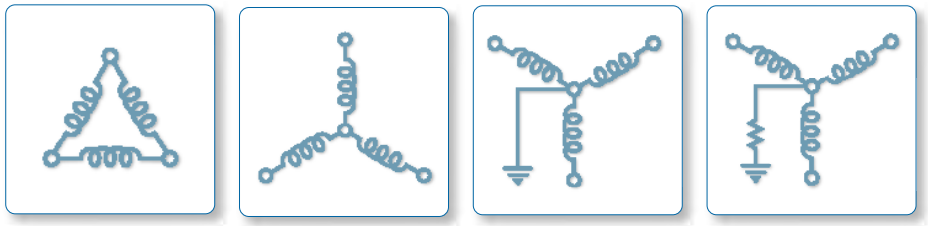
GARD

Unparalleled Protection

SIGMA 3-C

GROUND FAULT & MONITORING RELAY

Installation & Operation Manual



C-EG44EM, Manual Sept. 2025

***Applicable for SIGMA 3-C Serial No. 2213 and above**

Note: The SIGMA3-C relay is the latest generation, fully compliant with CEC 2024, and includes the 48-hour delay feature.

ABOUT I-GARD

I-Gard's commitment to electrical safety provides both industrial and commercial customers with the products needed to protect their electrical equipment and the people that operate them.

As the only electrical-safety focused company whose product portfolio includes neutral grounding resistors, high-resistance grounding systems and optical arc mitigation, we take pride in our technologies that reduce the frequency and impact of electrical hazards, such as arc flash and ground faults.

For those customers who have purchased from us over the last 30 years, you know us for the quality and robustness of our products, our focus on customer service and technical leadership. We build on this foundation by investing in developing new products in electrical safety education by actively participating in the IEEE community programs on technical and electrical safety standard, and working with local universities at discovering new technologies. We remain unrelenting in our goal of improving electrical safety in the workplace.

Our commitment to excellence is validated by long-standing relationships with industry leaders in fields as diverse as petroleum and gas, hospitals, automotive, data centers, food processing, aerospace, water and waste water plants, and telecommunications. We provide our customers with the product and application support required to ensure that their electrical distribution system is safe and reliable.

TABLE OF CONTENTS

1. GENERAL INFORMATION

This manual is intended for installation and maintenance of the SIGMA3-C. Carefully read and make sure that you understand all instructions before you mount, connect, and configure the SIGMA3-C.

The manual is available on:
https://i-gard.com

1.1 INTRODUCTION

The SIGMA3-C combines ground fault protection and Resistor Path Fault (RPF) monitoring to safeguard systems from ground faults and open or short circuits in the Neutral Grounding Resistor (NGR) and its connecting conductor.

Designed for both High Resistance Grounded (HRG) systems (5kV or below with fault currents up to 10 amps) and Low Resistance Grounded (LRG) systems (5kV or above with fault currents above 10 amps), the SIGMA3-C is a versatile solution.

A typical setup includes four components: the NGR (HRG or LRG), the SIGMA3-C relay, a Zero Sequence Current Sensor (ZSCS, TXA or RX-YA), and an NGRXS-## sensing resistor. The SIGMA3-C utilizes both current and voltage sensors to monitor the ground path from the X0 source bushing to the ground, with the NGRXS-## measuring voltage across the NGR and the ZSCS measuring current through it.

1.2 SAFETY NOTES

In this user manual, these symbols are used:

WARNING
General warning symbol indicates the presence of a hazard which could result in personal injury and damage to equipment or property.

WARNING
Warning symbol indicated the presence of hazardous voltage which could result in personal injury.

WARNING
Approved personnel are allowed to install and make the electrical connection of the Softstarter in accordance with existing laws and regulations.

INFORMATION
Information sign tells the reader important facts and conditions.

2. PRODUCT DESCRIPTION

2.1 OVERVIEW

2.1.1 SIGMA3-C Monitor Relay

The SIGMA3-C monitor relay measures the current through the NGR, the transformer neutral-to-ground voltage, and the NGR resistance. It compares these values with preset field settings and provides relay outputs and LED indications when abnormalities are detected. The ground fault trip levels and trip time settings can be adjusted using DIP switches or the SIGMA3-C TDM touchscreen interface.

2.1.2 Zero Sequence Current Sensor (ZSCS)

The ZSCS measures ground fault current.

2.1.3 NGRXS Sensing Resistor

The NGRXS measures the neutral-to-ground voltage and works with the SIGMA3-C and ZSCS to monitor the NGR resistance. This monitoring complies with the requirements of CSA C22.1 section 10-302 (2024).

2.1.4 Pulsing terminals

Pulsing signal terminals are available for NGR pulsing as a ground fault locating technique when equipped with a solid-state relay pulsing contactor.

2.2 TYPE DESIGNATION

SIGMA3-C: Ground Fault & Monitoring Relay
SIGMA3-C-TDM: Touchscreen Display Module for SIGMA3-C Ground Fault & RP Monitoring Relay
NGRXS: Sensing Resistor
TxA ZSCS: Zero Sequence Current Sensors for indoor application (0°C to 65°C).
TRxEC ZSCS: Extreme Temperature Zero Sequence Current Sensors for outdoor application (-80°C to 130°C).

2.3 MARKING AND CONNECTIONS

See Figure 2.3 below for the typical system with the SIGMA3-C connections.

WARNING
Terminals 39-52 and DI1-DI6 are reserved for future use. Do not connect or use these terminals.

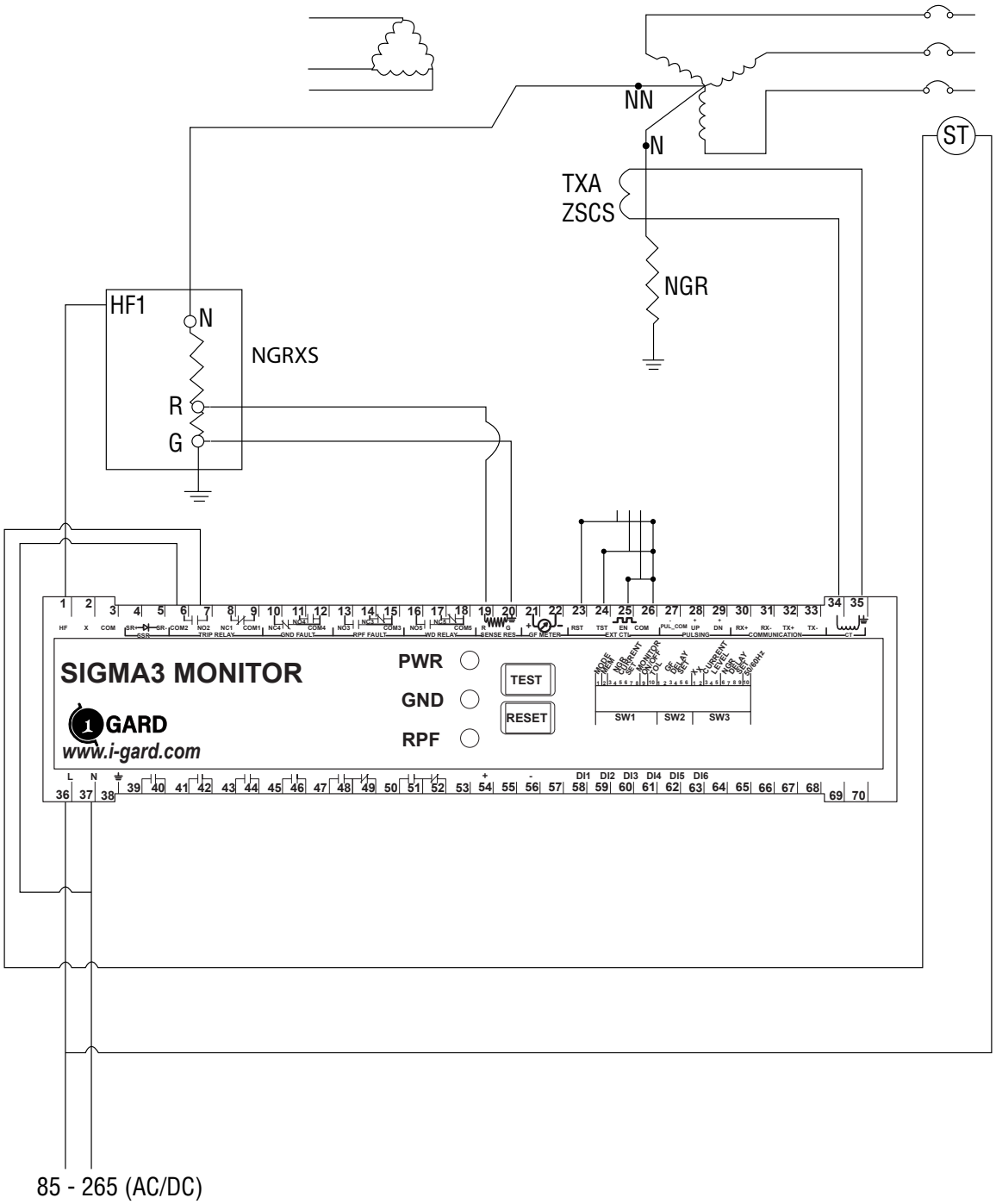


Figure 2.3: SIGMA3-C Typical System Diagram (HRG System)

2.4 TECHNICAL DATA

2.4.1 SIGMA3-C

General Data	Description		
Power supply	Rated supply voltage	110-240 VAC/DC 50/60 Hz 36W Power supply [1]	
	Tolerance	-22.72% to +10% (85-264 AC/DC)	
Frequency range	50 / 60 Hz		
Temperature Range	Operating	-40°C to +60°C	
	Storage	-50°C to +70°C	
Electrical Tests	Surge test	3 kV	
	Dielectric test	2 kV for 1 minute	
NGR Let-Through Current Settings	1-1000A		
Output Relay Contacts	Trip Relay (See Fig 2.4.1)	Type	Form Z (NO and NC pair)
		Rating	8 A, 250 VAC 0.4 A, 125 VDC
	Ground Fault (See Fig 2.4.2)	Type	1 Form C (NO/ NC)
		Rating	8 A, 250 VAC/ 24 VDC 0.4 A, 125 VDC
	RP Fault (See Fig 2.4.2)	Type	1 Form C (NO/ NC)
		Rating	8 A, 250 VAC/ 24 VDC 0.4 A, 125 VDC
Watchdog Relay (Default is DC)	DC	Type	1 Form A (NO), Fail-safe Mode DC
		Rating	1 A @ 120 VDC Relay
	AC [2]	Type	1 Form C (NO/ NC)
		Rating	8 A, 250 VAC/ 24 VDC
Meter Output	0-1 mA DC (0-100% of Let through Current Setting)		
Ground Fault Trip Settings	Trip Level	5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%	
	Trip Time	60 - 9300 ms	
Operating Modes	Fail-safe (Under-voltage Trip) / Shunt-trip [3]		
	Trip Memory On / Trip Memory Off		

Table 2.4.1 SIGMA3-C Technical Specifications

[1] 24V DC and 48V DC control supply is also available upon customer request

[2] Available upon customer request

[3] In Shunt Trip mode, the Trip relay is normally closed (NC) and changes to the normally open (NO) state when tripped. In Failsafe mode, the relay operates in reverse, remaining normally open (NO) and changing to normally closed (NC) when tripped.

