



Multiloop and Multifunction Safety
Logic Solver and Alarm



SLA

User's Manual

All product names are registered trademarks of their respective companies.



Demand MOORE Reliability

Customer Support

Moore Industries is recognized as the industry leader in delivering top quality to its customers in products and services. We perform a sequence of stringent quality assurance checks on every unit we ship. If any Moore Industries product fails to perform up to rated specifications, call us for help. Our highly skilled staff of trained technicians and engineers pride themselves on their ability to provide timely, accurate, and practical answers to your process instrumentation questions. Our headquarters and other facilities phone numbers are listed below.

There are several pieces of information that can be gathered before you call the factory that will help our staff get the answers you need in the shortest time possible. For fastest service, gather the complete model and serial number(s) of the problem unit(s) and the job number of the original sale.

Locations

World Headquarters

16650 Schoenborn Street
North Hills, California
91343-6196, U.S.A.
Tel: (818) 894-7111
Fax: (818) 891-2816
E-mail: info@miinet.com
TOLL FREE: 1-800-999-2900
www.miinet.com

Europe

1 Lloyds Court, Manor Royal,
Crawley
W. Sussex RH10-9QU
United Kingdom
Tel: 01293 514488
Fax: 01293 387752
FREE PHONE: 0800 525107
sales@mooreind.com
www.miinet.com/uk

Australia

Sydney, NSW
3/1 Resolution Drive
Caringbah, New South Wales
2229
Australia
Tel: (02) 8536-7200
Fax: (02) 9525-7296
sales@mooreind.com.au
www.miinet.com/au

China

Room 102, No. 101,
Lane 1058,
Xinzhen Street, Xinqiao Town
Songjiang District,
Shanghai, 201612, P. R. China
Tel: 86-21 62491499
Fax: 86-21 62490635
E-mail: sales@mooreind.sh.cn
www.miinet.com

Benelux

Kontichsesteenweg 38A A01
2630 Aartselaar
Belgium
Tel: 03/448.10.18
Fax: 03/440.17.97
info@mooreind.be
www.miinet.com/dbe

Perth, WA
TOLL FREE: 1-800-784-899
sales@mooreind.com.au
www.miinet.com/au



www.miinet.com

Safety Messages

Please read this manual in its entirety. It should answer most of your questions. For personal and system safety, and for optimum product performance, make sure you thoroughly understand the contents before installing, using, or maintaining this product. Should you still have questions please visit our website at www.miinet.com or contact any of our sales/ support offices nearest you.

Your safety and the safety of others is very important. We have provided many important safety messages in this manual. Please read these messages carefully. These safety messages alert you to potential hazards that could hurt you or others or render damage to units.

All Moore Industries instrumentation should only be used for the purpose and in the manner described in this manual. If you use this product in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.

Each safety message is associated with a safety alert symbol. These symbols are found in and throughout the manual. The definition of these symbols is described below:

Pay particular attention wherever you see the following symbols:



Note – Information that is helpful for a procedure, condition or operation of the unit.



Caution – Hazardous procedure or condition that could damage or destroy the unit.



Warning – Hazardous procedure or condition that could injure the operator.

Qualified Personnel

The Moore Industries product/systems described in this manual may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these Moore Industries products/systems.

Proper use of Moore Industries products

Moore Industries products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Moore Industries. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

We have reviewed the contents of this publication to ensure consistency with the hardware and/or software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions. Specifications and information are subject to change without notice.

All product and company names are trademarks™ or registered® trademarks of their respective holders. Use of them does not imply any affiliation with or endorsement by them unless otherwise specified.

Table of Contents

1	SLA Quick Start Guide	10
1.1	Factory Default User Configuration for SLA.....	10
2	SLA Introduction.....	13
2.1	Overview	13
2.2	Features.....	15
2.3	Model Numbers and Options.....	16
2.4	SLA Inputs.....	16
2.5	SLA Outputs.....	17
2.6	SLA Power	17
2.7	SLA Options.....	17
2.8	SLA Housing	17
2.9	Alarms, Faults and Failsafe Terminology.....	18
3	SLA Calibration and Bench Check.....	24
3.1	Calibration	24
3.2	Setting the Configuration Jumper	25
3.3	Bench Check.....	25
3.4	Front Panel Display and LEDs.....	27
4	SLA Wiring and Installation.....	28
4.1	Network and Cyber Security Best Practices	28
4.2	Input Channel Selection	29
4.3	Terminal Designations.....	30
4.4	Dimensions	34
4.5	Installation	35
4.6	Mounting	35
4.7	Electrical Safety Information.....	35
4.8	User Configurable Hardware	38
4.8.1	Configuration Jumpers	38
4.8.2	Security Jumpers.....	40
4.8.3	Fault Relay Jumper	41
5	SLA Configuration Overview.....	42
5.1	SLA Configuration Introduction.....	42
5.1.1	Basic Setup.....	43
5.1.2	Advanced Setup.....	46
5.1.3	Floating Point Representation	49

Safety Logic Alarm

5.1.4	Roundoff Error Example.....	49
5.1.5	Mathematical Behavior.....	50
5.1.6	Internal Variable Equation/Expression Editor and References.....	50
5.2	Configuration Software Setup (FDT/DTM).....	61
5.2.1	FDT Frame Application.....	61
5.2.2	FDT/DTM Software Installation.....	62
5.2.3	Installing PACTware from Moore Industries.....	62
5.2.4	Moore Industries SLA Device DTM Installation.....	63
5.3	SLA IP Address and Network Configuration.....	63
5.3.1	Fixed Network Settings or DHCP.....	64
5.3.2	Locating SLA and Network Settings.....	64
5.3.3	Changing SLA Network Settings.....	65
5.4	User Configuration with DTM.....	66
5.4.1	Adding SLA Device.....	68
5.4.2	Displaying and Uploading the SLA Configuration.....	69
5.4.3	Downloading the Configuration to the SLA (DTM).....	71
5.4.4	Saving the Configuration File to a Location.....	71
5.4.5	Disconnecting the SLA.....	72
5.4.6	Offline Configuration.....	72
6	SLA Configuration – Basic DTM Settings.....	73
6.1	Parameter Menu Configuration.....	73
6.2	Configuration Summary Screen.....	74
6.3	Analog Input Channels.....	74
6.3.1	Analog Input Channels: AI Channels.....	75
6.3.2	Analog Input Configuration.....	75
6.4	Alarms.....	79
6.4.1	Alarms: Process Alarms.....	79
6.4.2	Alarm Configuration for All Alarms.....	79
6.4.3	Alarm Configuration for Trip Alarms.....	81
6.4.4	Alarm Configuration for Band Alarms.....	82
6.4.5	Alarm Configuration for Rate of Change Alarms.....	83
6.4.6	Alarm Configuration for Stuck Input Alarms.....	84
6.4.7	Alarm Configuration for Discrete Alarms.....	85
6.5	Relay Outputs.....	86

Safety Logic Alarm

6.5.1	Relay Output Configuration	87
6.6	Discrete I/O	89
6.6.1	Discrete I/O Configuration	90
6.6.2	Discrete Output Diagnostics	93
6.7	Analog Outputs	95
6.7.1	Analog Output Configuration	96
6.8	SLA System Settings.....	98
6.8.1	General Settings	99
6.8.2	Network Security Settings	101
6.8.3	Enabling and Disabling the Web server.....	102
6.8.4	MODBUS Settings.....	103
6.8.5	Display Settings	105
6.9	Event Logger Settings	106
6.9.1	Event Logger Settings Example, Alarm Settings	110
6.9.2	Event Logger Settings Example, Relay Output Settings	111
6.9.3	Discrete Input/Output Event Logger Settings.....	112
6.9.4	Analog Output Event Logger Settings.....	112
6.10	Event Logger Settings (Advanced)	113
7	SLA Configuration – Advanced DTM Settings	114
7.1	Alarms (Advanced).....	114
7.1.1	Trips.....	114
7.1.2	Band.....	115
7.1.3	Rate of Change & Stuck Input	115
7.2	Internal Variables/Functions (Advanced)	115
7.2.1	Internal Variables/Functions (Advanced), Equation Editor	115
7.2.2	Internal Variables/Functions (Advanced), Timer Function.....	118
7.2.3	Internal Variables/Functions (Advanced), Running Min/Max Function	120
7.2.4	Internal Variables/Functions (Advanced), Custom Curve.....	122
7.3	SLA Additional Functions	124
7.3.1	Event Log Save and Clear.....	124
7.3.2	Menu for Importing and Exporting Custom Curve Settings	124
7.3.3	Setting the Time and Date.....	130
7.4	SLA Online Simulation.....	130
8	SLA Web Server and Web Pages.....	134

Safety Logic Alarm

8.1	Home: System Information Web Page.....	135
8.2	Process Data Web Page	136
8.3	System Status Web Page.....	137
8.4	Configuration Web Page	138
8.5	MODBUS Registers Web Page.....	140
8.6	Event Log.....	141
9	SLA Operation and Maintenance.....	142
9.1	Operation	142
9.2	Firewall Configuration.....	142
9.3	SLA Front Panel.....	143
9.4	Status LEDs	144
9.5	SLA Diagnostic and Fault Alarms	144
9.6	Diagnostic Messages	146
9.6.1	Overall System Status.....	146
9.6.2	Safety Section Summary	146
9.6.3	Network Section Summary	150
9.6.4	Input Fault Summary	151
9.6.5	Input Warning Summary.....	152
9.6.6	Analog Input Status	153
9.6.7	Failover Sensor Status	154
9.6.8	Discrete Input/Output Status	155
9.6.9	Alarm Status.....	157
9.6.10	Relay Status.....	158
9.6.11	Analog Output Status	160
9.6.12	Expression Status	161
9.6.13	Timer Status.....	163
9.6.14	Running Min/Max Status	164
9.7	Maintenance.....	165
9.7.1	Repair and Replacement.....	165
9.7.2	Recording and Reporting of SLA Performance.....	165
10	SLA MODBUS Interface Specification	166
10.1	Overview	166
10.2	Supported Function Codes.....	166
10.3	MODBUS Configuration Settings.....	167
10.3.1	Floating Point Word Order Setting.....	167

Safety Logic Alarm

10.3.2	Number of Decimal Places Setting	168
10.3.3	Fixed Location Registers	170
10.3.4	Data Path Registers	172
10.3.5	System Status Registers	173
10.3.6	System Information Registers	174
10.3.7	Coils	174
11	SLA in Safety Instrumented System	175
11.1	Functional Safety Description	175
11.2	Failure Rate Data	175
11.3	Product Life	175
11.4	Process Safety Time	176
11.5	Configuration	176
11.5.1	High Integrity vs High Availability	176
11.5.2	Analog Inputs	176
11.5.3	Alarms	177
11.5.4	Relay Outputs	177
11.5.5	Discrete Outputs	178
11.5.6	Analog Outputs	178
11.6	Common Features	178
11.7	Simulation	179
11.8	Proof Test	180
11.8.1	Equipment Required	181
11.8.2	Proof Test Procedure	181
11.9	Applying the SLA FMEDA Data – Application Scenarios	182
11.9.1	Application 1	184
11.9.3	Application 2	185
11.9.5	Application 3	186
11.9.6	Application 4	187
11.9.8	Application 5	188
11.9.10	Application 6	189
12	SLA Application Examples	190
12.1	HIPPS (High Integrity Pressure Protection System) 2oo3 Voting Shutdown System	190
12.2	High Temperature and Flow Safety Instrumented Function	192
12.3	Temperature Alarm Safety Instrumented Function	194

Safety Logic Alarm

12.4	High Resolution Flow Calculator and Safety Alarm.....	196
13	SLA Specifications	198
14	SLA Ordering Information	201
14.1.1	Accessories.....	201
14.1.2	Certifications	201
15	SLA Warranty Disclaimer	202

1 SLA Quick Start Guide

The SIL 2/3 capable SLA Multiloop and Multifunction Safety Logic Solver and Alarm is ready to install and is set up either with your specified configuration or the default configuration.

After programming your SLA, install the unit into your application using the connection diagrams and terminal designation tables located in this manual.

If you are using the SLA in a Safety Instrumented System (SIS), then you must read and follow **Section 11** in this user's manual.

1.1 Factory Default User Configuration for SLA

The Device Type Manager (DTM) default (when no unit is connected) assumes all options are fitted (-3AO, -MB485), Relay 4 is set (jumper configurable – see section 4.8.3) to its default position as a Fault Relay, and all Analog Input channels are set to HLPRG (mA/V) type inputs.

The SLA is shipped from the factory with the following jumper/switch settings:

- Security jumpers
 - Network configuration = Read / Write
 - User configuration = Read / Write
 - Fault Relay Jumper = Use R4 as fault relay
- Analog Input Switches (Channels 1-3)
 - HLPRG (mA/V)

The following defaults will be set (dependent on unit options, jumpers and switches):

- Analog Inputs AI1A, AI1B, AI2A, AI2B, AI3A, AI3B
 - Enabled
 - Failover = Disabled
 - Broken Wire = Enabled, Hold off=0 seconds
 - Running Average Filter = 1
 - Input OOR limit = 2% of input span
 - Scaling = Off
 - Trim Mode = Factory Trim
 - Input Faults Latch = Disabled, Reset Source = None
 - Input Warnings Latch = Disabled, Reset Source = None
 - HLPRG (mA/V)
 - Current Mode = 0-25mA
 - Input range: URV = 20mA LRV = 4mA
 - Broken Wire level = 3.6mA
 - TPRG (Temperature, ohm, mV)
 - 4Wire RTD Pt3850-100Ω
 - Input range: URV = 100C, LRV = 0C
 - Temperature units: deg C
- Process Alarms ALM1-16
 - Disabled
 - High Availability
 - All sources = Not Used; All Constants = 0
 - Delay and Additional Startup Delay = 0 seconds
 - Latch = Disabled, Reset Source = None
 - Suppress Source = Unused (Disabled)
 - Alarm Type defaults
 - Trip Mode = High trip
 - Rate of Change Mode = Rise and Fall
 - Discrete = Voting 0 of 0
- Relay Outputs RO1, RO2, RO3, RO4
 - Relay Mode = Failsafe
 - Voting = 0 out of 0
 - System Warnings = None

Safety Logic Alarm

- Input Faults and Warnings = None
- Delay and Additional Startup Delay = 0 seconds
- Latch = Disabled, Reset Source = None
- Suppress Source = Unused (Disabled)

- RO1, RO2, RO3, RO4 Process Relays
 - Disabled
 - System Faults = None

- RO4 Process/Fault Relay (Jumpered as Fault Relay)
 - Enabled (non-configurable)
 - System Faults = Selected (non-configurable)

- Discrete Input/Outputs DIO1, DIO2, DIO3, DIO4
 - DI - Enabled on all four channels
 - DI Mode = Non-Failsafe
 - Debounce delay = 5mS
 - DO – Disabled on all four channels
 - DO Mode = Failsafe
 - Voting = 0 out of 0
 - System and Input Faults and Warnings = None
 - Delay and Additional Startup Delay = 0 seconds
 - Latch = Disabled, Reset Source = Unused
 - Suppress Source = Unused (Disabled)
 - Diagnostic=Enabled; Diagnostic pulse width = 500 microseconds

- Analog Outputs (-AO3 Option) AO1, AO2, AO3
 - AO Source: AO1 = AI1A, AO2 = AI2A, AO3 = AI3A
 - For HLPRG Source: Zero = 4mA and Full = 20mA For TPRG Source Zero = 0C and Full = 100C
 - AO Zero = 4mA and Full = 20mA
 - Damp time = 0 seconds
 - Fail Mode = Low
 - Fail on System Fault = Disabled
 - Initial Value = 0.0mA
 - Trimming = Off

- Internal Variables/ Functions (Advanced)
 - Internal Variables IV1-16
 - Type = Not Used (Disabled)
 - All Fields = 0

 - TIMER1-8
 - Duration = Blank (disabled)
 - All sources = Not Used
 - Pause/Reset Mode = Reset
 - Reset Detection Mode = Rising edge
 - Timer Output = TRUE when expired

 - Running Min/Max RMM1-8
 - Capture Mode: Not Used (Disabled)
 - Availability/Integrity Mode = High Availability
 - All sources: Not Used
 - Initial/Reset Value = 0

 - Custom Curve CCURVE1-4
 - CC Points: 2
 - Curve Data: First two points are: (0,0), (100,100), the rest are (0,0)

Safety Logic Alarm

- MODBUS
 - Floating Point Word Order = Standard LSW
 - Number of Decimal Points = 0
 - MODBUS Fail Mode = NaN (Not a Number)

- MODBUS RTU (–MB485 Option)
 - Slave Address = 1
 - Baud Rate = 9600
 - Parity = No Parity
 - Character Timeout = 1.5
 - Response Delay = 0

- System Settings
 - Startup Delay = 0 seconds
 - System Fault Latch = Enabled (non-configurable), Reset Source = None
 - System Warning Latch = Disabled, Reset Source = None
 - Simulation mode = OFF, Timeout = 15 minutes
 - Time and Date = default date and time
 - Logger = Disabled

- Display Settings
 - Display Auto Scroll = Disabled
 - Custom Display = Disabled

- Network Settings
 - Network address DHCP = ON
 - Name = SLA
 - Location = TBD
 - MODBUS/TCP connections = 4
 - Web Server Settings = Enabled

2 SLA Introduction

This is the user's manual for the Moore Industries Functional Safety SLA Multiloop and Multifunction Safety Logic Solver and Alarm.

The Moore Industries SLA Safety Logic Solver and Alarm is designed and manufactured to provide a high level of availability for safety critical applications and for use as a component part of a Safety Instrumented System.

This manual contains information needed to install, configure, operate and maintain this product. When the SLA is used in a SIL rated safety application (as defined by IEC 61508), Section **11 SLA in Safety Instrumented System** of this manual must be read and followed in order for the SLA to meet its IEC 61508 certification requirements.

2.1 Overview

The Moore Industries SLA is a versatile multiloop and multifunction Safety Logic Solver and Alarm that acts on hazardous process conditions; warns of unwanted process parameters; provides emergency shutdown; or provides on/off control in Safety Instrumented Systems (SIS) and traditional alarm trip applications.

The Field Device Tool/Device Type Manager (FDT/DTM) programmable 4-wire (line/mains-powered) SLA accepts up to four discrete and six analog inputs from a wide array of devices and sensors including:

- Current and Voltage Signals
- Temperature (RTD and T/C) Sensor Inputs
- Resistance and Potentiometer Devices
- Direct Millivolt Sources
- Low Voltage Contacts

The SLA has four relay outputs and up to four discrete contact closure outputs that can be driven by any of the programmable 16 internal alarms. Individual or multiple alarms can be assigned to each relay or discrete output. Relay and discrete outputs can also be triggered by any input or internal diagnostic fault.

Safety Logic Alarm

Advanced features include arithmetic and logical equations, timers, running min/max functions and custom curves. Also included is an event logger which can be configured for each variable (inputs, alarms, outputs, timers, etc.) to capture either summary or detailed information.

Three optional analog outputs allow retransmission of any input, internally calculated equation, or variable.

The SLA is designed to separate the core process functionality (safety related functions) from the user and data communication (non-safety related functions). Once the unit is configured, a hardware jumper can be set to stop write access (a data diode) to the safety related functions. This prevents any communications from users or other computers (e.g. reconfiguration, simulation, and cyber-attacks).

Safety Related Operations and Functions	Non-Safety Related Operations and Functions
<ul style="list-style-type: none">- Analog Inputs- Discrete Inputs/Outputs- Relay Outputs- Analog Outputs- Internal processing of input and outputs- Internal equations or advanced functions	<ul style="list-style-type: none">- Display- LEDs- MODBUS/TCP- Web Server (HTML Pages)- MODBUS RTU- DTM Programming- Event Logger

2.2 Features

The Moore Industries SLA device offers the following features:

- *exida* certified IEC 61508:2010. For systematic integrity up to SIL 3 and for random integrity up to SIL 2. This means that an SLA is approved for single use in a SIS up to SIL 2 and in redundant architectures (1oo2, 2oo3, etc.) up to SIL 3.
- FDT/DTM Programmable. No custom or licensed software required. The SLA is programmed with any FDT compliant host. The SLA's DTM even includes full monitoring and simulation capabilities that allow you to test your alarming or safety function before commissioning (this does not replace a proof-test that is required for safety instrumented systems).
- Dynamic Alarming Capability. With up to 16 alarms and eight physical alarm outputs, simple and complex alarming strategies can be implemented with easy-to-use drop-down menus, radio buttons, and checkboxes. Even complex alarm voting architectures like 1oo2, 2oo3, 3oo5 are simple to employ.
- Secure Programming and Communication. The SLA includes Configuration Security Jumpers that can be set to prevent unauthorized reprogramming and ensure read-only communication through the Ethernet and MODBUS ports.
- Intuitive Equation Editor for Math and Logic Functions. No PLC programmers are required. With the SLA's powerful but easy-to-use equation editor you can create monitoring, alarming, and control schemes that involve simple to complex equations using timers, running min/max functions, prebuilt analog and discrete logic functions and more.
- HART Pass-through Capable. The SLA allows HART communication from connected field devices to pass-through to the SLA's analog outputs, allowing HART enabled hosts or asset managers full communication, monitoring or programming capabilities.
- Digital Communications. The SLA supports MODBUS/TCP and MODBUS RTU industrial protocols. An embedded read-only web server allows all inputs, outputs, internal variables and various other parameters to be read with a simple web browser.
- Embedded Event Logger. An on-board event logger can be configured to record SLA inputs, outputs, alarms, events and more. The data log file can then be exported to a CSV file for analysis and archiving.

2.3 Model Numbers and Options

The following section provides details of the Moore Industries model number and the available options for the SLA.

Moore Industries uses the model and serial numbers of our instruments to track information regarding each unit that we sell and service. If a problem occurs with your instrument, check for a tag affixed to the unit listing these numbers. Supply the Customer Support representative with this information when contacting.

An example of a Moore Industries model number for the SLA is structured as follows:

Unit / Input / Output / Power / -Options [Housing]
SLA / 6PRG / 4PRG / 10-30DC / -3AO-MB485 [DIN]

Refer to **Section 14 SLA Ordering Information** for a quick reference table of ordering information.

2.4 SLA Inputs

6PRG

There are three dual input channels, for a total of six analog inputs, that are configured via input switches for either High Level – HLPRG (Current or Voltage) or Low Level - TPRG (RTD, T/C, Ohms or mV) type inputs. Both inputs on each channel must be configured similarly. For example, channel one that includes AI1A and AI1B must both be configured as High Level or Low Level type inputs.

Each input programs to accept:

<u>Current:</u>	Any range between 0-25mA including: 0-20mA, 4-20mA, 20-4mA, etc.
<u>Voltage:</u>	Any range between 0-10Vdc including: 0-5Vdc, 1-5Vdc, 0-10Vdc, etc.
<u>RTD:</u>	2-, 3- and 4-wire; platinum, copper, and nickel
<u>Thermocouple:</u>	J, K, E, T, R, S, N, C, B
<u>Ohms:</u>	0-4000 ohms (Potentiometer, 4000 Ohms max.)
<u>Millivolts:</u>	-50 to +1000mV

The SLA includes as standard four programmable discrete channels where each can be configured as an input or output.

Safety Logic Alarm

2.5 SLA Outputs

4PRG

The SLA includes four relay outputs as standard. Each relay is a single-pole/double-throw; SPDT, 1 form C, rated 3A@250Vac or 3A@30Vdc, 50/60Hz, non-inductive.

The SLA includes as standard four programmable discrete channels where each can be configured as an input or output.

2.6 SLA Power

10 - 30DC

The SLA is a 4-wire (line/mains powered) device that accepts 10-30DC operating power making it suitable for remote locations where power is limited.

2.7 SLA Options

-3AO

Three analog outputs (isolated and linearized) are scalable for any range between 0-21.6mA into 600 ohms (current outputs are user-wired for internally sourced or externally powered, sink) with HART pass-through capability.

-MB485

MODBUS RTU (RS-485) serial data port.

2.8 SLA Housing

[DIN]

DIN-style housing mounts on 35mm (EN50022) Top Hat DIN-rails.

[FLB]

Flange bracket provides a secure mount for high vibration applications.

2.9 Alarms, Faults and Failsafe Terminology

Before setting up the SLA, or incorporating the unit in your application, Moore Industries suggests that all users take a few moments to become familiar with some of the terms associated with the use of process instrumentation alarms, faults, relays and discrete I/O.

High Availability vs. High Integrity— All alarms with analog inputs can behave differently if the input goes bad (e.g. broken wire, out of range etc.) In “High Availability” mode, the alarm maintains its current state with a bad input (avoiding spurious trips). In “High Integrity” mode, the alarm will be set if it has a bad input. These settings allow flexibility in dealing with bad inputs in different voting scenarios.

Trip Point – The trip point is the process input level at which the user wants an alarm to change state, typically going into an alarm condition, or *tripping*. In the SLA, the user sets the trip point for each alarm and then assigns each alarm (or multiple alarms) to a relay or discrete output.

Delay - A delay can be set to avoid false trips. The unit must be in an alarm condition for the delay time before an alarm is set.



Note: Delays can also be applied to both alarms and relay/discrete outputs independently.

Reset Point – The Reset Point is the process input level at which the user wants an alarm relay to change state, typically going from alarm to non-alarm. The reset point is not necessarily the same as the trip point, because most applications call for a buffer zone or deadband around the trip point to allow for minute fluctuations in the process input. In the SLA, the reset point is determined by the deadband setting.

Deadband – The deadband is the range in which an alarm remains tripped even after the process input has returned to or passed the trip point. Deadband is not required. When it is not used the trip point and reset point are the same.

Latching and Non-latching – Once tripped, a latching alarm remains in an alarm state until the input returns to a non-alarm level AND is reset. Non-latching alarms return to a non-alarm state whenever the process input returns to the Reset Point.

Suppress –Alarms can be overridden using a suppress signal. The alarm will be held in a non-alarm state while the suppress signal is active. Once the active suppress signal is removed the alarm will become active based on trip and delay settings. However, if the alarm was latched prior to the suppress signal, it will remain latched once the suppression is removed until the latch is reset.



Warning: Using suppression on alarms is **NOT** recommended for safety functions. Use startup delay instead to suppress alarms during system initialization.

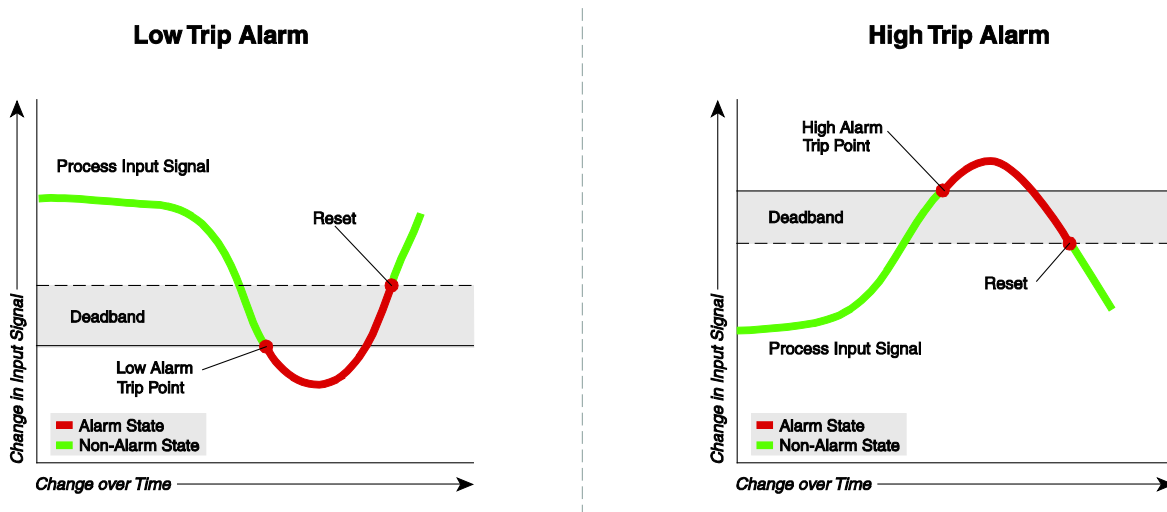
Safety Logic Alarm

The SLA has five different types of alarms which are explained in more detail below:

- Trip
- Band
- Rate of Change
- Stuck Input
- Discrete

Trip Alarm – Can be a high or low alarm. High Alarms trip when the process input goes above the trip point. Low Alarms trip when the process input drops below the reset point.

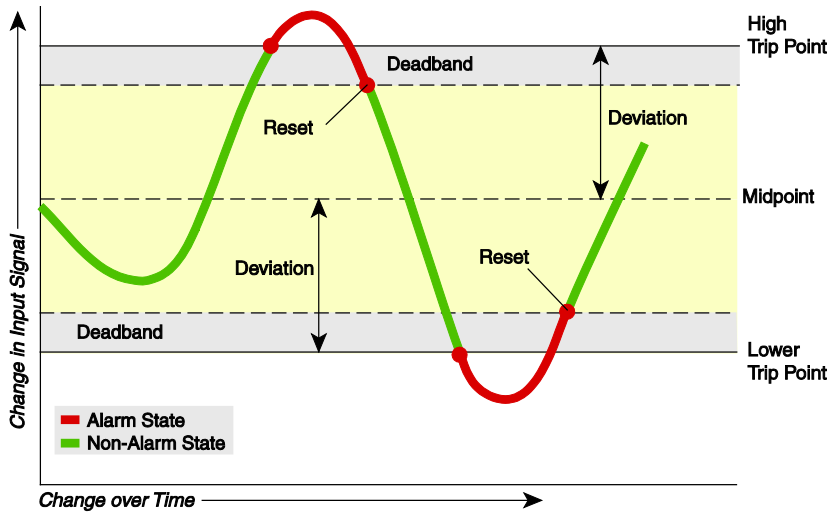
Figure 2.1 Trip Alarm with Reset Point and Deadband Setting



Safety Logic Alarm

Band Alarm - The Band Alarm is a high and low trip alarm combined. It can be set using low and high trip points. Deadband can also be set for this alarm type.

Figure 2.2 Band Alarms Example



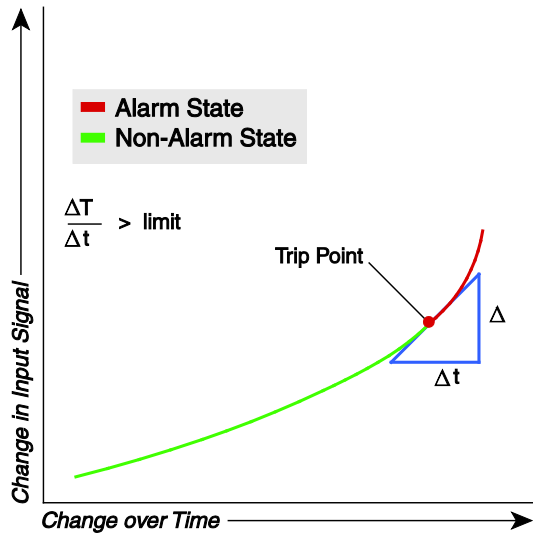
Rate-of-Change and Stuck Input Alarms - are used to detect changes or lack of changes in the measured value in units per second.

Rate-of-Change Alarm monitors an input for a change in value with respect to time (**Figure 2.3** below). The alarm is set to trip when the input rate-of-change exceeds a user-selected amount (Delta) over a user-selected time period (Delta Time). This can be set to detect:

- Rise alarm if the input is rising too fast
- Fall alarm if the input is falling too fast
- Rise and fall alarm if the input rises or falls too fast

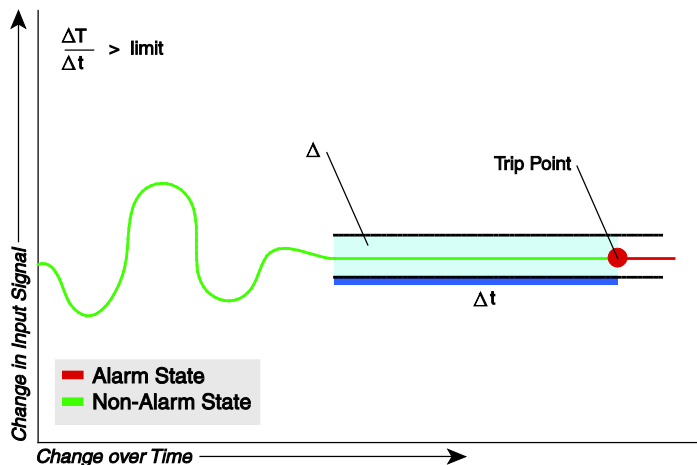
Safety Logic Alarm

Figure 2.3 Rate-of-Change Alarm Trip



A Stuck Input Alarm also monitors an input for a change in value with respect to time (Figure 2.4 below). The alarm is set to trip when the input does not change by a user-selected amount (Delta) over a user-selected time period (Delta Time). To set the correct value for delta and delta time, you need to understand the expected process variations to avoid false trips and the input signal noise and averaging filter settings to prevent missing stuck inputs.

Figure 2.4 Stuck Input Alarm Trip



Safety Logic Alarm

Discrete Alarms- These alarms are different from the other alarm types. They allow up to eight discrete variables that may consist of Alarms, Discrete Inputs/Outputs, Relay Outputs, Timers, Equations (referred to as Internal Variables or “IV”s), faults and warnings to be combined in a XooY voting configuration. It has similar functionality to Relay Outputs (RO) and Discrete Outputs (DIO) but allows more variable types to be used as voting sources (DIO, RO, Timers, Equations (IV)) in addition to Alarms, Faults and Warnings.

These alarms can also be delayed, latched and suppressed in the same way as other alarms.

Faults and Warnings

System Faults and Warnings are generated by internal diagnostics within the SLA. Diagnostic events are categorized as Faults if they occur in active processes. Other diagnostic events are categorized as warnings. These include online simulation and network security events.

Input Faults and Warnings are generated by the SLA which is performing continuous sensor diagnostics on each of the six analog inputs. Input Faults detected are:

- **Input/Sensor Failure** is set when there is a broken wire on a sensor or a High Level (mA/V) input falls below a set threshold.
- **Out of Range** is set when the input signal goes outside a % (0-5%) of the user specified input range.
- **Input Saturation** is set when the input signal exceeds 110% of sensor conformance range.

The above faults will be classified as Input Warnings on any input where failover is enabled and only one sensor (a or b) has a failure.

Failsafe and Non-Failsafe

Failsafe Inputs and Outputs (DIO, RO) are **tripped** or **active** when power to the SLA is off.

In Failsafe Mode:

- **Discrete Inputs** – An open input is active and a closed input is inactive
- **Discrete Outputs** – An active output is open and an inactive output is closed
- **Relay Outputs** - De-energized when tripped (active) and energized when not tripped (inactive)

In Non-Failsafe Mode:

- **Discrete Inputs** – A closed input is active and an open input is inactive
- **Discrete Outputs** – An active output is closed and an inactive output is open
- **Relay Outputs** - Energized when tripped (active) and de-energized when not tripped (inactive)

Relay Contacts: Normal is the term used to describe the **shelf-state** of relay contacts. The contacts of a **Normally Open** relay are open (infinite resistance) when the relay is not energized. The contacts of a **Normally Closed** relay are closed when the relay is not energized.

Safety Logic Alarm



Note: Sometimes a non-alarm input level is referred to as being in a **normal** condition. This practice is intentionally avoided in this manual. Do not confuse the term **normal**, as in Normally Open or Normally Closed, with a non-alarm input condition. In this manual, **normal** is an exclusive reference to the shelf state or quiescent state of a relay's contacts, whether open or closed.

3 SLA Calibration and Bench Check

3.1 Calibration

Every SLA is calibrated to our specifications prior to shipment. We recommend that you check the calibration every year and re-calibrate only when necessary. Please also review **Table 44** Long-Term Stability in this manual. Calibration by the end user can be performed in the field by capturing or trimming the input and/or trimming the analog output. Input trimming increases the measurement accuracy of your instrument by matching the reading of its actual input to its scaling.

Likewise, output trimming (for optional -3AO analog outputs) increases the measurement accuracy of the SLA by calibrating its Analog Output(s) to the device that is receiving the output (such as a BPCS or PLC). This ensures that the output of the SLA is being correctly interpreted.



Warning: To perform trimming, the SLA must have the user configuration jumper in the read/write position.

For instructions on the installation and setup of the SLA DTM with PACTware or another FDT frame, please refer to Section **5.2 Configuration Software Setup (FDT/DTM)**.

Set up and connect equipment in **Table 1 Necessary Equipment for Bench Checking and Calibrating the SLA**. For wiring and terminal designations see **Figure 4.2** and **Figure 4.3** for SLA input connections and **Figure 4.4** for output and power connections.

Table 1 Necessary Equipment for Bench Checking and Calibrating the SLA

Device	Specifications
Input Source (Dependent on input type)	Accurate to $\pm 0.05\%$ of span for the intended application.
Power Supply	10.5-30Vdc
Load Resistor (for AO trim)	250 ohms with $\pm 0.01\%$ precision
Multimeter	Calibrated to an accuracy of $\pm 0.025\%$, or better; such as Fluke Model 725, or similar
PC with PACTware or FDT frame application	PACTware version 5 or newer
Ethernet Cable	CAT 5/6

3.2 Setting the Configuration Jumper

If trimming was performed on any inputs or outputs, it is recommended to set the user configuration jumper from read/write to read-only, see Section **4.8.2 Security Jumpers**. This will ensure that calibration settings will not be accidentally overwritten.

3.3 Bench Check

We strongly recommend that you initially configure and test the SLA on your bench prior to installing it in the field. Doing this will ensure it is operating within your expectations or requirements.

To perform the bench check of your SLA set up the equipment in **Table 1** Necessary Equipment for Bench Checking and Calibrating the SLA as shown in

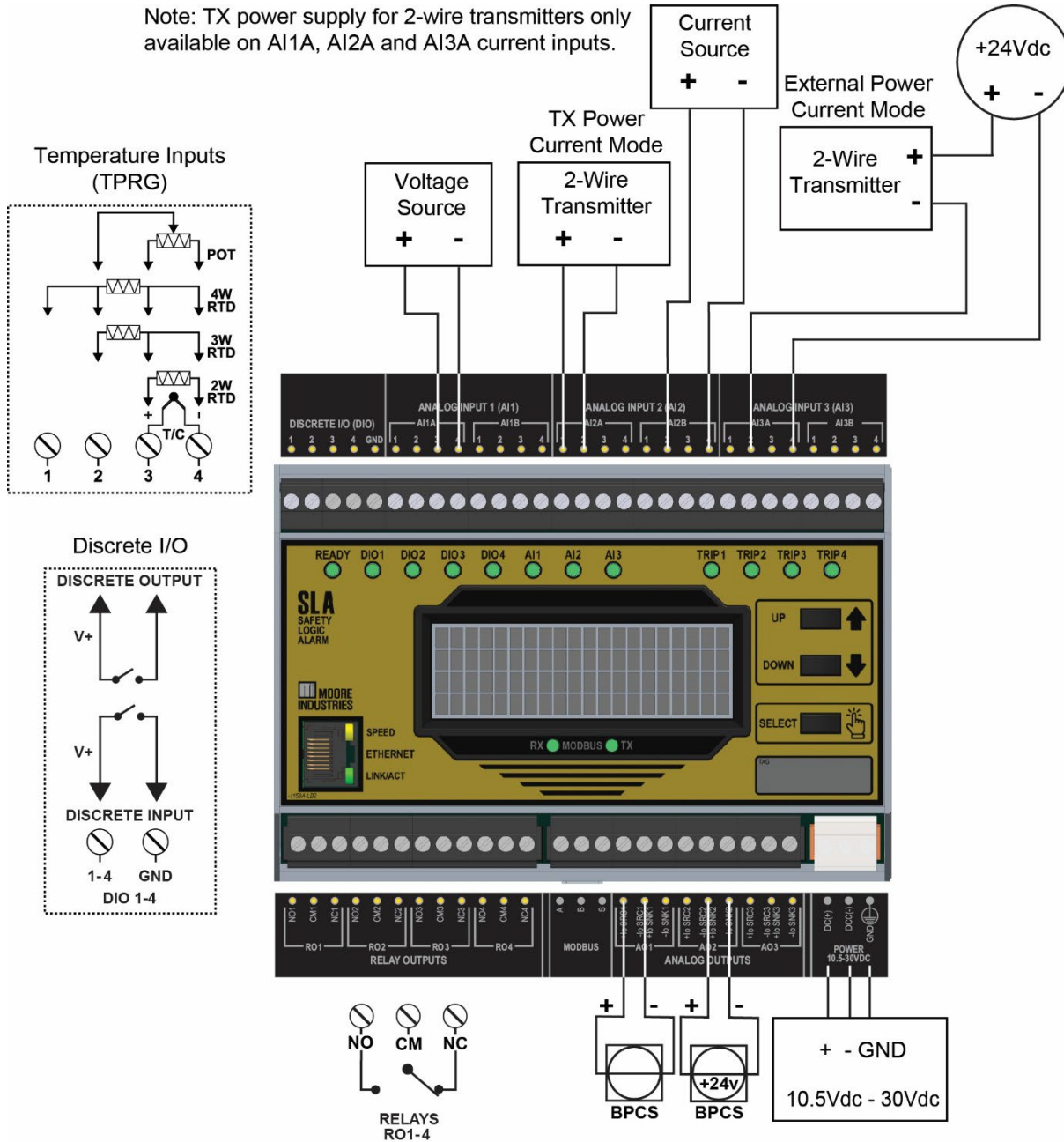
Figure 3.1 Hookup Diagram.

For instructions on installation and setup of the SLA DTM with PACTware or another FDT frame and for SLA configuration please refer to **Section 5.2**. If possible, use the exact input sensor (e.g. RTD, thermocouple, transmitter) that you will be using in your final application. Apply power to the SLA and see that it is providing the correct output(s) for the given input(s). Utilizing the SLA's Web Server and HTML pages can be an effective tool for viewing SLA internal values of equations, alarms, etc.

Hookup Diagram

Figure 3.1 Hookup Diagram

Note: TX power supply for 2-wire transmitters only available on AI1A, AI2A and AI3A current inputs.





Note: The SLA has three channels where each channel has two inputs A & B, for a total of six analog inputs. Both inputs on each channel must be of same type, i.e. HLPRG or TPRG.

3.4 Front Panel Display and LEDs

During calibration and bench check the SLA's front panel display and LEDs can be monitored for configuration accuracy. The front panel of the SLA has four types of LEDs: **READY**, **DIO1-4**, **AI1-3**, **TRIP1-4**. The LEDs all have red, green, or orange colors and are lit steadily, blinking on or off. Please refer to **Table 10** LED Indication and Device Status for LED Indication information.

4 SLA Wiring and Installation

Instructions in this section and others may require special precautions to ensure the safety of the personnel performing the operations. Notes, Cautions, and Warnings that may cause potential safety issues are indicated throughout this manual by symbols. Please refer to Page 3 of this manual to view and familiarize yourself with these safety message symbols.



Note: Make sure to configure, calibrate and bench-check the instruments prior to installation. Also, install all instruments in their intended application before making any electrical connections. For DIN rail-mounted instruments, allow enough room for pivoting instruments vertically on the rail for removal in applications involving multiple banks of units. To remove the unit from the DIN rail you will need a simple tool such as a straight blade screwdriver. Insert the blade of the screwdriver into the cavity at the bottom of the locking mechanism and rotate it. This will release the locking mechanism from the DIN rail and allow you to remove the unit.

4.1 Network and Cyber Security Best Practices

The following are recommended security precautions for installing the SLA:

- The SLA should be installed in a secure facility/locked enclosure.
- Ensure all network connections to the SLA are on a secured network per IEC 62443.
- Utilize an external system to monitor the SLA such that a power cycle is detected (this could be through observing a RO/AO/DO going to shelf state or a MODBUS/TCP connection failure during an SLA reboot)
- After configuration, the configuration jumper should be installed to **Read-Only** mode.
- A tamper evident seal should be applied to the access hatch once configuration and network jumpers are configured.
- For maximum network security, but at the expense of data availability, remove all network interfaces to the unit.

4.2 Input Channel Selection

Using the built-in DIP switches on the top of the SLA, you can set the input type for each channel (if this has not already been done during calibration and bench check). This must be done before the unit is turned on and inputs are connected.



Note: Factory setting will be all channels set to mA/V (HLPRG).

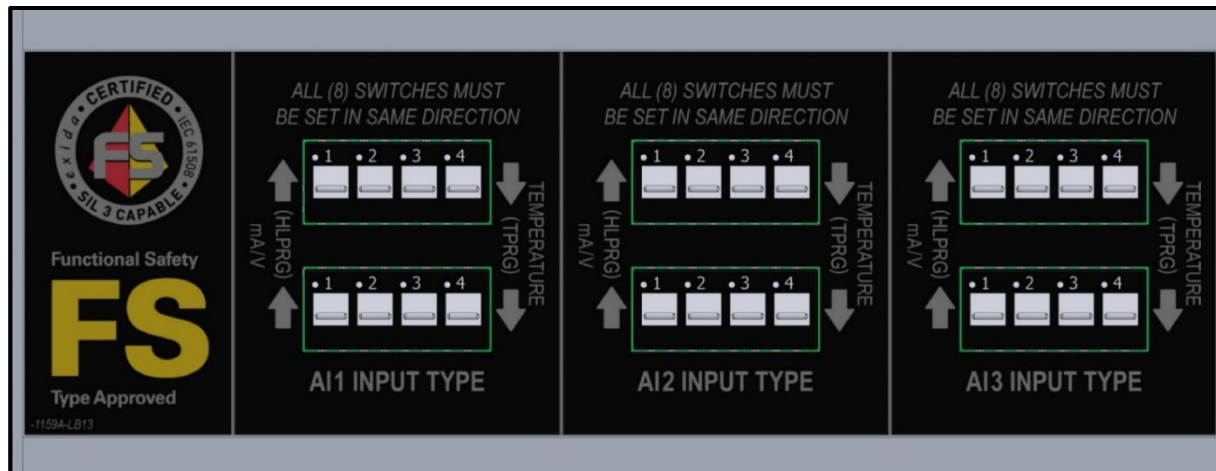


Note: Each of the three channels on the SLA (AI1-AI3) can be independently configured for HLPRG (mA/V) or TPRG (Temperature) input type but both inputs (A & B) on each channel must be of the same type, e.g. both mA inputs or both RTD inputs.



Warning: Double-check input channel switches before wiring inputs as damage to the unit could occur if wired incorrectly. Switches on each channel must be set in same direction as Input Label graphic below shows.

Figure 4.1 Input channel DIP switches on the top of the SLA - all three channels showing TPRG or Temperature Input Type



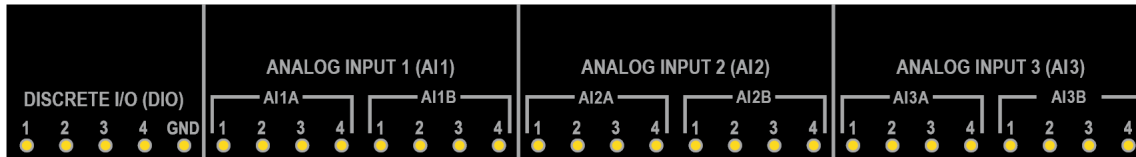
Note: The top of the unit has a switch protection cover. To change DIP switch settings - temporarily move the switch protection cover by loosening the bottom left screw (counterclockwise) allowing the cover to slide & rotate clockwise exposing the DIP switches. If the SLA unit is equipped with the FLB (Flange Brackets) type housing – unscrew & remove the bottom left screw allowing the switch protection cover to slide & rotate counterclockwise. Once switches have been set, replace the switch cover and secure.

