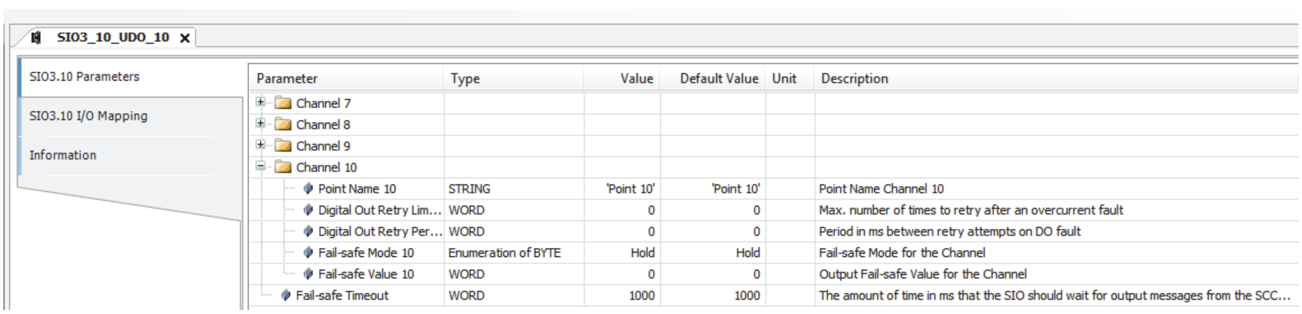


Figure 8-4 SIO3.10 Parameters in the Bedrock IDE

Table 8-3 SIO3.10 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Digital Out Retry Limit	Number of retries (up to 255) in an overcurrent situation. If set to zero, the channel stays latched off.
Digital Out Retry Period	Number of milliseconds (1-255) between retries in an overcurrent situation. The parameter is ignored if Digital Out Retry Limit is zero.
Fail-safe Mode	Used in event of communication failure with the Controller. Set to one of the following: Fail-safe – Module output is set to a default fail-safe value. Hold – Module output is held at the current level

Table 8-3 SIO3.10 Configurable Parameters

Parameter Name	Description
Fail-safe Value	Default fail-safe value if there is a communication failure with the Controller and Fail-safe Mode is set to “Fail-safe”
Fail-safe Timeout	Amount of time in milliseconds that the SIO should wait for output messages from the Controller before entering fail-safe mode. The timeout value applies to all channels on the module and cannot be set for individual channels. Enter 10-65535 ms.

Simplified Output Circuit

Figure 8-5 shows a simplified circuit diagram of the SIO3.10.

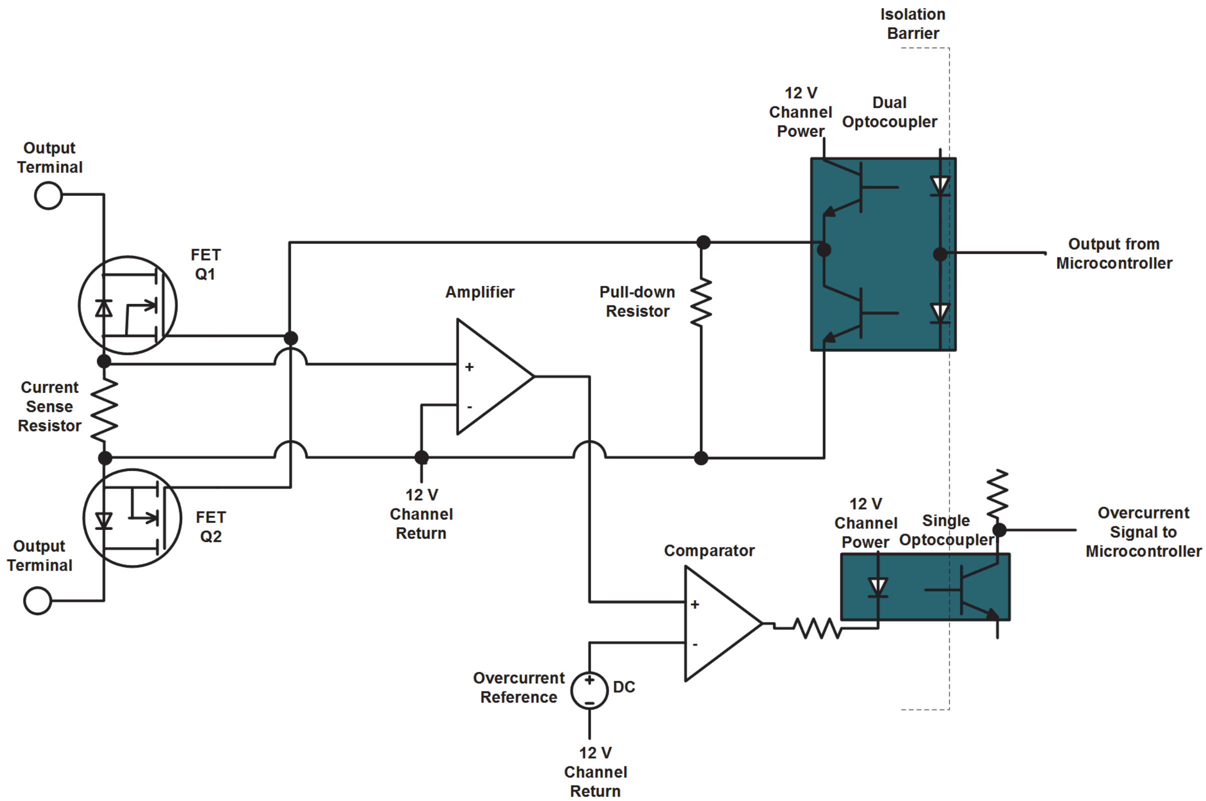


Figure 8-5 SIO3.10 Simplified Output Circuit

Wiring the Module

See Appendix C, "Wiring Diagrams and Pin Out Information" for wiring information for the SIO3.10.

Module Fault and Status Indication

See Appendix G, "SPM and SIO Blink Code Summary" for the list of blink codes used to indicate module status for the SIO3.10.

Recommended Practices

The following are recommended practices for use of the SIO3.10:

- External fusing is recommended for all outputs.
- External surge protection is required across the load for inductive loads greater than 50 mH. Suppression circuits for AC and DC loads are shown in Figure 8-6 and Figure 8-7, respectively.

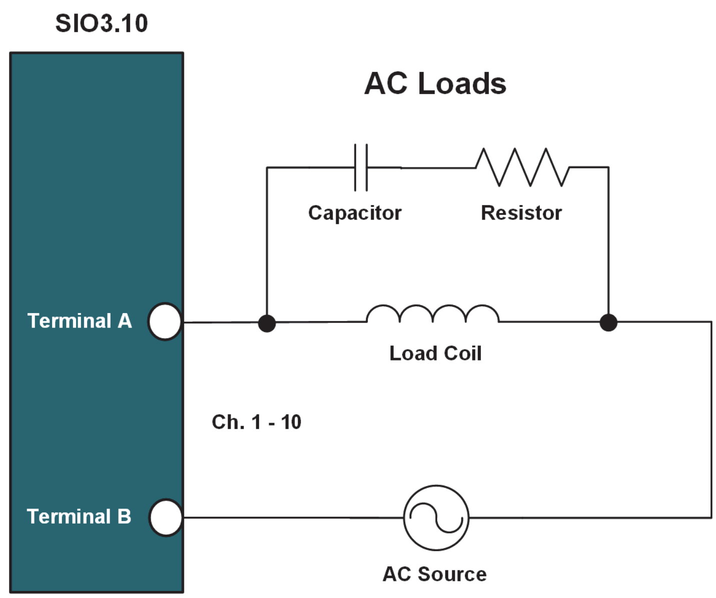


Figure 8-6 SIO3.10 Suppression Circuit with AC Load

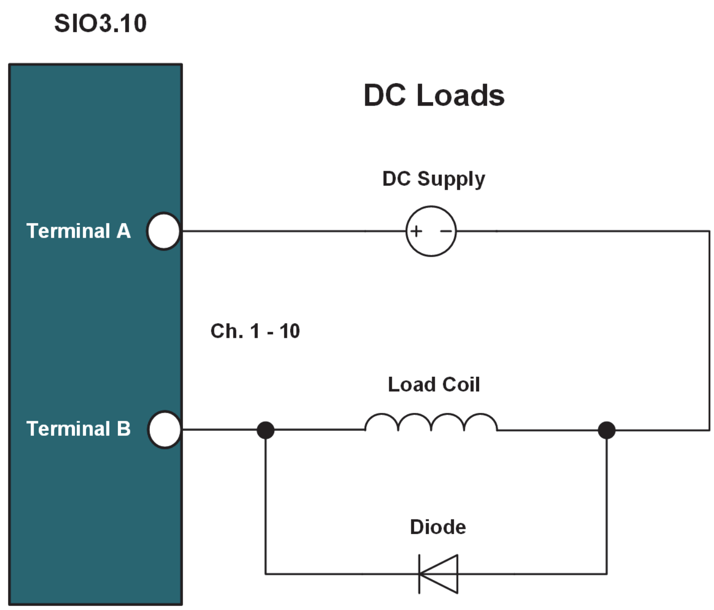


Figure 8-7 SIO3.10 Suppression Circuit with DC Load

High-Speed Discrete Input Module (SIO5.10 - DI.10)

Introduction

The SIO5.10 is a 10-channel high-speed discrete input module. Each channel is configurable for voltage monitor or contact closure. Each channel can measure frequency or perform pulse accumulation.

Frequency Measurement / Pulse Accumulation

Each channel is configurable for discrete on/off detection or the channel can be used for frequency measurement up to 100 kHz. Each channel can also be used for pulse accumulation. Up to 4 billion pulses can be captured. Pulses are captured on falling edges. Autoranging handles switching between frequency measurement and pulse accumulation.

Software Configurable Options

Parameters for the SIO5.10 that are configurable in the Bedrock IDE are shown in Figure 8-8 and summarized in Table 8-4.

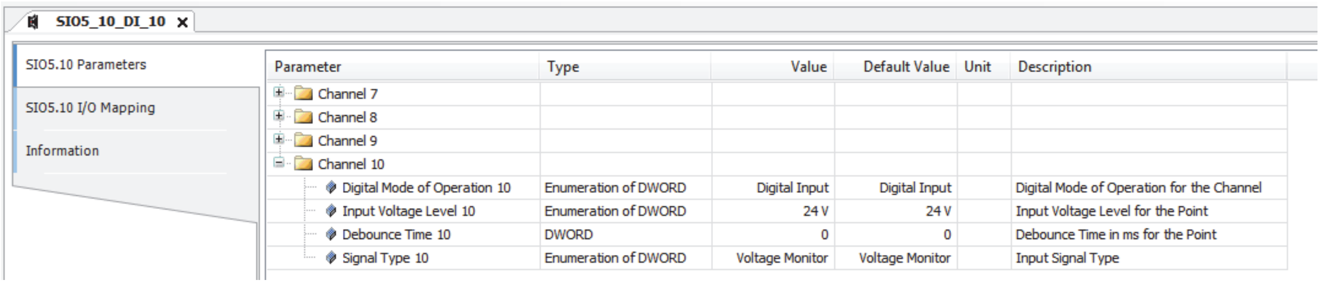


Figure 8-8 SIO5.10 Parameters in the Bedrock IDE

Table 8-4 SIO5.10 Configurable Parameters

Parameter Name	Description
Digital Mode of Operation	Mode of operation for discrete inputs - Digital Input, Counter, or Frequency
Input Voltage Level	Input voltage level for the module. The threshold for which the module is on is half the input voltage.
Debounce Time	Number of milliseconds (1-255) used for debounce filtering Set to zero for no debounce filtering
Signal Type	Voltage monitor or Contact Sense

Additional detail pertaining to SIO5.10 configuration parameters appears below.

Digital Mode of Operation

The SIO5.10 can be configured for one of the digital modes of operation listed in Table 8-5. The recommended digital mode of operation is affected by the input frequency. The table shows the recommended modes for the listed input frequencies.

Table 8-5 SIO5.10 Recommended Modes of Operation

Input Frequency	Recommended Digital Mode of Operation	Description
< 100 Hz	Digital Input	standard digital input with a debounce filter
> 100 Hz	Counter	high-speed counter
> 100 Hz	Frequency	frequency measurement

Note that regardless of the mode selected, the digital, counter, and frequency values will all update in the Bedrock IDE. The most accurate value will be the one corresponding to the selected mode.

Debounce Filter

The SIO5.10 has a programmable debounce filter. The debounce filter can be set to values of 0-255 milliseconds. If the filter is set to zero milliseconds, no debounce filtering will occur. A non-zero value specifies the number of milliseconds used for debounce filtering. See Figure 8-2 for a timing diagram for the debounce filter.

Voltage Input Range

The voltage input ranges and thresholds for the SIO5.10 are shown in Table 8-6. The threshold for which the module is on is half the input voltage.

Table 8-6 SIO5.10 Voltage Input Ranges and Thresholds

Voltage Input	Threshold
5 V DC	2.5 V DC
12 V DC	6 V DC
24 V DC	12 V DC

Controller Update Rate

The Controller update rate for the SIO5.10 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

Voltage Monitor or Contact Sense

A voltage monitor or contact sense with a 24 V wetting voltage is configurable on a channel by channel basis.

Simplified Input Circuit

Figure 8-9 shows a simplified circuit diagram of the SIO5.10.

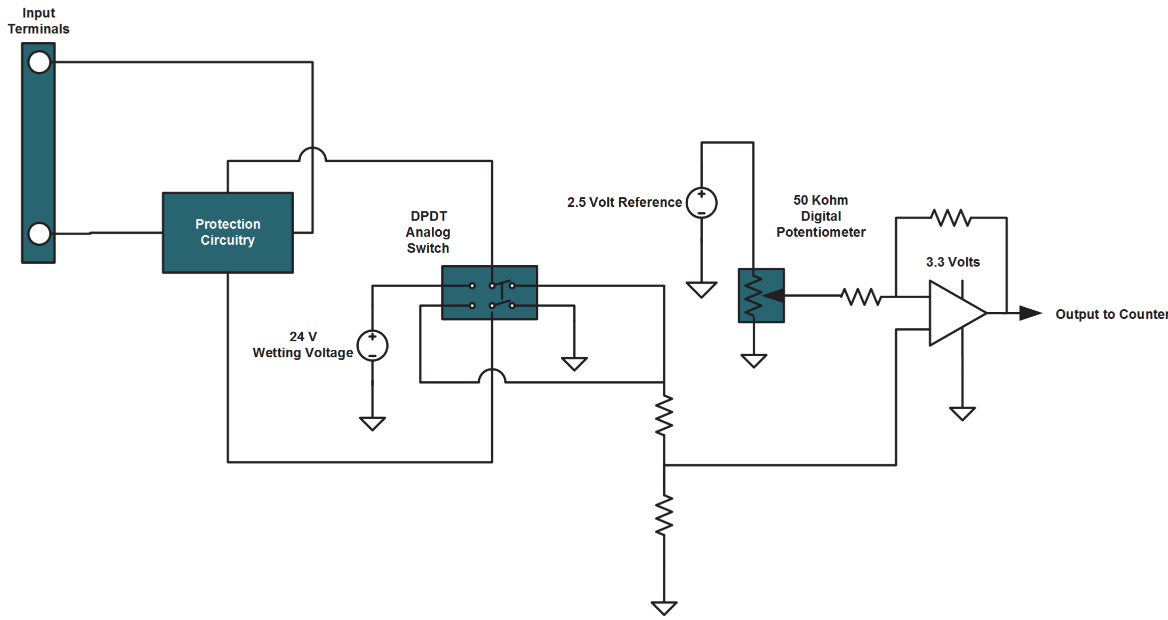


Figure 8-9 SIO5.10 Simplified Input Circuit

Wiring the Module

See Appendix C, “Wiring Diagrams and Pin Out Information”for wiring information for the SIO5.10.

Module Fault and Status Information

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIO5.10.

Discrete Input Module (SIO7.20 - DI.20)

Introduction

The SIO7.20 is a 20-channel discrete input module. Each channel is configured for AC or DC inputs. DC inputs can be turned on by negative or positive DC voltages. Each channel is galvanically isolated from each other and ground.

Software Configurable Options

Parameters for the SIO7.20 that are configurable in the Bedrock IDE are shown in Figure 8-10 and summarized in Table 8-7.

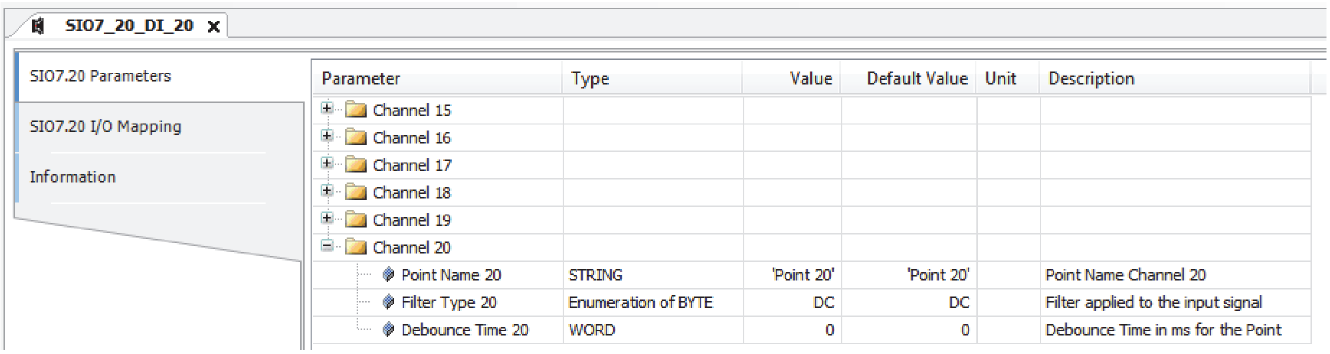


Figure 8-10 SIO7.20 Parameters in the Bedrock IDE

Table 8-7 SIO7.20 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Filter Type	Specifies input type for the module. AC or DC.
Debounce Time	Number of milliseconds (1-255) used for debounce filtering Set to zero for no debounce filtering

Additional detail pertaining to SIO7.20 configuration parameters appears below.

Debounce Filter

The SIO7.20 has a programmable debounce filter. The debounce filter can be set to values of 0-255 milliseconds. If the filter is set to zero milliseconds, no debounce filtering will occur. A non-zero value specifies the number of milliseconds used for debounce filtering. See Figure 8-2 for a timing diagram for the debounce filter.

DC Voltage Input Range

The DC voltage input range for the SIO7.20 is fixed. The guaranteed off threshold is ±7 volts. The guaranteed on threshold is ±20 volts. The on and off thresholds for the SIO7.20 are represented in Figure 8-12. The maximum DC voltage for the SIO7.20 is 60 V DC.

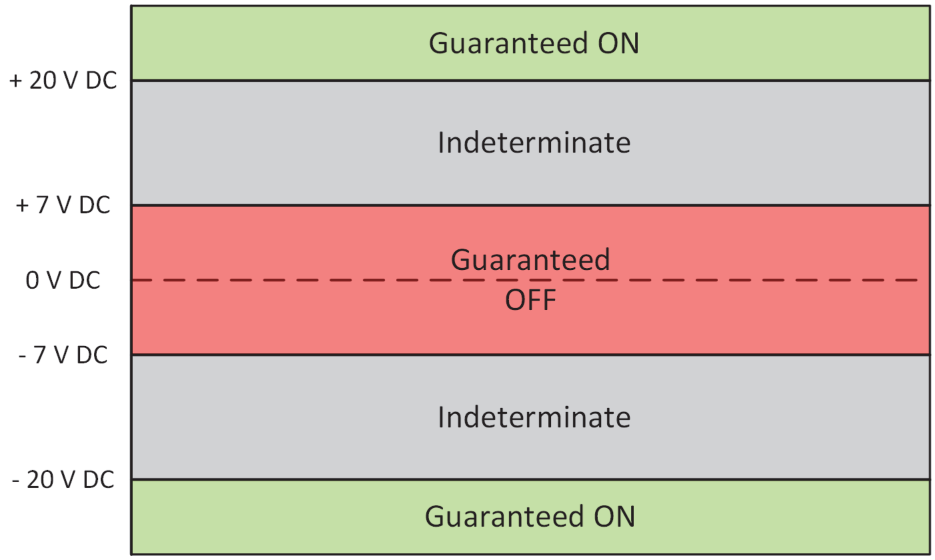


Figure 8-11 SIO7.20 DC Voltage Thresholds

AC Voltage Input Range

The AC voltage input range for the SIO7.20 is fixed. The guaranteed off threshold is ±5.0 volts. The guaranteed on threshold is ±14.1 volts. The on and off thresholds for the SIO7.20 are represented in Figure 8-12. The maximum AC voltage for the SIO7.20 is 42.4 V AC.

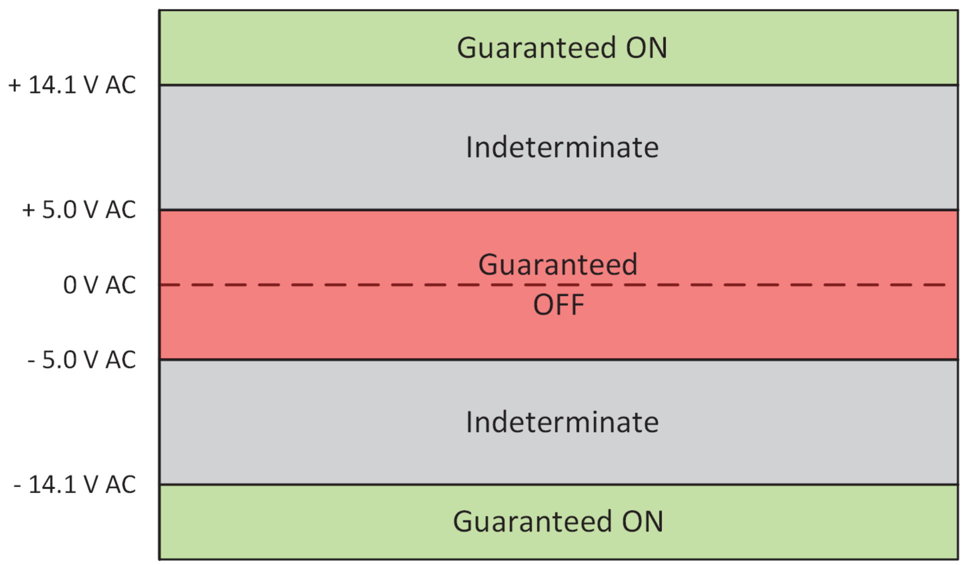


Figure 8-12 SIO7.20 AC Voltage Thresholds

Controller Update Rate

The Controller update rate for the SIO7.20 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

Simplified Input Circuit

Figure 8-13 shows a simplified circuit diagram of the SIO7.20.

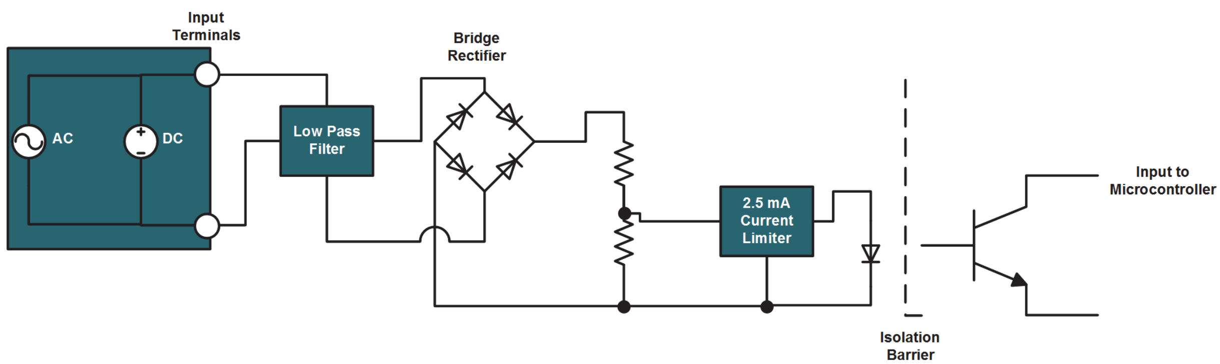


Figure 8-13 SIO7.20 Simplified Input Circuit

Wiring the Module

See Appendix C, "Wiring Diagrams and Pin Out Information".

Module Fault and Status Information

See Appendix G, "SPM and SIO Blink Code Summary".

Discrete Output Module (SIO8.20 - DO.20)

Introduction

The SIO8.20 is a 20-channel discrete output module. Each channel is galvanically isolated from each other and ground.

Simplified Output Circuit

Figure 8-14 shows a simplified circuit diagram of the SIO8.20.

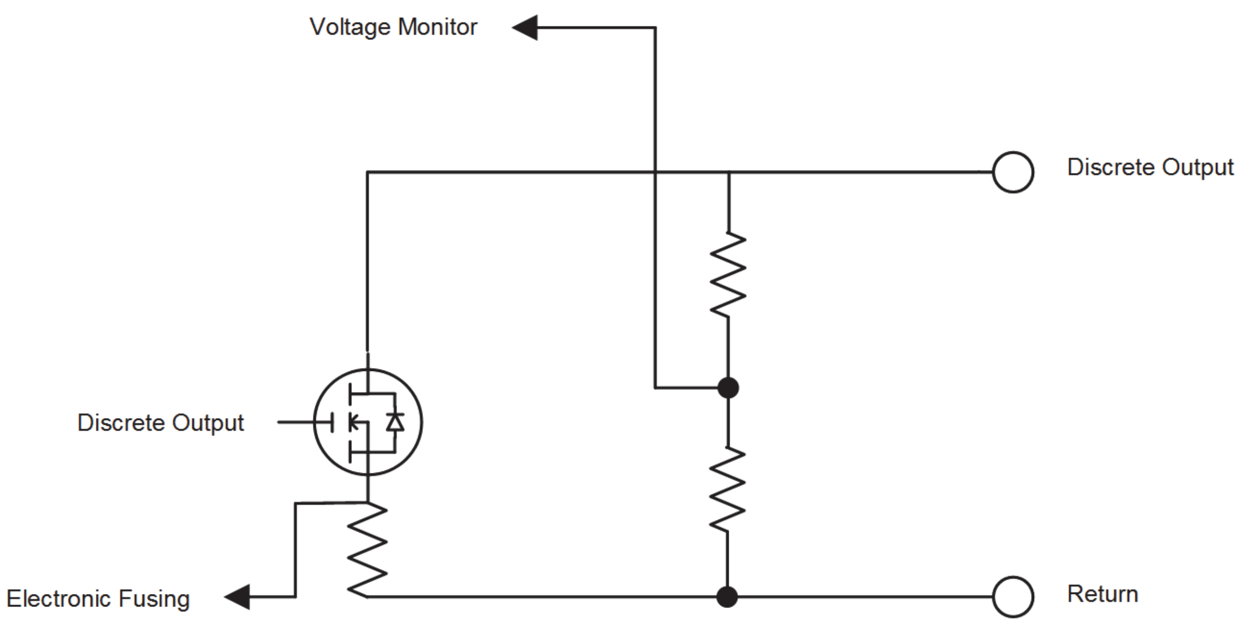


Figure 8-14 SIO8.20 Simplified Output Circuit

Discrete Output Switches

The output switch consists of a high-powered MOSFET capable of switching up to 1 amp at 30 V DC.

Electronic Fusing

Each channel can utilize an electronic fuse that will disable the channel if the current exceeds a programmable threshold up to 1 amp. Each channel's electronic fuse can be configured to latch off or auto retry during an overcurrent condition. When the channel has been latched off, the channel must be disabled (turned off) to clear the fault condition. Channel faults can be detected in the Bedrock IDE by the XOR of the expected binary output value and the actual output value. A non-zero result of the XOR operation indicates a fault.

Discrete Outputs

SIO8.20 discrete outputs are externally sourced. A circuit diagram for an externally sourced discrete output is shown in Figure 8-15.

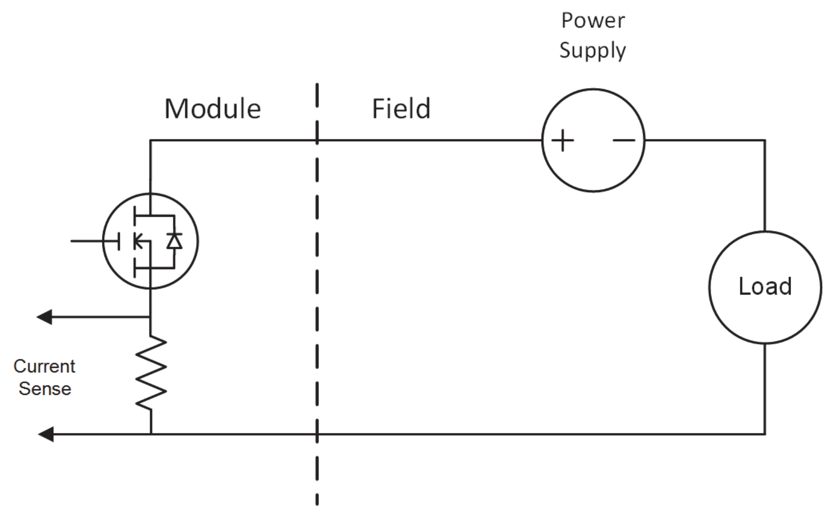


Figure 8-15 Externally Sourced Discrete Output

Discrete Output Accuracy

The discrete output current measurement is accurate to within 1.5% of full scale.

Recommended Practices

The following are recommended practices for use of the SIO8.20:

- External fusing is recommended for all discrete outputs.
- External surge protection is required across the load for inductive loads greater than 60 mH. A suppression circuit for DC loads is shown in Figure 8-16.

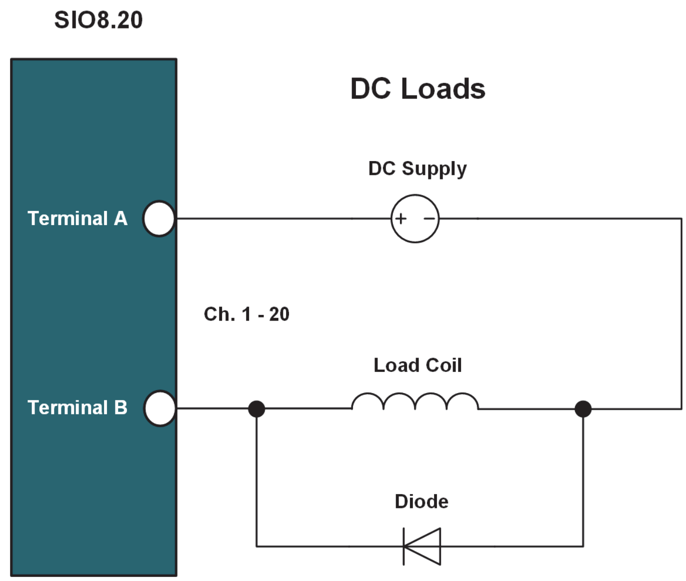


Figure 8-16 SIO8.20 Diode Suppression Circuit with DC Load

Software Configurable Features

The following are SIO8.20 features that are configurable using the Bedrock IDE:

Overcurrent Retry

After an overcurrent situation occurs, each channel can either stay latched off or back-off and retry. The Bedrock IDE uses the following parameters for configuration of back-off and retry. See Table 8-8 for parameter descriptions.

- Digital Out Retry Limit
- Digital Out Retry Period
- Digital Out OC Threshold

The overcurrent response time is one millisecond.

Fail-safe Output Feature

The SIO8.20 has a fail-safe output feature that protects the module in the event of communication failure with the Controller. If no communication is received from the Controller within the timeout period (configured separately for each channel), the output of each channel on the SIO8.20 will be set to either a configured fail-safe value or held at the current level. The Bedrock IDE uses the following parameters for configuration of the fail-safe output feature. See Table 8-8 for parameter descriptions.

- Fail-safe Mode
- Fail-safe Value
- Fail-safe Timeout

Controller Update Rate

The Controller update rate for the SIO8.20 can be as fast as 3 milliseconds with a single Controller and as fast as 10 milliseconds with redundant Controllers. It is configured by setting the task interval in the Bedrock IDE.

SIO8.20 IDE Parameters

Bedrock IDE parameters for overcurrent retry and fail-safe output are shown in Figure 8-17 and summarized in Table 8-8. All parameters are configured separately for each channel on the SIO8.20 except where noted.

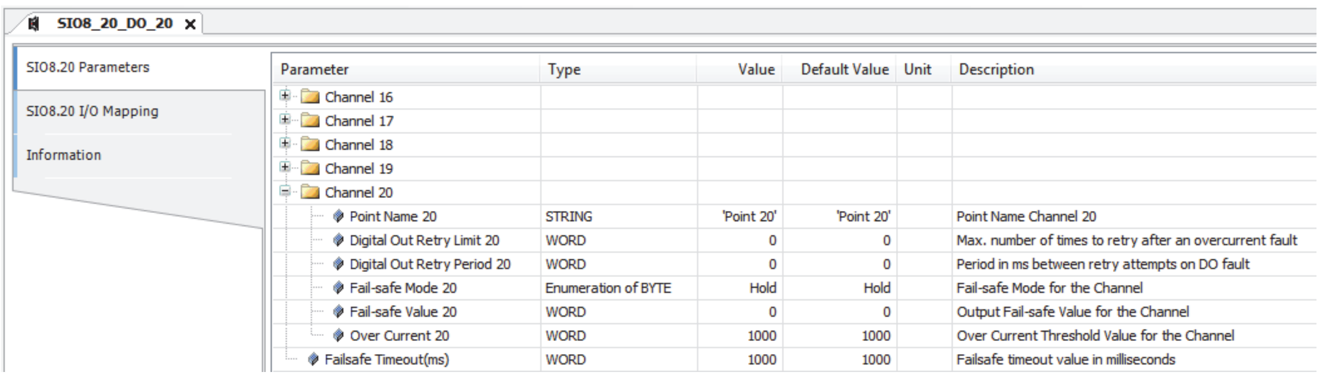


Figure 8-17 SIO8.20 Parameters in the Bedrock IDE

Table 8-8 SIO8.20 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Digital Out Retry Limit	Number of retries (up to 255) in an overcurrent situation. If set to zero, the channel stays latched off.
Digital Out Retry Period	Number of milliseconds (1-255) between retries in an overcurrent situation. The parameter is ignored if Digital Out Retry Limit is zero.
Fail-safe Mode	Used in event of communication failure with the Controller. Set to one of the following: Fail-safe – Module output is set to a default fail-safe value. Hold – Module output is held at the current level

Table 8-8 SIO8.20 Configurable Parameters

Parameter Name	Description
Fail-safe Value	Default fail-safe value if there is a communication failure with the Controller and Fail-safe Mode is set to “Fail-safe”
Overcurrent Threshold	Maximum allowable current before a fault occurs. Specified in milliamps.
Fail-safe Timeout	Amount of time in milliseconds that the SIO should wait for output messages from the Controller before entering fail-safe mode. Applies to the entire module.

Wiring the Module

See Appendix C, “Wiring Diagrams and Pin Out Information” for wiring information for the SIO8.20.

Module Fault and Status Indication

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIO8.20.

SIO Communication Modules

The SIO Communication Modules chapter contains information relative to the operation of SIO communication modules.

Secure Ethernet Module (SIO4.E - UE.5)

Introduction

The SIO4.E is a 5-port smart communication module that is capable of 10/100 Mbps half/full duplex communication with other devices that use Ethernet-based protocols, e.g., EtherNet/IP or Modbus TCP. Each port connects to other devices using a standard Cat5 shielded Ethernet cable. Additionally, each port can use Power over Ethernet (PoE) to power other devices when the SIO4.E is supplied negative 48 V using the Bedrock Power Over Ethernet Cable Assembly.

SIO4.E Block Diagram

Figure 9-1 shows a block diagram of the SIO4.E.

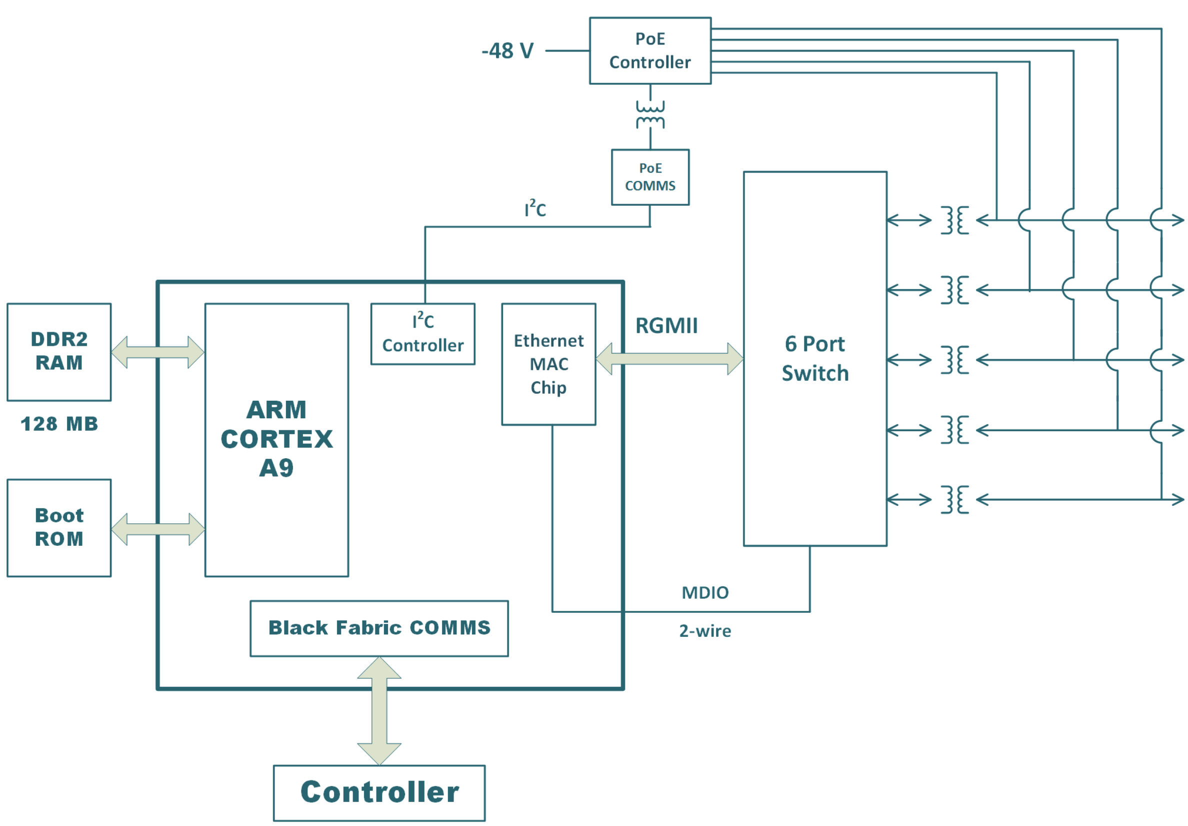


Figure 9-1 SIO4.E Block Diagram

Power Over Ethernet

The SIO4.E can be used as IEEE 802.3af/at compliant power sourcing equipment (PSE), specifically, a 10BASE-T/100BASE-TX Endpoint PSE. The SIO4.E has five Ethernet ports as shown in Figure 9-2.

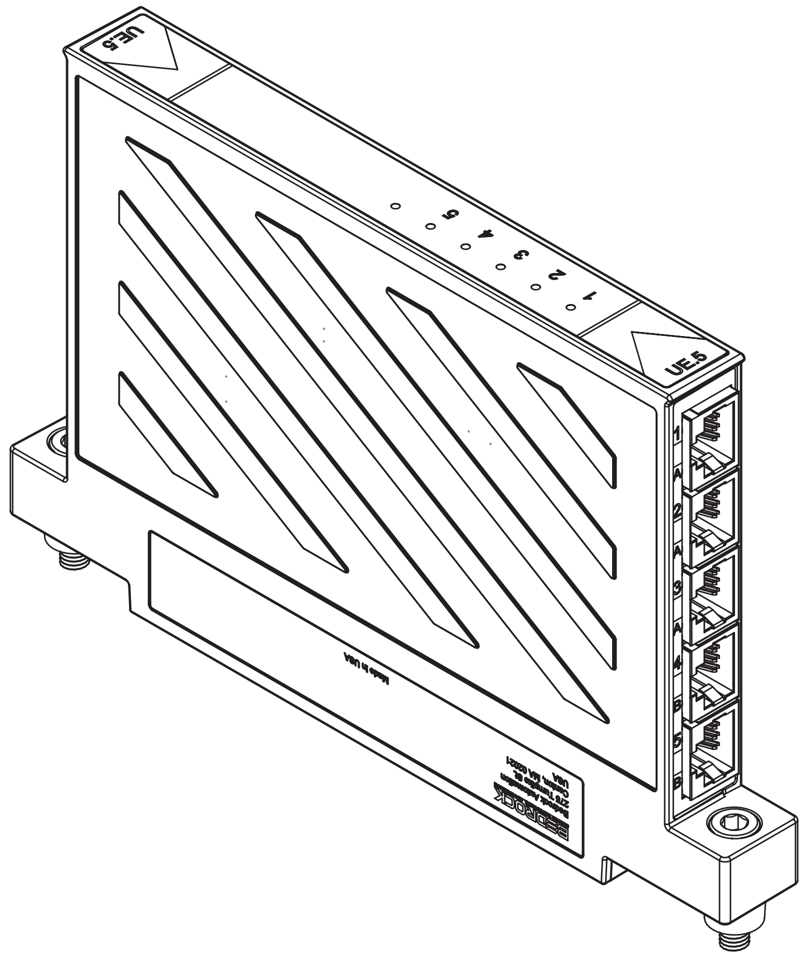


Figure 9-2 SIO4.E Ethernet Ports

The IEEE 802.3at-2009 standard provides two alternatives for transmitting power over Ethernet cabling. Alternative A transmits power over the same pair of cables that is used for data. Alternative B transmits power over the unused pair of cables. Ports 1, 2, and 3 of the SIO4.E are wired to support Alternative A while ports 4 and 5 are wired to support Alternative B. The ports are both labeled and color coded to show which alternative is supported by each port as shown in Figure 9-2.

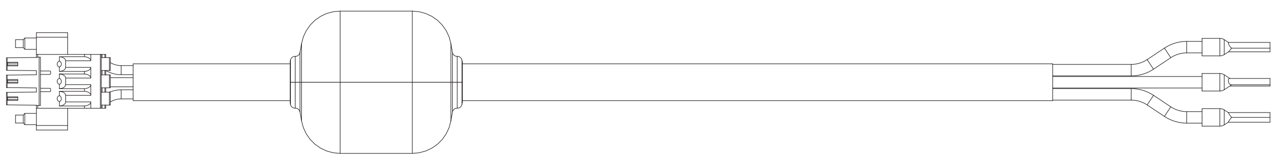
See Appendix C, “Wiring Diagrams and Pin Out Information” for PSE wiring information.

SIO4.E Power Input

The SIO4.E has two DC power inputs that allow the customer to enable PoE functionality by providing -48 V DC to the SIO4.E. Bedrock Automation provides the Bedrock Power Over Ethernet Cable for this purpose. The Power

Over Ethernet Cable is shown in Figure 9-3. The power input connectors are shown in Figure 9-4. A pair of screws on each connector allow the connectors to be securely fastened to the module. Either a single cable can be used to supply power or two cables can be used to supply redundant power. If a single power source is used, the cable may be plugged into either connector 1 or 2. When using redundant power, the DC power inputs are diode “OR”ed. The inputs are fuse protected.