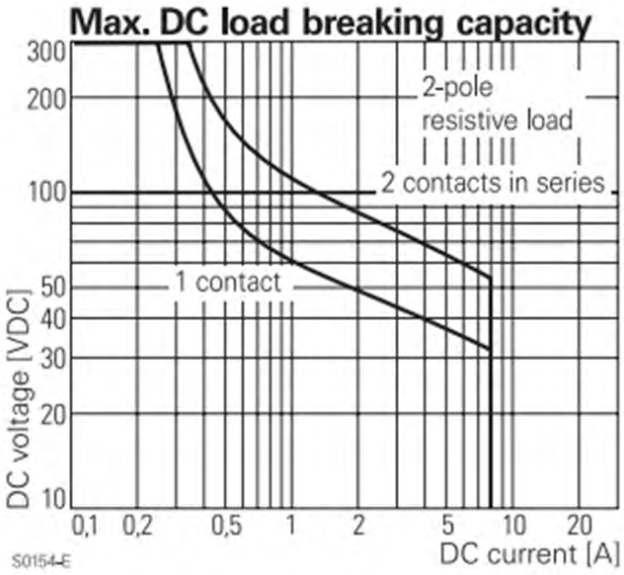


Figure 2.4.1: Maximimun switching power Volts and Amps (AC/DC)

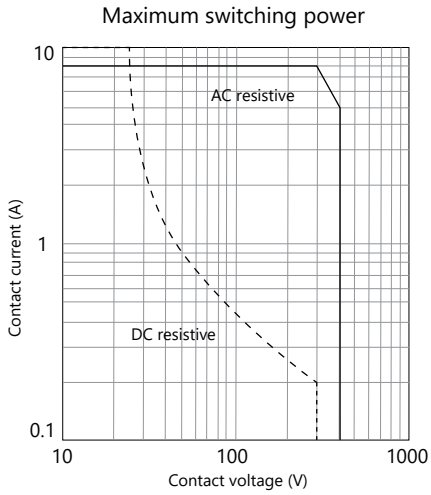


Figure 2.4.2: Maximimun switching power Volts and Amps (AC/DC)

2.4.2 SIGMA3-C TDM

General Data	Description
Screen size	7" Touchscreen
Touchscreen Technology	10-point multi-touch touchscreen
Resolution	800 x 480 RGB LCD Display, 24-bit color
Processor	Broadcom BCM2837B0, quad-core A53 (ARMv8) 64-bit, 1.4GHz
Memory	1GB LPDDR2 SCRAM Expandable non-volatile memory - 32GB
Connectivity	Gigabit Ethernet and 4x USB
Communication	MODBUS TCP, MODBUS RTU
Vertical Viewing Angle	130°
Horizontal Viewing Angle	140°
Temperature Range	0° to 50° C

Table 2.4.2 SIGMA3-C-TDM Technical specifications

2.5 APPLICABLE SAFETY STANDARDS

To ensure safety and quality the SIGMA3-C has been tested according to the following standards:

Standards	Description
UL 1053	Ground-Fault Sensing and Relaying Equipment
CSA C22.2 No 14	Industrial control equipment
CSA C22.2 No 144	Ground Fault Circuit Interrupters
CSA C22.1 Section 10 and Table 17	Impedence Grounded Systems

Table 2.5 Safety standards

3. MOUNTING

This chapter describes instructions on how to receive the SIGMA3-C and how to mount it in a proper way.

3.1 RECEIVING, UNPACKING AND CHECKING

- Check that the package is turned with the correct side up
- Remove the transport casing.
- Visually inspect the SIGMA3-C.
- Check that all items are included, according to the delivery note.

WARNING
Examine the SIGMA3-C and the package when you unpack your new product. If there are damages, please contact the transportation company or the I-Gard reseller/office immediately.

3.2 MOUNTING SIGMA3-C RELAY

WARNING
Mounting and electrical connection of the units must be made by authorized personnel and in accordance with existing laws and regulations

WARNING
Make sure that supply voltage is switched off before mounting and connecting the SIGMA3-C

INFORMATION
The SIGMA3-C monitor relay should be located as close as possible to the system's isolating device, circuit breaker, or contactor.

Fix the mounting clips delivered with the device as illustrated.

1. Snap the device on the DIN rail.
2. Press the device lightly onto the DIN rail.
3. Secure the relay to the DIN rail by engaging the release latches at the bottom of the relay.

WARNING
If mounting in any other position, take appropriate steps to prevent the relay from disengaging from the DIN rail.

INFORMATION
Use a 35 mm DIN rail that is bolted or firmly fixed to a flat surface. Ensure at least 20 mm of rail extends beyond each end of the relay.

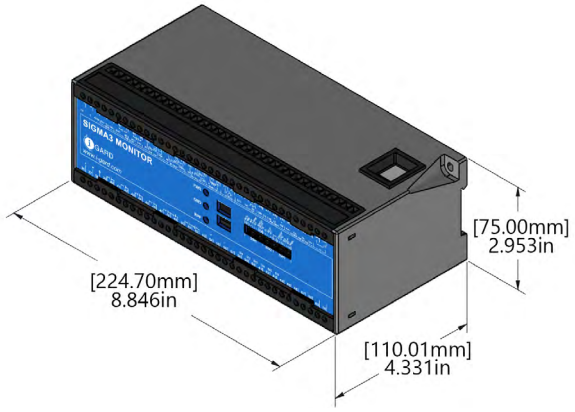


Figure 3.1: SIGMA3-C Dimensions

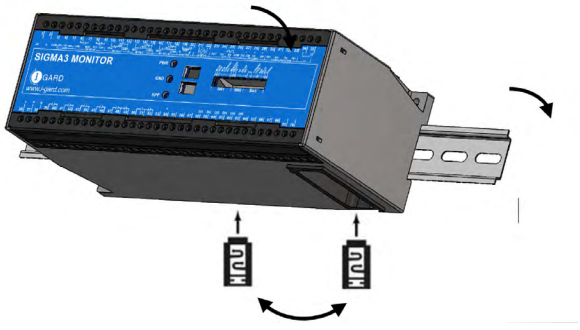


Figure 3.2: SIGMA3-C Mounting reference

3.3 MOUNTING SIGMA3-C TDM

INFORMATION

The recommended height for installing the SIGMA3-C-TDM (Display Module) is between 3 to 5 feet (1-1.5 meters) from the floor to the center of the display for easy access and use.

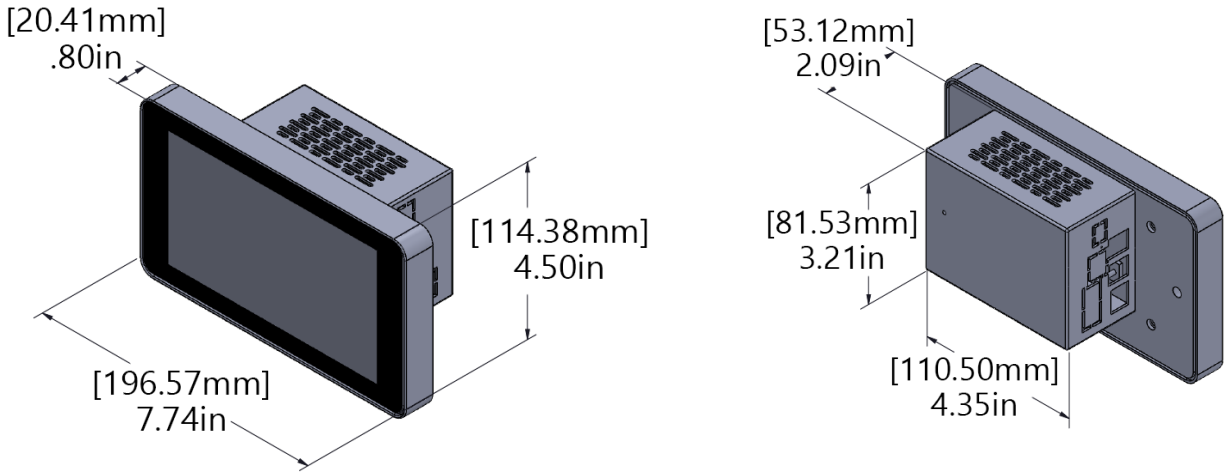


Figure 3.3.1: SIGMA3-C-TDM Dimensions

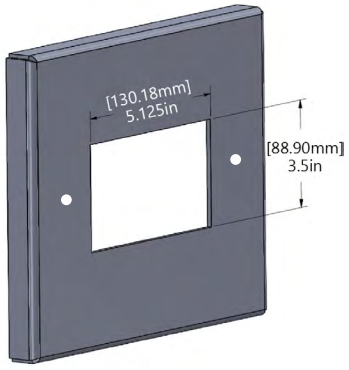
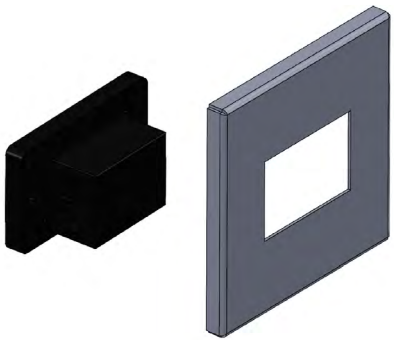
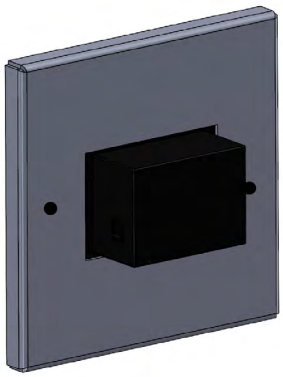
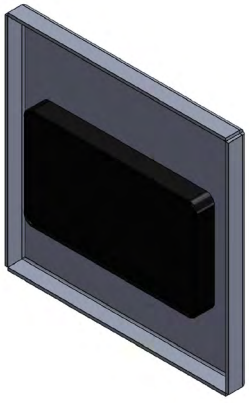
1. Measure and cut an opening in the panel door and drill 2 holes as shown in the image.	2. Place the back of the TDM into the cutout
	