Safety Logic Alarm

4.3 Terminal Designations

Figure 4.2 and Figure 4.4 contain the terminal designation information for Discrete I/O, Analog Input Channels, Relays, Analog Outputs, MODBUS, and Power Terminals.

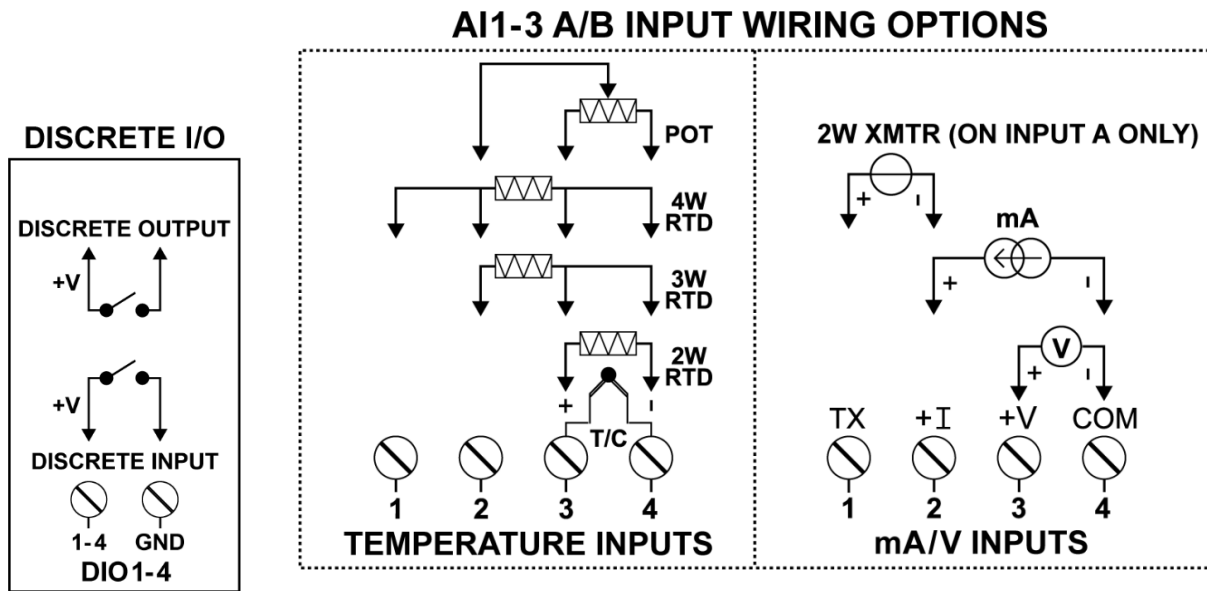
Figure 4.2 Discrete I/O and Analog Input Connections (Top Terminals)



Gray: Not Applicable	DIO					AI1A				AI1B				AI2A				AI2B				AI3A				AI3B											
Top Terminal Numbers (Left to Right)	1	2	3	4	GND	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
TPRG Input																																					
HLPRG Input									COM								COM								COM												COM
DIO																																					

KEY:
 COM = Analog Common I = Current Input V = Voltage Input
 GND = Discrete I/O Ground TX = Power for 2-wire Transmitter

Figure 4.3 Discrete I/O and Analog Input Wiring Details

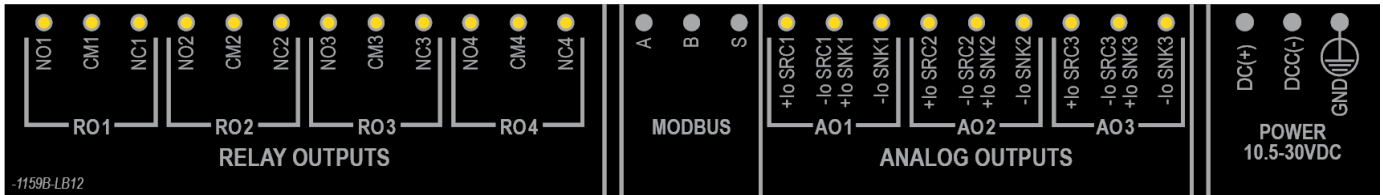


Note: TX power is only available on input A of each channel and is only enabled if the input channel is HLPARG with mA input configuration.



Caution: The SLA's Discrete Outputs (DO) operates as an open collector transistor. During normal operation, DOs are active low. During a fault condition, The DOs are open therefore the device connected to the DO must be pulled up.

Figure 4.4 Relay, MODBUS, Analog Output, and Power Connections (Bottom Terminals)



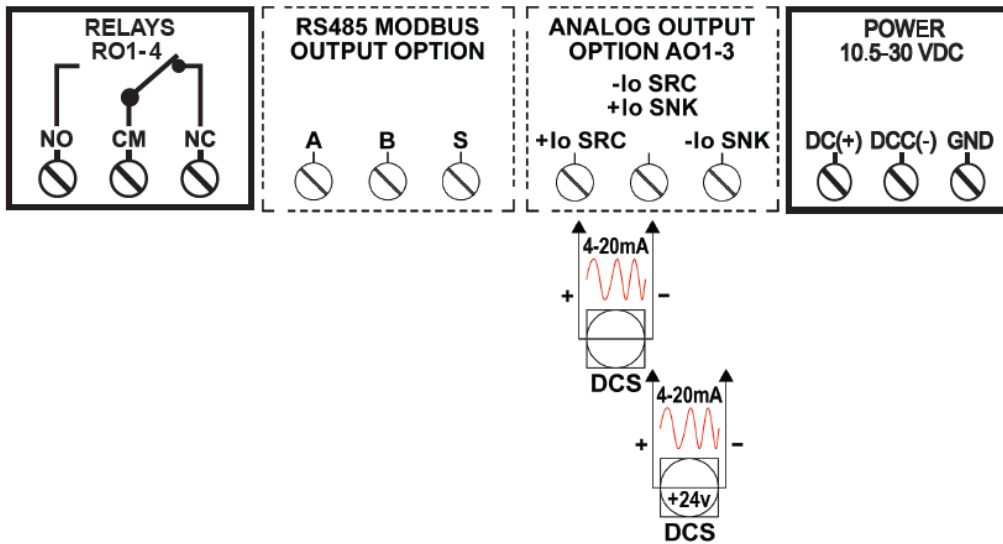
Gray: Not Applicable	RO1			RO2			RO3			RO4			MODBUS			AO1			AO2			AO3			10.5-30VDC					
Bottom Terminals (Left to Right)	NO1	CM1	NC1	NO2	CM2	NC2	NO3	CM3	NC3	NO4	CM4	NC4	A	B	S	+IO SRC1	-IO SRC1	+IO SNK1	-IO SNK1	+IO SRC2	-IO SRC2	+IO SNK2	-IO SNK2	+IO SRC3	-IO SRC3	+IO SNK3	-IO SNK3	DC+	DCC-	GND
RELAY Output	NO1	CM1	NC1	NO2	CM2	NC2	NO3	CM3	NC3	NO4	CM4	NC4																		
MODBUS RTU (optional)													A	B	S															
ANALOG Output (optional)																+IO SRC1	-IO SRC1	+IO SNK1	-IO SNK1	+IO SRC2	-IO SRC2	+IO SNK2	-IO SNK2	+IO SRC3	-IO SRC3	+IO SNK3	-IO SNK3			
10.5-30VDC Power																											DC+	DCC-	GND	

KEY:

CM = Relay Common	NO = Normally Open
DC = Power Input	SNK = Current Sink
DCC = Power Input	SRC = Current Source
GND = Ground (Case)	A = MODBUS Signal
IO = Current Output	B = MODBUS Signal
NC = Normally Closed	S = MODBUS Shield

Safety Logic Alarm

Figure 4.5 Relay, MODBUS, Analog Output and Power Connection Details



Note: Terminal blocks can accommodate 14-22 AWG solid wiring. Tighten terminals to four inch-pounds (maximum).



Caution: Terminals on this unit may be connected to hazardous voltages. Before making ANY connections to this unit, always remove power from the loop or instrument power terminals.

4.4 Dimensions

This section provides dimension information for the Moore Industries SLA.

Figure 4.6 SLA Front and Side Panel View

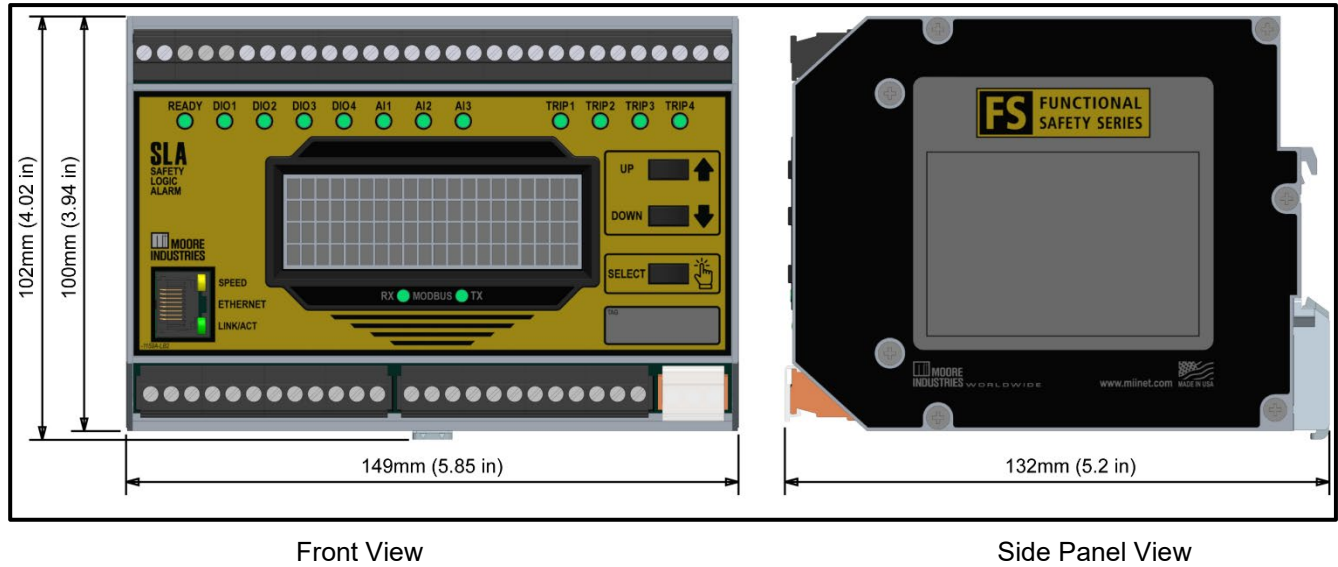
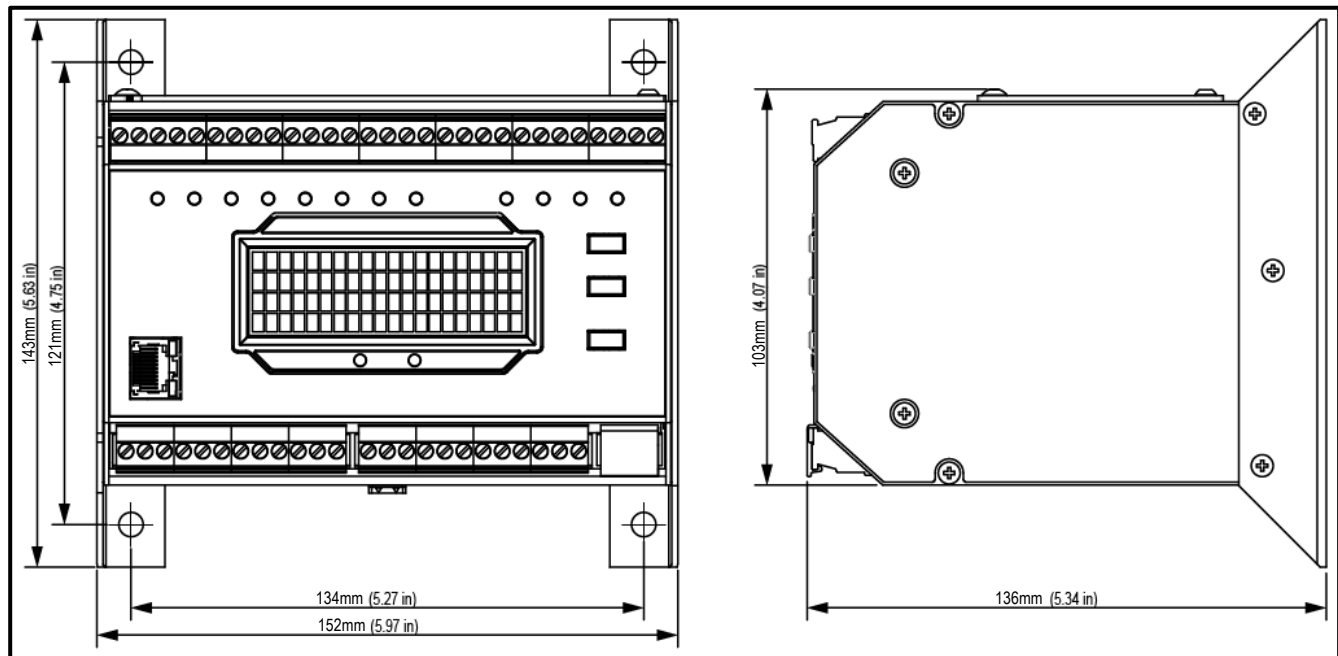


Figure 4.6B SLA with FLB Brackets Front and Side Panel View



Safety Logic Alarm

4.5 Installation

Installation consists of physically mounting the unit, grounding the instrument, and completing the electrical connections.



Note: All terminals are rated CAT 1.

4.6 Mounting

The SLA is designed to snap easily onto 35mm Top Hat (EN50022) DIN rails.

4.7 Electrical Safety Information

When installing any Moore Industries product, always follow all local regulations and standards for grounding, shielding, and safety.

Installation Category

All terminals are rated CAT I.

Equipment Ratings

Contact Relays

The SLA does not generate hazardous voltages but can switch outputs up to 3A at up to 250Vac or 30Vdc on its relay contacts. Products connected to the SLA should be designed to receive this type of input.

Analog Output

The SLA does not generate hazardous voltages, it provides a low current (4-20mA) and voltage (0-10V) input and a 4-20mA output. Products connected to the SLA should be designed to receive this type of input.

Discrete Outputs

The SLA does not generate hazardous voltages but can switch outputs up to 120mA at up to 30Vdc on its discrete output contacts. Products connected to the SLA should be designed to receive this type of input.

Safety Logic Alarm



Caution: If this unit is used in a manner not specified by Moore Industries, the protection provided by the equipment may be impaired.

Power Supply Wiring

All power connections should be made with 14 or 16 AWG (2mm² or 1.3mm²) wire. The end of each conductor should be stripped no more than 0.25in (7mm). The end of the stripped wire should be tinned with solder or inserted into a ferrule and crimped before being placed into a terminal block. Tighten the screws on the terminal block to 4.4 - 5.3 lbf/in² (0.5 - 0.6 N/m²).

Protective Earth Conductor

The Protective Earth Conductor shall be of equal or larger size wire than the other two power conductors. The Protective Earth Conductor shall be the first conductor connected to the unit when the unit is being wired. It shall be the last conductor removed when the unit is being un-wired.

Input/Output Wiring

The Input/Output connections can be made with 14 to 24 AWG (2.5mm² to 0.2mm²) wire. The end of each conductor should be stripped no more than 0.25in (7mm). Tighten the screws on the terminal block to 4.4 - 5.3 lbf/in² (0.5 - 0.6 N/m²).

Recommended Ground Wiring Practices

Moore Industries recommends the following ground wiring practices:

- Any Moore Industries product in a metal case or housing should be grounded.
- The protective earth conductor must be connected to a system safety earth ground before making other connections.
- All input signals to, and output signals from, Moore Industries products should be wired using a shielded, twisted pair wiring technique. Shields should be connected to an earth or safety ground.
- For the best shielding, the shield should be run all the way from the signal source to the receiving device. (see Note below)
- The maximum length of un-shielded input and output signal wiring should be two inches



Note: Some Moore Industries instruments can be classified as receivers (IPT2, IPX2, etc.) and some can be classified as transmitters (TRX, TRY, etc.) while some are both a receiver and a transmitter (SLA, HIM, etc.). Hence, your shield ground connections should be appropriate for the type of signal line being shielded. The shield should be grounded at the receiver and not at the signal source.

CE and UKCA Certification-Related Guidelines

Installation of any Moore Industries products that carry the CE marking must adhere to the guidelines in the Recommended Ground Wiring Practices section in order to meet the EN 61326 requirements set forth in the applicable EMC directive. The Low Voltage Directive also applies to the SLA when connecting any of its output relay contacts to voltages greater than 50 Vac. To comply with EN61010-1 (Low Voltage Directive) all guidelines in this section must be followed.

Contact/Load Suppression

When the instrument relays are used to switch an inductive load such as an external relay coil, contactor or solenoid, large voltage spikes may be created in nearby cable harnesses. When excessive, these voltage spikes can disrupt the operation of all nearby electronics including this product. Inductive loads should have suppression devices installed at the load (for external relays this would be right across the relay coil itself). Usually this is a simple diode for DC circuits. AC circuits routinely use an R-C snubber. Please follow the external load manufacturer instructions for their recommended suppression kits.

4.8 User Configurable Hardware

4.8.1 Configuration Jumpers

The SLA provides access to internal jumpers allowing the user to make specific settings in a safe and secure manner. The jumpers are accessed by a sliding panel on the bottom of the SLA (see Figure 4.7).

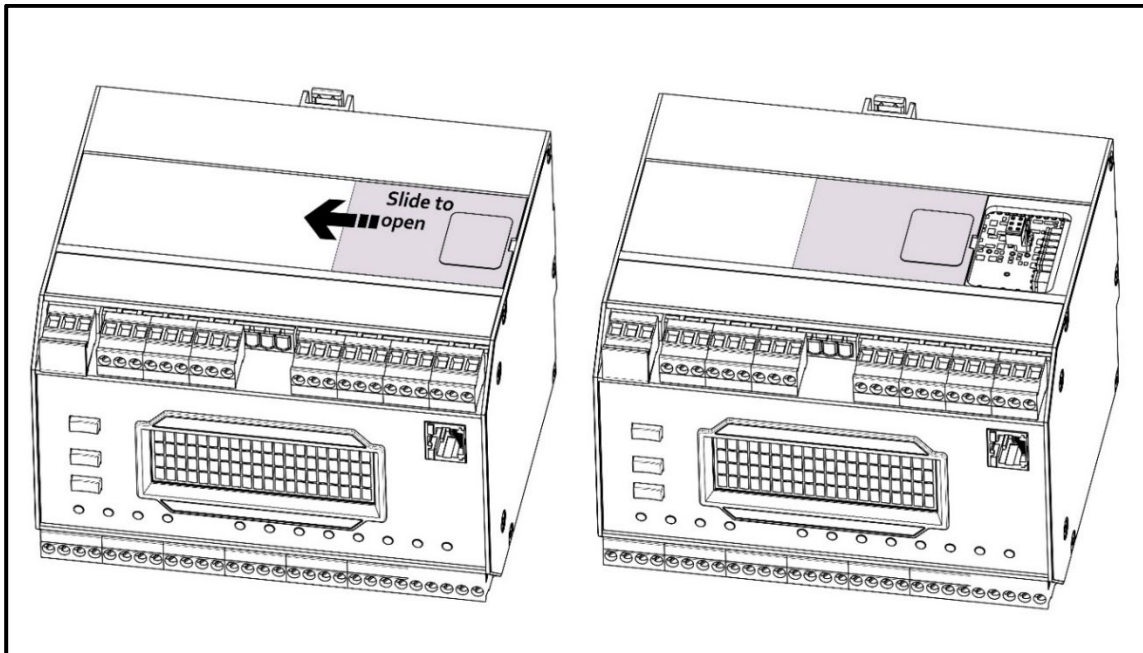


Caution: The unit must be powered down before accessing and changing these jumpers. Any changes to jumpers are only recognized by the unit on power up.



Note: Prior to installation it is recommended to install jumpers in Read-Only mode and a tamper evident seal applied across the sliding panel.

Figure 4.7 Access to Configuration Jumpers Located on the Bottom of the SLA Under a Sliding Panel



Safety Logic Alarm

Table 2 Jumper Settings and Positions

Jumper Name	Jumper Type	Position 1 (Default)	Position 2	Function
User Configuration	Ganged 2x3 (Black)	Installed one position to the right of the far-left pin - Read/Write	Installed Far Left Read-Only	Controls access to User Configuration settings modified by the DTM Software.
Network Configuration	2x1 (Grey)	Jumper installed on both pins - Read/Write	Jumper parked and installed on one pin-Read-Only	Controls access to Network Configuration settings modified by the NAC Client Software.
Fault Relay	Ganged 2x3 (Black)	Jumper parked and installed on three upper pins - Relay 4 is Fault Relay	Jumper installed on all pins - Relay 4 is Process Relay	Designates Relay 4 as a Fault or Process Relay



Note: The SLA is shipped from the factory with the following jumper settings:
 User configuration = Read / Write, Network configuration = Read / Write,
 Fault Relay Jumper = Use Relay 4 as Fault Relay.

Safety Logic Alarm

4.8.2 Security Jumpers

The SLA provides two configurable security jumpers, one for user configuration and one for network access. Each jumper can be independently positioned for read/write (full reconfiguration access) or read-only access. The far jumper to the right is not used and should remain installed as shown in **Figure 4.8**.

Figure 4.8 Bottom Jumper Access Panel – User and Network Configuration Security Jumpers in READ/WRITE Position

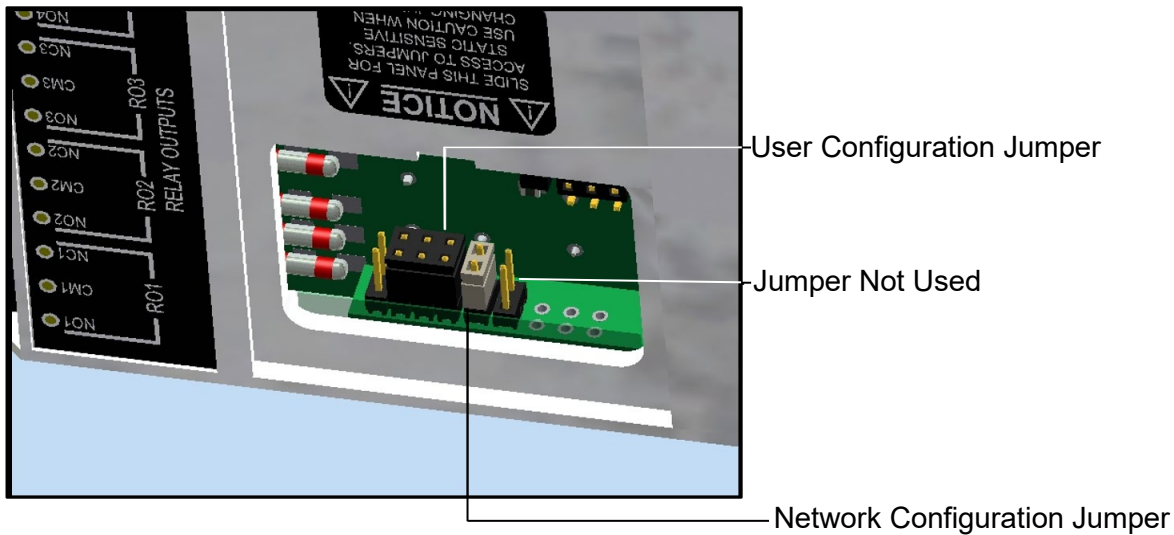
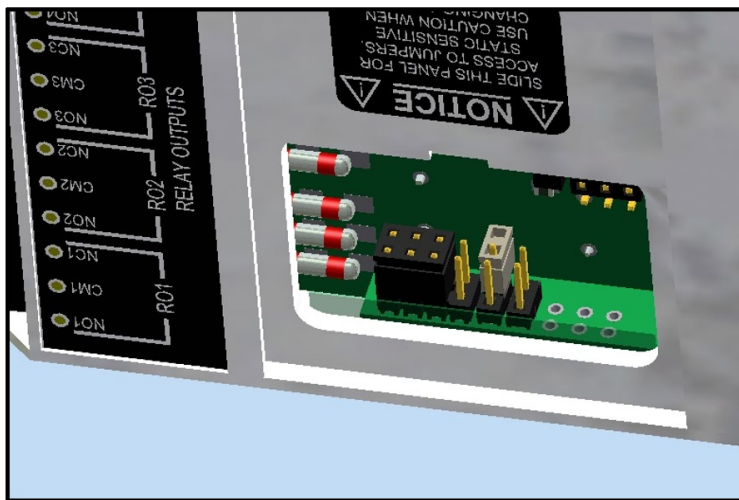


Figure 4.9 User and Network Configuration Security Jumpers in READ-ONLY position.



4.8.3 Fault Relay Jumper

Relay 4 (RO4) is jumper configurable to act as a Fault or Process relay. The jumper is accessed by the same sliding panel on the bottom of the SLA as the Security Jumpers shown in Figure 4.8 and Figure 4.9

Figure 4.10 shows the **Fault Relay** position and Figure 4.11 shows the **Process Relay** position.

When **RO4** is configured as a Fault Relay (the default position), system faults are always enabled, including directly wired hardware faults. System faults are always latched and cannot be overridden. System faults can also be selected for Relays 1-3 (**RO1-3**) but these will not include hardware faults (which may not be detected by the software). If RO4 is configured as a process relay, then it behaves like RO1-3.



Warning: If the firmware has a critical fault and the **RO4** jumper is in the Process Relay position, hardware diagnostics are not guaranteed to be reacted upon. This impacts the Failure data, see **Table 35** Failure data from exida's FMEDA report MII 700-702-32, row 2.

Figure 4.10 Relay 4 jumper in the factory default position configured for Fault Relay.



Figure 4.11 Relay 4 jumper moved to the stowed position, changing relay to a process relay.



Note: For jumper configuration changes to take effect, the SLA will need to be power cycled (turn power off and back on). Also, the jumper settings are read by the DTM and are also viewable on the SLA Home web page in the Security table.

5 SLA Configuration Overview

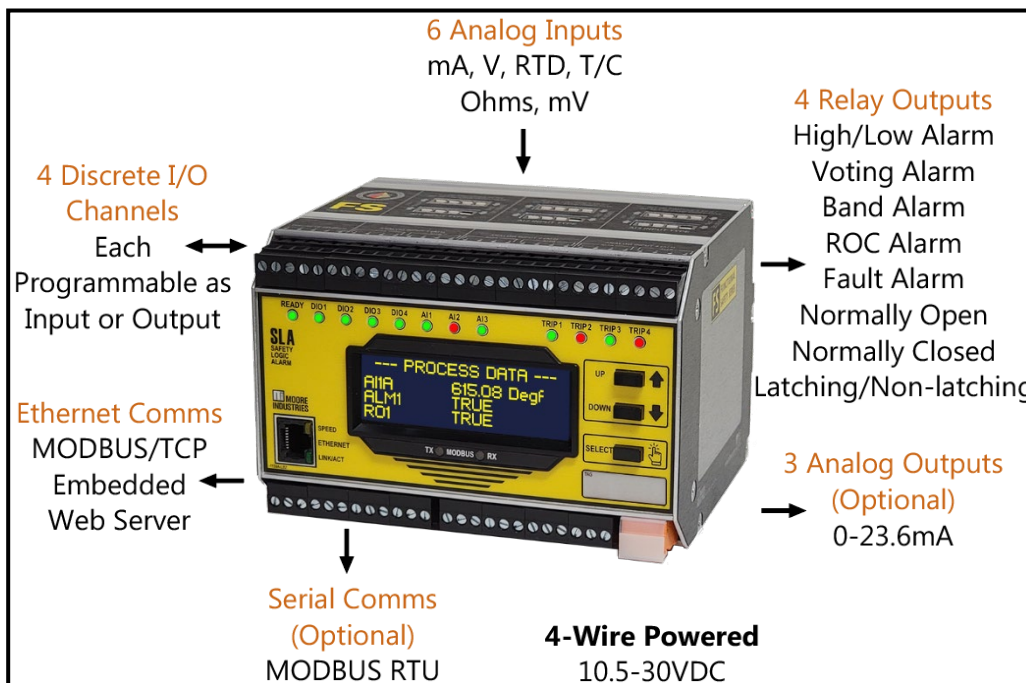
5.1 SLA Configuration Introduction

The SLA is configured via ethernet using a PC running an FDT/DTM program. Details of how to set up the FDT/DTM and the specific configuration screens are provided later. This section provides some general guidance on configuring the SLA. Section 12 also provides some examples of typical SLA applications.

SLA accepts up to six analog inputs, has four relay outputs, and three optional analog outputs. Additionally, there are four on-board discrete I/O channels that can be configured as inputs or outputs. When configured as outputs, these discrete contact closures and four relay outputs can be driven by any of the 16 programmable internal alarms. Individual or multiple alarms can be assigned to each relay or discrete output. Relay and discrete outputs can also be triggered by any input or internal diagnostic fault. The three optional analog outputs allow the retransmission of any input or internally calculated equation or variable.

An event logger can also be configured for each variable (inputs, alarms, outputs, etc.) to capture either summary or detailed information.

Figure 5.1 SLA Functional Capabilities



Safety Logic Alarm

5.1.1 Basic Setup

Step by step instructions for a basic SLA configuration.

1. Configure sensor inputs.
 - a. Determine the number of inputs and input channel type: high (current, voltage) or low (rtd, t/c, resistance, mV).
 - b. Decide whether you want failover capability on inputs a & b of the channel.
 - c. Set the input range and apply any scaling/custom EGU (Engineering Units).
 - d. Determine whether you want to latch input faults & warnings.
2. Configure discrete inputs.
 - a. Set the number of discrete inputs you need for latch reset or discrete alarms.
 - b. Configure the DIO as input, failsafe/Non-Failsafe and input debounce.
3. Configure process alarms – high/low trip, band, rate of change, and stuck alarms.
 - a. Decide whether you want the alarms to be high integrity (fail on an input failure) or high availability (hold last value).
 - b. Set the trip/delta, deadband, and delay.
 - c. Determine whether you want to latch the alarms. (Relay and discrete outputs can also be independently latched from the alarms). If so, then what's the reset signal?
 - d. Decide whether an additional startup delay is needed (specific to this alarm). This will add an additional delay to any system startup delay to allow the process to stabilize further.
4. Determine whether you need any discrete alarms. Discrete alarms can be used to vote on any combination of discrete inputs, outputs, relay outputs, system faults, input faults or warnings.
 - a. Decide whether you want to add a delay, suppression, and/or latching.
 - b. Determine whether an additional startup delay is needed.
5. Configure Fault Relay Output (RO4).

By default, RO4 will be enabled as a failsafe relay with system faults. System warnings, input faults, and warnings can also be selected in addition to alarm voting.

 - a. Determine whether you want a combined fault/trip relay (high integrity) or a dedicated fault relay which is wired separately from the process trip (high availability)?
 - b. For a dedicated fault relay, add any input faults and warnings. These faults cannot be suppressed or delayed and are automatically latched (relay latching is separate from fault latching).
 - c. For a high integrity application:
 - i. Select the alarms and voting configuration (e.g. 1oo1, 2oo3).
 - ii. Decide whether you want to add a delay and latching. The alarms also have delay and latch settings which are separate in addition to this.
 - iii. Is an additional startup delay needed (specific to this output)?
6. Configure other Relay and Discrete Outputs.

RO and DO have essentially the same configurable settings.

 - a. Select the alarms and voting configuration.
 - b. Decide whether you want to add a delay and latching. Alarms also have delay and latching which is separate in addition to this.
 - c. Determine whether an additional startup delay is needed (specific to this output).

Safety Logic Alarm

- d. Add any system/input faults and warnings. These are not part of the voting so they will activate the output whenever one of them is set.
7. Configure optional Analog Outputs.

Each AO can retransmit any of the six analog inputs or internal variables that were created. If HART pass-through is required, take note that the HART signal on input AI1A is hardwired to AO1, AI2A to AO2 and AI3A to AO3. No HART data is available from AI1B, AI2B, or AI3B inputs.

 - a. Select the AI input and set the input range, any damping, and output range.
 - b. Configure the fail response and decide if you want to fail on system faults.
8. Configure System Settings.
 - a. Decide whether you want a system startup delay. This may be needed to allow the process to stabilize before any inputs, alarms, or outputs are processed.
 - b. Configure a reset source for System Faults. If none is set, then the unit will need to be powered to clear system faults (for some hardware faults the unit must be power cycled). Configure the latch and reset for system warnings.
9. Configure the Event Logger if required.
10. Review and update Network Security settings.
11. Review the configuration summary, download the configuration to your unit, and record the Config ID. You may also want to save this configuration file to a secure location for later use or reference.
12. Run a simulation to check the alarms and outputs are working as expected.
13. For added security, power down the unit and set the network and configuration jumpers to read-only mode.

Safety Logic Alarm

Functional Reference (Basic Settings)

The following table identifies the SLA Basic setup functions including inputs, alarms, outputs and system settings.

Table 3 SLA Inputs, Alarms, Outputs and System Settings Overview – Basic Setup

Function	Inputs	Settings	Additional Features*
Analog Input Channels (AI)	1 or 2 inputs per channel: RTD, Res, T/C, MV, Pot, mA, or V	Failover, Input range, Scaling, Custom EGU	Broken wire incl holdoff, Average filter, Input Fault & Warning Latch
Discrete Input (DIO)	Discrete input or Output	Failsafe/Non-Failsafe	Input Debounce Time
Trip Alarm	Analog Input	Availability/Integrity, Low/High alarm, Trip point, Deadband	Additional Startup Delay, Delay, Latch, Suppress
Band Alarm	Analog Input	Availability/Integrity Low and High Trip points, Deadband	Additional Startup Delay, Delay, Latch, Suppress
Rate of Change (ROC) Alarm	Analog Input	Availability/Integrity Rise, Fall or Rise and Fall, Delta, Delta Time, Deadband	Additional Startup Delay, Delay, Latch, Suppress
Stuck Input Alarm	Analog Input	Availability/Integrity Delta, Delta Time, Deadband	Additional Startup Delay, Delay, Latch, Suppress
Discrete Alarm	Discrete Input/ Output, Relay Output, Alarm, System/Input Faults and Warnings**	Voting XooY for up to 8 inputs**	Additional Startup Delay, Delay, Latch, Suppress
Relay Output (RO)/ Discrete Output (DIO)	Alarm, System/Input Faults and Warnings	Failsafe/Non-Failsafe, Voting XooY for up to 16 alarms, Faults and Warnings selectable***	Additional Startup Delay, Delay, Latch, Suppress, DO diagnostic****
Analog Output (AO)	Analog Inputs, Internal Variables, including Failover	Source Zero & Full, AO Range	Damp Time, Initial Value, Fail Mode, Fail on System Fault
System	Internal Settings	Startup Delay Online Simulation Time, Network Security, Display, MODBUS	System Fault & Warning Latch

* Latch Reset and Suppress inputs can be any Discrete Variable (DI, Alarm)

** Voting on DIO, RO, faults, and warnings is unique to discrete alarms

*** Faults and Warnings are ORed with voting output. They are NOT part of voting. When Relay 4 (RO4) is a Fault Relay, System Faults are always selected.

****Diagnostic setting applies to Discrete Output only

5.1.2 Advanced Setup

If your application requires additional operations on inputs, advanced features including arithmetic and logical equations, timers, running min/max, and custom curve functions are available.

For more advanced settings it is recommended to document the application (see Section **12 SLA Application Examples**) and define any equations/functions before programming the unit.

1. Configure sensor inputs - see step 1 Basic setup.
2. Configure discrete inputs - see step 2 Basic setup.
Discrete inputs may also be used for timers and equations.
3. Configure any advanced functions – timers, custom curves, running min/max (RMM), or equations. See the equation/expression reference table and operator precedence tables below for more details.



Note: All variables must be defined before using them in an equation.

4. Configure analog alarms - see step 3 Basic setup.
Advanced settings allow Trip points/Deltas to be set by any input, internal variable (IV), or RMM as well as a fixed value (in the basic setup).
5. Configure discrete alarms - see step 4 Basic setup.
Timer and equations (IVs) may also be inputs for voting.
6. Configure Relay/Discrete Outputs - see steps 5 & 6 Basic setup.
7. Configure optional Analog Outputs - see step 7 Basic setup.
AOs can also use equations (IVs) and RMM as input sources.
8. Configure System settings - see step 8 Basic setup.
9. Configure the event logger if required.
10. Review and update network security settings.
11. Review the configuration summary, download the configuration to your unit and record the Config ID. You may also want to save this configuration in your FDT application (PACTware).
12. Run a simulation to check that functions, equations, alarms, and outputs are working as expected.
13. For added security, power down the unit and set the network and configuration jumpers to read-only mode.

Safety Logic Alarm

Functional Reference (Advanced Settings)

The following table identifies the SLA Advanced setup functions including inputs, alarms, outputs and system settings.

Table 4 SLA Inputs, Alarms, Outputs and System Settings Overview – Advanced Setup

Function	Inputs	Settings	Additional Features*	COMMENTS
Analog Input Channels (AI)	1 or 2 inputs per channel: RTD, Res, T/C, MV, Pot, mA, or V	Failover, Input range, Scaling, Custom EGU	Broken wire incl holdoff, Average filter, Input Fault & Warning Latch	
Discrete Input (DIO)	Discrete Input or Output	Failsafe/Non-Failsafe	Input Debounce Time	
Trip Alarm	Analog Input, Equation (IV), Running min/max (RMM)	Availability/Integrity, Low/High alarm, Trip point, Deadband	Additional Startup Delay, Delay, Latch, Suppress	Advanced settings allow Trip point to be set by any input, IV or RMM
Band Alarm	Analog Input, Equation (IV), Running min/max (RMM)	Availability/Integrity Low and High Trip points, Deadband	Additional Startup Delay, Delay, Latch, Suppress	Advanced settings allow Trip points to be set by any input, IV or RMM
Rate of Change (ROC) Alarm	Analog Input, Equation (IV), Running min/max (RMM)	Availability/Integrity Rise, Fall or Rise and Fall, Delta, Delta Time, Deadband	Additional Startup Delay, Delay, Latch, Suppress	Advanced settings allow Delta to be set by any input, IV or RMM
Stuck Input Alarm	Analog Input, Equation (IV), Running min/max (RMM)	Availability/Integrity Delta, Delta Time, Deadband	Additional Startup Delay, Delay, Latch, Suppress	Advanced settings allow Delta to be set by any input, IV or RMM
Discrete Alarm	Discrete Input/ Output, Relay Output, Alarm, Equation (IV), Timer, System/Input Faults and Warnings	Voting XooY for up to 8 inputs**	Additional Startup Delay, Delay, Latch, Suppress	

Safety Logic Alarm

Function	Inputs	Settings	Additional Features*	COMMENTS
Relay Output (RO)/ Discrete Output (DIO)	Alarm, System/Input Faults and Warnings	Failsafe/Non-Failsafe, Voting XooY for up to 16 alarms, Faults and Warnings selectable***	Additional Startup Delay, Delay, Latch, Suppress, DO diagnostic****	
Analog Output (AO)	Analog Input, Equation (IV), Running min/max (RMM)	Source Zero & Full, AO Range	Damp Time, Initial Value, Fail Mode, Fail on System Fault	
System	Internal Settings	Startup Delay Online Simulation Time, Network Security, Display, MODBUS	System Fault & Warning Latch	
Timer	Discrete Input/Output, Relay Output, Alarm, Equation (IV), Timer, System/Input Faults and Warnings	Reset/Pause Mode, Duration, Output Logic	Reset Source, Reset Detection Mode	
Running Min/Max	Analog Input, Equation (IV), Running min/max (RMM)	Availability/Integrity, Highest/Lowest Value,	Reset Source, Initial/Reset Value, Additional Startup Delay	
Custom Curve	User defined	Number of points		A Custom curve is applied as part of an equation

* Latch Reset and Suppress inputs can be any Discrete Variable (DI, Alarm)

** Voting on DIO, timer, equations, RO, faults and warnings is unique to discrete alarms

*** Faults and Warnings are ORed with voting output. They are NOT part of voting. When Relay 4 (RO4) is a Fault Relay, System Faults are always selected.

****Diagnostic setting applies to Discrete Output only

5.1.3 Floating Point Representation

The vast majority of electronic devices, including the SLA, store floating point values per IEEE 754 as 32 bit values. Since only a finite number of real values can be represented, all devices experience the same problems with math. Representing numbers with a limited number of bits introduces tiny roundoff errors. Small truncation or additional roundoff errors can also accumulate when numbers are used in calculations.

The IEEE 754 representation includes enough significant digits to store input and output values at the SLA's stated accuracy without degradation. There are additional digits that can absorb most of the math errors.

It is unlikely that a user will observe math errors affecting their results greater than the accuracy of the device. Performing a moderate number of calculations (e.g. evaluating a complex polynomial) will not introduce excessive errors, however performing thousands of calculations may result in visible errors.

5.1.4 Roundoff Error Example

An example of accumulated roundoff errors can be seen when repeatedly adding a number to a variable.

Consider the two equations below, both of which increment themselves by constant value each processing cycle:

IV1: **Analog, IV1 + 0.5**

IV2: **Analog, IV2 + 0.7**

It is possible for the floating-point value to represent 0.5 exactly, as well as all "whole" and "whole-plus-a-half" numbers, i.e. 0.5, 1.0, 1.5, 2.0, 2.5, ... These numbers will only ever have zeros as digits to the right of the tenths column.

It is not possible for a floating-point value to represent 0.7 exactly, therefore every time the addition is performed a tiny error will be introduced. Ideally, the stored values should not change beyond the tenth's digit (i.e.: 0.7, 1.4, 2.1, 2.8, 3.5). However, the internal representation will have non-zero digits to the right of the tenth's column.

Initially the error in IV2 is very small. Since the web page rounds the value to three decimal places, the error is not visible. However, after running for a few minutes the errors accumulate and can be seen. IV1 continues to be exactly the "whole" or "whole-plus-a-half" value, but IV2 has non-zero digits in the hundredths and thousandths places.



Note: In the examples, there is an upper limit on numbers that can be stored. Eventually the number will get so large that the tenths column will lose significance and the computation will fail.



Note: Aside from the math-error related issues, MII advises against expressions like those used in the example. There should be a guard limiting the "counter" and a mechanism to reset it back to 0 or some other initial value.

5.1.5 Mathematical Behavior

The SLA has behavior meant to help with mathematical issues:

- Round to zero - values that are within the interval $[-10^{-6}, 10^{-6}]$ are treated as zero.
 - Magnitude warning - adding a large number (e.g. 10^{20}) to a small number (e.g. 10^{-3}) will have no effect. The result will be the large number since there is no overlap of significant digits.
 - Convert +/- infinity as NaN/BAD - When a result is too large to represent, it will be encoded (per IEEE 754) as infinity. The SLA detects this and changes the representation to a NaN with BAD quality.
 - Custom Curve instead of Iterative Calculations - The SLA limits the functions available that use iterative solutions (e.g. it does not provide SIN or LOG which might be calculated using a Taylor or Maclaurin series). Instead, a custom curve is used. This allows the user to verify that the errors introduced by linear interpolation of the curve are within their safety margin.
-



Warning: There are potential issues with floating point math. The user must ensure they are accounted for and/or mitigated when using custom expressions.

5.1.6 Internal Variable Equation/Expression Editor and References

The SLA allows up to 16 Internal Variables (IV1-IV16) to be defined for use in logic statements, arithmetic equations or for alarming requirements. When setting up an Internal Variable, you must declare it as an Analog or Discrete type variable, see **Figure 7.3**. Thereafter, you can create an Equation or Expression, utilizing prebuilt functions or standard operations, that represent or define this variable. The output result or value of an Analog Internal Variable must always be analog in nature, i.e. 45.2 or 128.0. Alternatively, the output result or value of a Discrete Internal Variable will always be TRUE or FALSE. If you need to convert a TRUE or FALSE value to a 1.0 or 0.0 to be used in an analog equation or expression, you must use the conversion function **A(X)**, as outlined in **Table 7**.

SLA inputs, outputs, alarms, faults, warnings, internal variables and more can all be used as elements of your custom-built equations or expressions. **Table** and **Table** below define both analog and discrete variable types.

Table 5 Analog Variables

Variable Type	Identifier	Description
Analog Input Variable	AI1A, AI1B, AI2A, AI2B, AI3A, AI3B	Analog Input variables.
RJC Variables	AI1RJC, AI2RJC, AI3RJC	Reference Junction Compensation variables. Automatically enabled when one of the channel's sensors is configured for Thermocouple.
Failover Variable	AI1FO, AI2FO, AI3FO	Analog Input Failover variables.
Running Min/Max Variable	RMM1, RMM2, ... RMM8	Enabled Running Min/Max variables.
Internal Variables	IV1, IV2, ... IV16	Internal Variables when configured as an analog variable
Analog Output Variable	Not Applicable	It is not possible to reference an AO in an expression
Constants	NaN	Not a Number

Table 6 Discrete Variables

Variable Type	Identifier	Description
Discrete Input Variable	DI1, DI2, DI3, DI4, DIO1, DIO2, DIO3, DIO4	Logical state of Discrete Input / Output variables when configured as an input. NOTE: The Failsafe / Non-Failsafe configuration setting maps input contact closure state to DI Logical State.
Discrete Output Variable	DO1, DO2, DO3, DO4, DIO1, DIO2, DIO3, DIO4	Logical state of Discrete Input / Output variables when configured as an output. NOTE: The Failsafe / Non-Failsafe configuration setting maps DO Logical State to output voltage level.
Alarm	ALM1, ALM2, ... ALM16	Alarming state of Alarm variables.
Internal Variable	IV1, IV2,... IV16	Internal Variables when configured as a discrete variable.
Timer Variable	TMR1, TMR2, ..., TMR8	Output values of Timer variables. NOTE: Timers can be configured to be TRUE or FALSE when expired.
Relay Variable	RO1, RO2, RO3, RO4	Logical state of Relay variables. NOTE: Failsafe / Non-Failsafe configuration maps Relay Logical state to Relay coil state.

Safety Logic Alarm

System Fault	SYSF	TRUE when there is a System Fault. FALSE when there is no System Fault.
System Warning	SYSW	TRUE when there is a System Warning. FALSE when there is no System Warning.
Input Fault	ANYAIF	TRUE when any input has a fault. FALSE when no input has a fault.
Input Warning	ANYAIW	TRUE when any input has a warning. FALSE when no input has a warning.
Input Fault	AI1AF, AI1BF, AI2AF, AI2BF, AI3AF, AI3BF	TRUE when the input has a fault. FALSE when the input has no fault.
Input Warning	AI1AW, AI1BW, AI2AW, AI2BW, AI3AW, AI3BW	TRUE when the input has a warning. FALSE when the input has no warning.

*All analog functions use analog inputs and all discrete functions use discrete inputs unless specified.

The Internal Variable Expression Editor is be used to create variables that range in complexity. Variables can be anything from a simple analog constant used in other equations, to a complex mixture of analog and discrete functions. The editor will check that the parameters to the functions are the correct type (e.g. that two analog variables are being added.) But cannot check that the math being performed is correct for the application (e.g. it doesn't know if it is correct to square or take the square-root of a variable.)