See Appendix D, “SIO Module Specifications” for information on the SIO4.E power specifications. The power supply must be sized accordingly. The IEEE 802.3at-2009 standard provides additional information.



PIN NO.	COLOR	FUNCTON
PIN 3	GREEN	GROUND
PIN 2	BLACK	- 48 VOLTS
PIN 1	RED	VOLTAGE IN

Figure 9-3 Power Over Ethernet Cable

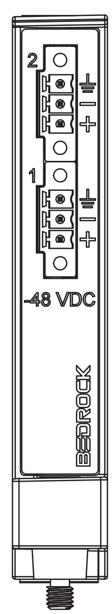


Figure 9-4 SIO4.E Power Input Connector

SIO4.E Wiring

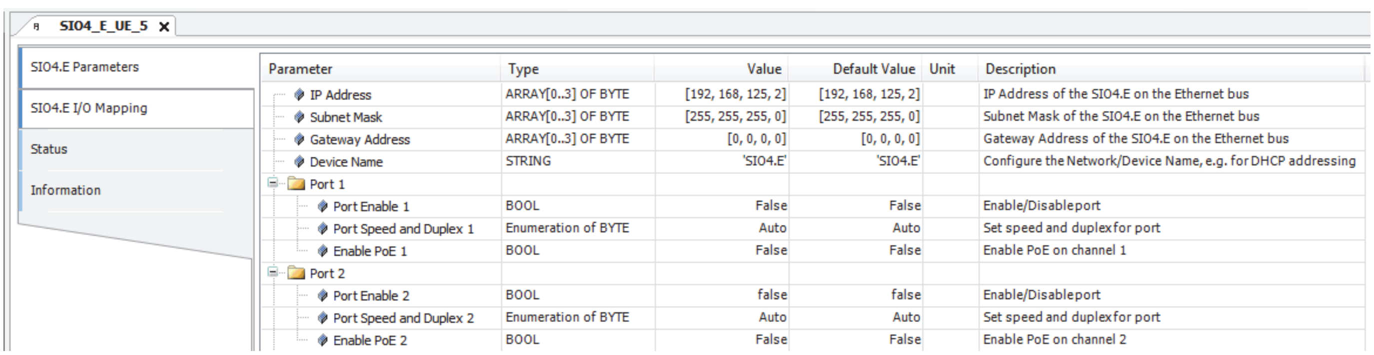
Labels and functions of both power input connectors are shown in Table 9-1.

Table 9-1 SIO4.E Input Connector Pin Out

Pin #	Label	Function
3	⏚	Safety ground for system
2	—	Negative 48 V
1	+	48 V return

Software Configurable Options

Parameters for the SIO4.E that are configurable in the Bedrock IDE are shown in Figure 9-5 and summarized in Table 9-2.



Parameter	Type	Value	Default Value	Unit	Description
IP Address	ARRAY[0..3] OF BYTE	[192, 168, 125, 2]	[192, 168, 125, 2]		IP Address of the SIO4.E on the Ethernet bus
Subnet Mask	ARRAY[0..3] OF BYTE	[255, 255, 255, 0]	[255, 255, 255, 0]		Subnet Mask of the SIO4.E on the Ethernet bus
Gateway Address	ARRAY[0..3] OF BYTE	[0, 0, 0, 0]	[0, 0, 0, 0]		Gateway Address of the SIO4.E on the Ethernet bus
Device Name	STRING	'SIO4.E'	'SIO4.E'		Configure the Network/Device Name, e.g. for DHCP addressing
Port 1					
Port Enable 1	BOOL	False	False		Enable/Disable port
Port Speed and Duplex 1	Enumeration of BYTE	Auto	Auto		Set speed and duplex for port
Enable PoE 1	BOOL	False	False		Enable PoE on channel 1
Port 2					
Port Enable 2	BOOL	false	false		Enable/Disable port
Port Speed and Duplex 2	Enumeration of BYTE	Auto	Auto		Set speed and duplex for port
Enable PoE 2	BOOL	False	False		Enable PoE on channel 2

Figure 9-5 SIO4.E Parameters in the Bedrock IDE

Table 9-2 SIO4.E Configurable Parameters

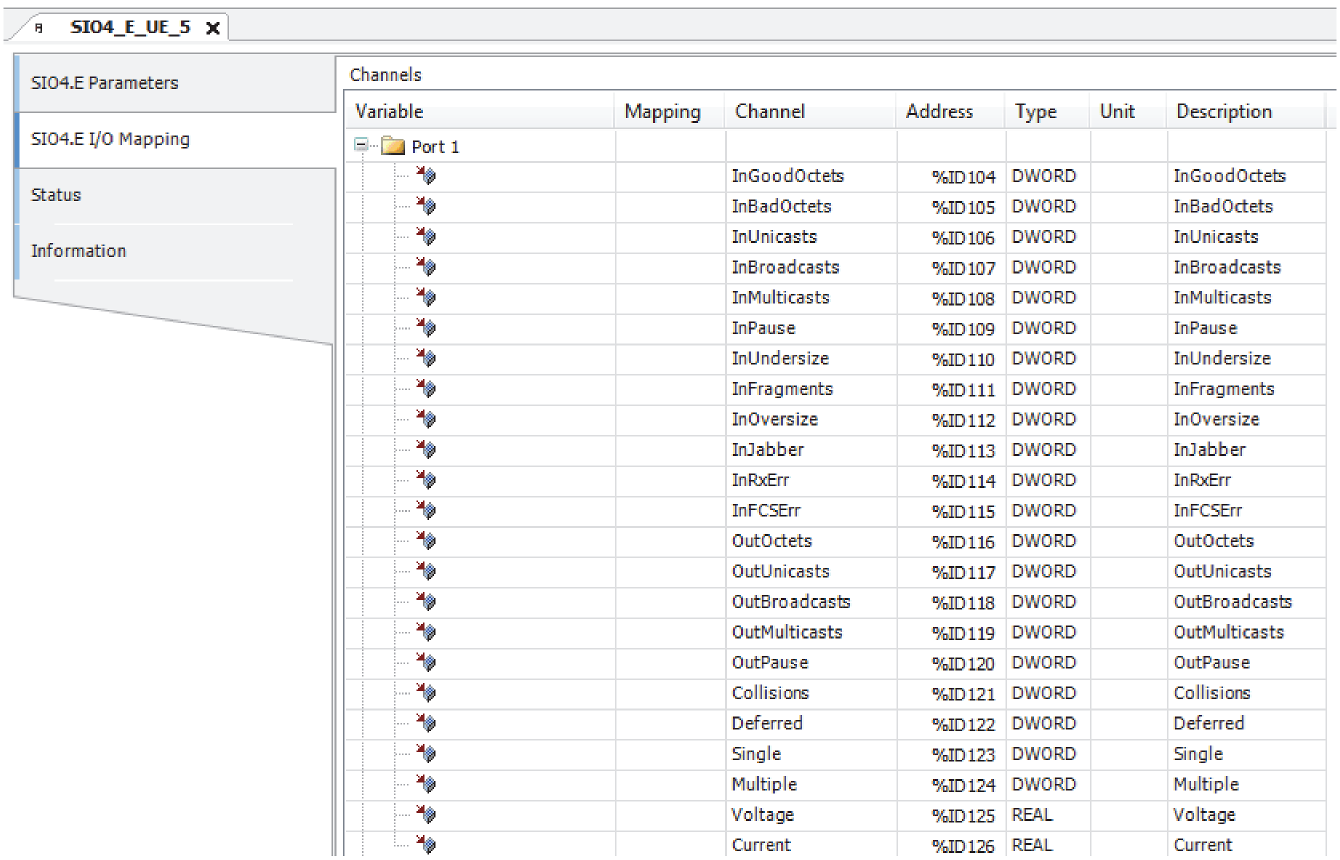
Parameter Name	Description
IPAddress	IP Address of the SIO4.E on the Ethernet bus
SubnetMask	Subnet Mask of the SIO4.E on the Ethernet bus
GatewayAddress	Gateway Address of the SIO4.E on the Ethernet bus
DeviceName	Network device name, e.g., for DHCP addressing
Port Enable [n]	Enable (true) or disable (false) port n
Port Speed and Duplex [n]	Speed and duplex of port n. Set to one of the following: Auto 10 Mbit full 10 Mbit half 100 Mbit full 100 Mbit half

Table 9-2 SIO4.E Configurable Parameters

Parameter Name	Description
Enable PoE [n]	Enable (true) or disable (false) Power over Ethernet for port n

Switch Counters

The SIO4.E has 23 switch counters per port that provide diagnostic information. The switch counters are viewable in the Bedrock IDE as shown in Figure 9-6. The counters are also listed in Table 9-3.



SIO4_E_UE_5

SIO4.E Parameters
SIO4.E I/O Mapping
Status
Information

Channels

Variable	Mapping	Channel	Address	Type	Unit	Description
Port 1						
		InGoodOctets	%ID104	DWORD		InGoodOctets
		InBadOctets	%ID105	DWORD		InBadOctets
		InUnicasts	%ID106	DWORD		InUnicasts
		InBroadcasts	%ID107	DWORD		InBroadcasts
		InMulticasts	%ID108	DWORD		InMulticasts
		InPause	%ID109	DWORD		InPause
		InUndersize	%ID110	DWORD		InUndersize
		InFragments	%ID111	DWORD		InFragments
		InOversize	%ID112	DWORD		InOversize
		InJabber	%ID113	DWORD		InJabber
		InRxErr	%ID114	DWORD		InRxErr
		InFCSErr	%ID115	DWORD		InFCSErr
		OutOctets	%ID116	DWORD		OutOctets
		OutUnicasts	%ID117	DWORD		OutUnicasts
		OutBroadcasts	%ID118	DWORD		OutBroadcasts
		OutMulticasts	%ID119	DWORD		OutMulticasts
		OutPause	%ID120	DWORD		OutPause
		Collisions	%ID121	DWORD		Collisions
		Deferred	%ID122	DWORD		Deferred
		Single	%ID123	DWORD		Single
		Multiple	%ID124	DWORD		Multiple
		Voltage	%ID125	REAL		Voltage
		Current	%ID126	REAL		Current

Figure 9-6 SIO4.E Switch Counters in the Bedrock IDE

Table 9-3 SIO4.E Switch Counters

Switch Counter Name (repeats for each port)	
InGoodOctets	OutOctets
InBadOctets	OutUnicasts
InUnicasts	OutBroadcasts
InBroadcasts	OutMulticasts
InMulticasts	OutPause
InPause	Collisions
InUndersize	Deferred
InFragments	Single
InOversize	Multiple
InJabber	Voltage
InRxErr	Current
InFCSErr	

EtherNet/IP Devices

The SIO4.E can have a single EtherNet/IP connection for each connected EtherNet/IP device. The Bedrock IDE can be used to configure the SIO4.E for control of EtherNet/IP devices as follows:

First, right-click the SIO4.E module in the Bedrock IDE Devices panel and select “Add Device...” as shown in Figure 9-7.

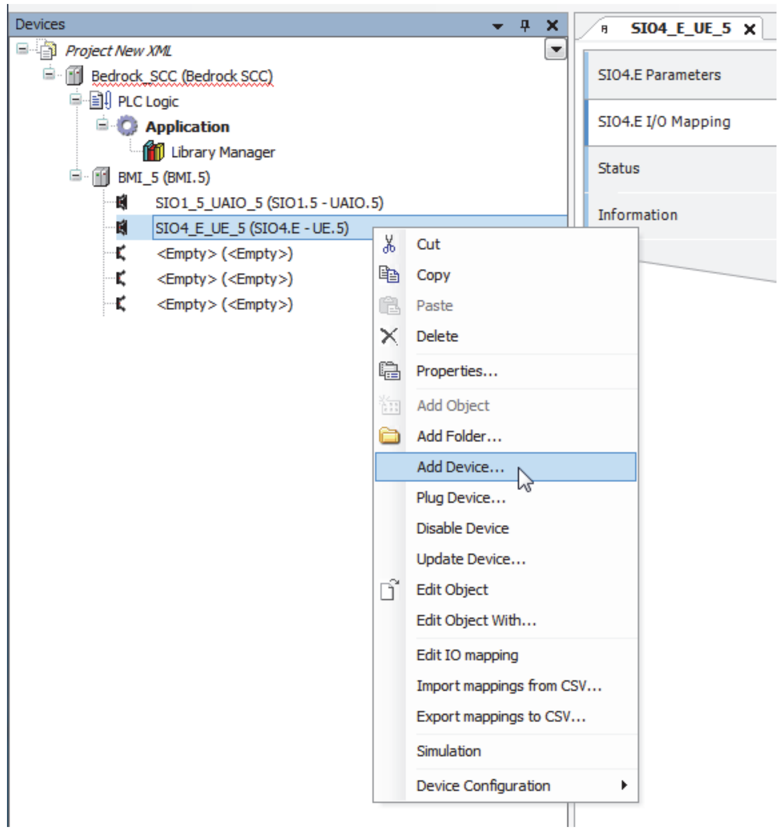


Figure 9-7 Adding a Device to the SIO4.E

Next, add an SIO4.E EtherNet/IP Scanner device as shown in Figure 9-8. Make sure that “Append device” is selected as the Action option.

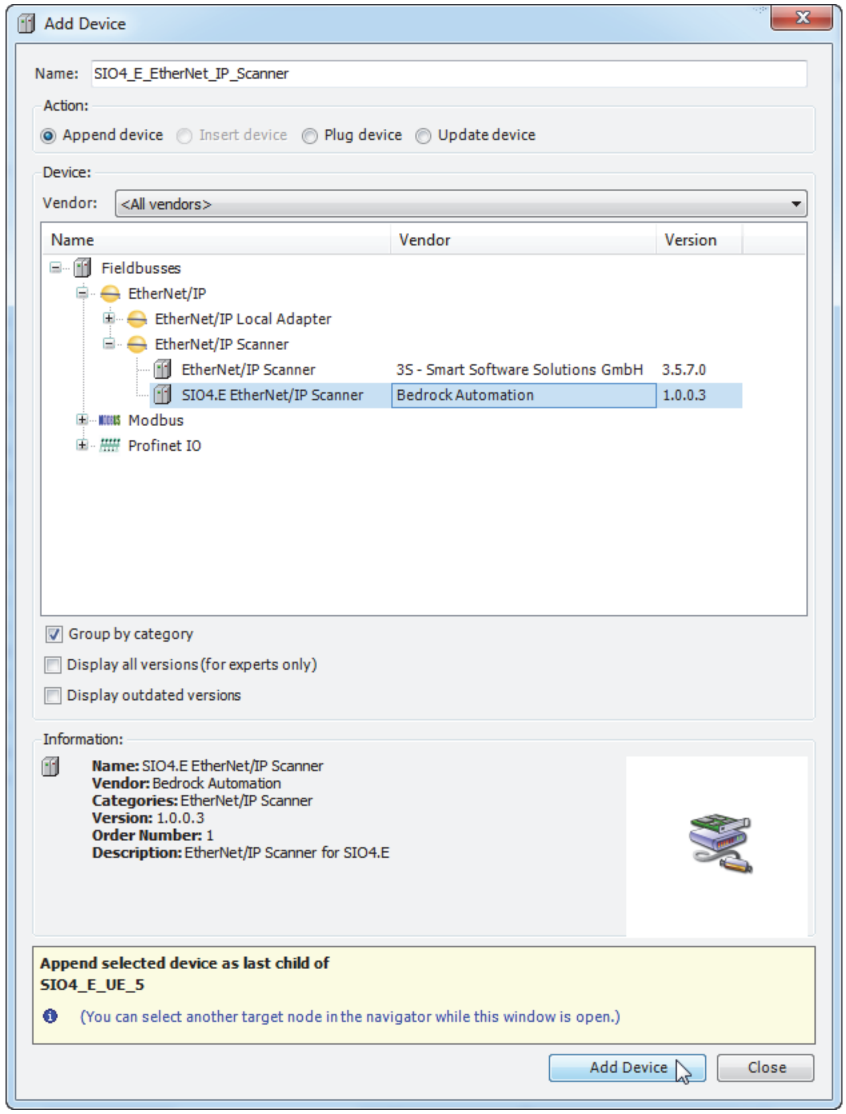


Figure 9-8 Adding an EtherNet/IP Scanner Device

Modbus Devices

The SIO4.E can also be configured as a Modbus TCP master device for control of Modbus TCP slave devices. The SIO4.E supports a maximum of 128 Modbus TCP slaves. Each Modbus slave can have up to 32 slave channel mappings and a maximum of 400 bytes of I/O data.

Configuration is done by right-clicking the SIO4.E module in the Bedrock IDE Devices panel and selecting “Add Device...” as shown in Figure 9-7. Next, a Modbus TCP master device can be added as shown in Figure 9-9. Make sure that “Append device” is selected as the Action option.

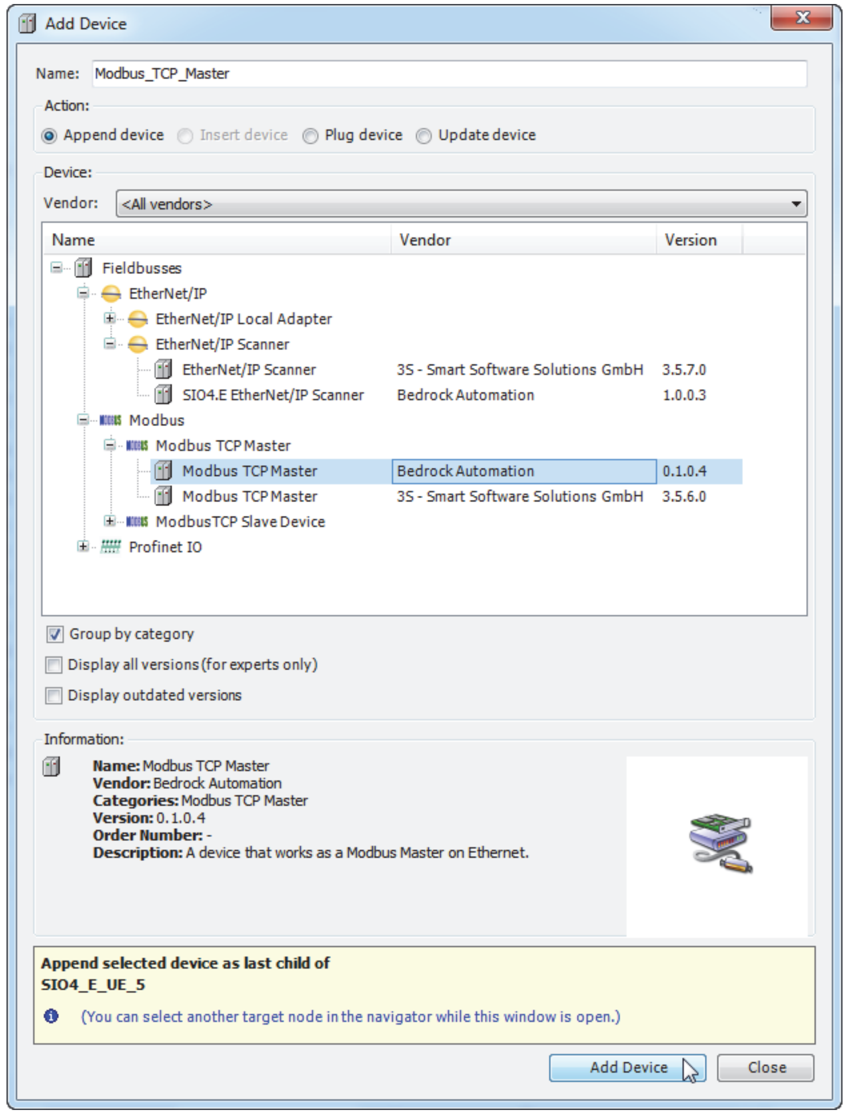


Figure 9-9 Adding a Modbus TCP Master Device

The SIO4.E supports the Modbus function codes listed in Table 9-4.

Table 9-4 Supported Modbus Function Codes

Function Name	Function Code
Read Discrete Inputs	2
Read Coils	1
Write Single Coil	5
Write Multiple Coils	15
Read Input Registers	4
Read Multiple Holding Registers	3

Table 9-4 Supported Modbus Function Codes

Function Name	Function Code
Write Single Holding Register	6
Write Multiple Holding Registers	16

UPS and SPS Control and Monitoring

The SIO4.E can use an Ethernet connection to a Bedrock UPS.500 or SPS.500 power supply to send and receive control and status information to and from the power supply. The Bedrock IDE is used to configure the SIO4.E and the power supply and also to display the power supply status information. The power supply is added as a device under the SIO4.E in the Bedrock IDE Devices pane. Figure 9-10 shows a UPS.500. The procedure is the same for the SPS.500.

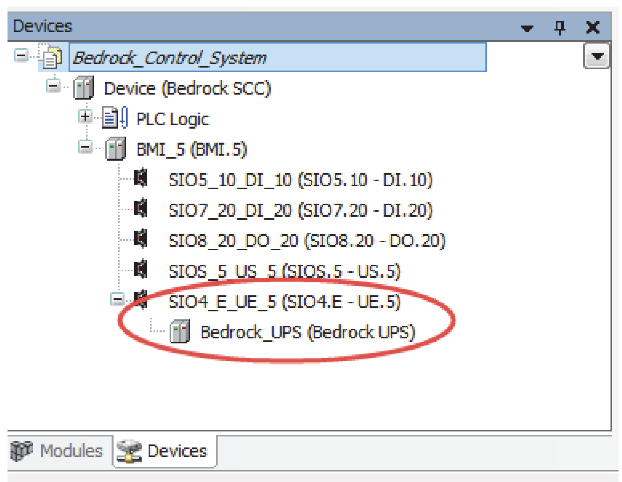
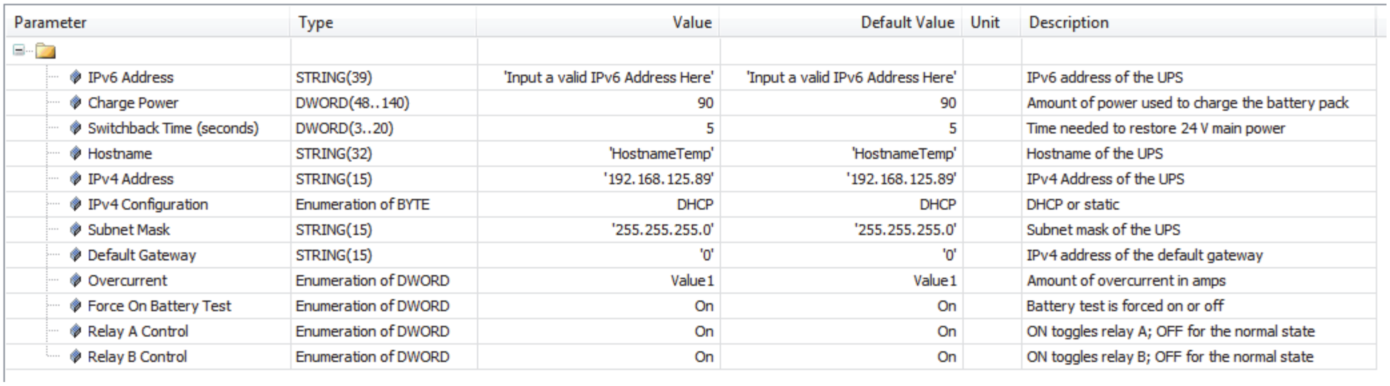


Figure 9-10 UPS Added under SIO4.E

The Bedrock IDE allows for the configuration and display of parameters and mapped variables for the Bedrock power supplies as shown in the following figures and tables. UPS parameters are shown in Figure 9-11. The parameters are described in Table 9-5.



Parameter	Type	Value	Default Value	Unit	Description
IPv6 Address	STRING(39)	'Input a valid IPv6 Address Here'	'Input a valid IPv6 Address Here'		IPv6 address of the UPS
Charge Power	DWORD(48..140)	90	90		Amount of power used to charge the battery pack
Switchback Time (seconds)	DWORD(3..20)	5	5		Time needed to restore 24 V main power
Hostname	STRING(32)	'HostnameTemp'	'HostnameTemp'		Hostname of the UPS
IPv4 Address	STRING(15)	'192.168.125.89'	'192.168.125.89'		IPv4 Address of the UPS
IPv4 Configuration	Enumeration of BYTE	DHCP	DHCP		DHCP or static
Subnet Mask	STRING(15)	'255.255.255.0'	'255.255.255.0'		Subnet mask of the UPS
Default Gateway	STRING(15)	'0'	'0'		IPv4 address of the default gateway
Overcurrent	Enumeration of DWORD	Value1	Value1		Amount of overcurrent in amps
Force On Battery Test	Enumeration of DWORD	On	On		Battery test is forced on or off
Relay A Control	Enumeration of DWORD	On	On		ON toggles relay A; OFF for the normal state
Relay B Control	Enumeration of DWORD	On	On		ON toggles relay B; OFF for the normal state

Figure 9-11 UPS Parameters Tab

Table 9-5 UPS Parameters Tab Variables

Parameter Name	Description
IPv6 Address	IPv6 address of the UPS
Charge Power	Amount of power used to charge the battery pack
Switchback Time (seconds)	Time needed to restore 24 V main power
Host Name	Host name of the UPS
IPv4 Address	IPv4 Address of the UPS
IPv4 Configuration	DHCP or Static configuration
Subnet Mask	Subnet mask of the UPS
Default Gateway	IPv4 address of the default gateway
Overcurrent	Amount of overcurrent in amps
Force On Battery Test	Battery test is forced on or off
Relay A Control	ON toggles relay A; OFF for the normal state
Relay B Control	ON toggles relay B; OFF for the normal state

UPS data on the mapping tab for the Bedrock UPS is shown in Figure 9-12. See the Bedrock IDE online help for information on configuring the SIO4.E and UPS in the Bedrock IDE.

Variable	Mapping	Channel	Address	Type	Unit	Description
		Input Voltage	%ID500	REAL		Voltage on the 24 V input of the UPS
		Output Voltage	%ID501	REAL		Voltage on the 24 V output of the UPS
		Pack Voltage	%ID502	REAL		Voltage present across the battery pack
		Regulated Pack Voltage	%ID503	REAL		Regulated output voltage
		"OR"ing Temperature	%ID504	REAL		Temperature of the "OR"ing circuit
		Buck Temperature	%ID505	REAL		Temperature of the buck regulator
		CPU Temperature	%ID506	REAL		Temperature of the CPU
		Operating Mode	%ID507	DWORD		Operating state of the power supply
		Pack Charge	%ID508	REAL		Percentage of remaining charge for the battery pack
		Time Stamp	%IL255	LWORD		Time of last update of UPS data
		Output Current	%ID512	REAL		Output current of the UPS
		UPS Diagnostic Data	%ID513			UPS Diagnostic Data Descriptions
		Cell Voltage	%ID513	ARRAY [0..7] OF REAL		Measured voltage for each cell
		Cell Current	%ID521	ARRAY [0..7] OF REAL		Measured current for each cell
		Cell Temperature	%ID529	ARRAY [0..7] OF REAL		Measured temperature for each cell
		Cell Charge	%ID537	ARRAY [0..7] OF DINT		Remaining charge for each cell. Measured in milliamp hours (mAh)
		Charger Temperature	%ID545	ARRAY [0..7] OF REAL		Measured temperature of the charger for each cell
		Charger Voltage	%ID553	REAL		Measured voltage of the 12 V supply to all cells
		Version	%IB2216	ARRAY [0..31] OF BYTE		UPS firmware version
		Tx Good and Bad	%ID562	DINT		Total no. of transmitted packets
		Tx After Single Collision	%ID563	DINT		No. of transmitted packets after a single collision
		Tx After Multiple Collision	%ID564	DINT		No. of transmitted packets after multiple collisions
		Tx Bytes	%ID565	DINT		No. of transmitted bytes
		Rx Good and Bad	%ID566	DINT		Total no. of received packets
		Rx CRC Errors	%ID567	DINT		No. of CRC errors detected
		Rx Alignment Errors	%ID568	DINT		No. of alignment errors detected
		Good Unicast Frames	%ID569	DINT		No. of good unicast frames
		Charge Power	%ID570	DWORD		Amount of power used to charge the battery pack
		Switchback Time	%ID571	DWORD		Time needed to restore 24 V main power
		Overcurrent	%ID572	DWORD		Amount of overcurrent in amps
		Hostname	%IB2292	ARRAY [0..31] OF BYTE		Hostname of the UPS
		IPv4 Configuration	%IB2324	Enumeration of BYTE		DHCP or static
		IPv4 Address	%IB2325	ARRAY [0..14] OF BYTE		IPv4 address of the UPS
		Subnet Mask	%IB2340	ARRAY [0..14] OF BYTE		Subnet mask of the UPS
		Default Gateway	%IB2355	ARRAY [0..14] OF BYTE		IPv4 address of the default gateway
		Time	%IL297	LWORD		Set the time of day in the battery pack

Figure 9-12 UPS Mapping Tab

The UPS data on the mapping tab of the Bedrock IDE is described in Table 9-6.

Table 9-6 UPS Mapping Tab Variables

Parameter Name	Description
Input Voltage	Voltage on the 24 V input of the UPS
Output Voltage	Voltage on the 24 V output of the UPS
Pack Voltage	Voltage present across the battery pack
Regulated Pack Voltage	Regulated output voltage
“OR”ing Temperature	Temperature of the “OR”ing circuit
Buck Temperature	Temperature of the buck regulator
CPU Temperature	Temperature of the CPU

Table 9-6 UPS Mapping Tab Variables

Parameter Name	Description
Operating Mode	Operating state of the power supply. Valid values and states are: 0x00000100 normal 0x00000200 brown out 0x00000300 24 V input voltage failure) 0x00000400 24 V input voltage restored; still running on batteries 0x00010000 battery monitoring 0x00020000 battery discharging 0x00030000 battery charging 0x00040000 battery faulted 0x00050000 preparing charge 0x00060000 battery resting
Pack Charge	Percentage of remaining charge for the battery pack
Time Stamp	Time of last update of UPS data
Output Current	Amount of load current in amps
UPS Diagnostic Data	
Cell Voltage	Measured voltage for each cell
Cell Current	Measured current for each cell
Cell Temperature	Measured temperature for each cell
Cell Charge	Remaining estimated charge for each cell. Measured in milliamp hours (mAh)
Charger Temperature	Measured temperature of the charger for each cell
Charger Voltage	Measured voltage of the 12 V supply to all cells
Version	UPS firmware version
Tx Good and Bad	Total no. of transmitted packets
Tx After Single Collision	No. of transmitted packets after a single collision
Tx After Multiple Collision	No. of transmitted packets after multiple collisions
Tx Bytes	No. of transmitted bytes
Rx Good and Bad	Total no. of received packets
Rx CRC Errors	No. of CRC errors detected
Rx Alignment Errors	No. of alignment errors detected
Good Unicast Frames	No. of good unicast frames
Charge Power	Amount of power used to charge the battery pack
Switchback Time	Time needed to restore 24 V main power
Overcurrent	Amount of overcurrent in amps
Hostname	Hostname of the UPS
IPv4 Configuration	DHCP or static
IPv4 Address	IPv4 address of the UPS
Net mask	Subnet mask of the UPS
Default Gateway	IPv4 address of the default gateway
Time	Set the time of day in the battery pack

SPS parameters are shown in Figure 9-13. The parameters are described in Table 9-7.

Parameter	Type	Value	Default Value	Unit	Description
IPv6 Address	STRING(39)	'Input a valid IPv6 Address Here'	'Input a valid IPv6 Address Here'		IPv6 address of the SPS
Host Name	STRING(32)	'HostnameTemp'	'HostnameTemp'		Hostname of the SPS
IPv4 Address	STRING(15)	'192.168.125.89'	'192.168.125.89'		IPv4 address of the SPS
IPv4 Configuration	Enumeration of BYTE	DHCP	DHCP		DHCP or static
Net mask	STRING(15)	'255.255.255.0'	'255.255.255.0'		Subnet mask of the SPS
Default Gateway	STRING(15)	'0'	'0'		IPv4 address of the default gateway
Overcurrent	Enumeration of DWORD	Value1	Value1		Amount of overcurrent in amps
Relay A Control	Enumeration of DWORD	On	On		ON toggles relay A; OFF for the normal state
Relay B Control	Enumeration of DWORD	On	On		ON toggles relay B; OFF for the normal state
Output Voltage	DWORD(22..28)	22	22		Voltage on the 24 V output of the SPS
SPS Startup Mode	Enumeration of DWORD	Autostart	Autostart		Auto start or manual
SPS On/Off	Enumeration of DWORD	SPS On	SPS On		Turn the SPS on or off
"OR"ing Controller Fault Management	Enumeration of DWORD	auto retry	auto retry		"OR"ing Controller Fault Management
"OR"ing Output Enable	Enumeration of DWORD	Off	Off		Enable or disable "OR"ing output

Figure 9-13 SPS Parameters Tab

Table 9-7 SPS Parameters Tab Variables

Parameter Name	Description
IPv6 Address	IPv6 address of the SPS
Host Name	Host name of the SPS
IPv4 Address	IPv4 Address of the SPS
IPv4 Configuration	DHCP or Static configuration
Net Mask	Subnet mask of the SPS
Default Gateway	IPv4 address of the default gateway
Overcurrent	Amount of overcurrent in amps
Relay A Control	ON toggles relay A; OFF for the normal state
Relay B Control	ON toggles relay B; OFF for the normal state
Output Voltage	Voltage on the 24 V output of the SPS
SPS Startup Mode	Auto start or manual
SPS On/Off	Turn the SPS on or off
“OR”ing Controller Fault Management	“OR”ing Controller Fault Management
“OR”ing Output Enable	Enable or disable “OR”ing output

SPS data on the mapping tab of the Bedrock IDE is shown in Figure 9-14. See the Bedrock IDE online help for information on configuring the SIO4.E and SPS in the Bedrock IDE.

Variable	Mapping	Channel	Address	Type	Unit	Description
		Input Voltage	%ID570	REAL		AC input voltage to the SPS
		Input Current	%ID571	REAL		Input current to the SPS
		Input Power	%ID572	REAL		Input power to the SPS
		Output Voltage	%ID573	REAL		Voltage on the 24 V output of the SPS
		Output Current (Regular)	%ID574	REAL		Output current from a single SPS
		Output Current ("OR"ed)	%ID575	REAL		Output current from the "OR"ing circuit
		Output Power	%ID576	REAL		Output Power from the SPS
		Efficiency	%ID577	REAL		Measured efficiency of the SPS
		Line Period	%ID578	REAL		Measured input frequency
		CPU Temperature	%ID579	REAL		Measured temperature of the CPU
		Internal Temperature	%ID580	REAL		Measured temperature of the SPS
		Status Flags	%ID581	DWORD		SPS status flags
		Time Stamp	%IL291	LWORD		Time of last update of SPS data
		12 V Auxiliary Supply	%ID584	REAL		12 V auxiliary supply
		PW Status	%IW1170	WORD		PW status description
		Latched Flag 0	%IB2342	BYTE		Latched Flag 0 Description
		Latched Flag 1	%IB2343	BYTE		Latched Flag 1 Description
		Latched Flag 2	%IB2344	BYTE		Latched Flag 2 Description
		Output Voltage Control	%IW1173	WORD		Voltage on the 24 V output of the SPS
		SPS Ethernet Counters	%ID587			SPS Ethernet Counters
		Tx Good and Bad	%ID587	DINT		Total no. of transmitted packets
		Tx After Single Collision	%ID588	DINT		No. of transmitted packets after a single collision
		Tx After Multiple Collision	%ID589	DINT		No. of transmitted packets after multiple collisions
		Tx Bytes	%ID590	DINT		No. of transmitted bytes
		Rx Good and Bad	%ID591	DINT		Total no. of received packets
		Rx CRC Errors	%ID592	DINT		No. of CRC errors detected
		Rx Alignment Errors	%ID593	DINT		No. of alignment errors detected
		Good Unicast Frames	%ID594	DINT		No. of good unicast frames

Figure 9-14 SPS Mapping Tab

The SPS data on the mapping tab of the Bedrock IDE is described in Table 9-8.

Table 9-8 SPS Mapping Tab Variables

Parameter Name	Description
Input Voltage	AC input voltage to the SPS
Input Current	Input current to the SPS
Input Power	Input power to the SPS
Output Voltage	Voltage on the 24 V output of the SPS
Output Current (Regular)	Output current from a single SPS
Output Current (“OR”ed)	Output current from the “OR”ing circuit

Table 9-8 SPS Mapping Tab Variables

Parameter Name	Description
Output Power	Output power from the SPS
Efficiency	Measured efficiency of the SPS
Line Period	Measured input frequency
CPU Temperature	Measured temperature of the CPU
Internal Temperature	Measured temperature of the SPS
Status Flags	SPS status flags
Time Stamp	Time of last update of SPS data
12 V Auxiliary Supply	12 V auxiliary supply
PW Status	PW status description
Latched Flag 0	Latched flag 0 description
Latched Flag 1	Latched flag 1 description
Latched Flag 2	Latched flag 2 description
Output Voltage Control	Sets voltage on the 24 V output of the SPS
SPS Ethernet Counters	
Tx Good and Bad	Total no. of transmitted packets
Tx After Single Collision	No. of transmitted packets after a single collision
Tx After Multiple Collision	No. of transmitted packets after multiple collisions
Tx Bytes	No. of transmitted bytes
Rx Good and Bad	Total no. of received packets
Rx CRC Errors	No. of CRC errors detected
Rx Alignment Errors	No. of alignment errors detected
Good Unicast Frames	No. of good unicast frames

Module Fault and Status Indication

See Appendix G, “SPM and SIO Blink Code Summary” for the list of blink codes used to indicate module status for the SIO4.E.

Secure Serial Module (SIOS.5 - US.5)

Introduction

The SIOS.5 is a five channel communication module that is capable of interfacing with field devices using the RS-232, RS-485, or RS-422 serial communication standards. The SIOS.5 has five Micro-D connectors for connection to other serial devices via the Bedrock SIOS.5 Serial Communication Cable.

SIOS.5 Block Diagram

Each channel of the SIOS.5 has its own processor. Figure 9-15 shows a block diagram for a single channel of the SIOS.5. The Programmable Level Controller processes the transmit and receive data for the supported serial communication standards.

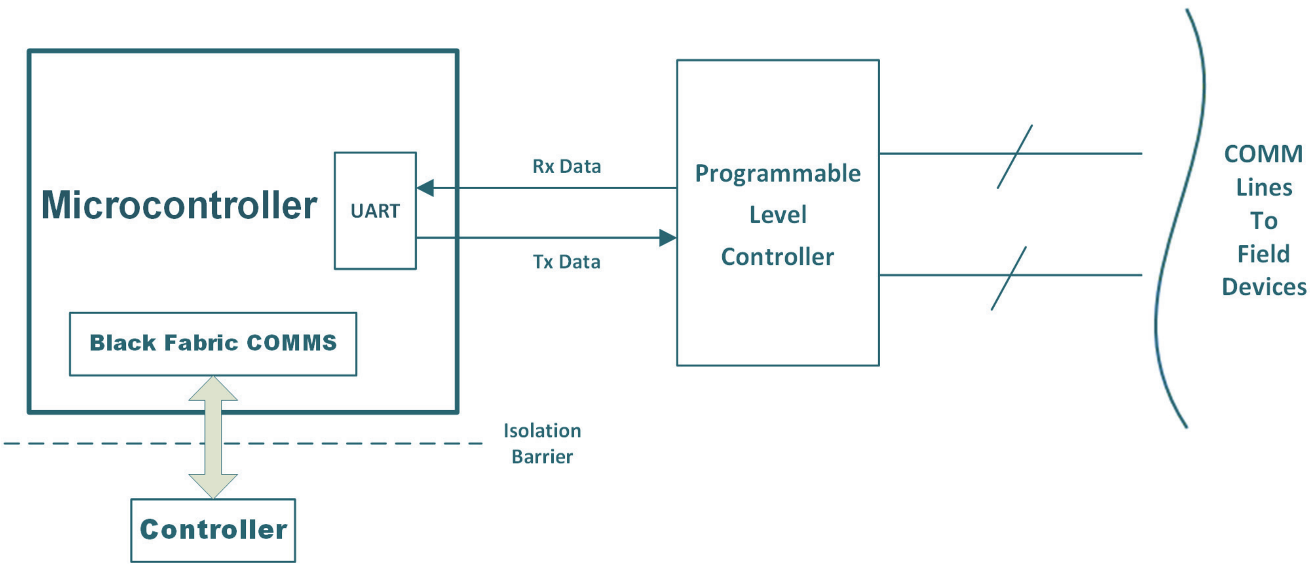


Figure 9-15 SIOS.5 Block Diagram

A circuit diagram of the Programmable Level Controller is shown in Figure 9-16.

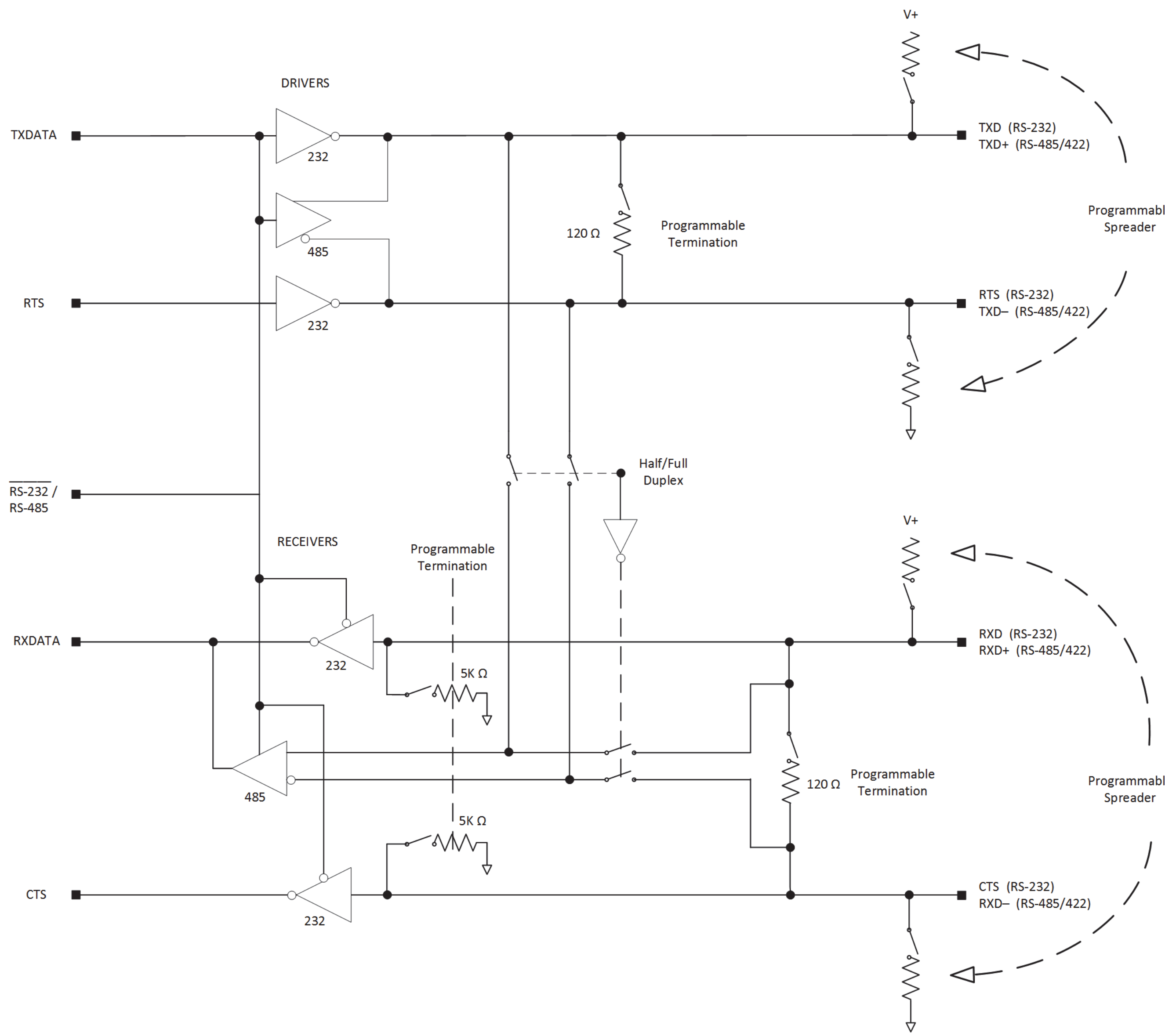


Figure 9-16 Programmable Level Controller

Serial Interface

Figure 9-17 shows the SIOS.5 with a view of three of the Micro-D connectors. The remaining two connectors are on the opposite side of the module.