3. Insert and tighten the screws to hold the display unit in place	4. Front view of SIGMA3-C-TDM after mounting
	

Figure 3.3.2: SIGMA3-C-TDM Mounting step by step

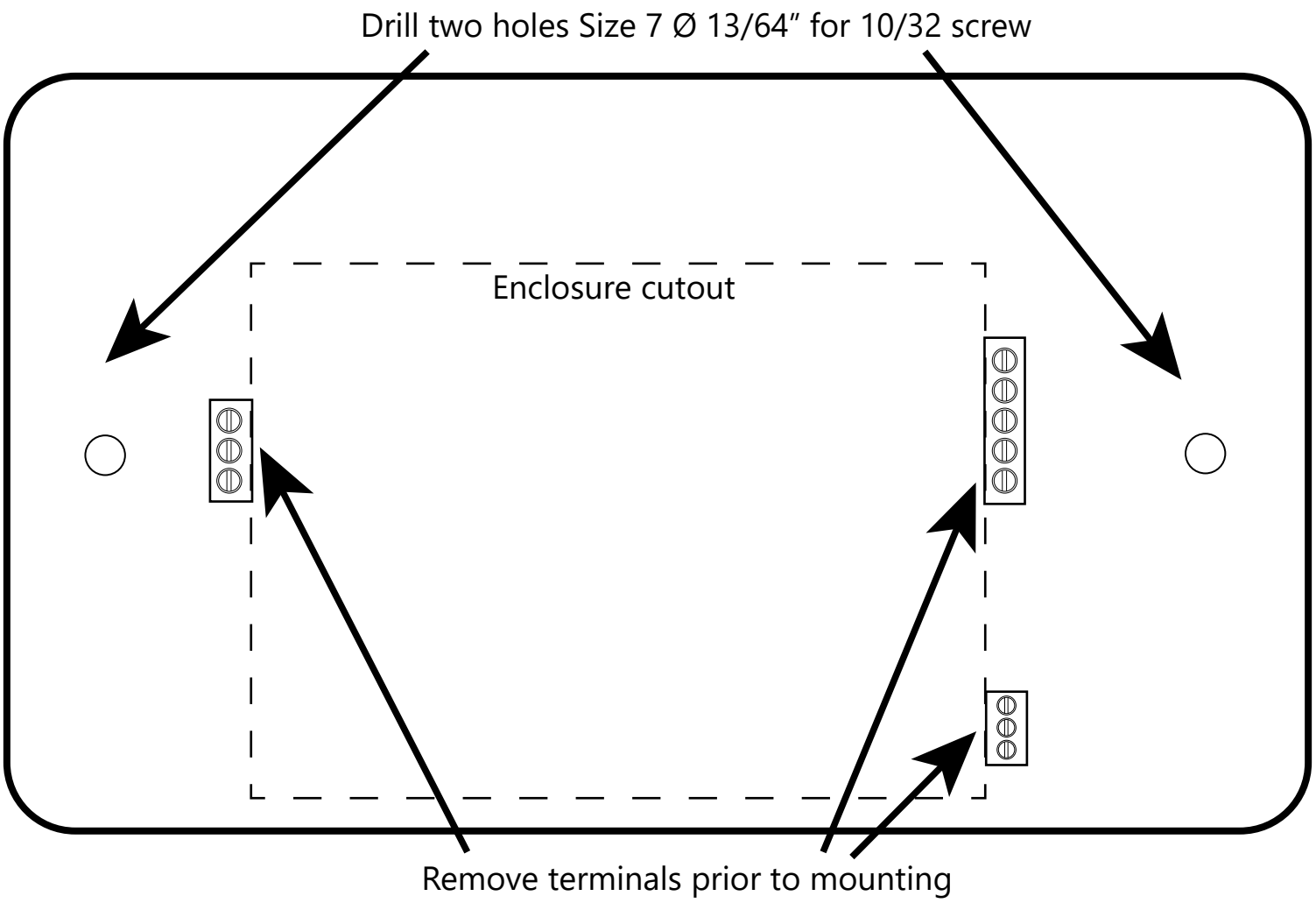


Figure 3.3.3: SIGMA3-C-TDM Mounting Template real size to cutout

4. CONNECTION

This chapter describes the electrical connections as well as connections for communication devices that have to be made before you can use the SIGMA3-C.

WARNING
Mounting and electrical connection of the units must be made by authorized personnel and in accordance with existing laws and regulations.

WARNING
Hazardous voltage. Will cause death or serious injury. Turn off and lock out all power supplying this device before starting work on this equipment

INFORMATION
Terminals on the SIGMA3-C relay accepts up to #14 AWG wire.

INFORMATION
No chassis bond is required as the relay's housing is non-metallic.

WARNING
Ensure the SIGMA3-C monitor relay is located as close as possible to the system's isolating device, circuit breaker, or contactor to ensure proper functionality.

4.1 GROUNDING

- Connect the G terminal (Terminal 38) on the SIGMA3-C monitor relay directly to a suitable grounding point or ground bus.

WARNING
This grounding point should be electrically common to the grounding point of the NGR.

4.2 CONTROL POWER

- Connect control power to Terminal L (36) and Terminal N (37) for AC supply.

INFORMATION
When connecting the DC supply, connect terminal 36 for the positive (+ve) terminal and terminal 37 for the negative (–ve) terminal, respectively.

INFORMATION
An isolation transformer is recommended as the source of supply to prevent excessive voltage from being applied to the relay's internal power supply.

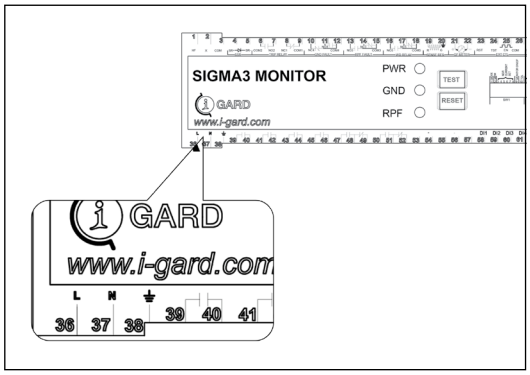


Figure 4.2: Control Power Terminal (36) and (37)

4.3 NGRXS SENSING RESISTOR CONNECTION

INFORMATION

Mount the NGRXS sensing resistor near the system neutral (whether a transformer or a generator), along with the ZSCS and the NGR.

- Connect the N terminal of the NGRXS to the XO point of the source.
- Connect the HF1 terminal of the NGRXS to terminal 1 on the SIGMA3-C monitor relay.
- Connect the R terminal of the NGRXS to terminal 19 on the SIGMA3-C monitor relay.
- Connect the G terminal of the NGRXS to terminal 20 on the SIGMA3-C monitor relay.
- Connect G to the Ground bus within the NGR enclosure.

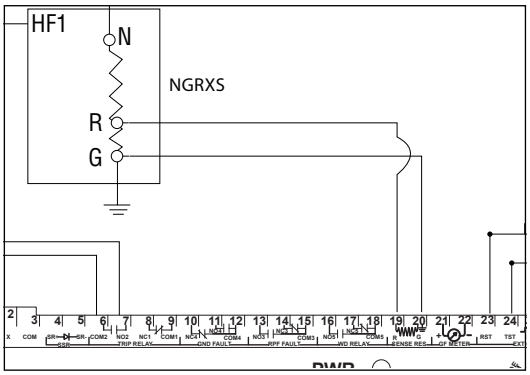


Figure 4.3: NGRXS Connection diagram

WARNING

Terminal (R) and (G) on the NGRXS are polarity sensitive. Interchanging these could potentially damage the circuit.

4.4 ZSCS CONNECTIONS

Refer table no. 4.3 for ZSCS Selection

INFORMATION

Mount the ZSCS around the system neutral conductor (whether a transformer or a generator), along with the NGRXS and the NGR.

- Connect terminal 34 on the SIGMA3-C monitor relay to the X1 terminal of the ZSCS.
- Connect terminal 35 on the SIGMA3-C monitor relay to the X2 terminal of the ZSCS.

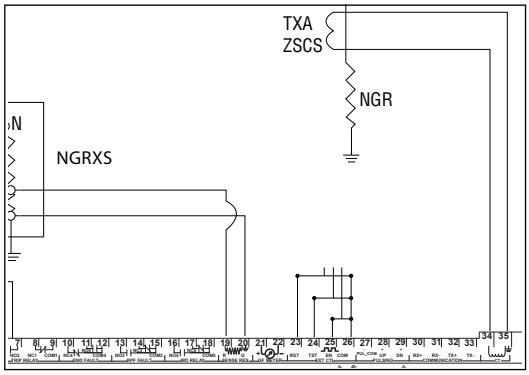


Figure 4.4: ZSCS Connection diagram

WARNING

If there is a shorting terminal block (TB) for the current transformer (CT), ensure that the CT shorting screw is removed.

WARNING

Ensure that neither of the current transformer (CT) terminals 34 or 35 on the SIGMA3-C is grounded.

System Voltage (L-L)	NGRXS Sensing Resistor	ZSCS*
480 or 600	NGRXS-6	T3A
690	NGRXS-7	T3A
1050	NGRXS-10	T3A
1100	NGRXS-11	T6A
2200	NGRXS-22	T6A
2400	NGRXS-25	T6A
3300	NGRXS-33	T6A
4160	NGRXS-50	T6A
6600	NGRXS-70	T6A
7200	NGRXS-75	T6A
11000	NGRXS-110	T9A
13800	NGRXS-150	T9A
25000	NGRXS-250	T9A
27600	NGRXS-270	T9A
34500	NGRXS-350	T9A

*For outdoor application with temperature below 0°C use TRxEC ZSCS

Table 4.3: Recommended Sensing Resistor and current sensor

4.5 PULSING

The pulsing feature of the SIGMA3-C relay can be activated either from the TDM or through the terminals (27, 28, and 29) on the SIGMA3-C relay.

Refer section 5.2 for more information on pulsing.

4.5.1 Enabling Pulsing

- **HMI Control (Recommended):**
  Pulsing is enabled using the SIGMA3-C TDM touchscreen HMI.

- **Manual Enabling:**
  In the absence of SIGMA3-C-TDM, Pulsing can be enabled by closing terminals (25) and (26).