Table 7 Analog Functions: Expression results in an analog variable

Type	Function	Description	Example
Standard Math	+	Addition - Adds two numbers or analog variables	AI1A + 100.0
	-	Subtraction - Subtracts one number or analog variable from another NOTE: The equation editor understands "-1.0", and "1.0 - AI1A", but does not understand "-AI1A". Use NEG(AI1A) to negate a variable.	RMM1 - AI2FO
	*	Multiplication - Multiplies two numbers or analog variables	IV1 * 100
	/	Division - Divides one number or analog variable by another	IV1 / 2
	^	Exponentiation - Raises one number or analog variable to the power of another	AI1A ^ (1/2) Raise AI1A to the one half power (which is equivalent to taking the square root of AI1A).
	SQRT(X)	Square Root - Computes the square root of a number or analog variable	SQRT(RMM1)
	ABS(X)	Absolute Value - Take the absolute value of a number or analog variable	ABS(IV1)
	NEG(X)	Negative - Take the negative of a number of analog variable. NOTE: The equation editor understands "-1.0", and "1.0 - AI1A", but does not understand "-AI1A".	NEG(AI1A)
Custom Math	CCURVE(#, Var)	Custom Curve - Applies the numbered custom curve to the variable Var. Custom curve numbers range from 1 to 4. If Var's value is outside the X Data Range of the specified custom curve, the result will be extrapolated but will be assigned BAD quality.	CCURVE(1,AI1A)
	AVG(X1, ... Xn)	Average - Calculates the average of up to 8 values. If one or more has BAD quality, the result will be NaN/BAD.	AVG(AI1A, AI1B, AI2A, AI2B)
	AVGD(X1, ... Xn)	Average with Dropping - Calculates the average of up to 8 values. If a value's quality is BAD, it will be dropped and the remaining values are	AVGD(AI1A, AI1B, AI2A, AI2B)

Type	Function	Description	Example
		averaged. If all values are dropped, the result will be NaN/BAD.	
	MIN(X1, ... Xn)	Minimum - Finds the smallest of up to 8 values. If one or more has BAD quality, the result will be NaN/BAD.	MIN(IV1, IV2, IV3, IV4, IV6, IV7, IV8)
	MIND(X1, ... Xn)	Minimum with Dropping - Finds the smallest of up to 8 values. If a value's quality is BAD, it will be dropped and the smallest will be found from the remaining values. If all values are dropped, the result will be NaN/BAD.	MIND(IV1, IV2, IV3, IV4, IV6, IV7, IV8)
	MAX(X1, ... Xn)	Maximum - Finds the largest of up to 8 values. If one or more has BAD quality, the result will be NaN/BAD.	MAX(AI1A, RMM1, IV1)
	MAXD(X1, ... Xn)	Maximum with Dropping - Finds the largest of up to 8 values. If a value's quality is BAD, it will be dropped and the largest will be found from the remaining values. If all values are dropped, the result will be NaN/BAD.	MAXD(AI1A, RMM1, IV1)
Conversion	A(X)	Discrete to Analog - Converts a discrete to an analog value with GOOD quality: TRUE is converted to 1.0. FALSE is converted to 0.0.	$100 + AI1A * A(DI1) + AI2A * A(DI2)$ Starting with 100: If DI1 is pressed, add AI1A. If DI2 is pressed, add AI2A.
Data Quality (control)	GOOD(X)	Force Variable Quality to GOOD - This can be done to use a variable that has BAD quality in a High Availability way. For example, if CCURVE extrapolates, the quality is set to BAD. Using GOOD() recovers from this.	$GOOD(IV1) / 2.0$ Ignore that IV1 has BAD quality, use the held-last value and divide it by 2 anyhow.
	BAD(X)	Force Variable Quality to BAD - This can be done to cause a fail response in another block (eg by an AO that is sourcing the variable that was forced BAD).	$IF (DI1, BAD(RMM1), RMM1)$ IF DI1 is TRUE, the result is RMM1 forced to have BAD quality. If DI1 is FALSE, the result is RMM1 as-is.

Table 8 Discrete Functions: Expression results in a discrete variable

Type	Function	Description	Example
Logic	AND	Logical AND - TRUE when both discrete arguments are TRUE. FALSE when one or both are FALSE.	SYSF AND IV1
	OR	Logical OR - TRUE when one or both discrete arguments are TRUE. FALSE when both are FALSE.	DI1 OR DI2
	XOR	Logical Exclusive OR - TRUE when one discrete argument is TRUE and one is FALSE. FALSE when both are TRUE or both are FALSE.	IV1 XOR ALM1
	NOT()	Logical NOT - TRUE when the discrete argument is FALSE. FALSE when the discrete argument is TRUE.	NOT(ALM1)
Logical Comparisons	==	Logical Equality - TRUE when the discrete arguments are the same. FALSE when the discrete arguments are different.	IV1 == DI3
	!=	Logical Inequality - TRUE when the discrete arguments are different FALSE when the discrete arguments are the same.	DI1 != DI2
Analog Comparisons	>	Greater Than - TRUE when the left analog argument is larger than the right. FALSE when the left analog argument is smaller than, or equal to the right.	IV1 > RMM2

Type	Function	Description	Example
	>=	Greater Than or Equal - TRUE when the left analog argument is larger than or equal to the right. FALSE when the left analog argument is smaller than the right.	AI1A >= IV1
	<	Less Than - TRUE when the left analog argument is smaller than the right. FALSE when the left analog argument is greater than, or equal to the right.	IV1 < IV2
	<=	Less Than or Equal - TRUE when the left analog argument is smaller than, or equal to the right. FALSE when the left analog argument is less than the right.	RMM1 <= AI3B
Data Quality (test)	ISGOOD(X)	Is Quality GOOD - Test if an analog value has good quality TRUE if the analog variable has GOOD quality. FALSE if it the analog variable has BAD quality.	ISGOOD(AI1FO) IF AI1FO has GOOD quality, the result is TRUE. IF AI1FO has BAD quality, the result is FALSE.
Conditional - analog result	IF (X, Y, Z)	IF with analog result - Evaluates the discrete function x, if TRUE number or analog variable Y is assigned to the variable. If FALSE number or analog variable Z is assigned.	IF(DI1, RMM1, AI1A) If DI1 is TRUE, the result is RMM1. If DI1 is FALSE, the result is AI1A.
Conditional - discrete result	IF(X, Y, Z)	IF with discrete result - Evaluates the discrete function x, if TRUE logical value or discrete variable Y is assigned to the variable. If FALSE logical value or discrete variable Z is assigned.	IF(IV1 <= RMM3, DI1, IV2) If IV1 is less than or equal to RMM3, the result is DI1. If IV1 is greater than

Safety Logic Alarm

Type	Function	Description	Example
			RMM3, the result is IV2.
Precedence - analog result	()	Parenthesis - Groups operations in an expression. Must come in balanced pairs. Used to override operator precedence. (See precedence table below.) The contents of the pair must be a valid analog expression.	(AI1A + 100) * 3 Multiplication has a higher precedence than addition. The parentheses force the addition to take place first.
Precedence - discrete result	()	Parenthesis - Groups operations in an expression. Must come in balanced pairs. Used to override operator precedence. (See precedence table below.) The contents of the pair must be a valid discrete expression.	(IV1 OR IV2) AND SYSF AND has a higher precedence than OR. The parentheses force the OR to take place first.

Safety Logic Alarm

Table 9 Operations Precedence Table

Precedence	Operations	Description
Highest	Function	SQRT, ABS, NEG, CCURVE, AVG, AVGD, MIN, MIND, MAX, MAXD, ISGOOD, IF, A
	()	parenthesis
	^	power of
	*, /	multiplication, division
	+, -	addition, subtraction
	<, >, <=, >=	analog comparison
	==, !=	discrete equality, discrete inequality
	NOT	logical not
	AND	logical and
	OR, XOR	logical or, logical exclusive or
Lowest	,	comma

Expressions will be processed using the following operator precedence, highest first. If operators are at the same level of precedence they will be evaluated left to right. If in doubt, use parentheses () to ensure you have the correct operator precedence.

Safety Logic Alarm

Nested IF Statements

It is possible to use multiple IF statements together. The basic **if - else** can be nested in different ways to create complicated constructs. The only limitation is in each expression's 128 character limit and the total number of expressions. To overcome the length limit, the construct can be broken across multiple IVs. This may also benefit readability which improves maintainability.

Example 1:

```
IV1 = "IF(A, B, IF(C, D, IF(E, F, G) ) )"
```

As pseudocode:

```
if (A) then
  IV1 = B
else if (C) then
  IV1 = D
else if (E) then
  IV1 = F
else
  IV1 = G
```

Broken Up:

```
IV1 = "IF(E,F,G)"
IV2 = "IF(C,D,IV1)"
IV3 = "IF(A,B,IV2)"
```

Almost the same pseudocode is produced. The difference in behavior is that the result would be stored in IV3 instead of IV1.

Example 2:

```
IV1 = "IF(A, IF(B, C, D), IF(E, F, G) )"
```

As pseudocode:

```
if (A) then
{
  if (B) then
    IV1 = C
  else
    IV1 = D
}
else
{
  if (E) then
    IV1 = F
```

Safety Logic Alarm

```
    else
      IV1 = G
    }
```

Broken Up:

```
IV1 = "IF(B,C,D)"
```

```
IV2 = "IF(E,F,G)"
```

```
IV3 = "IF(A,IV1,IV2)"
```

As before, the only functional difference is that the result is stored in IV3 instead of IV1.

5.2 Configuration Software Setup (FDT/DTM)

Four different pieces of software are required for configuring your SLA. All software can be downloaded from the Moore Industries website at: <http://www.miinet.com/>.

The required software includes:

- PACTware or any FDT frame application
- Moore Industries MIIP Communications DTM
- Moore Industries SLA Device DTM
- Moore Industries Network Address Configuration (NAC) Client

For users who already have an FDT Frame Application, all the following information is still relevant except for the PACTware installation. For more information on FDT/DTM please refer to www.fdtgroup.org.



Note: If configuring the SLA through a firewall, please ensure the relevant ports are open for the services you need.

- HTTP 80
- MODBUS/TCP 502
- MIIP DTM (HART-IP) 5094
- NAC Client 2850/2851

5.2.1 FDT Frame Application

The SLA will require the use of an FDT frame application, which allows configuration and adjustment of any and all field instruments that have a DTM. For users who do not already have an FDT frame application, PACTware can be downloaded from the Moore Industries website at www.miinet.com.

An FDT frame application, such as PACTware, is a PC program which interfaces with individual software modules for instrument operation. This interface is regarded as the FDT; the individual software modules for instrument adjustment are called DTMs (Device Type Manager). This configuration makes user-friendly adjustments possible because the interface for instrument adjustment is optimally adapted to each instrument.

When installing the latest version of PACTware supplied by Moore Industries, the installation will include three communication DTMs. One is a generic HART Communication DTM and the other two are Moore Industries proprietary communication DTMs. These are the MISPP (Moore Industries Serial Port) DTM and the MIIP (Moore Industries Internet Protocol) DTM. The SLA only uses the MIIP DTM.

If you have a previous version of PACTware supplied by Moore Industries or other vendor or have a different FDT frame application that you utilize, you can download the SLA required **MIIP Communication DTM** and **SLA Device DTM** as separate files from our website.

Safety Logic Alarm

5.2.2 FDT/DTM Software Installation

In order to get started you will need to either install the PACTware software and DTMs or just install the DTMs (if you already have an FDT frame application installed). All the files you need can be found on our website www.miinet.com.

The PACTware installer file will install PACTware and all required communication DTMs. The SLA and other device DTMs need to be installed separately (see below).

PACTware_vxxx_FDT_DTM_Installation_Moore_Industries.exe

When you run the installer, you will have the option to select which components you want to install.



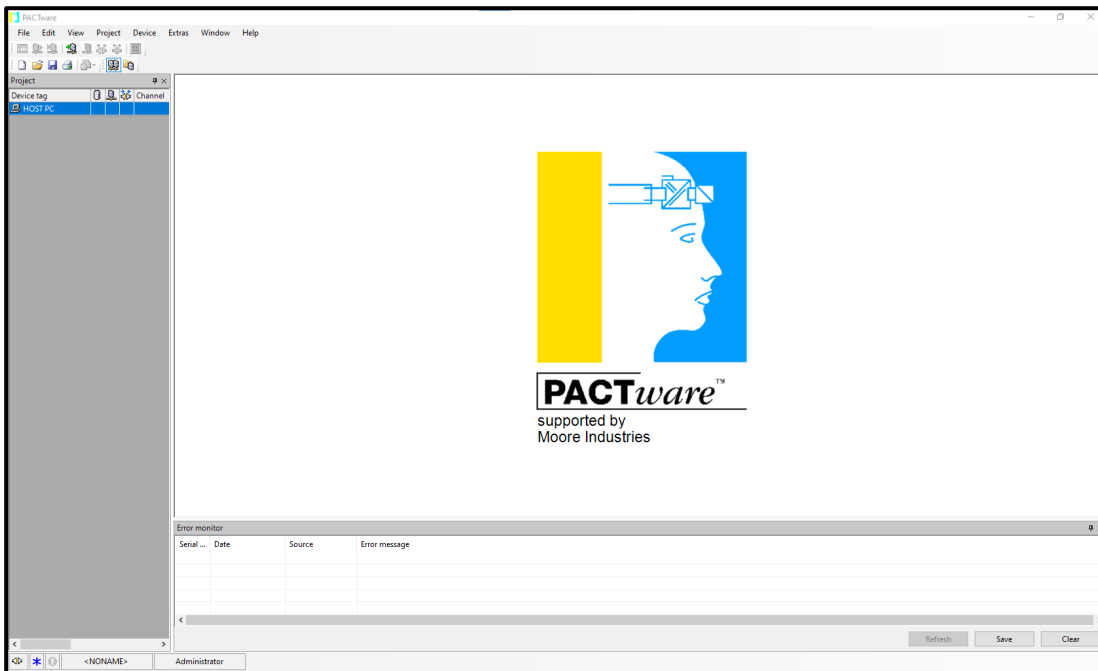
Note: Download the latest version of all software to assure compatibility.

5.2.3 Installing PACTware from Moore Industries

Click on the installer file **PACTware_vxxx_FDT_DTM_Installation_Moore_Industries.exe**, and follow prompts. This install will PACTware and all Moore Industries DTMs.

Individual DTM installers can be found on the Moore Industries website. Use these to install or update Moore Industries DTMs.

Figure 5.2 PACTware Home Page



Moore Industries MIIP and SLA DTM Installation

To communicate with the SLA you will need to install the MIIP Communications DTM. The MIIP DTM can be found on the Moore Industries website at www.miinet.com.

To install, simply locate the MIIP DTM installer file, double click and follow on-screen instructions.



Note: The MIIP Communications DTM utilizes Moore Industries Internet Protocol, which allows communication with the SLA via Ethernet.

5.2.4 Moore Industries SLA Device DTM Installation

To install the SLA device DTM simply download the installer file from the web site, double click file and follow on-screen instructions.

Once you have installed all the necessary DTMs on your system, you are now ready to launch the FDT frame application (PACTware) and configure your device.



Note: In order to connect to the SLA with your FDT application (i.e. PACTware), you will need to first ensure that you have installed the Moore Industries Network Address Configuration (NAC) Client Software. This software is used to set the SLA's IP address and other pertinent network settings, see Section **5.3.2 Locating SLA and Network Settings**.

5.3 SLA IP Address and Network Configuration

The SLA comes from the factory with DHCP enabled by default. Configuring the SLA for your local area network (LAN) is the first step in this process. Our Network Address Configuration (NAC) Client software will help you configure the SLA properly. Begin by installing the NAC Client software onto your PC.

The NAC Client software can be downloaded from the download center at www.miinet.com. Simply locate the SLA product page section and download the NAC Client installer file. Run the installer file and follow on-screen instructions.

The setup program may require you to upgrade certain Windows® components before it is installed.

Safety Logic Alarm

5.3.1 Fixed Network Settings or DHCP

To use the SLA on a given Ethernet network, three settings must be configured— IP address, gateway and subnet mask. The SLA comes with DHCP (Dynamic Host Configuration Protocol) enabled, allowing the network settings to be acquired automatically when the SLA is connected to a network with a DHCP server. It is strongly recommended that DHCP addressing not be permanently used. Fixed addresses should be obtained from your network system administrator. Use NAC Client to update the SLA to use the fixed settings.



Note: If the SLA is using DHCP at start up, the network address information displayed in the list box is how the SLA is currently configured. When you double-click to open the Edit window, the network settings boxes are disabled. You cannot set the IP address, subnet mask or gateway address manually if DHCP is enabled.



Caution: The use of DHCP network settings introduces the possibility of change or loss of IP address, caused by DHCP server outages or configuration specifics, or by an untimely power outage to the SLA. The use of fixed network settings in the SLA is recommended and avoids these potential problems.

5.3.2 Locating SLA and Network Settings

To locate and access the network settings of the SLA, run the NAC Client on a PC connected to the same network as the SLA or, if no network is available, connect a network cable between the Ethernet ports of the SLA and PC. No crossover cable is necessary.

1. Start the NAC Client Program.
2. Once the program is running, click **Find All**.
3. The NAC Client Program will list all Moore Industries Ethernet enabled devices on the network.
4. If more than one SLA is on the network, disconnect the network cable from the SLA in question, click **Find All** again and determine which SLA disappeared from the list.

Safety Logic Alarm

5.3.3 Changing SLA Network Settings

To change the SLA Network Settings:

1. Locate SLA you want to modify (see Section 5.3.2).
2. Double-click on that SLA. This will open a second window (**Figure 5.4**) where you can view and change all network settings.
3. Un-check the **DHCP Enabled** box.
4. Set **Static IP** address, **Subnet Mask** and **Gateway** settings.
5. Change **Name** and **Location** settings as desired.
6. Click **OK** when you are finished.

Figure 5.3 NAC Client Windows

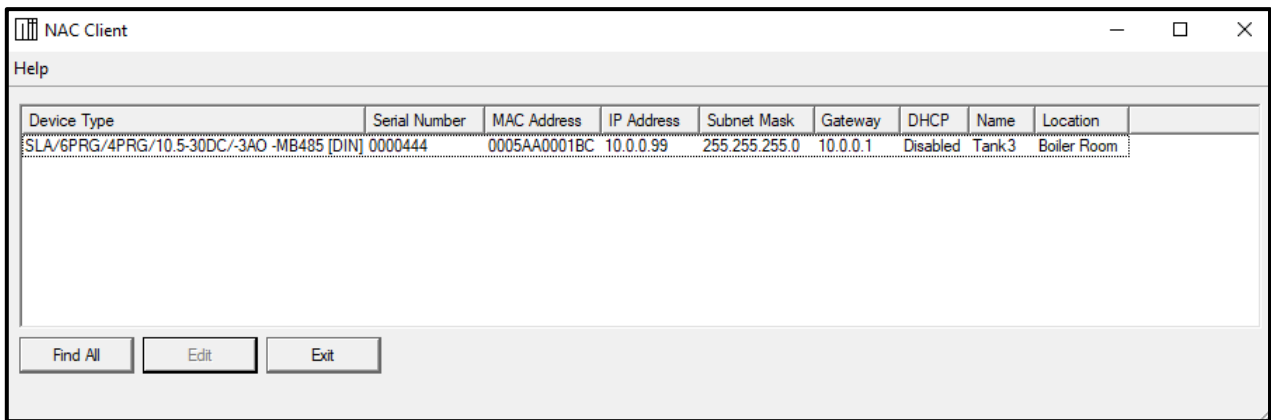
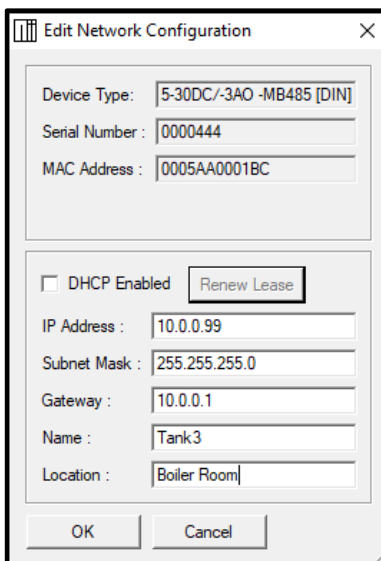


Figure 5.4 Edit Network Configuration Window



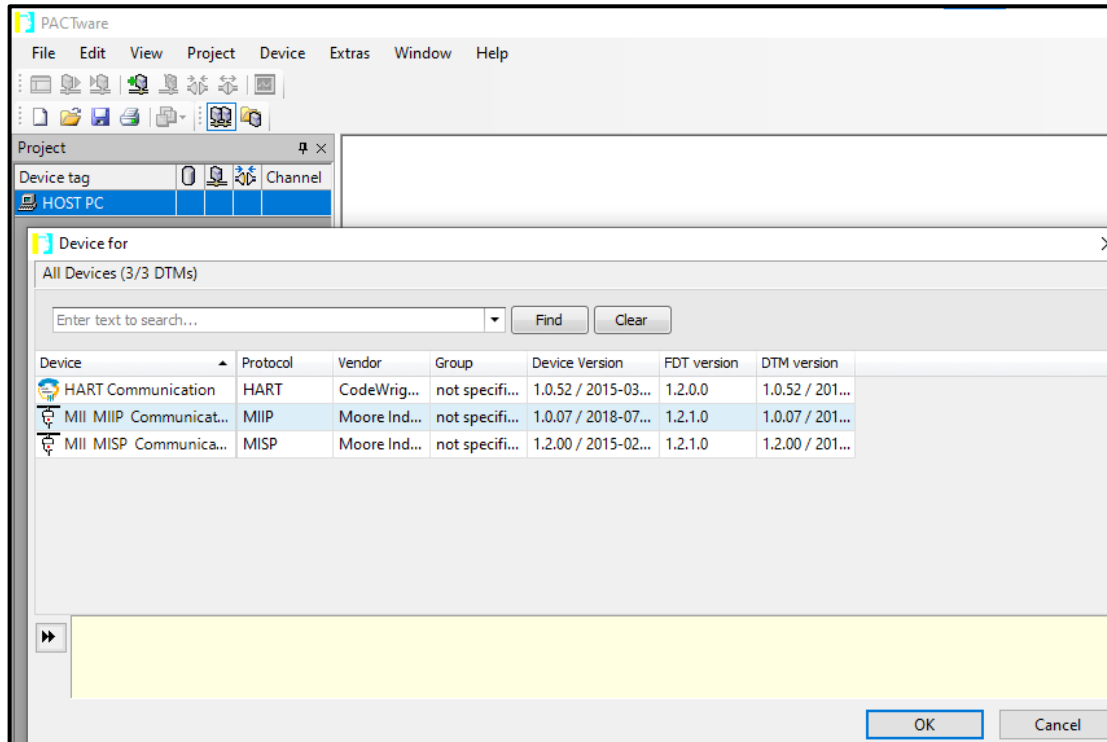
Safety Logic Alarm

5.4 User Configuration with DTM

Once you have installed all the necessary DTMs and have successfully configured the SLA's IP address (using NAC Client), you are now ready to launch the FDT frame application (e.g. PACTware), connect to the SLA and perform an on-line configuration.

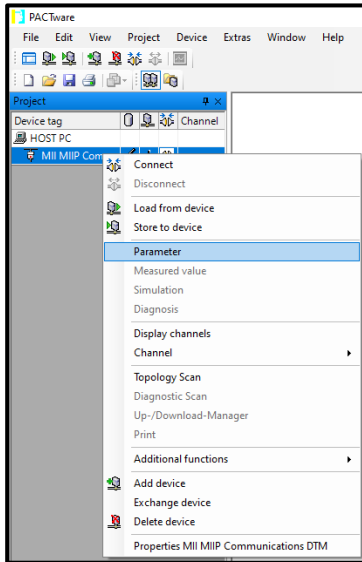
1. Launch the PACTware software and right-click on Host PC.
2. Click **Add Device** and select **MIIP Communications DTM**.
3. Click **OK**.

Figure 5.5 PACTware – Project Window



Safety Logic Alarm

4. Right click on **MII MIIP Communication DTM** and select **Parameter, Figure 5.6**.
5. Enter the IP address of the SLA device and click **Apply**. Your MIIP Communication DTM has now been configured.

Figure 5.6 PACTware – Configuring MIIP Communication DTM

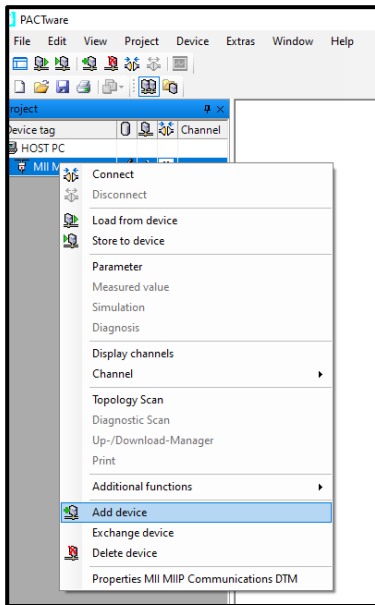
Safety Logic Alarm

5.4.1 Adding SLA Device

This section provides instructions about how to add the SLA to the MIIP DTM and connect the FDT frame application to the SLA device.

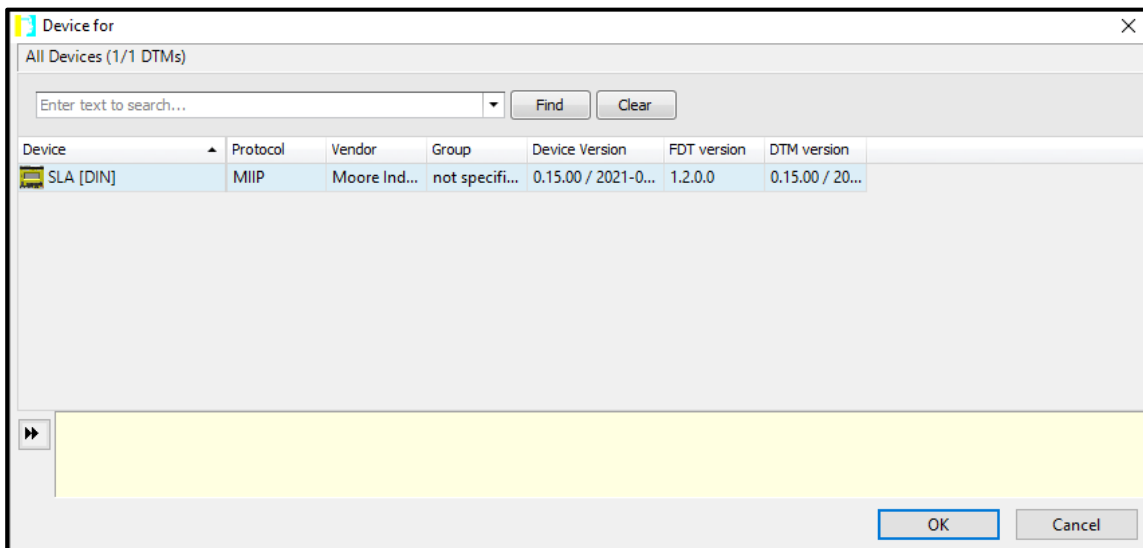
1. Right click on the **MII MIIP Communications DTM**.

Figure 5.7 PACTware – Adding a Device



2. Click **Add Device** and select **SLA**.

Figure 5.8 PACTware – Adding Device



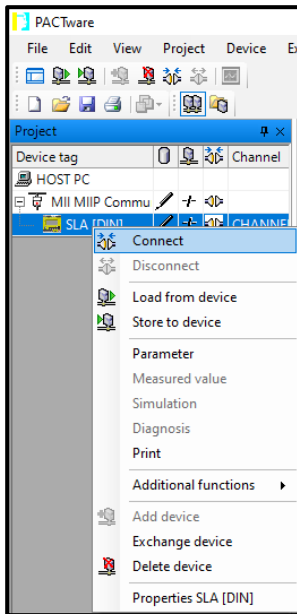
Safety Logic Alarm

5.4.2 Displaying and Uploading the SLA Configuration

This section provides instructions about how to connect to the SLA and upload its current configuration.

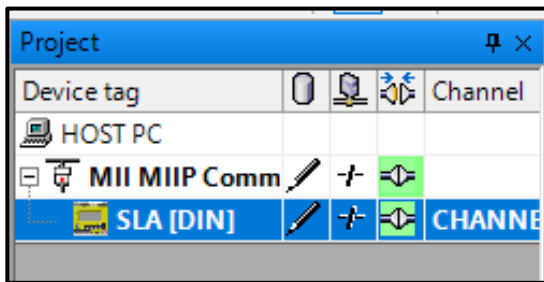
1. Right click on the SLA (selected DTM), and then select **Connect**.

Figure 5.9 PACTware – Connecting Device



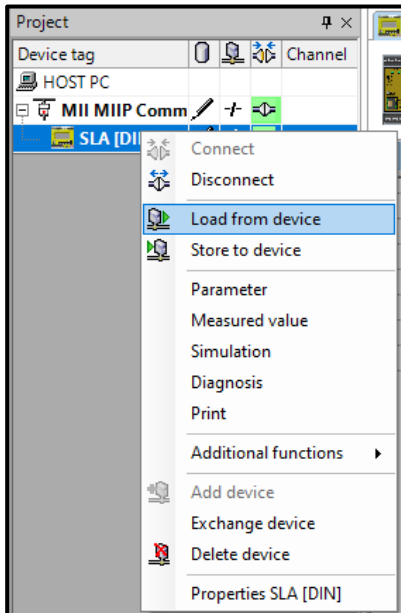
If your network settings in the MII MIIP Communication DTM and SLA are correct, a green box will appear around the connection symbols showing the device connected. If not, re-check network settings and repeat this step.

Figure 5.10 PACTware – Device Connected



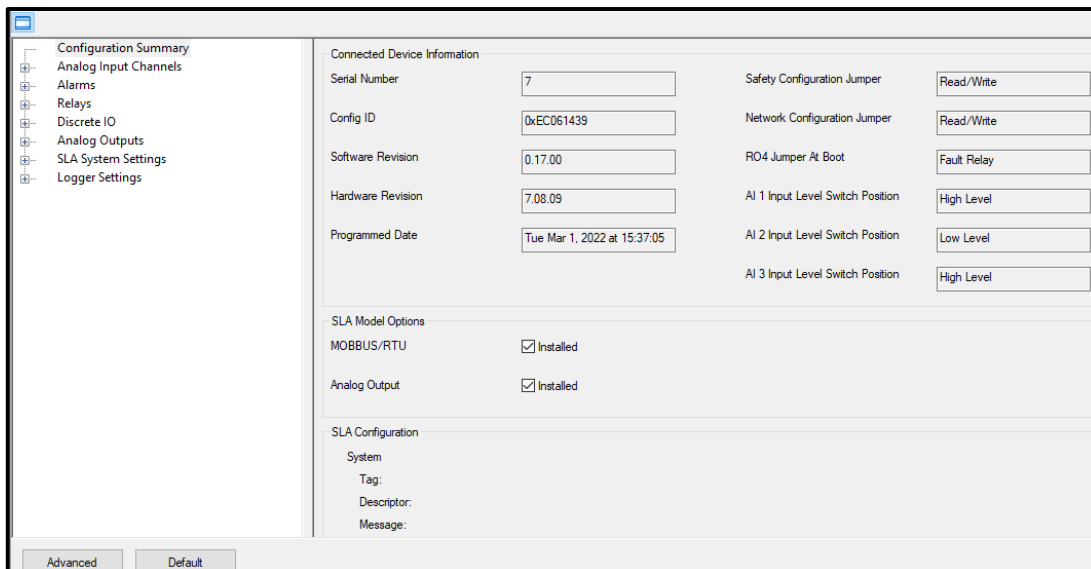
- Right click on the SLA, select **Load From Device**.

Figure 5.11 PACTware – Loading Parameters from a Device



- The SLA configuration is now uploaded and the **Configuration Summary** screen is ready to be displayed. Double click the SLA device in the project tree to view the Configuration Summary page.

Figure 5.12 PACTware – Configuration Summary Screen (Top Half)



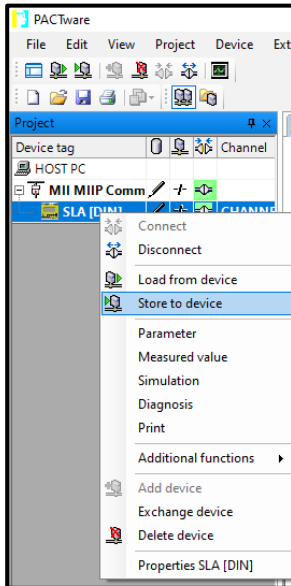
Safety Logic Alarm

5.4.3 Downloading the Configuration to the SLA (DTM)

Once you have finished configuring your unit, remember to download the new settings to your SLA. To save the configuration to the SLA:

1. Connect to the SLA device, and then right-click on the **SLA**.
2. Select **Store to Device**.

Figure 5.13 PACTware – Storing to Device



5.4.4 Saving the Configuration File to a Location

1. Click on the **File** Menu, and then click **Save as**.
2. Select a location to save and name the file, click **Save**.
3. Access the web page to verify the configuration and check the MODBUS register locations.

Safety Logic Alarm

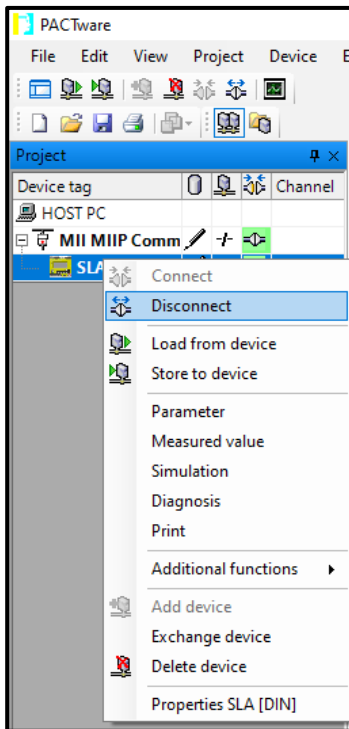
5.4.5 Disconnecting the SLA

Before closing your FDT frame application (PACTware) it is recommended to disconnect all SLA devices.

To disconnect:

1. Right click on MIIP Communication DTM.
2. Click **Disconnect**.

Figure 5.14 Disconnecting SLA



5.4.6 Offline Configuration

Once the DTM is installed, the SLA configuration can also be set up offline (no SLA connected).

Before configuring you should check the correct options (AO and/or MODBUS RTU), input levels and Fault Relay settings are selected for the target SLA. The SLA DTM default is that all options are fitted, Analog Input (AI) channels are configured for High Level (ma/V inputs) and **RO4** is configured as a Fault Relay.

6 SLA Configuration – Basic DTM Settings

Once you have added and connected the SLA with PACTware, you are ready to make the configuration changes to device parameters that best fit your needs. There are two configuration views within the DTM, **Basic** and **Advanced**. By default, you will be shown the **Basic** Setup, which will provide configuration appropriate for most applications.

If you need to configure the advanced features such as **equations, timers, custom curves** etc., you will need to select the **Advanced** Setup menu by clicking on the **Advanced** button on the bottom left of the window. To view Advanced Setup features and functions see the SLA **Advanced** Settings later in this section.



Note: The **Advanced** Setup menu contains all the **Basic** Setup plus the advanced features, so the following **Basic** Setup description is applicable to **Advanced** Setup also.

6.1 Parameter Menu Configuration

There are eight main menu items, including the **Configuration Summary** section referred to above. Clicking on each of the options shows a summary of the specific parameters for the SLA (e.g. clicking on **Alarms** will list all the alarm configurations). Clicking on the **+** next to each item will show subpages which are used for configuring the SLA parameters.

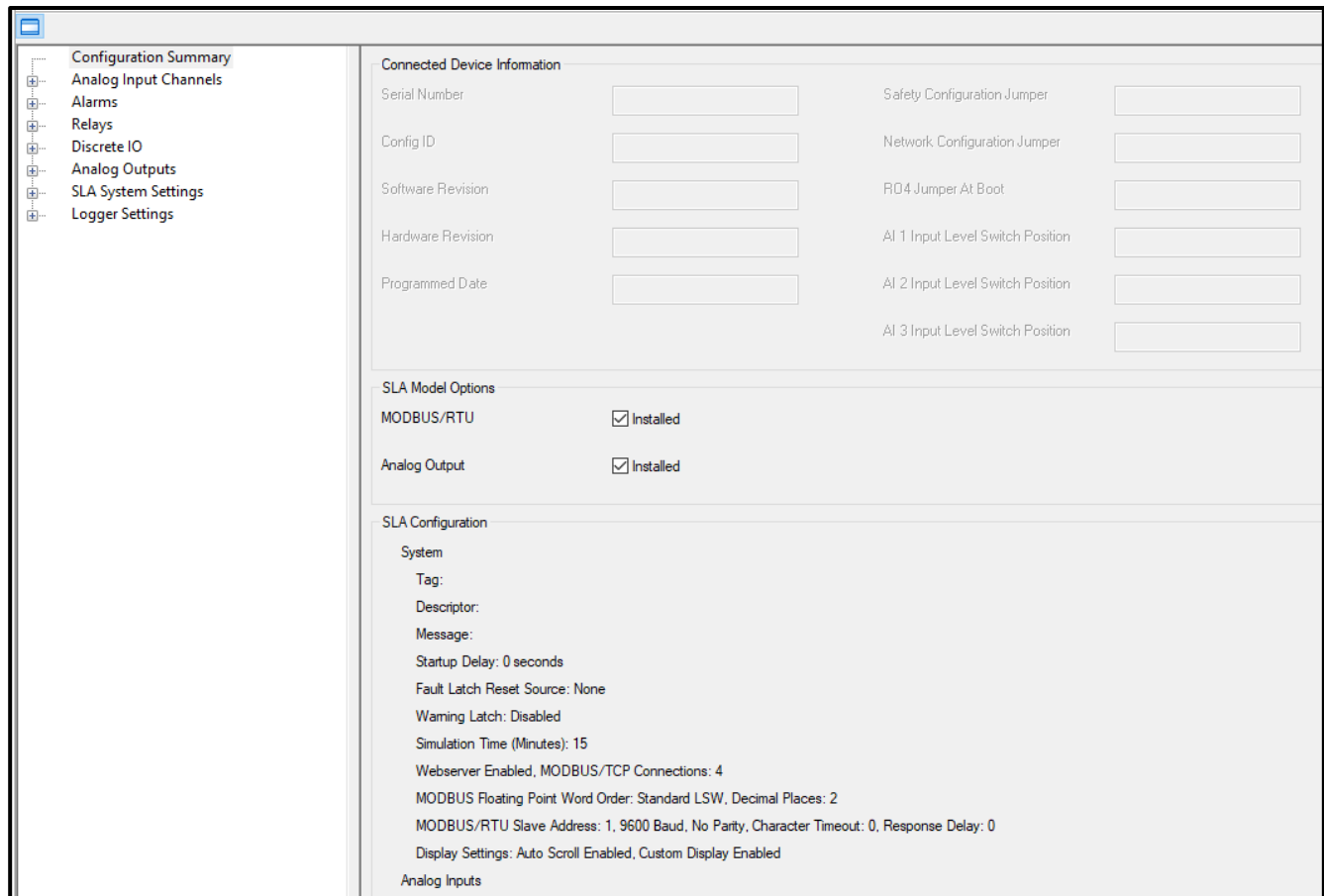
- **Configuration Summary** - Displays a summary of the SLA's configuration and model option information. Refer to the Configuration Summary section for a complete description.
- **Analog Input Channels** - Allows you to configure the Analog Input parameters. Refer to the *Analog Input Channels* section for a complete description.
- **Alarms** - Alarm parameters are configured here. Refer to the *Alarms* section for a complete description.
- **Relays** - Allows you to configure Relay Outputs. Refer to the *Relays* section for a complete description.
- **Discrete I/O Digital Channels** - Each channel can be configured as a Digital Input or Output. Refer to the *Discrete I/O* section for a complete description.
- **Analog Outputs** - If the -3AO option is fitted, configuration of the Analog Outputs is performed here. Refer to the *Analog Output* section for a complete description.
- **SLA System Settings** - include the General Settings, Network Security Settings, MODBUS Settings and Display Settings is performed here. Refer to the *SLA System Settings* section for a complete description.
- **Logger Settings** - Enable/disable the logger and select events to be logged. Refer to the *Logger Settings* section for a complete description.

6.2 Configuration Summary Screen

Configuration Summary Provides a summary for your entire SLA configuration including the Config ID and last programmed date of the unit (only available when the unit is connected). It also identifies what options are installed (**-3AO** and/or **-MB485**) in the SLA. This is automatically populated when uploading an SLA configuration. If you are using the DTM offline, both options are enabled by default but can be manually selected/deselected using the checkboxes.

The PACTware configuration summary screen displays detailed information about the SLA unit.

Figure 6.1 PACTware – Configuration Summary Screen



6.3 Analog Input Channels

The SLA has a total of three Analog Input Channels. Each channel has two available Analog Inputs.

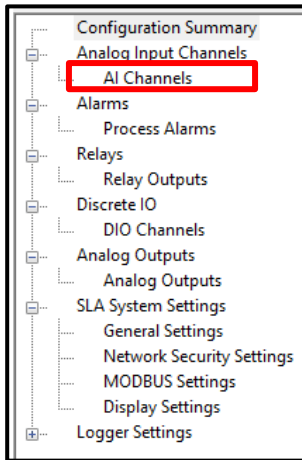
Analog Inputs for the same channel must be the same **Input Type** (Low or High). However, each separate channel can have different Input Types.

Safety Logic Alarm

6.3.1 Analog Input Channels: AI Channels

In the lefthand window of the SLA DTM, click + next to **Analog Input Channels** and select **AI Channels** to configure your Analog Inputs.

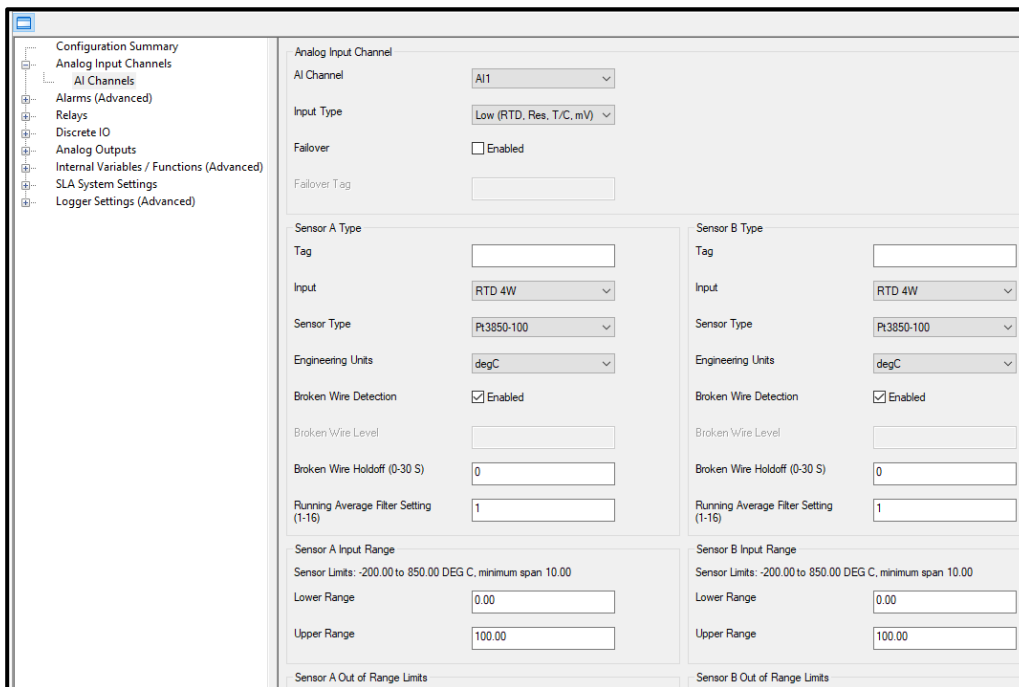
Figure 6.2 PACTware – Analog Input Channels



6.3.2 Analog Input Configuration

You can configure the Analog Input using the PACTware program.

Figure 6.3 PACTware – Analog Input Configuration Screen (Upper-half)



Safety Logic Alarm

AI Channel— Select which analog input channel you would like to configure, AI1, AI2 or AI3.

Input Type— Select your input type. Low is for a temperature sensing element (RTD, Resistances, T/C, mV). High is for either a voltage (V) or current input (mA).



Note: If connected to an SLA, the input type will reflect the input switch settings on the unit. When downloading to an SLA the configuration will be downloaded and the input type checked against the switch settings. A configuration error will occur if they do not match. This can be corrected by changing the switch settings or input type configuration.

Failover— Select Failover if you want sensor AI1B to be the backup sensor for AI1A. When Failover is selected and sensor AI1A fails, the SLA will automatically use AI1B in its place.



Note: If failover is selected then the two inputs must result in the same engineering units and range. They can be identical or different sensor types with the same units or different units scaled to the same units and range.

Tag— 20 character freeform field for the Analog Input Tag name.

Input— Select the type of input, RTD, resistance, mV, thermocouple or potentiometer for **Low Input Type**. Select current (mA) or voltage (V) for *High Input Type*.



Note: Each AI channel allows for two analog inputs (Sensor A & Sensor B). If you would like to use only one sensor, choose Not Used as your Input selection for the unused Sensor A or Sensor B, to turn off input diagnostics for that unused sensor.

Sensor Type— For temperature inputs, select your sensor from the dropdown menu of choices. All other input types have sensor type automatically assigned.

Engineering Units— Select the engineering units for your temperature measurement. All other input types have engineering units automatically assigned.

Broken Wire Detection- The Broken Wire feature can be enabled or disabled.



Warning: For safety applications, **Broken Wire Detection** must be enabled, which turns on sensor failure diagnostics.

Broken Wire Level— Used with V and mA inputs, this is the threshold defining input failure. When the input drops below this threshold, the input will be declared broken. This threshold must be less than or equal to the input Lower Range value.



Warning: Broken Wire Detection will be automatically disabled if the Lower Range Value (LRV) is set to zero.

Broken Wire Holdoff (0.0-60.0secs)— This adds a time delay before broken wire is declared, which can provide some noise immunity and prevent false alarms caused by other factors that may be misinterpreted as a broken wire.

Running Average Filter Setting (1-16)— This function is for filtering a noisy input signal. The SLA has a running average filter with a user-selected range between 1 and 16.



Note: A higher Running Average Filter setting provides smoother output transitions; however, increases response time. Conversely, a lower setting provides a faster response time, but may seem more unstable.

Figure 6.4 PACTware – Analog Input Configuration (lower half of screen)

The screenshot displays the lower half of the PACTware configuration interface. On the left is a navigation tree with the following items: Configuration Summary, Analog Input Channels, Alarms (Advanced), Relays, Discrete IO, Analog Outputs, Internal Variables / Functions (Advanced), SLA System Settings, and Logger Settings (Advanced). The main area is divided into two columns for Sensor A and Sensor B. Each column contains the following sections:

- Sensor Input Range:** Sensor Limits: -200.00 to 850.00 DEG C, minimum span 10.00. Lower Range: 0.00. Upper Range: 100.00.
- Sensor Out of Range Limits:** Out of Range Zero (0-5%): 2.00. Out of Range Full (0-5%): 2.00.
- Sensor Input Scaling / Custom EGU:** Scaling: Enabled. Scaled Zero: [text box]. Scaled Full: [text box]. Scaling Engineering Units: [dropdown menu]. Use Custom EGU: Enabled. Custom EGU: [text box].
- Sensor Faults and Warnings:** Input Faults: Latch Enabled. Latch Reset Source: [dropdown menu]. Input Warnings: Latch Enabled. Latch Reset Source: [dropdown menu].