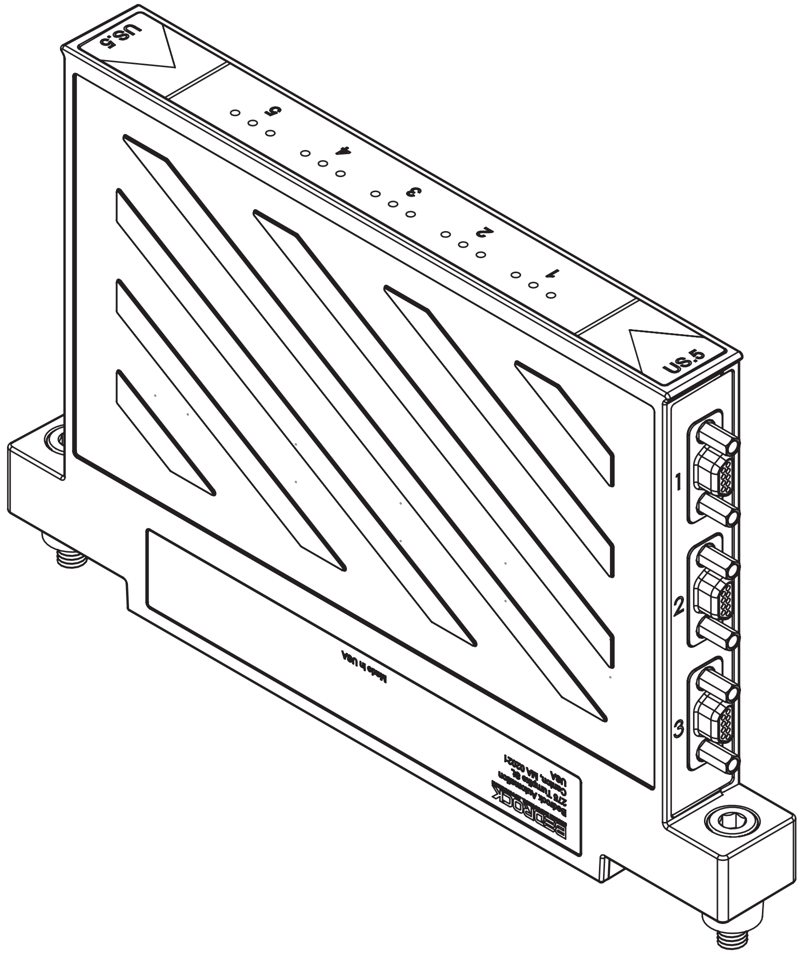
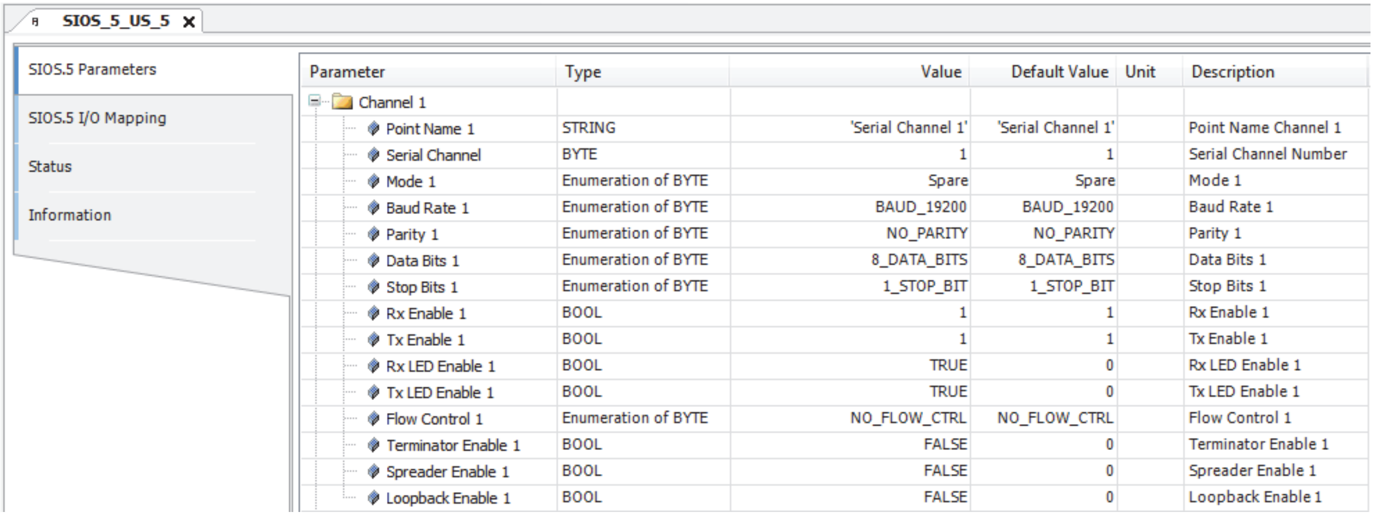


Figure 9-17 SIOS.5 with Micro-D Connectors

The Bedrock SIOS.5 Serial Communication Cable has a Micro-D connector on one end for connection to SIOS.5 ports and a 9-pin female D-Sub connector (the same as can be found on a standard PC) on the other end for connection to field devices. See Appendix C, “Wiring Diagrams and Pin Out Information” for pin out information for the supported serial communication standards.

Software Configurable Options

Parameters for the SIOS.5 that are configurable in the Bedrock IDE are shown in Figure 9-18 and summarized in Table 9-9.



Parameter	Type	Value	Default Value	Unit	Description
Channel 1					
Point Name 1	STRING	'Serial Channel 1'	'Serial Channel 1'		Point Name Channel 1
Serial Channel	BYTE	1	1		Serial Channel Number
Mode 1	Enumeration of BYTE	Spare	Spare		Mode 1
Baud Rate 1	Enumeration of BYTE	BAUD_19200	BAUD_19200		Baud Rate 1
Parity 1	Enumeration of BYTE	NO_PARITY	NO_PARITY		Parity 1
Data Bits 1	Enumeration of BYTE	8_DATA_BITS	8_DATA_BITS		Data Bits 1
Stop Bits 1	Enumeration of BYTE	1_STOP_BIT	1_STOP_BIT		Stop Bits 1
Rx Enable 1	BOOL	1	1		Rx Enable 1
Tx Enable 1	BOOL	1	1		Tx Enable 1
Rx LED Enable 1	BOOL	TRUE	0		Rx LED Enable 1
Tx LED Enable 1	BOOL	TRUE	0		Tx LED Enable 1
Flow Control 1	Enumeration of BYTE	NO_FLOW_CTRL	NO_FLOW_CTRL		Flow Control 1
Terminator Enable 1	BOOL	FALSE	0		Terminator Enable 1
Spreader Enable 1	BOOL	FALSE	0		Spreader Enable 1
Loopback Enable 1	BOOL	FALSE	0		Loopback Enable 1

Figure 9-18 SIOS.5 Parameters in the Bedrock IDE

Table 9-9 SIOS.5 Configurable Parameters

Parameter Name	Description
Point Name	User assigned name for the I/O point
Serial Channel	Unique number that identifies the SIOS.5 channel within a configured system.
Mode	Specifies communication mode for the channel Spare - channel not used RS232 RS422 RS485_4WIRE RS485_2WIRE
Baud Rate	Minimum: 1200 bps Maximum: 230,400 bps
Parity	Specifies parity for the channel NO_PARITY EVEN_0 - even number of zero bits ODD_0 - odd number of zero bits EVEN_1 - even number of one bits ODD_1 - odd number of one bits
Data Bits	Number of data bits per character - 5, 6, 7, or 8
Stop Bits	Number of stop bits per character: 1_STOP_BIT - one stop bit will be used 1.5_TO_2_STOP_BITS - 1.5 stop bits when using 5 data bits, otherwise 2 stop bits
Rx Enable	Set to TRUE to enable receive function for the channel

Table 9-9 SIOS.5 Configurable Parameters

Parameter Name	Description
Tx Enable	Set to TRUE to enable transmit function for the channel
Rx LED Enable	Set to TRUE to enable receive LED for the channel
Tx LED Enable	Set to TRUE to enable transmit LED for the channel
Flow Control	Specifies flow control for the channel NO_FLOW_CTRL - no flow control HW - hardware flow control
Terminator Enable	Enables 120 ohm terminator resistor (RS-422 and RS-485 only). Used for long communication lines.
Spreader Enable	Used to reduce noise on RS-485 lines
Loopback Enable	Set to TRUE to use the Rx line to verify that data was transmitted correctly. Disables the external receiver.

Channel Status Indication

See Appendix G, "SPM and SIO Blink Code Summary" for the list of blink codes used to indicate status for each of the channels on the SIOS.5.

In addition to channel status, each channel has a transmit activity LED and a receive activity LED. See the "Monitoring and Troubleshooting" chapter for more information.

Hardware Installation

Important User Information

The section contains instructions to install the Bedrock Control System hardware. Read the instructions and follow all warnings and notes prior to beginning installation.

Complete these tasks before you install the system.

- Verify that you have the components required to install your system.
- Read and understand the safety and environmental warnings and considerations explained in the installation instructions.

Hazardous Location Information

WARNING

EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT WHILE THE CIRCUIT IS LIVE OR UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITABLE CONCENTRATIONS.

Important

Note the following with regard to installation of Bedrock Control System equipment in hazardous locations:

THE EQUIPMENT IS AN OPEN-TYPE DEVICE MEANT TO BE INSTALLED IN AN ENCLOSURE SUITABLE FOR THE ENVIRONMENT AND THAT IS ONLY ACCESSIBLE WITH THE USE OF A TOOL.

THE EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C, AND D HAZARDOUS LOCATIONS, OR NONHAZARDOUS LOCATIONS ONLY.

Important

The following information pertains to installing Bedrock SIO Modules as nonincendive field wiring apparatus (inputs) or associated nonincendive field wiring apparatus (outputs) with connections to equipment in Class I Division 2, Groups A, B, C, and D hazardous locations.

For Models SIO1.5, SIOU.10, SIO4.E, and SIOS.5:

THIS EQUIPMENT IS SUITABLE FOR USE IN HAZARDOUS AND NONHAZARDOUS LOCATIONS, WITH NONINCENDIVE INPUTS AND ASSOCIATED NONINCENDIVE OUTPUTS FOR CLASS I DIVISION 2, GROUPS A, B, C, AND D HAZARDOUS LOCATIONS WHEN INSTALLED PER CONTROL DOCUMENT BRDOC010_003 (BEDROCK HARDWARE INSTALLATION GUIDE FOR HAZARDOUS LOCATIONS).

For Model SIO5.10:

THIS EQUIPMENT IS SUITABLE FOR USE IN HAZARDOUS AND NONHAZARDOUS LOCATIONS, WITH ASSOCIATED NONINCENDIVE OUTPUTS FOR CLASS I DIVISION 2, GROUPS A, B, C, AND D HAZARDOUS LOCATIONS WHEN INSTALLED PER CONTROL DOCUMENT BRDOC010_003 (BEDROCK HARDWARE INSTALLATION GUIDE FOR HAZARDOUS LOCATIONS).

For Models SIO2.10, SIO3.10, SIO6.20, and SIO7.20:

THIS EQUIPMENT IS SUITABLE FOR USE IN HAZARDOUS AND NONHAZARDOUS LOCATIONS, WITH NONINCENDIVE INPUTS FOR CLASS I DIVISION 2, GROUPS A, B, C, AND D HAZARDOUS LOCATIONS WHEN INSTALLED PER CONTROL DOCUMENT BRDOC010_003 (BEDROCK HARDWARE INSTALLATION GUIDE FOR HAZARDOUS LOCATIONS).

Important

Secure any external connections that mate to the equipment by using screws, sliding latches, threaded connectors, or other means provided with this product

Substitution of components may impair suitability for operation in a Class I Division 2 location.

If this product contains batteries, the batteries may only be charged in an area known to be nonhazardous.

Important

Perform all power wiring in accordance with Class I, Division 2 wiring methods as defined in *Article 501-4 (b)* of the *National Electrical Code, NFPA 70* (for installation within the United States) or as specified in *Section 18-152* of the *Canadian Electrical Code* (for installation in Canada).

Environment and Enclosure

Important

This equipment is intended for use in a Pollution Degree 2 industrial environment, in over-voltage Category II application (as defined in IEC 60664-1), at altitudes up to 2000 m (6562 ft) without derating.

This equipment is supplied as an open-type equipment. It must be mounted with an enclosure that is suitably designed for those specific environmental conditions that will be present and appropriately designed to prevent personal injury resulting from accessibility to live parts. The interior of the enclosure must be accessible only by the use of a tool.

Subsequent sections of this publication may contain information regarding specific enclosure type ratings that are required to comply with certain product safety certifications

In addition to this publication, see the following: NEMA Standard 250 and IEC 60529, as application for explanation of the degrees of protection provided by enclosure.

The following information applies when operating the equipment in hazardous locations:

Products marked "CL I, DIV 2, GP A, B, C, D" are suitable for use in Hazardous Locations and nonhazardous locations only. Each product is supplied with markings on the rating nameplate indicating the hazardous location temperature code. When combining products within a system, the most adverse temperature code (lowest "T" number) may be used to help determine the overall temperature code of the system. Combinations of equipment in your system are subject to investigation by the local Authority Having Jurisdiction at the time of installation.

Removal and Insertion Under Power (RIUP)

WARNING

When inserting or removing an SPM or Controller while power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous prior to proceeding. Repeated electrical arcing causes excessive wear to contacts on both the module and its connector. Worn contacts may create electrical resistance that can affect module operation.

Important

Although the module is designed to support Removal and Insertion Under Power, when removing or inserting a removable terminal block with field-side power applied, unintended machine motion or loss of process control may occur. Exercise extreme caution when using this feature.

Preventing Electric Static Discharge

Note

This equipment is designed to be resistant to Electric Static Discharge (ESD) up to 4 kV contact discharge and 8 kV air discharge in accordance with IEC 61000-4-2.

WARNING

This equipment is sensitive to electrostatic discharge, which can cause internal damage and affect normal operations. Follow these guidelines when handling this equipment.

- Touch a grounded object to discharge potential static.
- Wear an approved grounding wrist or ankle strap.
- Do not touch connectors or pins on component boards.
- When not in use, store equipment in appropriate static-safe packaging.

Note

Please be sure to keep original packaging including the anti-static bags to be used for storage or shipping.

Safety-Related Programmable Electronic Systems

Attention

Personnel responsible for the application of safety-related programmable electronic systems (PES) shall be aware of the safety requirements in the application of the system and shall be trained in use of the system.

Optical Ports

Attention

Under certain conditions, viewing the optical port may expose the eye to hazard. When viewed under some conditions, the optical port may expose the eye beyond the maximum permissible-exposure recommendations.

SCC and SCS Controllers are Class 1 laser products pursuant to FDA/CDRH and EN (IEC) 60825 regulations. Laser radiation is present when the system is open. Only trained and qualified personnel are allowed to install, replace or service this equipment.

When not in use, covers should be in place.

BMI Installation

The following options are available for installing the BMI:

- BMIs (5-slot, 10-slot, or 20-slot) can be installed onto a 19” rack mount or enclosure back panel.
- The 5-slot or 10-slot BMIs can be installed in either the horizontal or vertical position. When installing the BMI in the vertical position, the SPM must be on the top, i.e., the upper position.

The recommended mounting orientation for the BMIs is horizontal. If a BMI is going to be mounted vertically, the SPM must be on top. A 5-slot BMI that has been mounted vertically is shown in Figure 10-1. A 20-slot BMI that has been horizontally mounted is shown in Figure 10-2. There is no reason to derate power when a BMI is mounted vertically.

See the “BMI” chapter for information on BMI dimensions,

A safety ground connection should be made to the BMI using the screw connection marked earth ground. A minimum of 16 AWG or 1.5 mm^2 wire should be used. Larger gauge wire may be necessary depending on the overcurrent protection of the field wiring.

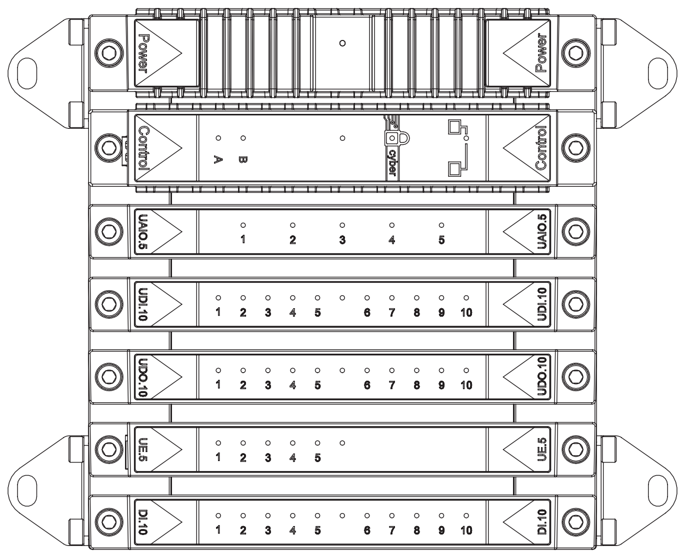


Figure 10-1 5-Slot BMI Vertically Mounted

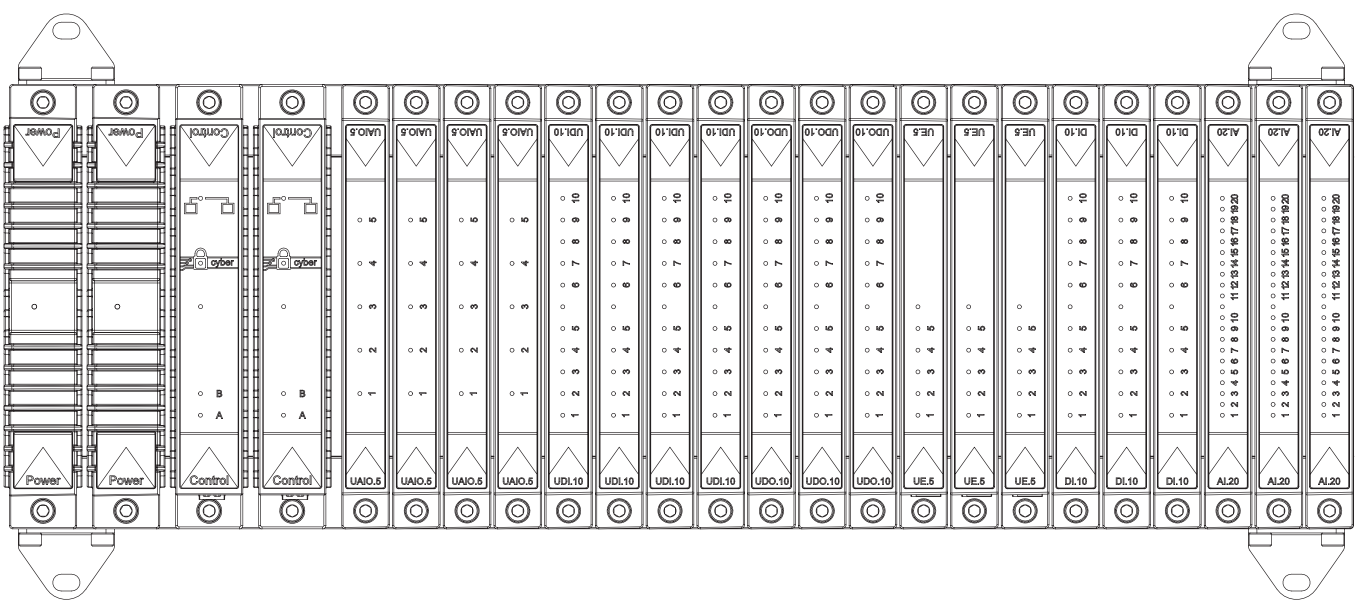


Figure 10-2 20-Slot BMI Horizontally Mounted

SPM Installation

Install SPMs as described in the following steps. Note that to assist with installation, an SPM has two pins that align with holes in the BMI. In addition, the bottom of the SPM also has an orange triangle and orange circles that will align with corresponding markers on the BMI. These features are present to ensure that the SPM is correctly installed on the BMI.The bottom view of an SPM module is shown in Figure 10-3.

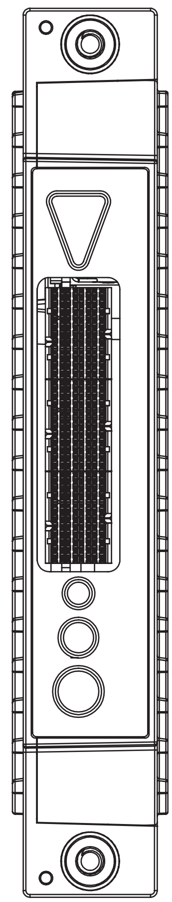


Figure 10-3   SPM Bottom View

1. Install the SPM into the first SPM slot as shown in Figure 10-4. The SPM will be flush against the BMI when seated properly.

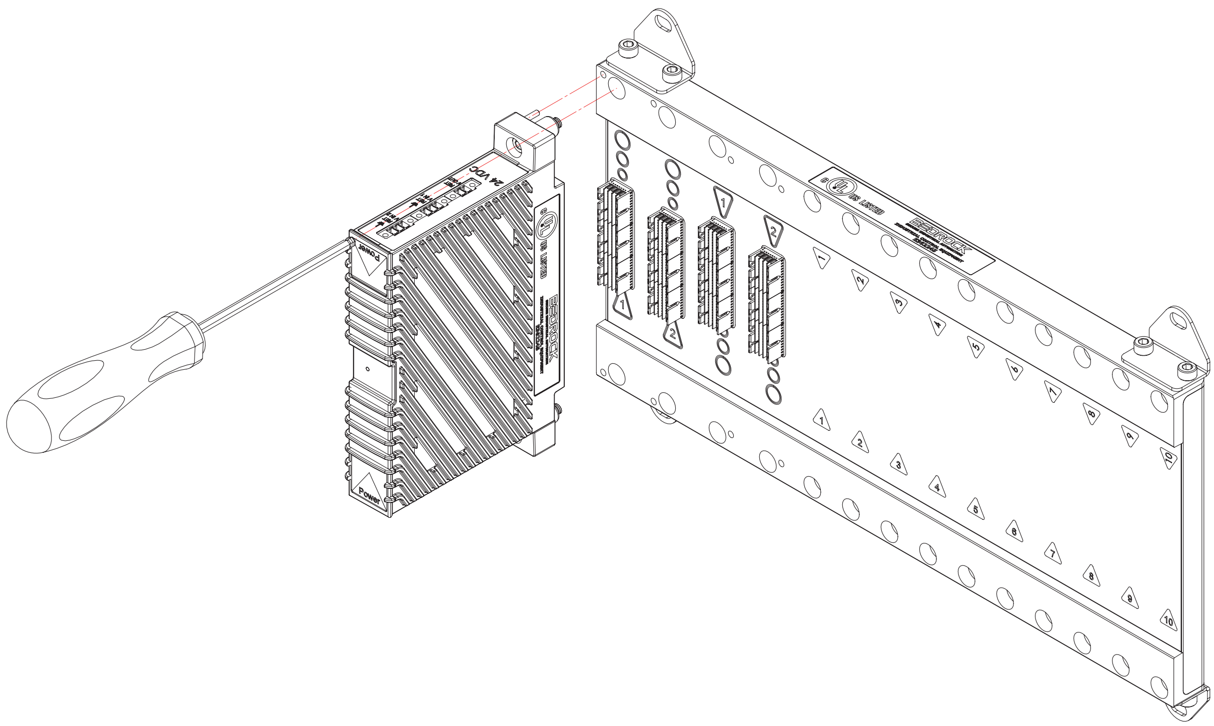


Figure 10-4 Single SPM

2. Hand tighten screws as shown. Use a maximum torque of 8.1 N·m (6 lb·ft).
3. If installing a redundant system, install the second SPM into the second SPM slot shown in Figure 10-5. The SPM will be flush against the BMI when seated properly.

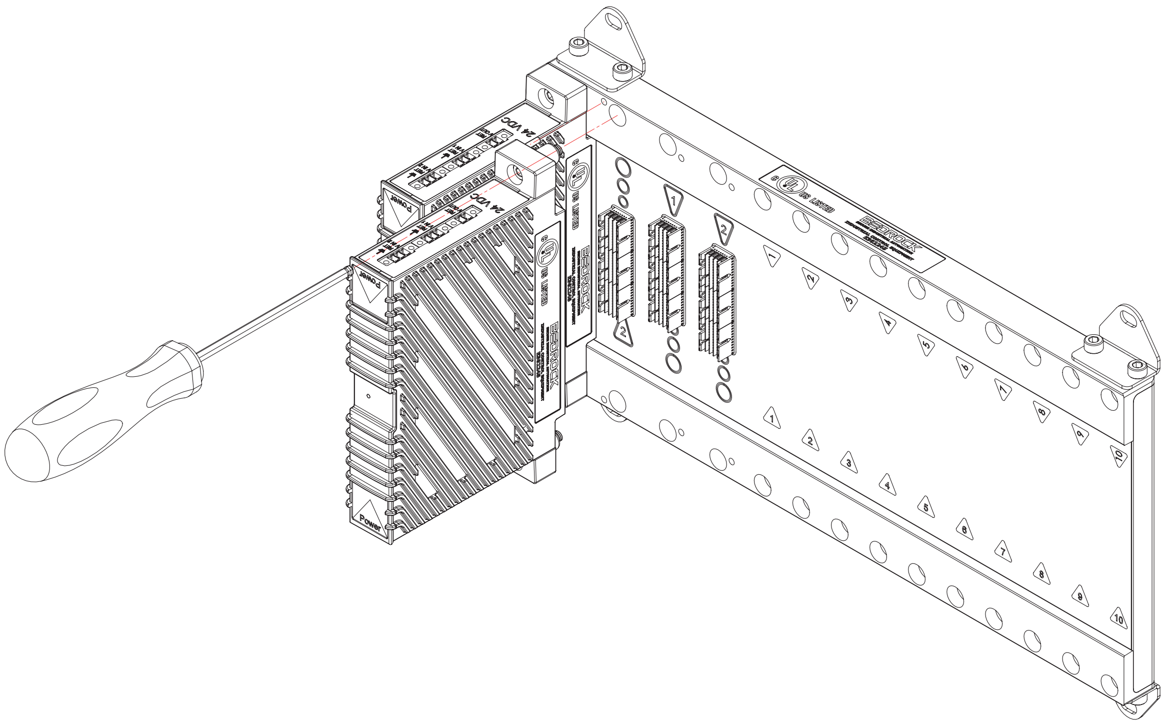
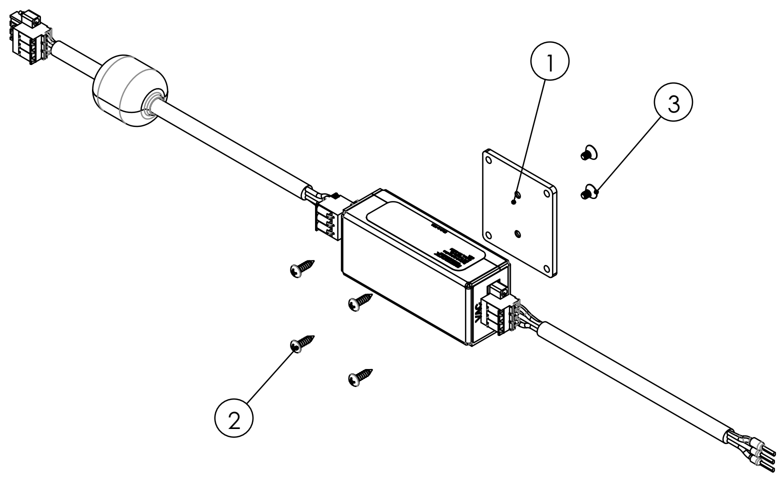


Figure 10-5 Redundant SPMs

4. Hand tighten screws as shown. Use a maximum torque of 8.1 N·m (6 lb·ft).

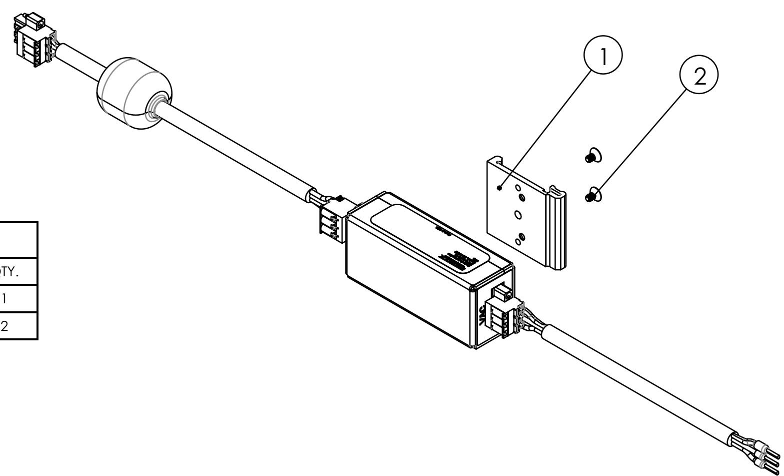
SPM AC Line Filter Assembly

Two options are provided for mounting the SPM AC Line Filter Assembly (SPM.U only). Figure 10-6 shows a panel mount configuration. Figure 10-7 shows a DIN rail mount configuration.



PANEL MOUNT PARTS LIST		
ITEM	DESCRIPTION	QTY.
1	AC FILTER PANEL MOUNTING BRACKET	1
2	6-32 X 1/2 SELF TAPPING SCREW	4
3	6-32 X 1/4 FLAT HEAD CAP SCREW	2

Figure 10-6 SPM AC Filter Panel Mount



DIN RAIL MOUNT PARTS LIST		
ITEM	DESCRIPTION	QTY.
1	DIN RAIL MOUNTING PLATE	1
2	6-32 X 1/4 FLAT HEAD CAP SCREW	2

Figure 10-7 SPM AC Filter DIN Rail Mount

Controller Installation

Note that this section applies to all types of Bedrock Controllers. SCC controllers are shown in the illustrations.

Install a Controller as described in the following steps. Note that to assist with installation, a Controller has two pins that align with holes in the BMI. In addition, the bottom of a Controller also has a blue triangle and blue circles that will align with corresponding markers on the BMI. These features are present to ensure that the Controller is correctly installed on the BMI. The bottom view of a Controller is shown in Figure 10-8.

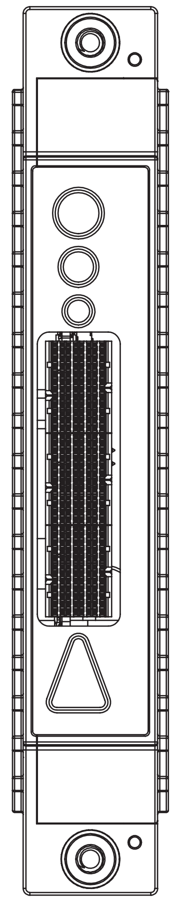


Figure 10-8 Controller Module Bottom View

1. Install a Controller module into the first Controller slot as shown in Figure 10-9. The Controller will be flush against the BMI when seated properly.

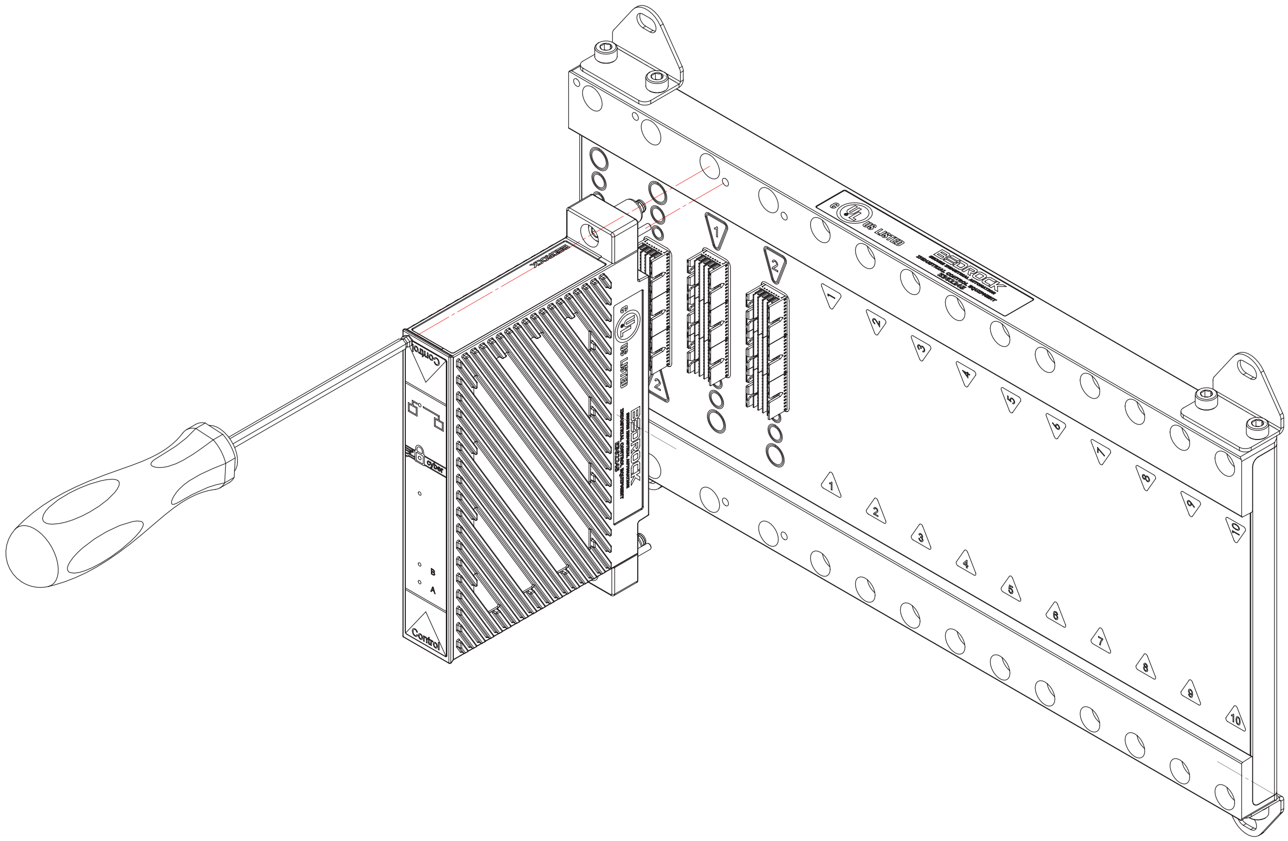


Figure 10-9 Single Controller Module

2. Hand tighten screws as shown. Use a maximum torque of 8.1 N·m (6 lb·ft).
3. If installing in a redundant system, install the second Controller into the second Controller slot as shown in Figure 10-10. The Controller will be flush against the BMI when seated properly.

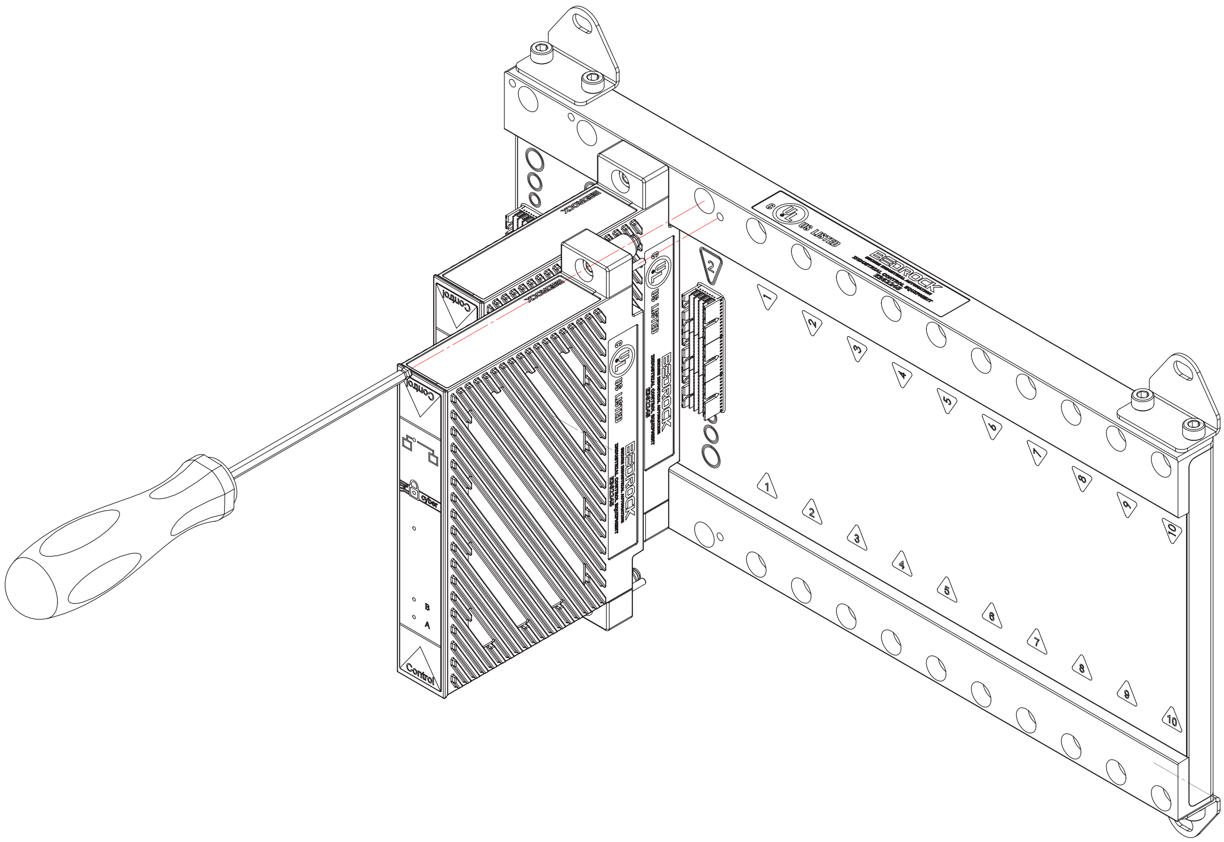


Figure 10-10 Redundant Controller Modules

4. Hand tighten screws as shown. Use a maximum torque of 8.1 N·m (6 lb·ft).

Connect Modules via Ethernet

A fiber-optic or Cat6 shielded copper cable may be used to connect to the Bedrock Control System as shown in Figure 10-11.

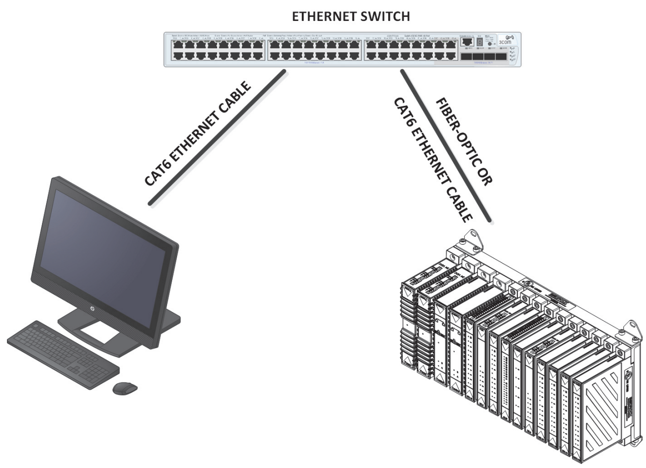


Figure 10-11 Connect via Ethernet

Fiber-optic Cables

The following are the fiber-optic cable specifications:

- 9/125 µm SMF fiber
- 1310 nm wavelength
- 1.25 Gbit bi-directional
- Up to 10 km range

Cat6 Copper Cables

The following are the Cat6 shielded copper cable specifications:

- 10/100/1000 Mbps
- full and half duplex communication
- 100 m maximum cable length

SFP Modules

The fiber-optic or Cat6 shielded copper cable plugs into an SFP module in Port A of a Controller as shown in Figure 10-12. Note that Port B, if present, is a spare and is currently disabled. The SFP modules for use with the different cable types are listed in Table 10-1.

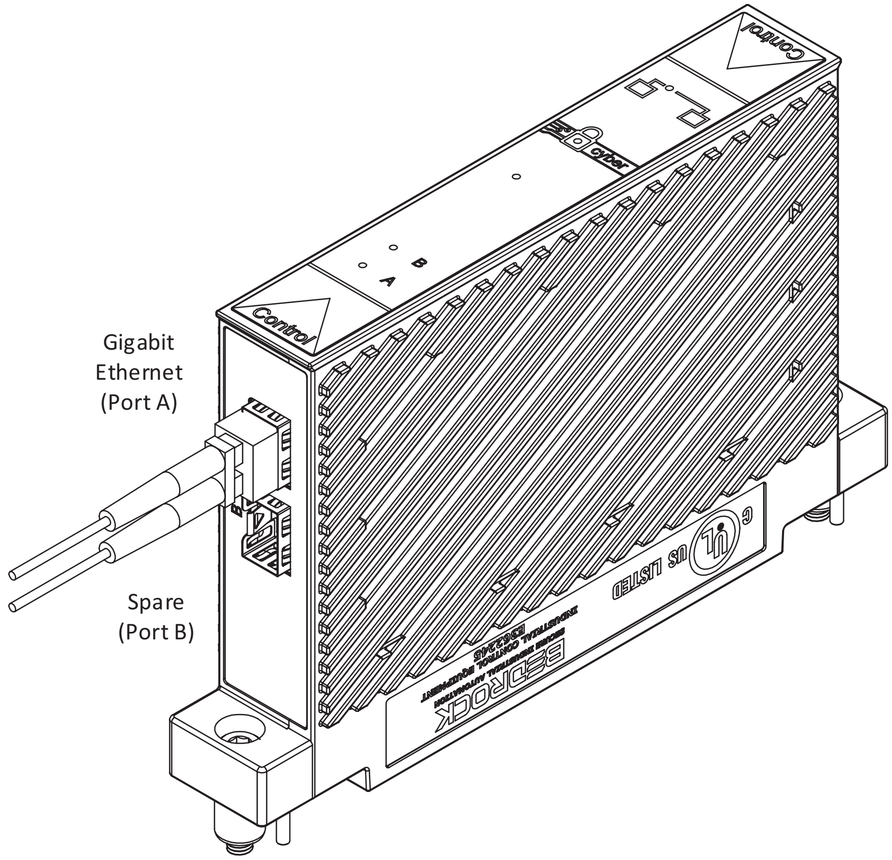


Figure 10-12 SCC Gigabit Ethernet Port

Table 10-1 Bedrock SFP Modules

Cable Type	SFP Module
Fiber-optic	Fiber Ethernet SFP Interface Module
Cat6	Copper Ethernet SFP Interface Module

SIO Module Installation

Bedrock Control System SIO modules are designed for Removal and Insertion Under Power (RIUP) which provides flexibility for module maintenance during operation.