Figure 4.5: Pulsing screen SIGMA3-C-TDM

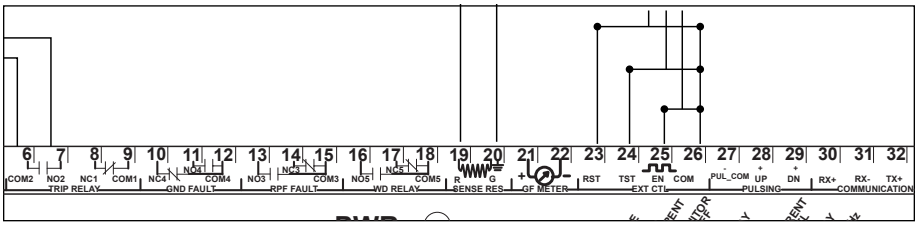


Figure 4.5.1: Pulsing terminals (25) and (26).

INFORMATION

When pulsing is enabled, the pulse signals cycle at a frequency of 1 Hz, the cycle frequency can be adjusted using the SIGMA3-C TDM touchscreen HMI.

4.5.2 Pulsing Configuration

WARNING
Always ensure correct terminal connections and verify settings before enabling pulsing. Interchanging the polarity may cause malfunction of the pulsing function.

- **Pulsing Up:**
  Connect terminals (27) and (28) on the SIGMA3-C relay.

INFORMATION
Terminals (27) and (28) are normally de-energized.

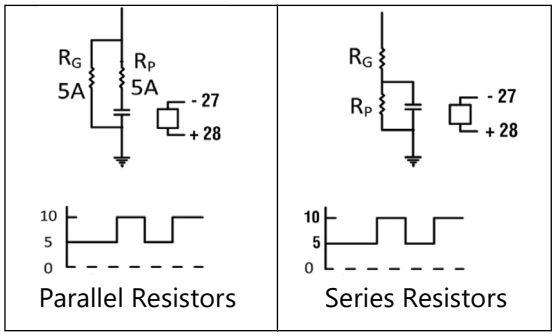


Figure 4.5.2 (a): Pulse up

- **Pulsing Down:**
  Connect terminals (27) and (29) on the SIGMA3-C relay.

INFORMATION
Terminals (27) and (29) are normally energized with +5.4VDC.

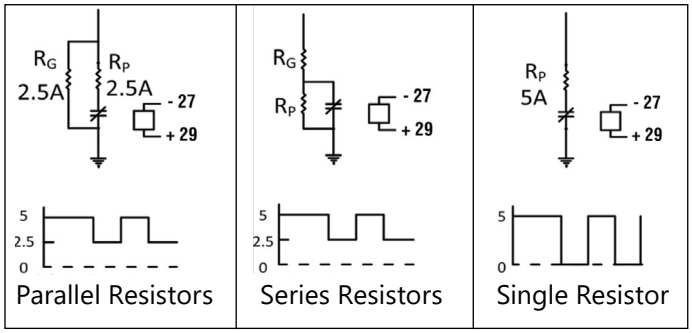


Figure 4.5.2 (b): Pulse down and single resistor

4.6 SIGMA3-C TDM CONNECTIONS

INFORMATION
TDM supports MODBUS TCP/IP communication.

4.6.1 Connection of Sigma3-C and TDM using Ix cable.

INFORMATION
When connecting the TDM to the SIGMA3-C relay, use only the IX cable supplied by I-Gard.

WARNING
TDM operates with a maximum power supply of 5.25 VDC, provided through the IX cable. Do not connect an external power supply, as it may damage the device.

Figure 4.6: SIGMA3-C-TDM Connection

- Connect the SIGMA3-C to the TDM using the supplied IX cable as illustrated in Image 5.6.

- IX cable provides both communication and power supply from the SIGMA3-C relay to the TDM

4.6.2 Connection of SIGMA3-C and TDM using the 4-wire RS485 port and external power supply

- Connect terminals on the SIGMA3-C to terminals on the TDM, as shown in Table 4.6.2 and Figure 4.6.2
- Connect an external 5 VDC power supply to the TDM as illustrated in Figure 4.6.2

SIGMA3-C TERMINALS	TERMINAL REFERENCE	SIGMA3-C-TDM TERMINALS
30	Rx+	Tx+
31	Rx-	Tx-
32	Tx+	Rx+
33	Tx-	Rx-

Table 4.6.2: Reference for SIGMA3-C-TDM Mounting using 4 wire

WARNING
Use only the 5 V DC power supply (Minimun 10W). Using any other voltage may damage the SIGMA3-C TDM and void the warranty.

WARNING
Ensure correct polarity when connecting the power supply to the SIGMA3-C TDM. Incorrect polarity may damage the device.

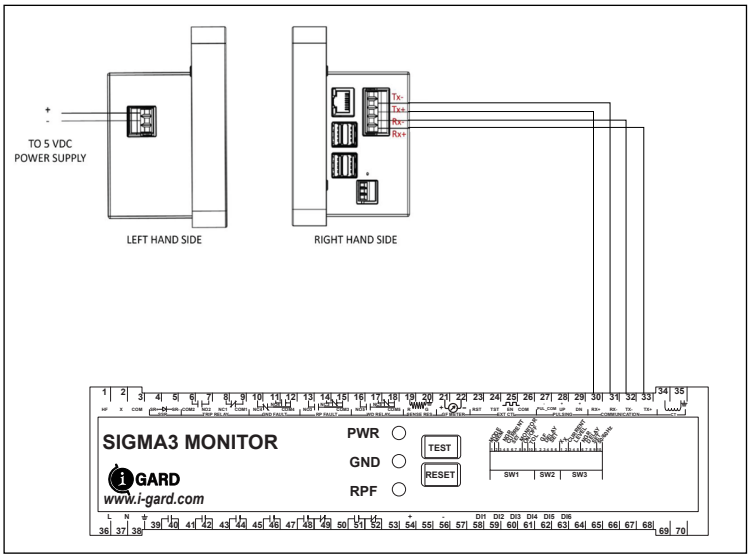


Figure 4.6.2: SIGMA3-C-TDM Mounting using 4 wire

4.7 EXTERNAL CONTROLS

- **Reset Control:**
  For door/panel mounted or remote reset controls, connect a momentary single pole single throw (SPST) normally open contact push button to terminal 23 on the SIGMA3-C monitor relay.

- **Test Control:**
  For door/panel mounted or remote test controls, connect a momentary single pole single throw (SPST) normally open contact push button to terminal 24 on the SIGMA3-C monitor relay.

WARNING
Ensure these contacts are voltage-free.

5. FUNCTIONS

This chapter contains descriptions of all the SIGMA3-C functions.

5.1 GROUND FAULT DETECTION

The SIGMA3-C monitoring relay detects ground faults by measuring the current through the Neutral Grounding Resistor (NGR) using the ZSCS sensors (TxA or TRxEC). When the measured current exceeds the preset threshold, the following actions occur:

- The GNDFLT LED illuminates.
- The GNDFLT form-C contact energizes.

5.2 PULSING

Pulsing is a method used in high-resistance grounded systems to locate ground faults. A ground fault can be identified using a clamp-on ammeter and the pulsing function of the SIGMA3-C relay.

In this system, the neutral grounding resistor (NGR) has two parts: a non-pulsing section and a pulsing section that includes a contactor. The SIGMA3-C sends pulse signals that create a changing current pattern by controlling a normally open (N.O.) solid-state relay, which acts as the pulsing contactor.

When the contactor is activated, the pulsing section causes the NGR's current to cycle between different levels, usually between 50% and 100% of the rated current. This changing current pattern, known as the pulsing signature, helps locate the ground fault.

5.3 RESISTOR PATH FAULT (RPF) MONITORING

The SIGMA3-C relay monitors the health of the ground path from the X0 bushing through the NGR to the ground to identify any open or short circuit conditions. If the SIGMA3-C determines that this path is compromised, the following actions occur:

- The RPF LED illuminates.
- The RPF form-C contact energizes.
- The TRIP RELAY energize after set time delay expires.

The SIGMA3-C relay uses two methods to monitor the integrity of the ground path: Measurement Mode and Injection Mode.

5.3.1 Measurement Mode

If the leakage current through the NGR exceeds 5% of the rated let-through current, the SIGMA3-C operates in Measurement Mode. In this mode:

- The ZSCS measures the leakage current through the NGR.
- The NGRXS measures the voltage across the NGR.

The SIGMA3-C uses these measurements to calculate the resistance of the NGR. If the calculated resistance is over 150% or less than 66% of the nominal value, the SIGMA3-C will signal an RPF.

Refer section 7.3.3.4 System Calibration for Detail Settings.

5.3.2 Injection Mode

5.3.2.1 Injection Mode Considerations

1. **Low Voltage/Current (Less than 5%):**

When the system measures no voltage or current (less than 5%), the integrity of the resistor cannot be monitored using Measurement Mode. In this scenario, the SIGMA3-C relay switches to Injection Mode. It actively applies a high-frequency current through the NGRXS to the resistor to confirm that the resistor is still connected from neutral to ground.

2. **Presence of Voltage Without Accompanying Current**

Injection Mode also handles situations where voltage is present across the NGR without accompanying current. This scenario is characterized by high, fluctuating values and typically occurs when voltage is measured across the neutral, but the current is insufficient to activate Measurement Mode. To adjust the system sensitivity appropriately in such cases, the following formula must be satisfied:

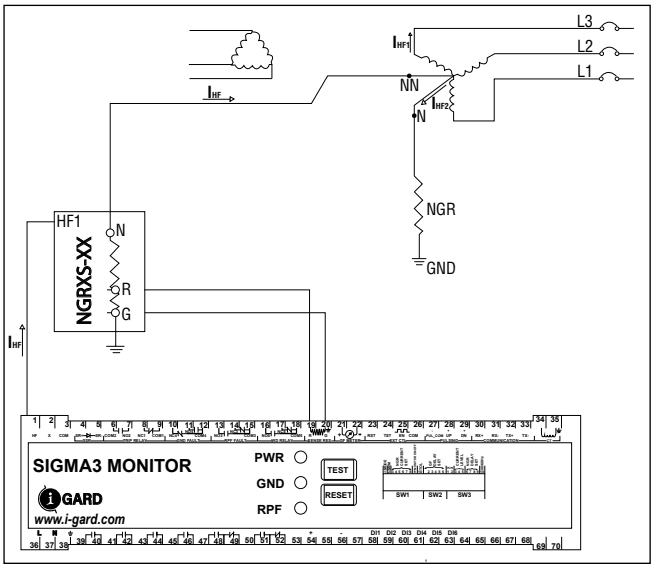


Figure 5.3.2.1: Injection Mode

Zero Drift < (Online Coupling Impedance * 255)

Where the NGRX Sensor Zero Drift is a user input.