Sensor Input Range— Allows you to set your Lower Range and Upper Range values within the range of the chosen Input.

Sensor Out of Range Limits (0-5%)— Allows you to independently set the low limit and high limit where the SLA declares your input Out-of-Range. Each can be set 0-5% of input span.



Warning: For safety applications, the sensor Out of Range value must be set to 2% or less.

Sensor Input Scaling/Custom EGU— This allows you to scale the input to a different range or engineering unit. For example: if your process is sending a 4-20mA signal to the SLA and you wish to use the input as 0-100% then this can be accomplished with the Scaling feature.

1. Click **Scaling Enabled** from the **Mode** dropdown menu.
2. Enter the values when your Input is at Scaled Full and Scaled Zero.
3. Select the engineering units from the dropdown **Scaling Engineering Units** menu.

Custom EGU— This allows you to assign a custom label, or EGU (Engineering Unit), which may not be available under the Scaling Engineering Units option.

1. Click **Enabled** for the Use Custom EGU checkbox.
2. Enter the custom label you would like to use in the **Custom EGU** field.

Sensor Faults and Warnings— Analog Input diagnostic faults and warnings can be set to latch or not latch. If input faults and warnings are not latched, they will clear automatically once the Analog Inputs are valid. If input faults and warnings are latched, they can be set to clear by any discrete inputs or variables.

If you do not want to latch your analog input faults and/or warnings, leave the Input Faults and/or Input Warnings checkboxes unchecked.

If you want to latch your Analog Input faults and/or warnings, perform the following steps:

1. Click **Latch Enabled** for the Input Faults and/or Input Warning checkboxes.
2. Select which discrete variable you would like to use for the Latch Reset Source from the dropdown list. If None is selected, the SLA will need to be power cycled to reset the latched fault or warning.



Note: Only enabled discrete variables (discrete inputs, alarms, timers, internal variables) will be available to select for latch reset source.

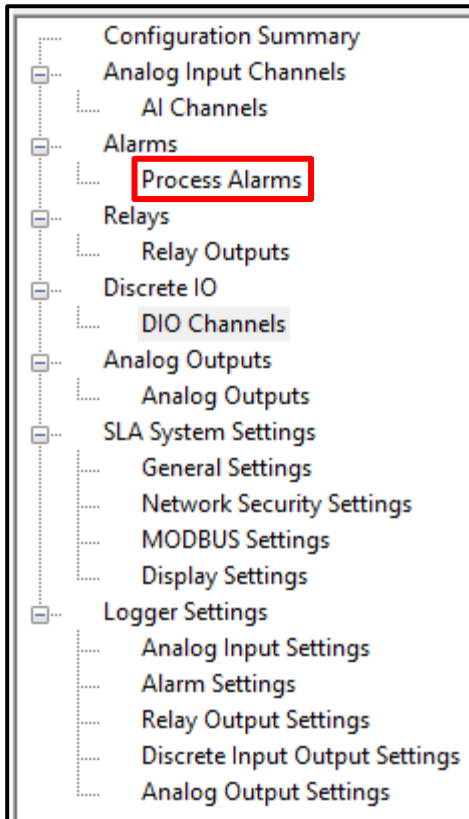
Safety Logic Alarm

6.4 Alarms

The SLA has 16 available Alarms. If no alarm input and/or source data is configured, the alarm is disabled and the alarm state set to FALSE.

6.4.1 Alarms: Process Alarms

Figure 6.5 PACTware – Process Alarms



From the lefthand window of the SLA DTM, select Process Alarms under Alarms to configure up to 16 available alarms.

6.4.2 Alarm Configuration for All Alarms

The following configuration settings are applied to all alarm types. After choosing which alarm and type of alarm you would like to configure, some menu choices will change accordingly. The unique configuration settings for each alarm type are explained separately in their respective sections.

Alarms and their current states are free floating in memory until tied to a relay output, discrete output, equation (Interval Variable) or latching reset function.

Safety Logic Alarm

Figure 6.6 PACTware – Alarm Configuration

Alarm— Select which alarm you would like to configure (1-16).

Alarm Type— Select your alarm type. Choose between **Trip**, **Band**, **Rate of Change**, **Stuck Input**, and **Discrete** (see Section 2.9 **Alarms, Faults and Failsafe Terminology** for an explanation of the different alarm types).

Tag— Select the label or shorthand name for your alarm, 20 characters.

High Availability vs. High Integrity— Select **High Availability** or **High Integrity** depending on the critical nature and operational needs of your process. In high availability mode the alarm will hold its current state if its input is bad (e.g. it has a broken wire). In **High Integrity** Mode, the alarm will trip if it has a bad input.



Note: **High Availability** vs. **High Integrity** is not applicable to discrete alarms.

Additional Startup Delay (0, 10-600s)— Set in increments of 1 second. This allows you to select an additional startup delay for the alarm, to allow the process input to stabilize. This delay occurs after an SLA power cycle or a reconfiguration of the unit. During the delay, all *Alarms* are suppressed (held in non-alarm state).



Note: This delay is in addition to the SLA startup delay set in system settings.

Delay (0 to 120s)— When your unit is in an alarm condition, the delay is the amount of time you set to elapse before an alarm trips. This can be set in increments of 1 second.

Safety Logic Alarm

Latching— Alarms can be set to latch or not latch. If Trip Alarms are not latched, they will clear automatically once the inputs reach the reset point (trip point plus Deadband). If Trip Alarms are latched, any discrete inputs or variables can be configured as a reset signal. To latch your Alarm, follow these steps:

1. Click the **Enabled** checkbox under **Latching**.
2. Select which discrete variable you would like to use for the **Latch Reset Source** from the dropdown list. If **None** is selected, then the SLA will need to be power cycled to reset the latched alarm.

Suppress— Alarms can be suppressed from occurring by a discrete input or variable, such as another alarm or timer. To suppress your Alarm, select which discrete variable you would like to use for your **Suppress Source** from the dropdown list.



Warning: Using suppression on alarms is **NOT** recommended for safety functions. Use startup delay instead to suppress alarms during system initialization.

6.4.3 Alarm Configuration for Trip Alarms

Use the PACTware program to configure Trip Alarms.

Figure 6.7 PACTware – Alarm Configuration for Trip Alarms

Alarm Source— Select any analog input or analog internal variable (IV) to track for your alarm.

Alarm Mode— Select High Alarm to track when the alarm goes above the Trip Point and Low Alarm to track when your alarm goes below the Trip Point.

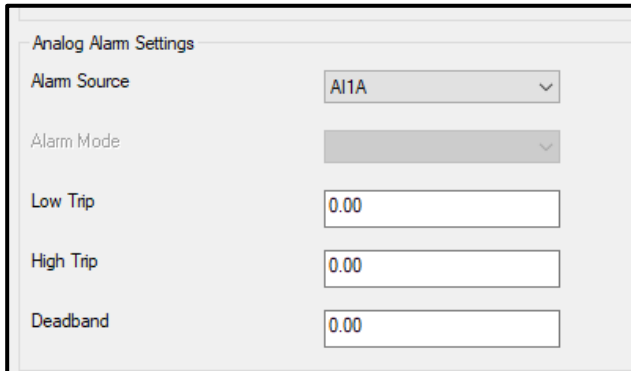
Trip Point— Select the input level at which you want your *Alarm* to trip.

Deadband— Deadband is the reset point of the alarm and it is expressed as the deviation from trip point. To reset the alarm, the input needs to travel past the trip point plus the deadband.

Safety Logic Alarm

6.4.4 Alarm Configuration for Band Alarms

Figure 6.8 PACTware – Analog Alarm Settings



Analog Alarm Settings	
Alarm Source	AI1A
Alarm Mode	
Low Trip	0.00
High Trip	0.00
Deadband	0.00

Alarm Source— Select any analog input or analog internal variable (IV) to track for your *Alarm*.

Low Trip— Select the low input level at which you want your *Alarm* to trip.

High Trip— Select the high input level at which you want your *Alarm* to trip.

Deadband— Deadband is the reset point of the alarm and it is expressed as the deviation from trip point. To reset the alarm, the input needs to travel past the trip point plus the deadband.

Safety Logic Alarm

6.4.5 Alarm Configuration for Rate of Change Alarms

Figure 6.9 PACTware – Alarm Configuration for Rate of Change Alarms

Analog Alarm Settings	
Alarm Source	AI1A
Alarm Mode	Rise and Fall
Delta	0.00
Delta Time (0-60 S)	0.00
Deadband	0.00

Alarm Source— Select any analog input or analog internal variable (IV) to track for your alarm.

Alarm Mode— Select **Rise**, **Fall**, or **Rise and Fall** for your Rate of Change alarm type.

- Rise Alarm will trip when the input is rising too fast.
- Fall Alarm will trip when the input is falling too fast,
- Rise and Fall Alarm will trip when the input is rising or falling too fast, beyond a user-selected amount (Delta) over a user-selected time period (Delta Time). The input Delta over the Time Delta forms the Trip Point slope.

Delta— Select the change in value of your input. The **Delta** shall be configurable as a constant or analog variable with a restricted range based upon the **Alarm Mode**:

- Rise: any value greater than 0.0.
- Fall: any value smaller than 0.0.
- Rise/Fall: any value greater than 0.0 (which is applied to the absolute value of the measured Rate of Change).

Delta Time— Select the time period over which you want to measure your input. The Delta Time is configurable as a constant from 1 to 60 seconds.

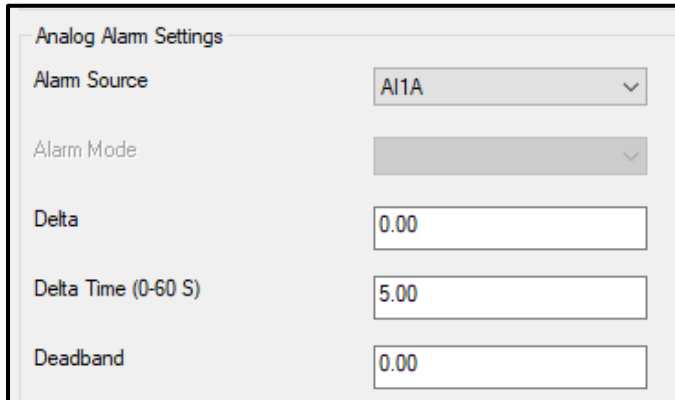
Deadband— Deadband is the reset point of the alarm and it is expressed as the deviation from the Delta. To reset the alarm, the input needs to travel past the Delta plus the deadband.

- *RoC Rise* (user delta is always positive): $\text{delta} - \text{deadband}$.
- *RoC Fall* (user delta is always negative): $\text{delta} + \text{deadband}$.
- *RoC Rise/Fall* (user delta is always positive): if was rising: $\text{delta} - \text{deadband}$ and if it was falling: $-(\text{delta} - \text{deadband})$.

Safety Logic Alarm

6.4.6 Alarm Configuration for Stuck Input Alarms

Figure 6.10 PACTware – Alarm Configuration for Stuck Alarms



Analog Alarm Settings	
Alarm Source	AI1A
Alarm Mode	
Delta	0.00
Delta Time (0-60 S)	5.00
Deadband	0.00

Alarm Source— Select any analog input or analog internal variable (IV) to track for your *Alarm*.

Delta— Select the expected change in value of your input. For stuck input alarms, the Delta shall be configurable as a constant or analog variable for any positive value greater than 0.0.

Delta Time— Select the time period over which you want to measure your input. The Delta Time shall be configurable as a constant from 0 to 60 seconds.

Deadband— Deadband is the reset point of the alarm and it is expressed as the deviation from the Delta. To reset the alarm, the input needs to travel past the Delta plus the deadband.

- *Stuck Input* (user delta is always positive): delta + deadband

6.4.7 Alarm Configuration for Discrete Alarms

Figure 6.11 PACTware – Alarm Configuration for Discrete Alarms.

Discrete Alarm Settings	
Voting	1
Out Of	3
Source 1	DO1
Source 2	DI3
Source 3	Not Used
Source 4	ANY INPUT FAULT
Source 5	Not Used
Source 6	Not Used
Source 7	Not Used

Source— Select the input sources for your Discrete Alarm (up to 8 input sources may be defined). In addition to other alarms the input sources can be any discrete variables (i.e. equations, timers, relays, DIOs) or system and input faults and warnings.



Note: If no source data is configured, the alarm shall be disabled and the alarm state set to False.

Voting Selection (XooY)— Select your voting preference, where Y is the total number of Sources selected and X is any number from 1 to Y. For example, if you have selected 6 input sources to be evaluated and you want the Discrete Alarm to be true only if 4 of the 6 inputs are true, then your voting is 4oo6 or 4 out of 6.



Note: During operation, discrete alarms shall apply voting to the Source Data then use delay, latch and suppress values to determine the alarm state.

Safety Logic Alarm

6.5 Relay Outputs

The SLA has four available *Relay Outputs*. Relays 1-3 are available as *Process* relays.

Relay 4 (RO4) is selected as a *Fault* relay by default (jumper uninstalled). If it is a Fault relay then the following additional requirements apply:

- Relay mode shall be fixed as failsafe.
- System faults shall always be selected for RO4.
- All hardware faults shall be wired directly to RO4 only.

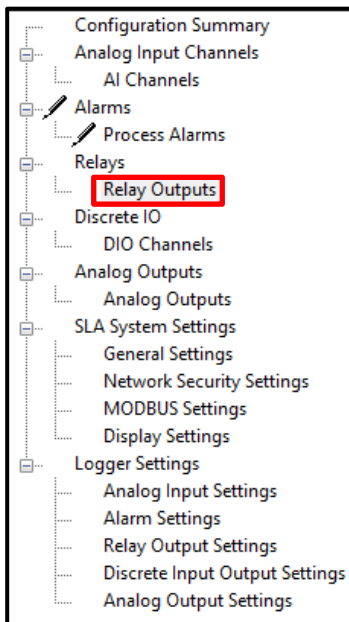
If you wish to utilize RO4 as an additional process relay, the “No Fault Relay jumper” should be installed. In this case, the hardware faults will be disconnected from RO4.



Warning: For safety applications, it is recommended to use **RO4** as a Fault relay.

The Relay Output configuration is available for configuration from the PACTware program.

Figure 6.12 PACTware – Relay Output

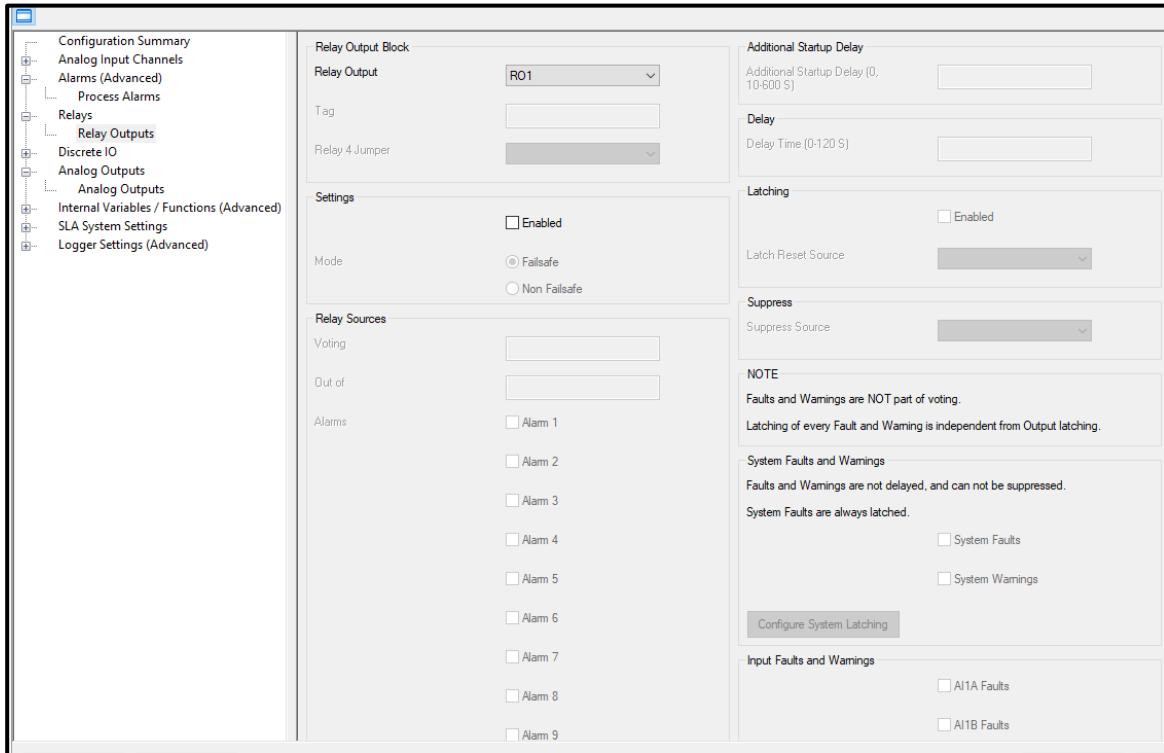


In the lefthand window of the SLA DTM, click on the + next to **Relays** and select **Relay Outputs** to configure.

6.5.1 Relay Output Configuration

You can configure the Relay using the PACTware program.

Figure 6.13 PACTware – Relay Output Configuration



Relay Output— Select which one of the four available relay outputs you want to configure, and then checkmark Enabled.

Tag— Select the label or shorthand name for the relay output, 20 characters.

Mode— Select whether you want your relay output to be configured as Failsafe (de-energized to trip) or Non-Failsafe (energized to trip).

- Failsafe mode: a TRUE state shall open NO contacts and close NC contacts and a FALSE state shall close NO contacts and open NC contacts.
- Non-Failsafe mode: a FALSE state shall open NO contacts and close NC contacts and a TRUE state shall close NO contacts and open NC contacts.

Voting Selection (XooY)— First, select each of the 16 Alarms that you want included in the Voting scheme for this relay. Then in the Voting field set the number of Alarms that must be true in order to make the Relay true. X can be from 1 to Y.

Safety Logic Alarm

Additional Startup Delay (0, 10-600s)— Set in increments of 1 second. This allows you to select an additional startup delay for a *Relay Output*, to allow the process input to stabilize. This delay occurs after an SLA power cycle or a reconfiguration of the unit. During the delay, all Relay Outputs are suppressed (held in non-alarm state).



Warning: This delay is in addition to the SLA startup delay set in system settings.

Delay (0 to 120s)— When a relay output is in an alarm state, the delay is the amount of time you set to elapse before the relay energizes. This can be set in increments of 1 second.

Latching— Relay Outputs can be set to latch or not latch. If Relay Outputs are not latched, they will clear automatically once the alarm voting and selected faults and warnings are FALSE. If Relay Outputs are latched, they can be set to clear by any discrete inputs or variables. To latch your Relay Output, follow these steps:

1. Click the Enabled checkbox under **Latching**.
2. Select which Discrete variable you would like to use for the **Latch Reset Source** from the dropdown list. If **None** is selected, then the SLA will need to be power cycled to reset the latched fault or warning.

Suppress— Relay outputs can be suppressed from occurring by a discrete input or variable, such as another alarm or timer. To suppress your relay output, select which discrete variable you would like to use for your Suppress Source from the dropdown list.



Warning: Using suppression on relay outputs is **NOT** recommended for safety. Use startup delay instead to suppress relay outputs during system initialization.

Faults and Warnings- System and Input Faults and Warnings can be selected for the Relay in addition to or instead of the alarm voting. They are not part of the voting so if any selected fault or warning is TRUE this will set the Relay Output TRUE.

System Faults and Warnings— Click the **System Faults** and **System Warnings** checkboxes if you wish to apply these to your relay output.



Note: Using suppression on relay outputs is **NOT** recommended for safety. Use startup delay instead to suppress relay outputs during system initialization.

Input Faults and Warnings— Faults and Warnings for any and all of the six available Analog Inputs can additionally be selected to activate this relay. In summary, a relay can be defined to be true based upon Alarm Voting OR System Faults and Warnings OR Input Faults and Warnings.

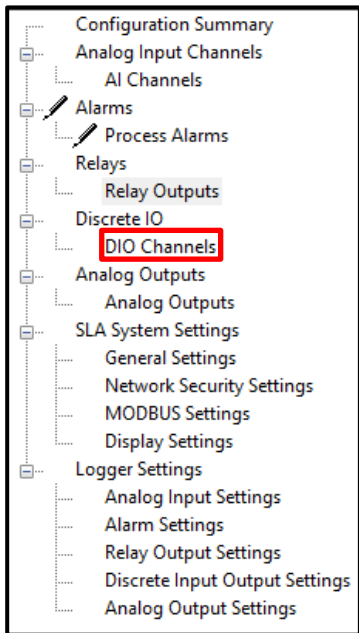
Safety Logic Alarm

6.6 Discrete I/O

The SLA has four available Discrete I/Os, each one configurable as either an input or output.

In the lefthand window of the SLA DTM, click + next to **Discrete I/O** and select **DIO Channels** to configure.

Figure 6.14 PACTware – Discrete I/O Channels



Safety Logic Alarm

6.6.1 Discrete I/O Configuration

The following configuration settings will be performed for all Discrete I/Os. Once you have chosen whether you want to configure an input or output, the configuration options will change for each. Their unique configuration settings are explained separately in respective sections.

Figure 6.15 PACTware – Discrete I/O Configuration Window

Discrete Input/Output— Select which one of the four available Discrete I/Os you want to configure, then under Settings checkmark Enabled checkbox.

Tag— Select the label or shorthand name for your Discrete I/O, 20 characters.

Data Direction— Select whether you want this DIO to be a discrete input or output.

Discrete Input Configuration

Figure 6.16 PACTware – Discrete Input Configuration Window

Mode— Select whether you want your Discrete Input to be configured as Failsafe or Non-Failsafe.

- In failsafe mode, an open input shall have a logic value of 1 and a closed input shall have a value of 0.
- In Non-Failsafe mode, an open input shall have a logic value of 0 and a closed input shall have a value of 1.

Input Debounce Time (5 to 100mS)— Each *Discrete Input* shall support a configurable delay from 5 to 100mS for debounce to prevent contact bounce from being interpreted as a switching input. Write in your preferred delay time here.

Discrete Input Scan Time Requirements

When a Discrete I/O channel on the SLA is configured for an Input type, the SLA must have sufficient time to scan and process the Discrete Input's ON to OFF or OFF to ON transition state. Generally speaking, the input's new state must hold for at least 200 mS to guarantee it is applied to the application. There is a subtle difference between if the input is being used in a level or edge sensitive way. Some examples:

Unlatching an alarm is a level sensitive operation. If the Latch Reset Source is a DI, it must remain TRUE for at least 200 ms to guarantee it is properly processed. If it were to go FALSE for a short time (e.g. 50 mS) and then again TRUE, the SLA may fail to process that it was FALSE. However, since it goes TRUE again there is no harm in missing the transition to FALSE for this scenario.

Resetting a timer is an edge sensitive operation. If the timer is configured to Reset on a Rising Edge, the fact that it is FALSE must be properly detected by the system. Consider the scenario: The DI starts FALSE, goes TRUE for ≥ 200 mS, goes FALSE for ~ 50 mS, and then goes and stays TRUE. Since the FALSE input was < 200 mS, the system may not detect it, and then would not apply the second timer Reset.

A set of custom equations may make a comparison between the DI's current state and previous state and react in some way. If the DI change happens too quickly, the user's logic may not behave as desired.

Ensuring that changes in DI state last at least 200 mS, regardless of application type, will allow the SLA to correctly recognize and process the change.

Discrete Output Configuration

The Discrete Output Configuration window allows you to configure the Discrete Output. The DO is an open collector with a maximum rating of 30V.

Figure 6.17 PACTware – Discrete Output Configuration

Mode— Select whether you want your *Discrete Output* to be configured as “Failsafe” or “Non-Failsafe.”

- In Failsafe mode, a logic value of 0/False/Non-Alarm will drive the DO to 0V and a logic value of 1/True/Alarm will pull High.
- In Non-Failsafe mode, a logic value of 0/False/Non-Alarm will pull High and a logic value of 1/True/Alarm will drive to 0V.

6.6.2 Discrete Output Diagnostics

Output Diagnostic Enabled / Disabled: Enables intermittent Output Diagnostic Pulses. This tests if the SLA is in control of the output line.

Diagnostic Pulse Width: Input the pulse width between 500 and 2000 μ S. The SLA pulses this DO every 20S to confirm the DO is controllable.



Warning: For safety applications, the discrete output diagnostic must be enabled.

Voting Selection (XooY)— First, select each of the 16 Alarms that you want included in the Voting scheme for this Discrete Output. Then in the Voting field set the number of Alarms that must be true in order to make the DO true. X can be from 1 to Y.

Additional Startup Delay (0, 10-600s)— Set in increments of 1 second. This allows you to select an additional startup delay for discrete outputs, to allow the process input to stabilize. This delay occurs after an SLA power cycle or a reconfiguration of the unit. During the delay, all discrete outputs are suppressed (held in non-alarm state).



Note: This delay is in addition to the SLA startup delay set in system settings.

Delay (0 to 120s)— When a Discrete Output is in an alarm state, the delay is the amount of time you set to elapse before the output sends a signal. This can be set in increments of 1 second.

Latching— Discrete Outputs can be set to latch or not latch. If Discrete Outputs are not latched, they will clear automatically once the alarm voting and selected faults and warnings are FALSE. If Discrete Outputs are latched, they can be set to clear by any discrete inputs or variables. To latch your Discrete Output, follow these steps:

1. Click the **Enabled** checkbox under **Latching**.
2. Select which discrete variable you would like to use for the **Latch Reset Source** from the dropdown list. If **None** is selected, then the SLA will need to be power cycled to reset the latched fault or warning.

Suppress— Discrete outputs can be suppressed from occurring by a discrete input or variable, such as another alarm or timer. To suppress your discrete output, select which discrete variable you would like to use for your Suppress Source from the dropdown list.

Safety Logic Alarm



Warning: Using suppression on discrete outputs is NOT recommended for safety. Use startup delay instead to suppress discrete outputs during system initialization.

Faults and Warnings— System and Input Faults and Warnings can be selected for the discrete output in addition to or instead of the alarm voting. They are not part of the voting so if any selected Fault or Warning is TRUE this will set the discrete output TRUE.

System Faults and Warnings— Click the System Faults and System Warnings checkboxes to apply these to your discrete output.



Note: System Faults and Warnings are not delayed, and they cannot be suppressed. System Faults are also latched.

Input Faults and Warnings— Faults and Warnings for any of the six available analog inputs. Using the checkboxes, select the specific analog input faults and warnings you want assigned to the firing of this DO.

Safety Logic Alarm

6.7 Analog Outputs

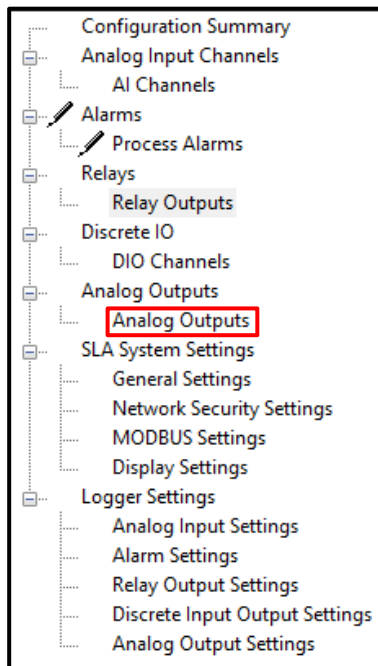
Analog outputs (AO) are optional for the SLA. Three analog outputs are installed with the **-3AO** option. If analog outputs are not installed, all AO features shall be disabled.

Each AO shall pass HART data through from its corresponding AI Channel when wired for mA input. HART data on **AI1A** will pass-through to **AO1**, **AI2A** to **AO2** and **AI3A** to **AO3**. No HART data from inputs AI1B, AI2B or AI3B will be available on analog outputs. HART pass-through is a non-configurable hardware feature.

Analog Outputs configuration is available on the PACTware program.

In the lefthand window of the SLA DTM, click **+** next to **Analog Outputs** and select **Analog Outputs** to configure.

Figure 6.18 PACTware – Analog Outputs



6.7.1 Analog Output Configuration

Figure 6.19 PACTware – Analog Output Configuration Window

Analog Output— Select which one of the three available *Analog Outputs* you want to configure.

Tag— Select the label or shorthand name for your *Analog Output*, 20 characters.

Output Source— Select any *analog input* or *analog internal variable* (as a result of an equation or running min/max).

Source Zero— The SLA needs to know the scaling of the Output Source so it can be accurately converted to the AO range. Input the lower range value of the Output Source.

Source Full— Input the full-scale value of the Output Source.

Damp Time (0, 0.5-60s)— Output damping allows the reduction of short-lived spikes, should they occur.



Note: The SLA shall perform the damping function such that, in response to a step change in the source, the analog output reaches 63% of its final steady-state value after one period of the configured damping period has elapsed provided that the input remains constant.

Initial Value (0 to 23.6mA)— This parameter is only used in conjunction with System Startup Delay. The AO will be set to Initial Value during the System Startup Delay.

AO Zero (mA)— Input the zero value for your *analog output* from 0 to 21.6mA.

AO Full (mA)— Input the full value for your *analog output* from 0 to 21.6mA.

Safety Logic Alarm



Note: The AO full value can be less than the AO zero value (for a reverse output) but the difference between them must be greater than 4mA (minimum span).

Fail Response— The mA values for fail responses when the AO saturates or is in fail mode are calculated from the AO zero and full values. These values are shown for information only and are not configurable.



Note: If the AO is saturated it shall be linear to the Saturation Point value, hold the output and set a warning bit in the status.

Fail Mode— The AO can be configured to fail to one of four values. If the source data has bad quality, the analog output is set to its selected Fail Mode.

The default is set to Fail Low which is the recommended setting for use in a safety application.

Fail Low: Select to set your analog output to its Fail Low Value upon failure.

Fail High: Select to set your analog output to its Fail High Value upon failure.

Hold Last: Select to hold your analog output to its last value upon failure.

Fail Preset: Select to set your analog output to a customized value upon failure.

Fail To Value (mA): Input in your customized value here when you select Fail Preset for your analog output upon failure.

Fail on System Fault— Click the Enabled checkbox when you want your analog output to fail upon a System Fault.



Warning: If the AO is part of the safety path, then either the fail on system fault needs to be enabled or system faults need to be monitored separately.



Note: If a system fault occurs at start up then the unit will hold output value at 0.0mA.

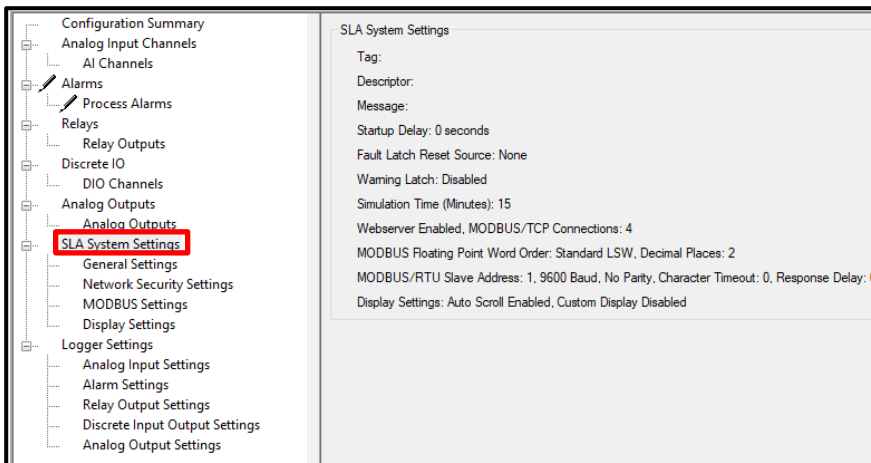
Safety Logic Alarm

6.8 SLA System Settings

This page summarizes parameters set in the General Settings, Network Security Settings, MODBUS Settings and Display Settings pages.

In the left window of the SLA DTM, click + next to **SLA System Settings** to expand and show sub-pages.

Figure 6.20 PACTware – SLA System Settings Window



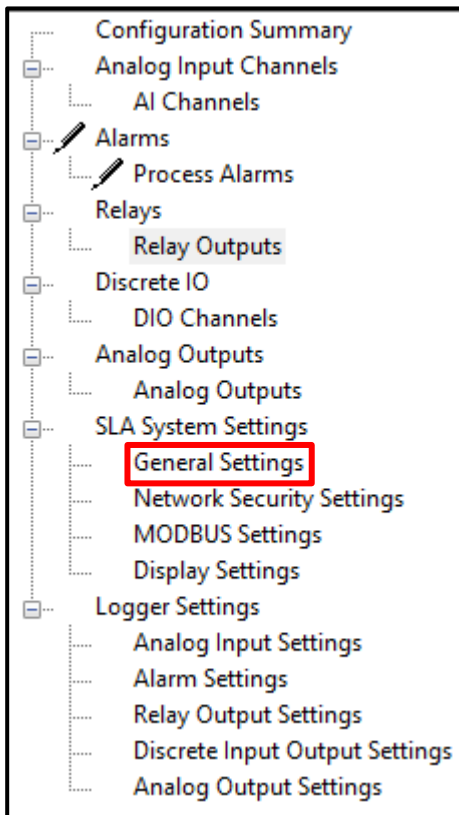
Safety Logic Alarm

6.8.1 General Settings

General Settings Page— Access this page to enter the information of the unit. Unique Tag Identifiers can be used to label process, Descriptor, or Message. Fault Latch Reset Source, System Warning Latch Enable and Simulation Time can be configured.

Click **General Settings** in the left window to show parameters in the General Settings page. See **Figure 6.21**.

Figure 6.21 PACTware – General Settings



General System Settings

Figure 6.22 PACTware – General Settings Window

Tag, Descriptor and Message: Enter the **Tag Identifier** (up to 20 Alphanumeric characters), Descriptor (up to 16 Alphanumeric characters) and Message (up to 32 Alphanumeric characters).

Startup Delay (0, 10-3600s)— Set in increments of 1 second, from 10 seconds up to 60 minutes. This allows a startup delay for the instrument to allow process inputs to stabilize. This delay occurs after an SLA power cycle.



Note: Factory Default Startup Delay shall be set to 0 seconds.

System Fault/Warning Settings

Fault Latch Reset Source— System Faults are always latched. This setting chooses a discrete variable that can be used to unlatch some faults, Refer to Section **9.5 SLA Diagnostic and Fault Alarms** for more detail.

Systems Warnings— By default, system warnings are not latched. Click the **Latch Enabled checkbox** if you want to latch SLA System Warnings.

Warning Latch Reset Source— The latch can be configured to clear by any enabled discrete inputs or variables selected from the pull down menu. If none are selected, then the latch will only be cleared by a power cycle.

Online Simulation Settings



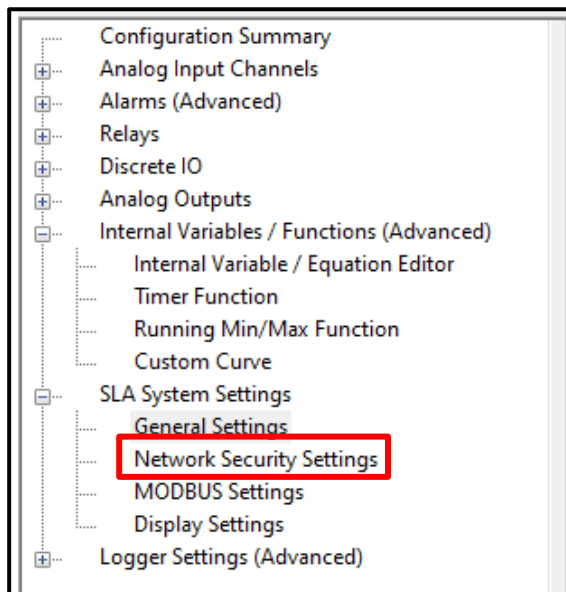
Caution: System warnings include network and security alerts. For cybersecurity, it is recommended that the SLA should be configured to route warnings to a monitored output (DO or RO).

Simulation Time (5 to 30 Minutes)— A simulation timer is set to prevent simulation mode from being left on. When this timer expires, the system is taken out of simulation mode and all I/O is processed normally. The default simulation time is 15 minutes.

6.8.2 Network Security Settings

This section provides information about the network security settings for the SLA.

Figure 6.23 PACTware – Network Security Settings



In the left window of the SLA DTM, click + next to **SLA System Settings** and select **Network Security Settings** to configure.

Safety Logic Alarm

6.8.3 Enabling and Disabling the Web server

Use the steps below to configure the Web server.

Enabling and Disabling the web server

The web server settings can be found in the **SLA System Settings**, under Network Security Settings.

1. Click **SLA System Settings**, and then click **Network Security Settings**.
2. From the **Web server Settings** section, add check mark to enable or; remove check mark to disable the web server.
3. Click **Apply** to apply the changes, and then click **OK**.



Caution - The SLA's web server is **read-only**. For maximum network security, disabling the web server is recommended.

MODBUS/TCP Security Settings

MODBUS/TCP Connections— The number of MODBUS/TCP Connections can be selected in this section. Choose the number of MODBUS/TCP Connections (0-4) for your SLA.



Caution - For optimum network security, all unused MODBUS/TCP connections should be disabled.



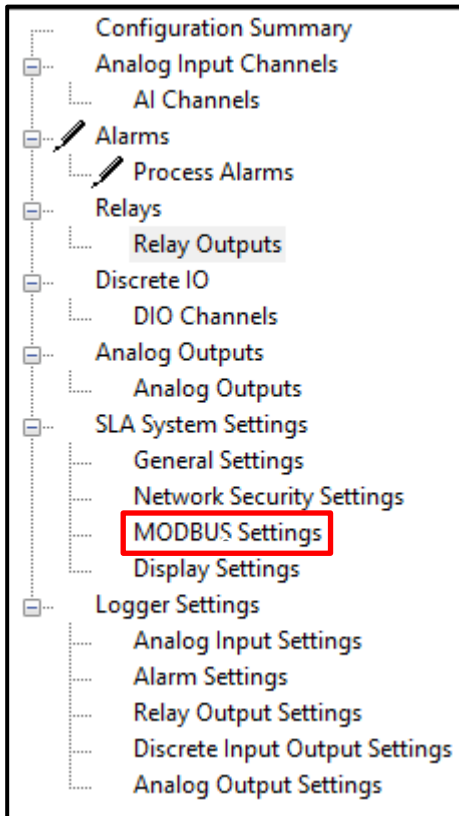
Note: SLA IP address and network settings can only be configured by the NAC Client software.

Safety Logic Alarm

6.8.4 MODBUS Settings

Use the information provided here to configure the MODBUS settings.

Figure 6.24 PACTware – MODBUS Settings



In the left window of the SLA DTM, click MODBUS Settings to configure MODBUS settings and RTU settings if –MB485 option is fitted.

MODBUS Settings

Floating Point Word Order—

- Standard LSW: Least significant word; this stores the most significant bits in the second register and the least significant bits in the first register.
- Swapped MSW: Most significant word; will reverse the order, storing the most significant bits in the first register and the least significant bits in the second register.

Number of Decimal Places— Select Number of Decimal Places (0 to 3) for Integer format. See Section 10.3.2 for more details.

Safety Logic Alarm

MODBUS/RTU Settings (when –MB485 option is fitted)

Figure 6.25 PACTware – MODBUS Settings Window

RTU Address— Enter the MODBUS Slave Address for your SLA.

Baud Rate— The MODBUS RTU Baud Rate settings shall be one of: 1200, 2400, 4800, 9600, 19.2k, 38.4k and 57.6k. Factory Default settings shall be set to 9600.

Parity— A method in serial communications of “checking” that characters have been sent correctly to help reduce errors. This should be set to match the properties of the bus. The MODBUS RTU Parity settings shall be one of: Even, Odd and No Parity. Factory Default settings shall be set to “No Parity.”

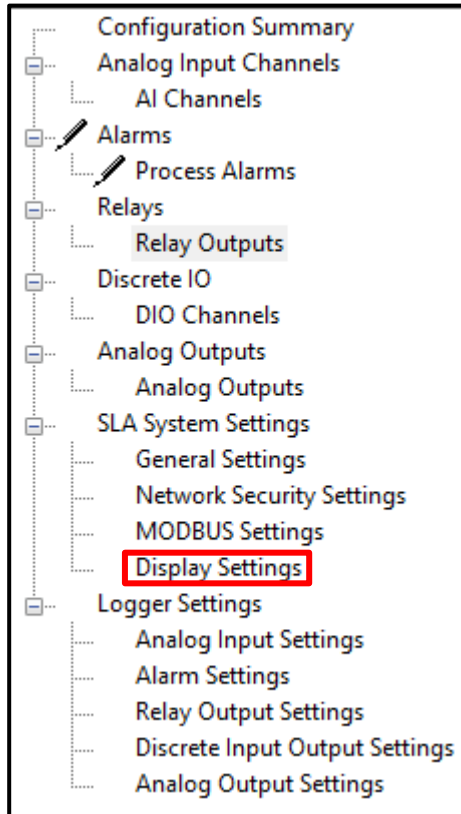
Character Timeout— This relaxes timing when receiving MODBUS messages. It allows for silence in between received bytes or characters without declaring a fault. This is a user-selectable value represented in character times. The MODBUS RTU Character Timeout settings shall be one of: 1.5, 5, 10, 25, 50, 100, 200 and 255 character times. Factory Default settings shall be set to 1.5.

Response Delay— This causes the SLA to pause before transmitting a generated MODBUS message. This is a user-selectable value represented in character times. The MODBUS RTU Response Delay settings shall be one of: 0, 5, 10, 25, 50, 100, 200 and 255 character times. Factory Default settings shall be set to 0.

6.8.5 Display Settings

This section provides information on the SLA display settings.

Figure 6.26 PACTware – Display Settings

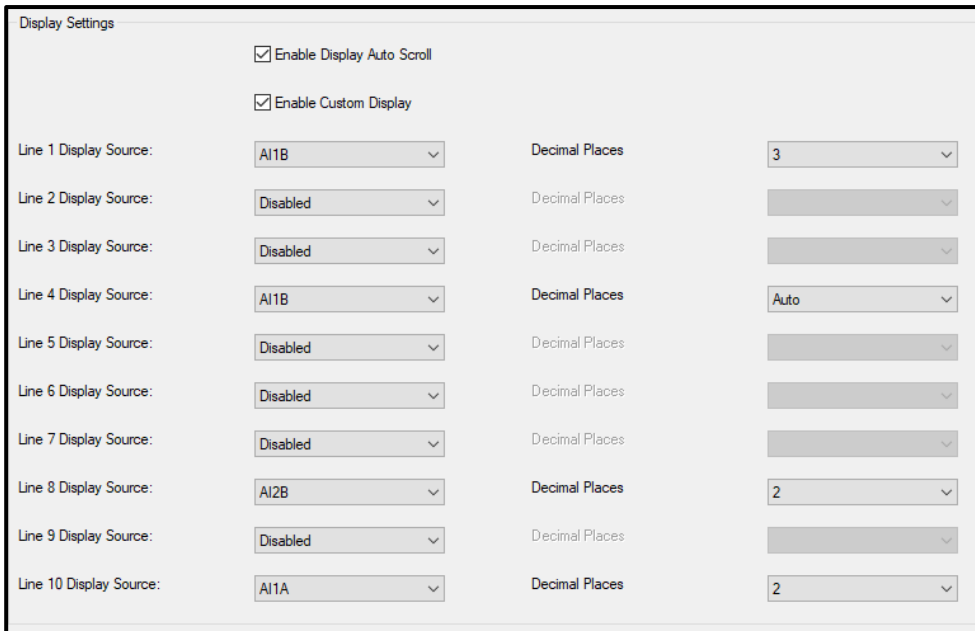


Enable Display Auto Scroll- When checked, SLA display will automatically scroll through selected parameters.

Enable Custom Display- When checked, allows customizing of SLA display. See figure 6.30 below. Each parameter (AI1A, AI1B, etc) can be assigned to a display line and decimal places can be set. When the Decimal Places is set to Auto, the # of Decimals will change with a changing source. This can make reading the source confusing. Using a fixed # of decimals, 1 or 2 or 3, prevents this possibility.

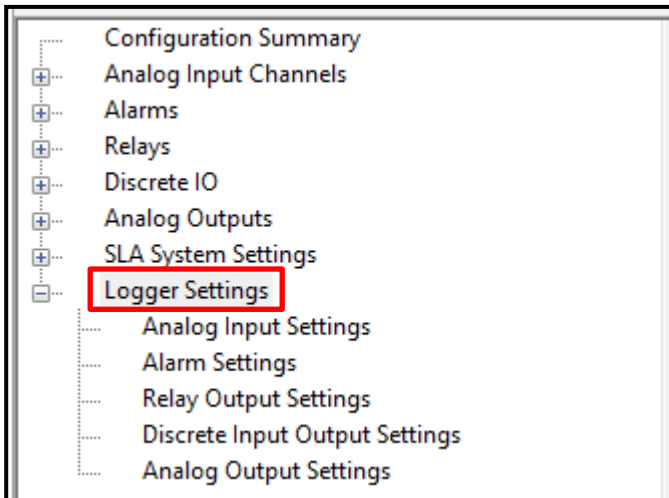
Safety Logic Alarm

Figure 6.27 PACTware – Display Settings Window



6.9 Event Logger Settings

Figure 6.28 Basic Logger Settings



The Logger can be configured for various event types, such as:

- Physical Security**- A physical security change event will be logged anytime switches or jumpers are changed.
- Network**-A Network event will be logged anytime the maximum MODBUS connections have been exceeded, Web Server has been enabled or disabled, MIIP connection has been established.