Prior to installation, become familiar with the warnings and notes that appear in the Important User Information at the beginning of “Hardware Installation”.

For compliance with UL requirements, adhere to the following:

- use 60/75°C copper (Cu) conductor only
- wire size range: 12-30 AWG, solid/stranded
- terminal tightening torque: 0.565-0.791 N·m (5-7 lb-in)

- maximum surrounding air temperature: see Table A-1 in Appendix A.

Install the SIO Modules

Install SIO modules on to the BMI as follows:

1. Install the required SIO modules into any numbered location (1 through 5, 10, or 20) on a 5-slot, 10-slot, or 20-slot BMI marked for installation as shown in Figure 10-13.

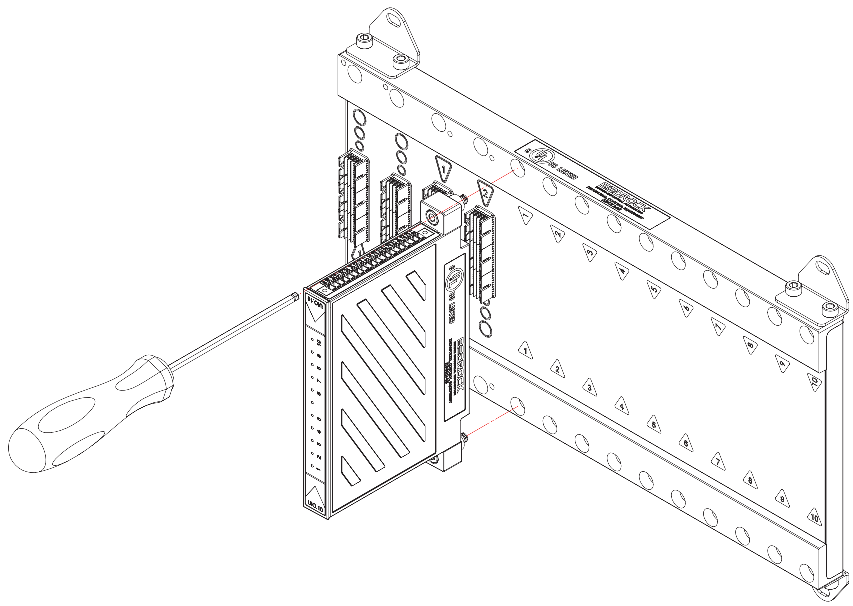


Figure 10-13 Install an SIO Module onto BMI

2. Hand tighten screws with 4 mm ball end hex driver as shown in Figure 10-13.
3. Tighten to 8.1 N·m (6 lb_f ·ft), as appropriate, using a ball screw driving torque.

NOTE

Unlike SPMs and Controllers which can only mount in one direction, SIO modules can mount in either orientation. When mounting an SIO Module, care should be taken during installation to ensure the best wiring configurations.

SIO modules being installed into a BMI.10 are shown in Figure 10-14 with both orientations.

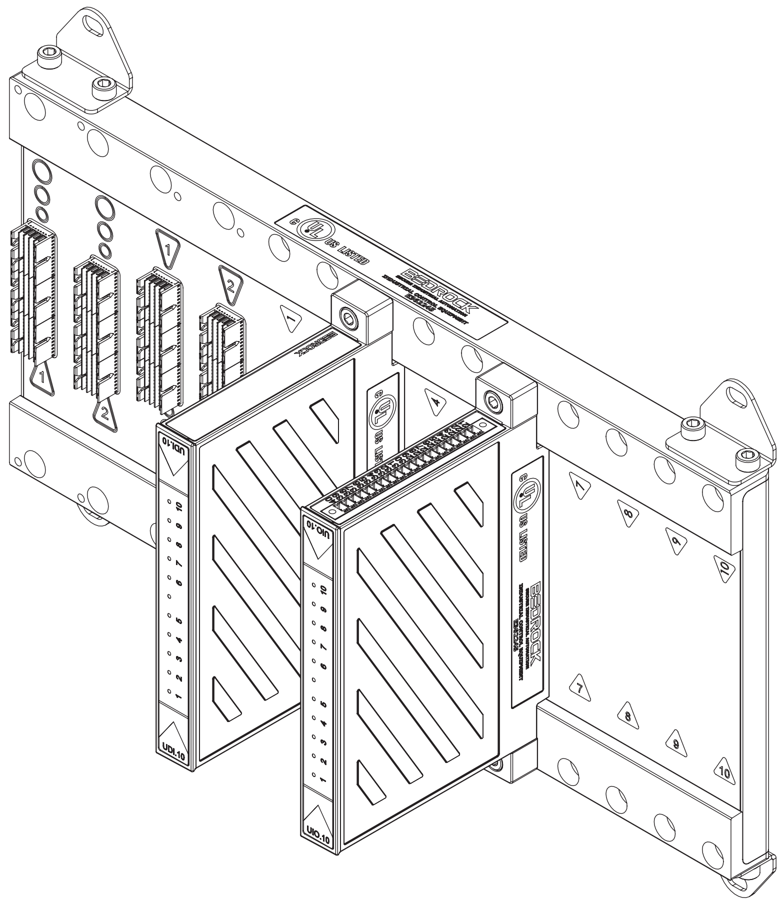


Figure 10-14 SIO Modules in both Orientations

Installation with the Bedrock Universal Cable

Analog and discrete SIO modules are connected to the field terminal strips via the Bedrock Universal Cable. Thumb screws located on the cable assembly secure the assembly to the SIO module. Connect the assembly to the module as shown in Figure 10-15.

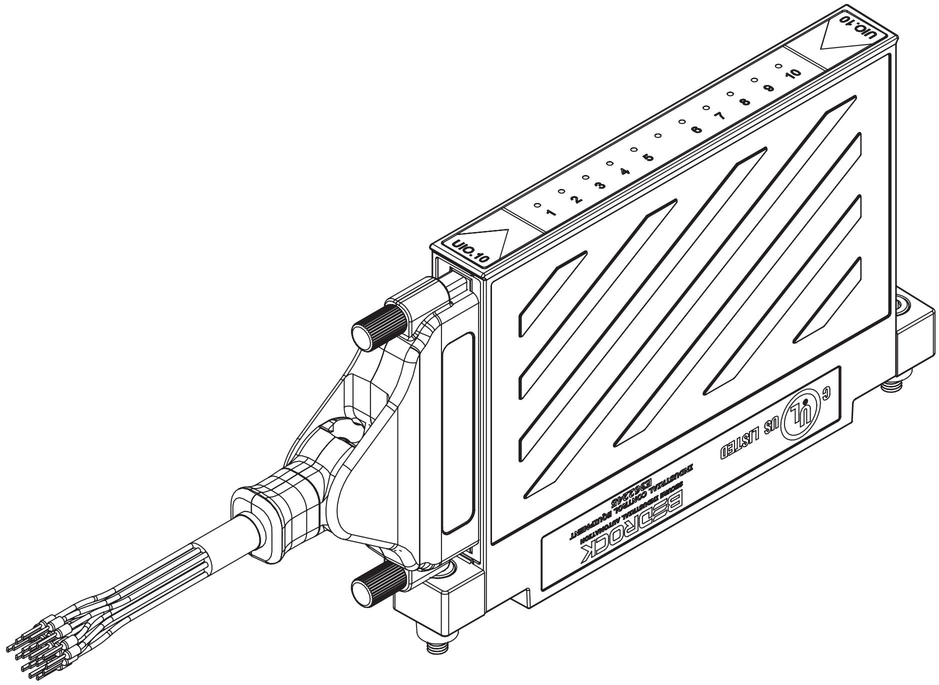
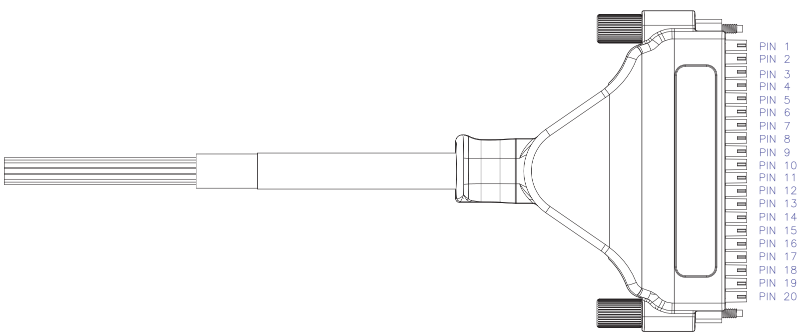


Figure 10-15 Bedrock Universal Cable Connected to SIO Module

The wiring diagram and pin outs for the universal cable and SIO module are shown in Figure 10-16.



WIRING DIAGRAM FOR SIO MODULE		
PAIR 1	BLACK	PIN 1
	RED	PIN 2
PAIR 2	BLACK	PIN 3
	WHITE	PIN 4
PAIR 3	BLACK	PIN 5
	GREEN	PIN 6
PAIR 4	BLACK	PIN 7
	BLUE	PIN 8
PAIR 5	BLACK	PIN 9
	BROWN	PIN 10
PAIR 6	BLACK	PIN 11
	YELLOW	PIN 12
PAIR 7	BLACK	PIN 13
	ORANGE	PIN 14
PAIR 8	RED	PIN 15
	GREEN	PIN 16
PAIR 9	RED	PIN 17
	WHITE	PIN 18
PAIR 10	RED	PIN 19
	BLUE	PIN 20

Figure 10-16 Universal Cable Pin Out Diagram

Thermocouples

NOTE

If installing an SIO1.5 and using a thermocouple, a CJC unit must be installed between the thermocouple and the cable termination for each channel configured as a thermocouple.

An SIO1.5 with a thermocouple and CJC unit is shown in Figure 10-17.

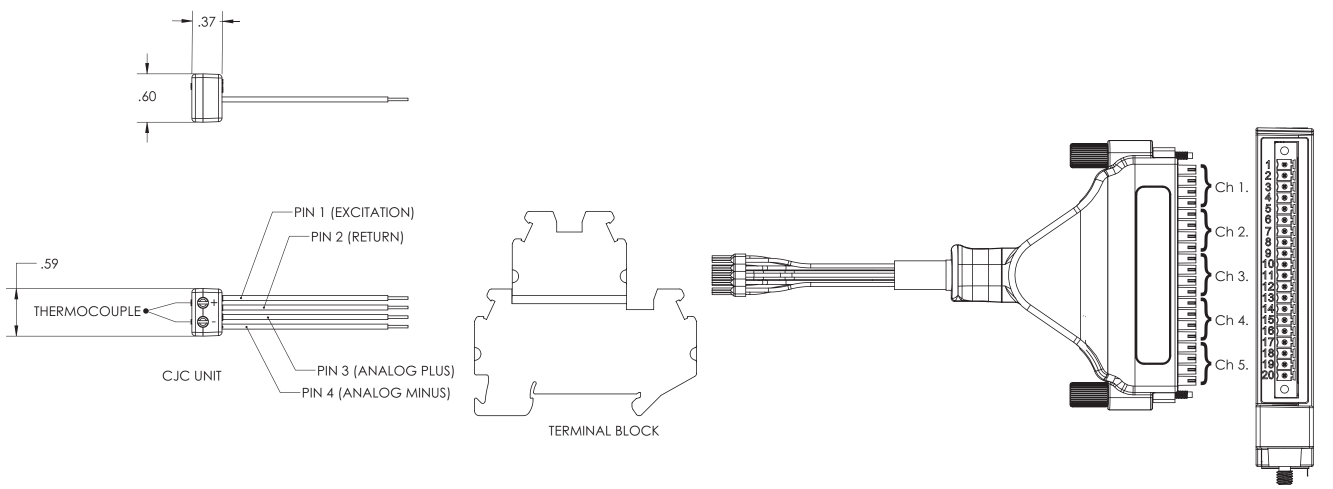


Figure 10-17 SIO1.5 Configured with Thermocouple Connected to CJC Unit

Cabling for SIO4.E Communication Modules

SIO4.E communication modules use Ethernet cabling for data and power connections to field devices. Ensure that the Ethernet cable has the additional wiring needed to supply power. A Cat5 shielded cable is recommended.

Cabling for SIOS.5 Communication Modules

Each port on an SIOS.5 communication module can be connected to field devices by using the Bedrock SIOS.5 Serial Communication Cable. One end of the cable connects to a Micro-D connector on the SIOS.5 module while the other end of the cable has a 9-pin female D-Sub connector (the same as can be found on a standard PC) for connection to field devices. See Appendix C, “Wiring Diagrams and Pin Out Information” for pin out information for the supported serial communication standards.

HART Device Configuration

Overview

The Bedrock Field Device Tool (FDT) provides the capability to configure and maintain smart field devices and Bedrock SIO modules that support the HART Communication Protocol. This chapter provides information on the following tasks necessary to prepare the Bedrock FDT for configuring HART field devices:

- installation of the Bedrock FDT
- installation of Bedrock and third-party DTMs
- enabling SIO modules for HART communication in the Bedrock IDE
- configuration of Bedrock hardware in the Bedrock FDT
- configuration of third-party hardware in the Bedrock FDT

The following Bedrock SIO modules can be configured for communication with HART field devices:

- SIO1.5
- SIO6.20
- SIOU.10

Intended Audience

The information in this section is intended for use by engineers, programmers, and technicians who need to configure HART devices for use with the Bedrock Control System.

HART Communication Protocol

The HART Communication Protocol supports bi-directional communication and provides a digital communication link between host systems and smart field devices.

HART passthrough is supported using the Bedrock FDT. For a list of available HART variables, see Appendix G, “HART Variables”. The Bedrock IDE provides the ability to map HART variables to your control program.

For more information on the HART Communication Protocol, see the HART Communication Foundation website (http://www.hartcomm.org).

Bedrock Field Device Tool

The Bedrock Field Device Tool is a frame application based on FDT technology. The tool provides users with the capability to configure devices that support the HART Communication Protocol so that the devices can be used with the Bedrock Control System. The Bedrock FDT allows the user to scan their environment for network cards, BMIs, Controllers, SIO modules, and field devices. Additional information on the Bedrock FDT can be found within the Bedrock FDT help content.

DTMs

Device type managers (DTMs) are software components that provide an interface for configuring the Bedrock Control System and third-party devices that support HART. DTMs are implemented within the frame application and can be categorized as follows:

- Communication and gateway DTMs provided by Bedrock Automation provide an interface to Bedrock devices on the user's network. Bedrock provides DTMs for network interfaces, BMIs, Controllers, and SIO modules.
- Device DTMs provide an interface to and allow configuration of third-party devices that support HART. Third-party DTMs are supplied by the device manufacturer and not Bedrock Automation.

Software Installation

The following software components must be installed to configure HART devices for use with the Bedrock Control System. Windows Installer files for the Bedrock FDT and Bedrock DTMs can be downloaded from the Bedrock Automation website:

https://www.bedrockautomation.com/download/

1. Install the Bedrock Field Device Tool as follows:
   a. Download and extract the contents of the Bedrock Field Device Tool zip file
   b. Run *Setup.exe*
2. Install the Bedrock DTMs as follows:
   a. Download and run *BedrockDTMsSetup.msi*
3. Install any DTMs for field devices as required. Contact the device manufacturer to obtain files needed for installation.

Configuration of a HART Device Using the Bedrock FDT

This section provides an example of how to use the Bedrock FDT to setup a basic configuration of a HART device. Several of the user actions described below are available both in the application Ribbon as well as by right-clicking an item and selecting from a context menu. The examples below will show user selections from the Ribbon.

Steps for adding gateway or device DTMs will provide instructions for both scanning a network as well as manually adding a DTM to the network topology. Manually adding DTMs is useful for working offline, e.g., in cases where a network is unavailable.

1. Ensure that software installation of the Bedrock FDT, Bedrock DTMs, and any DTMs from device manufacturers has been completed as described above. Ensure that the software is up to date.
2. Create a blank project from the start page of the Bedrock FDT. A network node will be highlighted in the Network View (see Figure 11-1). If the DTMs were installed for the first time or if existing DTMs were updated, the device catalogue will need to be updated as shown in the figure.

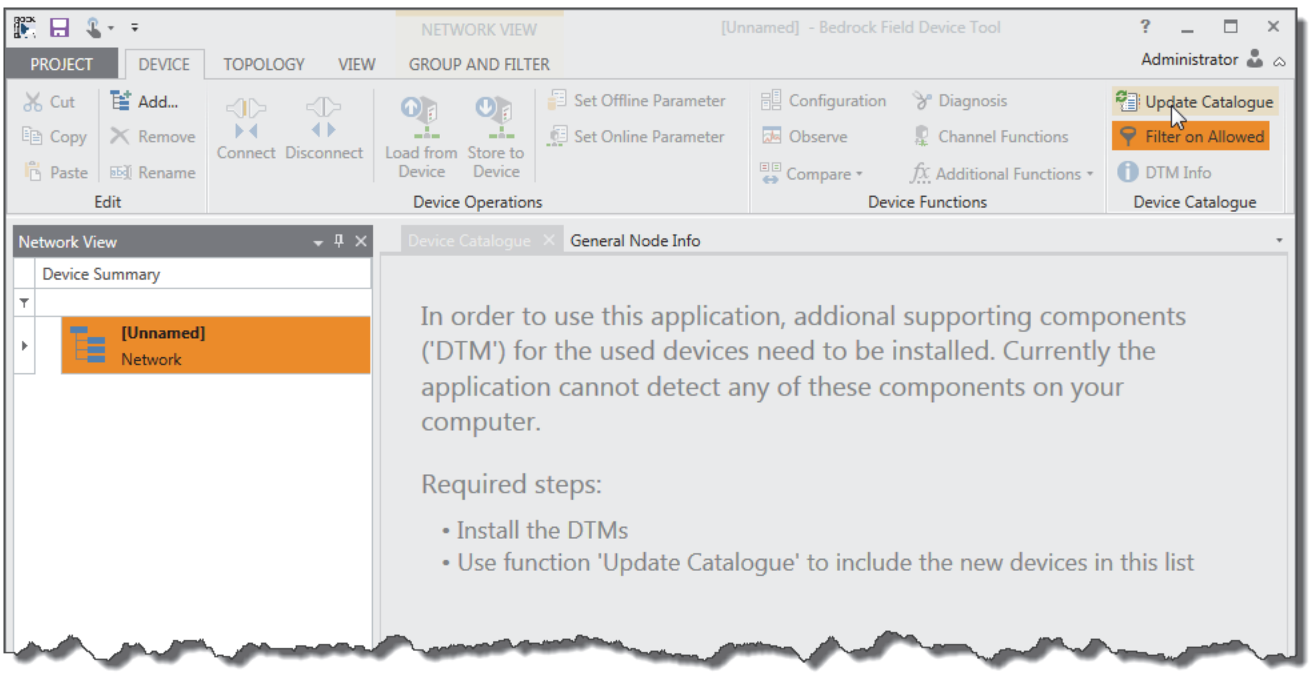


Figure 11-1 New FDT Project

3. Select a Bedrock communication DTM from the Device Catalogue as shown in Figure 11-2.

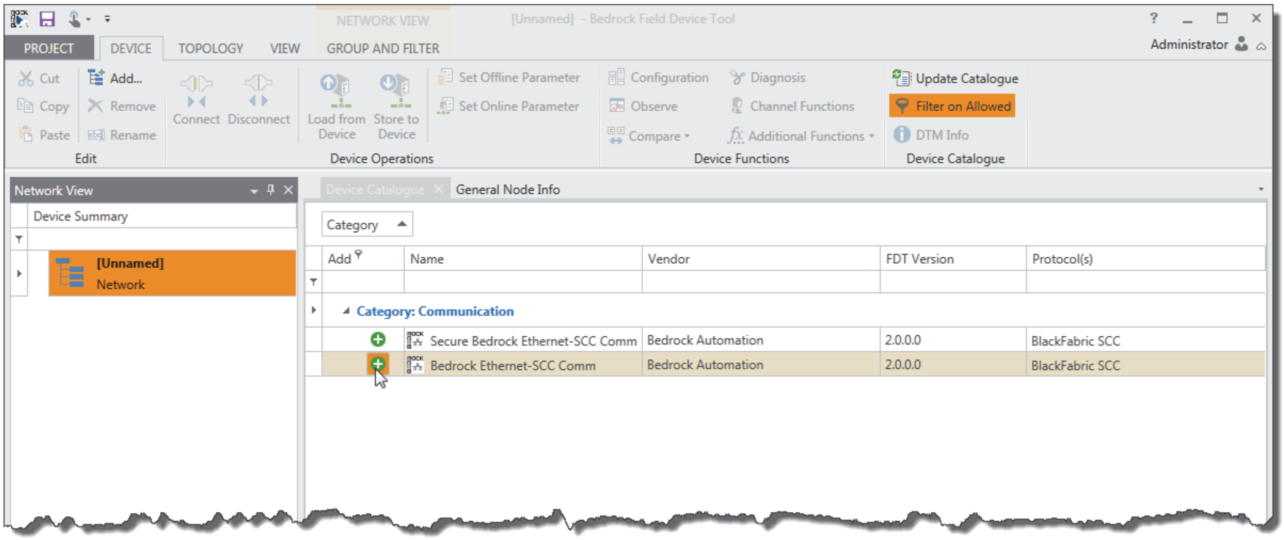


Figure 11-2 Select Communication DTM

4. Double-click the communication DTM that was just added to the Network View as shown in Figure 11-3.

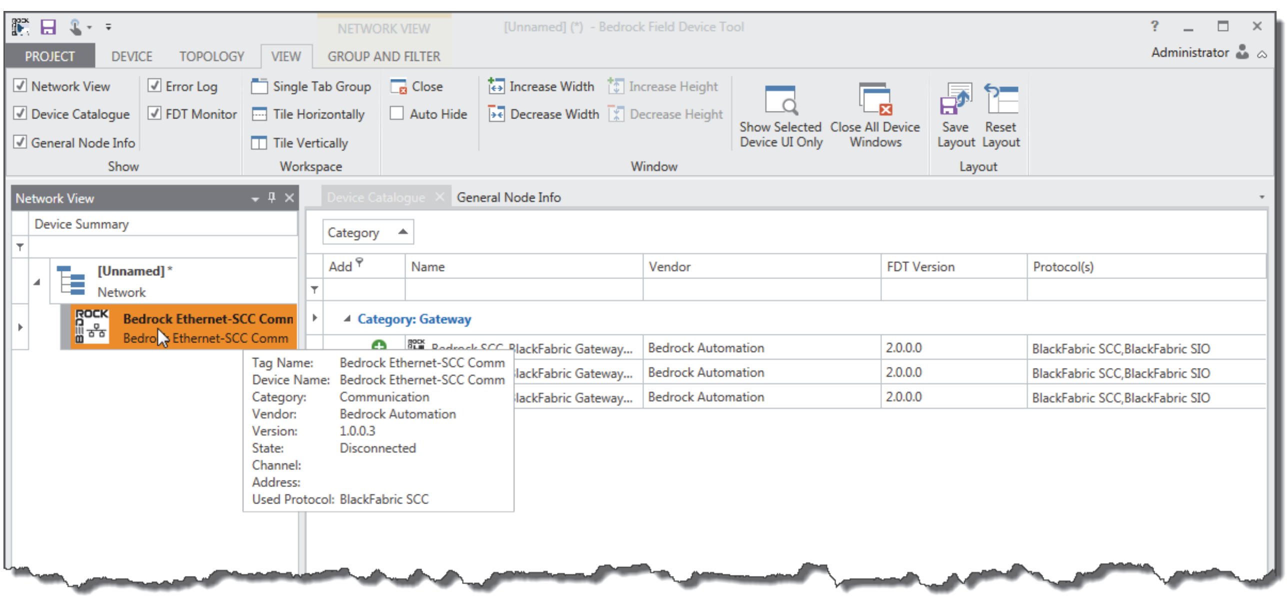


Figure 11-3 Select Network Adapter

5. In the Network Card Selection pane, select the network card for the Controller that you are trying to connect to from the drop-down menu as shown in Figure 11-4.

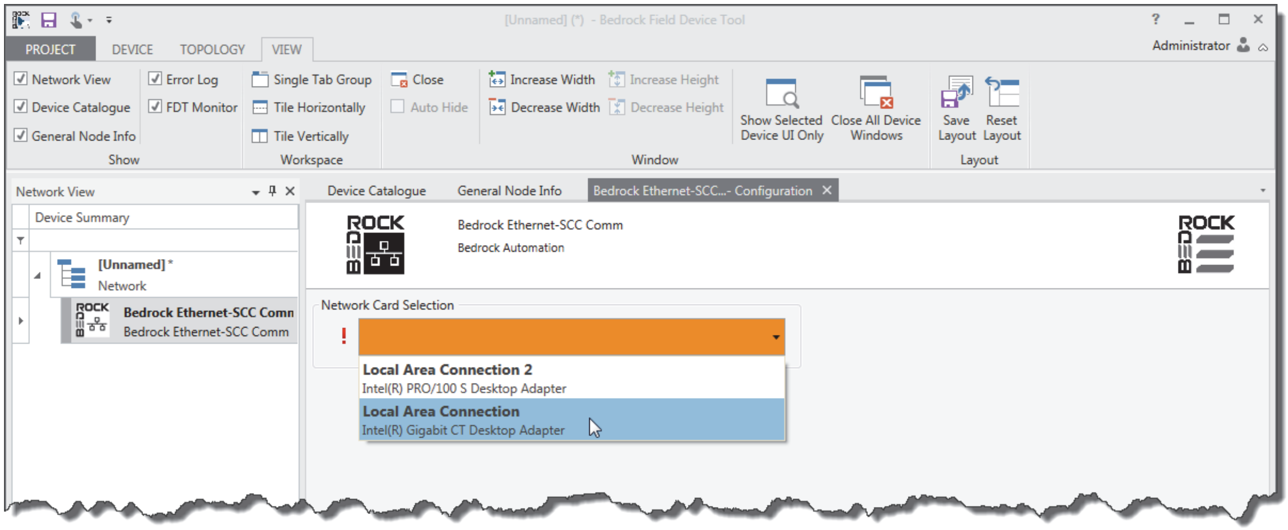


Figure 11-4 Select Network Device

6. Click OK. A list of available SCC-BlackFabric gateway DTMs will be displayed as shown in Figure 11-5.

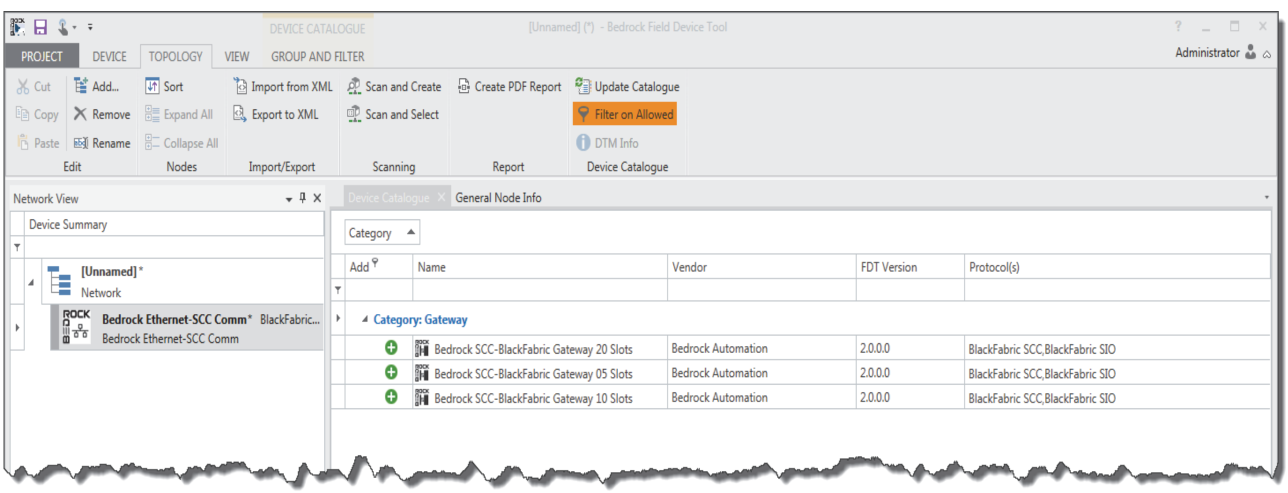


Figure 11-5 SCC-Black Fabric Gateway DTMs

7. Add a gateway DTM for SCC-BlackFabric. The gateway DTM can be added either automatically or manually. Select the communication DTM in Network View and then choose one of the following:
    - To automatically add a gateway DTM for SCC-BlackFabric, click Scan and Select on the Topology tab in the Ribbon as shown in Figure 11-6. The Bedrock FDT will query the network for available modules. Go to step 8.

- **Or** to manually add a DTM to your network topology without querying the network, click the plus sign next to the DTM name (see Figure 11-6) in the Device Catalogue. Go to step 9.

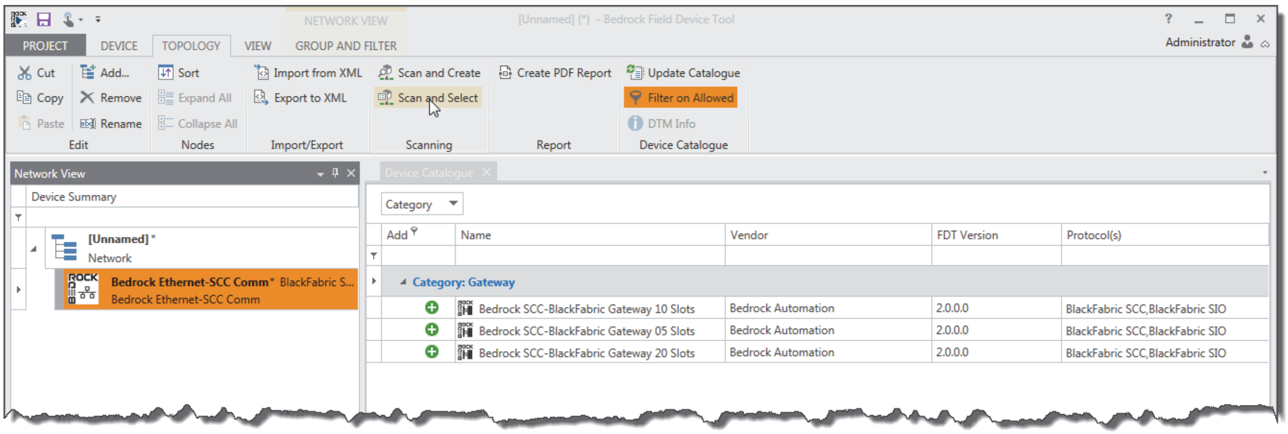


Figure 11-6 Adding a Gateway DTM

8. If you elected to automatically add a DTM in the previous step, a list of the DTMs that were found will be displayed as shown in Figure 11-7. Use the checkboxes to select the DTM(s) you would like to add to your project and then do one of the following:
    - Click Add All and Close. This will add all compatible DTMs in the list to your project.
    - **Or** click Add Selected Nodes to Project. This will add only those DTMs with check marks to your project. Click Close to dismiss the dialog.

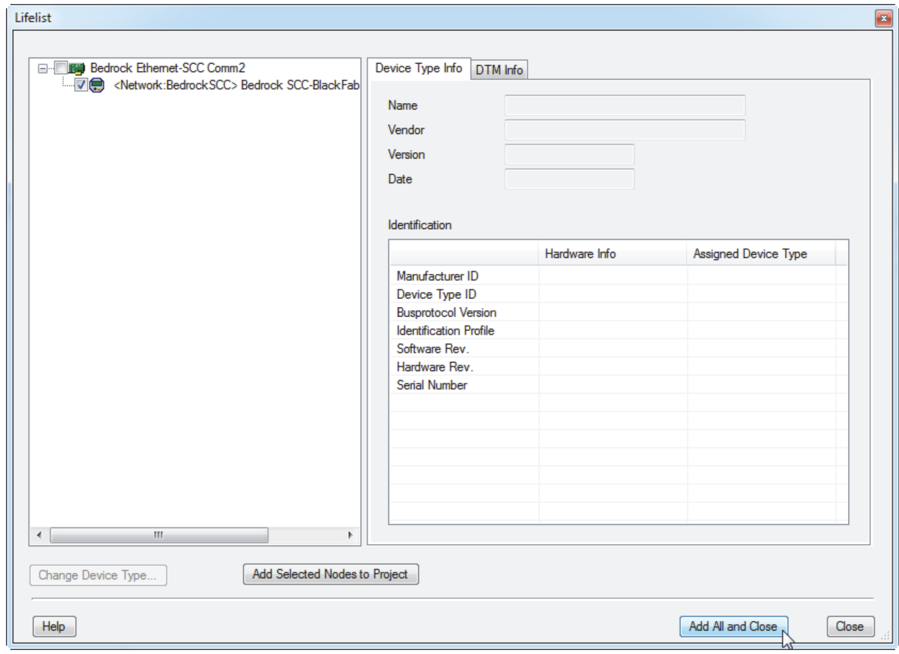


Figure 11-7 Adding Gateway DTMs After Scan

9. The Network View pane will be updated with the selected DTM(s) as shown in Figure 11-8. Select an SCC-BlackFabric DTM in the Network View to display a list of gateway DTMs for SIO-Hart.

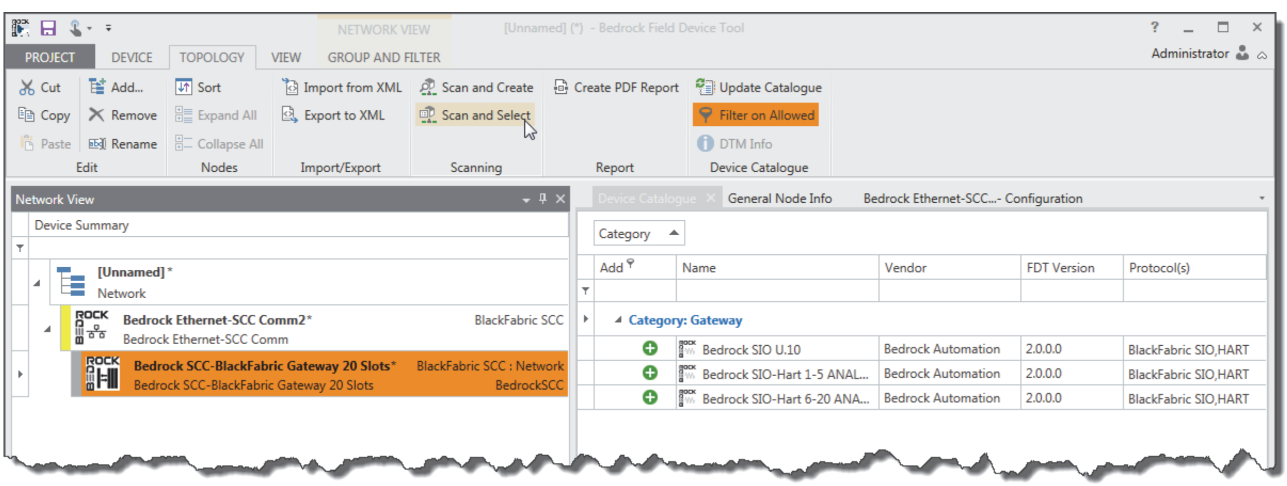


Figure 11-8 Select and Scan SCC-BlackFabric DTM in Network View

10. Add a gateway DTM for SIO-Hart. The gateway DTM can be added either automatically or manually. Choose one of the following.

- To automatically add a gateway DTM for SIO-Hart, click Scan and Select on the Ribbon as shown in Figure 11-8. The

Bedrock FDT will query the network for available modules. Go to step 11.

- **Or** to manually add a gateway DTM for SIO-Hart to your network topology without querying the network, click the plus sign next to the DTM name in the Device Catalogue. Go to step 12.

11. If you elected to automatically add a DTM (Scan and Select) in the previous step, you will be prompted for a list of channels to scan as shown in Figure 11-9. These correspond to physical slots on the BMI.

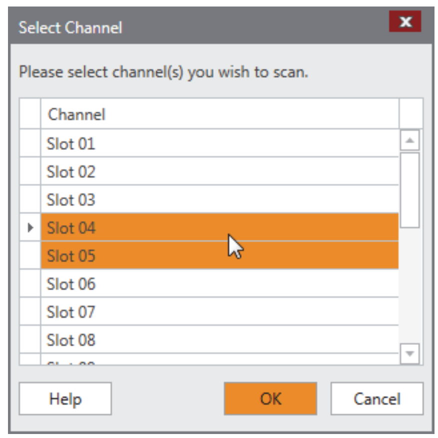


Figure 11-9 Select BMI Slots for Scan

a. Select the slots you would like to scan and then click OK.

b. A list of the DTMs that were found will be displayed as shown in Figure 11-10. The DTMs in the list correspond to HART-enabled SIO modules. Use the checkboxes to select the DTM(s) you would like to add to your project and then do one of the following:

   - Click Add All and Close. This will add all compatible DTMs in the list to your project.
   - **Or** click Add Selected Nodes to Project. This will add only those DTMs with check marks to your project. Click Close to dismiss the dialog.

c. Go to step 13.

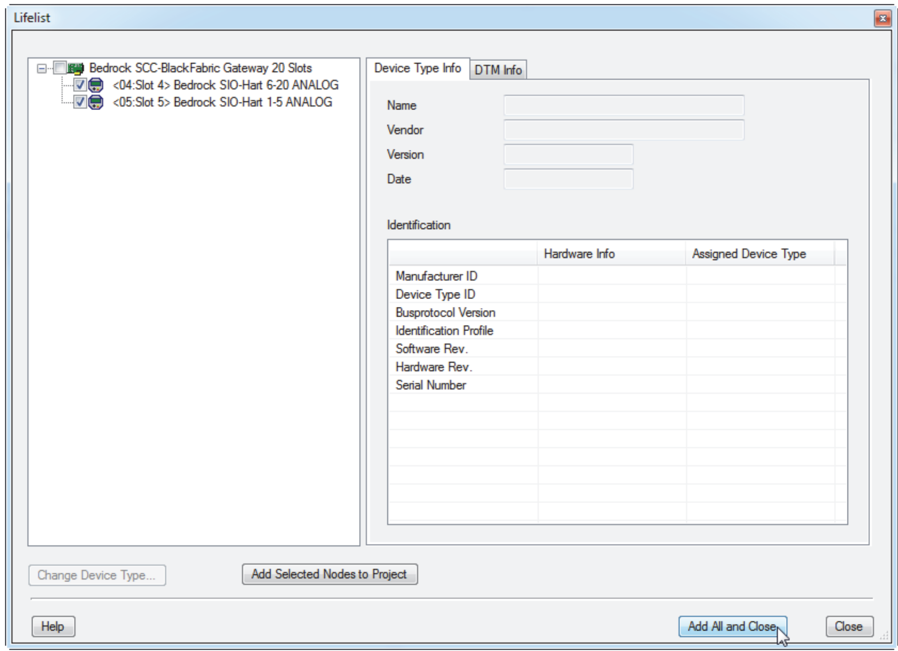


Figure 11-10 Adding DTMs After Scan

12. If you elected to manually add a gateway DTM for SIO Hart, you will be prompted for a list of channels to scan as shown in Figure 11-11. These correspond to physical slots in the BMI. Select the slots you would like to scan and then click OK.

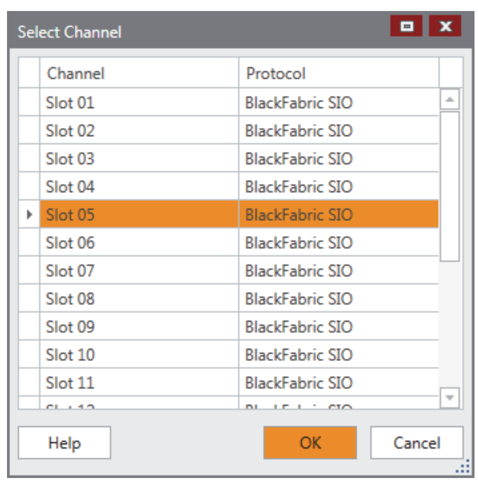


Figure 11-11 Select BMI Slots (Manually Adding DTM)

13. Once gateway DTMs for SIO Hart have been added to your project, the Network View pane will be updated as shown in Figure 11-12. Select a DTM for SIO Hart to see a list of device DTMs for HART devices in the Device Catalogue.

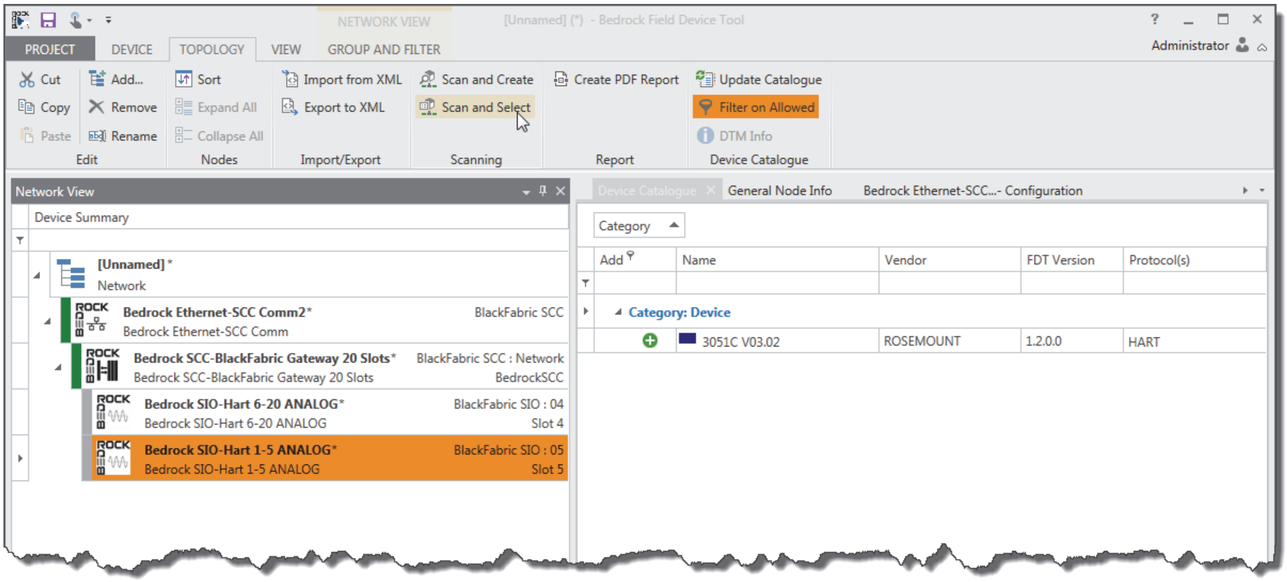


Figure 11-12 Device DTM in Device Catalogue

14. Add a device DTM for a HART device. The device DTM can be added either automatically or manually. Choose one of the following.
    - To automatically add a device DTM for a HART device, click Scan and Select on the Ribbon as shown in Figure 11-12.
    - **Or** to manually add a device DTM to your network topology without querying the network, click the plus sign next to the DTM name in the Device Catalogue.
15. You will be prompted for a list of channels to scan as shown in Figure 11-13. These correspond to channels on the SIO module. Select the channels you would like to scan and then click OK.