The current I_{HF} is represented by the Conductance Measurement displayed on the calibration screen of the TDM. The value of I_{HF} varies in relation to the impedance of the NGR— as the NGR impedance decreases, the current I_{HF} increases.

5.3.2.2 Setting Thresholds Based on Conductance

Once the system's conductance is determined, you can set the open and short circuit thresholds as follows (Refer to Figure 5.3.2.2 for a visual example of a healthy system):

- The "Low Peak" must be greater than the "Low Fluctuating Value."
- The "High Peak" must be greater than the "High Fluctuating Value."
- The "Conductance Measurement" during normal operation must be greater than the "Open Circuit Threshold."
- The "Conductance Measurement" during normal operation must be less than the "Short Circuit Threshold."

Figure 5.3.2.2: SIGMA3-C-TDM System Calibration screen

Note: The values shown in the following images are scalar.

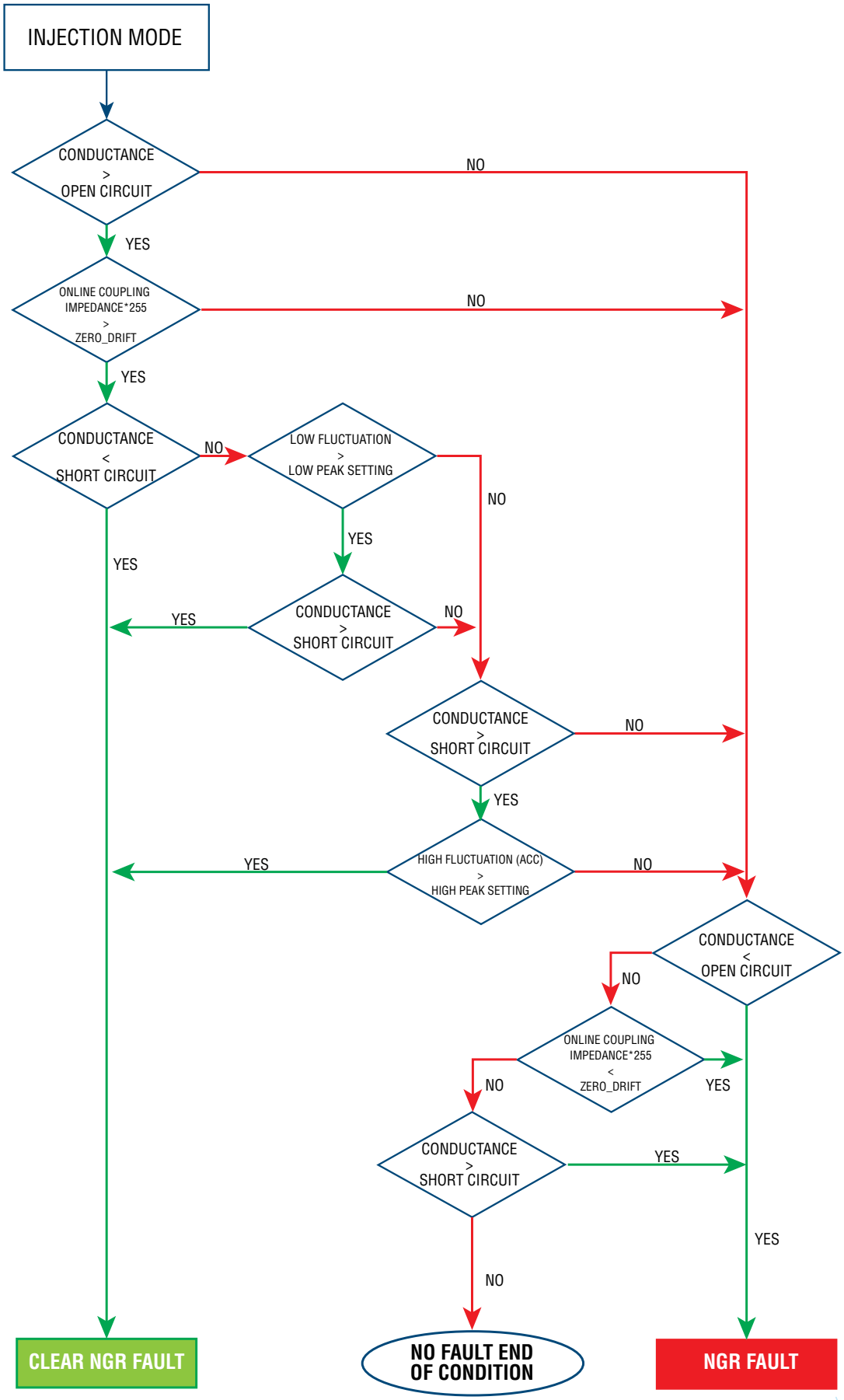


Figure 5.3.2.2.1 Setting Thresholds Based on Conductance Chart

5.4 OUTPUT RELAYS

The SIGMA3-C has four output relays:

- Trip Relay
- Resistor Path Fault Auxiliary Relay
- Ground Fault Auxiliary Relay
- Watchdog Auxiliary Relay

All relays within the system are electrically held, meaning they remain in a de-energized state when the control power is switched off. The de-energized states of these relays are visibly indicated on the front of the SIGMA3-C. It is important to note that this holds true regardless of the operating mode of the trip relay.

INFORMATION

Each relay can exist in one of two states: idle or tripped. The status of the trip relay, whether it is energized or de-energized in each of these states, is determined by its operating mode. This mode is configured using SW#1, DIP Switch 1.

5.4.1 TRIP RELAY – Terminals 6-7 and 8-9

The trip relay comprises a pair of normally open (NO) and normally closed (NC) terminals. Terminal (8-9) corresponds to the NC configuration, while terminal (6-7) corresponds to the NO configuration. The relay is energized when there is a RP fault after the NGR delay expires (up to 48 hours)

The trip relay can be configured for shunt trips or fail-safe operations.

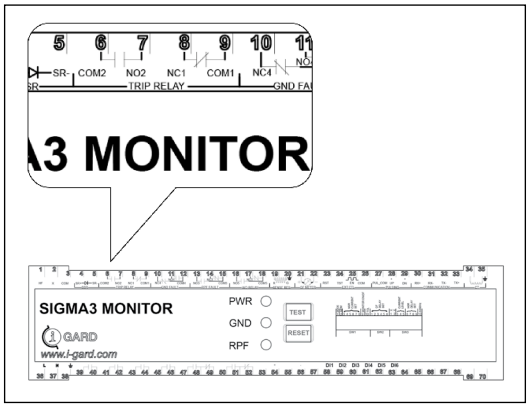


Figure: 5.4.1 Trip relay – Terminals 6-7 and 8-9

Feature	Shunt Trip Mode	Fail-Safe (Undervoltage Trip) Mode
Control Voltage Application	Trip relay remains Normally Closed (NC) when applied during normal operation.	Trip relay Normally Opens (NO) approximately 1 second after control voltage is applied.
Trip Conditions	Trip relay Normally Opens (trip) when: • NGR resistance exceeds threshold settings. • SIGMA3-C is reset. • Control voltage is removed.	Trip relay Normally Closes (NC) under any of the following conditions: • NGR resistance exceeds threshold settings. • SIGMA3-C is reset. • Control voltage is removed.
Post-Trip State	Trip relay remains Normally Open (NO) until reset, regardless of whether the fault is present.	Trip relay remains Normally Closed (NC) (if control voltage is present)until the SIGMA3-C is reset, regarless of whether the fault is present.
Trip Memory Option	• If OFF: Trip relay stays Normally Closed (NC). • If ON and a trip state is stored: Trip relay Normally Opens (NO) after approximately 1 second.	• If OFF: Trip relay remains Normally Open (NO). • If ON and a trip state is stored: Trip relay Normally Closes (NC) after approximately 1 second.

Reset Conditions	Trip relay Normally Closes (NC) upon local or remote reset.	Trip relay Normally Opens (NO) upon local or remote reset.
Fault Detection After Reset	Upon reset, the system resumes monitoring. If a fault remains, it will re-trip and Normally Open (NO) the trip relay.	Upon reset, the system resumes monitoring. If a fault remains, it will re-trip and Normally Closes (NC) the trip relay

Table 5.4.1: Trip Relay Operating Modes

5.4.2 GROUND (GND) FAULT Auxiliary Relay – Terminals 10, 11, 12

A Form-C auxiliary contact for ground faults is provided. The GROUND FAULT auxiliary relay operates exclusively in shunt trip mode regardless of DIP switch setting.

The relay changes state when a ground fault occurs in the system and the ground fault time delay expires.

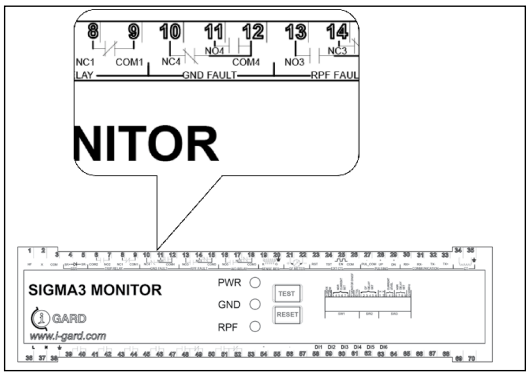


Figure 5.4.2: Trip relay 10, 11 and 12 terminals

Operating Mode	Type Of Fault	GND FAULT Relay Status	TRIP RELAY Status
Shunt trip Mode	Ground Fault	NO	NC
Fail Safe Mode	Ground Fault	NO	NO

Table 5.4.2: Auxiliarity Relay Status during GND Fault

5.4.3 RESISTOR PATH (RPF) FAULT Auxiliary Relay – Terminals 13, 14, 15 (specifically for use with the resistor monitoring feature)

A Form-C auxiliary contact for RP Fault is provided. The RPF auxiliary relay operates exclusively in shunt trip mode regardless of DIP switch setting.

The relay changes state when a RP Fault occurs. After this relay changes state, the NGR delay starts.

Note: Use this contact for the initial warning of the RP fault before the NGR delay trips the main trip contact.