Safety Logic Alarm

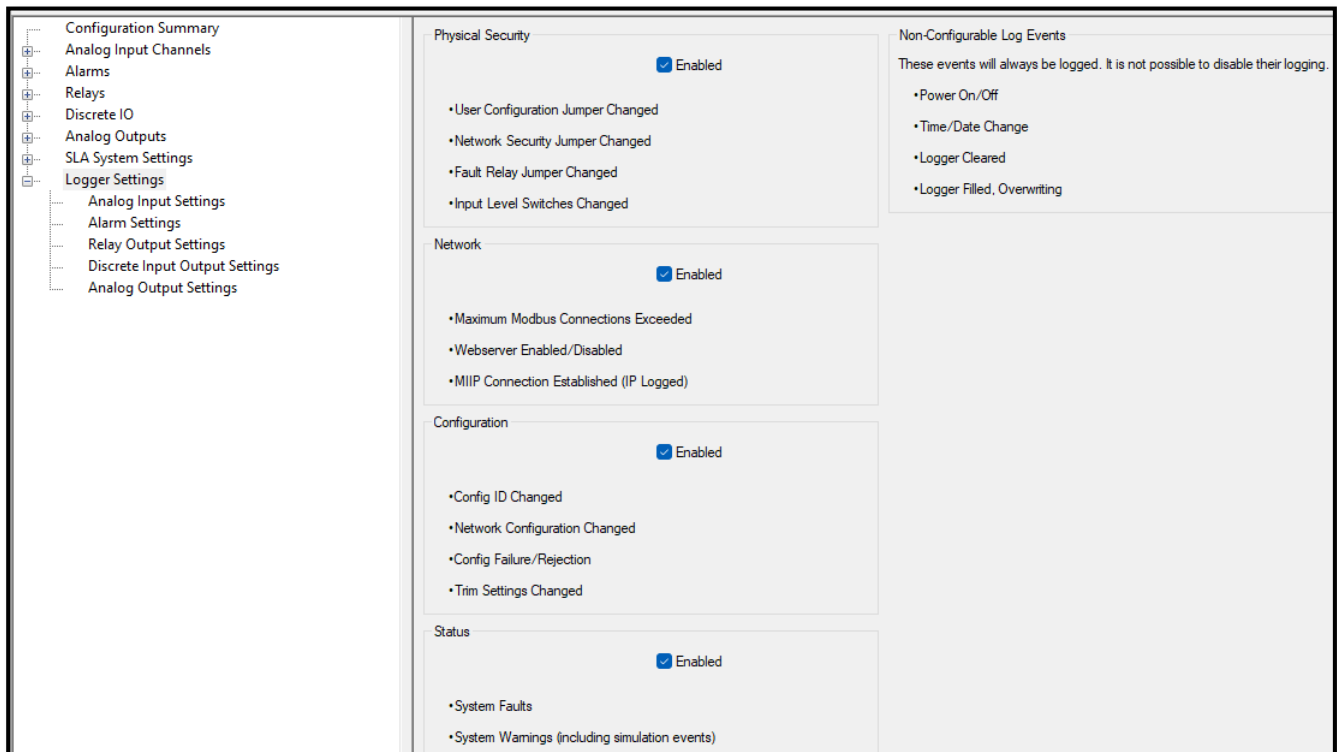
-**Configuration**-A Configuration event will be logged anytime the system configuration has changed or has failed or rejected, and if Trim setting has changed.

-**Status**-A Status event will be logged anytime the system reports Faults or Warnings. This includes simulated events.

Non-Configurable Log Events- The following events are always logged and cannot be turned off.

- Power On/Off
- Time/Date Change
- Logger Cleared
- Logger Filled, Overwriting

Figure 6.29 Security, Network, Configuration and Status Logger Settings



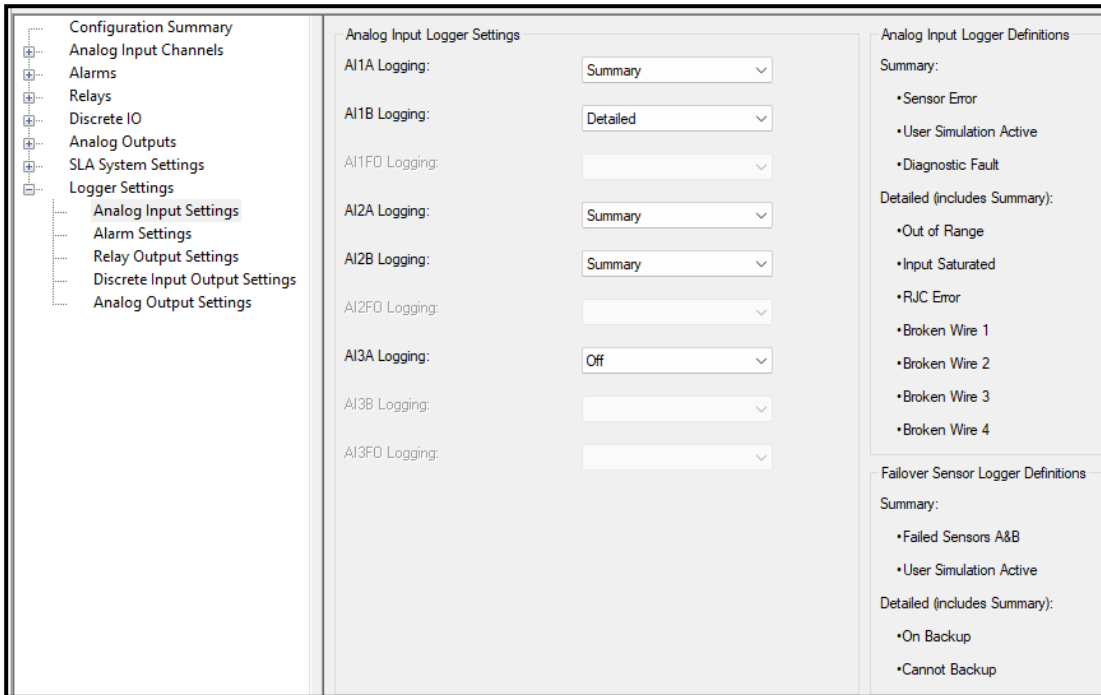
Safety Logic Alarm

The SLA has a configurable event Logger for the following types of events:

- System Faults, Warnings and Security events
- Analog Input Settings
- Alarm Settings
- Relay Output Settings
- Discrete Input / Output Settings
- Analog Output Settings
- Internal Variable Setting (Advanced Mode)
- Timer Setting (Advance Mode)
- Running Min/Max Settings (Advance Mode)

Logging can be set to **Off**, **Summary**, or **Detailed** for each variable type. On the right side of the DTM screen we show the level of detail that gets logged when Detailed and Summary are selected.

Figure 6.30 Analog Input Logger Settings



The Logger provides a date/time stamp for each event and has the capacity to store at least 1000 records. This should be considered when determining which events and the level of detail to be logged.

The event log is not part of the safety function. It can be saved as a csv file and cleared using the Additional Functions menu in the DTM. Refer to Operations section for saving and resetting log.

Safety Logic Alarm



Caution: When the logger is full it will overwrite events starting with the oldest record.



Note: The logger can be cleared even if the Security Configuration Jumper is in read-only position.

Safety Logic Alarm

6.9.1 Event Logger Settings Example, Alarm Settings

In the left window of the SLA DTM, click + next to **Logger Settings** and select **Alarm Settings** to configure the **Logger Settings** for each of the configured Alarms (up to 16).

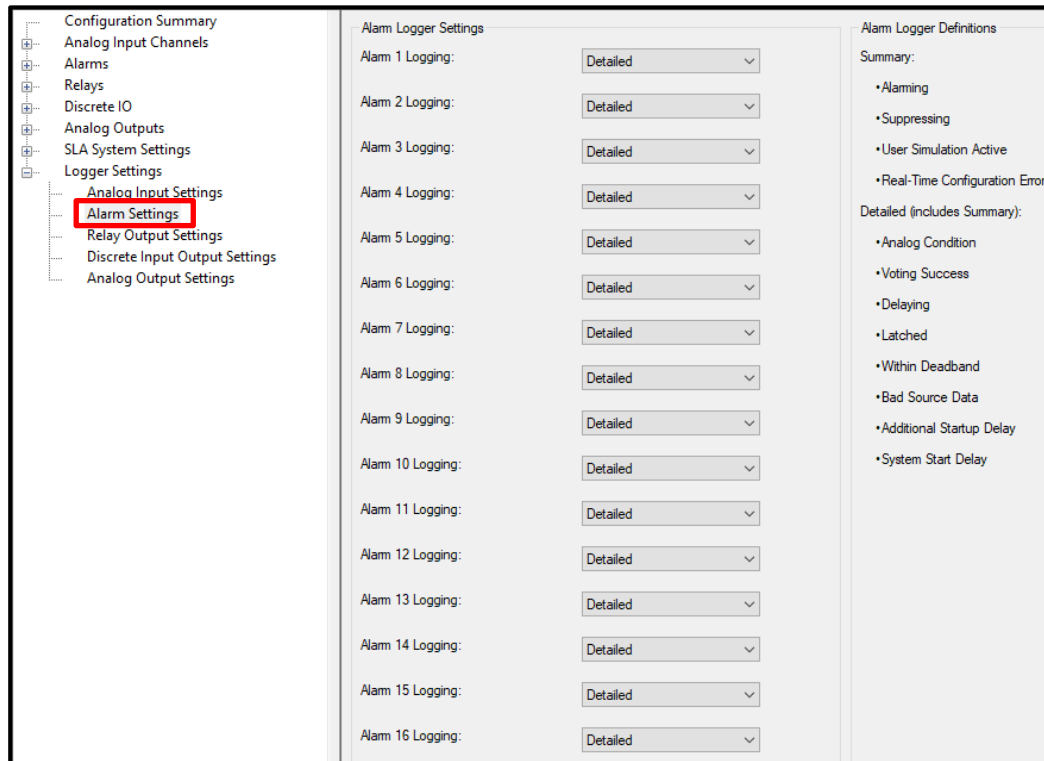
The following is an example of how to log events for Alarms.

Logger Alarm Settings

Alarm 1-16 Logging— Select Summary or Detailed for each alarm needed to be logged.

A summary for the parameters that are being logged in Summary versus Detailed are shown in the Logging Configuration DTM under Alarm Logger Definitions. Default for all Alarm Logs is set to Off.

Figure 6.31 PACTware – Event Logger’s Alarm Settings Window



Safety Logic Alarm

When Summary is selected only the following events are logged:

- Alarming
- Suppressing
- User Simulation Active
- Real-Time Configuration Error

When Detailed is selected, the following events are logged in addition to Summary events:

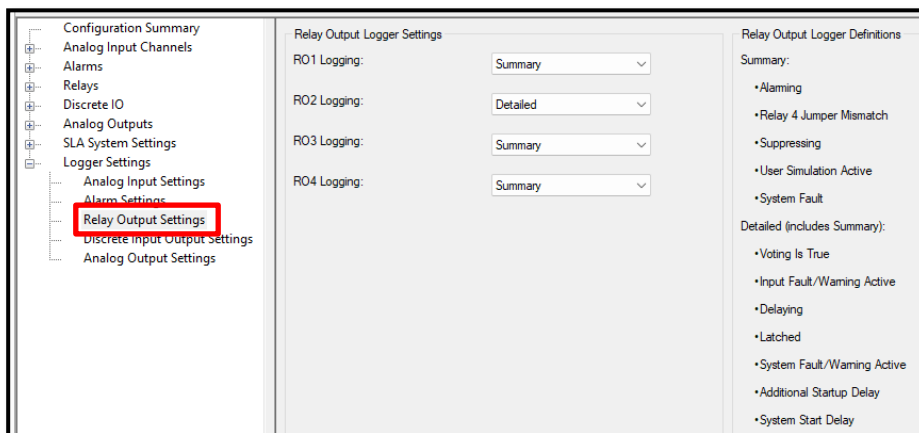
- Analog Condition
- Voting Success
- Delaying
- Latched
- Within Deadband
- Bad Source Data
- Additional Startup Delay
- System Start Delay

6.9.2 Event Logger Settings Example, Relay Output Settings

For each relay, RO1 through RO4, choose either a Detailed log, a Summary log or choose to keep the relay log turned off.

A summary for the parameters that are being logged in Summary versus Detailed are shown in the Logging Configuration DTM under Relay Output Logger Definitions. Default for all Relay Logs is set to Off.

Figure 6.32 Relay Output Logger Settings



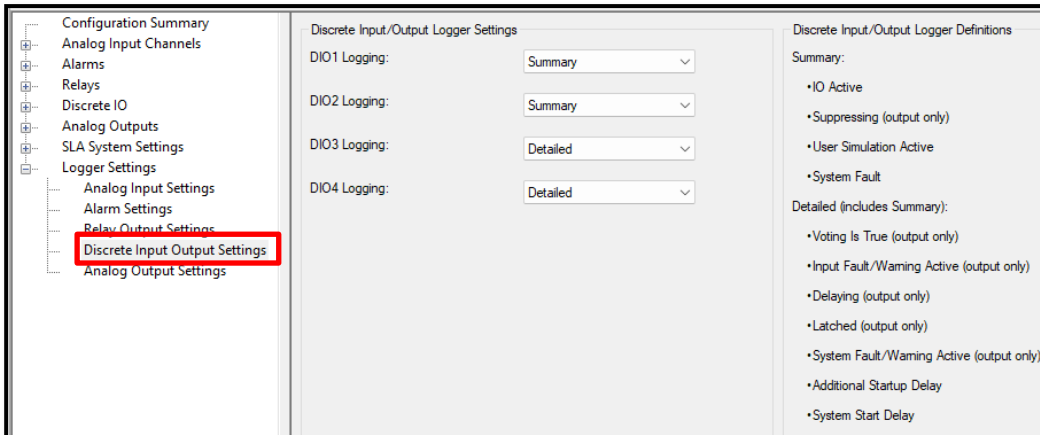
Safety Logic Alarm

6.9.3 Discrete Input/Output Event Logger Settings

For each Discrete I/O, DIO1 through DIO4, choose either a Detailed log, a Summary log or choose to keep the Discrete I/O log turned off.

A summary for the parameters that are being logged in Summary versus Detailed are shown in the Logging Configuration DTM under Discrete Input/Output Logger Definitions. Default for all DIO Logs is set to Off.

Figure 6.33 Discrete I/O Logger Settings

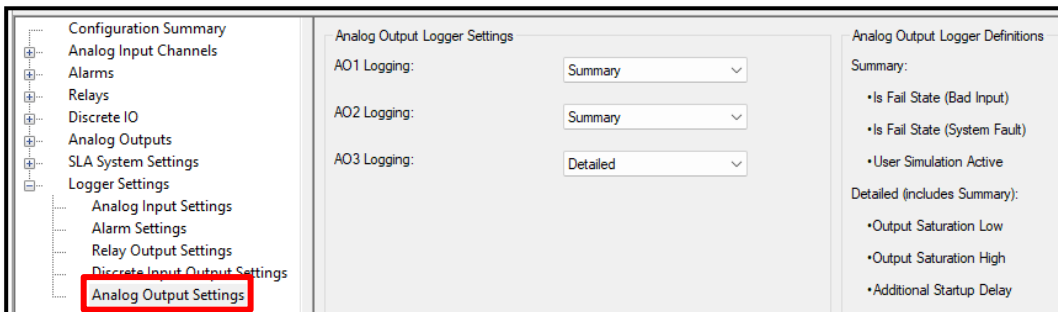


6.9.4 Analog Output Event Logger Settings

For each Analog Output, AO1 through AO3, choose either a Detailed log, a Summary log or choose to keep the Analog Output log turned off.

A summary for the parameters that are being logged in Summary versus Detailed are shown in the Logging Configuration DTM under Analog Output Logger Definitions. Default for all AO Logs is set to Off.

Figure 6.34 Analog Output Logger Settings



6.10 Event Logger Settings (Advanced)

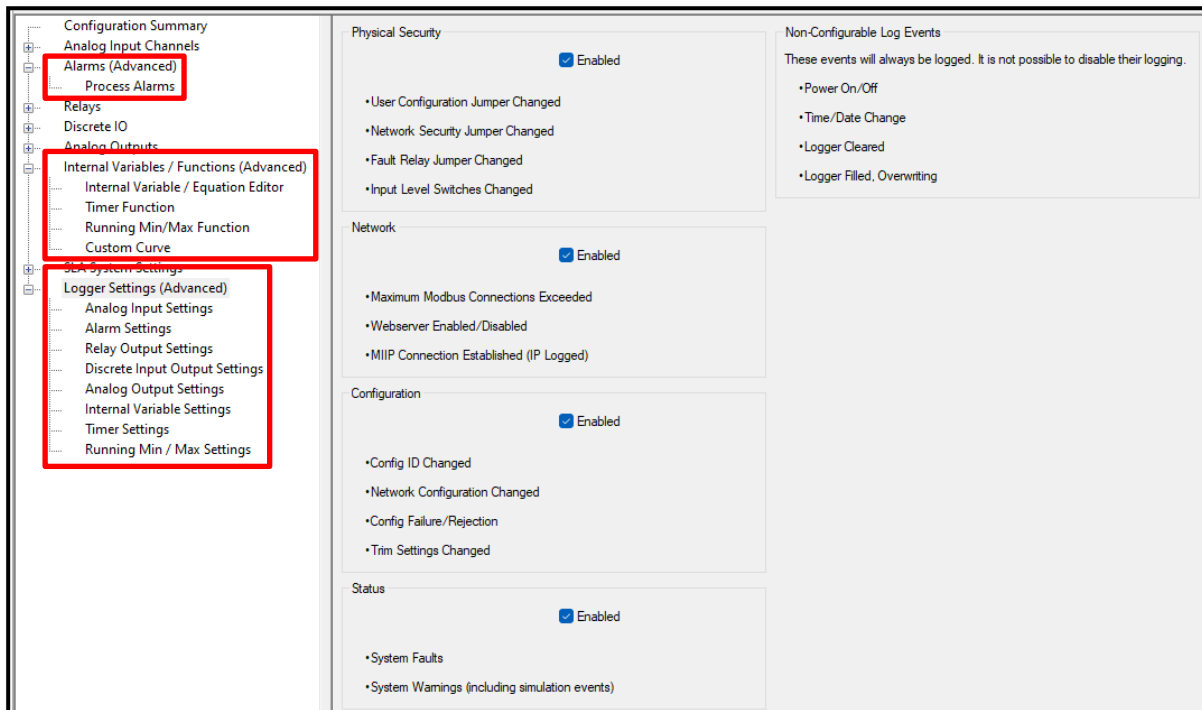
In advanced settings, the event Logger can also be configured to capture these additional event types:

- Internal Variable Settings - Each configured IV event can be logged as Summary (Bad Quality, User Simulation Active) or Detailed (Bad Source Data, Illegal Parameter, Magnitude Warning, Result Out of Range events will be in addition to Summary events).
- Timer Settings - Each configured Timer event can be logged as Summary (Timer Expired, User Simulation Active) or Detailed (Timing, Reset Detected, Pause events will be in addition to Summary events).
- Running Min/Max Settings - Each configured Running Min/Max event can be logged as Summary (Bad Quality, Reset Detected, User Simulation Active) or Detailed (Was Bad Source, Base Source Data will be in addition to Summary events).

7 SLA Configuration – Advanced DTM Settings

The SLA has additional programming options that are available for more advanced applications. To select these options within the **Advanced Configuration** menus, click on the **Advanced** button on the bottom left of the DTM window. To go back to viewing only the Basic Configuration, simply click on the **Basic** button that appears when viewing Advanced Configuration.

Figure 7.1 PACTware – SLA Advanced Configuration Menu



When Advance Mode is selected, the following sections describe Menus and Menu items that are added.

7.1 Alarms (Advanced)

In addition to the basic settings, analog alarms can be configured to use any enabled analog variable (analog inputs, internal variables, running min/max) as a trip point, delta, delta time or deadband source.

7.1.1 Trips

In Advance mode, a Trip Point Source pull down menu is added. This allows any analog input or internal variable to be used as a trip point source.

Safety Logic Alarm

7.1.2 Band

In Advance mode, a Low and a High Trip Point Source pull down menu are added. This allows any analog input or internal variable to be used as a trip point source.

7.1.3 Rate of Change & Stuck Input

In Advance mode, a Delta Source pull down menu is added. This allows any analog input or internal variable to be used as a trip point source.

7.2 Internal Variables/Functions (Advanced)

The SLA Internal Variables/Functions summary page displays the following variables and their values:

- 16 Internal Device Variables (IVs)
- 8 Timers
- 8 Running Min/Max Functions
- 4 Custom Curves

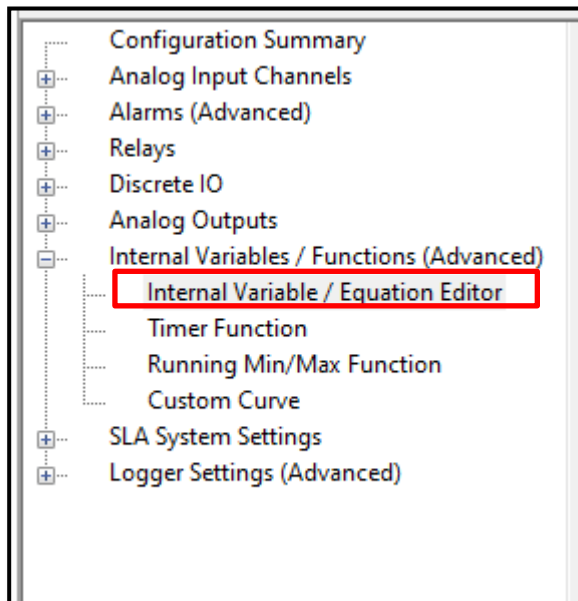


Note: Factory Default for all Internal Variables, Timers, and Running Min/Max is set to Not Used.

7.2.1 Internal Variables/Functions (Advanced), Equation Editor

Use PACTware to edit internal variables/functions and use the **Equation Editor**.

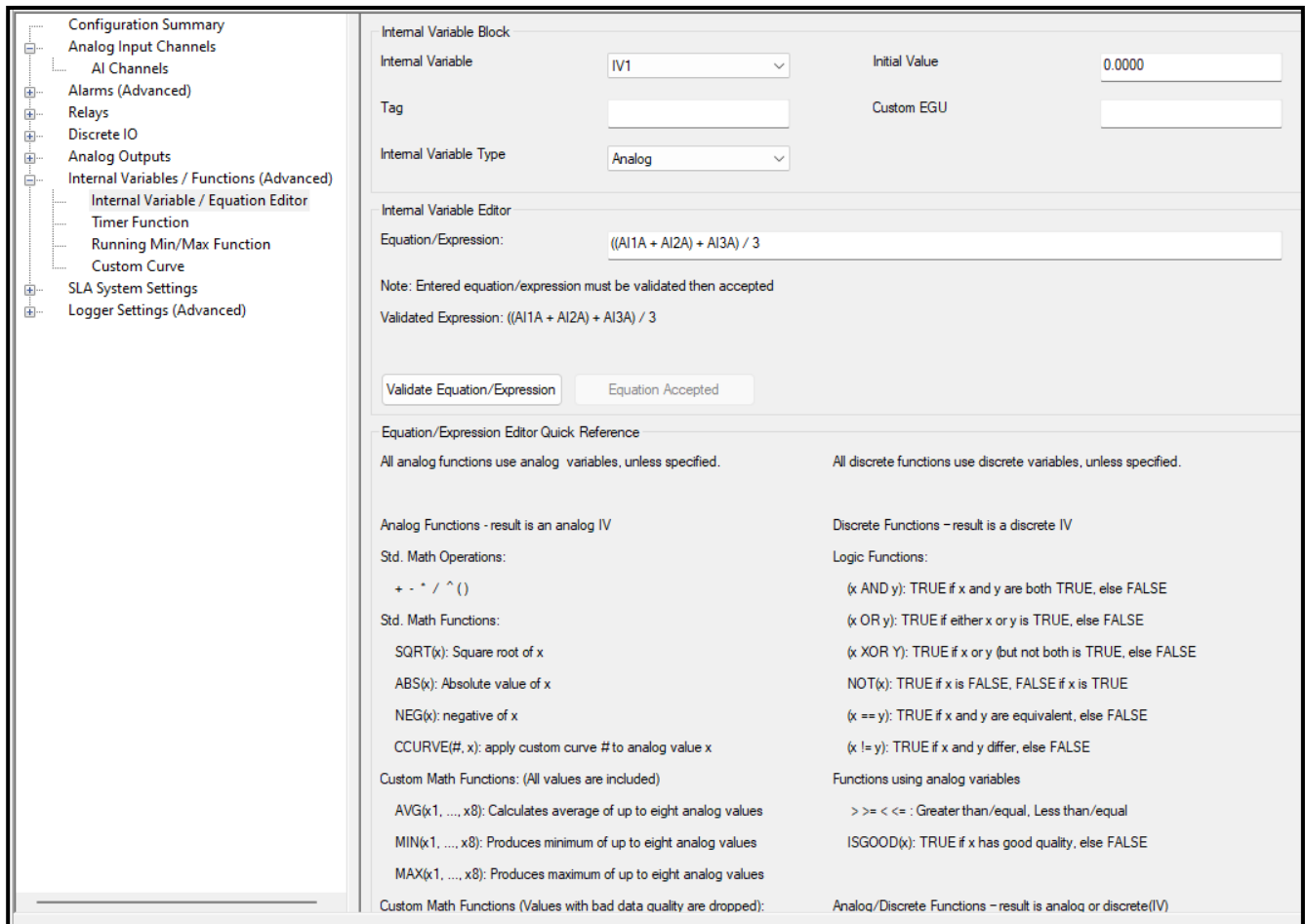
Figure 7.2 PACTware – Internal Variables/Functions & Equation Editor



In the left window of the SLA DTM, click **+** next to **Internal Variables/Functions (Advanced)** and select **Internal Variable/Equation Editor** to configure the equations associated with each of the available Internal Variables.

The SLA provides up to 16 Internal Variables (IV1-16) which can be defined as either analog or discrete. Analog variables can be used as input to analog alarms, running min/max, analog outputs or other equations, Discrete variables can be used as inputs to discrete alarms, equations and as latch reset/suppression sources.

Figure 7.3 PACTware – Internal Variable/Equation Editor Configuration Window



Internal Variable— Select which one of 16 available *Internal Variables* to be configured.

Tag— Select the label or shorthand name for the selected *Internal Variable* (20 Characters).

Internal Variable Type— Choose **Analog** or **Discrete** for the selected Internal Variable, or Not Used to leave it disabled.

Initial Value (Analog variables only) — Input the starting or initial value for *Internal Variable* (Default is 0). This will be set after power up and during any system startup delay. Discrete variables are always set to FALSE during startup.

Safety Logic Alarm

Custom EGU (Analog variables only) — Input the Engineering Units you want to associate with your *Internal Variable*. It is a user defined string of up to 5 characters.

Internal Variable Editor Equation/Expression— Enter Equation or Expression here. After entering the formula click **Validate Equation/Expression**. The equation will be validated and may be rejected or updated with any changes (e.g. added parentheses). After reviewing the validated expression, click **Accept Equation**.

Please see **Expression/Equation Reference Table 7** for a list of expressions and equations.

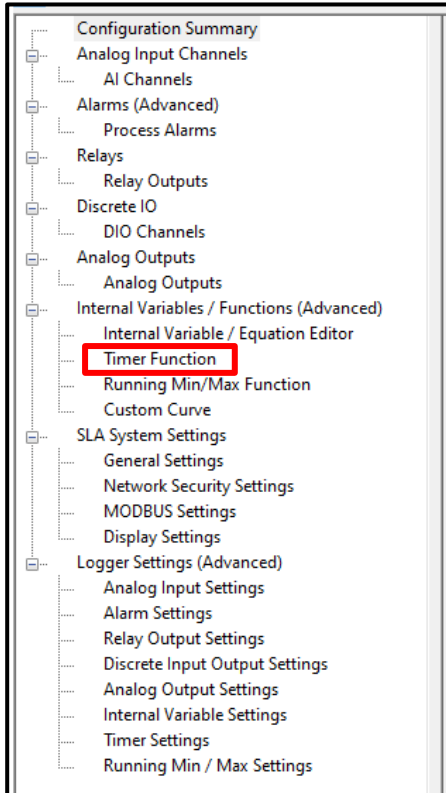


Note: All Equation/Expressions must be validated and accepted.

7.2.2 Internal Variables/Functions (Advanced), Timer Function

Within the Advanced section of **Internal Variables/Functions** menu is a **Timer Function**.

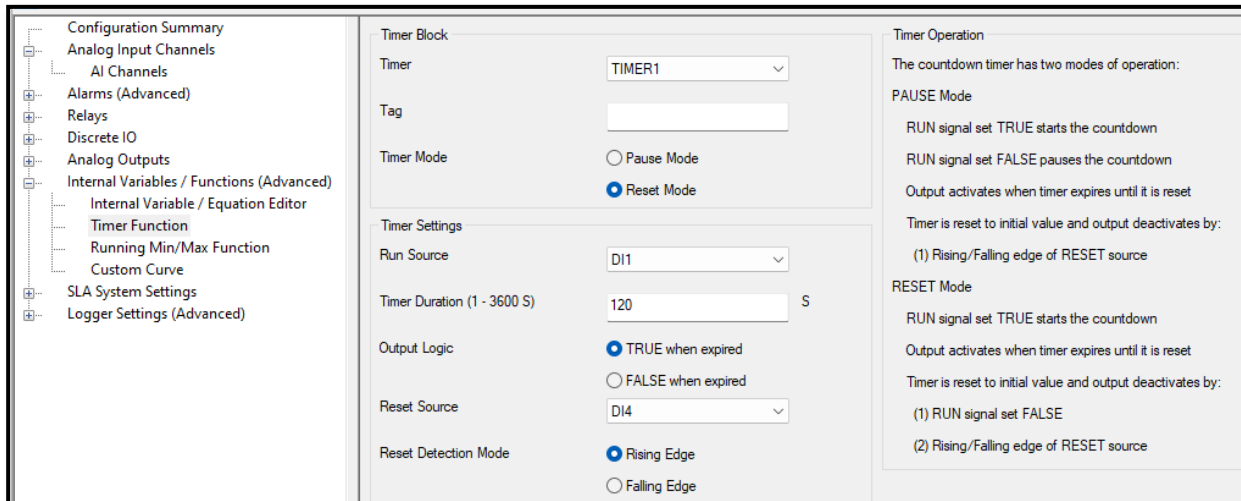
Figure 7.4 PACTware – Internal Variables/Functions (Advanced), Timer Function



In the left window of the SLA DTM, click + next to **Internal Variables/Functions (Advanced)** and select **Timer Function** to configure the eight available Timers.

7.2.2.1 Timer Function Configuration

Figure 7.5 PACTware – Configuring Timer Function



Timer— Select which one of eight available Timers to configure.

Tag— Select the label or shorthand name for the selected Timer.

Timer Mode— Select the Timer mode of operation: Pause Timer or Reset Timer.

Pause Timer: RUN signal set TRUE starts Timer countdown.

RUN signal set FALSE pauses Timer countdown.

Output activates when Timer expires until it is reset.

Timer is reset to initial value and output deactivates by—

(1) Rising/Falling edge of RESET source.

Reset Timer: RUN signal set TRUE starts Timer countdown.

Output activates when Timer expires until it is reset.

Timer is reset to initial value and output deactivates by—

(1) RUN signal set FALSE.

(2) Rising/Falling edge of RESET source.

Run Source— Select the trigger or start source of the Timer.

Timer Duration (1-3600s)— Enter the Timer’s duration here.

Output Logic— Select the Timer’s output logic.

TRUE when expired, FALSE when not expired .

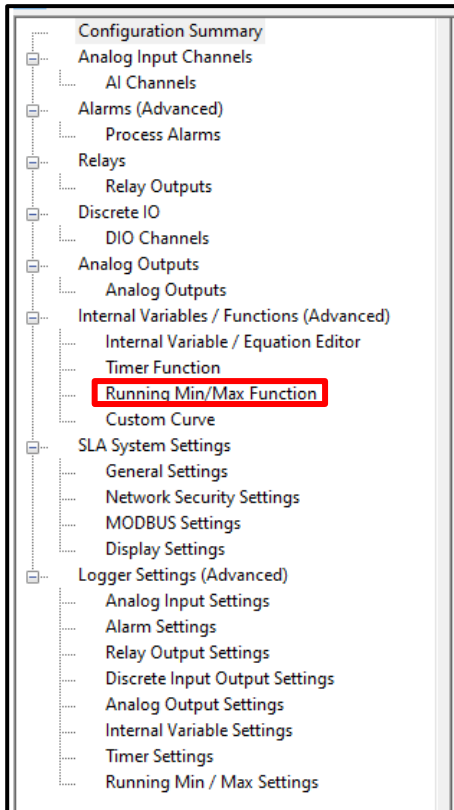
TRUE when not expired FALSE when expired.

Reset Source— Select the Reset Source of the Timer.

Reset Detection Mode— Select whether the Timer resets on Rising Edge (power up) or Falling Edge (power down) of the Reset Source.

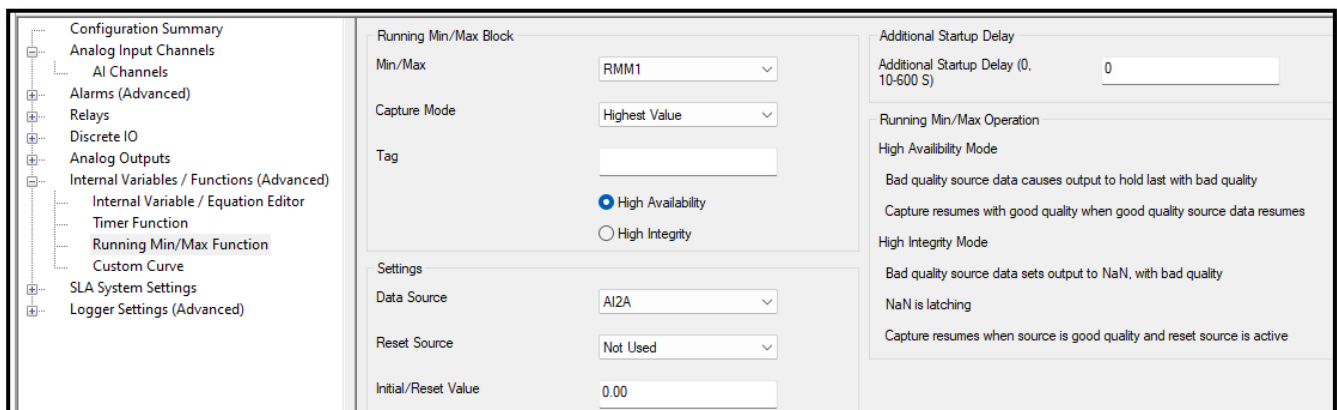
7.2.3 Internal Variables/Functions (Advanced), Running Min/Max Function

Figure 7.6 PACTware – Running Min/Max Function



In the left window of the SLA DTM, click + next to **Internal Variables/Functions (Advanced)** and select **Running Min/Max Function** to configure the eight available Running Min/Max Functions.

Figure 7.7 PACTware – Running Min/Max Function



Safety Logic Alarm

Min/Max— Select which one of the eight available Running Min/Max Functions to be configured.

Capture Mode— Select the Capture Mode for the Running Min/Max Function, defined as follows:

Highest Value: min/max output shall be the highest recorded floating point value of the source data since power up or reset.

Lowest Value: min/max output shall be the lowest recorded floating point value of the source data since power up or reset.

Not Used: Select this option for any Running Min/Max variable not used.

Note: Factory Default is set to “Not Used.”

Tag— Select the label or shorthand name for the selected Running Min/Max Function (20 Characters).

High Availability vs. High Integrity— Select High Availability or High Integrity, defined as follows:

High Integrity: BAD Quality source data causes the captured min/max value to be set to NaN(Not a number) and is marked as BAD quality. This value is held until the source quality becomes GOOD.

High Availability: BAD quality source data causes the captured min/max value to hold its last value but it is marked as BAD quality. When GOOD source data resumes, the capture resumes, and the data quality flag gets posted as GOOD.

Data Source— Select the source to be tracked by the *Running Min/Max Function*.

Reset Source— Select the source to reset the Running Min/Max Function. The min/max will be reset on the rising edge of this signal.

Initial Value— Input the initial and reset value for the Running Min/Max Function. This will be the value at which the function begins and resets to.

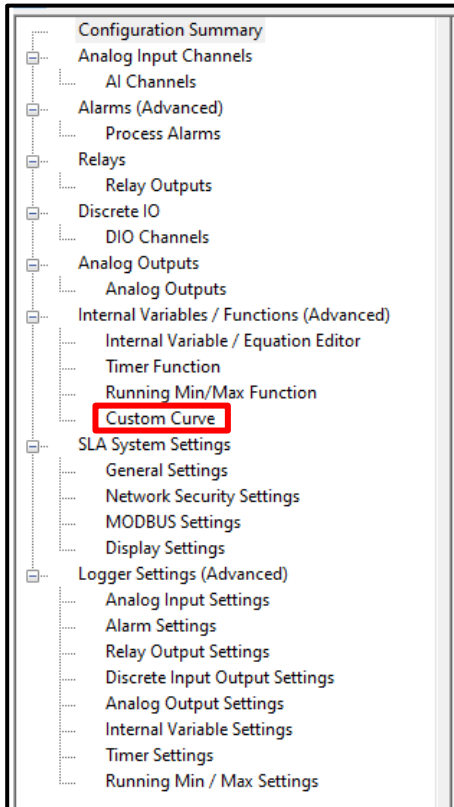
Additional Start Delay— Set in increments of 1 second, up to 60 minutes. This allows a startup delay for the instrument to allow process inputs to stabilize. This delay occurs after an SLA power cycle.

Safety Logic Alarm

7.2.4 Internal Variables/Functions (Advanced), Custom Curve

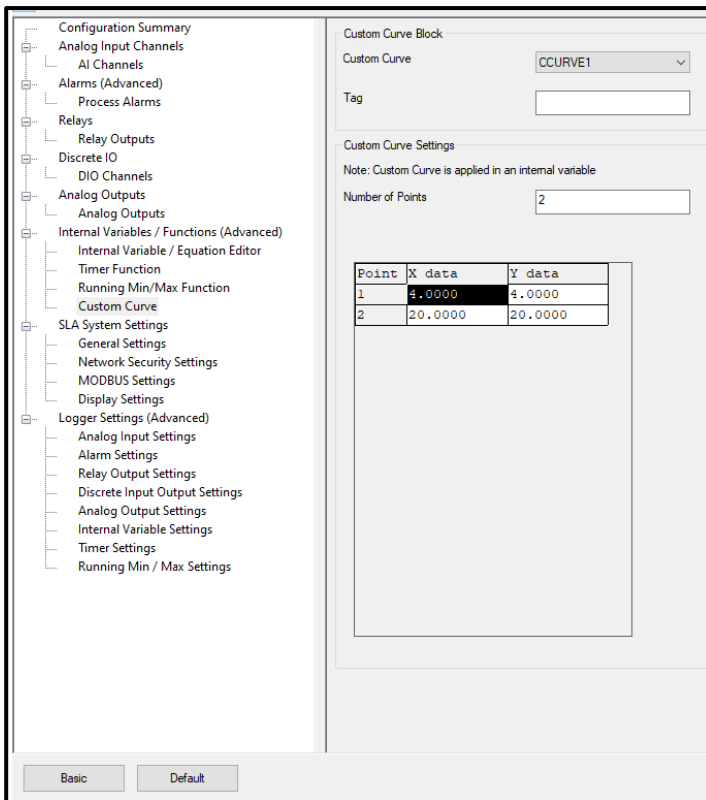
These can be used in any analog equation and applied to any analog variable.

Figure 7.8 PACTware – Custom Curve



In the left window of the SLA DTM, click + next to **Internal Variables/Functions (Advanced)** and select **Custom Curve** to define any of the four Custom Curves.

Figure 7.9 PACTware – Custom Curve Configuration



Custom Curve— Select which one of the four available Custom Curves (CCURVE1 through CCURVE4) to be configured.

Tag— Select the label or shorthand name for the selected Custom Curve (20 Characters).

Number of Points— Select the number of ordered pairs (X,Y) to include in the Custom Curve. The SLA supports 2-128 ordered pairs per curve.



Note: The EGU label for the custom curve output shall be defined in the equation and not in the custom curve function.

You can type the data into the table or alternatively import a .csv file using the Import Custom Curve function by choosing Device from the dropdown menu at the top and selecting Additional Functions.

7.3 SLA Additional Functions

7.3.1 Event Log Save and Clear

SLA Additional Functions menu includes Save Event Log and Clear Event Log function. These functions can be reached by:

1. From the top of the Main Menu, right click on the SLA [DIN] device.
2. Select Additional Functions.
3. Select either Save Event Log or Clear Event Log.

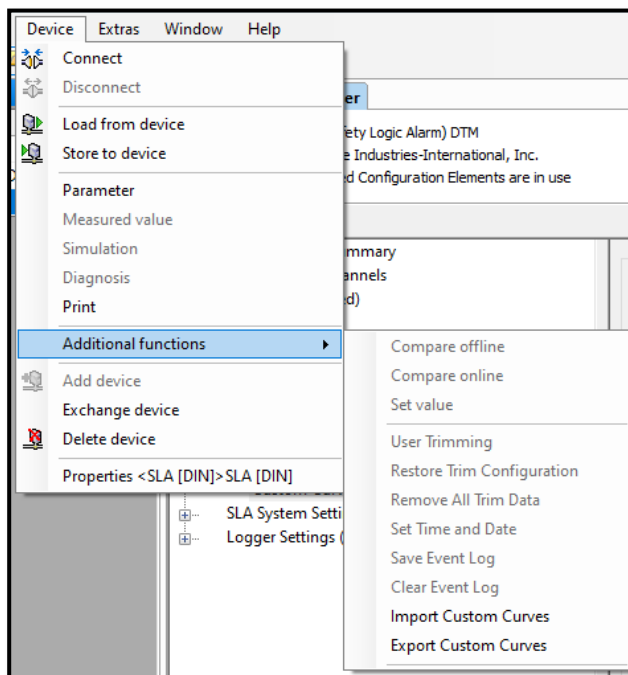
When **Save Event Log** is selected, a Save As dialog box will pop up where the path and filename can be given to the Event Log. Event Log files are saved as a *.CSV type file.

When **Clear Event Log** is selected, an “Are You Sure?” dialog box will pop up asking for confirmation. Select Yes to confirm or No to abort.

7.3.2 Menu for Importing and Exporting Custom Curve Settings

The SLA provides additional functions for importing and exporting custom curves.

Figure 7.10 PACTware – SLA Additional Functions



7.3.2.1 Importing Custom Curve

Previously Exported Custom Curves saved as *.csv files can be imported by using the Import Custom Curves feature. To import custom curves:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions and then select Import Custom Curves.
3. Up to four custom curves can be imported at a time (Custom Curve 1-4). Place a checkmark on desired custom curve checkbox to import.
4. For each custom curve to be imported, click the folder icon and provide the path to the *.csv file location.
5. Click OK to execute import.

7.3.2.2 Exporting Custom Curve

To export custom curves:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions and then select Export Custom Curves.
3. Up to four custom curves can be exported at a time (Custom Curve 1-4). Place a checkmark on desired custom curve checkbox to be exported.
4. For each custom curve to be exported, click the folder icon and provide the path where the *.csv file is to be saved.
5. Click OK to execute export.

Safety Logic Alarm

7.3.2.3 User Trimming

Trimming increases the measurement accuracy of your SLA by trimming the reading of its actual input, to either a calibrated source or the device to which it is connected. This verifies that the input to the transmitter is being interpreted correctly. You may trim any point between 0% and 100% along the scale.

To implement trimming, the SLA must be connected to the FDT application. To perform trimming:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions and then select User Trimming.
3. Review details below for implementing 1-point or 2-point trimming.

Figure 7.11 PACTware – Analog Input Trimming Window

AI Sensor: Select which sensor needs to be trimmed from the six available analog inputs.

Sensor Zero: Shows sensor Zero value (Read-only).

Sensor Full: Shows sensor Full Value (Read-only).

Sensor Value: Shows selected Analog Input reading (Read-only).

Sensor Quality: Displays the quality of the sensor measurement (Read-only).

Desired Trim Point Value: Enter the desired Sensor Value you want the SLA to display or use as the actual input after trimming has been performed.



Note: The difference between your Desired Trim Point Value and the corresponding Sensor Value must not be greater than 2% or the SLA will not allow the trimming configuration to be enabled.

Safety Logic Alarm

Trim Point 1: Use this button to set the Lower Desired Trim Point Value in 2-point trimming, or as the sole Desired Trim Point Value in 1-point trimming.

Trim Point 2: Use this button to set the upper Desired Trim Point Value in 2-point trimming, or as the sole Desired Trim Point Value in 1-point trimming.



Note: Trim Point 2 must be a higher value than Trim Point 1.

Reset Trim: This will reset your trimming configuration.

Trim Disable and Re-Enable

- **Disable-** Disables Trimming and keeps stored trim values.
- **Re-Enable Trim Pt 1-** Enables 1 point trimming using stored trim values.
- **Re-Enable Trim Pt 1 & 2-** Enables 2 point trimming using stored trim values.

Current Sensor Trim Status (Read-only) - This shows whether the current trim or trim reset was successful or not (i.e. Point 1 or 2 Trim Good, Point 1 or 2 Trim Bad, Point 1 or 2 Trim Reset, etc.).

Current Sensor Trim Configuration (Read-only) – Shows current trim point(s) data and SLA serial number.

Point 1 Set Value is the lower value the selected Analog Input is set to and is the value entered in Desired Trim Point Value when Trim Point 1 button was pressed.

Point 1 Trimmed Value is the lower value the selected Analog Input was reading when the Trim Point 1 button was pressed.

Point 2 Set Value is the upper value the selected Analog Input is set to and is the value entered in Desired Trim Point Value when Trim Point 2 button was pressed.

Point 2 Trimmed Value is the higher value the selected Analog Input was reading when the Trim Point 2 button was pressed.

7.3.2.4 Analog Output Trimming

Output trimming allows the output to be adjusted to match plant standards or match the input of the receiving device. This ensures that the instrument is being correctly interpreted. This feature is only available when connected to the SLA. Any output configuration changes must be downloaded to the unit before trimming.



Note: Output trimming can only be applied to output zero and full values, measured in mA. Unlike Input trimming, a separate range cannot be selected within the output Zero and Full values.

To access the AO Trimming window:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions then select User Trimming, and then select AO Trimming.

Figure 7.12 PACTware – Analog Output Trimming Configuration Window

Analog Output— Select which one of the three available analog AO outputs to trim.

Fix Output at Zero— Click this button to set the AO output to 4.00mA.

Fix Output at Full— Click this button to fix the AO output at 20.00mA.

Unfix Output— Click this button to unfix Analog Output.

Measured Output Current— Enter the measured value at the selected Analog Output terminals.



Note: The difference between your Measured Output Current and the corresponding untrimmed Analog Output value must not be greater than 2% or the SLA will not allow the trimming configuration to be enabled.

The right-hand column of the Analog Output Trimming page provides feedback on the progress and success of the trimming action. If problems occur, diagnostics provide specifics.

Steps to trim an analog output:

1. Select analog output to trim.
2. Select **Fix Output at Zero** button.
3. Enter the measured mA output in the **Measured Output Current** box.
4. Select **Trim Zero** button.
5. Select **Fix Output at Full** button.
6. Enter the measured mA output in the **Measured Output Current** box.
7. Select **Trim Full** button.
8. Unfix Output.

Trim / Trim Zero / Trim Full: This button is disabled until fixing the Analog Output and entering the measured output value. When enabled, click this button to execute the trimming process for either the Zero or the Full.

Reset Trim: Click Reset Trim to UNDO your Trim action.

AO Trim Status (Read-only): Display current Trim activity.

Time Data for Serial Number: Displays unit's serial number.

Trim Mode: Displays Trim Mode.

Zero Set Point: This displays the Measured Output Current for Fix Output at Zero.

Zero Trimmed Value: This displays the untrimmed value that your analog output is reading at zero.

Full Set Point: This displays your Measured Output Current for Fix Output at Full.

Full Trimmed Value: This displays the untrimmed value that the analog output is reading at full.

Safety Logic Alarm

7.3.2.5 Restore Trim Configuration

Selecting this function will download all trim values (analog input and analog output) from the currently connected DTM configuration file.

To access the Restore Trim Configuration function:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions then select Restore Trim Configuration.

7.3.2.6 Remove All Trim Data

Selecting this function will remove all Trim data and restore Trim data back to factory defaults.

To access the Restore Trim Configuration function:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions then select Remove All Trim Data.

7.3.3 Setting the Time and Date

To set the time:

1. Right click the SLA [DIN] device icon.
2. Select Additional Functions then select Set Time and Date.
3. Next, select how time will be set; Use Workstation Time or Manual Time.

Use Workstation Time: Select **User Workstation Time** to set the SLA time and date to correspond with the workstation time and date.