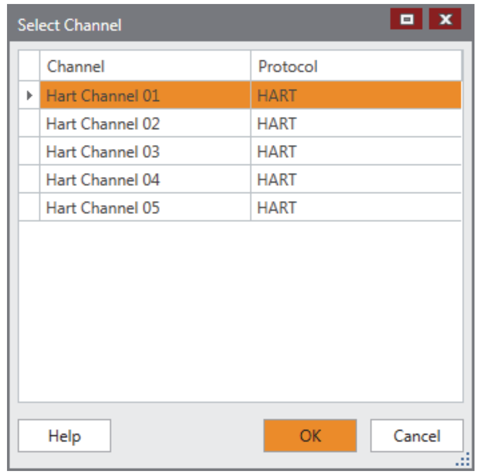


Figure 11-13 Scan Channels for HART Devices

16. Perform this step only if you elected to automatically add a device DTM. A list of the DTMs that were found will be displayed as shown in Figure 11-14. Use the checkbox to select the DTM(s) you would like to add to your project and then do ones of the following:
    - Click Add All and Close. This will add all compatible DTMs in the list to your project.
    - **Or** click Add Selected Nodes to Project. This will add only those DTMs with check marks to your project. Click Close to dismiss the dialog.

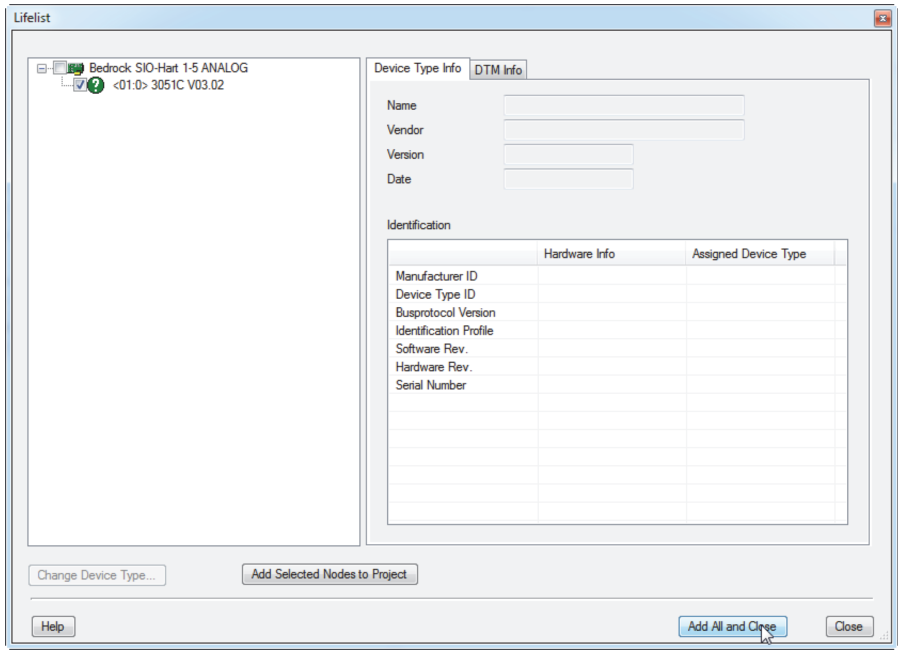


Figure 11-14 Adding a Device DTM

17. The Network View pane will be updated with device DTMs as shown in Figure 11-15. Do one of the following:
    - If you elected to automatically add a DTM in step 14, then select a device DTM and click the Connect button on the Device tab on the Ribbon to connect to a HART device.
    - **Or** if you elected to manually add a DTM in step 14, then go to step 19.

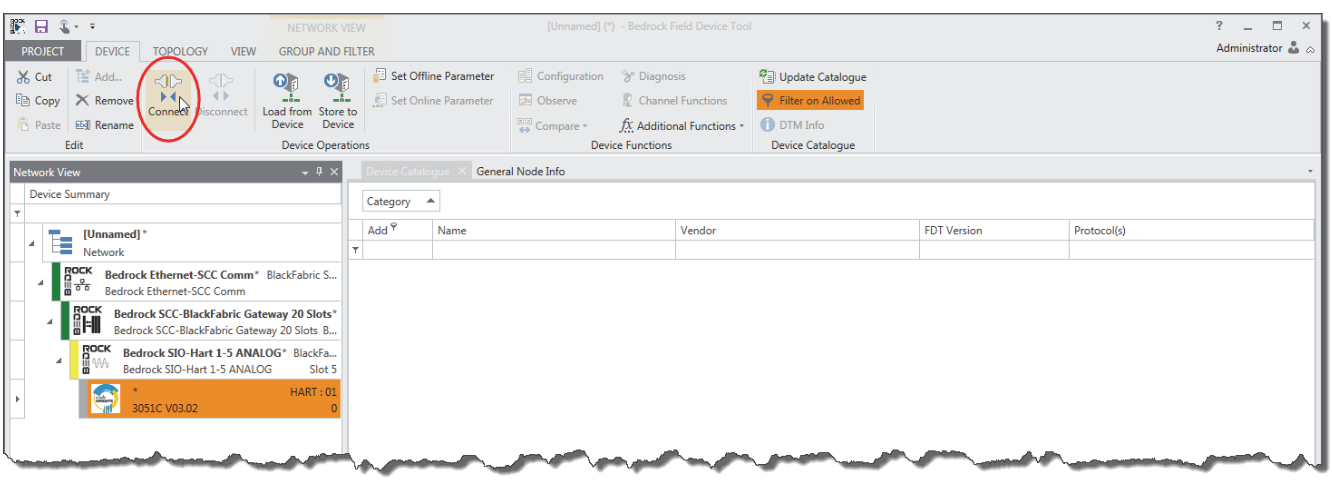


Figure 11-15 Device DTM Added to Network View

18. The nodes in the Network View Device Summary should all be in the Connected state as indicated by the green status bars. See Figure 11-16.

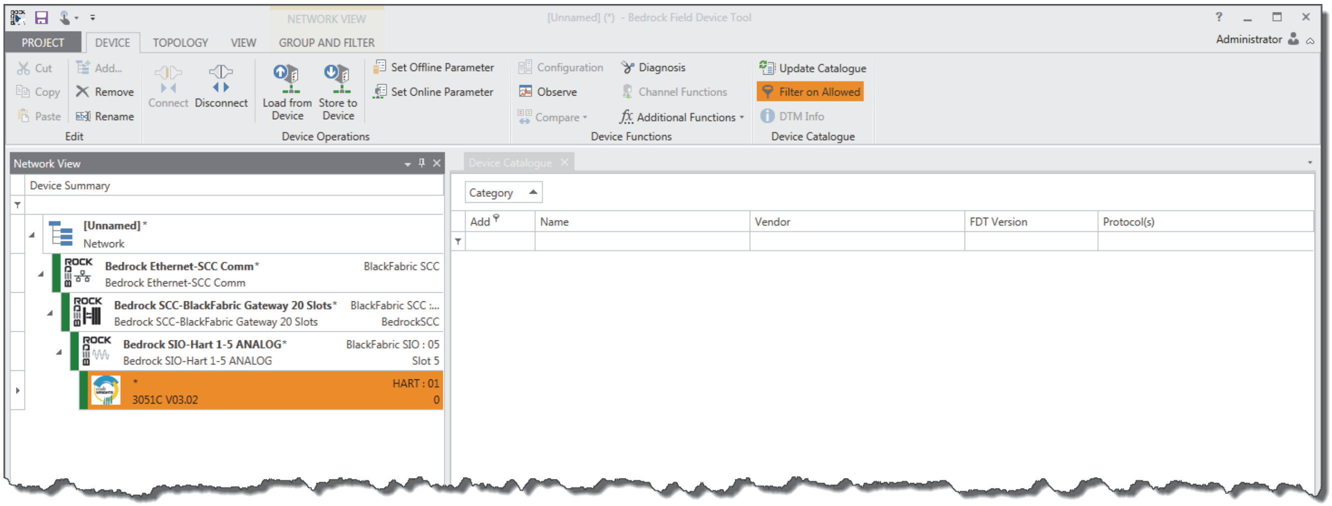


Figure 11-16 All Nodes Connected

19. Refer to the device manufacturer's instructions for using the DTM to configure and maintain the device.

Common Functions

This section summarizes common functions that are available in the Bedrock FDT user interface. In addition to being located on the FDT Ribbon, these functions can also be accessed from context menus (right-clicking).

Topology Tab

The following functionality is available on the Topology Tab located on the Bedrock FDT Ribbon.

Import from XML

Reads previously saved topology information from an XML file.

Export to XML

Saves topology information for the selected mode to an XML file. Selected devices must be offline.

Scan and Create

Use this to create a network and build a complete topology tree from scanned DTMs.

Scan and Select

Use this to scan the selected DTM in an existing network to find child DTMs.

Update Catalogue

Updates the device catalogue with any DTMs that were installed since the last update. This function can also be accessed from the Device Tab.

Device Tab

The following functionality is available on the Device Tab located on the Bedrock FDT Ribbon.

Connect

Send request to connect to selected device. This option is available for all DTMs.

Disconnect

Send request to disconnect from selected device. This option is available for all DTMs.

Load from Device

This option is available for HART Devices. Parameters from the device are loaded into the FDT memory. If the device state is Disconnected, the FDT will attempt to connect to the device.

Store to Device

This option is available for HART Devices. Parameters in the FDT memory are stored to the selected device. If the device state is Disconnected, the FDT will attempt to connect to the device.

Set Offline Parameter

This option is available for HART Devices and if selected will display the set of parameters that is saved with the project or default values if the project has not been saved. Behavior is specific to the selected device DTM. An example of a display of offline parameters is shown in Figure 11-17.

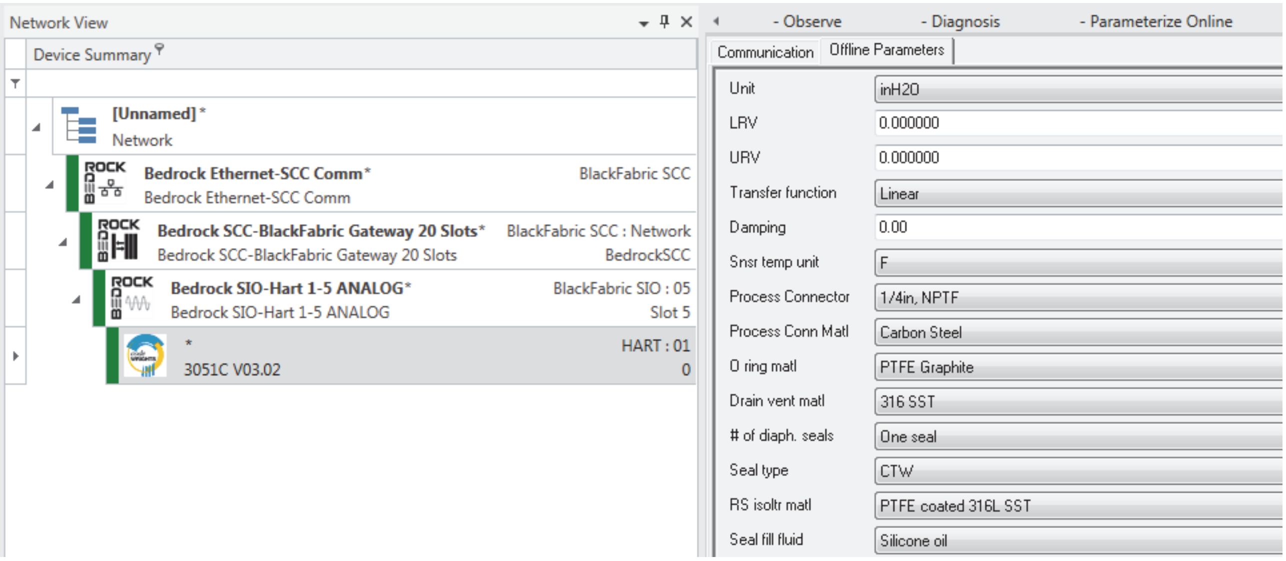


Figure 11-17 Offline Parameters for a HART Device

Set Online Parameter

This option is available for HART Devices and if selected will display the set of parameters that is saved with the HART device. The device must be in the Connected state for this option to be selected. Behavior is specific to the selected device DTM.

Configuration

Allows configuration of a device such as selection of a network card for a Communication DTM.

Observe

Allows observation of device operation. Behavior is specific to the selected device DTM.

Diagnosis

Displays diagnostic information for the selected device. Behavior is specific to the selected device DTM. A sample display of diagnostic information is shown in Figure 11-18.

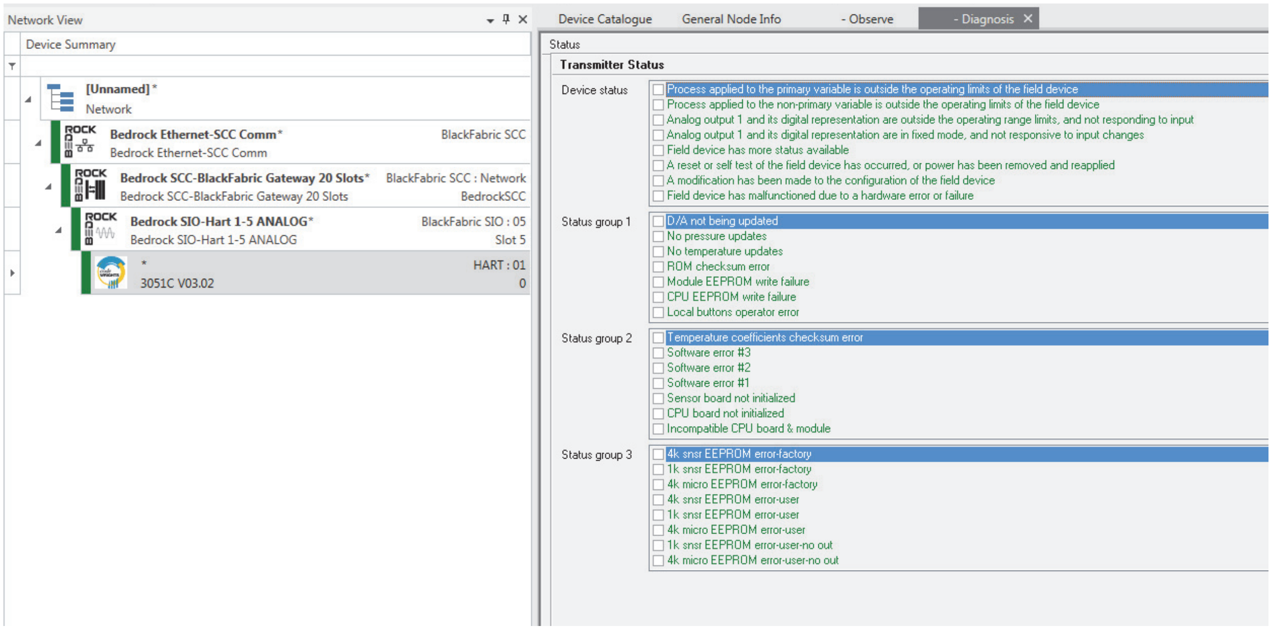


Figure 11-18 Diagnostic Information for a HART Device

Monitoring and Troubleshooting

Overview

The Bedrock IDE System Monitor tool provides a graphical display that allows users to view and monitor the status of system components. The System Monitor tool is described in the Bedrock IDE online help.

In addition to the System Monitor tool, the Bedrock Control System also provides status LEDs on the modules and a system logging feature to assist in troubleshooting the system. Both of these troubleshooting methods are discussed in the following sections. It may also be necessary to look at the Bedrock IDE code in order to troubleshoot control system issues.

Troubleshooting Flowchart

Follow the flowchart in Figure 12-1 should a user observe a problem with the Bedrock Control System.

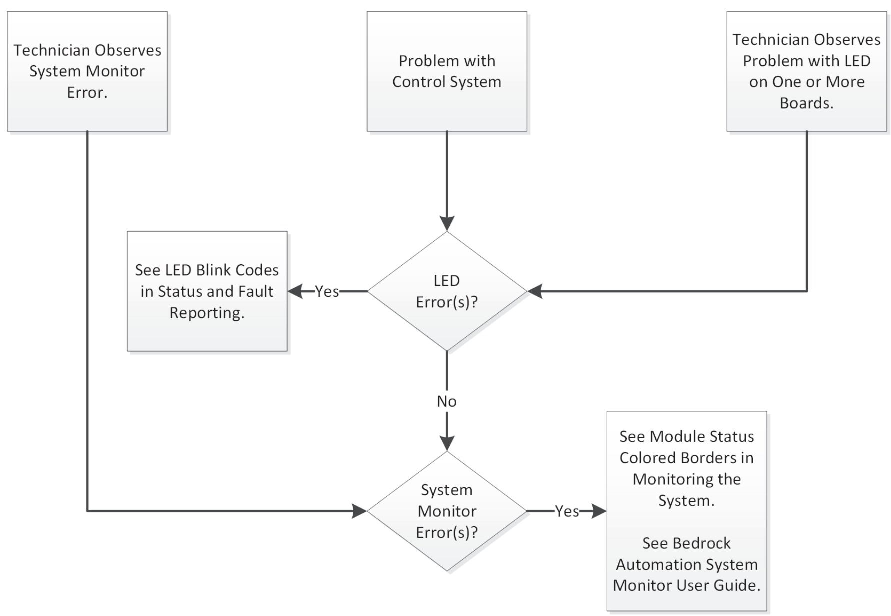


Figure 12-1 Troubleshooting Flowchart

General Troubleshooting Tasks

Use the LED blink codes to help determine which component may be compromised.

In addition to the status LED blink codes, use the following list of troubleshooting techniques to help resolve system errors.

- Verify the module has been correctly configured.

- Verify the module is in the correct slot.
- Verify slots that should have a module in them do.
- Verify modules are seated and secured correctly.
- Verify all physical wires are connected.
- Verify all physical wires are working.
- Use the Bedrock IDE to check that values are as expected.

Module and Channel Status LEDs

This section describes the status indicator LEDs for the SPMs, SIO modules, and Controllers. Module status blink codes for SPM and SIO modules are summarized in Table G-1 in Appendix G, "SPM and SIO Blink Code Summary".

SPM Status LED

The SPM has one status LED in the center of the top of the module as shown in Figure 12-2.

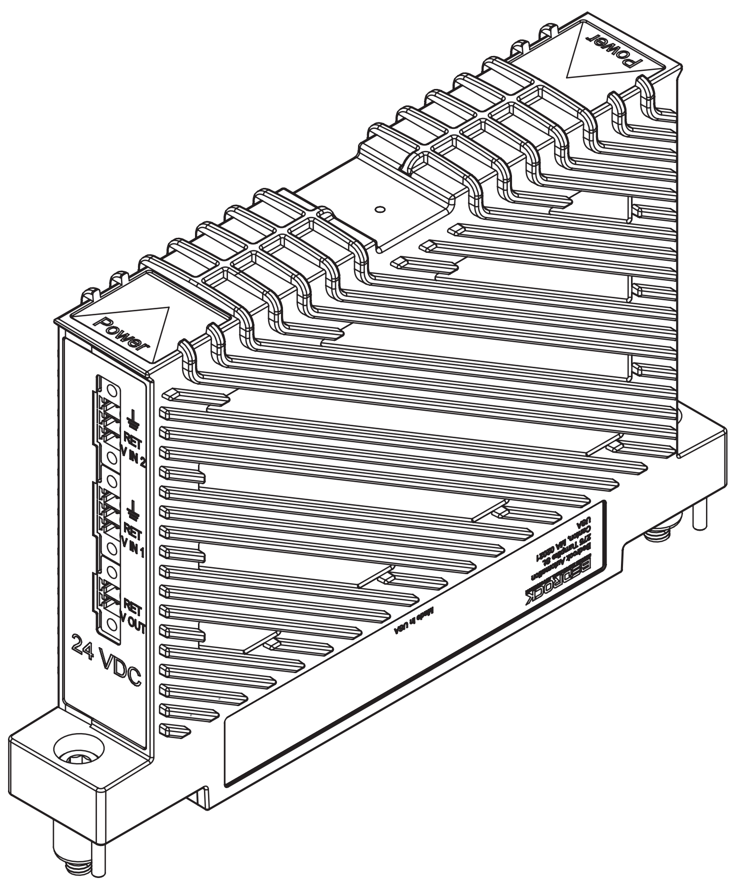


Figure 12-2 SPM LED Location

Analog and Discrete SIO Module LEDs

For analog and discrete SIO modules (excluding the SIO1.5), the ten-channel and twenty-channel SIO modules have eleven and twenty-one LEDs, respectively. These consist of a single module status LED, located in the center, plus channel status LEDs for each channel. The SIO1.5 has five module status LEDs since each channel on the SIO1.5 has its own processor. The SIO1.5 has no channel status LEDs.

Channel status LEDs indicate channel status as described in Table 12-1.

Table 12-1 SIO Module Channel Status LED Descriptions

Item No.	Module Type	Description
1	SIO6.20	ON during HART communication, otherwise OFF
2	SIOU.10	LED functionality is dependent on the operating mode of the SOU.10. For modes that support discrete input, including NAMUR input mode: • Digital Input - ON when the input is a logical 1, otherwise OFF • Frequency - ON when frequency measurement is valid, OFF if frequency cannot be detected or measured • Counter - LED is ON For discrete output mode, the LED is ON when the actual state of the output is a logical 1, otherwise OFF For 0-10 V input mode or for channels that are configured as a spare, the LED is OFF
3	SIO2.10	ON when the input is a logical 1, otherwise OFF
4	SIO3.10	ON when the actual state of the output is a logical 1, otherwise OFF
5	SIO5.10	LED functionality depends on the mode of operation as follows: • Digital Input - ON when the input is a logical 1, otherwise OFF • Frequency - ON when frequency measurement is valid, OFF if frequency cannot be detected or measured • Counter - LED is ON
6	SIO7.20	ON when the input is a logical 1, otherwise OFF
7	SIO8.20	ON when the actual state of the output is a logical 1, otherwise OFF

A ten channel SIO module is shown in Figure 12-3. The center LED is for module status.

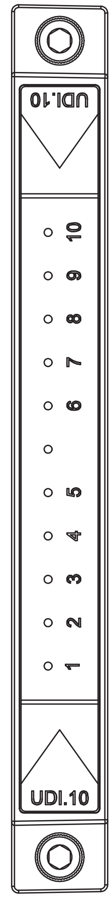


Figure 12-3   LEDs on Ten Channel SIO Module

A twenty channel SIO module is shown in Figure 12-4. The center LED is for module status.

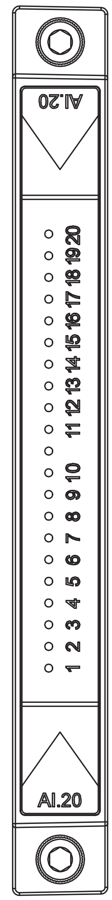


Figure 12-4 LEDs on Twenty Channel SIO Module

An SIO1.5 module with five module status LEDs is shown in Figure 12-5.

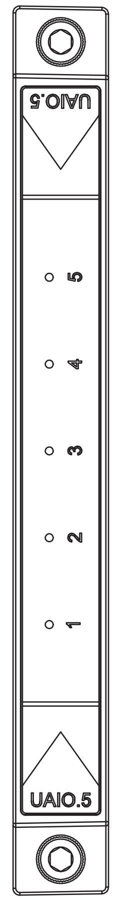


Figure 12-5 LEDS on SIO1.5

SIO4.E Communication Module LEDs

SIO4.E communication modules have a module status LED in the center of the module and five link status LEDs associated with each of the five communication ports. The SIO4.E LEDs are shown in Figure 12-6.

The link status LEDs are numbered and indicate an active link or link activity. These LEDs will show a steady light when there is a communication link with another device and will flash when there is activity on that link.

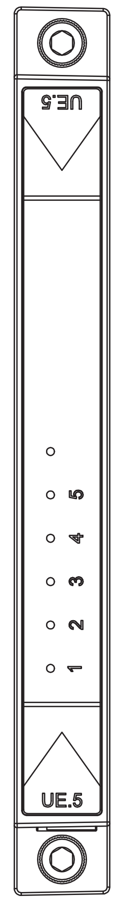


Figure 12-6 LEDs for SIO4.E Communication Module

SIOS.5 Communication Module LEDs

SIOS.5 communication modules have three LEDs for each channel. The center LED in each group indicates status for that channel. See Appendix G, "SPM and SIO Blink Code Summary" for status codes. Each channel also has a transmit activity LED and a receive activity LED that flash to indicate transmit and receive activity. The transmit and receive activity LEDs can be enabled or disabled using the Bedrock IDE. The SIOS.5 LEDs are shown in Figure 12-7.

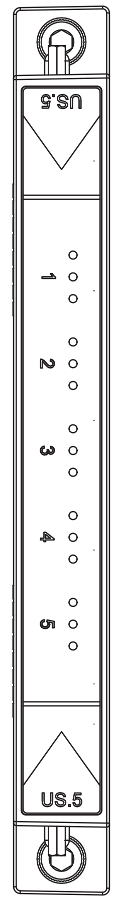


Figure 12-7 LEDs for SIOS.5 Communication Module

Controller LEDs

Bedrock Controllers feature the LED types described below for use in monitoring and troubleshooting control system functionality. Figure 12-8 shows the LEDs and Ethernet ports on an SCC Controller. SCS Controllers have only a single Ethernet port (Port A) with a corresponding Ethernet LED. There is also no Interlink Status LED on SCS Controllers since SCS Controllers do not support redundancy.

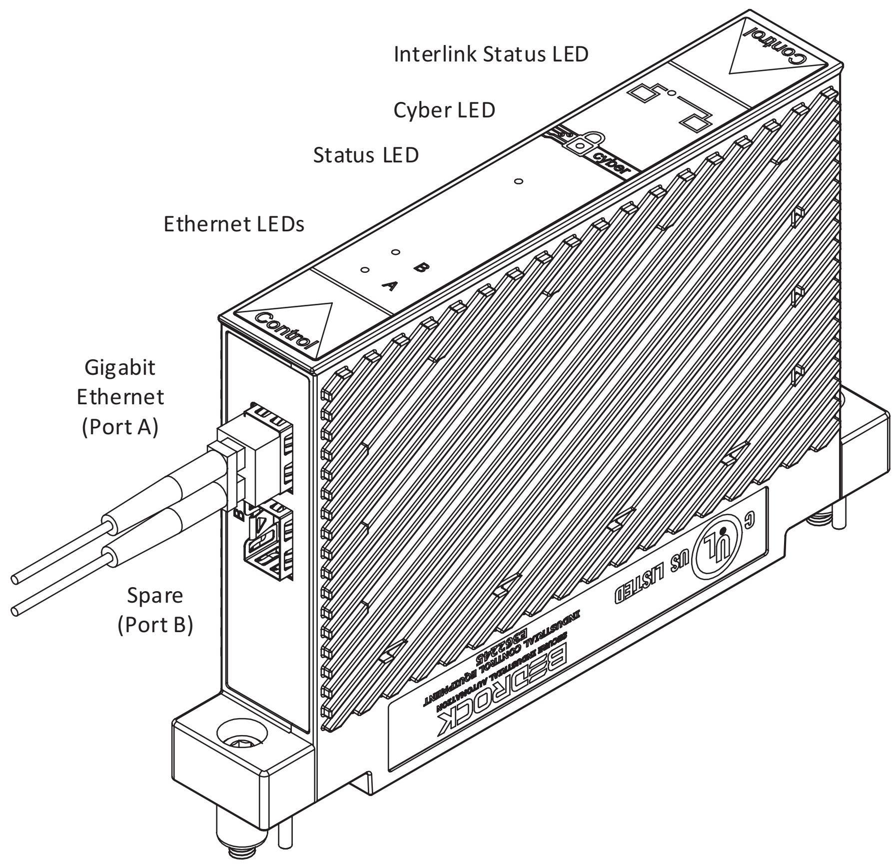


Figure 12-8 SCC Module LED Locations

Status LED

Controllers have a status LED in the center of the module as shown in Figure 12-8. Table 12-2 lists the Status LED states and corresponding descriptions.

Table 12-2 Controller Status LED States

Item No.	LED Color	LED Status	Description
1	None	OFF	No Power
2	Red	Solid	Power on; operating system not yet running or failed
3	Red	Flashing	While performing a software update, authentication failed
4	Orange	Solid	Operating system running; loading control software
5	Green	Solid	Controller is operating as the Active Controller of a redundant pair (SCC only) or is Standalone
6	Green	Flashing	While performing a software update, authentication is successful
7	Blue	Solid	Controller is the Passive Controller of a redundant pair (SCC only)

Cyber LED

Bedrock Controllers feature a Cyber LED (see Figure 12-8) that can be used to observe the loading and authentication sequence of security keys and certificates during Controller startup. During system operation, the Cyber LED indicates whether a connection request is successful or unsuccessful. Unsuccessful connection requests could indicate invalid keys or that Controller security has been compromised. Table 12-3 lists the Cyber LED states that can be observed during Controller startup. Table 12-4 lists the Cyber LED behavior during system operation.

Table 12-3 Cyber LED States During Startup

Item No.	LED Color	LED Status	Description
1	None	OFF	Cyber LED is off during startup
2	Red	Solid	Operating system is running
3	Purple	Solid	Controller is ready to load security keys and certificates
4	Purple	Flashing	No keys or certificates available to load
5	Blue	Solid	Key packages are being validated
6	Green	Solid	Keys and certificates have been loaded. If the keys cannot be loaded, the Cyber LED will remain solid blue.

Table 12-4 Cyber LED Behavior During System Operation

Item No.	LED Color	LED Status	Description
1	Green	3 flashes	Successful connection
2	Orange	3 flashes	Connection failed. X.509 certificate did not verify. LED will return to green.

Ethernet Status LEDs

Controllers have Ethernet Status LEDs that indicate the status of the Ethernet link and whether there is network traffic occurring over the Ethernet link. For SCC Controllers, the Port B Ethernet LED is not used. SCS Controllers only have a single Ethernet LED for Port A.

During system operation, the Ethernet Status LED is solid yellow when the link is good and there is no network traffic. The LED blinks yellow when there is network traffic. Table 12-5 shows the states of the Ethernet Status LED.

Table 12-5 Ethernet Status LED States

Item No.	LED Color	LED Status	Description
1	None	OFF	Operating system not running or Controller is not connected to the network.
2	Yellow	Solid	Boot completed - Ethernet link good
3	Yellow	Flashing	Indicates Ethernet traffic

Interlink Status LED

The Interlink Status LED (not present on SCS Controllers) is used to indicate that there is a good link between redundant Controllers and to indicate when there is Interlink traffic between the redundant Controllers.

During the boot sequence, the Interlink Status LED is not active before the Controller Status LED turns orange. Once the boot sequence is completed, the Interlink Status LED is off if there is no redundant SCC Controller installed or if the operating system is not running. Once the operating system is running, the Interlink Status LED will be on if there is a pair of redundant SCC Controllers installed and the link is good. It will blink when there is Interlink traffic. Table 12-6 shows the states of the Interlink Status LED.

Table 12-6 Interlink Status LED States

Item No.	LED Color	LED Status	Description
1	None	OFF	During initial boot phase - link good Boot completed - no link
2	Yellow	Solid	Redundant Interlink good
3	Yellow	Flashing	Interlink traffic

System Logging

The Bedrock Control System provides a logging feature for recording significant system events and storing that information in a SQL database. This will include information from SPMs, SIO modules, and Controllers. A Windows service named BedrockLogMonitor runs on the Bedrock Control System workstation and periodically sends requests for log data to a Controller. The Controller can then respond with messages that include its own log data plus log data from the SPMs and SIO modules that share the same BMI as the Controller. Log messages include information for events such as module startup or shutdown, changes in configuration, errors, and warnings. The BedrockLogMonitor service uses an ODBC driver to write log entries to the database.

The SQL database is selected by the user. The ODBC plug-in is provided by the database vendor.

Default Configuration

By default, SCC log data is written to a local SQLite database. The default location for the SQLite database is:

```
<IDE_install_dir>\Log Monitor\Log.db3
```

where `<IDE_install_dir>` is the installation location of the Bedrock IDE. By default that location is:

```
C:\ProgramFiles (x86)\Bedrock IDE
```

If the Bedrock IDE is installed in a location other than the default location, the database will be installed in that directory structure.

The remainder of this section describes the configuration needed for connection to an ODBC database, logging service execution, and the format of log data.

ODBC Database Setup and Configuration

The following setup is required to prepare BedrockLogMonitor for receiving log data from the Controllers. You must have administrative privileges to make changes to the configuration file.

- BedrockLogMonitor utilizes certain configurable parameters in the configuration file

```
<IDE_install_dir>\Log Monitor\
            BedrockLogMonitor.config.xml
```

These parameters are described in Table 12-7. A sample configuration file is shown in Figure 12-9. Controller information can be added or removed from the configuration when Controllers are selected or deselected in the Bedrock IDE (see below). Database connection information must be entered by manually editing the configuration file.

Table 12-7 Logging Service Parameters

Parameter	Description
ODBCConnectionString	Database connection information for the ODBC driver. Required for BedrockLogMonitor. This information must be added manually.
LogTableName	Specifies the name of the table in the SQL database where log entries will be written. This information must be added manually.
PollingInterval	Specifies interval in milliseconds between requests for log records from BedrockLogMonitor to the Controller.
MessageBufferAlertLevel	When the Controller's message buffer reaches the specified number of messages, the Controller will alert BedrockLogMonitor that it should send a request for log messages to the Controller. The maximum is 1024.
DeviceName	The name of the device
DeviceType	The type of the device ("CCM" for the Controller)
DeviceSlotNum	The slot number of the device
IPAddress	One entry for each Controller to be monitored. Each entry will contain an IPv6 address.
LocalCertificateThumbprint	The thumb print of the certificate to use from the local machine key store that identifies the workstation to the Controller..
RemoteCertificateThumbprint	The expected thumb print of the certificate coming from the Controller..

```
<?xml version="1.0" encoding="utf-8"?>
<SystemLoggerConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xsd="
http://www.w3.org/2001/XMLSchema">
  <ODBCConnectionString>Driver={MySQL ODBC 5.3 ANSI
  Driver};Server=labtest7;Database=system_log;User=syslog;Password=password;Option=3;</ODBCConnectionString>
  <LogTableName>log</LogTableName>
  <MonitoredSCCs>
    <SCCMonitorConfig PollingInterval="2000" MessageBufferAlertLevel="769">
      <DeviceName>Controller1</DeviceName>
      <DeviceType>CCM</DeviceType>
      <DeviceSlotNum>1</DeviceSlotNum>
      <IPAddress>fe80::9a02:d8ff:fee0:122</IPAddress>
      <LocalCertificateThumbprint>948C023920E0F2D6F9F1AA122F592A04B83A1CE4</LocalCertificateThumbprint>
      <RemoteCertificateThumbprint>3CBBEE021300EA410626F1C1801D62864804139B</RemoteCertificateThumbprint>
    </SCCMonitorConfig>
  </MonitoredSCCs>
</SystemLoggerConfig>
```

Figure 12-9   Sample XML Configuration File

- Select Tools --> Device Management in the Bedrock IDE to select the Controller from which BedrockLogMonitor will request log records. Controller-specific information will be updated in the configuration file.
- Since BedrockLogMonitor is started when Windows starts and since the service will periodically check for changes in the configuration file and reload the file if necessary, the service should not need to be started manually. Starting the service manually can be done using standard Windows procedures, e.g., Windows Control Panel, entering `services.msc` in the Windows Run dialog, using the `net` command from the Windows command prompt, etc.

Logging Service Execution

Once BedrockLogMonitor is started and configuration parameters are sent to the Controller, it will periodically send requests for log records via an Ethernet socket to the Controllers that were selected during setup and configuration. The Controller(s) will then respond with the requested log records and BedrockLogMonitor will update the SQL database. Note that it is BedrockLogMonitor that initiates the requests for log records. Controllers only send log records to BedrockLogMonitor in response to such a request. Subsequently, if BedrockLogMonitor is not running, there is no impact to the Controller(s). The status of the BedrockLogMonitor service is available in the Windows Event Viewer Application Log.

Figure 12-10 provides an overview of system logging in the Bedrock Control System.

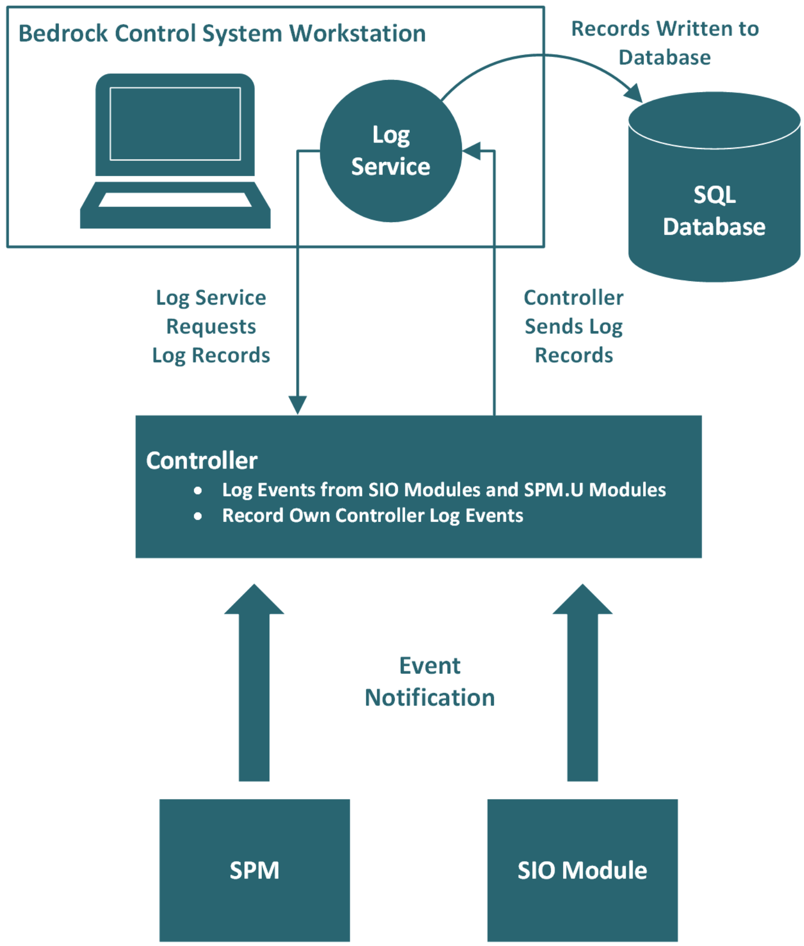


Figure 12-10 System Logging

The format of the log messages is shown in Table 12-8. Log messages can be read from the database using the Ignition HMI software or any database client software that is capable of reading a SQL database.

Table 12-8 Log Entry Format

Database Field Name	Descriptive Name	Description / Possible Values
tm	Timestamp	Time that the Controller received the message. Shown in the following format: YYYY-MM-DD HH:MM:SS:fff
msgnum	Message Number	64-bit field. The lower 32 bits (0-31) contain the sequential message number. The upper 32 bits (32-63) contain the boot count for the Controller.
msgtype	Message Type	String indicating the type of log message: STARTUP SHUTDOWN CONFIG UPDATE RUNTIME WARNING ERROR
name	Controller Name	String that uniquely identifies the Controller that is the source of the log message
sio	Module Type	String that identifies the type of Controller, SIO module, or SPM.
sltnum	Slot Number	BMI slot number of SIO module (1-20) Zero for a Controller 1 or 2 for SPMs
chnum	Channel Number	Communication channel used by the module (1-5)
devtag	Device Tag	Manufacturer-supplied string containing module information
errcode	Error Code	Positive integer that identifies the error
msg	Message	Error message string
added	Database Timestamp	Time that the entry was added to the database. Shown in the following format: YYYY-MM-DD HH:MM:SS:fff

Operating Temperature

The operating temperature is dependent upon the BMI type and type of power supplied to a single SPM. See “SPM (Power) Overview” chapter for information on supplying power to an SPM. The operating temperature is summarized in Table A-1.

NOTE: The maximum operating temperature for an SIO4.E module when using PoE is 70°C. The maximum operating temperature for an SIO4.E module when ***not*** using PoE is 80°C.

Table A-1 Operating Temperature

Type of Power	BMI.5	BMI.10	BMI.20
24 V DC Power	-40°C to 80°C	-40°C to 80°C	-40°C to 70°C
90-240 V AC Power (SPM.U Only)	-40°C to 70°C	-40°C to 60°C	-40°C to 50°C

Part Numbers

Part numbers for the modules used in the Bedrock Control System are listed in Table B-1. Also included in the table are the labels used to identify the function of each module type.

Table B-1 Module Part Numbers

Model Number	Label Number	Description	Part Number
SIO1.5	UAIO.5	Secure Universal Analog Module	BRSIO105
SIO2.10	UDI.10	Secure Universal Discrete Input Module	BRSIO210
SIO3.10	UDO.10	Secure Universal Discrete Output Module	BRSIO310
SIO4.E	UE.5	Secure Ethernet Module	BRSIO40E
SIO5.10	DI.10	Secure High Speed Discrete Input Module	BRSIO510
SIO6.20	AI.20	Secure Analog 4-20 mA Input Module	BRSIO620
SIO7.20	DI.20	Secure Discrete Input Module	BRSIO720
SIO8.20	DO.20	Secure Discrete Output Module	BRSIO820
SIOU.10	UIO.10	Secure Universal Input/Output Module	BRSIOU10
SIOS.5	US.5	Secure Serial Module	BRSIOS05
SCC	Control (SCC)	Secure Control and Communication Module	BRSCC100
SCC.X Upgrade	Control (SCC)	Firmware upgrade at the factory or in the field for SCC Controllers. Enables user custom cyber root keys. Supports all system configurations of SCC Controllers. Required to support secure OPC UA and SCADA security.	BRSCCX00
SCS.5	Control (SCS.5)	Secure Controller Single - 5 I/O Channels with 8 GB of Memory	BRSCS050
SCS.5X Upgrade	Control (SCS.5)	Firmware upgrade at the factory or in the field for SCS.5 Controllers. Enables custom-specific cyber root keys. Supports all system configurations of SCS.5 Controllers. Required to support secure OPC UA and SCADA security.	BRSCSX50
SCS.10	Control (SCS.10)	Secure Controller Single - 10 I/O Channels with 32 GB of Memory	BRSCS010
SCS.10X Upgrade	Control (SCS.10)	Firmware upgrade at the factory or in the field for SCS.10 Controllers. Enables custom-specific cyber root keys. Supports all system configurations of SCS.10 Controllers. Required to support secure OPC UA and SCADA security.	BRSCSX10
SPM.24	Power	Secure Power - 24 V DC Input	BRSPM024
SPM.U	Power	Secure Power - Universal Input	BRSPM100

Part numbers for the Bedrock Control System backplanes are listed in Table B-2.

Table B-2 Backplane Part Numbers

Model Name	Part Number	Description
BMI.5	BRBMI005	5 SLOT BMI Assembly
BMI.10	BRBMI010	10 SLOT BMI Assembly
BMI.20	BRBMI020	20 SLOT BMI Assembly

Additional part numbers for the components used in the Bedrock Control System are listed in Table B-3.