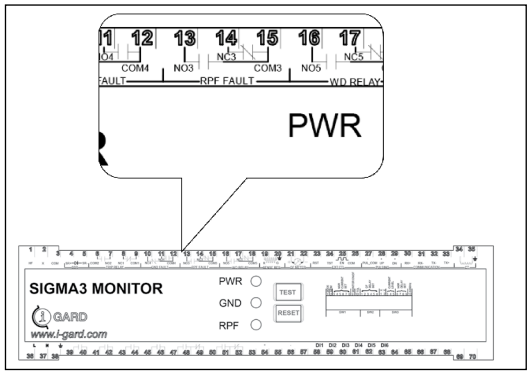


Figure 5.4.3: Trip relay 13, 14 and 15 terminals

Operating Mode	Calibration Mode	Type Of Fault	RPF FAULT Relay Status	TRIP RELAY Status
Shunt trip Mode	Measuring Mode	RPF Fault	NO	NO (After Time Delay)*
	Monitoring Mode	RPF Fault (Short Circuit)	NO	NO (After Time Delay)*
		RPF Fault (Open Circuit)	NO	NC
Fail Safe Mode	Measuring Mode	RPF Fault	NO	NC (After Time Delay) *
	Monitoring Mode	RPF Fault (Short Circuit)	NO	NC (After Time Delay)*
		RPF Fault (Open Circuit)	NO	NO

Table 5.4.3: Auxiliarity Relay Status during RPF Fault

*When there is a Resistor fault, the RP Fault contact will change state within approximately 10 seconds. The Trip Relay will change state only after the set delay time

5.4.4 Watchdog Auxiliary Relay – Terminals 4, 5

The terminal serves as the system normal watchdog. When the SIGMA3-C is not energized, it remains in an open state. When the SIGMA3-C is energized but not indicating an alarm, it remains closed. However, if the SIGMA3-C transitions into alarm mode, the watchdog changes its state and reverts to an open position.

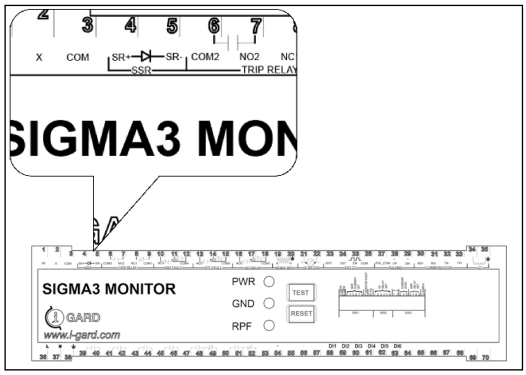


Figure 5.4.4: Trip relay 4, and 5 terminals

5.5 LED INDICATIONS ON SIGMA3-C RELAY

The SIGMA3-C has 3 indication LEDs located on its front panel: the Green PWR (POWER) LED, Red GND (GROUND) FAULT LED, and the Red RPF (RESISTOR PATH FAULT) LED.

The LED status indicators work as in Table 5.5 LED status:

Condition	LEDs Status		
	PWR	GND	RPF
Healthy	Solid Green	OFF	OFF
Ground Fault	Solid Green	Solid Red	OFF
RPF Fault	Solid Green	OFF	Flashing Red and then Solid Red after time delay
During Reset	Flashing Green	OFF	OFF
Relay malfunction	Flashing Green	OFF	OFF
Change of DIP Switch setting while power ON	Solid Green	Solid Red	OFF

Table 5.5: LED Indications Descriptions

5.6 TRIP MEMORY

The SIGMA3-C stores the states of the trip relay and auxiliary fault relays in non-volatile memory. Depending on the TRIP MEMORY Setting, it can restore the state of the trip relay when control power is reapplied.

Trip Memory	Description
On	The trip relay and auxiliary fault relays return to their idle operating states upon reapplying control supply.
Off	The trip relay and auxiliary fault relays restore to their previous states before the loss of control power. The states of the trip relay and auxiliary fault relays will be maintained untill the relay is manually reset.

Table 5.6: Trip Memory

6. SETTINGS

This chapter contains descriptions of all the SIGMA3-C parameters configuration.

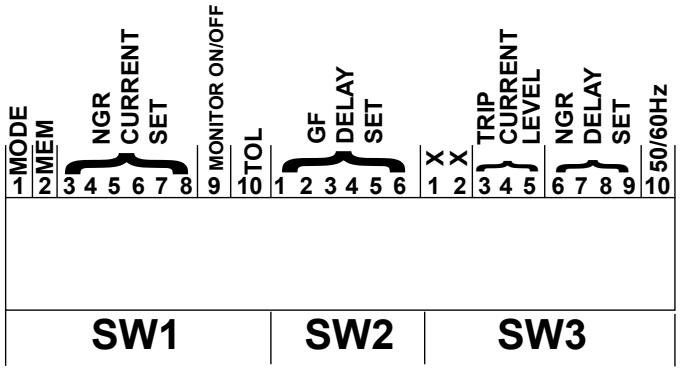


Figure 6: SIGMA3-C Dip Switch Array

6.1 PARAMETER LIST

Parameter	Setting range	Default value	Setting Through
Trip Relay operating Modes	Fail-safe (undervoltage trip), Non-fail Safe (Shunt Trip)	Non-fail Safe (Shunt Trip)	Dip Switch
Trip Memory settings	On, Off	Off	Dip Switch
NGR Let-through Current	1...1000 A	1 A	Dip Switch
NGR Fault Trip Time Delay	1 Min... 48 Min	10 Sec	Dip Switch
	1 Hour ... 48 Hours	10 Min	Dip Switch
RPF Monitor	On, Off	On [1]/ Off [2]	Dip Switch
RPF Tolerance	66 ... 300%, 66 ... 150%	66 ... 150%	Dip Switch
Ground Fault Trip Time Delay	60 ... 9300 ms	60 ms	Dip Switch
Ground Fault Trip Current Level	5 ... 50%	5%	Dip Switch
System Frequency	50 Hz , 60 Hz	60 Hz	Dip Switch
Pulsing	On, Off	Off	TDM
Pulse Frequency Range	1Hz - 3.25Hz	1Hz	TDM
Alarm mute delay	15 Min ... 24 Hr	15 Min	TDM
Voltage (L-L)	120 V ... 34.5 kV	-	TDM

Table 6.1: Parameter list

[1] For Canada Market RPF Monitor is ON as per CSA CSA C22.1 Section 10 and Table 17
[2] For US Market RPF Monitor is OFF

6.2 SW1

6.2.1 DIP Switch 1 (Trip Relay Operating Modes)

The trip relay operating can be set with SW1, DIP switch 1. The SIGMA3-C can be set for a shunt trip operating mode (not fail-safe) or an Undervoltage trip operating mode (fail-safe) operation with the trip relay operating mode dip switch.

Refer section 5.4.1 for details on Trip Relay Operating Mode

(1 = Up, 0 = Down)

Mode	Dip Switch Settings
Fail-safe (Undervoltage Trip)	1
Non-fail safe (Shunt Trip)	0

Table 6.2.1: Trip Relay Operating Mode SW1 DIP Switch 1 (left hand array)

6.2.2 DIP Switch 2 (Trip Memory Setting)

The trip memory can be set with SW1, DIP switch 2. The SIGMA3-C can be set for trip memory ON or trip memory OFF.

Refer section 5.6 for details on Trip Memory

(1 = Up, 0 = Down)

Trip Memory On/Off	Dip Switch Settings
TRIP MEMORY ON	1
TRIP MEMORY OFF	0

Table 6.2.2: Trip Memory Setting SW1 DIP Switch 2 (left hand array)

6.2.3 DIP Switch 3,4,5,6,7,8 (NGR Let-Through Current)

The NGR let-through current setting on the SIGMA3-C is configured using DIP switches to match the rating of the NGR. The trip level can be selected as a percentage of the RPF let-through current setting. The available percentages are 5%, 10%, 15%, 20%, 25%, 30%, 40%, and 50%.

The NGR let-through current can be set with SW 1, DIP SWITCH (3, 4, 5, 6, 7, 8).

(1 = Up, 0 = Down)

Current Settings (Amps)	Dip Switch Settings						ZSCS Employed
	3	4	5	6	7	8	
1	0	0	0	0	0	0	TxA or Rx-yA
2	1	0	0	0	0	0	TxA or Rx-yA
3	0	1	0	0	0	0	TxA or Rx-yA
4	1	1	0	0	0	0	TxA or Rx-yA
5	0	0	1	0	0	0	TxA or Rx-yA
6	1	0	1	0	0	0	TxA or Rx-yA
7	0	1	1	0	0	0	TxA or Rx-yA
8	1	1	1	0	0	0	TxA or Rx-yA
9	0	0	0	1	0	0	TxA or Rx-yA
10	1	0	0	1	0	0	TxA or Rx-yA

15	0	1	0	1	0	0	TxA or Rx-yA
20	1	1	0	1	0	0	TxA or Rx-yA
25	0	0	1	1	0	0	TxA or Rx-yA
30	1	0	1	1	0	0	TxA or Rx-yA
35	0	1	1	1	0	0	TxA or Rx-yA
40	1	1	1	1	0	0	TxA or Rx-yA
45	0	0	0	0	1	0	TxA or Rx-yA
50	1	0	0	0	1	0	TxA or Rx-yA
55	0	1	0	0	1	0	TxA or Rx-yA
60	1	1	0	0	1	0	TxA or Rx-yA
65	0	0	1	0	1	0	TxA or Rx-yA
70	1	0	1	0	1	0	TxA or Rx-yA
75	0	1	1	0	1	0	TxA or Rx-yA
80	1	1	1	0	1	0	TxA or Rx-yA
85	0	0	0	1	1	0	TxA or Rx-yA
90	1	0	0	1	1	0	TxA or Rx-yA
95	0	1	0	1	1	0	TxA or Rx-yA
100	1	1	0	1	1	0	TxA or Rx-yA
125	0	0	1	1	1	0	TxA or Rx-yA
150	1	0	1	1	1	0	TxA or Rx-yA
175	0	1	1	1	1	0	TxA or Rx-yA
200	1	1	1	1	1	0	TxA or Rx-yA
225	0	0	0	0	0	1	TxA or Rx-yA
250	1	0	0	0	0	1	TxA or Rx-yA
275	0	1	0	0	0	1	TxA or Rx-yA
300	1	1	0	0	0	1	TxA or Rx-yA
325	0	0	1	0	0	1	TxA or Rx-yA
350	1	0	1	0	0	1	TxA or Rx-yA
375	0	1	1	0	0	1	TxA or Rx-yA
400	1	1	1	0	0	1	TxA or Rx-yA
450	0	0	0	1	0	1	TxA or Rx-yA
500	1	0	0	1	0	1	TxA or Rx-yA
550	0	1	0	1	0	1	TxA or Rx-yA
600	1	1	0	1	0	1	TxA or Rx-yA
650	0	0	1	1	0	1	TxA or Rx-yA
700	1	0	1	1	0	1	TxA or Rx-yA
750	0	1	1	1	0	1	TxA or Rx-yA
800	1	1	1	1	0	1	TxA or Rx-yA
850	0	0	0	0	1	1	TxA or Rx-yA
900	1	0	0	0	1	1	TxA or Rx-yA
950	0	1	0	0	1	1	TxA or Rx-yA
1000	1	1	0	0	1	1	TxA or Rx-yA

Table 6.2.3: RPF Let-Through Current SW#1, DIP Switch #(3, 4, 5, 6, 7, 8) (Right Hand Array)

6.2.4 DIP Switch 9 (RPF Monitor ON/OFF)

The RPF Monitor can be set with SW1, DIP switch 9.