Use Manual Time: Select **User Manual Time** to manually specify the SLA time and date. The year, month, day, hour, minute, and second can be set.

4. After choosing time and data parameters, click **Set Time**, and then click **Ok** to set the Time and Date.



Note: The time and date settings are **NOT** part of the unit configuration and are set immediately. They can also be set when the unit configuration is in read-only mode.

7.4 SLA Online Simulation

The SLA supports online simulation utilizing the DTM and any FDT host. Simulation allows users to enter values to evaluate how alarms, relays, analog outputs and even internal variables behave and react. This can be very useful for safety practitioners to ensure the Safety Instrumented Function (SIF) that the SLA is designed for performs correctly. A programmable simulation timeout feature prevents the SLA from being left in simulation mode.

Safety Logic Alarm

To perform simulation, the SLA must be connected to the DTM with the Security Configuration Jumper in read/write position. During simulation the results can be monitored on the unit itself and/or using the SLA's web pages (See Section 8).

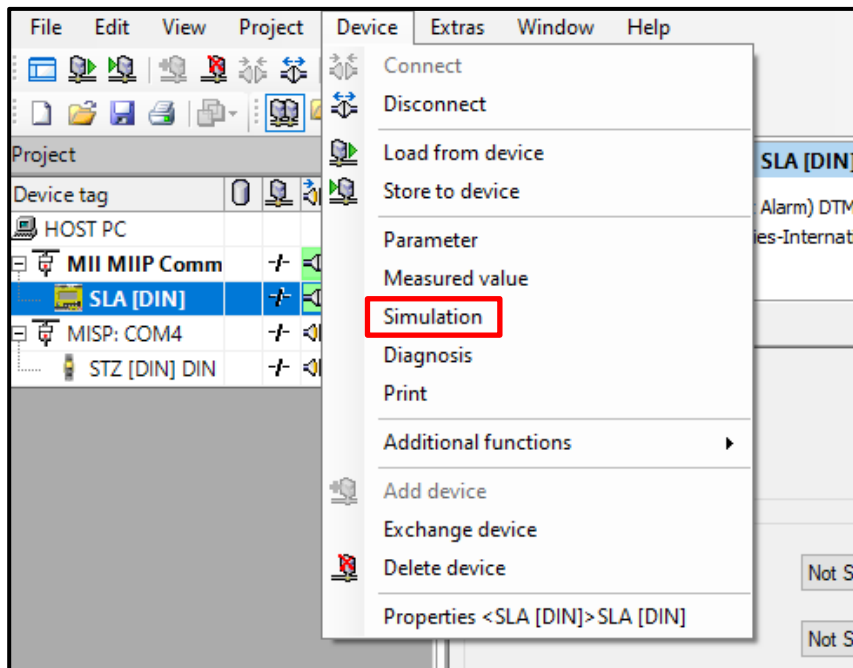


Warning: Simulation does not replace proof testing of the SLA.



Warning: The SLA must **NOT** be connected to the process or SIF (Safety Instrumented Function) while performing the simulation operation.

Figure 7.13 PACTware – Simulation



To perform a simulation:

1. From the Main Menu at the top of the DTM, right-click on the **Device**.
2. From the drop-down menu, click **Simulation**.
3. For the variable that is to be simulated, click **Not Simulated** pull down and select either, **Simulate GOOD Quality**, or **Simulate BAD Quality**.
4. For Analog parameters, enter the desired Simulated value or for Discrete parameters, select value (**TRUE** or **FALSE**) from the pull-down menu.
5. Click **Update Simulated Values**.

Safety Logic Alarm

6. Using the web pages, SLA display, or the MODBUS interface, observe the expected results of the simulation.
7. Enable, disable, or alter simulation for one or more variables and click **Updated Simulated Values** as many times as needed to confirm SLA configuration behaves as desired.
8. When finished, click **Clear Simulated Values**.
9. Using the web pages, SLA display, or the MODBUS interface, observe the SLA performing normal data processing.

If Simulation is active when a configuration is downloaded, simulation will be disabled for all variables.



Note: To perform a simulation, DTM must be connected to your SLA instrument. If not, the Simulation function is not available.

Figure 7.14 PACTware – Simulation Control

Simulation Control

Update Simulated Values

Clear Simulated Values

Capture Data

Simulation Status: Not Simulating

Notes

Simulation is run in connected device using its downloaded configuration.

Monitor the SLA outputs, display or webpages for simulation results.

If RO4 is configured as a fault relay, system faults will override simulation.

To change simulation time, reconfigure in SLA System Settings and store to device.

Variables

Variable	Status	Simulated Value
AI1A	Not Simulated	0.0000
AI1B	Not Simulated	0.0000
AI2A	Not Simulated	0.0000
AI2B	Not Simulated	0.0000
AI3A	Not Simulated	0.0000
DI1	Not Simulated	FALSE
DI2	Not Simulated	FALSE
DI3	Not Simulated	FALSE
DI4	Not Simulated	FALSE
RO4F	Not Simulated	FALSE
AO1	Not Simulated	0.0000
AO2	Not Simulated	0.0000
AO3	Not Simulated	0.0000

Safety Logic Alarm

Variables— This is a list of all configured variables that can run a simulation. This includes Analog Inputs and Outputs, Discrete I/Os, Alarms, and Relays.

Not Simulated is the default setting for all variables.

For all Analog Inputs, Good Data Quality or Bad Data Quality can be used to verify the proper behavior of the SLA.



Note: Simulation will automatically time out after 15 minutes if no desired simulation time is chosen.

Simulated Value— Input the desired simulation value for Analog parameters or select from the pull-down menu for Discrete parameters.

Simulation Control:

Update Simulated Values—Upload Simulated Values to SLA to run a simulation.

Clear Simulated Values—Clear Simulated Values from SLA and stop simulation.

Capture Data—Upload Input source values from SLA to be used as Simulated Values.

8 SLA Web Server and Web Pages

The SLA has a built-in HTTP web server to provide a quick and efficient way to view system information, runtime data, status and configuration information. It also provides the MODBUS register locations for all the device status and data.

To view the web pages, use any browser such as Chrome or Edge and enter the IP address of the SLA into the URL in the browser. The SLA's web pages are read-only; no data can be changed or modified from the browser.



Note: The web pages do not update the information automatically. The user must refresh the browser to see updated information.



Note: The Web server can be disabled such that no web pages will be displayed.

When the web server is enabled, the following pages can be navigated:

- **Home - System Information** - Home page providing system and security information.
- **Process Data** - Displays all variables and their status (needs to be refreshed to provide live data).
- **System Status** - Shows overall system and major subsystem status.
- **Configuration** - Displays the unit configuration information.
- **MODBUS Registers** - Lists the register number, and value for all MODBUS data.
- **Event Log** - Shows status of the Event Log, and Log contents.

Safety Logic Alarm

8.1 Home: System Information Web Page

The Home web page shows system information.

Figure 8.1 System Information Web Page

SLA: Safety Logic Alarm	
Home - System Information	
Unit	
Property	Value
System Date	Friday Mar 17, 2023
System Time	08:20:07.0
Serial Number	286437
Model Number	SLA/6PRG/4PRG/10.5-30DC/-3AO -MB485 [DIN]
Network Name	FlowCalc4
Network Location	Spillway 4
Tag	FC4
Descriptor	Flow Calcuator
Message	Example 4
Powered Up Since	Fri Mar 17, 2023 at 08:18:53
Last Power Down	Fri Mar 17, 2023 at 08:18:34
Programmed Date	Fri Mar 17, 2023 at 08:11:53
Calibration Date	Sat Jan 7, 2023 at 23:47:44
Configuration ID	0x86415D42
Build	
Property	Value
Hardware Version	1.0.0
Firmware Version	1.0.0
Security	
Property	Status
Safety Config Jumper at Boot	Read/Write
Network Config Jumper at Boot	Read/Write
RO4 Jumper at Boot	Process Relay
AI 1 Input Level Switches	Low Level (RTD, Res, T/C, mV)
AI 2 Input Level Switches	Low Level (RTD, Res, T/C, mV)
AI 3 Input Level Switches	Low Level (RTD, Res, T/C, mV)

Safety Logic Alarm

8.2 Process Data Web Page

This web page shows the current value, quality, and status of all enabled variables. The Data Path Register is shown for the value. An asterisk "*" next to an Analog Input or Analog Output variable indicates the variable has user trimming applied.

Figure 8.2 Process Data Web Page

SLA: Safety Logic Alarm		
Process Data		
Data Quality and Status		
Name	Value (Quality) [MB Reg]	Status Messages
AI1A (Low Flow Meter In)	13.020 MGD (GOOD) [4001]	No status bits set
AI2A (High Flow Meter In)	13.105 MGD (GOOD) [4003]	No status bits set
DI1 (Manual Reset)	FALSE [4005]	No status bits set
IV1 (Flow Selected)	13.105 (GOOD) [4007]	No status bits set
ALM1 (Hi Meter Select)	TRUE [4009]	(0) Alarming (1) Analog Trip Condition
ALM2 (Excess Flow Alarm)	FALSE [4011]	No status bits set
RO1 (Hi Meter Select Out)	TRUE [4013]	(0) Alarming (2) Voting is True (6) Latched
RO2 (Excess Flow Alm Out)	FALSE [4015]	No status bits set
RO4 (Sys Or In Fault)	FALSE [4017]	No status bits set
AO1 (0to13 MGD Out)	20.025 MA (GOOD) [4019]	No status bits set
AO2 (0to40 MGD Out)	9.242 MA (GOOD) [4021]	No status bits set
AO3 (Flow Out)	9.242 MA (GOOD) [4023]	No status bits set

Safety Logic Alarm

8.3 System Status Web Page

This web page shows a variety of status information. Included are fault and warning summaries, as well as network connection counts and event logger information.

Figure 8.3 System Status Web Page

SLA: Safety Logic Alarm	
System Status	
System Status Summary	
Register Name	(Bit) Status Messages
Fault Summary	No status bits set
Warning Summary	No status bits set
Input Fault Summary	No status bits set
Input Warning Summary	No status bits set
Physical Security Events	No status bits set
Safety Section Status	
Register Name	(Bit) Status Messages / Value
Safety Section Summary	No status bits set
Safety Section Diagnostic Summary	No status bits set
Safety Section Configuration Status	(0) Configuration Status is from SLA Internal Memory Load (5) Configuration Load Success
Safety Section Jumper / Switch Errors	No status bits set
Equation Processing Faults	No status bits set
Equation Processing Warnings	No status bits set
Startup Delay Time Remaining	0 seconds
User Simulation Time Remaining	0 seconds
>	
Network Section Status	
Register Name	(Bit) Status Messages / Value
Network Section Summary	No status bits set
Network Section Diagnostic Summary	No status bits set
Network Section Configuration Status	(0) Configuration Status is from SLA Internal Memory Load (5) Configuration Load Success
Jumper Events	No status bits set
NAC Server Status	(0) Service is enabled (3) Service is running
MODBUS/TCP Server Status	(0) Service is enabled (3) Service is running
MIIP Server Status	(0) Service is enabled (3) Service is running
Current / Max MODBUS/TCP Connections	0 / 4
Current / Max MIIP Connections	1 / 1
Logger Status	
Register Name	(Bit) Status Messages / Value
Logger Status	No status bits set
Total Records Logged Since Last Clear	15
Logger Store Failures	0
Date / Time of Last Logger Clear	Fri Mar 17, 2023 at 08:17:53

Safety Logic Alarm

8.4 Configuration Web Page

This web page shows system configuration status and information. The Safety and Network Section Configuration Status Registers show the status of startup and download attempts. It is normal for bits to be set in these registers.

A summary configuration string is shown for each variable, note that not all configurable parameters are shown.

Figure 8.4 Configuration Web Page

SLA: Safety Logic Alarm	
Configuration	
System Status Summary	
Register Name	(Bit) Status Messages
System Overall	No status bits set
Safety Section Config Status	(0) Configuration Status is from SLA Internal Memory Load (5) Configuration Load Success
Safety Section Jumper / Switch Errors	No status bits set
Network Section Config Status	(0) Configuration Status is from SLA Internal Memory Load (5) Configuration Load Success
Configuration ID	0x86415D42
System Settings	
Item	Setting
System Start Delay (s)	0
Fault Latch Reset Source	None
Warning Latch Enabled	FALSE
Warning Latch Reset Source	None
Simulation Time (minutes)	15
I/O and Variable Settings	
Item	Configuration Summary
AI1A (Low Flow Meter In)	Resistance 4W 4000 ohms, 0.00-4000.00 OHMS , scaled to 0.0000-13.0000 MGD, Broken Wire Enabled
AI2A (High Flow Meter In)	Resistance 4W 4000 ohms, 0.00-4000.00 OHMS , scaled to 0.0000-40.0000 MGD, Broken Wire Enabled
DI1 (Manual Reset)	Input Non Failsafe
IV1 (Flow Selected)	Analog Variable: IF(ALM1, AI2A, AI1A)
ALM1 (Hi Meter Select)	High Integrity Trip High on AI1A at trip point 12.90, Deadband 0.00
ALM2 (Excess Flow Alarm)	High Integrity Trip High on IV1 at trip point 39.00, Deadband 0.00
RO1 (Hi Meter Select Out)	Failsafe, Voting 1oo1, Latching with Reset Source: DI1
RO2 (Excess Flow Alm Out)	Failsafe, Voting 1oo1 or Input Faults, Latching with Reset Source: DI1
RO4 (Sys Or In Fault)	Process Relay, Failsafe, System Faults or Input Faults, Latching with Reset Source: DI1
AO1 (0to13 MGD Out)	Source AI1A, from 0.00-13.00 to 4.00-20.00 mA, Damp Time 0.00 s, Fail High
AO2 (0to40 MGD Out)	Source AI2A, from 0.00-40.00 to 4.00-20.00 mA, Damp Time 0.00 s, Fail High
AO3 (Flow Out)	Source IV1, from 0.00-40.00 to 4.00-20.00 mA, Damp Time 0.00 s, Fail High, Fail on System Faults

Configuration Web Page cont'

Analog Input Trim Status		
Name	(Bit) Status Messages	
AI1A (Low Flow Meter In) Trim Status	No status bits set	
AI2A (High Flow Meter In) Trim Status	No status bits set	

Analog Output Trim Status		
Name	Trim Mode	(Bit) Status Messages
AO1 (0to13 MGD Out) Trim Status	Not Trimmed	No status bits set
AO2 (0to40 MGD Out) Trim Status	Not Trimmed	No status bits set
AO3 (Flow Out) Trim Status	Not Trimmed	No status bits set

MODBUS Settings	
Item	Setting
Floating Point Word Order	MSW
Decimal Places	2

MODBUS/TCP Settings	
Item	Setting
Maximum MODBUS/TCP Connections	4

MODBUS/RTU Settings	
Item	Setting
RTU Address	1
Baud Rate	9600
Parity	None
Character Timeout	0
Response Delay	0

Safety Logic Alarm

8.5 MODBUS Registers Web Page

This web page shows the current value of all registers in the MODBUS map.

Figure 8.5 MODBUS Registers Web Page

SLA: Safety Logic Alarm				
MODBUS Data & Registers				
System Status				
Register / Property Name	MB Reg	Hex Value	(Bit) Status Messages / Value	
System Overall	8001	0x0000	No status bits set	
Safety Section Summary	8002	0x0000	No status bits set	
Network Section Summary	8003	0x0000	No status bits set	
Input Fault Summary	8004	0x0000	No status bits set	
Input Warning Summary	8005	0x0000	No status bits set	
Startup Delay Time Remaining	8006	0x0000	0 seconds	
User Simulation Time Remaining	8007	0x0000	0 seconds	
Jumper and Switch State	8008	0x05AA	(1) AI1 is Low Level (3) AI2 is Low Level (5) AI3 is Low Level (7) Relay 4 is Process Relay (8) User Configuration Jumper is R/W (10) Network Configuration Jumper is R/W	
Logger Status	8009	0x0000	No status bits set	
Logger Record Count A	8010	0x000F	15	
Logger Record Count B	8011	0x0000	n/a (see reg above)	
System Time: Year	8017	0x07E7	2023	
System Time: Month	8018	0x0003	3	
System Time: Day	8019	0x0011	17	
System Time: Hour	8020	0x0008	8	
System Time: Minute	8021	0x0016	22	
System Time: Second	8022	0x0010	16	
Variable Registers: Process Data, Quality, and Status				
Name	Float Value [MB Reg]	Integer Value (Hex Value) [MB Reg]	Quality Value (Quality) [MB Reg]	Status Value [MB Reg]
AI1A (Low Flow Meter In)	13.020 MGD [4001]	1302 (0x0516) [5001]	0x0001 (GOOD) [6001]	0x0000 [7001]
AI2A (High Flow Meter In)	13.105 MGD [4003]	1310 (0x051E) [5002]	0x0001 (GOOD) [6002]	0x0000 [7002]
DI1 (Manual Reset)	0.000 [4005]	0 (0x0000) [5003]	0x0001 (GOOD) [6003]	0x0000 [7003]
IV1 (Flow Selected)	13.105 [4007]	1310 (0x051E) [5004]	0x0001 (GOOD) [6004]	0x0000 [7004]
ALM1 (Hi Meter Select)	1.000 [4009]	100 (0x0064) [5005]	0x0001 (GOOD) [6005]	0x0003 [7005]
ALM2 (Excess Flow Alarm)	0.000 [4011]	0 (0x0000) [5006]	0x0001 (GOOD) [6006]	0x0000 [7006]
ALM3 (Hi Meter Select Out)	1.000 [4013]	100 (0x0064) [5007]	0x0001 (GOOD) [6007]	0x0005 [7007]

Safety Logic Alarm

8.6 Event Log

This web page shows system status, logger information, and the contents of the event log.

Figure 8.6 Event Log Web Page

SLA: Safety Logic Alarm		
Event Logger		
System Status		
Register Name	MB Reg	(Bit) Status Messages / Value
System Overall	8001	No status bits set
Safety Section Summary	8002	No status bits set
Non-Safety Section Summary	8003	No status bits set
Input Fault Summary	8004	No status bits set
Input Warning Summary	8005	No status bits set
Startup Delay Time Remaining	8006	0 seconds
User Simulation Time Remaining	8007	0 seconds
System Date	8017-8019	Friday Mar 17, 2023
System Time	8020-8022	08:22:34.9
Logger Status		
Register Name	(Bit) Status Messages / Value	
Logger Status	No status bits set	
Total Records Logged Since Last Clear	15	
Logger Store Failures	0	
Date / Time of Last Logger Clear	Fri Mar 17, 2023 at 08:17:53	
Event Log		
Timestamp	Event	Event Detail
03/17/23 08:19:50.6	DI1 Status	Bit FALSE: (0) DI Active
03/17/23 08:19:50.4	DI1 Status	Bit TRUE: (0) DI Active
03/17/23 08:19:47.8	Input Fault Summary	Bit FALSE: (1) AI1A Input Fault
03/17/23 08:19:47.8	Safety Summary	Bit FALSE: (6) Analog Input Fault
03/17/23 08:19:44.9	ALM2 Status	Bit FALSE: (0) Alarming
03/17/23 08:19:44.9	Input Fault Summary	Bit FALSE: (5) AI2A Input Fault
03/17/23 08:19:37.5	ALM2 Status	Bit TRUE: (0) Alarming
03/17/23 08:19:37.5	Input Fault Summary	Bit TRUE: (5) AI2A Input Fault
03/17/23 08:19:34.1	Input Fault Summary	Bit TRUE: (1) AI1A Input Fault
03/17/23 08:19:34.1	Safety Summary	Bit TRUE: (6) Analog Input Fault
03/17/23 08:19:22.1	ALM1 Status	Bit TRUE: (0) Alarming
03/17/23 08:19:19.2	MIIP Connection	10.0.0.100
03/17/23 08:18:53.0	Powered Up	
03/17/23 08:18:34.0	Powered Down	
03/17/23 08:17:53.4	Event Log Cleared	

9 SLA Operation and Maintenance

When the SLA is used in a SIL rated safety application, please refer to the Safety Instrumented Systems section of this manual before operating your unit.

9.1 Operation

Once installed, the SLA begins to operate. Depending upon environmental conditions, it can be expected to operate unattended for extended periods of time. No calibration is required.

9.2 Firewall Configuration

If you are connecting to the SLA through a firewall, please ensure the relevant ports are open for the services you need:

- WWW 80
- MODBUS/TCP 502
- MIIP DTM 5094
- NAC Client 2850/2851

Safety Logic Alarm

9.3 SLA Front Panel

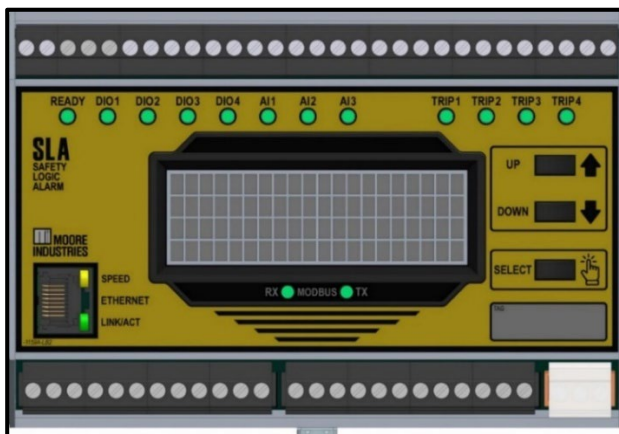
The SLA front panel displays all readings for analog inputs and outputs, Discrete I/Os, relays, and alarms. The user can toggle manually through the readings via the Up Button and Down Button or have the readings scroll automatically.

Configuration of the SLA cannot be performed via the display. All configuration must be completed with a FDT host such as PACTware.

The front panel buttons are also used to navigate the menus:

- Press **Select** to enter the **Main Menu**.
- Use **Up** and **Down** to choose between viewing the **Display**, **System**, **Status**, or **MODBUS**, and then press **Select** to enter the submenu.
- Use **Up** and **Down** to scroll through items in the submenu or change the auto-scroll mode (this change is not saved).
- Press **Select** to exit the submenu.
- Use **Up** and **Down** to choose **Exit**.
- Press **Select** to go back to the displayed readings.

Figure 9.1 SLA Front Panel



It is possible to toggle the Auto-scroll setting from the Display Settings screen. The change is not saved, therefore the Configuration ID is not affected. If the SLA is power-cycled, the last value set by the DTM will be applied.

Safety Logic Alarm

9.4 Status LEDs

The status indicator lights (or LEDs) provide an indication of the device's operating status, showing any System Faults, Discrete I/O readings, Analog Input Channel status, and whether any Relays have been tripped. See **Table 10** LED Indication and Device Status for the meaning of each LED's color.

Table 10 LED Indication and Device Status

LED	RED	GREEN	ORANGE	BLINKING	OFF
READY	SYSTEM FAULT	ALL GOOD	START UP/ CONFIG / COMMS LOSS	WARNING	POWER OFF
DIO1-4	ACTIVE	INACTIVE/ DISABLED	START UP / COMMS LOSS		POWER OFF
AI1-3	BOTH A AND B INPUTS ARE BAD	BOTH A AND B INPUTS ARE GOOD	START UP / COMMS LOSS	GREEN/RED EITHER A OR B INPUTS ARE BAD	POWER OFF
RO1-4	TRIPPED	NOT TRIPPED/ DISABLED	START UP/COMM LOSS	RED/OFF*	POWER OFF

*RO4 only, indicates user configuration and jumper mismatch.



Note: If the unit has an internal loss of communications from the safety section, then all LEDs will be orange and a system warning will be set.

9.5 SLA Diagnostic and Fault Alarms

The SLA has a high level of diagnostic capability to continually monitor itself and its inputs. Sensor Diagnostics are available for all sensors used in the device. For a full list of diagnostic messages and corrective actions please refer to Section 9.6.

Internal Diagnostics

On power up the unit runs through a thorough diagnostic, an initialization process, and starts processing the inputs. If the unit has a configured Startup Delay, all alarms are held in an inactive state and the AO is held at its configured initial value until the delay expires. If any system fault is found during power up, all outputs configured for system faults will alarm and an error message will be displayed. Once in operation, the unit continues diagnostic tests in the background and will set system faults/warnings.

Safety Logic Alarm

Configuration Diagnostics

On power up, the stored configuration is validated for corruption and mismatched input level switch settings. If something is invalid, then a system fault will be declared, and the unit will remain in shelf-state. Once the configuration error has been resolved by either changing the input level switch settings or downloading a valid configuration and rebooting, the system fault will be cleared.

Before saving a new configuration to the unit, it will be checked for validity. If it is invalid, the unit will reject the configuration and set a system fault but continue to run with the existing configuration. Once a corrected configuration is downloaded or input switch settings are corrected and the SLA rebooted, the system fault will be cleared, and the unit will start running.

Runtime Data Diagnostics

During operation, the SLA may detect a problem with an equation (e.g. divide by zero). This will hold the output at its last value and output an error message. It may also set a system warning depending on the error. If an alarm's sourced trip points are out of range the alarm will react according to its availability/integrity setting, output an error message, and set a system fault.

Input Diagnostics

The SLA has extensive hardware diagnostics of the analog inputs to detect broken wire and saturation. It also detects out of range and linearization errors.

All input faults and warnings can be configured to latch and can be selected as part of any discrete alarm and/or discrete output and/or relay outputs.

Discrete Output Diagnostics

A diagnostic is also available for any DIO which is configured as a discrete output. This pulses the output to verify it is not stuck. Any diagnostic failure is declared as a system fault.

System Fault and Warning Latching

If Relay 4 is configured as a fault relay and a Hardware Diagnostic detects a fault condition, Relay 4 will be latched in hardware. This requires a power cycle to clear. All diagnostics latch in software. By default, they also require a power cycle to clear.

It is possible to configure a discrete variable as the System Fault Latch Reset Source. If the variable goes TRUE, most system faults that are latched in software will be unlatched. There are a number of faults that cannot be unlatched, for example: Hardware Faults, RAM Diagnostic in an Input Channel Microprocessor and Physical Security Faults (switch or jumper moved while powered on).

By default, system warnings do not latch, however it is possible to configure them to do so. If latching is enabled but no Warning Latch Reset Source is configured, then a power cycle will be required to clear a warning. If the reset source is configured, and the variable goes TRUE most System Warnings will clear. Similar to faults, some warnings will not clear (e.g. RAM Diagnostic in an unused Input Channel.)

9.6 Diagnostic Messages

The following tables describe the diagnostic and status messages shown on the web pages and display. Each message corresponds to a specific bit position when the register is read via MODBUS/TCP or RTU.

9.6.1 Overall System Status

This table defines the Overall System status messages displayed on SLA web pages and accessed at MODBUS register 8001.

Table 11 Overall System Status Messages

Bit Position	Message	Description	Recommended Action
0	Overall System Fault	A fault has occurred in the SLA	Inspect registers to determine the source of the fault
1	Overall System Warning	A warning has occurred in the SLA	Inspect registers to determine the source of the warning
2	Communications with Safety Section Failure	The Network Section cannot communicate with the Safety Section.	This generally indicates an internal SLA hardware failure. This may happen during configuration or trimming.

9.6.2 Safety Section Summary

This table defines the Safety Section Summary messages displayed on SLA web pages, the display, and accessed at MODBUS register 8002. This is the highest level of summary for the safety section. Each bit corresponds to a functional area, for example, **Diagnostic Error**, **Non-volatile Memory Error**, **Latched Block Fault**, etc.

Table 12 Safety Section Summary Messages

Bit Position	Web page Message	Display Message	Description	Recommended Action
0	Diagnostic Fault	Diag Fault	The Safety Section is reporting a diagnostic fault.	View the Safety Section Diagnostic Summary register to see which microprocessor has the diagnostic fault. Power cycle the SLA, if the fault is still present, the unit requires service. If not, spurious event.
1	Nonvolatile Memory Error	NV Memory Error	There was a failure during either loading from or saving to non-volatile memory. This can occur if the unit loses power before a download is complete.	Reconfigure the unit's user configuration or network configuration and power cycle.

Bit Position	Web page Message	Display Message	Description	Recommended Action
2	Configuration Error	Config Error	<p>A configuration error was detected. This usually occurs when an input level switch or Relay 4 jumper is in the wrong position.</p> <p>It is possible that this bit could be set due to incorrect parameter validation by the DTM, resulting in an attempted download. In this case, the firmware has detected the error and rejected the configuration.</p>	<p>Refer to the Jumper and Switch Mismatches Register to determine which item is in the incorrect position.</p> <p>If the RO4 jumper was incorrect the unit must be power cycled.</p>
3	Jumper or switch does not match user configuration	Jumper or switch does not match	<p>A configuration error was detected. This usually occurs when an input level switch or Relay 4 jumper is in the wrong position.</p>	<p>Refer to the Jumper and Switch Mismatches Register to determine which item is in the incorrect position.</p> <p>If the RO4 jumper was incorrect the unit must be power cycled.</p>
4	A Block is reporting a Fault	Block Fault	<p>One or more blocks is reporting a system fault.</p>	<p>Power cycle the unit to clear the latched fault.</p> <p>or</p> <p>If a Fault Latch Reset Source is configured, cycle the source TRUE then FALSE.</p>
5	A Block is reporting a Warning	Block Warning	<p>One or more block(s) is reporting a system fault.</p> <p>This can occur if an unused analog input channel has a hardware fault, or if an expression has a runtime warning (e.g., attempting the square root of a negative or adding two numbers of excessively different magnitudes).</p>	<p>Address the underlying warning – e.g., sqrt (negative number)</p> <p>Power cycle the unit to clear the latched warning.</p> <p>If a Warning Latch Reset Source is configured, cycle the source TRUE then FALSE.</p>

Bit Position	Web page Message	Display Message	Description	Recommended Action
6	Analog Input Fault	Analog In Fault	<p>One of the analog inputs is reporting an (possibly latched) input fault. These faults are external to the SLA (e.g., broken wires or saturation).</p> <p>If a channel is configured for Failover Mode, and its corresponding sensor has an Input Fault, it will be downgraded to an Input Warning. If both sensors have Input Faults, they are not downgraded and remain categorized as faults.</p>	<p>Refer to the Sensor Block Input Fault Summary to determine which block has the Fault.</p> <p>View the system's runtime data and status, inspecting each sensor's consolidated status to determine which sensor has the fault, and what the fault is.</p>
7	Analog Input Warning	Analog In Warn	<p>One of the analog inputs is reporting an (possibly latched) input warning. These warnings are for conditions or connections that are external to the SLA.</p> <p>If a channel is configured for Failover Mode, and its corresponding sensor has an Input Fault, it will be downgraded to an Input Warning. If both sensors have Input Faults, they are not downgraded and remain categorized as faults.</p>	<p>Refer to the Sensor Block Input Fault Summary to determine which block has the Fault.</p> <p>View the system's runtime data and status, inspecting each sensor's consolidated status to determine which sensor has the fault, and what the fault is.</p>
8	Equation Processing Fault	Equation Fault	<p>A fault has occurred while evaluating an equation.</p> <p>This generally occurs as the result of some form of corruption.</p>	<p>View the system's runtime data and status, inspecting each expression's consolidated status to determine which variable has the fault, and what the fault is.</p>
9	Equation Processing Warning	Equation Warning	<p>A warning has occurred while evaluating an equation.</p> <p>The most common reason for this warning is an equation using a BAD quality analog variable.</p>	<p>View the system's runtime data and status, inspecting each expression's consolidated status to determine which variable has the warning, and what the warning is.</p>

Safety Logic Alarm

Bit Position	Web page Message	Display Message	Description	Recommended Action
10	Physical Security Fault (R4 or User Configuration Jumper changed while running)	Phys Sec Fault	<p>The Relay 4 jumper or the User Configuration Security jumper was changed while the unit is powered on.</p> <p>If the R4 jumper was moved, R4 will De-Energize to Trip (DET) regardless of configuration (e.g. if configured with R4 as Process Relay, non-failsafe, and the jumper is moved to Fault Relay, R4 will de-energize, even though it was configured non-failsafe which is energize to trip).</p>	Ensure the jumpers are in the desired position and power cycle.
11	Factory mode operation attempted	Factory mode Try	An action was attempted that required factory mode.	There are no user operations that require factory mode, contact customer support.
12	Diagnostic Warning	Diagnostic Warning	<p>The safety section is reporting a diagnostic warning.</p> <p>One cause of this is when an AI channel's sensors are both disabled, and that channel has a diagnostic error.</p>	<p>View the Safety Section Diagnostic Summary register to see which microprocessor has the diagnostic warning.</p> <p>Power cycle the SLA, if the fault is still present, the unit requires service. If not, spurious event.</p>
13	Startup Delay is Active	Startup Delay	<p>The user configured startup delay has not yet expired.</p> <p>The outputs are being held in their initial state: AO per user configuration, RO and DO logical FALSE.</p>	Wait for the delay time to elapse.

Safety Logic Alarm

9.6.3 Network Section Summary

This table defines the Network Section Summary messages displayed on SLA web pages and accessed at MODBUS register 8003. This is the highest summary level of for the network section. Each bit corresponds to a functional area, for example, **Diagnostic Error, Nonvolatile Memory Error, Network Service Error**, etc.

Table 13 Network Section Status Messages

Bit Position	Message	Description	Recommended Action
0	Diagnostic Error	The Non-Safety Section is reporting a diagnostic error.	View the Non-Safety Section Diagnostic Summary register to see which microprocessor has the diagnostic fault. Power cycle the SLA, if the fault is still present, the unit requires service. If not, spurious event.
1	Nonvolatile Memory Error	There was a failure during either loading from or saving to non-volatile memory. This can occur if the unit loses power before a download is complete.	Reconfigure the unit's user configuration or network configuration and power cycle.
2	Network Section Configuration Error	A configuration error was detected.	Check the configuration on the DTM and try downloading again.
4	Communication with Safety Section Error	The network section cannot communicate with the safety section. The safety function is likely unaffected; however no data is reaching the outside world.	This error can occur during trimming. If it does not clear, contact customer support, this error is not field addressable.
5	Logger System Error	The event logger is reporting an error. Generally this is some form of data corruption in the non-volatile memory	Use the DTM to clear the log, and power cycle the SLA.
14	Network Service Error	A network service has reported an error. This can occur if too many MODBUS connections are attempted, too many DTM connections are attempted, or if there is an internal failure	View the status web page to determine the reason for the error.

Safety Logic Alarm

Bit Position	Message	Description	Recommended Action
15	Physical Security Error	One of the input level switches or jumpers was changed while the unit was powered on.	Power cycle the SLA

9.6.4 Input Fault Summary

This table defines the Input Fault Summary messages displayed on SLA web pages and accessed at MODBUS register 8004. There is one bit per input directing attention to that input's consolidated status register.

Table 14 Input Fault Summary Messages

Bit Position	Message	Description	Recommended Action
0	AI1RJC Input Fault	AI1RJC has an input Fault.	A RJC failure indicates a hardware failure, or operating outside allowable temperature ranges.
1	AI1A Input Fault	Sensor AI1A has an input Fault.	Refer to the variable's consolidated status register for more information.
2	AI1B Input Fault	Sensor AI1B has an input Fault.	Refer to the variable's consolidated status register for more information.
3	AI1 Failover Input Fault	Sensor AI1 Failover has an input Fault.	Refer to the variable's consolidated status register for more information.
4	AI2RJC Input Fault	AI2RJC has an input Fault.	A RJC failure indicates a hardware failure, or operating outside allowable temperature ranges.
5	AI2A Input Fault	Sensor AI2A has an input Fault.	Refer to the variable's consolidated status register for more information.
6	AI2B Input Fault	Sensor AI2B has an input Fault.	Refer to the variable's consolidated status register for more information.
7	AI2 Failover Input Fault	Sensor AI2 Failover has an input Fault.	Refer to the variable's consolidated status register for more information.
8	AI3RJC Input Fault	AI3RJC has an input Fault.	A RJC failure indicates a hardware failure, or operating outside allowable temperature ranges.
9	AI3A Input Fault	Sensor AI3A has an input Fault.	Refer to the variable's consolidated status register for more information.
10	AI3B Input Fault	Sensor AI3B has an input Fault.	Refer to the variable's consolidated status register for more information.
11	AI3 Failover Input Fault	Sensor AI3 Failover has an input Fault.	Refer to the variable's consolidated status register for more information.

Safety Logic Alarm

9.6.5 Input Warning Summary

This table defines the Input Warning Summary messages displayed on SLA web pages and accessed at MODBUS register 8005. There is one bit per input directing attention to that input's consolidated status register.

Table 15 Input Warning Summary Messages

Bit Position	Message	Description	Recommended Action
1	AI1A Input Warning	Sensor AI1A has an input Warning	Refer to the variable's consolidated status register for more information.
2	AI1B Input Warning	Sensor AI1B has an input Warning	Refer to the variable's consolidated status register for more information.
3	AI1FO Input Warning	Sensor AI1FO has an input Warning	Refer to the variable's consolidated status register for more information.
5	AI2A Input Warning	Sensor AI2A has an input Warning	Refer to the variable's consolidated status register for more information.
6	AI2B Input Warning	Sensor AI2B has an input Warning	Refer to the variable's consolidated status register for more information.
7	AI2FO Input Warning	Sensor AI2FO has an input Warning	Refer to the variable's consolidated status register for more information.
9	AI3A Input Warning	Sensor AI3A has an input Warning	Refer to the variable's consolidated status register for more information.
10	AI3B Input Warning	Sensor AI13B has an input Warning	Refer to the variable's consolidated status register for more information.
11	AI3FO Input Warning	Sensor AI3FO has an input Warning	Refer to the variable's consolidated status register for more information.

Safety Logic Alarm

9.6.6 Analog Input Status

This table defines Analog Input diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 16 Analog Input Status Messages

Bit Position	Web page Message	Display Message	Description	Recommended Action
0	Sensor Error (BAD Quality)	Sensor Error	The sensor has BAD quality.	The sensor's quality is BAD, the underlying reason is indicated by other bits in this status register.
1	Sensor Out of Range	Out of Range	Sensor value is Outside the User Configured Range.	Address input signal that is out of range by more than the configured allowable amount.
2	Input Saturated	Saturated	The input is saturated. This includes: <ul style="list-style-type: none"> • ADC value too large/small (adc/hw sat). • Over 110% lin conformance (sw sat). • Outside sensor range (but not conformance). • Physical sensor value outside configured RTD/TC legal range. 	Address sensor related issues that would cause the instrument to read excessive values.
3	RJC Error	RJC Error	RJC Error (and in Thermocouple).	Verify that ambient temperature is and has been within SLA's operating range. If it has, contact customer service.
4	Broken Wire 1	Broken Wire 1	Broken Wire 1 has been detected.	Address the broken wire.
5	Broken Wire 2	Broken Wire 2	Broken Wire 2 has been detected.	Address the broken wire.
6	Broken Wire 3	Broken Wire 3	Broken Wire 3 has been detected.	Address the broken wire.
7	Broken Wires	Broken Wires	Multiple Broken Wires were detected, or it was not possible to determine which wire was broken.	Address the broken wire(s).
9	Input Level Mismatch	Inp Mismatch	AI Level switch position does not match user configuration.	Set the switch or download the correct configuration.

Safety Logic Alarm

Bit Position	Web page Message	Display Message	Description	Recommended Action
10	Trim Error	Trim Error	User Trimming encountered an error.	Address the issue reported by altering the input value.
11	Simulating Data	Simulating	User has used the DTM to enable simulation mode and has injected a simulation value for this variable.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
14	Channel Diagnostic Fault	Channel Fault	A channel diagnostic has detected a fault.	Contact customer support, this error is not field addressable.
15	Disabled	Disabled	This block is disabled.	N/A, informational.

9.6.7 Failover Sensor Status

This table defines Failover Sensor diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 17 Failover Sensor Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Failed Sensors A&B	Failed A&B	Both sensors have failed.	Address the reason for Sensor A and B's BAD quality. Refer to their consolidated status registers.
1	On Backup	On Backup	Sensor A is BAD, Sensor B is GOOD.	Address the reason for Sensor A's BAD quality. Refer to its consolidated status register.
2	Cannot Backup	Cannot Backup	Sensor A is GOOD, Sensor B is BAD.	Address the reason for Sensor B's BAD quality. Refer to its consolidated status register.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
15	Disabled	Disabled	The block is disabled.	N/A informational.

Safety Logic Alarm

9.6.8 Discrete Input/Output Status

This table defines Discrete Input / Output (DIO) diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 18 Discrete Input / Output Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	DI Active <i>(input only)</i> DO Active <i>(output only)</i>	DI Active <i>(input only)</i> DO Active <i>(output only)</i>	The discrete block output is TRUE.	Inspect the other bit in this register to determine the reason the block is active.
2	Voting is True <i>(output only)</i>	Voting True <i>(output only)</i>	X out of Y voting has succeeded ($\geq X$ sources are active).	Address the reason for (sources of) the votes.
3	Selected Input Fault Or Warning <i>(output only)</i>	In Fault/Warn <i>(output only)</i>	One of the selected Input Faults or Warnings is active.	Address the input fault or warning. Strobe the input fault or warn latch reset source if necessary.
4	Delaying <i>(output only)</i>	Delaying <i>(output only)</i>	An alarm condition has been detected but has not been passed to block output because the timer has not expired.	Address the underlying reason for being active----- -----.
6	Latched <i>(output only)</i>	Latched <i>(output only)</i>	Block output is latched.	Address the underlying reason for being active. Strobe the Latch Reset Source TRUE (and then FALSE prior to the next latch reset).
7	Suppressing <i>(output only)</i>	Suppressing <i>(output only)</i>	Block output is suppressed.	When the suppress source is active, this bit will be set. It will clear when suppression is released.
8	Selected System Fault Or Warning <i>(output only)</i>	Sys Fault/Warn <i>(output only)</i>	There is an active System Fault or Warning.	Address the system fault or warning. Strobe the system fault or warn latch reset source if necessary.
9	Unable to Pull Output Low <i>(output only)</i>	Can't Go Low <i>(output only)</i>	The Discrete Output Diagnostic could not pull the line low.	This can indicate a problem with wiring or an internal SLA problem. Check for shorts to the power supply. Pullup resistor is too small.
10	Unable to Set Output High <i>(output only)</i>	Can't Go High <i>(output only)</i>	When the DO Diagnostic released the line, it was not pulled up.	This can indicate a problem with wiring or an internal SLA problem. Check the DIO wires for shorts to each other or to ground. Verify the external pullup is present.

Safety Logic Alarm

Bit Position	Web Page Message	Display Message	Description	Recommended Action
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
12	Additional Startup Delay	Addl Strt Dly	The block is performing additional start delay, holding its initial value.	N/A, informational. This bit will turn on during block specific additional start delay, and off when the delay expires.
13	StartUp Delay	StartUp Dly	The system start delay timer is still active.	N/A, informational. This bit will turn on during startup delay, and off when startup delay expires.
14	Channel Diagnostic Fault (<i>output only</i>)	Channel Fault (<i>output only</i>)	There was an internal fault in this specific block instance.	DO Diagnostic can be triggered by excessive capacitance/cable size, increase the time allowed or disable the diagnostic.
15	Disabled	Disabled	The block is disabled.	N/A, informational.

Safety Logic Alarm

9.6.9 Alarm Status

This table defines Alarm diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 19 Alarm Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Alarming	Alarming	The discrete block output is TRUE.	Inspect the other bit in this register to determine the reason the block is active.
1	Analog Trip Condition	Analog Trip	An analog alarm condition is currently present.	Address the underlying analog alarm condition (i.e. the source's level, rate of change, etc.).
2	Voting is True	Voting True	X out of Y voting has succeeded ($\geq X$ sources are active).	Address the reason for (sources of) the votes.
4	Delaying	Delaying	An alarm condition has been detected but has not been passed to block output because the timer has not expired.	Address the underlying reason for being active (analog condition or votes).
6	Latched	Latched	Block output is latched.	Address the underlying reason for being active. Strobe the Latch Reset Source TRUE (and then FALSE prior to the next latch reset).
7	Suppressing	Suppressing	Block output is suppressed.	When the suppress source is active, this bit will be set. It will clear when suppression is released.
9	In Deadband	In Deadband	Analog alarm is within deadband.	Address the underlying analog alarm condition. It had entered the trip region and has pulled back, but not enough.
10	Bad Input	Bad Input	The sourced variable has BAD quality.	Address the BAD quality of the alarm source variable.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
12	Additional Startup Delay	Addl Strt Dly	The block is performing additional start delay, holding its initial value.	N/A, informational. This bit will turn on during block specific additional start delay, and off when the delay expires.

Safety Logic Alarm

Bit Position	Web Page Message	Display Message	Description	Recommended Action
13	StartUp Delay	StartUp Dly	The system start delay timer is still active.	N/A, informational. This bit will turn on during startup delay, and off when startup delay expires.
14	Illegal Parameter Value Sourced	Bad Param	There was an internal fault in this specific block instance.	Address the BAD quality of the sourced alarm parameter.
15	Disabled	Disabled	The block is disabled.	N/A, informational.

9.6.10 Relay Status

This table defines Relay diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 20 Relay Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Alarming	Alarming	The discrete block output is TRUE.	Inspect the other bit in this register to determine the reason the block is active.
2	Voting is True	Voting True	X out of Y voting has succeeded (at least X sources are active).	Address the reason for (sources of) the votes.
3	Selected Input Fault Or Warning	In Fault/Warn	One of the selected Input Faults or Warnings is active.	Address the input fault or warning. Strobe the input fault or warn latch reset source if necessary.
4	Delaying	Delaying	An alarm condition has been detected but has not been passed to block output because the timer has not expired.	Address the underlying reason for being active (analog condition or votes).
5	Relay 4 jumper position does not match configuration	R4 Jumper	Relay 4: The user configuration setting, and actual jumper position do not match.	Change the Relay 4 jumper and downloaded configuration to match. A power cycle may be necessary to clear.
6	Latched	Latched	Block output is latched.	Address the underlying reason for being active. Strobe the Latch Reset Source TRUE (and then FALSE prior to the next latch reset).

Safety Logic Alarm

Bit Position	Web Page Message	Display Message	Description	Recommended Action
7	Suppressing	Suppressing	Block output is suppressed.	When the suppress source is active, this bit will be set. It will clear when suppression is released.
8	Selected System Fault Or Warning	Sys Fault/Warn	There is an active System Fault or Warning.	Address the system fault or warning. Strobe the system fault or warn latch reset source if necessary.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
12	Additional Startup Delay	Addl Strt Dly	The block is performing additional start delay, holding its initial value.	N/A, informational. This bit will turn on during block specific additional start delay, and off when the delay expires.
13	StartUp Delay	StartUp Dly	The system start delay timer is still active.	N/A, informational. This bit will turn on during startup delay, and off when startup delay expires.
14	Channel Diagnostic Fault	Channel Fault	There was an internal fault in this specific block instance.	RO Diagnostic indicates a possible HW problem.
15	Disabled	Disabled	The block is disabled.	N/A, informational.