Table B-3 Assembly Part Numbers and Descriptions

Part Number	Description
BRUCB101	Bedrock Universal Cable (1 Meter)
BRUCB103	Bedrock Universal Cable (3 Meters)
BRUCB105	Bedrock Universal Cable (5 Meters)
BRUCB1XX (XX = length of cable in meters)	Bedrock Universal Cable (Custom Length)
BRACPFIL	AC Line Filter Assembly
BRCBLDCP	SPM DC Input Power Cable
BRCBLWET	Wetting Cable
BRCBLPOE	Power Over Ethernet Cable Assembly
BRCBLSER	SIOS.5 Serial Communication Cable
OP00003	Fiber Ethernet SFP Interface Module
OP00008	Copper Ethernet SFP Interface Module
BRACCCJC	CJC Unit

Wiring Diagrams and Pin Out Information

This appendix contains information for connecting SIO modules to field devices. A table containing pin out information for each type of SIO module is provided along with wiring diagrams that show channel wiring and configuration options.

Analog Modules

SIO1.5 - UAIO.5

Pin out information for SIO1.5 modules is shown in Table C-1.

Table C-1 SIO1.5 Pin Outs

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1 EXCITATION / LOOP POWER
	RED	2	CHAN. 1 EXCITATION RETURN
PAIR 2	BLACK	3	CHAN. 1 ANALOG PLUS
	WHITE	4	CHAN. 1 ANALOG MINUS
PAIR 3	BLACK	5	CHAN. 2 EXCITATION / LOOP POWER
	GREEN	6	CHAN. 2 EXCITATION RETURN
PAIR 4	BLACK	7	CHAN. 2 ANALOG PLUS
	BLUE	8	CHAN. 2 ANALOG MINUS
PAIR 5	BLACK	9	CHAN. 3 EXCITATION / LOOP POWER
	BROWN	10	CHAN. 3 EXCITATION RETURN
PAIR 6	BLACK	11	CHAN. 3 ANALOG PLUS
	YELLOW	12	CHAN. 3 ANALOG MINUS
PAIR 7	BLACK	13	CHAN. 4 EXCITATION / LOOP POWER
	ORANGE	14	CHAN. 4 EXCITATION RETURN
PAIR 8	RED	15	CHAN. 4 ANALOG PLUS
	GREEN	16	CHAN. 4 ANALOG MINUS
PAIR 9	RED	17	CHAN. 5 EXCITATION / LOOP POWER
	WHITE	18	CHAN. 5 EXCITATION RETURN
PAIR 10	RED	19	CHAN. 5 ANALOG PLUS
	BLUE	20	CHAN. 5 ANALOG MINUS

The following figures are the wiring diagrams for connecting the SIO1.5 to field devices.

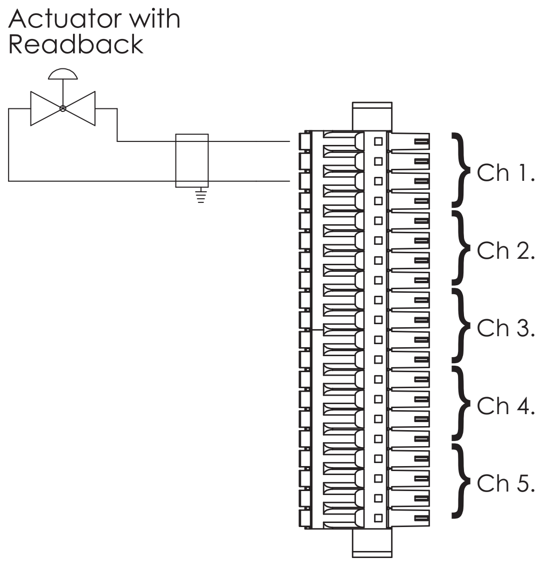


Figure C-1 SIO1.5: Actuator with Readback

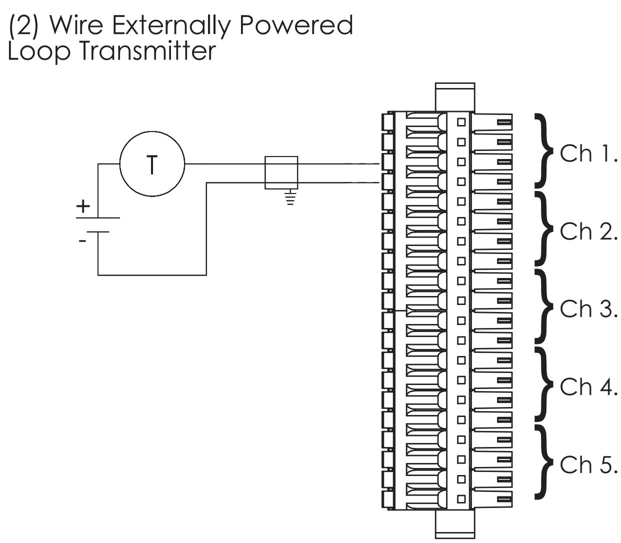


Figure C-2 SIO1.5: 2-Wire Externally Powered Loop Transmitter

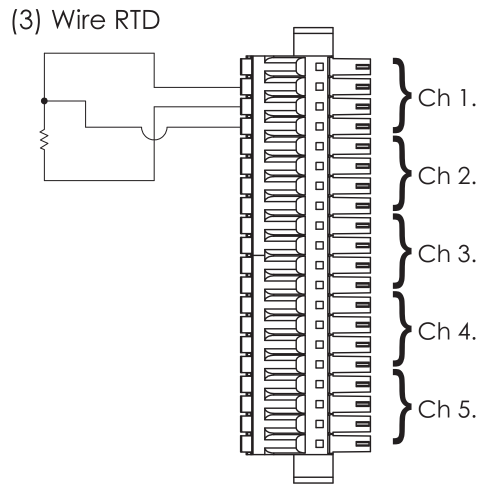


Figure C-3 SIO1.5: 3-Wire RTD

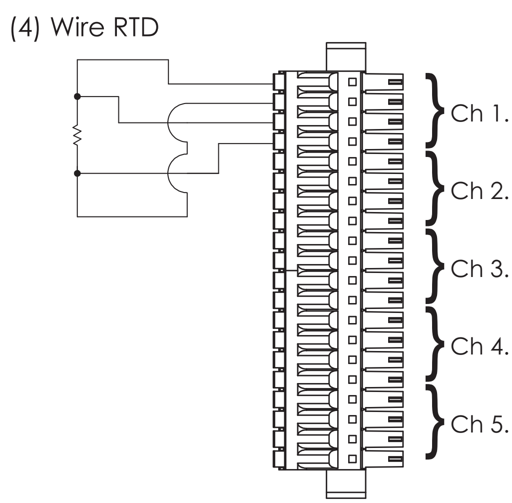


Figure C-4 SIO1.5: 4-Wire RTD

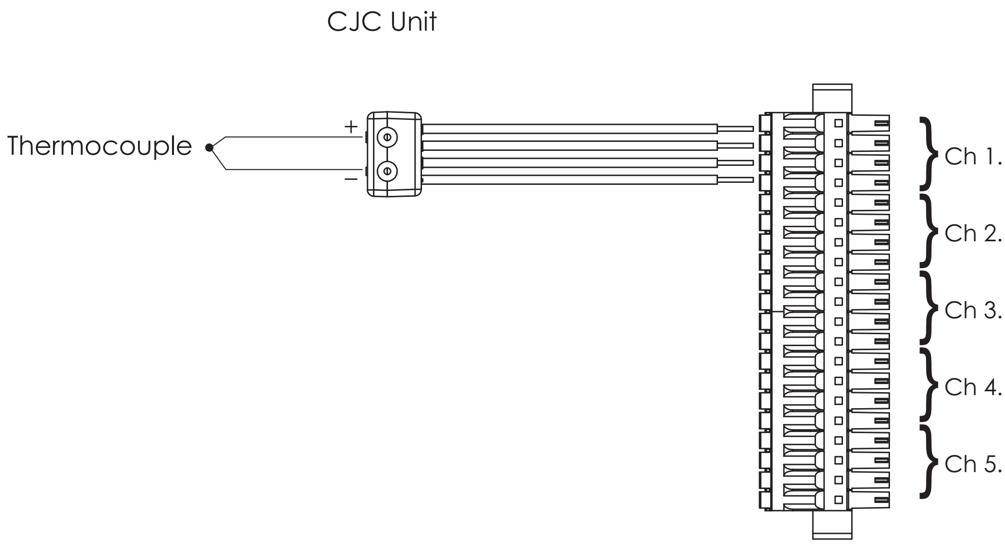


Figure C-5 SIO1.5: Thermocouple with CJC Unit

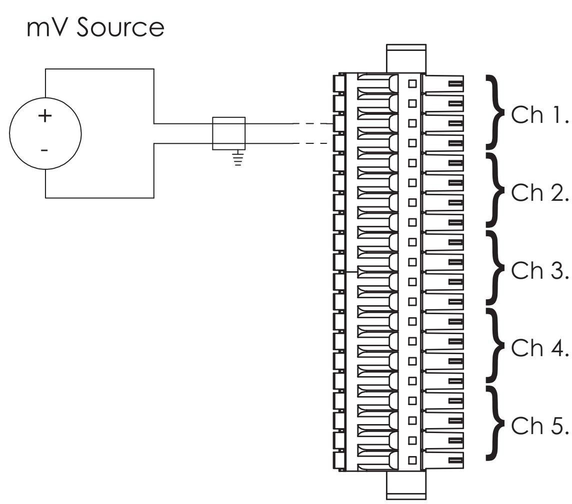


Figure C-6 SIO1.5: mV Source

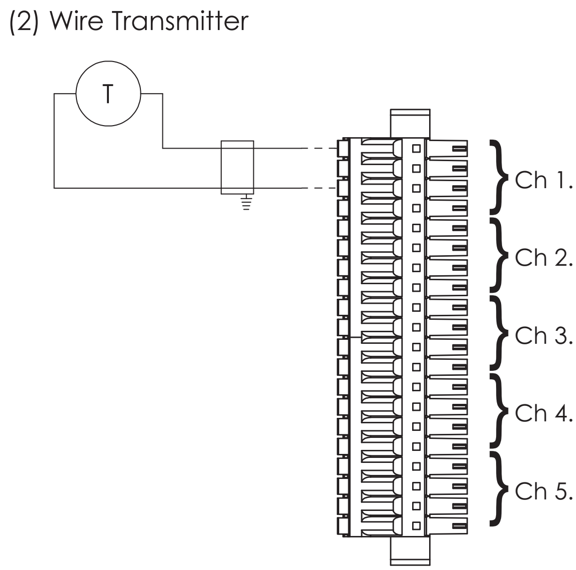


Figure C-7 SIO1.5: 2-Wire Transmitter

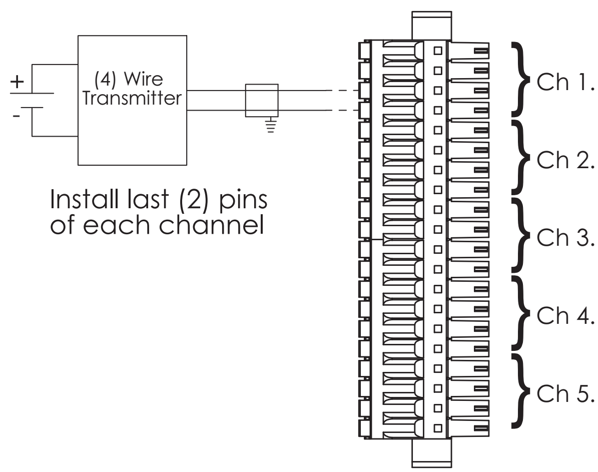


Figure C-8 SIO1.5: 4-Wire Transmitter

SIO6.20 - AI.20

SIO6.20 pin out information for channels 1-10 is shown in Table C-2. Pin out information for channels 11-20 is shown in Table C-3.

Table C-2 SIO6.20 Pin Outs for Channels 1-10

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1 + INPUT
	RED	2	CHAN. 1 - INPUT
PAIR 2	BLACK	3	CHAN. 2 + INPUT
	WHITE	4	CHAN. 2 - INPUT
PAIR 3	BLACK	5	CHAN. 3 + INPUT
	GREEN	6	CHAN. 3 - INPUT
PAIR 4	BLACK	7	CHAN. 4 + INPUT
	BLUE	8	CHAN. 4 - INPUT
PAIR 5	BLACK	9	CHAN. 5 + INPUT
	BROWN	10	CHAN. 5 - INPUT
PAIR 6	BLACK	11	CHAN. 6 + INPUT
	YELLOW	12	CHAN. 6 - INPUT
PAIR 7	BLACK	13	CHAN. 7 + INPUT
	ORANGE	14	CHAN. 7 - INPUT
PAIR 8	RED	15	CHAN. 8 + INPUT
	GREEN	16	CHAN. 8 - INPUT
PAIR 9	RED	17	CHAN. 9 + INPUT
	WHITE	18	CHAN. 9 - INPUT
PAIR 10	RED	19	CHAN. 10 + INPUT
	BLUE	20	CHAN. 10 - INPUT

Table C-3 SIO6.20 Pin Outs for Channels 11-20

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	21	CHAN. 11 + INPUT
	RED	22	CHAN. 11 - INPUT
PAIR 2	BLACK	23	CHAN. 12 + INPUT
	WHITE	24	CHAN. 12 - INPUT
PAIR 3	BLACK	25	CHAN. 13 + INPUT
	GREEN	26	CHAN. 13 - INPUT
PAIR 4	BLACK	27	CHAN. 14 + INPUT
	BLUE	28	CHAN. 14 - INPUT
PAIR 5	BLACK	29	CHAN. 15 + INPUT
	BROWN	30	CHAN. 15 - INPUT
PAIR 6	BLACK	31	CHAN. 16 + INPUT
	YELLOW	32	CHAN. 16 - INPUT

Table C-3 SI06.20 Pin Outs for Channels 11-20

Pair No.	Color	Pin No.	Function
PAIR 7	BLACK	33	CHAN. 17 + INPUT
	ORANGE	34	CHAN. 17 - INPUT
PAIR 8	RED	35	CHAN. 18 + INPUT
	GREEN	36	CHAN. 18 - INPUT
PAIR 9	RED	37	CHAN. 19 + INPUT
	WHITE	38	CHAN. 19 - INPUT
PAIR 10	RED	39	CHAN. 20 + INPUT
	BLUE	40	CHAN. 20 - INPUT

The following figure is the wiring diagrams for connecting the SIO6.20 to field devices.

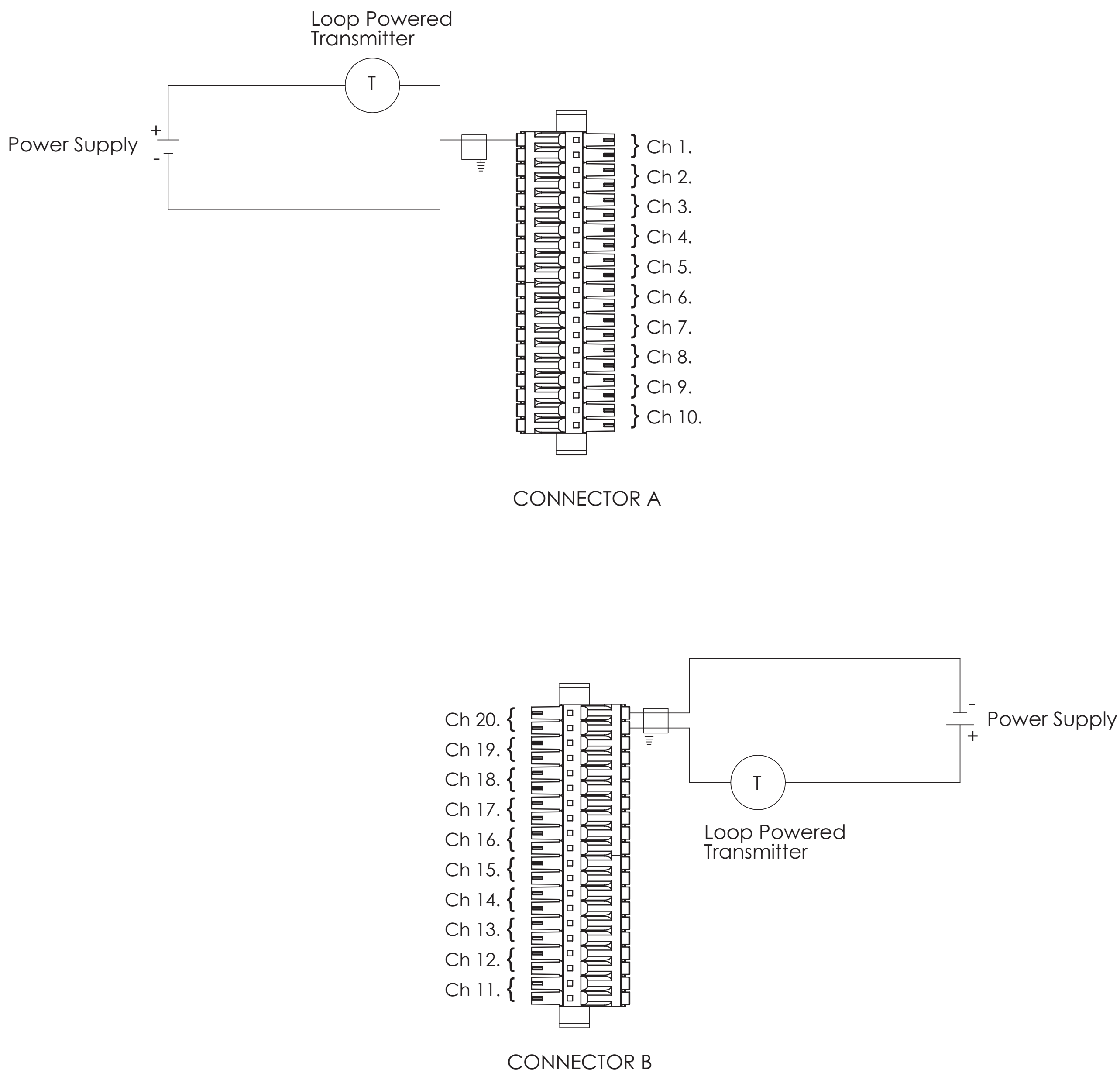


Figure C-9 SIO6.20: Loop Powered Transmitter

SIOU.10 - UIO.10

SIOU.10 pin out information for channels 1-10 is shown in Table C-4. Pin out information for channels 11-20 is shown in Table C-5.

Table C-4 SIOU.10 Pin Outs for Channels 1-5

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1 EXCITATION
	RED	2	CHAN. 1 ANALOG
PAIR 2	BLACK	3	CHAN. 1 RETURN
	WHITE	4	CHAN. 1 DISCRETE
PAIR 3	BLACK	5	CHAN. 2 EXCITATION
	GREEN	6	CHAN. 2 ANALOG
PAIR 4	BLACK	7	CHAN. 2 RETURN
	BLUE	8	CHAN. 2 DISCRETE
PAIR 5	BLACK	9	CHAN. 3 EXCITATION
	BROWN	10	CHAN. 3 ANALOG
PAIR 6	BLACK	11	CHAN. 3 RETURN
	YELLOW	12	CHAN. 3 DISCRETE
PAIR 7	BLACK	13	CHAN. 4 EXCITATION
	ORANGE	14	CHAN. 4 ANALOG
PAIR 8	RED	15	CHAN. 4 RETURN
	GREEN	16	CHAN. 4 DISCRETE
PAIR 9	RED	17	CHAN. 5 EXCITATION
	WHITE	18	CHAN. 5 ANALOG
PAIR 10	RED	19	CHAN. 5 RETURN
	BLUE	20	CHAN. 5 DISCRETE

Table C-5 SIOU.10 Pin Outs for Channels 6-10

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	21	CHAN. 6 EXCITATION
	RED	22	CHAN. 6 ANALOG
PAIR 2	BLACK	23	CHAN. 6 RETURN
	WHITE	24	CHAN. 6 DISCRETE
PAIR 3	BLACK	25	CHAN. 7 EXCITATION
	GREEN	26	CHAN. 7 ANALOG
PAIR 4	BLACK	27	CHAN. 7 RETURN
	BLUE	28	CHAN. 7 DISCRETE
PAIR 5	BLACK	29	CHAN. 8 EXCITATION
	BROWN	30	CHAN. 8 ANALOG
PAIR 6	BLACK	31	CHAN. 8 RETURN
	YELLOW	32	CHAN. 8 DISCRETE

Table C-5 SIOU.10 Pin Outs for Channels 6-10

Pair No.	Color	Pin No.	Function
PAIR 7	BLACK	33	CHAN. 9 EXCITATION
	ORANGE	34	CHAN. 9 ANALOG
PAIR 8	RED	35	CHAN. 9 RETURN
	GREEN	36	CHAN. 9 DISCRETE
PAIR 9	RED	37	CHAN. 10 EXCITATION
	WHITE	38	CHAN. 10 ANALOG
PAIR 10	RED	39	CHAN. 10 RETURN
	BLUE	40	CHAN. 10 DISCRETE

The following figures are the wiring diagrams for connecting the SIOU.10 to field devices.

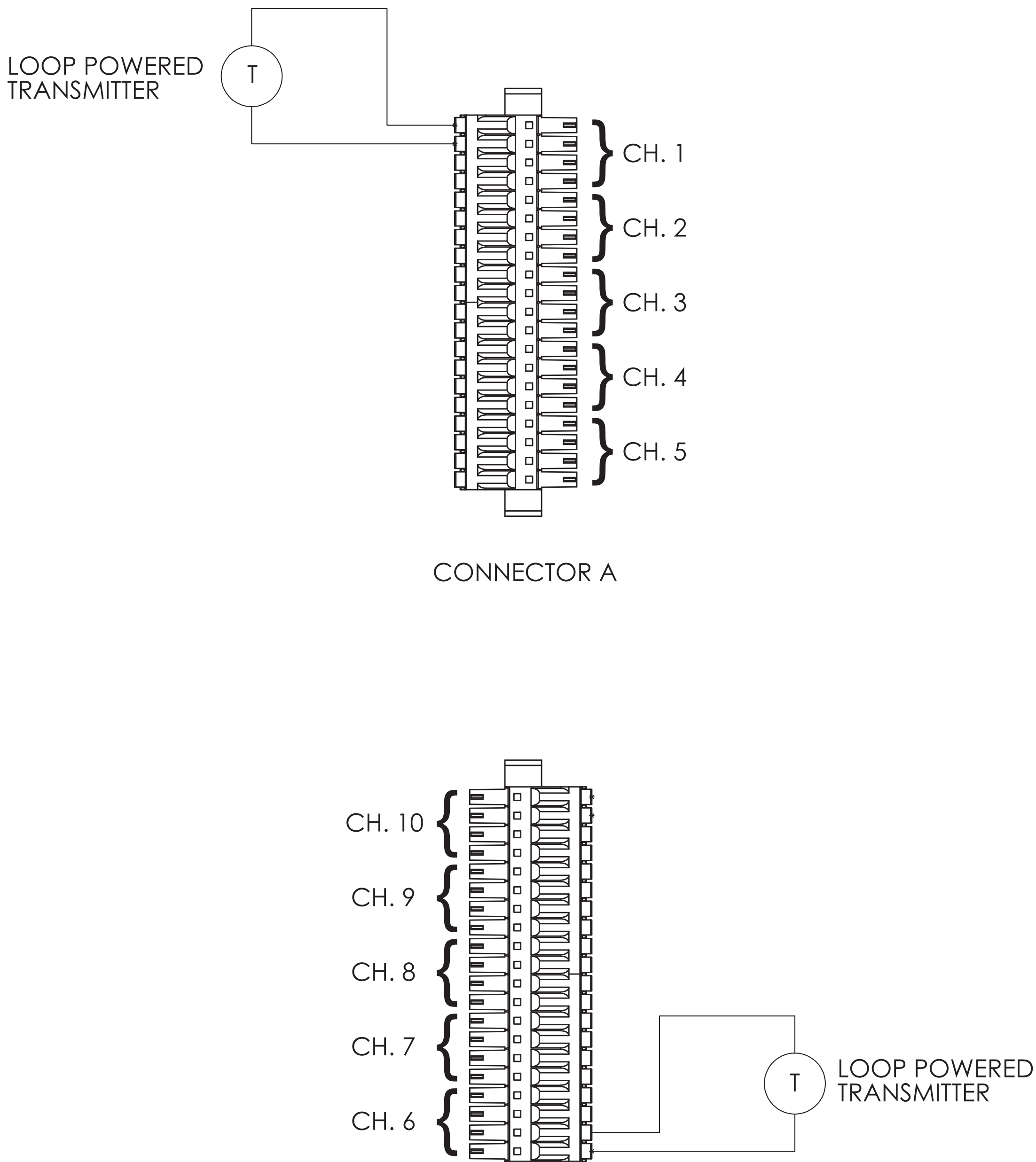


Figure C-10 SIOU.10: 4-20 mA Internal Loop Powered Transmitter

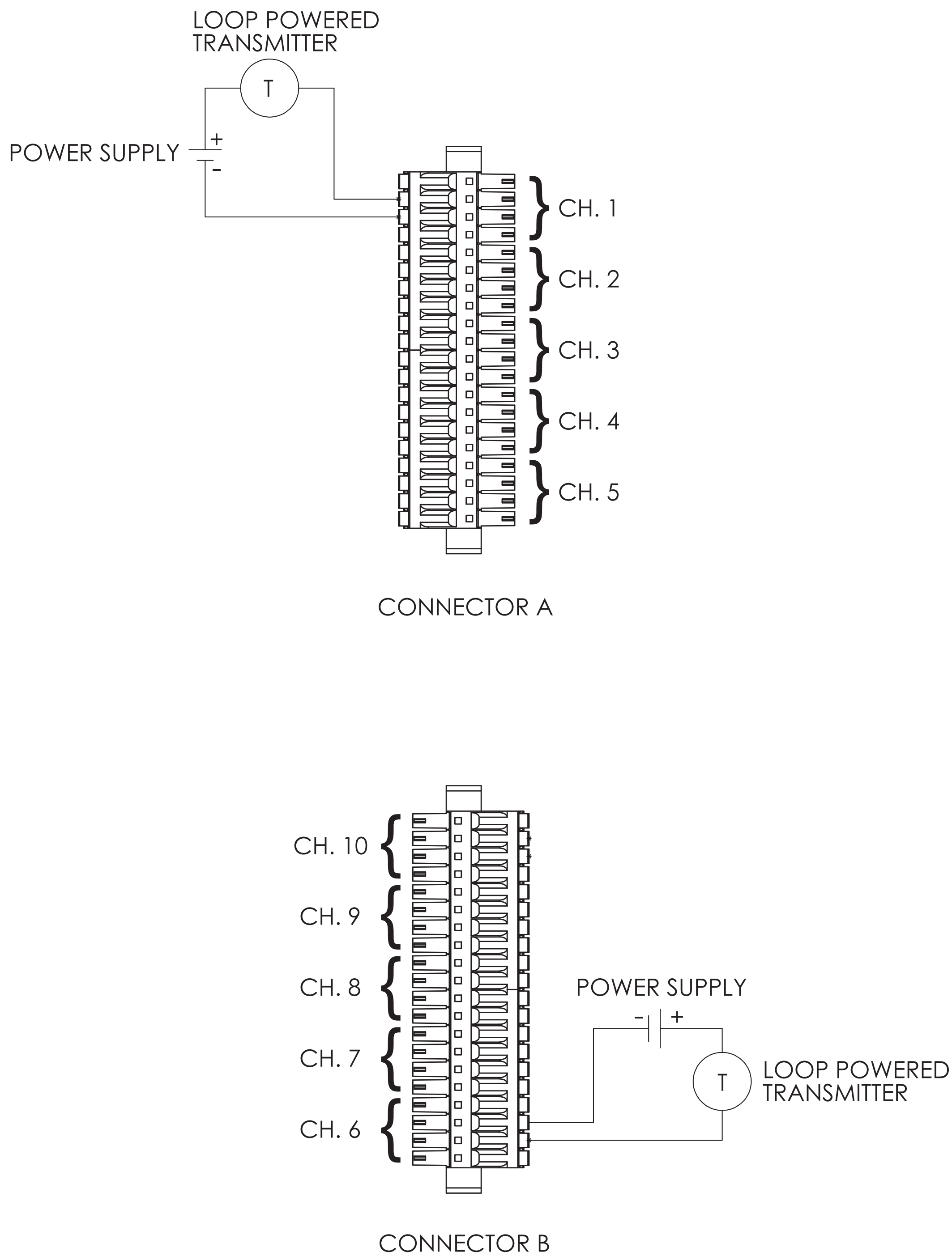


Figure C-11 SIOU.10: 4-20 mA External Loop Powered Transmitter

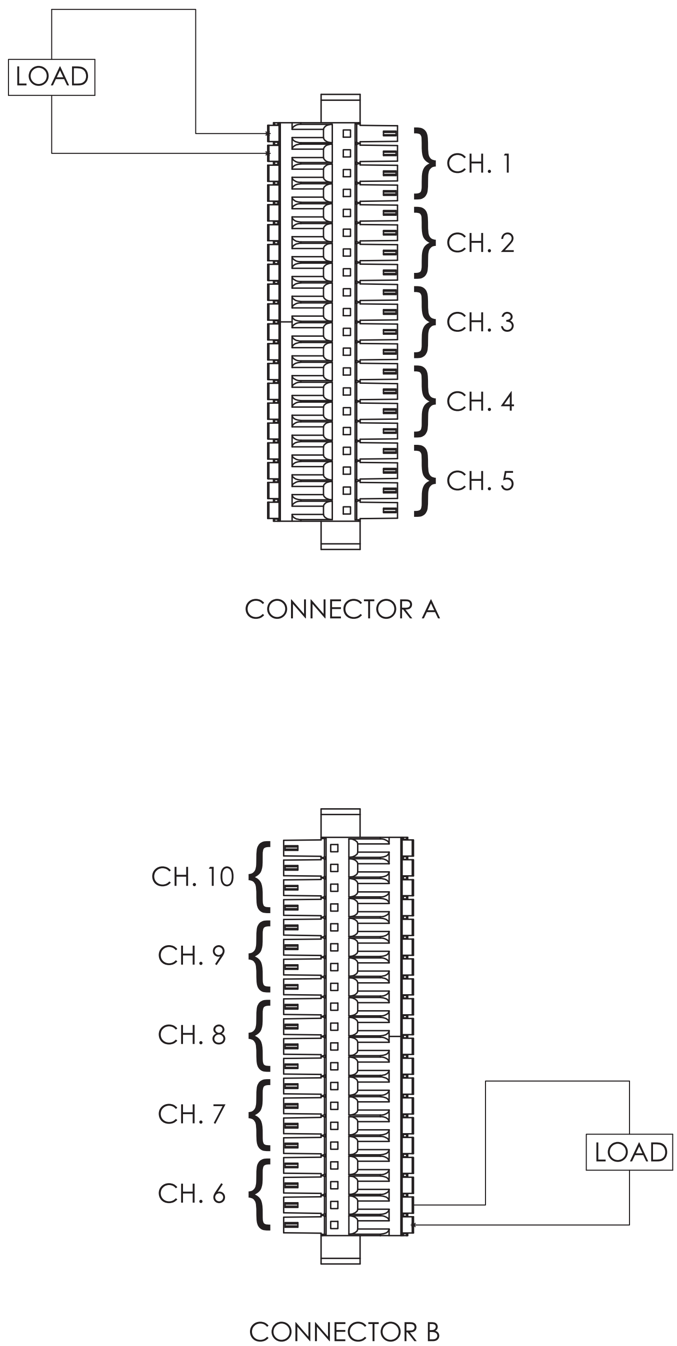


Figure C-12 SIOU.10: 4-20 mA Output with Internal Readback

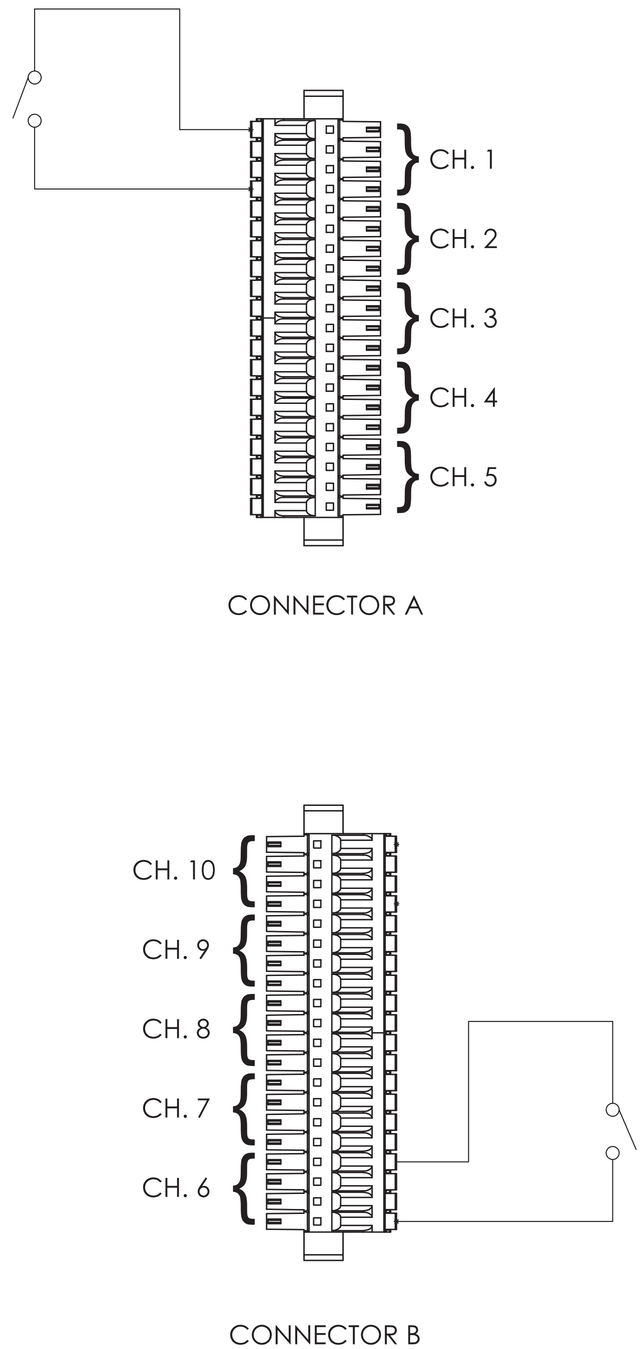


Figure C-13 SIOU.10: Discrete Input Contact Closure

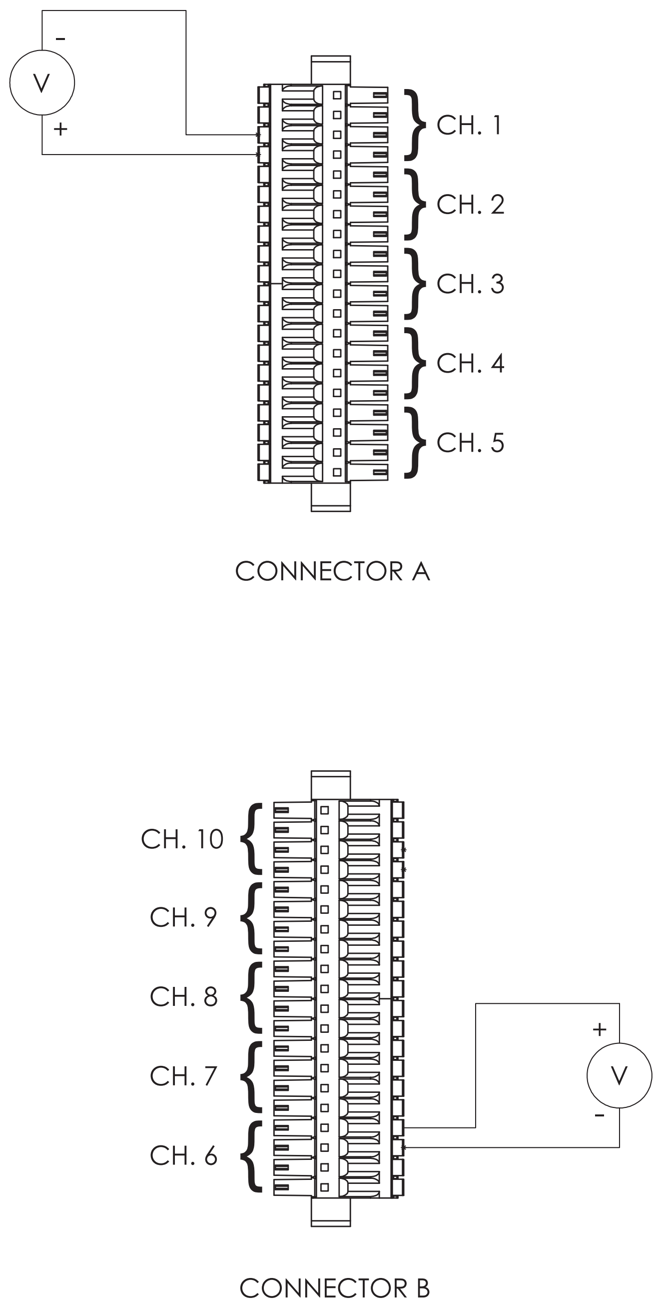
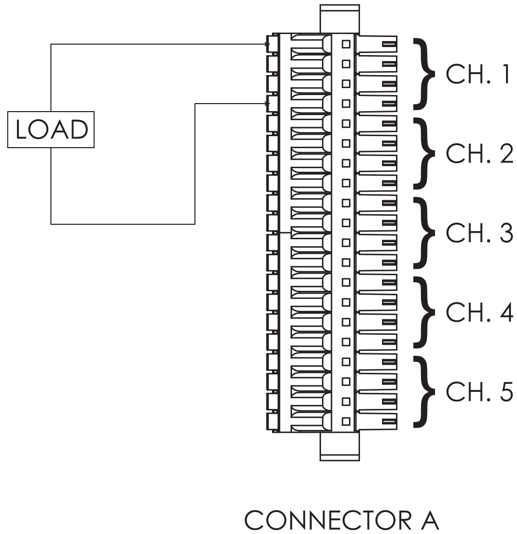


Figure C-14 SIOU.10: Discrete Input Voltage Monitor



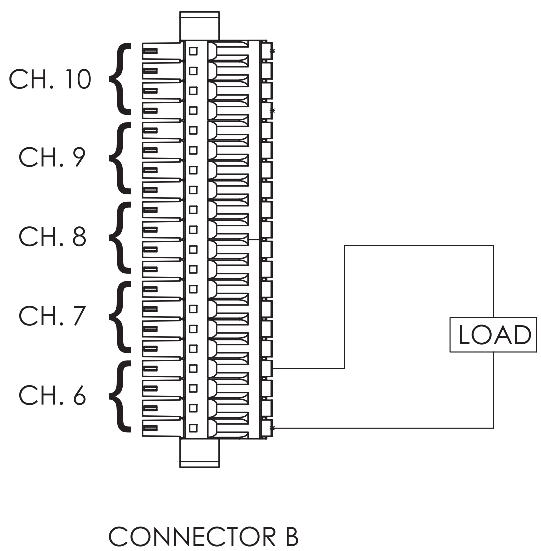


Figure C-15 SIOU.10: Discrete Output Internal Excitation

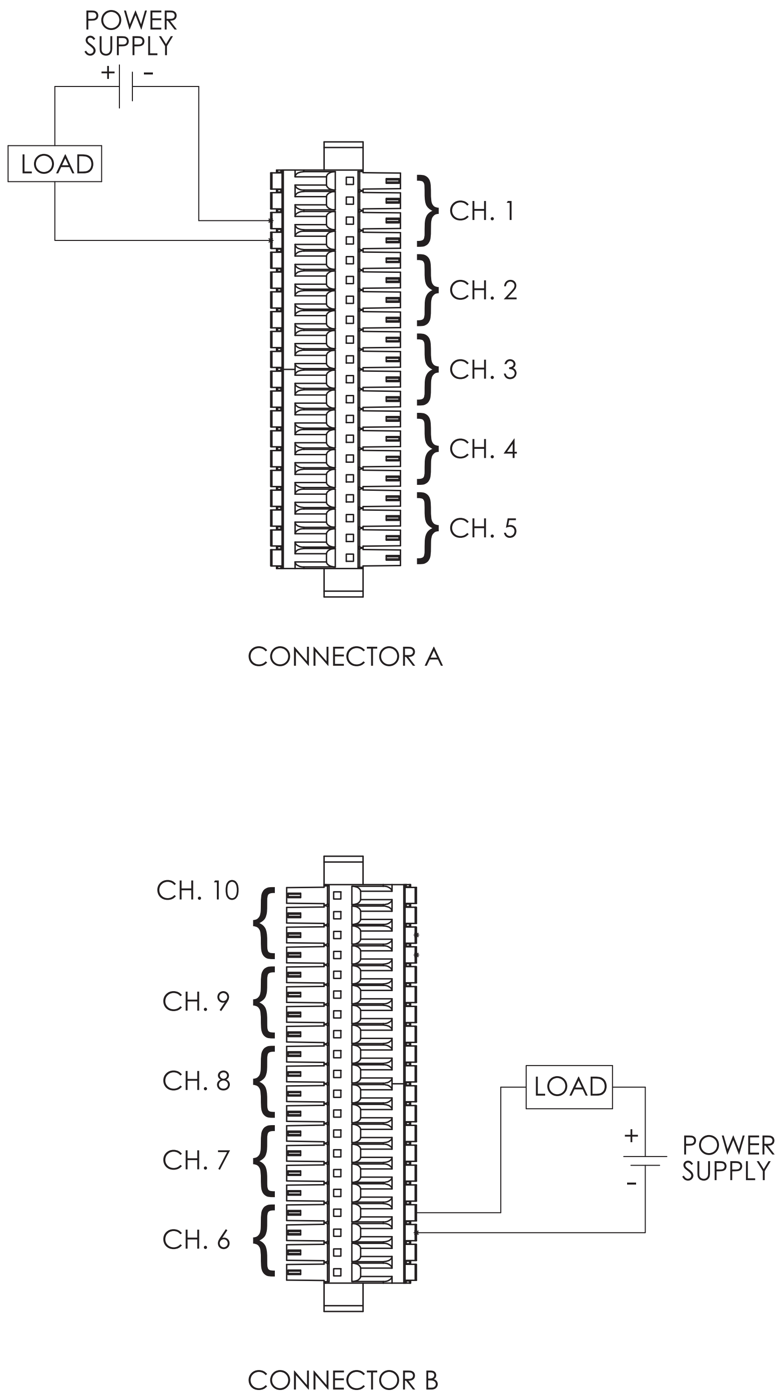
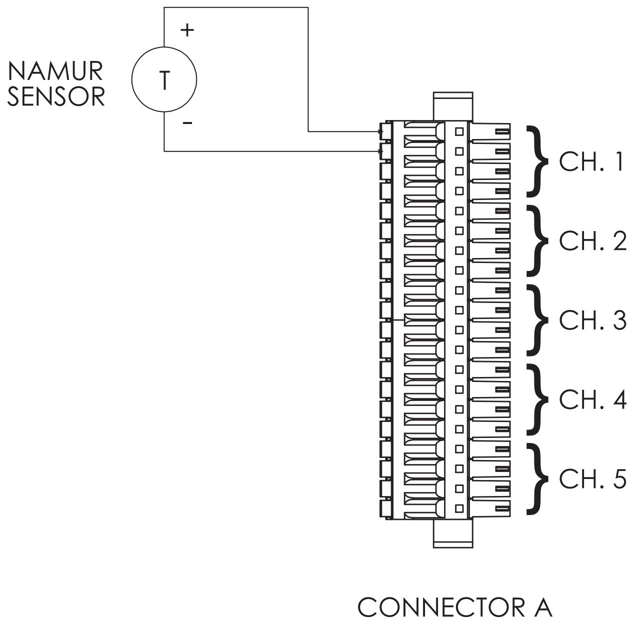


Figure C-16 SIOU.10: Discrete Output External Excitation



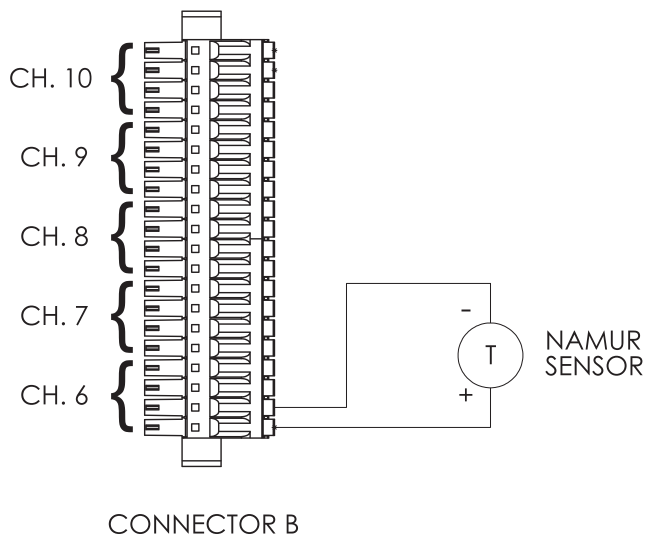


Figure C-17 SIOU.10: NAMUR Sensor

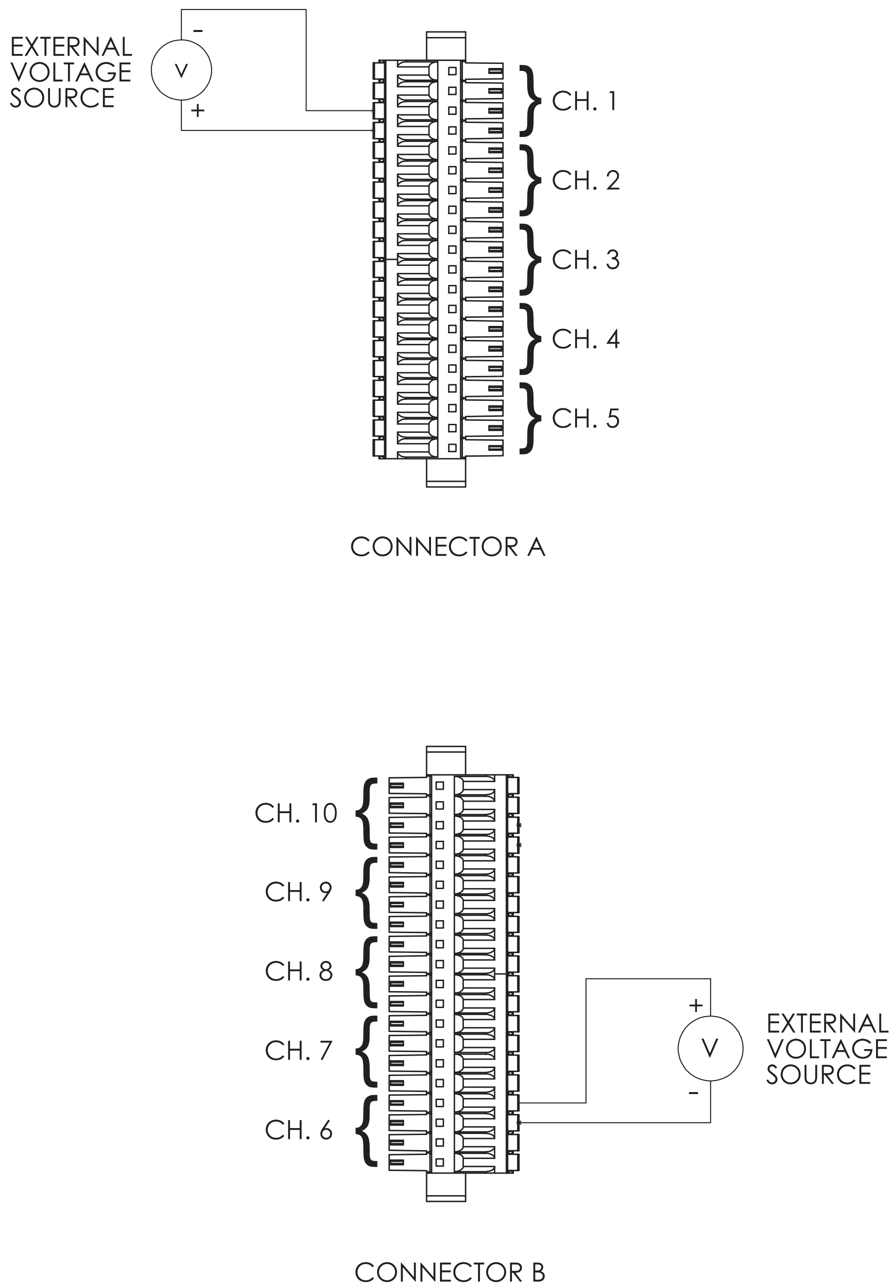


Figure C-18 SIOU.10: 0-10 Volt Input

Discrete Modules

SIO2.10 - UDI.10

Pin out information for SIO2.10 modules is shown in Table C-6.