Safety Logic Alarm

9.6.11 Analog Output Status

This table defines Analog Output diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 21 Analog Output Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Fail Response Active (Bad Input)	Fail Response	The AO is performing the configured fail response.	Address the reason for the source's BAD quality.
1	Fail Response Active (System Fault)	Fail Response	The AO is performing the configured fail response.	Address the system fault. Strobe the system fault latch reset source if necessary.
4	Output Saturation Low	Out Sat Low	Scaled output is below the low saturation point. Output is held at the low saturation point, either 5% below the lower end point or 3.8 mA, whichever is lower.	The output drive is being limited. If this is intentional, then it is an advisory. Consider logic to limit the drive, and instead output a sentinel value or limiting.
5	Output Saturation High	Out Sat High	Scaled output is above the high saturation point. Output is held at the high saturation point, either higher end point +0.5mA or 20.5mA, whichever is higher.	The output drive is being limited. If this is intentional, then it is an advisory. Consider logic to limit the drive, and instead output a sentinel value or limiting.
9	Trimming in Progress	Trimming	Trimming is active.	Complete the trimming process, and click the "Unfix Output" on the DTM.
10	Trim Error	Trim Error	User trimming encountered an error.	Address the indicated problem with the trim process.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
13	StartUp Delay	StartUp Delay	The system start delay timer is still active.	N/A, informational. This bit will turn on during block specific additional start delay, and off when the delay expires.

Safety Logic Alarm

Bit Position	Web Page Message	Display Message	Description	Recommended Action
14	System Fault (Calibration Error)	System Fault	Corrupt calibration data.	Contact customer support, this error is not field addressable.
15	Disabled	Disabled	This block is disabled.	N/A, informational.

9.6.12 Expression Status

This table defines Expression diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 22 Expression Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Bad Quality	Bad Quality	The variable has BAD quality.	Refer to the other bits in this register to determine why the quality was set BAD.
4	Bad Quality Parameter	Bad Qual Para	A Parameter used in the expression has BAD Quality.	Resolve the sourced variable's BAD quality, check the variable's consolidated status.
5	Illegal Parameter Value	Illegal Value	Illegal Parameter Value for the requested operation. One of the following: <ul style="list-style-type: none"> • Divide by Zero • Square root of a negative value. • The Math library has detected and reported a problem with one (or more) of the parameters. 	Consider the math being performed: <ul style="list-style-type: none"> • Use an IF() construct to detect the value is near zero and substitute a sentinel. For example: AI1A/IF(AI2A<-.01,0.0001,AI2A) • Floor the value being square rooted. For example: SQRT(MAX(IV1,0.0))

Bit Position	Web Page Message	Display Message	Description	Recommended Action
7	Math Warning	Math Warning	<p>There is a possible problem related to operand magnitude:</p> <ul style="list-style-type: none"> Addition or Subtraction when not enough overlap in the magnitude (eg: $10^{30} + 10^{-4}$). During AVG or AVGD, the accumulated sum was larger than $\sim 10^{30}$. 	Consider the math being performed and refactor to avoid the magnitude warning.
8	Result Out of Range (e.g. +-infinity)	Result OOR	<p>The calculated result is too large to represent, or is + / - infinity.</p> <p>The variable is holding last value and quality has been set to BAD.</p>	Consider the math being performed to determine why a value of + or - infinity was computed.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
13	StartUp Delay	StartUp Dly	Start Delay Is Active.	N/A informational. This bit will turn on during startup delay, and off when startup delay expires.
14	System Fault (Runtime Exception)	System Fault	System Fault Has occurred.	Unexpected behavior. Power cycle, if it occurs again, contact Customer Service.
14	Disabled	Disabled	The block is disabled.	N/A informational.

Safety Logic Alarm

9.6.13 Timer Status

This table defines Timer diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 23 Timer Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Expired	Expired	The timer has expired.	If the Timer is configured as a resetting timer, set the Run source FALSE or If a Reset Source is configured, give it the correct edge to be detected (eg if detection is on a rising edge, give it a rising edge).
1	Running	Running	The Timer is timing.	N/A, informational. This bit will be set when the timer is counting.
2	Reset Detected	Reset Detectd	The timer was reset.	The discrete Reset had the correct edge to be detected (eg if detection is on a rising edge, give it a rising edge.) This bit will only be active for one execution cycle, and it will clear.
4	Timing Paused	Paused	The timer is paused.	To continue timing, activate the Run source. or Activate the Reset Source to reset timing.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
13	StartUp Delay	StartUp Delay	System Start Delay Is Active	N/A, informational. This bit will turn on during startup delay, and off when startup delay expires.
15	Disabled	Disabled	This block is disabled.	N/A, informational.

Safety Logic Alarm

9.6.14 Running Min/Max Status

This table defines Running Min/Max diagnostic and status messages shown on SLA web pages, the display, and accessed by the variables' MODBUS registers.

Table 24 Running Min/Max Status Messages

Bit Position	Web Page Message	Display Message	Description	Recommended Action
0	Bad Quality - Not Updating	Bad Quality	The variable has BAD quality.	Address the underlying reason the source variable has BAD quality. If configured as Hi Integrity RMM, strobe the Reset source TRUE.
1	New Value Set	New Value Set	The block has captured a new min/max value.	N/A, informational. A new min/max value was captured.
2	Reset Detected	Reset Detectd	The Reset source is active, and the block's value has been set to the initial value.	N/A, informational. The Reset Source is TRUE.
9	Had Bad Source Data	Had Bad Srce	The Source data was BAD, but no longer is.	Strobe the Reset source TRUE. If there is no configured Reset Source, then the SLA must be power cycled to clear.
10	Has Bad Source Data	Has Bad Srce	The source data is currently BAD.	Address the underlying reason the source variable has BAD quality. If Hi Integrity RMM, strobe the Reset source TRUE.
11	Simulating Data	Simulating	User simulation is active for the block.	N/A, informational. This bit will turn on when simulation is active, and off when simulation is disabled or times out.
12	Additional Startup Delay	Addl Strt Dly	The block is performing additional start delay, holding its initial value.	N/A, informational. This bit will turn on during block specific additional start delay, and off when the delay expires.
13	StartUp Delay	StartUp Delay	System Start Delay Is Active.	N/A, informational. This bit will turn on during startup delay, and off when startup delay expires.
15	Disabled	Disabled	This block is disabled.	N/A, informational.

9.7 Maintenance

Moore Industries suggests a check for terminal tightness and general unit condition every 6-8 months. Always adhere to any site requirements for programmed maintenance.

9.7.1 Repair and Replacement

The SLA is not intended to be repaired on site and has no components needing maintenance or regular replacement. On device failure, the SLA should be returned to Moore Industries Worldwide Headquarters in North Hills, CA 91343 U.S.A. for repair and refurbishment (refer to Returns Procedures at the end of this manual).

The SLA is a certified Safety component. Repair or replacement of any component without authorization from Moore Industries International, Inc. will invalidate any remaining warranty and the IEC61508 certification.

9.7.2 Recording and Reporting of SLA Performance

It is the end user's responsibility to maintain records of all safety component failures, especially those that might be classified as potentially dangerous.

This feedback data not only helps the supplier identify and rectify reliability issues but also to provide quantitative data to increase confidence in the FMEDA analysis of dangerous failure rates. Please ensure that any components returned to Moore Industries International, Inc. are returned with a clear report identifying the fault experienced.

10 SLA MODBUS Interface Specification

There is a wide range of information available in the SLA. Status and process data is reported on the web pages and in the MODBUS Register Map. The following sections detail the MODBUS registers. For convenience, the MODBUS registers are also provided on the web pages.

The following tables define the MODBUS input and holding register assignments. These tables are based on one-based register assignments. If your MODBUS host requires programming using zero-based MODBUS addresses, then deduct 1 from the listed (or computed) one-based register value. Please refer to your MODBUS host documentation to determine if it should be programmed using address or register values.

The SLA supports MODBUS/TCP as standard, and MODBUS/RTU as an option. Both supported versions are read-only, no data or values can be written to the SLA. Both physical interfaces access the same data and have shared configuration settings. This document is limited in scope, only covering available data, its location, and the shared settings.

10.1 Overview

MODBUS/TCP is the primary interface to access data from the SLA. During normal operation, the SLA will continuously update the MODBUS registers with input, output, internal variable (e.g., Alarms and Timers) values. In addition, the SLA will be generating status information about processing and internal self-diagnostics. The SLA implements MODBUS/TCP in accordance with the MODBUS/TCP specification found here: <http://www.modbus.org/specs.php>

10.2 Supported Function Codes

Function codes 3 and 4 are used to read the SLA's 16-bit analog registers. Both commands access the same underlying data. The SLA has neither Boolean values (coils) nor writeable analog registers.

10.3 MODBUS Configuration Settings

10.3.1 Floating Point Word Order Setting

Table 25 Floating Point Options

Parameter	Meaning	Possible Values
Floating Point Word Order	Controls how 32-bit values (float and integer) are placed into the Modbus map	standard, swapped
Number of Decimal Places	Location of the fixed decimal points for the integer registers	0-3

Since the protocol only supports 16-bit registers, the 32-bit floating point and 32-bit integer values use two adjacent registers. The SLA supports standard and swapped floating point byte order:

- Standard: LSW First (Word-Swapped, Big-Endian order)
- Swapped: MSW First (Big-Endian order)

Table 26 Standard and Swapped Bytes

Value	Hexadecimal (left most hex digit is MS, right most is LS)	Standard LSW [Register 1 value], [Register 2 value]	Swapped MSW [Register 1 value], [Register 2 value]
Generic 32-bit value	0xAABB CCDD	[CCDD], [AABB]	[AABB], [CCDD]
Floating Point: 2000.0	0x44FA 0000	[0000], [44FA]	[44FA], [0000]
Floating Point: NaN	0x7FA0 0000	[0000], [7FA0]	[7FA0], [0000]
32-bit unsigned integer: 305,419,896	0x1234 5678	[4567], [1234]	[1234], [4567]

The MODBUS Protocol specifies that the bytes within each 16-bit register are in Big-Endian order. Therefore, the most significant byte is placed in the framed message before the least significant byte.

The (Float) word order setting operates on words, not bytes. Therefore, in Swapped mode, the bytes are in Big-Endian order. In Standard Order mode, the bytes are NOT in Little-Endian order. They are in Big-Endian with the words swapped.

Safety Logic Alarm

10.3.2 Number of Decimal Places Setting

In addition to the data collected from the Safety Section being presented as 32-bit floats, it is also available as 16-bit signed integers. The integers are a fixed-point version of the floating-point values with a radix point, or decimal place, position specified by the user in the MODBUS Settings section of the SLA System Settings. This decimal place setting is made in this place only and is applied to all integers in the system.

If a float's magnitude is too large a number, then the integer value shall be fixed to the limits of a signed 16-bit integer, either -32768 or 32767. Retrieving the values as Floats is always preferable as the range that can be represented by integers is reduced.

A float with a BAD quality or a value of NaN (Not a Number) shall be converted to an integer value of +32767.

Table 27 Reduced Range of Floats per Decimal Place

Number of Decimal Places Setting	Representable Float Range
0	-32768 to +32767
1	-3276.8 to +3276.7
2	-327.68 to +327.67
3	-32.768 to +32.767

Table 28 below shows how the example Float values are represented with the different Number of Decimal Places setting. Many of the values are pegged to the integer limit.

Table 28 Float Values Represented With Different Number of Decimal Places

Example Float	0 DP	1 DP	2 DP	3 DP
123.456	123	1234	12346	32767*
10	10	100	1000	10000
3.1415	3	31	314	3142
0.01	0	0	1	10
-400.321	-400	-4003	-32768*	-32768*
-3000	-3000	-30000	-32768*	-32768*



Note: Values marked with an asterisk (*) indicate that the integer portion of the value has exceeded the possible range for the corresponding DP setting for 16-bit registers.

Safety Logic Alarm

The MODBUS Map has four main groups of registers. This includes a group for system information, one for status, and two groups of data with different register layout.

Within the data groups, four different pieces of information are available for each variable:

- Variable Value (Float) - For Discrete variables, TRUE is represented as 1.0, and FALSE is 0.0.
- Variable Value (Signed Fixed Point Integer) - The same values as the floating-point group, except as integers with decimal point fixed per the user's configuration setting. For discrete variables, TRUE is represented as 1, and FALSE is 0. Note that the 1 will have the Fixed DP setting applied. For example, if the SLA is configured for 2 decimal places (the default), a TRUE will appear as the value 100.
- Variable Data Quality - 1, If the analog block has GOOD quality, 0, if BAD. Enabled discrete blocks are always 1, Disabled discrete blocks are always 0.
- Variable Consolidated Status - 16 bits of status. See the variable specific status registers described above in 9.6 Diagnostic Messages.

Table 29 MODBUS Register Groups

Base Register	Name	Description
0001	Fixed Location - Variable Value (Float)	Floating Point version of each variable, always at the same register
1001	Fixed Location - Variable Value (Signed Fixed Point Integer)	Signed fixed point integer version of each variable, always at the same register
2001	Fixed Location - Variable Data Quality (u16)	Variable Data Quality (Is Good) for each variable, always at the same register
3001	Fixed location - Variable Consolidated Status	Consolidated Status Register for each variable, always at the same register
4001	Data Path - Variable Value (Float)	Floating Point version of each enabled variable in execution order
5001	Data Path - Variable Value (Signed Fixed Point Integer)	Signed fixed point integer version of each enabled in execution order
6001	Data Path - Variable Data Quality (u16)	Data Quality indicator (Is Good) for each enabled variable in execution order
7001	Data Path - Variable Consolidated Status	Consolidated Status Register for each enabled variable in execution order
8001	System Status	System Summary Status information
9001	System Information	Information about the system including version, model information, and Configuration ID.

Safety Logic Alarm

10.3.3 Fixed Location Registers

Each variable's data can always be found at the same location in this register group. As a result, if a variable is disabled the register position will remain allocated but will have a float value of NaN.

Table 30 Fixed Location Registers Information

Offset	Variable	Float Register (Discrete Vars: T=1.0, F=0.0)	Integer Register (Fixed Point)	Data Quality Register (Is Good)	Consolidated Status Register
0	AI1 RJC	0001	1001	2001	3001
1	AI1A	0003	1002	2002	3002
2	AI1B	0005	1003	2003	3003
3	AI1 Failover	0007	1004	2004	3004
4	AI2 RJC	0009	1005	2005	3005
5	AI2A	0011	1006	2006	3006
6	AI2B	0013	1007	2007	3007
7	AI2 Failover	0015	1008	2008	3008
8	AI3 RJC	0017	1009	2009	3009
9	AI3A	0019	1010	2010	3010
10	AI3B	0021	1011	2011	3011
11	AI3 Failover	0023	1012	2012	3012
12	AO1	0025	1013	2013	3013
13	AO2	0027	1014	2014	3014
14	AO3	0029	1015	2015	3015
15	123.45 (Fixed)	0031	1016	2016	N/A
16	DIO1	0033	1017	N/A	3017
17	DIO2	0035	1018	N/A	3018
18	DIO3	0037	1019	N/A	3019
19	DIO4	0039	1020	N/A	3020
20	RO1	0041	1021	N/A	3021
21	RO2	0043	1022	N/A	3022
22	RO3	0045	1023	N/A	3023
23	RO4	0047	1024	N/A	3024
24	ALM1	0049	1025	N/A	3025
25	ALM2	0051	1026	N/A	3026
26	ALM3	0053	1027	N/A	3027
27	ALM4	0055	1028	N/A	3028
28	ALM5	0057	1029	N/A	3029
29	ALM6	0059	1030	N/A	3030
30	ALM7	0061	1031	N/A	3031
31	ALM8	0063	1032	N/A	3032
32	ALM9	0065	1033	N/A	3033

Offset	Variable	Float Register (Discrete Vars: T=1.0, F=0.0)	Integer Register (Fixed Point)	Data Quality Register (Is Good)	Consolidated Status Register
33	ALM10	0067	1034	N/A	3034
34	ALM11	0069	1035	N/A	3035
35	ALM12	0071	1036	N/A	3036
36	ALM13	0073	1037	N/A	3037
37	ALM14	0075	1038	N/A	3038
38	ALM15	0077	1039	N/A	3039
39	ALM16	0079	1040	N/A	3040
40	IV1	0081	1041	2041	3041
41	IV2	0083	1042	2042	3042
42	IV3	0085	1043	2043	3043
43	IV4	0087	1044	2044	3044
44	IV5	0089	1045	2045	3045
45	IV6	0091	1046	2046	3046
46	IV7	0093	1047	2047	3047
47	IV8	0095	1048	2048	3048
48	IV9	0097	1049	2049	3049
49	IV10	0099	1050	2050	3050
50	IV11	0101	1051	2051	3051
51	IV12	0103	1052	2052	3052
52	IV13	0105	1053	2053	3053
53	IV14	0107	1054	2054	3054
54	IV15	0109	1055	2056	3055
55	IV16	0111	1056	2056	3056
56	TMR1	0113	1057	2057	3057
57	TMR2	0115	1058	2058	3058
58	TMR3	0117	1059	2059	3059
59	TMR4	0119	1060	2060	3060
60	TMR5	0121	1061	2061	3061
61	TMR6	0123	1062	2062	3062
62	TMR7	0125	1063	2063	3063
63	TMR8	0127	1064	2064	3064
64	RMM1	0129	1065	2065	3065
65	RMM2	0131	1066	2066	3066
66	RMM3	0133	1067	2067	3067
67	RMM4	0135	1068	2068	3068
68	RMM5	0137	1069	2069	3069
69	RMM6	0139	1070	2070	3070
70	RMM7	0141	1071	2071	3071

Safety Logic Alarm

Offset	Variable	Float Register (Discrete Vars: T=1.0, F=0.0)	Integer Register (Fixed Point)	Data Quality Register (Is Good)	Consolidated Status Register
71	RMM8	0143	1072	2072	3072

10.3.4 Data Path Registers

This group is laid out dynamically based on the user's configuration. Only the variables that are enabled are added to this group.



Warning: Be aware that the Data Path Registers depend on the blocks enabled. Therefore changing the SLA's configuration may cause a variable's register number to change.

This table shows where the information for the variable is located. In this case "i" is the zero-based variable that will be evaluated. The order and MODBUS register are shown on the Process Data and MODBUS Registers web pages.

Table 31 Location Information for the Variable

Offset (for variable i, zero based)	Variable i	Float Registers i (Discrete Vars: T=1.0, F=0.0)	Integer Register i (Fixed Point)	Data Quality Register i (Is Good)	Consolidated Status Register i
0	First Variable in Path (Block 0)	4001 4002	5001	6001	7001
1	Second Variable in Path (Block 1)	4003 4004	5002	6002	7002
...
i	Variable i in Path (i is zero based)	$4001+1*2$	$5001 + i$	$6001+ i$	$7001 + i$
...
70	Next to Last Variable in Path (70)	4141 4142	5071	6071	7071
71	Last Variable in Path (71)	4143 4144	5072	6072	7072

Safety Logic Alarm**10.3.5 System Status Registers**

The System Status Registers contain dynamic information about the running system. This includes information about the jumpers, logger, and status summaries.

Table 32 Location of System Status Registers

Address	Register	Data	Type
8000	8001	System Fault Overall	Unsigned Int (16bit)
8001	8002	Safety Section Status Summary	Unsigned Int (16bit)
8002	8003	Network Section Status Summary	Unsigned Int (16bit)
8003	8004	Input Fault Summary	Unsigned Int (16bit)
8004	8005	Input Warning Summary	Unsigned Int (16bit)
8005	8006	System Start Up Time Remaining (Seconds)	Unsigned Int (16bit)
8006	8007	User Simulation Time Remaining (Seconds)	Unsigned Int (16bit)
8007	8008	Jumper and Switch State	Unsigned Int (16bit)
8008	8009	Logger Status	Unsigned Int (16bit)
8009	8010	Logger Record Count	Unsigned Int (32bit)
8010	8011	n/a (used by 32bit value above)	N/A, see above
8011-8015	8012-8016	Reserved	
8016	8017	Year	Unsigned Int (16bit)
8017	8018	Month	Unsigned Int (16bit)
8018	8019	Day	Unsigned Int (16bit)
8019	8020	Hour	Unsigned Int (16bit)
8020	8021	Minute	Unsigned Int (16bit)
8021	8022	Second	Unsigned Int (16bit)

10.3.6 System Information Registers

The System Information Registers contain fixed information that does not change at runtime. This includes things that are fixed in the device like the serial number and SW/HW versions. The Configuration ID is included in this group because it should not change during safety operation.

Table 33 System Information Registers

Address	Register	Data	Type
9000	9001	Configuration ID	Two ID bytes from the Safety Section, and two from the Network Section. Bytes ordered in this and next register per configuration setting.
9001	9002	N/A (used by 32bit value above)	N/A, see above
9002	9003	Serial number	24bit value, 8 most significant bits will always be 0 (i.e., 0x00MM LLLL). Bytes ordered in this and next register per configuration setting.
9003	9004	N/A (used by 32bit value above)	N/A, see above
9004	9005	SLA (Software) Version, Major	Unsigned Int (16bit)
9005	9006	SLA (Software) Version, Minor	Unsigned Int (16bit)
9006	9007	SLA (Software) Version, Build	Unsigned Int (16bit)
9007	9008	SLA Hardware Version, Major	Unsigned Int (16bit)
9008	9009	SLA Hardware Version, Minor	Unsigned Int (16bit)
9009	9010	SLA Hardware Version, Build	Unsigned Int (16bit)

10.3.7 Coils

The SLA does not provide access to any Boolean coils.

11 SLA in Safety Instrumented System

The SLA is designed for use as an element of a safety instrumented system as defined by IEC61508-4 para 3.4.1.

This user manual contains all the information needed to configure, install, operate, and maintain this product. For safety applications, the SLA must only be used in accordance with this information and the restrictions and limitations as detailed below.

Refer to the specifications table of this user manual for ambient conditions and required power input.

Follow the standard installation practices in this user manual including cybersecurity precautions.

Prior to use in a safety function, the user must validate the operation of the device offline (see Bench Check in Section 3.3).

Do not attempt to simulate or configure the unit while it is performing its safety function. All security jumpers should then be installed to read-only mode to prevent any interference of the safety function.

11.1 Functional Safety Description

The SLA has been certified, by exida ®* to IEC61508:2010 for systematic integrity up to SIL3 and for random integrity up to SIL2. This means that an SLA is approved for single use in Safety Instrumented Systems (SIS) up to SIL2 and in a redundant architecture (1oo2, 2oo3, etc.) up to SIL 3. It is classified as a Type B device according to IEC 61508. Therefore, table 2 in IEC61508-1 and table 3 in IEC61508-2 provide the Safety Failure Fraction (SFF) and PFD_{AVG} requirements for a given SIL rating.

The SLA's primary functionality/purpose is reading analog and discrete inputs, applying calculations and logic, and driving discrete and optional analog outputs. Its secondary purpose is to expose this information to the outside world in a number of ways including MODBUS/TCP, optional MODBUS/RTU, in a DTM (via ethernet) running on a pc, and on the SLA's front panel.

The primary functionality is to take place in the safety path. The remaining functionality is to be non-interfering.

11.2 Failure Rate Data

The SLA FMEDA report (Moore Industries Document No: 700-702-43) provides the failure data required for calculations to use the SLA as part of a Safety Instrumented System.

11.3 Product Life

The product life of the SLA is 10 years (based on worst case component life data).

However, IEC 61508-2, Section 7.4 states that a useful lifetime based on experience has more weight than the calculated figures; Note 3 in the section comments states that the useful lifetime of a transmitter is most often within 8 to 10 years.

11.4 Process Safety Time

Process safety time is the minimum time from the initiation of a hazardous event to the point where the hazardous event is unavoidable. Any safety function designed to either prevent the event or at least mitigate its effect must be capable of performing its specified safety function in a time period very much less than the process safety time.

Depending on the configuration, the SLA has a characteristic response time (end to end) between 0.5 and 1.5 seconds. The total diagnostic test time of the unit is less than 10 minutes.

11.5 Configuration

The unit can be configured using a PC running an FDT/DTM program as described in this manual. After making any configuration changes, the user must validate the operation of the SLA offline, to ensure that the changes work safely prior to putting it back into operation. All security jumpers should then be installed to read-only mode and the unit power cycled.

The following considerations and restrictions will apply when using the SLA in a safety application:

11.5.1 High Integrity vs High Availability

A high integrity configuration includes both process data and SLA fault data to determine the state of the SLA's relay output, analog output or discrete output. The SLA can also be configured to separate faults from alarms, relays and analog outputs in a high availability configuration. This minimizes nuisance trips and analog outputs driven to the desired failed states, but its use must be authorized only after a careful hazard and functional operations study involving suitably qualified persons.



Warning: When the SLA is configured for high availability, some faults may not trip or affect equipment under control.

11.5.2 Analog Inputs

11.5.2.1 Sensor Types

The SLA is designed for use with a wide variety of inputs. It is the end user's responsibility to ensure that the chosen sensor is capable of achieving the required loop SIL.

For safety critical inputs it is recommended to use two inputs per input channel in a failover configuration.

Safety Logic Alarm

11.5.2.2 Broken Wire Detection

The SLA is provided with the facility to detect both open circuit and short circuit analog inputs. This broken wire detection must always be enabled. This is essential to ensure that dangerous failure of the sensor or signal input is detected by the SLA and consequently alarmed.



Warning: For HIGH LEVEL (mA/V) inputs, the Lower Range Value (LRV) must be set higher than zero. Broken Wire Detection will be disabled if LRV is set to zero and will invalidate the safety function.

11.5.2.3 Sensor Out of Range Limits

Out of range limits must be configured for 2% or less (default setting is 2%).

11.5.2.4 Sensor Trimming Enable/Disable

Sensor trimming should be used with extreme care as this facility is allowed to trim the sensor accuracy by as much as 2% of the trimming point value. It is the user's responsibility to ensure that the safety application can tolerate this.

11.5.3 Alarms

High Availability/High Integrity

All alarms (except discrete) can be configured as high availability or high integrity. If an alarm is configured as high availability, then the associated input(s) must have input faults configured to activate a discrete alarm and/or output which is monitored by the safety system.

11.5.4 Relay Outputs

Fault Relay (Relay Output 4)

Relay 4 is, by default, a fault relay configured as failsafe with system faults (including hardware faults) directly wired to it. If RO4 is configured as a fault relay then this output should be used for the safety function (high integrity) OR it should be connected to a separate indicator to only alarm the fault while maintaining the process in normal operation (high availability).



Warning: For Safety Application, RO4 must be configured as Failsafe (De-Energized to Trip) and as a Fault Relay.

If Relay 4 is not part of the safety function or is jumpered as a trip relay, then system faults must be monitored on one of the outputs used in the safety function and R4 used as a process relay in FMEDA calculations – see below for more details.



Warning: If the RO4 jumper is in the Fault Relay position, RO4 must be monitored by external equipment for the Failure data to be valid.

Trip Relays-All trip relays (1-3, and 4, if jumpered as a trip relay) used in the safety function, must be configured as failsafe.



Warning: If the firmware has a critical fault and the RO4 jumper is in the Process Relay position, hardware diagnostics are not guaranteed to be reacted upon. This impacts the Failure data, see **Table 35** Failure data from exida's FMEDA report MII 700-702-32, row 2.

11.5.5 Discrete Outputs

All discrete outputs used in the safety function, must be configured as failsafe and have DO diagnostic enabled.

If the fault relay is not part of the safety function, then system faults must be monitored on one of the outputs used in the safety function and R4 treated as a process relay in FMEDA calculations – see below for more details.

11.5.6 Analog Outputs

All analog outputs used in the safety function, must be configured as a current output set at 4 to 20mA, fail low (fail high is a non-fail-safe condition when power is lost). The PLC/BPCS must be configured to detect both 'fail low' and 'fail high' conditions. The fault relay should also be monitored by the PLC/BPCS. Alternatively, the AO can be configured to fail on system fault (and R4 treated as a process relay in FMEDA calculations – see below for more details).



Note: The Safety Accuracy of SLA's outputs are 2% or less.

11.6 Common Features

Startup Delays

In addition to the system startup delay, which can be figured in increments of one second to maximum of one hour, most alarms functions and outputs can be independently configured with an additional startup delay of up to 10 minutes. All startup delays in the safety function need to be added together to ensure that the total delay does not infringe upon the needs of the safety function.

Delay

Alarms and outputs can be independently configured with delays of up to two minutes in increments of one second. All delays in the safety function need to be added together to ensure that the overall response time meets the needs of the safety function.

Latching & Latch Reset

The SLA is provided with the capability to latch alarms, and discrete/relay outputs independently. Use of latching will be determined by the application, but it is recommended that if the output state is latched externally to the SLA, any SLA corresponding latching option is disabled. Please note that system faults are always latched.

All latched faults including system faults (but excluding hardware system faults) may be cleared by a configurable discrete signal. If this reset is made part of the safety procedure, it must only be used under strict supervisory and procedural control. The use of a key operated momentary contact is suggested.

Safety Logic Alarm

Suppress

Using suppression on alarms and outputs is NOT recommended for safety functions. Use startup delay instead to suppress alarms during system initialization.

11.7 Simulation

Online simulation allows the user to fix any input, output or variable to a user defined value, independent of their source value.

Simulation is a useful feature for validating the safety function but must never be used during safety operation. It is highly recommended to set the user configuration jumper in read-only mode which prevents user simulation. If the jumper is in read/write mode, then set the simulation time to less than process safety time to mitigate leaving the unit in simulation.

When a variable is simulated, instead of performing its normal processing, the variable reports the user's value and quality. If a variable source is the simulated variable, it will obtain the user's value instead of the actual value.

For example:

- **IV1** is enabled as analog, and is performing a calculation.
- **AO1** is sourcing **IV1**, scaling **IV1's** result to mA and outputting it.
- The user simulates **IV1** with a GOOD quality value of X.
- **AO1** will output X scaled to mA instead of the result of **IV1's** calculation scaled to mA.
- If the user simulates **IV1** with a BAD quality value of X, **AO1** will perform it's configured fail response.

This can be used to manipulate the value of an Alarm to test a Relay's reaction, to change an Analog Input Variable to make sure an equation works correctly, to loop test an Analog Output, etc. Simulation cannot be used to alter a variable that is reacting to a system fault.



Note: Analog inputs and outputs must be fixed within their conformance range.



Note: **RO4** cannot be overridden when it is acting as a fault relay.

Cyber Security

The following are recommended security configurations during operation of the safety system:

- All unused MODBUS connections should be disabled by setting the max connections to the lowest needed by the application.
- Configure web server access to minimum required level or disable it.
- The SLA should be configured to route warnings to a monitored output (DO or RO).
- All jumpers should be installed to read-only mode.

11.8 Proof Test

It is normal practice with SIS that the components undergo periodic proof tests to expose dangerous faults that are not detected by internal diagnostic tests. Calculation of the required proof test interval can be made using data in the FMEDA report (Moore Industries Document No: 700-702-32). Periodically testing the SLA using the proof test steps outlined below, the accumulated PFD_{AVG} value can be reduced to a smaller but nonzero value (please refer to the SLA FMEDA Report Appendix B.2 for proof test coverage information).

The proof test shall cover the following functionality:

- Isolation and grounding
- Input accuracy within 2%
- Relay function
- TX input power supply (if used) * - See note below
- Analog Output accuracy within 2% (if used)

The proof test below is provided as an example covering safety functionality for an SLA. When using the product in a safety function, the proof test should be tailored to the specific SLA type and configuration since any faults related to unused features/configurations will not affect the safety function. It is the responsibility of the end user to define the specific proof test and proof test interval for their applications.



Note: If TX is used to power the safety transmitter, then verify TX@24V+/-10% at 20mA load on the relevant channel.

Safety Logic Alarm

11.8.1 Equipment Required

The following equipment is required:

- Analog Inputs:
 - Variable Input Source Current
 - Voltage, RTD/Resistance or Thermocouple/mV (dependent on your input type)
Accurate to +/-0.2% of span
- Discrete Inputs:
 - Contact closure
 - Switch
- Discrete Outputs:
 - Power Supply set to nominal voltage (e.g. 24VDC) Multimeter with an accuracy of 5%
 - Load resistor 250Ω 1/4W 0.1%

11.8.2 Proof Test Procedure

This section provides proof testing instructions.

For proof testing the SLA, perform the following:

1. Bypass the safety function and take appropriate action to avoid a false trip.
2. Disconnect all wires from the SLA.
3. Check that the resistance between the case and all terminals is $>1\text{M}\Omega$ except GND pin which = 0Ω .
4. Inspect the SLA for any leaks, visible damage, or contamination.
5. If jumper is set to read-only then change jumper to read/write to enable user simulation.
6. Reconnect all inputs and outputs required for proof test.
7. Connect power to the unit.
8. Use digital communication to retrieve any diagnostics and take appropriate action.
9. For each analog input used in safety function, apply lower, midpoint and upper range values and verify the input readings.
10. For each analog input used in safety function, remove the input and check broken wire diagnostic.
11. Exercise each discrete input and ensure all outputs go to correct values.
12. Simulate safety function alarms on/off and check expected relay and/or discrete outputs.
13. For each analog output used in safety function, simulate the following values and verify analog output current: Fail low, zero, midpoint, full, fail high values.
14. Restore configuration security jumper and recycle power if needed.
15. Remove the bypass and otherwise restore normal operation.

11.9 Applying the SLA FMEDA Data – Application Scenarios

This section provides application guidance on using the SLA FMEDA data in exida’s FMEDA report MII 700-702-32. Before using this guidance for your SIF calculations, please review the assumptions in Section 4.3 of the FMEDA report and the preceding contents of this section of the SLA user manual.

Because the SLA has multiple inputs and outputs (up to six analog inputs, four discrete I/O, four relays and three analog outputs) the failure data is presented in functional blocks. When calculating the failure rate and SFF, the data for each SLA functional block which is part of the safety function needs to be totaled. If using redundant inputs this also needs to be part of the calculation.

Table 34 Overview of Functional Blocks provides an overview of the different functional blocks within the SLA assessed for the FMEDA and **Table 35** Failure data from exida’s FMEDA report MII 700-702-32 contains the failure data for each of these blocks.

Table 34 Overview of Functional Blocks

Functional Block Information	
Common with HW Detect (R4 as Fault Relay)	Common components included in all SLA configurations with Relay 4 acting as a Fault Relay (direct hardware override enabled)
Common without HW Detect (R4 as Process Relay)	Common components included in all SLA configurations with Relay 4 acting as a Trip Relay (direct hardware override disabled)
DIO Common	Discrete I/O, common components included when any DIO channel is used
DI Channel	1 discrete input channel
DO Channel	1 discrete output channel
PRG 420	Programmable analog input channel configured for one or two 4-20mA inputs
PRG TC	Programmable analog input channel configured for one or two thermocouple inputs
PRG RTD	Programmable analog input channel configured for one or two 4 wire RTD inputs
Relay Channel	Relay output, de-energize to trip
AO Common	Optional analog output module, common components included in all configurations when –AO option is fitted
AO Channel	Optional analog output module, 1 output channel
MODBUS/RTU	Optional MODBUS/RTU module, common components included in all configurations when –MB485 option is fitted

Safety Logic Alarm

Table 35 Failure data from exida's FMEDA report MII 700-702-32

SLA Component	λ_{SD}	λ_{SUX}	λ_{DD}	λ_{DU}	# (No Effect)
Common with R4 as Fault Relay	578	491	123	70	1552
Common with R4 as Process Relay	547	503	107	86	1571
DIO Common	39	14	0	13	0.4
DI Channel	0	14	0	23	33
DO Channel	35	2	10	3	19
PRG 420	33	33	216	24	101
PRG TC	30	11	192	10	159
PRG RTD	30	22	188	22	144
Relay Channel	9	40	0	17	16
AO Common	56	72	0	5	28
AO Channel	0	32	168	19	55
MODBUS/RTU Common	20	22	0	7	253

All safety functions performed by the SLA will use either the Common with R4 as Fault Relay or Common with R4 as Trip Relay common block failure data. By default, R4 is factory set as a Fault Relay. As a Fault Relay, R4 has internal hardware faults wired to it which are independent from the SLA software. It can be configured to trip by alarms, input faults and warnings in addition to system faults. If using R4 as a Fault relay, then R4 must be either part of the safety path or monitored for dangerous detected faults. If monitored, then it must be included in the failure calculations and must be acted upon within the process safety time.

If R4 is configured (by jumper) as a Trip Relay, at least one output must be configured to respond to system faults and be part of the safety path or monitored for dangerous detected faults.

If the SLA is fitted with -3AO and/or -MB485 options, then the AO Common and MODBUS/RTU Common failures must be included in the overall SLA failure data even if they are not part of the safety path. If any of the DIO channels are used as part of the safety path, then DIO Common failure data must be included.

If the safety function uses redundancy e.g., 1oo2 voting on the inputs, the following common cause Beta factor is used (based on IEC 61508-6 Annex D): 10% for sensors and 2% for different input channels.



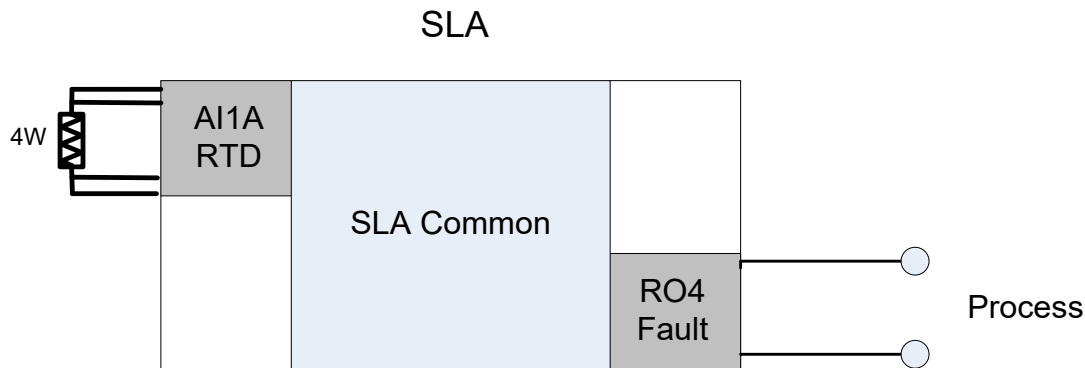
Note: Where levels of redundancy greater than 1oo2 are used, a multiplication factor is applied to Beta (refer to IEC61508-6 Table D.5). For example, 1oo3 voting applies 0.5 times the Beta factor and 2oo3 voting applies 1.5 times the Beta factor.

Following are SLA application examples with their associated failure data and calculated SFF (Safety Failure Fraction)

11.9.1 Application 1

Single RTD Input, Single Relay Output

Figure 11.1 SLA/6PRG/4PRG/10-30DC [DIN]



R4 Fault relay used as combined fault/trip relay.

Table 36 R4 Fault Relay Information

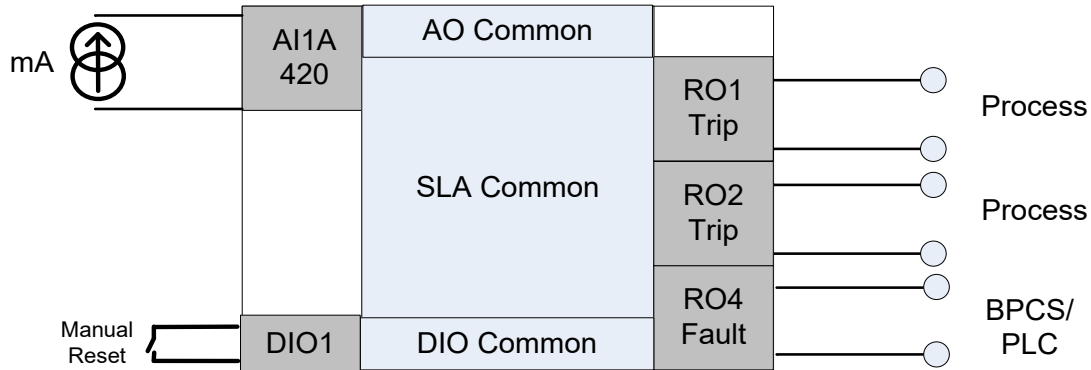
	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	# (No Effect)	Beta %	SFF%
RTD	0	3	44	3	0		
PRG RTD	30	22	188	22	144		
Common R4 as Fault Relay	578	491	123	70	1552		
Relay Channel	9	40	0	17	16		
	617	556	355	112	1712		93.2%

Safety Logic Alarm

11.9.3 Application 2

Single 4-20mA transmitter input, dual trip relay plus fault relay outputs, utilizing relay manual reset via discrete I/O.

Figure 11.2 SLA/6PRG/4PRG/10-30DC/-3AO [DIN]



R1 and R2 are used as process trips and R4 as a separate Fault relay to notify BPCS/PLC. DIO1 is used as a manual reset input. -3AO option is fitted but is NOT part of the safety function.

Table 37 R1 and R2 Fault Relay Information

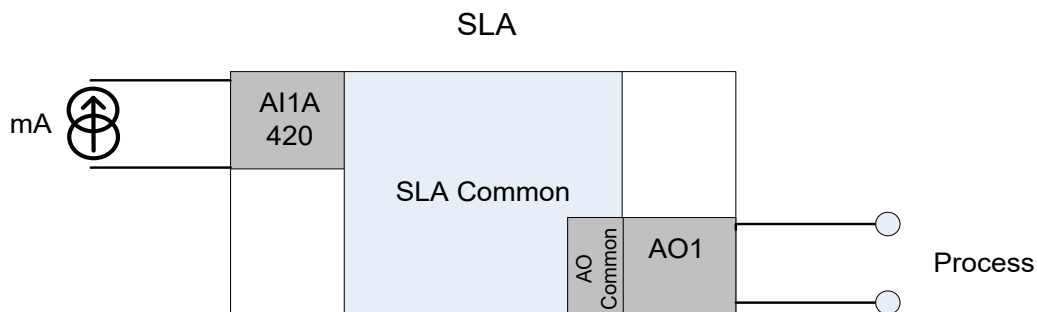
	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	# (No Effect)	Beta%	SFF%
PRG 420	33	33	216	24	101		
Common R4 as Fault Relay	578	491	123	70	1552		
DIO Common	39	14	0	13	0.4		
DI Channel	0	14	0	23	33		
AO Common	56	72	0	5	28		
Relay Channel	9	40	0	17	16		
Relay Channel	9	40	0	17	16		
Relay Channel	9	40	0	17	16		
	733	744	339	186	1762.4		90.7%

Safety Logic Alarm

11.9.5 Application 3

Single 4-20mA transmitter input, single analog output.

Figure 11.3 SLA/6PRG/4PRG/10-30DC/-3AO [DIN]



No Fault relay used, system faults are enabled on AO (this will not include hardware only detected faults).

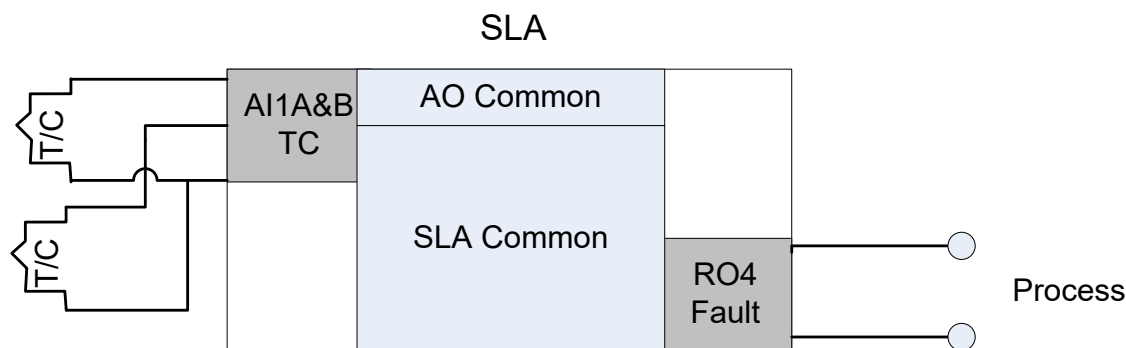
Table 38 No Fault Relay Used, System Faults Enabled

	λ SD	λ SU	λ DD	λ DU	# (No Effect)	Beta %	SFF %
PRG 420	33	33	216	24	101		
Common R4 as Process Relay	547	503	107	86	1571		
AO Common	56	72	0	5	28		
AO Channel	0	32	168	19	55		
	636	640	491	134	1755		93.0%

11.9.6 Application 4

Two thermocouple inputs in failover mode, one relay output*.

Figure 11.4 SLA/6PRG/4PRG/10-30DC/-3AO [DIN]



R4 Fault relay used as combined fault/trip relay; AO is used but is NOT part of the safety function.

Table 39 R4 Fault Relay Combined

		λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	#(No Effect)	Beta %	SFF %
1oo2	External Thermocouples	0	0.5	9.5	0.45	0	10%	
	PRG TC	30	11	192	10	159		
	AO Common	56	72	0	5	28		
	Common R4 as Fault Relay	578	491	123	70	1552		
	Relay Channel	9	40	0	17	16		
		673	614.5	324.5	102.5	1755		94.0%

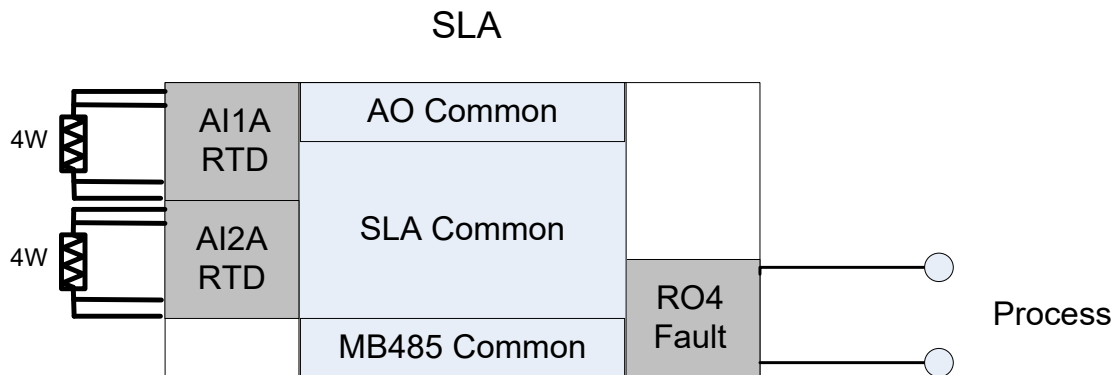
* The SLA input channels are not redundant but the thermocouple inputs are.

Safety Logic Alarm

11.9.8 Application 5

Two RTD inputs in 1oo2 voting mode, one relay output.

Figure 11.5 SLA/6PRG/4PRG/10-30DC/-3AO [DIN]



SLA with 1oo2 voting on RTDs wired to separate input channels. R4 Fault relay used as combined fault/trip relay, -3AO and -MB485 options are fitted but are NOT part of the safety function so only their common circuit fault factors need to be considered.