Table C-6 SIO2.10 Pin Outs

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1A INPUT
	RED	2	CHAN. 1B INPUT
PAIR 2	BLACK	3	CHAN. 2A INPUT
	WHITE	4	CHAN. 2B INPUT
PAIR 3	BLACK	5	CHAN. 3A INPUT
	GREEN	6	CHAN. 3B INPUT
PAIR 4	BLACK	7	CHAN. 4A INPUT
	BLUE	8	CHAN. 4B INPUT
PAIR 5	BLACK	9	CHAN. 5A INPUT
	BROWN	10	CHAN. 5B INPUT
PAIR 6	BLACK	11	CHAN. 6A INPUT
	YELLOW	12	CHAN. 6B INPUT
PAIR 7	BLACK	13	CHAN. 7A INPUT
	ORANGE	14	CHAN. 7B INPUT
PAIR 8	RED	15	CHAN. 8A INPUT
	GREEN	16	CHAN. 8B INPUT
PAIR 9	RED	17	CHAN. 9A INPUT
	WHITE	18	CHAN. 9B INPUT
PAIR 10	RED	19	CHAN. 10A INPUT
	BLUE	20	CHAN. 10B INPUT

The following figures are the wiring diagrams for connecting the SIO2.10 to field devices.

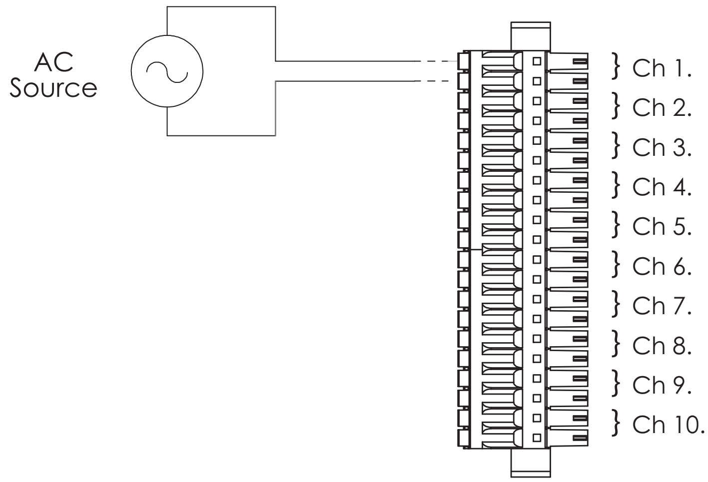


Figure C-19 SIO2.10: AC Voltage Monitor

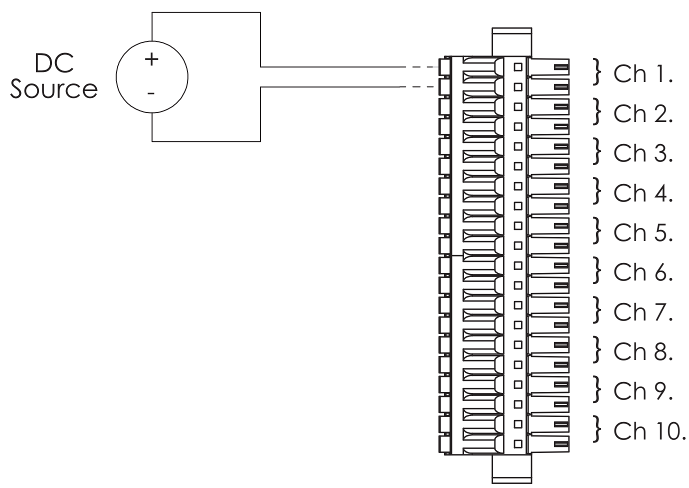


Figure C-20 SIO2.10: DC Voltage Monitor

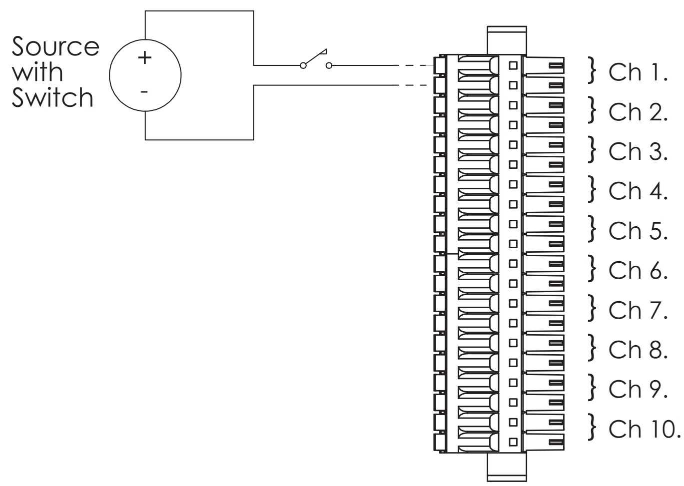


Figure C-21 SIO2.10: Contact Closure (with External DC Power Supply)

SIO3.10 - UDO.10

Pin out information for SIO3.10 modules is shown in Table C-7.

Table C-7 SI03.10 Pin Outs

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1A OUTPUT
	RED	2	CHAN. 1B OUTPUT
PAIR 2	BLACK	3	CHAN. 2A OUTPUT
	WHITE	4	CHAN. 2B OUTPUT
PAIR 3	BLACK	5	CHAN. 3A OUTPUT
	GREEN	6	CHAN. 3B OUTPUT
PAIR 4	BLACK	7	CHAN. 4A OUTPUT
	BLUE	8	CHAN. 4B OUTPUT
PAIR 5	BLACK	9	CHAN. 5A OUTPUT
	BROWN	10	CHAN. 5B OUTPUT
PAIR 6	BLACK	11	CHAN. 6A OUTPUT
	YELLOW	12	CHAN. 6B OUTPUT
PAIR 7	BLACK	13	CHAN. 7A OUTPUT
	ORANGE	14	CHAN. 7B OUTPUT
PAIR 8	RED	15	CHAN. 8A OUTPUT
	GREEN	16	CHAN. 8B OUTPUT
PAIR 9	RED	17	CHAN. 9A OUTPUT
	WHITE	18	CHAN. 9B OUTPUT
PAIR 10	RED	19	CHAN. 10A OUTPUT
	BLUE	20	CHAN. 10B OUTPUT

The following figures are the wiring diagrams for connecting the SIO3.10 to field devices.

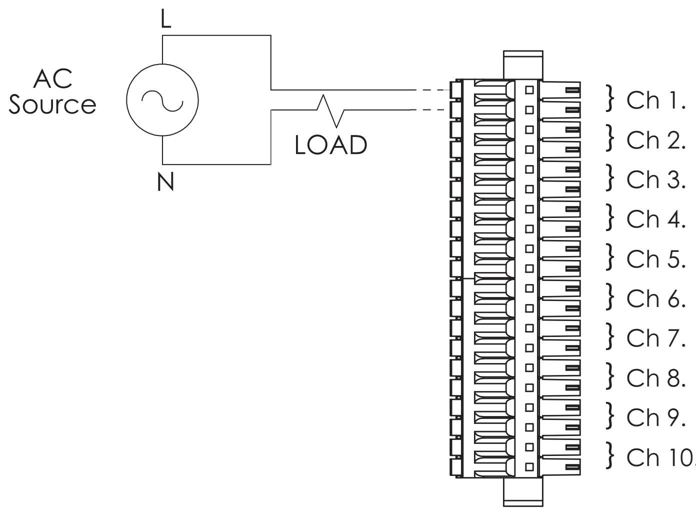


Figure C-22 SIO3.10: AC Load

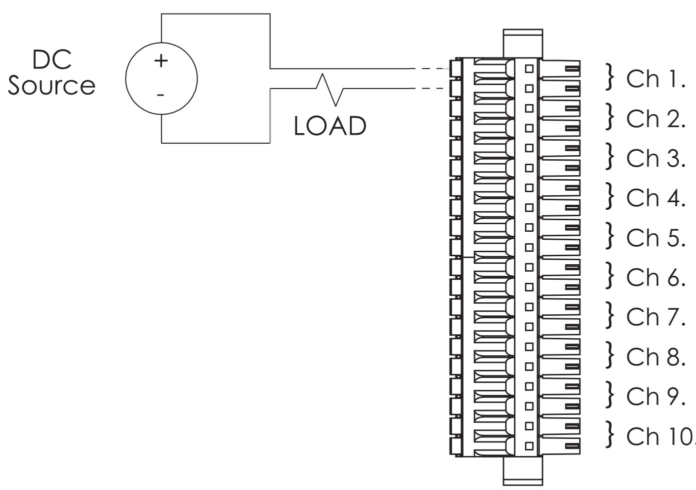


Figure C-23 SIO3.10: DC Load

SIO5.10 - DI.10

Pin out information for SIO5.10 modules is shown in Table C-8.

Table C-8 SIO5.10 Pin Outs

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1 - INPUT/EXCITATION
	RED	2	CHAN. 1 + INPUT
PAIR 2	BLACK	3	CHAN. 2 - INPUT/EXCITATION
	WHITE	4	CHAN. 2 + INPUT
PAIR 3	BLACK	5	CHAN. 3 - INPUT/EXCITATION
	GREEN	6	CHAN. 3 + INPUT
PAIR 4	BLACK	7	CHAN. 4 - INPUT/EXCITATION
	BLUE	8	CHAN. 4 + INPUT
PAIR 5	BLACK	9	CHAN. 5 - INPUT/EXCITATION
	BROWN	10	CHAN. 5 + INPUT
PAIR 6	BLACK	11	CHAN. 6 - INPUT/EXCITATION
	YELLOW	12	CHAN. 6 + INPUT
PAIR 7	BLACK	13	CHAN. 7 - INPUT/EXCITATION
	ORANGE	14	CHAN. 7 + INPUT
PAIR 8	RED	15	CHAN. 8 - INPUT/EXCITATION
	GREEN	16	CHAN. 8 + INPUT
PAIR 9	RED	17	CHAN. 9 - INPUT/EXCITATION
	WHITE	18	CHAN. 9 + INPUT
PAIR 10	RED	19	CHAN. 10 - INPUT/EXCITATION
	BLUE	20	CHAN. 10 + INPUT

The following figures are the wiring diagrams for connecting the SIO5.10 to field devices.

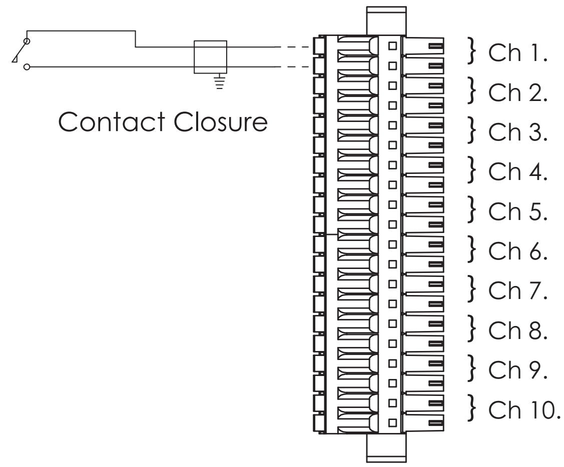


Figure C-24 SIO5.10: Contact Closure (with Internal Wetting Voltage)

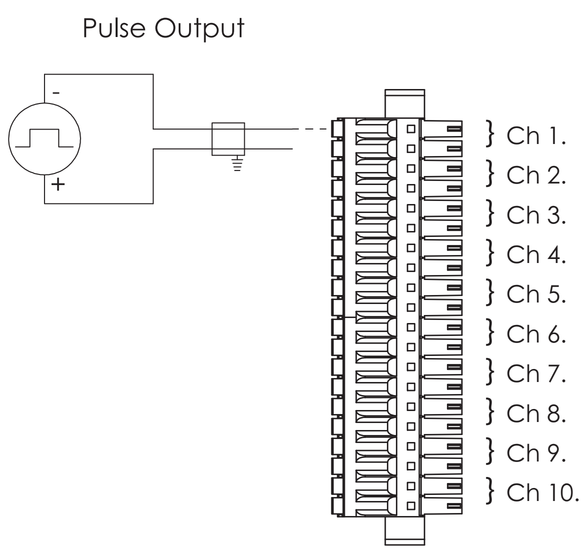


Figure C-25 SIO5.10: Voltage Monitor/Pulse Input

SIO7.20 - DI.20

SIO7.20 pin out information for channels 1-10 is shown in Table C-9. Pin out information for channels 11-20 is shown in Table C-10.

Table C-9 SIO7.20 Pin Outs for Channels 1-10

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1 + INPUT
	RED	2	CHAN. 1 - INPUT
PAIR 2	BLACK	3	CHAN. 2 + INPUT
	WHITE	4	CHAN. 2 - INPUT
PAIR 3	BLACK	5	CHAN. 3 + INPUT
	GREEN	6	CHAN. 3 - INPUT
PAIR 4	BLACK	7	CHAN. 4 + INPUT
	BLUE	8	CHAN. 4 - INPUT
PAIR 5	BLACK	9	CHAN. 5 + INPUT
	BROWN	10	CHAN. 5 - INPUT
PAIR 6	BLACK	11	CHAN. 6 + INPUT
	YELLOW	12	CHAN. 6 - INPUT
PAIR 7	BLACK	13	CHAN. 7 + INPUT
	ORANGE	14	CHAN. 7 - INPUT
PAIR 8	RED	15	CHAN. 8 + INPUT
	GREEN	16	CHAN. 8 - INPUT
PAIR 9	RED	17	CHAN. 9 + INPUT
	WHITE	18	CHAN. 9 - INPUT
PAIR 10	RED	19	CHAN. 10 + INPUT
	BLUE	20	CHAN. 10 - INPUT

Table C-10 SIO7.20 Pin Outs for Channels 11-20

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	21	CHAN. 11 + INPUT
	RED	22	CHAN. 11 - INPUT
PAIR 2	BLACK	23	CHAN. 12 + INPUT
	WHITE	24	CHAN. 12 - INPUT
PAIR 3	BLACK	25	CHAN. 13 + INPUT
	GREEN	26	CHAN. 13 - INPUT
PAIR 4	BLACK	27	CHAN. 14 + INPUT
	BLUE	28	CHAN. 14 - INPUT
PAIR 5	BLACK	29	CHAN. 15 + INPUT
	BROWN	30	CHAN. 15 - INPUT
PAIR 6	BLACK	31	CHAN. 16 + INPUT
	YELLOW	32	CHAN. 16 - INPUT

Table C-10 SI07.20 Pin Outs for Channels 11-20

Pair No.	Color	Pin No.	Function
PAIR 7	BLACK	33	CHAN. 17 + INPUT
	ORANGE	34	CHAN. 17 - INPUT
PAIR 8	RED	35	CHAN. 18 + INPUT
	GREEN	36	CHAN. 18 - INPUT
PAIR 9	RED	37	CHAN. 19 + INPUT
	WHITE	38	CHAN. 19 - INPUT
PAIR 10	RED	39	CHAN. 20 + INPUT
	BLUE	40	CHAN. 20 - INPUT

The following figures are the wiring diagrams for connecting the SIO7.20 to field devices.

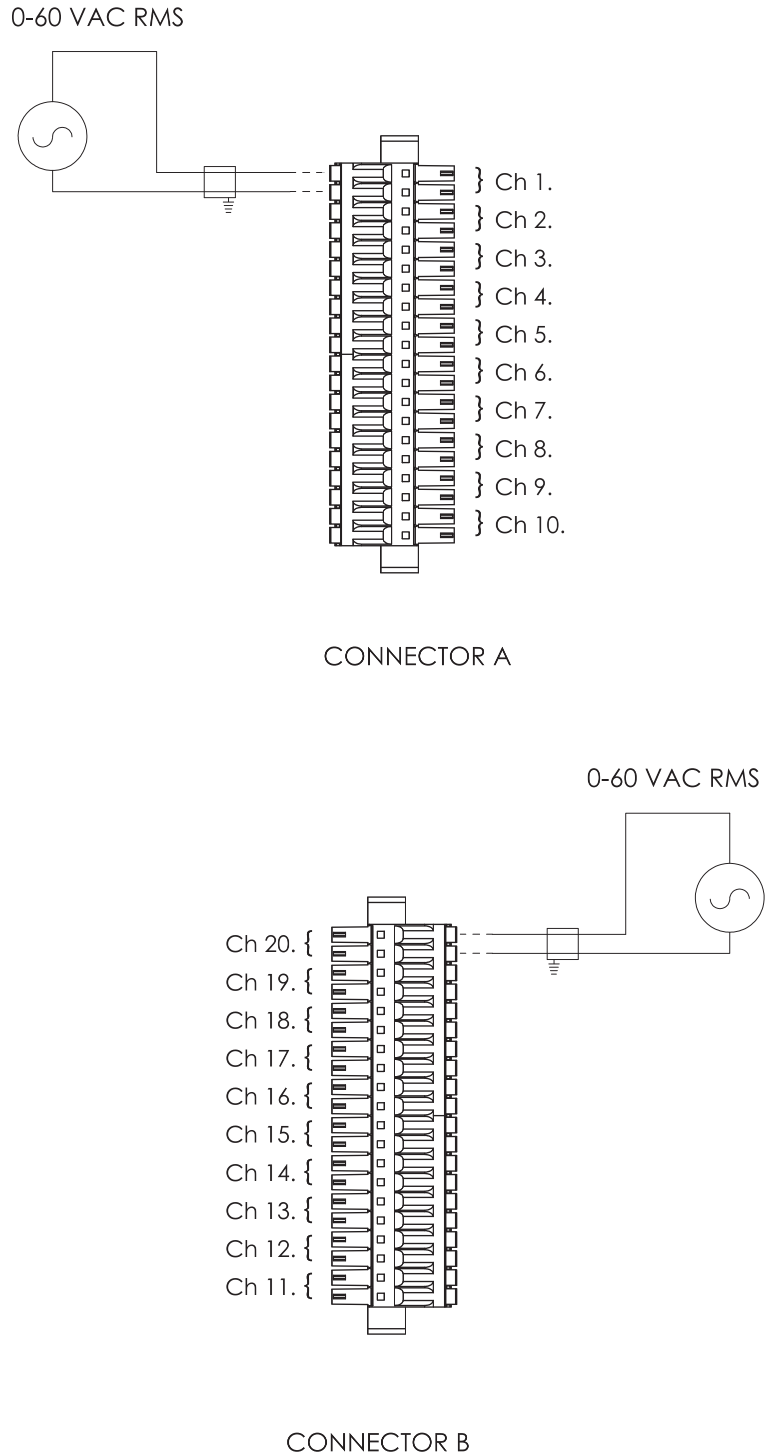


Figure C-26 SIO7.20: AC Input

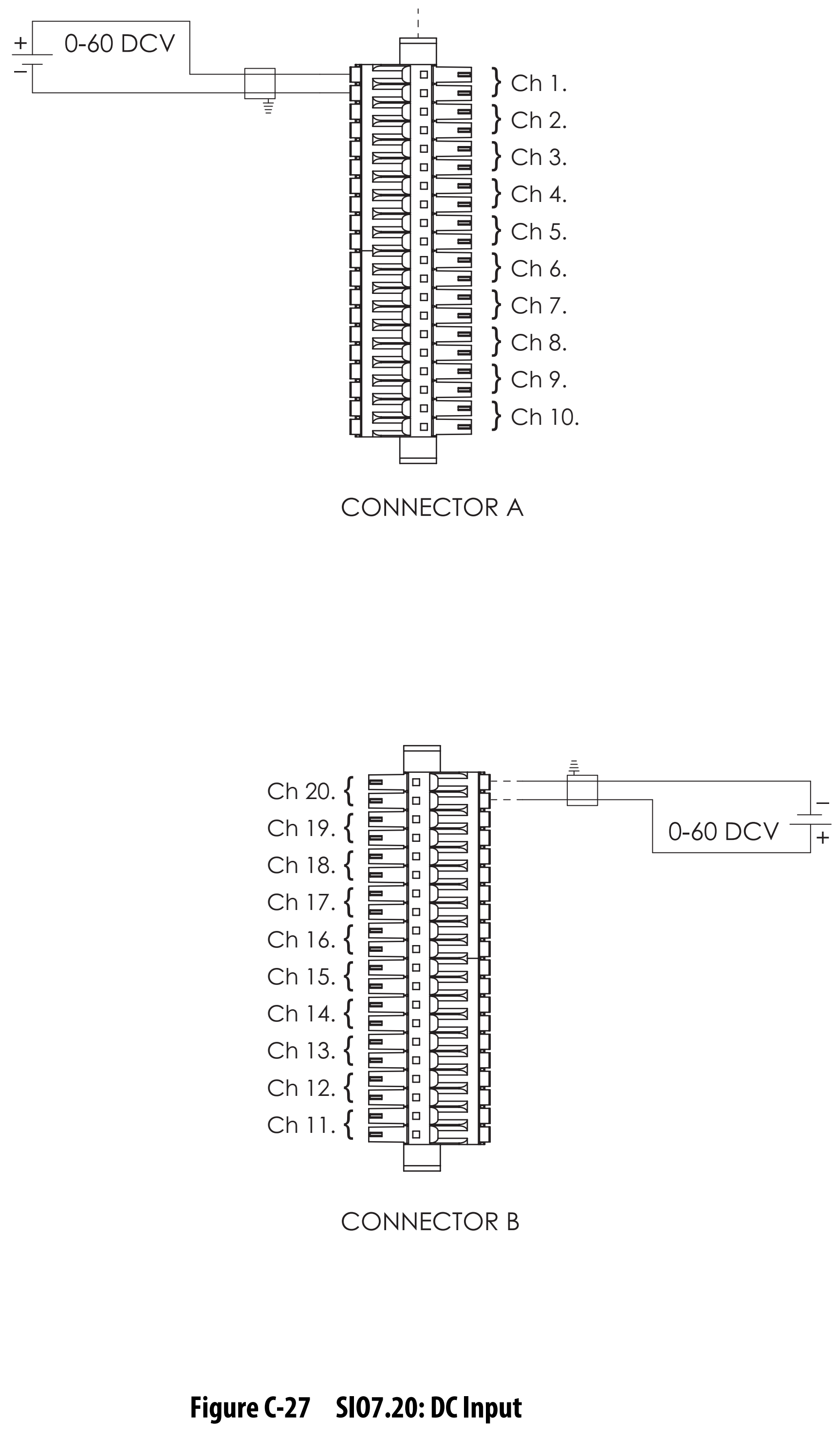


Figure C-27 SIO7.20: DC Input

SIO8.20 - DO.20

SIO8.20 pin out information for channels 1-10 is shown in Table C-11. Pin out information for channels 11-20 is shown in Table C-12.

Table C-11 SIO8.20 Pin Outs for Channels 1-10

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	1	CHAN. 1A OUTPUT
	RED	2	CHAN. 1B OUTPUT
PAIR 2	BLACK	3	CHAN. 2A OUTPUT
	WHITE	4	CHAN. 2B OUTPUT
PAIR 3	BLACK	5	CHAN. 3A OUTPUT
	GREEN	6	CHAN. 3B OUTPUT
PAIR 4	BLACK	7	CHAN. 4A OUTPUT
	BLUE	8	CHAN. 4B OUTPUT
PAIR 5	BLACK	9	CHAN. 5A OUTPUT
	BROWN	10	CHAN. 5B OUTPUT
PAIR 6	BLACK	11	CHAN. 6A OUTPUT
	YELLOW	12	CHAN. 6B OUTPUT
PAIR 7	BLACK	13	CHAN. 7A OUTPUT
	ORANGE	14	CHAN. 7B OUTPUT
PAIR 8	RED	15	CHAN. 8A OUTPUT
	GREEN	16	CHAN. 8B OUTPUT
PAIR 9	RED	17	CHAN. 9A OUTPUT
	WHITE	18	CHAN. 9B OUTPUT
PAIR 10	RED	19	CHAN. 10A OUTPUT
	BLUE	20	CHAN. 10B OUTPUT

Table C-12 SIO8.20 Pin Outs for Channels 11-20

Pair No.	Color	Pin No.	Function
PAIR 1	BLACK	21	CHAN. 11A OUTPUT
	RED	22	CHAN. 11B OUTPUT
PAIR 2	BLACK	23	CHAN. 12A OUTPUT
	WHITE	24	CHAN. 12B OUTPUT
PAIR 3	BLACK	25	CHAN. 13A OUTPUT
	GREEN	26	CHAN. 13B OUTPUT
PAIR 4	BLACK	27	CHAN. 14A OUTPUT
	BLUE	28	CHAN. 14B OUTPUT
PAIR 5	BLACK	29	CHAN. 15A OUTPUT
	BROWN	30	CHAN. 15B OUTPUT
PAIR 6	BLACK	31	CHAN. 16A OUTPUT
	YELLOW	32	CHAN. 16B OUTPUT

Table C-12 SIO8.20 Pin Outs for Channels 11-20

Pair No.	Color	Pin No.	Function
PAIR 7	BLACK	33	CHAN. 17A OUTPUT
	ORANGE	34	CHAN. 17B OUTPUT
PAIR 8	RED	35	CHAN. 18A OUTPUT
	GREEN	36	CHAN. 18B OUTPUT
PAIR 9	RED	37	CHAN. 19A OUTPUT
	WHITE	38	CHAN. 19B OUTPUT
PAIR 10	RED	39	CHAN. 20A OUTPUT
	BLUE	40	CHAN. 20B OUTPUT

The following figure is the wiring diagram for connecting the SIO8.20 to field devices.

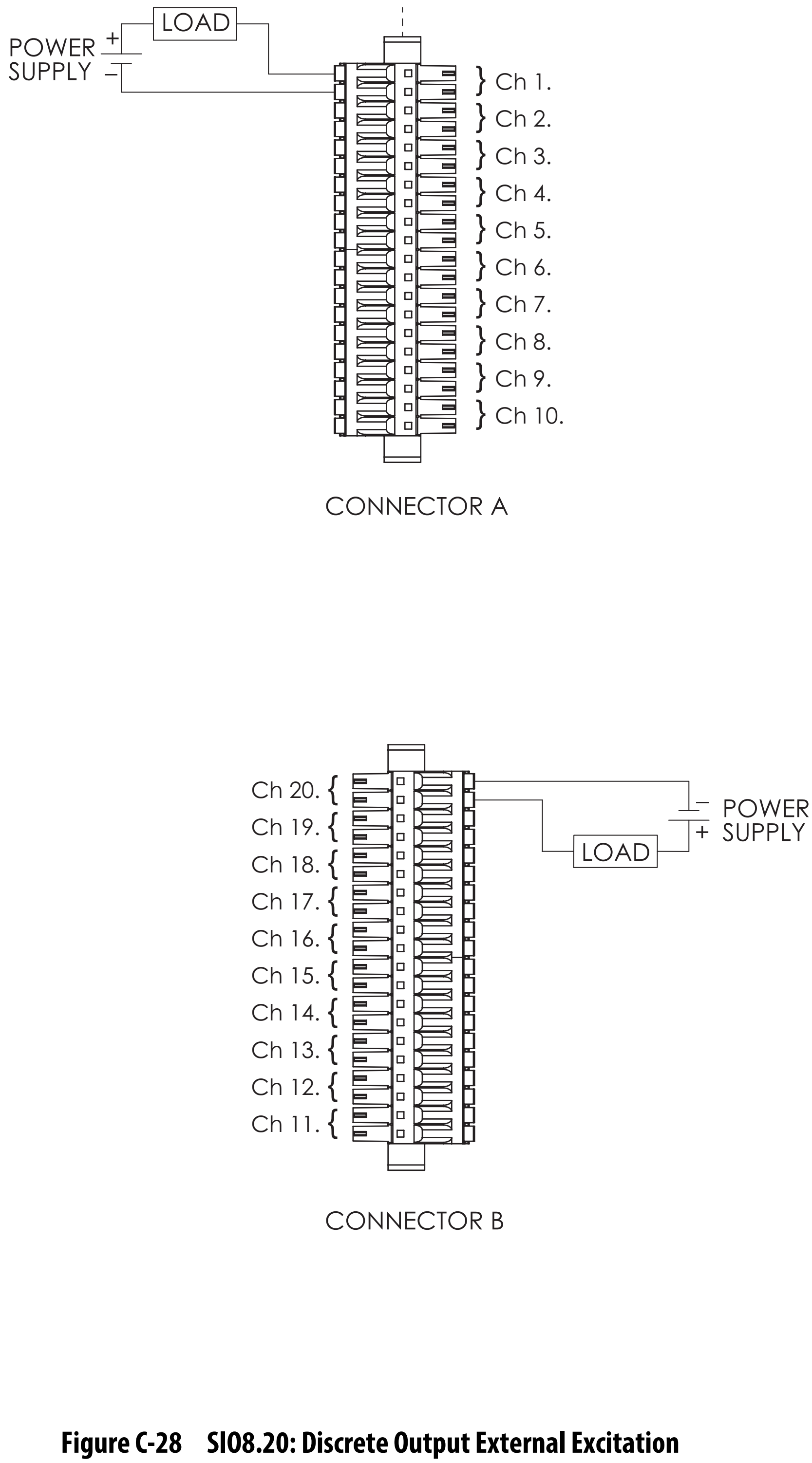


Figure C-28 SIO8.20: Discrete Output External Excitation

Communication Modules

SIO4.E - UE.5

As described in "SIO Communication Modules", IEEE 802.3at-2009 provides two alternatives for a PSE device to transmit power over Ethernet cabling. Pin out information for the two alternatives, using the RJ45 connector (Figure C-29), is shown in Table C-13. Ports 1, 2, and 3 of the SIO4.E are wired for Alternative A. Ports 4 and 5 are wired for Alternative B.

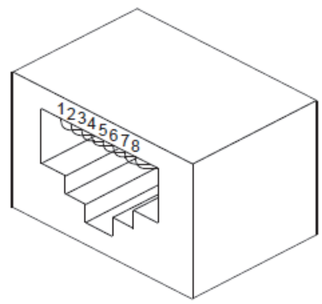


Figure C-29 RJ45 Connector for PD and PSE

Table C-13 PSE Pin Out Alternatives

Conductor	Alternative A (MDI)	Alternative B (All)
1	Positive V_{PSE}	
2	Positive V_{PSE}	
3	Negative V_{PSE}	
4		Positive V_{PSE}
5		Positive V_{PSE}
6	Negative V_{PSE}	
7		Negative V_{PSE}
8		Negative V_{PSE}

Figure C-30 shows the wiring diagram for connecting the SIO4.E to field devices using Alternative A and Alternative B.

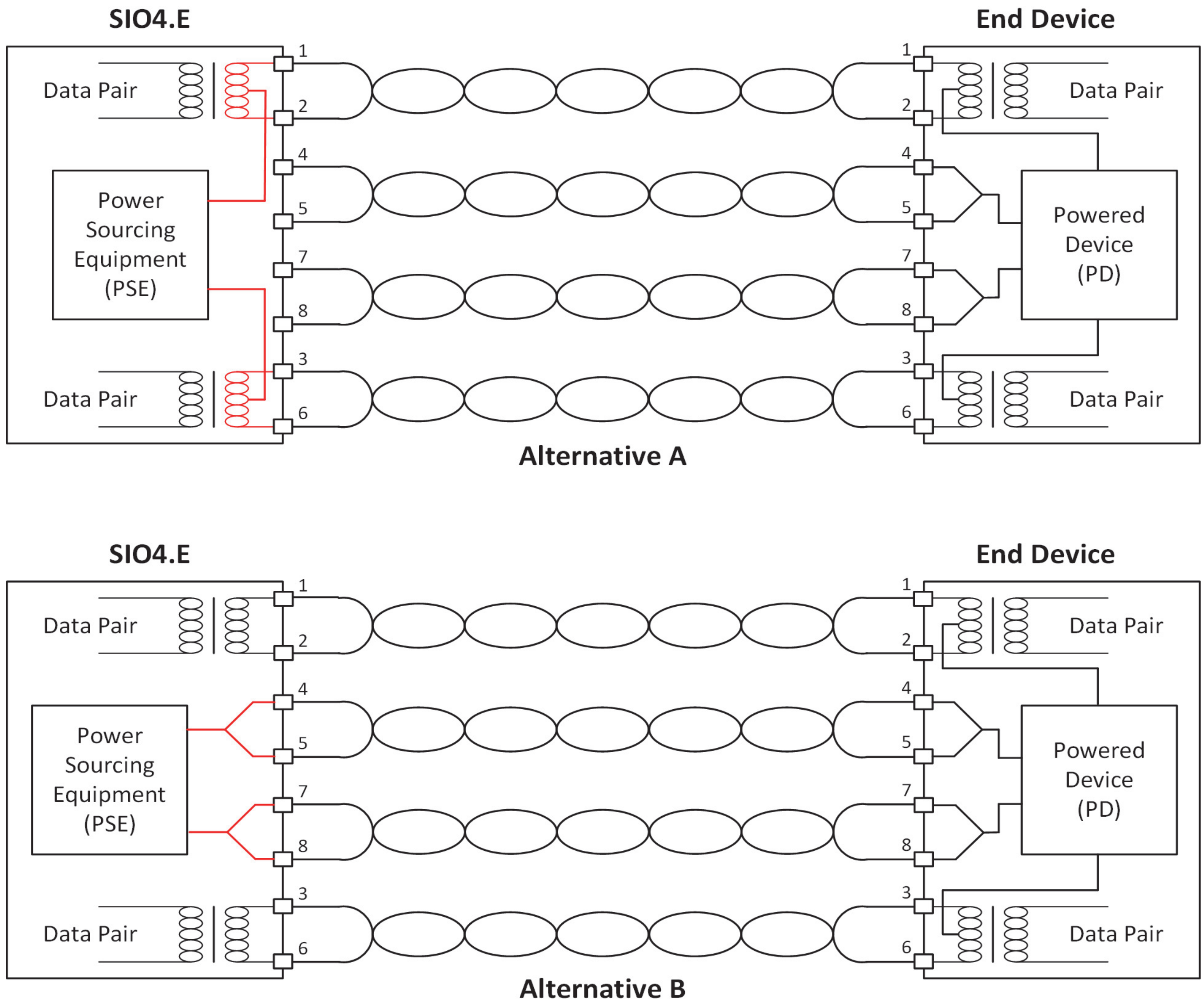


Figure C-30 SIO4.E Wiring for PoE

SIOS.5 - US.5

The SIOS.5 Serial Communication Cable is used to connect the SIOS.5 to field devices. One end of the cable has a Micro-D connector to connect to the module and the other end has a 9-pin female D-Sub connector (the same as can be found on a standard PC) to connect to field devices. The pin out for each connector is the same. The Micro-D connector with pin numbers is shown in Figure C-31.

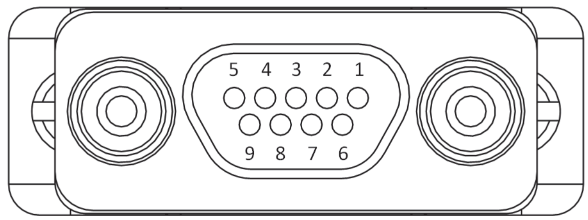


Figure C-31 S.5 Serial Cable Pin Numbering

The pin out information for each SIOS.5 operating mode is shown in Table C-14. Note that each channel is isolated and pin 5 must be connected in all modes.

Table C-14 SIOS.5 Pin Out Information

Pin Number	RS-232	RS-485	RS-422 / RS-485 Full Duplex
2	RXD		RXD+
3	TXD	DATA+	TXD+
5	GND	GND	GND
7	RTS	DATA-	TXD-
8	CTS		RXD-

SIO Module Specifications

The following are the specifications for each of the Secure Input Output (SIO) modules used in the Bedrock Control System.

Analog Modules

SIO1.5 - UAIO.5

The SIO1.5 is a five channel universal analog input/output module. The SIO1.5 power supply provides isolated power for each channel. This provides channel-to-channel and channel-to-ground galvanic isolation. Each channel has a dedicated, secure processor.

For information on the input types that the SIO1.5 can interface to and for information on the operation of the SIO1.5, see “SIO Analog Operation”.

The SIO1.5 also provides ±0.5 ms SOE time stamps for all data.

See Table D-1 for the SIO1.5 specifications.

Table D-1 SI01.5 Specifications

Specification	Value
Interface	5 channel isolated and independent channels
Power Consumption	9.5 watts
Power Dissipation	4 watts
Loop Compliance Voltage	18 V DC minimum at 24 mA
Current Input Sense Resistor (4-20 mA)	250 Ω, software selectable
TC and Millivolt Inputs	±78.125 mV range
Input Impedance (thermocouple mode)	10 MΩ per channel
RTD, Resistance Inputs	0 to 450 Ω maximum
Analog Output Load Resistance Minimum	250 Ω
Analog Output Load Resistance Maximum	750 Ω
Actual Input Range (current input)	3.5 mA - 24 mA
Actual Output Range	3.5 mA - 24 mA
Analog Input Accuracy	±0.015% of full-scale (between 4 mA and 20 mA) at 23°C
Analog Output Accuracy	±0.03% of full-scale (between 4 mA and 20 mA) at 23°C
CJC accuracy	±0.8°C
Excitation	Programmable: Loop Voltage Mode: 21.6 V DC @ 24 mA Resistance Sense Current: 500 µA
Temperature Coefficient	45 ppm/°C

Table D-1 SIO1.5 Specifications

Specification	Value
Input Resolution	19 bits plus sign bit
Output Resolution	16 bits
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Non-linearity	Included in accuracy
The channels are galvanically isolated from each other, and galvanically isolated (transformer isolation) from ground.	Channel to channel: 1200 V Channel to ground: 1500 V
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

Thermocouple Specifications

Table D-2 lists a variety of thermocouples supported by the SIO1.5 and their inaccuracy at 23°C.

Table D-2 Thermocouple Accuracy @ 2 3°C

Thermocouple Type	μV / °C	Error in °C
R	7	1.67
S	7	1.67
E	62	0.189
J	51	0.229
K	40	0.293
T	40	0.293
B	1	11.7
N	27	0.433
C	14	0.836

SIO6.20 - AI.20

The SIO6.20 has the following specifications: group isolated 4-20 mA, voltage monitor, HART Revision7, accuracy ±0.015%, deterministic backplane communications.

The SIO6.20 also provides ±0.5 ms SOE time stamps for all data.

Table D-3 lists the SIO6.20 electrical specifications.