Table 40 SLA with 1oo2 voting on RTDs

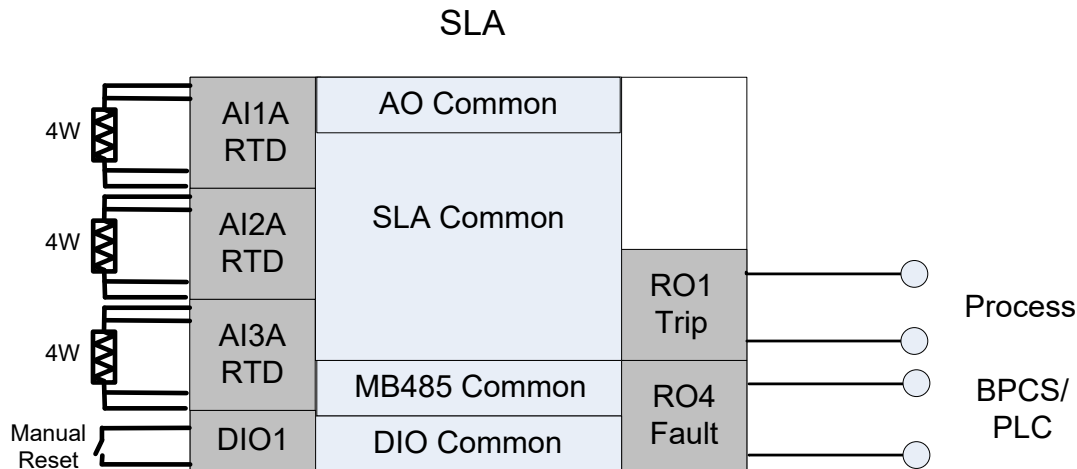
		λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	# (No Effect)	Beta %	SFF%
1oo2	External RTDs	0	3	4.4	0.3	0	10%	
1oo2	PRG RTD	30	22	3.76	0.44	144	2%	
	Common R4 as Fault Relay	578	491	123	70	1552		
	AO Common	56	72	0	5	28		
	MODBUS/RTU Common	20	22	0	7	253		
	Relay Channel	9	40	0	17	16		
		693	650	131.16	99.74	1993		93.7%

Safety Logic Alarm

11.9.10 Application 6

Three RTD inputs in 2oo3 voting mode, two relay outputs, utilizing relay manual reset via discrete I/O.

Figure 11.6 SLA/6PRG/4PRG/10-30DC/-3AO [DIN]



SLA with 2oo3 voting on RTDs wired to separate input channels. R1 is used as a process trip and R4 as a separate Fault relay to notify BPCS/PLC. DIO1 is used as a manual reset input. -3AO and -MB485 options are fitted but are NOT part of the safety function.

Table 41 SLA with 2oo3 voting on RTDs

		λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	#(No Effect)	Beta %	SFF%
2oo3	External RTDs	0	3	6.6	0.5	0.0	15%	
2oo3	PRG RTD	30	22	5.6	0.7	144.0	3%	
	Common R4 as Fault Relay	578	491	123.0	70	1552		
	DIO Common	39	14	0.0	13.0	0.4		
	DI Channel	0	14	0.0	23.0	33.0		
	AO Common	56	72	0.0	5.0	28.0		
	MODBUS/RTU Common	20	22	0.0	7.0	253.0		
	Relay Channel	9	40	0.0	17.0	16.0		
	Relay Channel	9	40	0.0	17.0	16.0		
		741	718	135.2	153.1	2042.4		91.2%

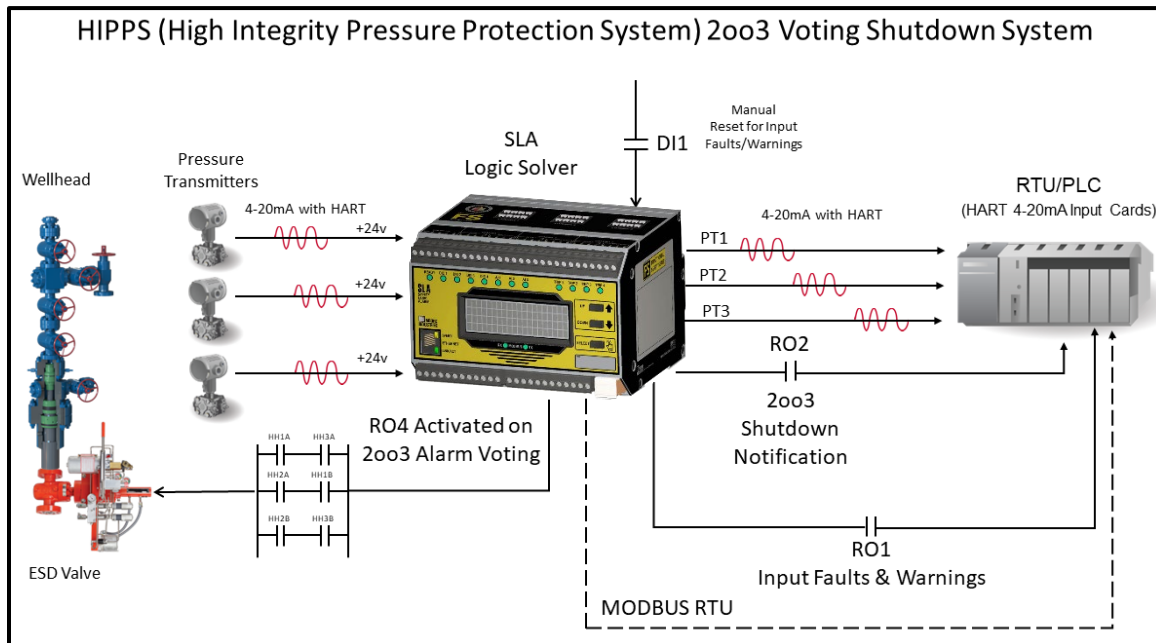
12 SLA Application Examples

The following are examples of SLA Safety Instrumented Systems (SIS) applications. Each example is described and includes a typical SLA configuration for that application.

12.1 HIPPS (High Integrity Pressure Protection System) 2oo3 Voting Shutdown System

Upstream gas wellheads can experience extremely high pressure and surges. In order to protect personnel and equipment wellhead casing pressure is often monitored in case there is a situation where the wellhead needs to be shutdown. Traditionally, simple pressure switches were used, but today companies are required to implement proper safety systems. **Figure 12.1** shows the SLA installed in a remote oil and gas wellhead application using 2oo3 voting logic to ensure pressure protection.

Figure 12.1 HIPPS (High Integrity Pressure Protection System) 2oo3 Voting Shutdown System



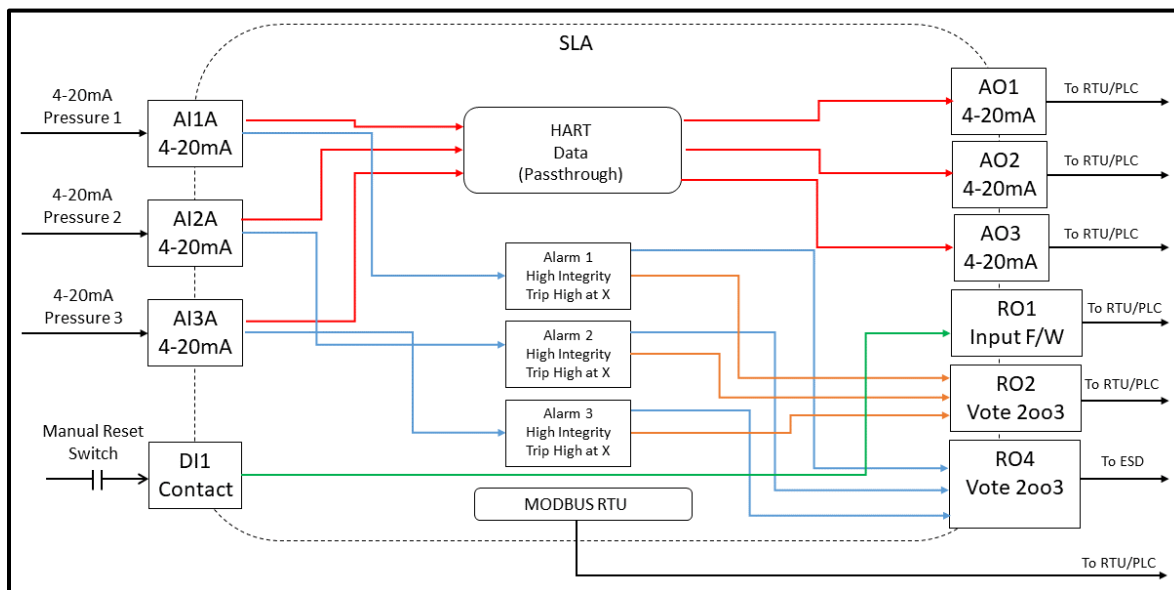
In this application, to protect personnel and the process from high pressure spikes, the three separate pressure transmitters are wired to the SLA where it can perform a 2oo3 safety voting architecture to shut down the well when dangerous conditions exist. The SLA's built in loop power supply on each of its three channels provides operating power to all three smart HART pressure transmitters. The HART signal from the three pressure transmitters is passed-through to each of the SLA's corresponding analog outputs so the RTU/PLC has direct access to all HART programming, variables, and diagnostics of each connected transmitter.

Safety Logic Alarm

The retransmission of these three pressure transmitters by the SLA, versus wiring in series with the RTU/PLC input cards, provides higher availability to the safety function since a catastrophic failure in one of the analog input cards or the RTU/PLC itself doesn't affect the 2oo3 logic shutdown function of the SLA.

Additional relay outputs of the SLA also keep the RTU/PLC informed of shutdown status and any input faults experienced by the SLA. A digital contact input allows any alarm or relay configured as latching to be manually reset. Finally, all inputs, outputs, internal equations, variables, alarms, relay status and more are digitally transmitted to the RTU/PLC via a read-only MODBUS RTU signal. **Figure 12.2** shows a flow chart for the programming logic of this application.

Figure 12.2 2oo3 Voting Shutdown System Programming Logic

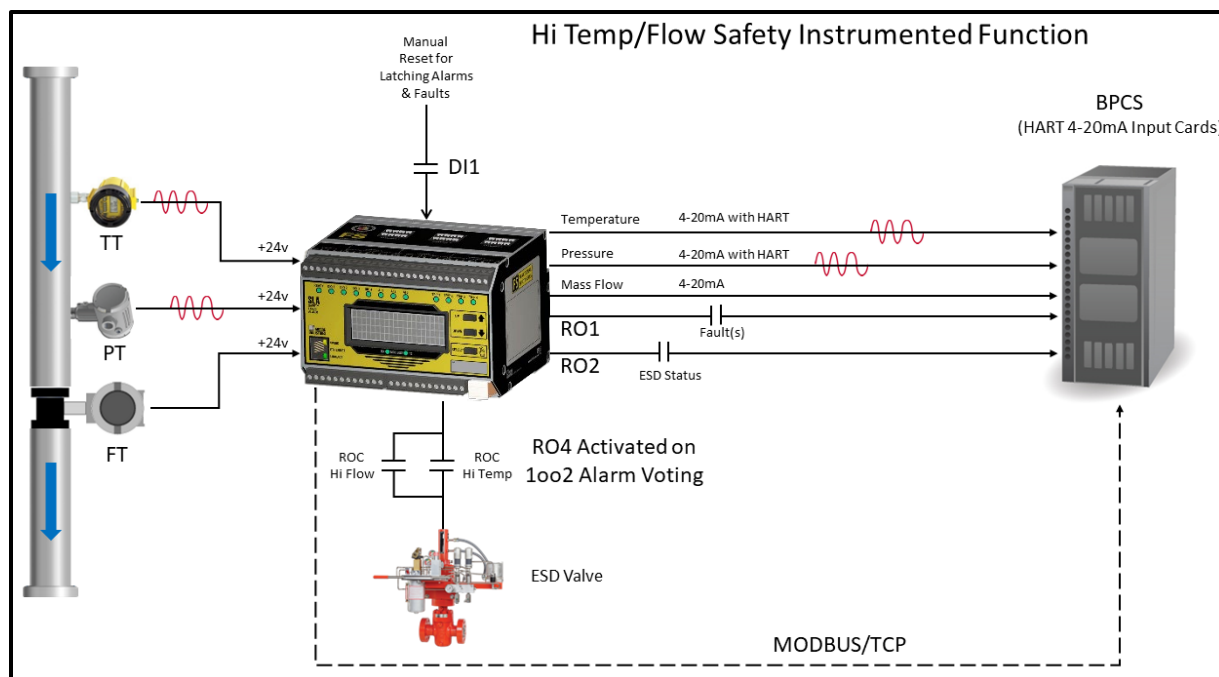


12.2 High Temperature and Flow Safety Instrumented Function

Many critical processes require that flow rates are closely monitored for both product quality and safety. Some of these processes are in a facility remotely located from the BPCS (Basic Process Control System). When calculations like mass flow are required for safety considerations, this can sometimes add precious decision-making time to an already burdened BPCS. With the SLA's built-in equation editor, calculations can be done locally, remote from the BPCS, and oftentimes faster, so process shutdowns can help mitigate dangerous situations.

Figure 12.3 shows the SLA installed in a high temperature and flow Safety Instrumented System (SIS) application.

Figure 12.3 High Temperature and Flow Safety Instrumented System



This application requires that a temperature, pressure, and volumetric flow signal be used to calculate mass flow to ensure a safe and proper flow rate to the process. Should mass flow or temperature rise too quickly, a dangerous process condition could occur.

Three loop-powered transmitters are powered and wired into the three isolated SLA input channels. The SLA uses built-in Rate of Change Alarms that monitor mass flow and temperature over time to prevent unwanted surges in process conditions that could lead to a dangerous situation. The SLA uses voting logic (1oo2) to shut down the process quickly, in the event of rapid increases of mass flow or temperature.

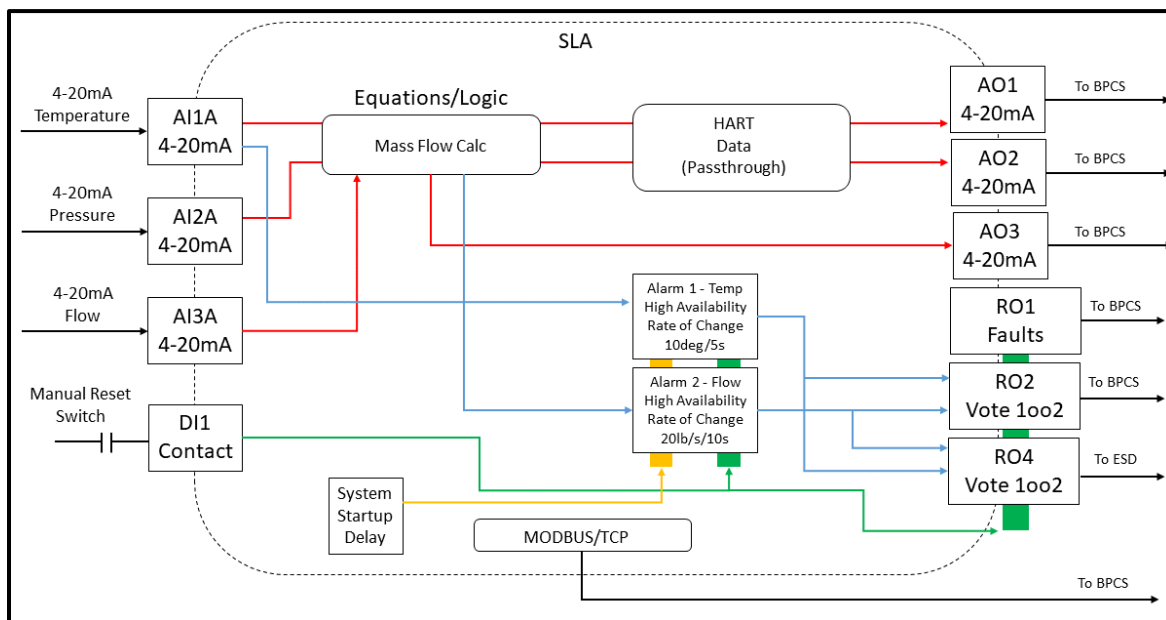
To minimize nuisance trips the alarms are configured as high availability, which means they will not trip if there is an input failure, only when the rate of change event occurs in temperature and/or mass flow. To ensure the integrity of the safety function, input faults along with any system faults are signaled to the BPCS.

Safety Logic Alarm

The remote BPCS is continually updated with process conditions by receiving three analog outputs from the SLA representing temperature and pressure readings along with the calculated mass flow. The HART signal from the connected temperature and pressure transmitters is passed-through the SLA so any monitoring of HART variables and diagnostics or programming of these connected instruments can be performed. Note that since the flow transmitter is NOT a smart HART transmitter no HART signal is passed through to the third analog output channel.

Status of the shutdown function, and any input or SLA faults, is also sent to the BPCS via SLA relay output contacts. An input contact is used to manually reset any latching alarms, faults, or relays. A system startup delay is set to suppress flow and temperature alarms which would initiate the shutdown logic. All inputs, outputs, alarms, internal variables, and faults, along with various other parameters, are transmitted via a secure digital and read-only MODBUS/TCP signal over Ethernet. This figure shows a flowchart for the programming logic of this application.

Figure 12.4 High Temperature and Flow SIS Programming Logic

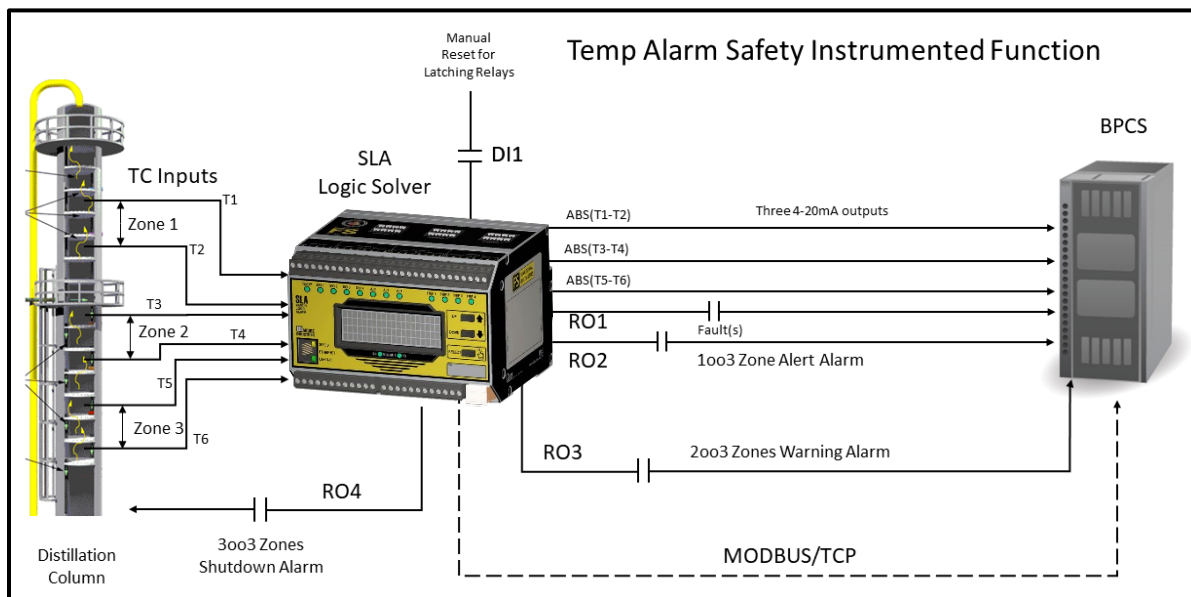


12.3 Temperature Alarm Safety Instrumented Function

Temperature stratification is normal in distillation columns. However, in some chemical or refinery processes too much temperature differential between layers within the column can yield poor quality product or create a dangerous condition that could lead to a column rupture or explosion.

The SLA can help mitigate this situation by accepting up to six temperature inputs, in this case thermocouples, and performing an absolute differential calculation between any temperature sections to ensure that temperature stratification levels within critical zones in each column never differ by more than a predetermined amount. The SLA can implement up to 16 alarms based on any input, equation, or combination of inputs/equations. **Figure 12.5** shows the SLA installed in a temperature alarm Safety Instrumented System (SIS) application.

Figure 12.5 Temperature Alarm Safety Instrumented System

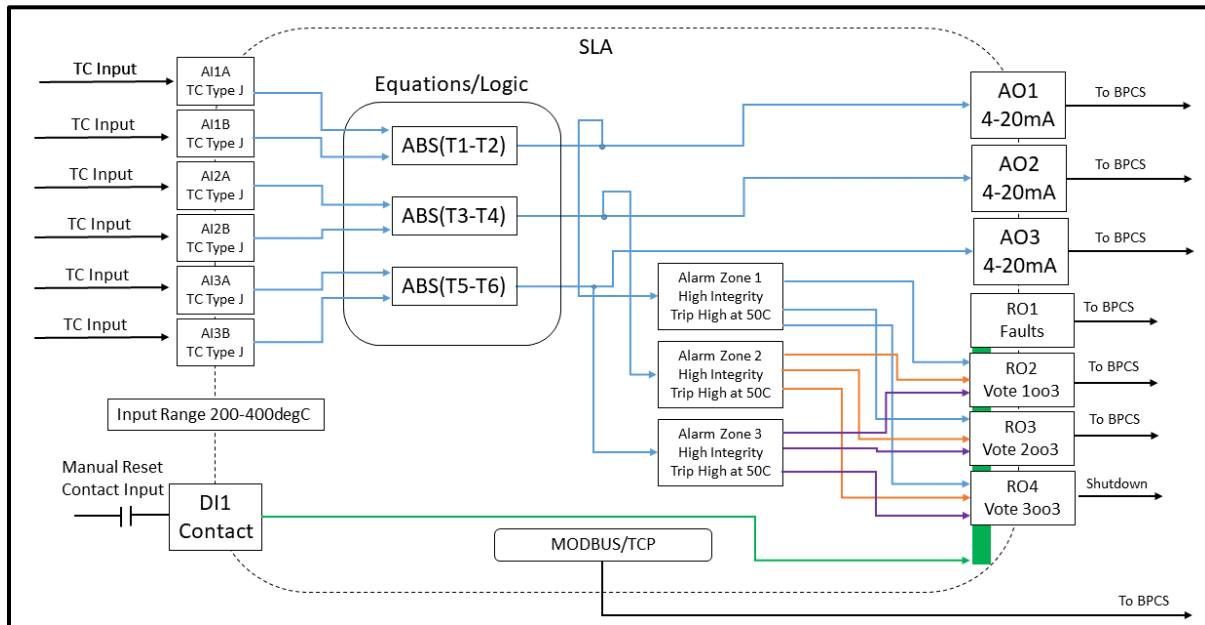


In this application, three separate alarms, one for each zone, are configured to alarm if more than a 50 degC temperature differential exists between the zone’s lower and upper temperature points. The temperature differential for each zone is calculated with an absolute differential equation via SLA’s advanced configuration settings. An alarm voting architecture is put in place where relay outputs will be activated to trigger an alert (1oo3 voting), warning (2oo3 voting), or shutdown (3oo3 voting) situation. A contact closure wired to one of the SLA’s four available Discrete I/O channels is used to release latching alarms and/or relays.

The BPCS (Basic Process Control System) monitors each zone’s temperature differential via the SLA’s three analog outputs. All inputs, outputs, alarms, faults, and various other parameters from the SLA are transmitted via MODBUS/TCP over Ethernet to the BPCS.

Safety Logic Alarm

Figure 12.6 Temperature Alarm SIS Programming Logic



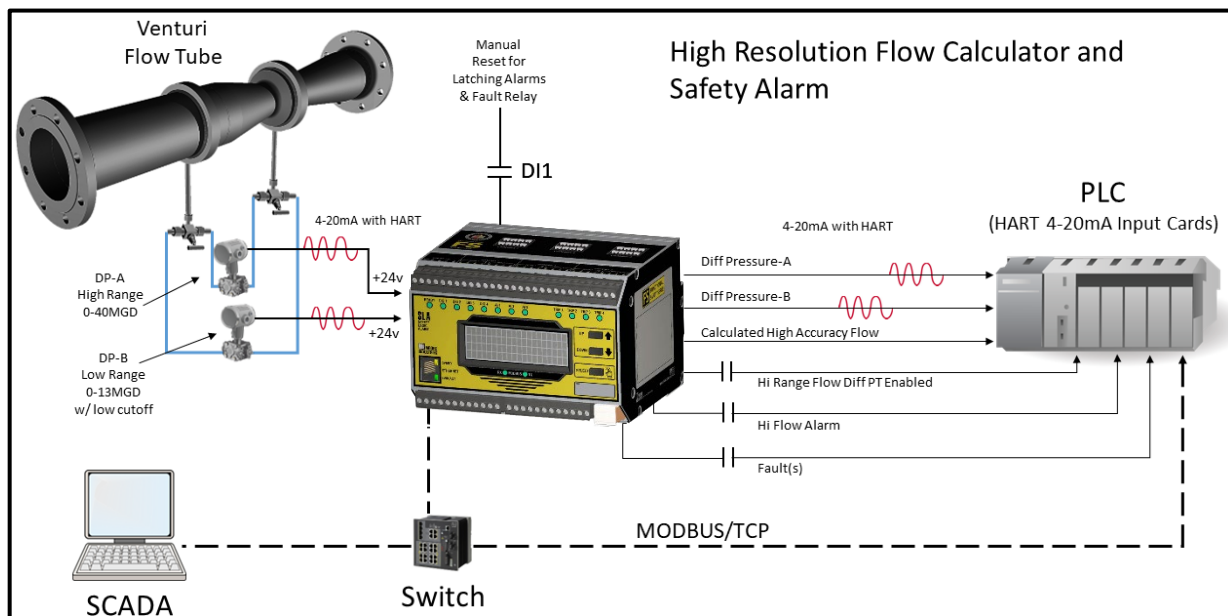
The SLA's built-in web server also provides quick and easy read-only viewing of inputs, alarms, outputs, internal variables, faults, warnings, and more via any standard web browser. Prebuilt web pages include simple to navigate menus and tables that neatly lay out all of the SLA's parameters. **Figure 12.6** shows a flowchart for the programming logic of this application.

12.4 High Resolution Flow Calculator and Safety Alarm

Plants that have large fluctuations in flow demand, like potable water plants, often need large flow capacity measuring devices that don't create large pressure reductions. Venturi tubes are good for these applications, but often if the flow span is large, consistent accuracy across the entire flow range is difficult to achieve. One way to alleviate this is to use double stacked differential pressure transmitters where one DP transmitter is ranged for lower flow rates while the other handles higher flow rates. With this type of configuration, there needs to be some type of smart device involved to automatically switch between transmitters to achieve the best flow accuracy results.

The SLA Safety Logic Alarm provides this decision-making capability and the safety layer of protection needed to alert the plant when demand has reached very high levels. While safety PLCs can accomplish such tasks, there may be a number of reasons why it is not convenient: cost, remote locations, difficulty of programming, or simply that the PLC has no spare memory capacity. This figure shows the SLA installed as a high-resolution flow calculator and safety alarm.

Figure 12.7 High Resolution Calculator and Safety Alarm



This application includes two differential pressure transmitters connected to the pressure ports of a venturi tube, ranged 0-13 million gallons/day and 0-40 million gallons/day for low and high flow rates respectively. Each of the smart HART differential pressure transmitters is powered by the SLA and their HART signals are passed through to PLC input cards. The SLA primarily serves as a safety logic alarm to notify the PLC when extremely high-demand situations occur.

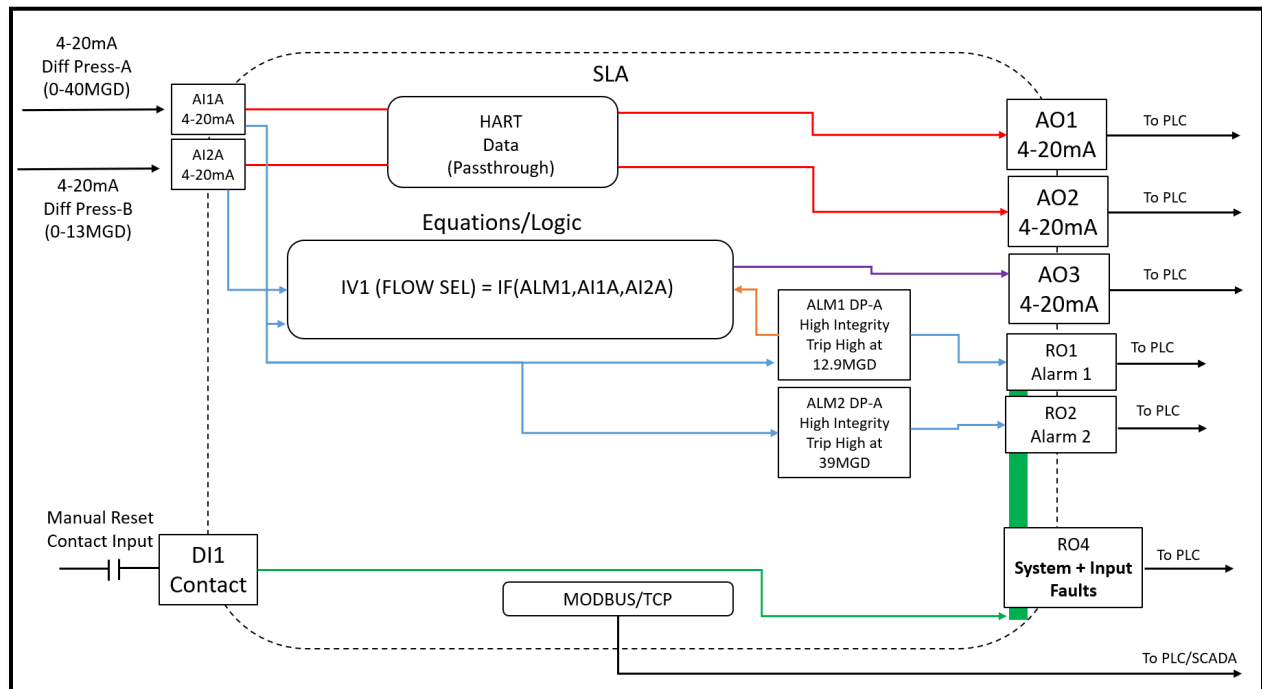
Safety Logic Alarm

Additionally, the PLC and SCADA system need to monitor accurate flow rates from the venturi tube. To ensure that the 4-20mA flow signal, and the MODBUS registers also representing the flow rate are as accurate as possible, the SLA is programmed to switch between the differential pressure transmitters, depending on current flow rates. The flow rates are calculated with a differential pressure flow equation via SLA's advanced configuration settings. When flow reaches a rate of 12.9MGD, the SLA automatically switches to the higher-ranged DP transmitter and automatically switches back to the lower-ranged DP transmitter when flow falls below 12.9MGD. This assures maximum flow rate accuracy across the entire flow rate span.

The SLA also retransmits each of the DP transmitter signals back to the PLC and provides relay outputs when the flow rate exceeds 39MGD, the high-range DP transmitter is selected, or when there are system or input faults captured by the SLA. A digital contact input allows any latched alarms or relays to be cleared. The SCADA system and PLC receive all inputs, outputs, internal equations, variables, alarms, relay status and more via the MODBUS/TCP read-only signal.

Figure 12.8 shows a flowchart for the programming logic of this application.

Figure 12.8 High Resolution Flow Calculator and Safety Alarm Programming Logic



13 SLA Specifications

Table 42 Specifications

<p>PERFORMANCE</p> <p>ANALOG INPUT Three dual input isolated channels with failover and switch selectable for HLPRG (mA/V) or TPRG (RTD, T/C, ohm, mV, Potentiometer) type inputs. Range and Accuracy: See</p> <p>Table 43 Accuracy Reference Junction Compensation Accuracy (T/C inputs only): ±0.45°C Long Term Stability: See Table 44 Long-Term Stability</p> <p>DISCRETE I/O Four non-isolated channels configurable as failsafe/non-failsafe input or output Input: Contact closure 26Vdc (Voc), 5mA (Isc). Debounce time 5-100mS. Input threshold: <8Vdc Low; >15Vdc High. Output: 30Vdc, 120mA max sink. Alarm voting and selectable system and input faults. Configurable latching, suppression, delay and startup delay (0-120seconds).</p> <p>RELAYS Four Process Relays with fourth relay jumper selectable as Fault Relay. Failsafe/non-failsafe with alarm voting and selectable system and input faults. Configurable latching, suppression, delay and startup delay (0-120seconds) Single- pole/double-throw SPDT, 1 form C, rated 3A@250Vac or 3A@30Vdc, 50/60Hz, non-inductive.</p> <p>ANALOG OUTPUT (option) Three optional analog outputs with hardwired HART pass through from sensor A of each AI to its corresponding AO channel Range: 0-21.6mA, Minimum Span 4mA Accuracy: ±3 uA Output Ripple (up to 120Hz): 10mV peak-to-peak measured across a 250 Ohm load resistor for current output Output Failure Limits: Compliant with Namur 43</p> <table border="1"> <thead> <tr> <th>Output</th> <th>Failure Limits</th> </tr> </thead> <tbody> <tr> <td>0-20mA</td> <td>0, 23.6mA</td> </tr> <tr> <td>4-20mA</td> <td>3.6, 23.6mA</td> </tr> <tr> <td>x-20mA (0<X<4)</td> <td>(90% of X), 23.6mA</td> </tr> </tbody> </table> <p>Load Capability: Source mode 600 Ohms; Sink Mode (External power Supply), 42Vdc Max Load Effect: ±0.01% of span from 0 to maximum load resistance on current output Step Response of AO: 100mS max from 10%-90% output</p> <p>SYSTEM ACCURACY The overall accuracy of the unit is the combined input and output accuracies. It includes the combined effects of linearity, hysteresis, repeatability and adjustment resolution. It does not include ambient temperature effect. For T/C input, add the RJC error.</p>	Output	Failure Limits	0-20mA	0, 23.6mA	4-20mA	3.6, 23.6mA	x-20mA (0<X<4)	(90% of X), 23.6mA	<p>PERFORMANCE (continued) Ambient Temperature Effect: See Table Power Supply Effect: ±0.002% of span per 1% line voltage change Noise Rejection: See Table OUTPUT TRIP RESPONSE TIME (Typical): TPRG Input - One sensor per channel: 750mS; Two sensors per channel: 1.3 seconds; HLPRG Input - One sensor per channel: 450 mS; Two sensors per channel: 700mS; for analog outputs add AO step response.</p> <p>FUNCTIONALITY</p> <p>SYSTEM System startup delay 0-60 minutes System simulation with configurable timeout</p> <p>ALARMS Up to sixteen alarms programmable as discrete or analog (Trip, Band, Rate of Change, Stuck Input). Configurable latching, suppression, delay and startup delay (0-120seconds) Analog alarms: High availability/integrity settings and configurable dead band. Discrete alarms: voting on faults, warnings, and discrete variables.</p> <p>INTERNAL VARIABLES/EQUATIONS and FUNCTIONS Up to 16 Internal Variables using analog and discrete equations and functions</p> <p>ADDITIONAL ADVANCED FUNCTIONS Eight countdown Timers (0-3600 Seconds); Eight Running Min/Max with high integrity/availability; Four Custom Curves (Linearization tables with 2-128 x,y entries).</p> <p>DIAGNOSTICS Comprehensive input and system diagnostics with configurable latching of input and system faults and warnings</p> <p>SECURITY User Configuration Jumper: read-only or read/write (In read-only mode, this jumper physically disconnects serial writes to the safety section); Network Configuration Jumper: read-only or read/write; Web server: Enabled/Disabled; MODBUS/TCP connection limit: 0-4.</p> <p>DISPLAY 4x20 OLED alphanumeric readout with push-buttons for menu selection and scrolling. Bright display with 160 degree viewing angle. LEDs: System (Green/Orange/Red); I/O (Green/ Red): DIO 1-4, AI1-3, RO1-4; Ethernet: LINK/ ACT (Green), Speed (Yellow); Modbus RTU (Green): TX, RX</p> <p>EVENT LOGGER Internal event logger stores up to ~2,000 time/date stamped FIFO records (100msec resolution) in non-volatile RAM that can be exported as .CSV file format</p>	<p>COMMUNICATIONS</p> <p>ETHERNET COMMUNICATIONS 10/100Base-T supports speeds up to 100Mb/second Standard RJ-45 Connection, Auto negotiation, Auto MDIX, DHCP or fixed IP address, Supported Protocol Types: MIIP (DTM), HTTP, MODBUS/TCP.</p> <p>PROTOCOL DETAILS</p> <p>MIIP/DTM Used with DTM for FDT/DTM interface for configuration and simulation</p> <p>HTTP Read-only web pages containing configuration, status and process data.</p> <p>MODBUS/TCP User-selectable Standard LSW (Least Significant Word) or Swapped MSW (Most Significant Word) 32 bit floats and 16 bit signed integers (0-3 decimal places)</p> <p>MODBUS RTU (Option) Configurable RS-485 port Baud Rates: 1200, 2400, 4800, 9600, 19.2k, 38.4k, and 57.6k; Parity: Even, Odd or No Parity (1 stop bit, fixed; default is No Parity); Device Address: 1-255 (Default is 1); Character Timeout: Default, 5, 10, 25, 50, 100, 200, and 255 character times; Response Delay: Default, 1.5, 5, 10, 25, 50, 100, 200, and 255 character times</p> <p>ELECTRICAL</p> <p>Isolation: 500Vrms between case, input, output, and power Power Supply: 10.5-30VDC Power Consumption: 11W (Typ), 13W (Max) Input Over-Range Protection: Temperature, Ohms and mV: +/-5VDC maximum; Current: ±50mA maximum; Voltage: ±30Vdc maximum Input Impedance: T/C and mV: 40Mohms nom; Current, 20 ohms; Voltage, 1Mohm Excitation Current: RTD and Ohms, 250 microamps, ±10% TX Power Supply: 24Vdc, ±10% @ 24mA per Analog Input (Input A only)</p> <p>AMBIENT CONDITIONS Operating and Storage Range: -40°C to +85°C (-40°F to +185°F) Relative Humidity: 5-95%, non-condensing RFI/EMI Protection: 20V/m@80-1000MHz, 1kHz AM, when tested to IEC61326 WEIGHT: 1.3kg (3lb)</p>
Output	Failure Limits									
0-20mA	0, 23.6mA									
4-20mA	3.6, 23.6mA									
x-20mA (0<X<4)	(90% of X), 23.6mA									

Table 43 Accuracy

Input	Type	α	Ohms	Conformance Range	Minimum Span	Input Accuracy/ Repeatability	Maximum Range
RTD 2-Wire, 3-Wire, 4-Wire	Platinum	0.003850	100	-200 to 850°C (-328 to 1562°F)	10°C (18°F)	±0.1°C (±0.18°F)	-240 to 960°C (-400 to 1760°F)
			200				
			300				
			400				
			500				
		1000					
	Nickel	0.003902	100	-100 to 650°C (-148 to 1202°F)		-240 to 580°C (-400 to 1076°F)	
			200				
			400				
			500				
Copper	0.003916	100	-200 to 510°C (-328 to 950°F)	-100 to 360°C (-148 to 680°F)			
		120			-80 to 320°C (-112 to 608°F)	-240 to 280°C (-400 to 536°F)	
Copper	0.00427	9.035	-50 to 250°C (-58 to 482°F)	±1.0°C (±1.8°F)			-65 to 280°C (-85 to 536°F)
		Ohms			Direct Resistance	n/a	
Potentiometer	n/a		100-4000	0-100%	10%	±0.1%	0-100%
T/C	J	n/a	n/a	-180 to 760°C (-292 to 1400°F)	35°C (63°F)	±0.25°C (±0.45°F)	-210 to 770°C (-346 to 1418°F)
	K	n/a	n/a	-150 to 1370°C (-238 to 2498°F)	40°C (72°F)	±0.3°C (±0.54°F)	-270 to 1390°C (-454 to 2534°F)
	E	n/a	n/a	-170 to 1000°C (-274 to 1832°F)	35°C (63°F)	±0.2°C (±0.36°F)	-270 to 1013°C (-454 to 1855.4°F)
	T	n/a	n/a	-170 to 400°C (-274 to 752°F)	35°C (63°F)	±0.25°C (±0.45°F)	-270 to 407°C (-454 to 764.6°F)
	R	n/a	n/a	0 to 1760°C (32 to 3200°F)	50°C (90°F)	±0.55°C (±0.99°F)	-50 to 1786°C (-58 to 3246.8°F)
	S	n/a	n/a	0 to 1760°C (32 to 3200°F)	50°C (90°F)	±0.55°C (±0.99°F)	-50 to 1786°C (-58 to 3246.8°F)
	B	n/a	n/a	400 to 1820°C (752 to 3308°F)	75°C (135°F)	±0.75°C (±1.35°F)	200 to 1836°C (392 to 3336.8°F)
	N	n/a	n/a	-130 to 1300°C (-202 to 2372°F)	45°C (81°F)	±0.4°C (±0.72°F)	-270 to 1316°C (-454 to 2400.8°F)
	C	n/a	n/a	0 to 2300°C (32 to 4172°F)	100°C (180°F)	±0.8°C (±1.44°F)	0 to 2338°C (32 to 4240.4°F)
mV	DC	n/a	n/a	n/a	4mV	±70 microvolts	-50 to 1000mV
mA	Current	n/a	n/a	0-25mA	4mA	±2microamps	0-25mA
V	Voltage	n/a	n/a	0-11V	1V	±1mV	11V

Table 44 Long-Term Stability

Stability (% of maximum span)	Input to Analog Output (Years)			Input to Relay/DO (Years)		
	1 yr	3 yrs	5 yrs	1 yr	3 yrs	5 yrs
T/C	.08	.14	.18	.008	.014	.019
RTD	.09	.16	.21	.047	.081	.104
mA	0.081	0.14	0.18	0.047	0.081	0.105
V	0.093	0.16	0.21	0.066	0.114	0.147

Table 45 Ambient Temperature Effect

Input	Accuracy per 1°C (1.8°F) Change in Ambient
RTD	0.003°C +0.0015% of reading
Type B Thermocouple	0.003°C +0.0015% of reading
Thermocouples (All types except B)	0.0003°C +0.0015% of reading
Millivolt	0.0005 mV +0.0015% of reading
Ohm	0.002Ω +0.0015% of reading
mA	0.01% of 20mA
V	0.01% of 10V
Output	
mA	3uA

Table 46 Normal Mode Rejection Ratio

Sensor Type	Max. p-p Voltage Injection for 70dB at 50/60 Hz
T/C: E	120mV
T/C: J, K, N, C	60mV
T/C: T, R, S, B	30mV
Pt RTD: 100 ohms	120mV
Pt RTD: 200 ohms	200mV
Pt RTD: 300, 400, 500, 1000 ohms	400mV
Pt RTD: 1000 ohms	800mV
Ni: 120 ohms	200mV
Cu: 9.03 ohms	30mV
Resistance 4K ohms/mV, 1000mV	800mV
mA	25mA
V	1V

14 SLA Ordering Information

This section provides ordering information.

Table 47 Ordering Information

Unit	Input	Output	Power	Options	Housing
SLA SIL 2/3 Capable Programmable Safety Logic Solver and Alarm	<p>6PRG* Programs to accept: Current: Any range between 0-25mA including: 0-20mA, 4-20mA, 20-4mA, etc. Voltage: Any range between 0-10Vdc including: 0-5Vdc, 1-5Vdc, 0-10Vdc RTD: 2-, 3- and 4-wire; platinum, copper, and nickel Thermocouple: J, K, E, T, R, S, N, C, B Ohms: 0-4000 ohms (Potentiometer, 4000 ohms max.) Millivolts: -50 to +1000mV</p> <p>*Three dual input channels where both inputs on each channel have to be same type, ie TPRG - Temperature Sensor type or HLPRG - Current/Voltage type</p>	<p>4PRG Four relays are single-pole/double-throw; SPDT, 1 form C, rated 3A@250Vac or 3A@30Vdc, 50/60Hz, non-inductive By default fourth relay is configured as a fault relay but can be reconfigured for process relay All models include four Discrete Channels, each Programmable as Input or Output</p>	10-30DC	<p>-3AO Three analog outputs (isolated and linearized) scalable for any range between 0-21.6mA into 600 ohms (Current outputs are user-wired for internally sourced or externally powered, sink) -MB485 MODBUS RTU (RS-485) serial data port</p>	<p>DIN DIN-style housing mounts on 35mm (EN50022) Top Hat DIN-rails FLB Flange bracket provides a secure mount for high vibration applications</p>

When ordering, specify: Unit / Input / Output / Power / Options [Housing]
Model number example: SLA / 6PRG / 4PRG / 10-30DC / -3AO [DIN]

14.1.1 Accessories

Part Number 700-702-43	FMEDA Report consistent with IEC 61508-2:2010 providing the information necessary to design a Safety Instrumented System (One copy provided free with each order Upon Request)
----------------------------------	---

14.1.2 Certifications

exida Certified
IEC 61508:2010 Parts 1-3
Functional Safety of
Electrical/Electronic/Programmable
Electronic Safety-Related Systems
CE & UKCA Conformant (EMC, LVD and
ROHS)

Part Number 700-702-43	FMEDA Report consistent with IEC 61508-2:2010 providing the information necessary to design a Safety Instrumented System (One copy provided free with each order Upon Request)
<p>To Request a FMEDA (Failure Modes, Effects and Diagnostics Analysis) Report with an SLA Logic Alarm Order, See “Accessories”</p>	

15 SLA Warranty Disclaimer

Moore Industries ("The Company") makes no express, implied or statutory warranties (including any warranty of merchantability or of fitness for a particular purpose) with respect to any goods or services sold by the company. The company disclaims all warranties arising from any course of dealing or trade usage, and any buyer of goods or services from the company acknowledges that there are no warranties implied by custom or usage in the trade of the buyer and of the company, and that any prior dealings of the buyer with the company do not imply that the company warrants the goods or services in any way.

Any buyer of goods or services from the company agrees with the company that the sole and exclusive remedies for breach of any warranty concerning the goods or services shall be for the company, at its option, to repair or replace the goods or services or refund the purchase price. The company shall in no event be liable for any consequential or incidental damages even if the company fails in any attempt to remedy defects in the goods or services, but in such case the buyer shall be entitled to no more than a refund of all monies paid to the company by the buyer for purchase of the goods or services.

Any cause of action for breach of any warranty by the company shall be barred unless the company receives from the buyer a written notice of the alleged defect or breach within ten days from the earliest date on which the buyer could reasonably have discovered the alleged defect or breach, and no action for the breach of any warranty shall be commenced by the buyer any later than twelve months from the earliest date on which the buyer could reasonably have discovered the alleged defect or breach.

Return Policy

For a period of thirty-six (36) months from the date of shipment, and under normal conditions of use and service, Moore Industries ("The Company") will at its option replace, repair or refund the purchase price for any of its manufactured products found, upon return to the Company (transportation charges prepaid and otherwise in accordance with the return procedures established by The Company), to be defective in material or workmanship. This policy extends to the original Buyer only and not to Buyer's customers or the users of Buyer's products, unless Buyer is an engineering contractor in which case the policy shall extend to Buyer's immediate customer only. This policy shall not apply if the product has been subject to alteration, misuse, accident, neglect or improper application, installation, or operation. THE COMPANY SHALL IN NO EVENT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

To return equipment to Moore Industries for repair, follow these four steps:

1. Call Moore Industries and request a Returned Material Authorization (RMA) number.

Warranty Repair –

If you are unsure if your unit is still under warranty, we can use the unit's serial number to verify the warranty status for you over the phone. Be sure to include the RMA number on all documentation.

Non-Warranty Repair –

If your unit is out of warranty, be prepared to give us a Purchase Order number when you call. In most cases, we will be able to quote you the repair costs at that time. The repair price you are quoted will be a "Not To Exceed" price, which means that the actual repair costs may be less than the quote. Be sure to include the RMA number on all documentation.

2. Provide us with the following documentation:
 - a) A note listing the symptoms that indicate the unit needs repair.
 - b) Complete shipping information for return of the equipment after repair.
 - c) The name and phone number of the person to contact if questions arise at the factory.
3. Use sufficient packing material and carefully pack the equipment in a sturdy shipping container.
4. Ship the equipment to the Moore Industries location nearest you.

The returned equipment will be inspected and tested at the factory. A Moore Industries representative will contact the person designated on your documentation if more information is needed. The repaired equipment, or its replacement, will be returned to you in accordance with the shipping instructions furnished in your documentation.