Table D-3 SIO6.20 Electrical Specifications

Specification	Value
Interface	20 channel (two groups of ten channels) group isolated analog inputs
Input Impedance	250 Ω per channel
Power Consumption	3.5 watts
Power Dissipation	3.0 watts
Temperature Coefficient	45 ppm/°C
Input Resolution	19 bits plus sign bit
Actual Input Range (current input)	3.5 mA - 24 mA
Analog Input Accuracy	±0.015% of full-scale (between 4 mA and 20 mA) at 23°C
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Non-linearity	Included in accuracy
Two banks of I/O that are galvanically isolated from each other, ground, and module logic.	Group to group: 1200 V Group to ground: 1500 V
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	± 0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

SIOU.10 - UIO.10

Each SIOU.10 channel can be independently configured for one of the operating modes described in Table D-4. Depending upon the mode selected, the following functionality is available:

- 4-20 mA input or output with or without HART
- discrete input with programmable debounce enables the SIOU.10 to count debounced pulses in addition to the input state
- counter mode (discrete input) where the SIOU.10 accumulates high-speed pulses up to 100 kHz
- frequency mode (discrete input) where the SIOU.10 provides accurate frequency measurement from 10 Hz to 100 kHz.
- NAMUR input for monitoring low-level current.
- 0-10 V voltage input

See Table D-4 for general specifications for the SIOU.10, i.e., specifications that are not specific to analog, discrete, or NAMUR operation. Those specifications are presented in subsequent tables.

Table D-4 SIOU.10 General Specifications

Specification	Value
Interface	Ten channel isolated and independent channels. Each channel can be configured for analog input or output, discrete input or output, or as a NAUMUR input depending on the operating mode
Operating Modes	• 4-20 mA analog input (loop power set to 25 mA) with HART and discrete input • 4-20 mA analog output with readback with HART and discrete input • 4-20 mA analog input (loop power set to 25 mA) and discrete input • 4-20 mA analog output with readback and discrete input • internally or externally powered discrete output with readback (excitation maximum current of 25 mA) • NAMUR input • 0-10 V voltage input Channels may also be configured as a spare
Power Consumption	10 watts
Power Dissipation	5 watts

Table D-4 SIOU.10 General Specifications

Specification	Value
The channels are galvanically isolated from each other and galvanically isolated from ground.	Channel to channel: 1200 V Channel to ground: 1500 V
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

See Table D-5 for SIOU.10 specifications that are specific to analog operation.

Table D-5 SIOU.10 Analog Specifications

Specification	Value
Loop Compliance Voltage	18 V DC minimum at 22 mA
Current Inputs Sense Resistor	250 Ω, software selectable
Analog Output Load Resistance Minimum	250 Ω
Analog Output Load Resistance Maximum	750 Ω
Analog Input Accuracy (4-20 mA)	±0.015% of full-scale (between 4 mA and 20 mA) at 23°C
Actual Input Range (current input)	3.25 mA - 22 mA
Actual Output Range (current output)	3.25 mA - 22 mA
Analog Input Accuracy for 10 V Input (0-10 V)	±0.025% of full-scale at 23°C
Actual Input Range (voltage input)	0.1 V - 12 V
Voltage Input Impedance	20 kΩ
Analog Output Accuracy	±0.035% of full-scale (between 4 mA and 20 mA) at 23°C
Excitation	Programmable: Loop Voltage Mode: 21.6 V @ 22 mA
Temperature Coefficient	50 ppm/°C
Input Resolution	20 bits
Output Resolution	14 bits
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Non-linearity	Included in accuracy

The SIOU.10 supports the following discrete input types:

- voltage monitor
- contact sense

and the following discrete output types:

- externally sourced
- internally sourced.

SIOU.10 specifications related to each of the discrete input and output types are presented in the following tables.

Table D-6 lists SIOU.10 specifications that are specific to voltage monitor inputs.

Table D-6 SIOU.10 Specifications for Voltage Monitor Inputs

Specification	Value
Programmable Thresholds	See Table 7-11
Input Impedance (discrete input voltage)	20 kΩ
Overcurrent Limit	Soft-selectable up to 1.0 amps
Input Frequency Range	10 Hz to 100 kHz
Filter/Debounce Time	Programmable 0-255 ms
Frequency Accuracy	±0.035% of full-scale
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers

Table D-7 lists SIOU.10 specifications that are specific to contact sense inputs.

Table D-7 SIOU.10 Specifications for Contact Sense Inputs

Specification	Value
Maximum Voltage on Excitation	25 V
Filter/Debounce Time	Programmable 0-255 ms
Frequency Accuracy	±0.035% of full-scale
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers

Table D-8 lists SIOU.10 specifications that are specific to externally sourced discrete outputs.

Table D-8 SIOU.10 Specifications for Externally Sourced Discrete Outputs

Specification	Value
Maximum On Current	1 amp
Maximum Switching Voltage	30 V
Programmable Overcurrent Shutoff	Latch-off or back-off retry
Overcurrent Delay (Retry Period)	3-255 ms •Back-off versus latch-off •Back-off and retry count setting After an overcurrent condition occurs, each channel can either stay latched off or back-off and retry. If back-off and retry is chosen, the number of retries can be selected. The total number of turn-on attempts is one plus the number of configured retries.
Inductive Loads	Outputs require protective diodes or metal-oxide varistors when connected to an inductive load
Blanking Time	3 ms
On State Resistance	< 0.25 Ω
Off State Resistance	20 kΩ
Maximum Off Voltage	35 V DC
Overcurrent Limit	Soft-selectable up to 1.0 amps
Discrete Output Current Accuracy	1.5% of full scale

Table D-9 lists SIOU.10 that are specific to internally sourced discrete outputs.

Table D-9 SIOU.10 Specifications for Internally Sourced Discrete Outputs

Specification	Value
Maximum Voltage on Excitation	25 V
Maximum Current	25 mA
Discrete Output Current Accuracy	1.5% of full scale

See Table D-10 for SIOU.10 specifications that are specific to NAMUR input operation.

Table D-10 SIOU.10 NAMUR Input Specifications

Specification	Value
NAMUR Input Impedance	1 kΩ
NAMUR Sensor Failure	< 0.2 mA
NAMUR Input Off	1.1 mA
NAMUR Input On	2.0 mA
NAMUR Voltage	7-12 V

Discrete Modules

SIO2.10 - UDI.10

The SIO2.10 has the following specifications: channel isolated, voltage monitor, 24 to 240 V AC/DC, ±0.5 ms sequence of events (SOE) and time stamp.

Table D-11 lists the SIO2.10 electrical specifications.

Table D-11 SIO2.10 Electrical Specifications

Specification	Value
Number of Channels	10 isolated input channels
Input Types	Soft-selectable range of 24–240 V AC/DC (polarity independent), voltage monitor
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Filter/Debounce Time	Programmable 0-255 ms
Channels are galvanically isolated (transformer isolated) from each other, and from ground and module logic.	Channel to channel: 1200 V Channel to ground: 1500 V
Programmable Thresholds	See the Programmable Thresholds table for details.
Input Impedance	79 kΩ
Power Consumption	2.5 watts
Power Dissipation	4.0 watts
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

The programmable thresholds for the SIO2.10 are shown in Table D-12. The thresholds are polarity independent

Table D-12 SIO2.10 Programmable Thresholds

Setting	Off Voltage	On Voltage
24 V AC/DC	8	20
48 V AC/DC	20	40
120 V AC/DC	45	90
240 V AC/DC	90	150

SIO3.10 - UDO.10

The SIO3.10 has the following specifications: channel isolated, contact closure, 0 to 240 V AC/DC, ±0.5 ms SOE and time stamp.

Table D-13 lists the SIO3.10 electrical specifications.

Table D-13 SIO3.10 Electrical Specifications

Specification	Value
Interface	10- Universally Configurable - Bedrock Virtual Marshalling Series
Output Types	0–240 V AC/DC
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Blanking Time (time between overcurrent detection and shutdown)	2 ms
Programmable Overcurrent Shutoff	Latch-off or Back-off retry
Overcurrent Delay	1-255 ms •Back-off versus latch-off •Back-off and retry count setting After an overcurrent condition occurs, each channel can either stay latched off or back-off and retry. If back-off and retry is chosen, the number of retries can be selected. The total number of turn-on attempts is one plus the number of configured retries.
Inductive Loads	Outputs require protective diodes or metal-oxide varistors when connected to an inductive load
Power Consumption	5.5 watts
Power Dissipation	7.0 watts
On State Resistance	< 0.25 Ω
Off State Resistance	> 100 kΩ
Maximum Off Voltage	240 V AC or DC
Maximum On Current	1.5 amps per channel, 3 channel max. 0.6 amps per channel, 10 channels
Overcurrent Limit	2.8 amps (peak)
Channels are galvanically isolated from each other, and from ground and module logic.	Channel to channel: 1200 V Channel to ground: 1500 V
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)

Table D-13 SIO3.10 Electrical Specifications (Continued)

Specification	Value
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

SIO5.10 - DI.10

The following functional modes are available on the SIO5.10:

- discrete input mode with programmable debounce enables the SIO5.10 to count debounced pulses in addition to the input state
- counter mode where the SIO5.10 accumulates high-speed pulses up to 100 kHz
- frequency mode where the SIO5.10 provides accurate frequency measurement from 10 Hz to 100 kHz.

The SIO5.10 may be configured for the following modes of input:

- voltage monitor for a 5, 12, or 24 volts DC input signal
- contact sense with 24 V wetting voltage

The SIO5.10 also provides ±0.5 ms SOE time stamps for all data.

Table D-14 lists the SIO5.10 electrical specifications.

Table D-14 SIO5.10 Electrical Specifications

Specification	Value
Number of Channels	10 high speed, group isolated, discrete inputs
Filter/Debounce Time	Soft-selectable 0-255 ms
Input Type	Soft-selectable voltage monitor or contact closure (wetting voltage from module)
Input Threshold	See Table 8-6 for details.
Hysteresis Level	0.5 V
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
The channels are group isolated from ground	Group to ground: 1500 V
Input Impedance	12 kΩ
Power Consumption	4.5 watts
Power Dissipation	4.0 watts
Wetting Voltage	24 V DC ± 10%
Input Frequency Range	10 Hz to 100 kHz
Frequency Accuracy	±0.03% of full-scale

Table D-14 SIO5.10 Electrical Specifications

Specification	Value
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

SIO7.20 - DI.20

The SIO7.20 has the following specifications: channel isolated, voltage monitor, 0 to 60 V AC/DC, ±0.5 ms SOE and time stamp.

Table D-15 lists the SIO7.20 electrical specifications.

Table D-15 SIO7.20 Electrical Specifications

Specification	Value
Number of Channels	20 Low Voltage Discrete Inputs
Input Types	Soft-selectable AC/DC voltage monitor
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Filter/Debounce Time	Programmable 0-255 ms
Channels are galvanically isolated (transformer isolated) from each other, and from ground and module logic.	Channel to channel: 1200 V Channel to ground: 1500 V
DC Thresholds	Off Voltage: ±7 V DC On Voltage: ±20 V DC
AC Thresholds	Off Voltage: ±5.0 V AC On Voltage: ±14.1 V AC
Maximum Input Voltage	42 V AC, 60 V DC
Input Impedance	12 kΩ
Power Consumption	1.5 watts
Power Dissipation	3.0 watts
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)

Table D-15 SIO7.20 Electrical Specifications

Specification	Value
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

SIO8.20 - DO.20

The SIO8.20 has twenty discrete output channels. Each channel is galvanically isolated from each other and ground.

Table D-16 lists the SIO8.20 electrical specifications.

Table D-16 SIO8.20 Electrical Specifications

Specification	Value
Interface	20 channel isolated, high density, discrete output channels
Output Type	30 V DC
Controller Update Rate	3 ms with a single Controller 10 ms with redundant Controllers
Blanking Time (time between overcurrent detection and shutdown)	1 ms
Programmable Overcurrent Shutoff	Latch-off or Back-off retry
Overcurrent Delay	1-255 ms •Back-off versus latch-off •Back-off and retry count setting After an overcurrent condition occurs, each channel can either stay latched off or back-off and retry. If back-off and retry is chosen, the number of retries can be selected. The total number of turn-on attempts is one plus the number of configured retries.
Inductive Loads	Outputs require protective diodes or metal-oxide varistors when connected to an inductive load
Power Consumption	4.0 watts
Power Dissipation	6.5 watts
On State Resistance	< 0.25 Ω
Off State Resistance	500 kΩ
Maximum Switching Voltage	30 V DC
Maximum Off Voltage	35 V DC
Maximum On Current	1 amp per channel, 12 amp max.
Overcurrent Limit	Soft-selectable up to 1.0 amps
Discrete Output Current Accuracy	5% of full scale
Channels are galvanically isolated from each other, and from ground and module logic.	Channel to channel: 1000 V Channel to ground: 1000 V

Table D-16 SI08.20 Electrical Specifications (Continued)

Specification	Value
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Time Stamp Resolution	10 ns
Time Stamp Accuracy	±0.5 ms
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

Communication Modules

SIO4.E - UE.5

The SIO4.E is a five port smart communication module that is capable of 10/100 Mbps half/full duplex communication with other smart devices that use the EtherNet/IP protocol. Each port connects to other devices using a standard Cat5 shielded Ethernet cable and can power other devices using PoE.

Table D-17 lists the SIO4.E specifications.

Table D-17 SI04.E Specifications

Specification	Value
Power Supplied per Port	-48 V at 0.5 amps (25 watts)
Port Power Alternative	Ports 1, 2, and 3 - Alternative A Ports 4 and 5 - Alternative B
Power Consumption	4 watts
PoE Maximum Power Consumed (module plus loads)	127 watts total
PoE Voltage Drop	0.8 V
PoE Power Dissipation	2 watts
Maximum EtherNet/IP Connections	128
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

SIOS.5 - US.5

The SIOS.5 is a five channel serial communication module that connects to serial devices using the RS-232, RS-422, or RS-485 standards. Each port connects to other serial devices using the Bedrock SIOS.5 Serial Communication Cable.

Table D-18 lists the SIOS.5 specifications.

Table D-18 SIOS.5 Specifications

Specification	Value
Channels are galvanically isolated (transformer isolated) from each other, and from ground and module logic.	Channel to channel: 1200 V Channel to ground: 1500 V
Serial Communication Standards	RS-232, RS-422, RS-485
Maximum Serial Connections	5
Power Consumption	4.0 watts
Power Dissipation	4.0 watts
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Height	167.894 mm (6.61 inches)
Width	18.034 mm (0.71 inches)
Depth	106.426 mm (4.19 inches)
Weight	~290 g (10.2 ounces)

SPM Specifications

The following are the specifications for the Secure Power Modules (SPMs) used in the Bedrock Control System.

SPM.U Specifications

The SPM.U can accept any combination of a universal AC input or two DC power inputs. A 24 V DC output is also provided. Table E-1 lists the electrical specifications for the SPM.U.

Table E-1 SPM.U Electrical Specifications

Specification	Value
Input Voltage Range (AC)	90-240 V AC rms 50/60 Hz or 125-330 V DC
Input Current Range (AC)	2 amps (120 V AC) load dependent 1 amp (220 V AC) load dependent
Input Voltage Range (DC)	22-26 V DC
Input Current Limit (DC)	7 A (load dependent)
Inrush Surge Current	<30 amps for 16.6 ms
Input Fuse (AC)	5 A internal
Input Fuse (DC)	15 A internal
Choice of Suitable Fuses	10 A...16 A (AC: Characteristics B, C, D, K)
Input Protection	Transient Surge Protection
Type	Metal Oxide Varistor
Output Wetting Voltage, DC for External Use	24 V DC
Output Current, DC for External Use	1 to 5 amps, software configurable
Redundancy	Redundant interlink via BMI
Efficiency	91% Peak
Module Location	Magnetic Induction Backplanes BMI.5, BMI.10, or BMI.20
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Shock	IEC 60068-2-27 Operating 30 g, Non-operating 50 g
Vibration	IEC 60068-2-6 2 g @ 10-500 Hz
Radiated Emissions	CISPR 11 30 MHz to 230 MHz 40 db uV/m Quasi-peak at 10 meters 230 MHz to 1 GHz 47 db uV/m Quasi-peak at 10 meters
ESD Immunity	IEC 61000-4-2 6 kV contact discharges, 8 kV air discharges

Table E-1 SPM.U Electrical Specifications

Specification	Value
Radiated RF Immunity	IEC 61000-4-3 1 kHz sine-wave 80% AM 10 V/m (80 MHz to 1000 MHz) 3 V/m (1.4 GHz to 2.0 GHz), 1 V/m (2.0 GHz to 2.7 GHz)
EFT/B Immunity	IEC 61000-4-4 ±2 kV at 5 kHz on signal ports
Surge Transient Immunity	IEC 61000-4-5 ±2 kV line-earth (CM) on shielded ports
Conducted RF Immunity	IEC 61000-4-6 10 Vrms with 1 kHz sine-wave 80% AM from 150 kHz to 80 MHz
Radiated Susceptibility, Transient Electromagnetic Field (EMP testing)	MIL-STD-461G, requirement RS105
Installation in Class I Division 2 Hazardous Locations	ANSI/ISA-12.12.01-2105
Height	167.9 mm (6.61 inches)
Width	25.4 mm (1.0 inches)
Depth	106.4 mm (4.19 inches)
Weight	~483 g (17.25 ounces)

SPM.24 Specifications

The SPM.24 features two DC power inputs and a 24 V DC output. Table E-2 lists the electrical specifications for the SPM.24.

Table E-2 SPM.24 Electrical Specifications

Specification	Value
Input Voltage Range (DC)	22-26 V DC
Input Fuse (DC)	15 A internal
Input Protection	Transient Surge Protection
Type	Metal Oxide Varistor
Output Voltage, DC for External Use	24 V
Output Current, DC for External Use	1 to 5 amps, software configurable
Redundancy	Redundant interlink via BMI
Module Location	Magnetic Induction Backplanes BMI.5, BMI.10, or BMI.20
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative humidity	5% to 95% non-condensing
Shock	IEC 60068-2-27 Operating 30 g, Non-operating 50 g

Table E-2 SPM.24 Electrical Specifications

Specification	Value
Vibration	IEC 60068-2-6 2 g @ 10-500 Hz
Radiated Emissions	CISPR 11 30 MHz to 230 MHz 40 db uV/m Quasi-peak at 10 meters 230 MHz to 1 GHz 47 db uV/m Quasi-peak at 10 meters
ESD Immunity	IEC 61000-4-2 6 kV contact discharges, 8 kV air discharges
Radiated RF Immunity	IEC 61000-4-3 1 kHz sine-wave 80% AM 10 V/m (80 MHz to 1000 MHz) 3 V/m (1.4 GHz to 2.0 GHz), 1 V/m (2.0 GHz to 2.7 GHz)
EFT/B Immunity	IEC 61000-4-4 ±2 kV at 5 kHz on signal ports
Surge Transient Immunity	IEC 61000-4-5 ±2 kV line-earth (CM) on shielded ports
Conducted RF Immunity	IEC 61000-4-6 10 Vrms with 1 kHz sine-wave 80% AM from 150 kHz to 80 MHz
Radiated Susceptibility, Transient Electromagnetic Field (EMP testing)	MIL-STD-461G, requirement RS105
Installation in Class I Division 2 Hazardous Locations	ANSI/ISA-12.12.01-2105
Height	167.9 mm (6.61 inches)
Width	25.4 mm (1.0 inches)
Depth	106.4 mm (4.19 inches)
Weight	~483 g (17.25 ounces)

Controller Specifications

The following are the specifications for Controller modules used in the Bedrock Control System.

SCC Controllers

Secure Control Communication (SCC) Controllers can support up to twenty channels of I/O and can be used with any Bedrock BMI. A 1 Gb proprietary Interlink is available for systems running redundant SCC Controllers. Two 1 Gb Ethernet ports are available for connection to a local intranet (one is reserved for future use).

Table F-1 lists the electrical specifications for SCC Controllers.

Table F-1 SCC Electrical Specifications

Specification	Value
Processor	Dual-Core ARM Cortex™ processor
RAM	512 MB DDR3 RAM at 1066 MT/s
Flash Memory	32 GB
MRAM	8 kB in SCC Controllers with a hardware revision of rev. G or greater. MRAM is not present in earlier revision of SCC Controllers.
Controller Redundancy	Full redundancy via dedicated proprietary interlink
Control Cycle Time (Redundant Operation)	10 ms
Control Cycle Time (Standalone Operation)	3 ms
Module Location	Magnetic Induction Backplanes; BMI.5, BMI.10, or BMI.20
BMI Supported	1 local + 9 remote
IO Capacity	400 local I/O + 3600 remote I/O
RTOS	Green Hills INTEGRITY™
Open Control Package Support	Bedrock IDE
Ethernet Communication	1 Gbit Dual SFP (Fiber or Copper) transceiver slots
IP Stack	Dual-mode IPv4/IPv6
Power Requirement	24 volts at ±20% 0.5 amps
Power Consumption	7 watts
Power Dissipation	7 watts
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Shock	IEC 60068-2-27 Operating 30 g, Non-operating 50 g

Table F-1 SCC Electrical Specifications

Specification	Value
Vibration	IEC 60068-2-6 2 g @ 10-500 Hz
Radiated Emissions	CISPR 11 30 MHz to 230 MHz 40 db uV/m Quasi-peak at 10 meters 230 MHz to 1 GHz 47 db uV/m Quasi-peak at 10 meters
ESD Immunity	IEC 61000-4-2 6 kV contact discharges, 8 kV air discharges
Radiated RF Immunity	IEC 61000-4-3 1 kHz sine-wave 80% AM 10 V/m (80 MHz to 1000 MHz) 3 V/m (1.4 GHz to 2.0 GHz), 1 V/m (2.0 GHz to 2.7 GHz)
EFT/B Immunity	IEC 61000-4-4 ±2 kV at 5 kHz on signal ports
Surge Transient Immunity	IEC 61000-4-5 ±2 kV line-earth (CM) on shielded ports
Conducted RF Immunity	IEC 61000-4-6 10 Vrms with 1 kHz sine-wave 80% AM from 150 kHz to 80 MHz
Radiated Susceptibility, Transient Electromagnetic Field (EMP testing)	MIL-STD-461G, requirement RS105
Installation in Class I Division 2 Hazardous Locations	ANSI/ISA-12.12.01-2105
Height	167.9 mm (6.61 inches)
Width	25.4 mm (1.0 inches)
Depth	106.4 mm (4.19 inches)
Weight	~428 g (15.10 ounces)

SCS.10 Controllers

SCS.10 Controllers can support up to ten channels of I/O and are recommended to be used with a BMI.10 or BMI.5. When used with a BMI.10, the SCS.10 can be configured with redundant power. SCS.10 Controllers do not support Controller redundancy. A single 1 Gb Ethernet port is available for connection to a local intranet.

Table F-2 lists the electrical specifications for SCS.10 Controllers.

Table F-2 SCS.10 Electrical Specifications

Specification	Value
Processor	Dual-Core ARM Cortex™ processor
RAM	512 MB DDR3 RAM at 1066 MT/s

Table F-2 SCS.10 Electrical Specifications

Specification	Value
Flash Memory	32 GB
MRAM	8 kB
Controller Redundancy	Not supported
Control Cycle Time	3 ms
Module Location	Magnetic Induction Backplanes; BMI.5 or BMI.10
BMI Supported	1 local
IO Capacity	200 I/O
RTOS	Green Hills INTEGRITY™
Open Control Package Support	Bedrock IDE
Ethernet Communication	Single 1 Gbit SFP (Fiber or Copper) transceiver slot
IP Stack	Dual-mode IPv4/IPv6
Power Requirement	24 volts at ±20% 0.5 amps
Power Consumption	6 watts
Power Dissipation	6 watts
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Shock	IEC 60068-2-27 Operating 30 g, Non-operating 50 g
Vibration	IEC 60068-2-6 2 g @ 10-500 Hz
Radiated Emissions	CISPR 11 30 MHz to 230 MHz 40 db uV/m Quasi-peak at 10 meters 230 MHz to 1 GHz 47 db uV/m Quasi-peak at 10 meters
ESD Immunity	IEC 61000-4-2 6 kV contact discharges, 8 kV air discharges
Radiated RF Immunity	IEC 61000-4-3 1 kHz sine-wave 80% AM 10 V/m (80 MHz to 1000 MHz) 3 V/m (1.4 GHz to 2.0 GHz), 1 V/m (2.0 GHz to 2.7 GHz)
EFT/B Immunity	IEC 61000-4-4 ±2 kV at 5 kHz on signal ports
Surge Transient Immunity	IEC 61000-4-5 ±2 kV line-earth (CM) on shielded ports
Conducted RF Immunity	IEC 61000-4-6 10 Vrms with 1 kHz sine-wave 80% AM from 150 kHz to 80 MHz
Radiated Susceptibility, Transient Electromagnetic Field (EMP testing)	MIL-STD-461G, requirement RS105
Installation in Class I Division 2 Hazardous Locations	ANSI/ISA-12.12.01-2105
Height	167.9 mm (6.61 inches)
Width	25.4 mm (1.0 inches)

Table F-2 SCS.10 Electrical Specifications

Specification	Value
Depth	106.4 mm (4.19 inches)
Weight	~428 g (15.10 ounces)

SCS.5 Controllers

SCS.5 Controllers can support up to five channels of I/O and are recommended to be used with a BMI.5. SCS.5 Controllers do not support redundant power or Controller redundancy. A single 1 Gb Ethernet port is available for connection to a local intranet.

Table F-3 lists the electrical specifications for SCS.5 Controllers.

Table F-3 SCS.5 Electrical Specifications

Specification	Value
Processor	Dual-Core ARM Cortex™ processor
RAM	256 MB DDR3 RAM at 1066 MT/s
Flash Memory	8 GB
MRAM	8 kB
Controller Redundancy	Not supported
Control Cycle Time	3 ms
Module Location	Magnetic Induction Backplane; BMI.5
BMI Supported	1 local
IO Capacity	100 I/O
RTOS	Green Hills INTEGRITY™
Open Control Package Support	Bedrock IDE
Ethernet Communication	Single 1 Gbit SFP (Fiber or Copper) transceiver slot
IP Stack	Dual-mode IPv4/IPv6
Power Requirement	24 volts at ±20% 0.5 amps
Power Consumption	6 watts
Power Dissipation	6 watts
Operating Temperature	See Appendix A, Operating Temperature
Storage Temperature	-40°C to 85°C
Relative Humidity	5% to 95% non-condensing
Shock	IEC 60068-2-27 Operating 30 g, Non-operating 50 g
Vibration	IEC 60068-2-6 2 g @ 10-500 Hz

Table F-3 SCS.5 Electrical Specifications

Specification	Value
Radiated Emissions	CISPR 11 30 MHz to 230 MHz 40 db uV/m Quasi-peak at 10 meters 230 MHz to 1 GHz 47 db uV/m Quasi-peak at 10 meters
ESD Immunity	IEC 61000-4-2 6 kV contact discharges, 8 kV air discharges
Radiated RF Immunity	IEC 61000-4-3 1 kHz sine-wave 80% AM 10 V/m (80 MHz to 1000 MHz) 3 V/m (1.4 GHz to 2.0 GHz), 1 V/m (2.0 GHz to 2.7 GHz)
EFT/B Immunity	IEC 61000-4-4 ±2 kV at 5 kHz on signal ports
Surge Transient Immunity	IEC 61000-4-5 ±2 kV line-earth (CM) on shielded ports
Conducted RF Immunity	IEC 61000-4-6 10 Vrms with 1 kHz sine-wave 80% AM from 150 kHz to 80 MHz
Radiated Susceptibility, Transient Electromagnetic Field (EMP testing)	MIL-STD-461G, requirement RS105
Installation in Class I Division 2 Hazardous Locations	ANSI/ISA-12.12.01-2105
Height	167.9 mm (6.61 inches)
Width	25.4 mm (1.0 inches)
Depth	106.4 mm (4.19 inches)
Weight	~428 g (15.10 ounces)

SPM and SIO Blink Code Summary

The Bedrock Control System reports status information via blink codes from the module status LEDs. The LED blink codes for the SPM and SIO modules are listed in Table G-1. Descriptions of each code and recommended user actions are also provided.

Contact information for Bedrock Automation Field Support is:

(781) 821-0280
support@bedrockautomation.com
https://www.bedrockautomation.com/support/

Table G-1 SPM and SIO Module Blink Codes

Item No.	LED Color	LED Status	SPM	SIO	Description	User Action
1	Green	Solid	X	X	Status OK	Status: no action required
2	Green	1 blink		X	No redundant power warning	Check both power inputs
3	Green	3 blinks	X	X	Black Fabric COMM warning	Reseat module and tighten screws
4	Green	4 blinks	X		ADC test warning	Check wiring. If condition still exists, contact Bedrock Field support.
5	Green	4 blinks		X	Channel test warning	Contact Bedrock Field Support
6	Green	6 blinks		X	Loop voltage warning	Check sensor wiring
7	Green	7 blinks		X	Loop current warning	Contact Bedrock Field Support
8	Green	8 blinks		X	Thermocouple (TC) integrity warning	Check sensor wiring
9	Green	9 blinks		X	Resistance temperature detector (RTD) integrity warning	Check sensor wiring
10	Red	Solid	X	X	FATAL Error	Contact Bedrock Field Support
11	Red	1 blink	X	X	FATAL: RAM test failed	Contact Bedrock Field Support
12	Red	4 blinks	X		FATAL: PWM test failed	Contact Bedrock Field Support
13	Red	5 blinks	X		FATAL: FPGA test failed	Contact Bedrock Field Support
14	Red	6 blinks	X	X	FATAL: Loop-back test failed	Contact Bedrock Field Support
15	Red	7 blinks	X		FATAL: Check core voltage test failed	Contact Bedrock Field Support
16	Blue	Solid	X		Redundant SPM and power sharing is not on	Investigate why power sharing is not on. If condition continues, contact Bedrock Field Support.
17	Blue	1 blink	X		SEVERE: Low 24 V input power	Check power supply
18	Blue	1 blink		X	SEVERE: Channel error	Contact Bedrock Field Support
19	Blue	2 blinks	X	X	SEVERE: Authentication failure	Contact Bedrock Field Support

Table G-1 SPM and SIO Module Blink Codes

Item No.	LED Color	LED Status	SPM	SIO	Description	User Action
20	Blue	3 blinks		X	SEVERE: Wrong module type	Check configuration in the Bedrock IDE
21	Blue	4 blinks	X		SEVERE: SPM power fault	Check power supply
22	Blue	5 blinks		X	SEVERE: Image upgrade failure	Retry upgrade. If condition still exists, contact Bedrock Field support.
23	Purple	Solid	X	X	Module not configured	Configure module in the Bedrock IDE
24	Purple	1 blink	X	X	Authenticating on start-up	Status: no action required
25	Orange	Solid		X	Module off-line	Status: no action required
26	None	Off	X	X	No power	Status: no action required

HART Variables

The Bedrock Control System uses the HART variables listed in this appendix. HART runtime data is listed in Table H-1. HART configuration data is listed in Table H-2. The HART variable names in the two tables correspond to the description fields displayed in the Bedrock IDE.

Table H-1 HART Runtime Data

HART Variable Name	Size	Type/Range
Loop Current	4 bytes	Float
Primary Value Unit Code	2 bytes	1-255
Primary Value	4 bytes	Float
Secondary Value Unit Code	2 bytes	1-255
Secondary Value	4 bytes	Float
Tertiary Value Unit Code	2 bytes	1-255
Tertiary Value	4 bytes	Float
Quaternary Value Unit Code	2 bytes	1-255
Quaternary Value	4 bytes	Float
Communication Status	1 byte	8 bit field
Device Status	1 byte	8 bit field

The bit definitions for the Comm Status field in Table H-1 are listed in Table H-3. The bit definitions for the Device Status field in Table H-1 are listed in Table H-4.

Table H-2 HART Configuration Data

HART Variable Name	Size	Type/Range
Device Tag	12 bytes	Null terminated character string
Device Descriptor	16 bytes	Null terminated character string
Date	12 bytes	Null terminated character string
Device Message	32 bytes	Null terminated character string
Long Tag	32 bytes	Null terminated character string
PV Upper Range	4 bytes	Float
PV Lower Range	4 bytes	Float
Damping Value	4 bytes	Float
Sensor Serial Number	4 bytes	Integer Number
Device ID	4 bytes	Integer Number
Upper Sensor Limit	4 bytes	Float
Lower Sensor Limit	4 bytes	Float

Table H-2 HART Configuration Data

HART Variable Name	Size	Type/Range
Minimum Span	4 bytes	Float
Private Label Distributor Code	1 byte	Integer Number
Sensor Unit Code	1 byte	1-255
Number of Preambles	1 byte	Integer Number
Range Units	1 byte	1-255
Poll Address	1 byte	Integer Number
Manufacturer ID	1 byte	1-255
Device Type	1 byte	Integer Number
Universal Command Revision	1 byte	Integer Number
Device-specific Command Revision	1 byte	Integer Number
Software Revision	1 byte	Integer Number
Hardware Revision	1 byte	Integer Number

Table H-3 Communication Status Bit Descriptions

Communication Status Bit	Description
Reserved 0	
Buffer Overflow	Message buffer has overflowed
Reserved 1	
Longitudinal Parity Error	Parity error of a serial byte
Frame Error	Message framed incorrectly
Overrun Error	Serial controller chip has overrun buffer
Vertical Parity Error	Parity error of transmitted message
Communications Error	Generic communications failure

Table H-4 Device Status Bit Descriptions

Device Status Bit	Description
Primary Value Out of Limit	PV outside of high or low limit
Non-Primary Value Out of Limit	Other value outside of high or low limit
Loop Current Saturated	Loop current past high limit
Loop Current Fixed	Loop current forced to a fixed value
More Status Available	Extra status bits are available
Cold Start	Device has restarted
Configuration Changed	Configuration has changed
Device Malfunction	Fatal error of device

Certifications and Standards

Certifications

The Bedrock Control System has received certification for the following:

CE Testing

European EMC Directive 2014/30/EU including:

- EN 61326-1 EMC Requirements
- CISPR 11: 2010 Radiated Emissions, AC Mains Conducted Emissions
- IEC 61000-4-2 ESD Immunity
- IEC 61000-4-3 Radiated RF Immunity
- IEC 61000-4-4 Electrical Fast Transient/Burst Immunity
- IEC 61000-4-5 Surge Immunity
- IEC 61000-4-6 Conducted RF Immunity

ATEX Directive Certification

The Bedrock Control System has received certification that the system complies with requirements for the design and construction of products intended for use in potentially explosive atmospheres given in the ATEX Directive (Equipment or Protective Systems intended for use in Potentially Explosive Atmospheres, Directive 2014/34/EU).

See “Hardware Installation” in this document and refer to the *Bedrock Hardware Installation Guide for Hazardous Locations* (BRDOC010_003) for information on installing and operating the equipment in hazardous locations and for information on adhering to requirements of the ATEX directive.

Underwriters Laboratories (UL) Safety Compliance

The Bedrock Control System has received UL approval for use in Class I, Division 2, Groups A, B, C and D, Hazardous Locations, “Bedrock Automation” Series, Model nos. SPM, SCC, BMI.5, BMI.10, BMI.20. See “Hardware Installation” for information on installing and operating the equipment in hazardous locations.

Additionally, the following UL approvals apply to Bedrock Automation SIO modules:

- USL, CNL - Associated nonincendive field wiring outputs to Nonincendive Field Wiring Apparatus and nonincendive field wiring inputs to Associated Nonincendive Field Wiring Apparatus for use in Class I, Division 2, Groups A, B, C and D, Hazardous Locations, Programmable Controllers, “Bedrock Automation” Series, Secure I/O (SIO) Modules, Model nos. SIO1.5, SIOU.10, SIO4.E, and SIOS.5 when installed per Control Document No. BRDOC010_003.

- USL, CNL - Associated nonincendive field wiring outputs to Nonincendive Field Wiring Apparatus for use in Class I, Division 2, Groups A, B, C and D, Hazardous Locations, Programmable Controllers, “Bedrock Automation” Series, Secure I/O (SIO) Modules, Model no. SIO5.10 when installed per Control Document No. BRDOC010_003.
- USL, CNL - Nonincendive field wiring inputs from Associated Nonincendive Field Wiring Apparatus for use in Class I, Division 2, Groups A, B, C and D, Hazardous Locations, Programmable Controllers, “Bedrock Automation” Series, Secure I/O (SIO) Modules, Model nos. SIO2.10, SIO3.10 SIO6.20, and SIO7.20 when installed per Control Document No. BRDOC010_003.

The above approvals are in accordance with the following documents:

- ANSI/ISA-12.12.01-2015, Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III Divisions 1 and 2 Hazardous (Classified) Locations
- CAN/CSA C22.2 NO. 213-15, Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III Divisions 1 and 2 Hazardous (Classified) Locations

The Bedrock Control System has also passed the following UL testing:

- PLC code UL 508 (US) and CSA C22.2 No. 142-M1987 (Canada)

IEC Environmental Testing

The Bedrock Control System meets the following environmental specifications:

- Drop Test - IEC 60068-2-31
- Cold - IEC 60068-2-1
- Dry Heat - IEC 60068-2-2
- Change of Temperature (Non-Operational) - IEC 60068-2-14
- Change of Temperature (Operational) - IEC 60068-2-14
    - Temperature range for testing using a Bedrock SPM DC Power Cable was -30°C to 80°C

    - Temperature range for testing using a Bedrock SPM AC Power Cable was -30°C to 60°C
    - Temperature range specified above extended the range of the IEC standard
- Relative Humidity - IEC 60068-2-30
- Vibration (sinusoidal) - IEC 60068-2-6
- Shock (Operating) - IEC 60068-2-27
- Shock (Non-Operating) - IEC 60068-2-27

EIA Publication 364

The Bedrock Universal Cable was tested in accordance with the following test procedures described in EIA Publication 364.

- EIA-364-23C, Low Level Circuit Resistance for Electrical Connectors and Sockets
- EIA-364-91, Dust Test Procedure for Electrical Connectors and Sockets
- EIA-364-27C, Mechanical Shock (Specified Pulse) Test Procedure of Electrical Connectors and Sockets
- EIA-364-28A, Vibration Test Procedure for Electrical Connectors and Sockets
- EIA-364-21D, Insulation Resistance Test Procedure for Electrical Connectors, Sockets, and Coaxial Contacts
- EIA-364-20D, Withstanding Voltage Test Procedure for Electrical Connectors, Sockets and Coaxial Contacts
- EIA-364-32E, Thermal Shock (Temperature Cycling) Test Procedure for Electrical Connectors and Sockets
- EIA-364-31C, Humidity Test Procedure for Electrical Connectors and Sockets
- EIA-364-17B, Temperature Life with or without Electrical Load Test Procedure For Electrical Connectors and Sockets
- EIA-364-41E, Cable Flexing Test Procedure for Electrical Connectors

- EIA-364-38C, Cable Pull-Out Test Procedure for Electrical Connectors

FCC Testing

The Bedrock Control System has passed testing that demonstrates compliance with the following Federal Communications Commission (FCC) standard:

- Code of Federal Regulation (CFR) FCC Part 15 Subpart B, Class A (2016) (Radiated Emissions and AC Mains Conducted Emissions)

EMP Testing

The Bedrock Control System has passed testing that demonstrates that the system is able to withstand transient electromagnetic fields under the following requirement:

- MIL-STD-461G, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment — Requirement RS105, Radiated Susceptibility, Transient Electromagnetic Field.

Standards

The Bedrock Control System adheres to the following:

IEC 61131

IEC 61131 is an open standard developed by the International Electrotechnical Commission (IEC) standard. It applies to programmable logic controllers (PLCs). The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

IEC-61131-3 specifies the syntax and semantics of a unified suite of programming languages for programmable controllers. The suite consists of the following:

- textual languages
    - Instruction List (IL)
    - Structured Text (ST)
- graphical languages
    - Ladder Diagram (LD)
    - Sequential Function Chart (SFC)
    - Continuous Function Chart (CFC) (extension to IEC-61131-3)

In addition, features are defined which facilitate communication among programmable controllers and other components of automated systems.

Acronyms

Table J-1 contains a list of acronyms and symbols used in this document.

Table J-1 Table of Acronyms and Symbols

Acronym / Symbol	Meaning
Ω	Ohms
AC	Alternating Current
ADC	Analog to Digital Converter
AWG	American Wire Gauge
BMI	Backplane Magnetic Interconnect
CFC	Continuous Function Chart
CFR	Code of Federal Regulation
CJC	Cold Junction Compensation
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
Cu	Copper
DC	Direct Current
DCS	Distributed Control System
DDR2	Double Data Rate 2
DDR3	Double Data Rate Type 3 (used with SDRAM)
DHCP	Dynamic Host Configuration Protocol
DTM	Device Type Manager
ECC	Error Correction Code
EMC	Electromagnetic Compatibility
FCC	Federal Communications Commission
FDT	Field Device Tool
FIPS	Federal Information Processing Standard
GB	Gigabyte
Gbit	Gigabit
GHz	Gigahertz
HART	Highway Addressable Remote Transducer Protocol
HMI	Human Machine Interface
IDE	Integrated Development Environment
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IL	Instruction List
IP	Internet Protocol
ISA	International Society of Automation
ISO	International Organization for Standardization

Table J-1 Table of Acronyms and Symbols

Acronym / Symbol	Meaning
kHz	Kilohertz
LD	Ladder Diagram
LED	Light-emitting Diode
LSB	Least Significant Bit
LVLC	Low Voltage, Limited Current
Mbps	Megabits Per Second
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
MDI	Media Dependent Interface
MUX	Multiplexer
mA	Milliamps
mAh	Milliamp Hour
MB	Megabyte
MDIO	Management Data Input/Output
mH	Millihenry
MHz	Megahertz
MRAM	Magnetoresistive Random Access Memory
ms	Millisecond
MSB	Most Significant Bit
MT/s	MegaTransfers per second
mV	Millivolts
NIC	Network Interface Card
NIST	National Institute of Standards and Technology
ODBC	Open Database Connectivity
OPC UA	OPC Unified Architecture
PC	Programmable Controller
PLC	Programmable Logic Controller
PoE	Power Over Ethernet
POU	Program Organization Unit
ppm	Parts per Million
PSE	Power Sourcing Equipment
PWM	Pulse Width Modulation
RAM	Random Access Memory
RGMII	Reduced Gigabit Media-independent Interface
RIUP	Removal and Insertion Under Power
rms	Root Mean Square
RTD	Resistance Temperature Detector
RTOS	Real-Time Operating System
SCADA	Supervisory Control and Data Acquisition
SCC	Secure Control and Communication
SCS	Secure Controller Single

Table J-1 Table of Acronyms and Symbols

Acronym / Symbol	Meaning
SDRAM	Synchronous Dynamic Random Access Memory
SFC	Sequential Function Chart
SFP	Small Form-factor Pluggable
SIO	Secure Input/Output
SMF	Single Mode Fiber
SOE	Sequence of Events
SPM.24	Secure Power Module - 24 V DC Input
SPM.U	Secure Power Module - Universal Input
SPS	Secure Power Supply
ST	Structured Text
SUDs	Startup Diagnostics
TCP	Transmission Control Protocol
TLS	Transport Layer Security
µA	Microamp
UL	Underwriters Laboratory
ULC	Underwriters Laboratory of Canada
UPS	Uninterruptible Power Supply
µV	Microvolt
XOR	Exclusive OR operation
XML	Extensible Mark-up Language