Refer section 5.2 for details on Resistor path monitoring.

(1 = Up, 0 = Down)

Mode	Dip Switch Settings
On	1
Off	0

Table 6.2.4: RPF Monitor On/Off SW#1, DIP Switch #9

6.2.5 DIP Switch 10 (RPF Tolerance)

The SIGMA3-C offers two RPF tolerance settings, where it calculates the apparent resistance of the NGR using the current from the ZSCS and the voltage across the NGR from the NGRX:

- **66% to 150%:** If the calculated resistance is greater than 150% or less than 66% of the nominal value, the SIGMA3-C will signal an RPF fault.
- **66% to 300%:** If the calculated resistance is greater than 300% or less than 66% of the nominal value, the SIGMA3-C will signal an RPF fault.

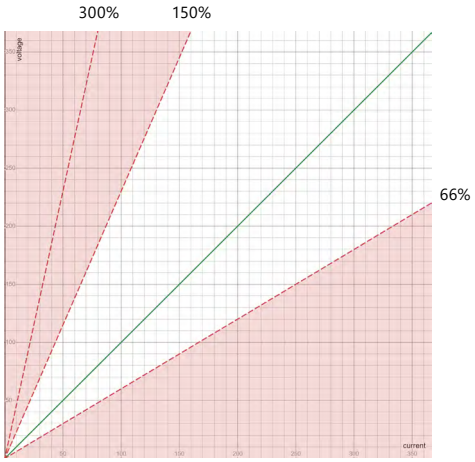


Figure 6.2.5: RPF Tolerance

The RPF Tolerance can be set with SW1, DIP switch 10. The RPF Tolerance feature is OFF when RPF Monitor is OFF.

(1 = Up, 0 = Down)

RPF Tolerance %	Dip Switch Settings
66% to 300%	1
66% to 150%	0

Table 6.2.5: RPF Tolerance SW#1, DIP Switch #10

6.3 SW2

6.3.1 DIP Switch 1, 2, 3, 4, 5, 6 (Ground Fault Delay Set)

The ground fault trip delay setting determines the duration that a ground fault must persist before being recognized as a fault. This setting is adjustable using DIP switches, ranging from a minimum of 60 milliseconds to a maximum of 9.3 seconds

The Ground Fault Trip Time Delay can be set with SW2, DIP switch 1,2,3,4,5,6.

(1 = Up, 0 = Down)

Ground Fault Trip Time Delay (in milliseconds)	Dip Switch Settings					
	1	2	3	4	5	6
60	0	0	0	0	0	0
150	1	0	0	0	0	0
300	0	1	0	0	0	0
450	1	1	0	0	0	0
600	0	0	1	0	0	0
750	1	0	1	0	0	0
900	0	1	1	0	0	0
1050	1	1	1	0	0	0
1200	0	0	0	1	0	0
1350	1	0	0	1	0	0
1500	0	1	0	1	0	0
1650	1	1	0	1	0	0
1800	0	0	1	1	0	0
1950	1	0	1	1	0	0
2100	0	1	1	1	0	0
2250	1	1	1	1	0	0
2400	0	0	0	0	1	0
2550	1	0	0	0	1	0
2700	0	1	0	0	1	0
2850	1	1	0	0	1	0
3000	0	0	1	0	1	0
3150	1	0	1	0	1	0
3300	0	1	1	0	1	0
3450	1	1	1	0	1	0
3600	0	0	0	1	1	0
3750	1	0	0	1	1	0
3900	0	1	0	1	1	0
4050	1	1	0	1	1	0
4200	0	0	1	1	1	0
4350	1	0	1	1	1	0
4500	0	1	1	1	1	0
4650	0	1	1	1	1	1
4800	1	0	0	0	0	0

4950	1	0	0	0	0	1
5100	0	1	0	0	0	1
5250	1	1	0	0	0	1
5400	0	0	1	0	0	1
5550	1	0	1	0	0	1
5700	0	1	1	0	0	1
5850	1	1	1	0	0	1
6000	0	0	0	1	0	1
6150	1	0	0	1	0	1
6300	0	1	0	1	0	1
6450	1	1	0	1	0	1
6600	0	0	1	1	0	1
6750	1	0	1	1	0	1
6900	0	1	1	1	0	1
7050	1	1	1	1	0	1
7200	0	0	0	0	1	1
7350	1	0	0	0	1	1
7800	0	1	0	0	1	1
7950	1	1	0	0	1	1
8100	0	0	1	0	1	1
8250	1	0	1	0	1	1
8400	0	1	1	0	1	1
8550	1	1	1	0	1	1
8700	0	0	0	1	1	1
8850	1	0	0	1	1	1
9000	0	1	0	1	1	1
9150	1	1	0	1	1	1
9300	0	0	1	1	1	1
9300	1	0	1	1	1	1
9300	0	1	1	1	1	1
9300	1	1	1	1	1	1

Table 6.3.1: Ground Fault Trip Time Delay SW#2, DIP Switches #(1,2,3,4,5,6) (left hand array)

6.4 SW3

6.4.1 DIP Switch 1, 2 (Dummy)

DIP Switch 1 and 3 are dummy and are not connected to circuit.

6.4.2 DIP Switch 3, 4, 5 (Ground Fault Trip Current Level)

The ground fault trip current level can be set with SW 3, DIP Switch 3, 4, 5. The SIGMA3-C can be programmed for a number of ground fault trip levels expressed as a percentage of the NGR let-through current setting. Eight ground fault trip level settings are available and are: 5%; 10%; 15%; 20%; 25%; 30%; 40%; 50%.

(1 = Up, 0 = Down)

Ground Fault Trip Level (% of NGR Let-Through Current)	Dip Switch Settings		
	3	4	5
5%	0	0	0
10%	1	0	0
15%	0	1	0
20%	1	1	0
25%	0	0	1
30%	1	0	1
40%	0	1	1
50%	1	1	1

Table 6.4.2: Ground Fault Trip Current Level SW#3, DIP Switches #(3, 4, 5) (Right hand array)

6.4.3 DIP Switch 6, 7, 8, 9 (NGR Delay Set)

The NGR delay can be set to minutes or hours based on the position of dip switch 9 on SW3. If dip switch 9 is OFF, the delay is set in minutes. If it is ON, the delay is set in hours.

The RPF delay can be set with SW3, DIP switch 6,7,8,9.

Minutes	Dip Switch Settings			
	6	7	8	9
1	0	0	0	0
6	1	0	0	0
12	0	1	0	0
18	1	1	0	0
24	0	0	1	0
30	1	0	1	0
36	0	1	1	0
48	1	1	1	0

Table 6.4.3.1: NGR Delay Set SW#3, DIP Switch #(6, 7, 8, 9) Min

Hours	Dip Switch Settings			
	6	7	8	9
1	0	0	0	1
6	1	0	0	1
12	0	1	0	1
18	1	1	0	1
24	0	0	1	1
30	1	0	1	1
36	0	1	1	1
48	1	1	1	1

Table 6.4.3.2: NGR Delay Set SW#3, DIP Switch #(6, 7, 8, 9) Hr

6.4.4 DIP Switch 10 (System Frequency)

The system frequency setting can be set with SW 3, DIP Switch 10. A system frequency of 50 Hz or 60 Hz can be chosen.

(1 = Up, 0 = Down)

System Frequency 50/60 Hz	Dip Switch Setting
System Frequency 50 Hz	1
System Frequency 60 Hz	0

Table 6.4.4: System Frequency SW#3, DIP Switch #10 (right hand array)

7. SIGMA3-C-TDM HMI

The SIGMA3-C can be used with a touchscreen HMI called the SIGMA3-C-TDM. The SIGMA3-C is connected to the SIGMA3-C-TDM using its MODBUS communication port. The connection of the SIGMA3-C to the SIGMA3-C-TDM is shown in Figure 7

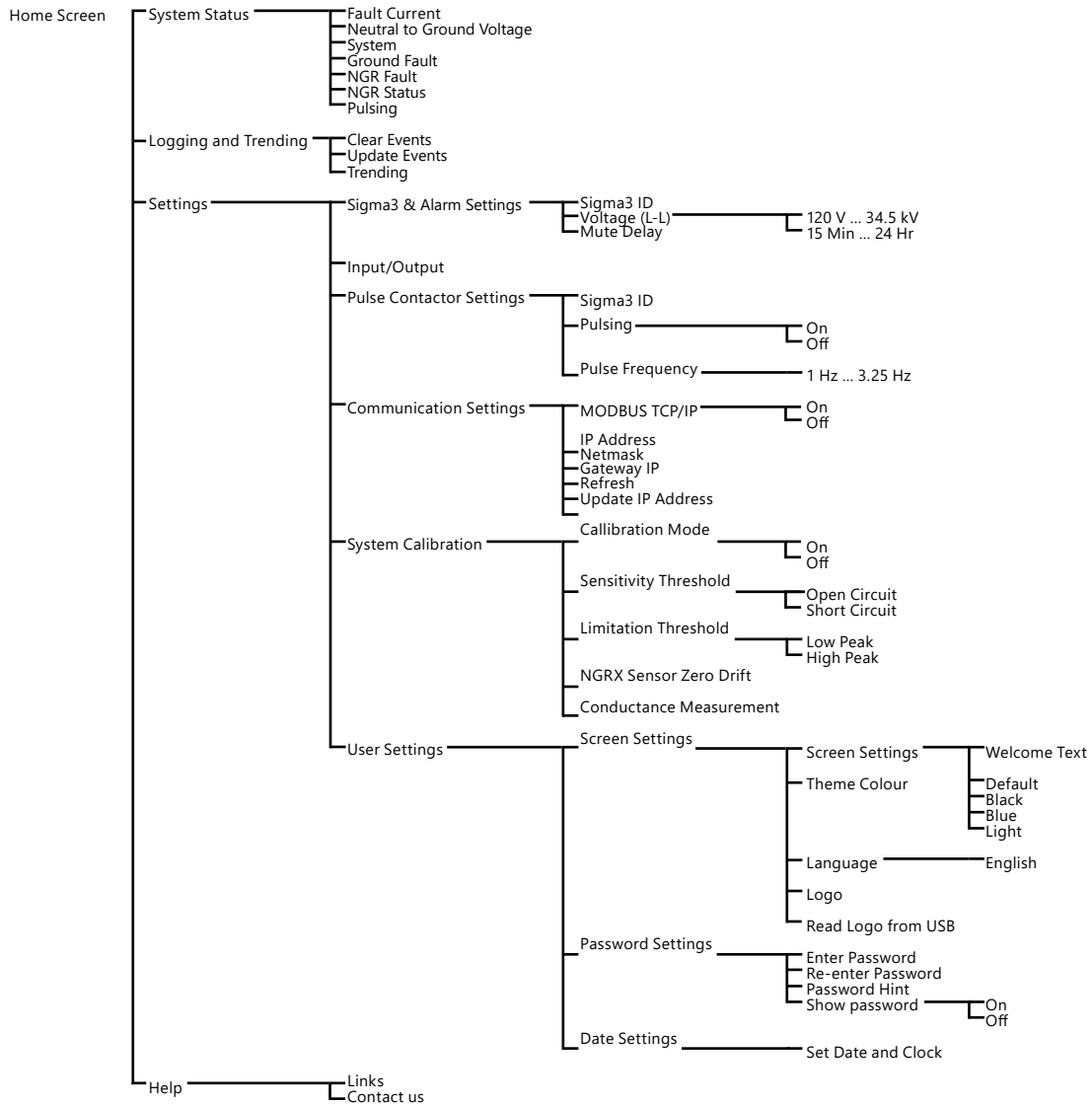
Features of SIGMA3-C-TDM:

- Display SIGMA3-C status and readings.
- Configure pulse contactor settings.
- Access logging and trending data.
- Enable remote reset of SIGMA3-C.
- Support TCP/IP communication.

Refer 4.6 SIGMA3-C TDM Connections.

Figure 7: SIGMA3-C and TDM connection

7.1 MENU OVERVIEW



7.2 SETTING UP SIGMA3-C TDM

INFORMATION
Before beginning the setup, refer to Section 5.6, "SIGMA3-C TDM Connections," for instructions on connecting the SIGMA3-C to the TDM.

1. Upon connection, the home screen will appear as shown in Figure 7.2.
2. To begin the setup, switch to Admin mode using the drop-down menu at the top, as illustrated in Figure 7.2.
3. Enter the password, as shown in Figure 8.3

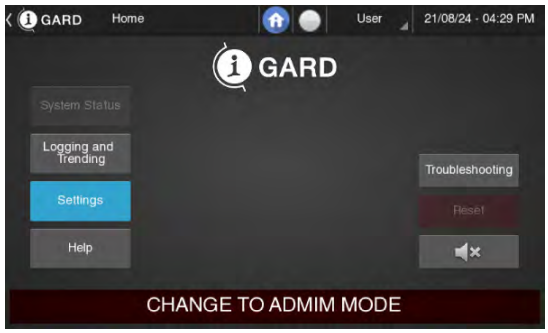


Figure 7.2.1: SIGMA3-C-TDM Home Screen / User

INFORMATION
The default password is set to 8421 and can be changed after setup. Refer to Section 8.1.2 for instructions on changing the password.

4. Return to the home screen, navigate to the "Settings", and enter the "SIGMA3 & Alarm Settings". Select the SIGMA3 ID from the drop-down menu, as shown in Figure 8.4 and tick the "Active" box.

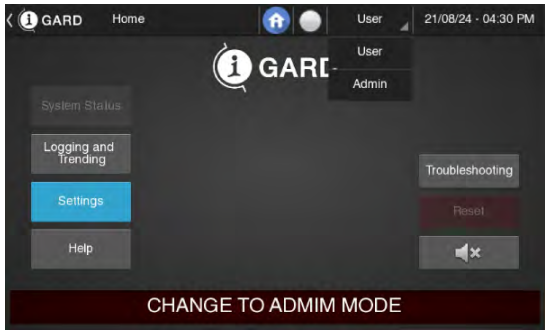


Figure 7.2.2: SIGMA3-C-TDM Home Screen / User

INFORMATION
SIGMA3 ID corresponds to the last digit of the SIGMA3-C serial number (located on the right side of the SIGMA3-C relay). Ensure the "Active" box is checked.

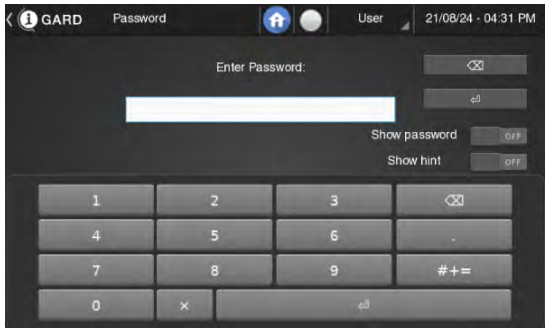


Figure 7.2.3: SIGMA3-C-TDM Password screen

Figure 7.2.4: SIGMA3-C-TDM Settings screen

7.3 NAVIGATION AND FUNCTIONS

Upon set up , the home screen will appear as shown in Figure 7.3

Figure 7.3: SIGMA3-C-TDM Home Screen / Admin

7.3.1 System Status

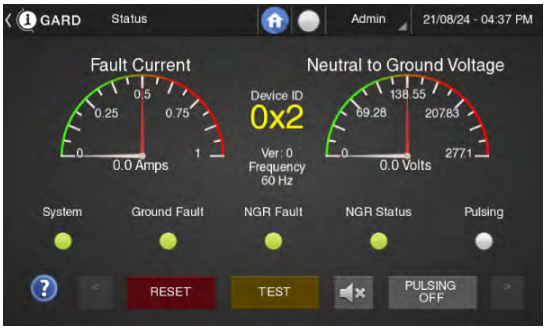


Figure 7.3.1: SIGMA3-C-TDM System status Screen

7.3.2 Events Logging and trending

SIGMA3-C TDM can store up to 1,000 trip history records on a first-in, first-out (FIFO) basis

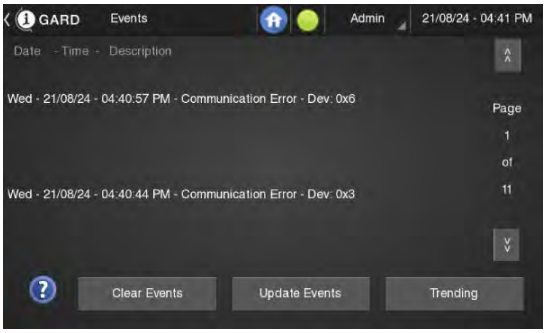


Figure 7.3.2: SIGMA3-C-TDM Events Logging and trending screen

7.3.3 Settings

Navigate to "Settings" page (Figure 8.5) to configure SIGMA3-C settings:

Figure 7.3.3: SIGMA3-C-TDM Settings screen

7.3.3.1 SIGMA3 & Alarm Settings

Select the required System Voltage (L-L) and Alarm Mute Delay from the drop-down menus. After making your selections, click "Save Settings," return to the "Home" screen, and press "RESET." Refer figure 7.3.3.1**.**

Figure 7.3.3.1: SIGMA3-C-TDM SIGMA3-C Alarm Settings screen

7.3.3.2 Pulse Contactor Settings

Pulsing feature is set to OFF by default. To enable it, change the setting to ON and select the desired pulse frequency from the drop-down menu. Refer figure 7.3.3.2

Figure 7.3.3.2: SIGMA3-C-TDM Pulse Contactor Settings Screen

7.3.3.3 Communication Settings

ModBUS TCP is set to OFF by default. To enable it, change the setting to ON and Configure the communication. Refer figure 7.3.3.3

Figure 7.3.3.3: SIGMA3-C-TDM Communication Settings Screen

7.3.3.4 System Calibration

Calibration Mode is set to OFF by default. Turn "Calibration Mode" ON. Confirm the SIGMA3-C ID is correct and the GREEN pilot light is visible.

INFORMATION
Parameters will display in green or red. If displayed in red, please verify the calibration values.

Figure 7.3.3.4: SIGMA3-C-TDM System Calibration Screen

1. System Calibration Screen:

Given Parameters	User Inputs
Conductance Measurement	Open Circuit Threshold
Online Coupling Impedance	Short Circuit Threshold
Low Fluctuating Value	Low Peak Threshold
High Fluctuating Value	High Peak Threshold
CT Current	NGRX Sensor Zero Drift

Table 7.3.3.4: SIGMA3-C System Calibration Parameters

2. Enter values for the user inputs as per the instructions:

INFORMATION
Open and short circuit thresholds are determined through conductance measurement. Peak thresholds are established based on fluctuating values.

- **Open/Short Circuit Thresholds:**

  1. Conductance Measurement must be greater than the "Open Circuit Threshold."
  2. Conductance Measurement must be less than the "Short Circuit Threshold."

- **Peak Threshold Values:**

  3. "Low Peak Threshold" must be slightly greater than the "Low Fluctuating Value."
  4. "High Peak Threshold" must be slightly greater than the "High Fluctuating Value."

3. Press "SAVE."

INFORMATION
In some cases, a voltage may be present across the NGR without sufficient current to trigger measurement mode, which is indicated by high "Fluctuating Values" and a Neutral-Ground Voltage with minimal current.
Refer section 5.3.2 Injection mode

4. Return to the "Home" screen and press "RESET." Monitor the system for approximately 5 minutes until communications reset, and ensure there is no RPF alarm.

7.3.3.5 User Setting

Enter the user settings as shown in Figure 7.3.3.5 to configure the screen settings, password settings, and date settings.

Figure 7.3.3.5: User Settings Screen

7.3.3.5.i Screen settings

Figure 7.3.3.5.i: Interface Screen settings

7.3.3.5.ii Password settings

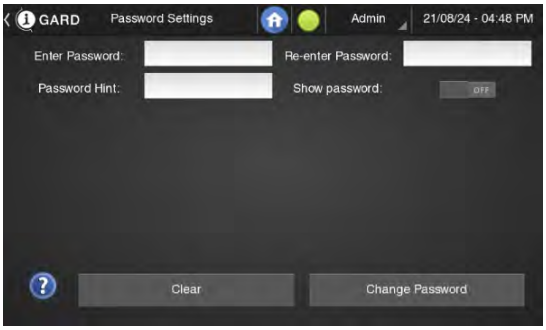


Figure 7.3.3.5.ii: Password Screen settings

7.3.3.5.iii Date settings

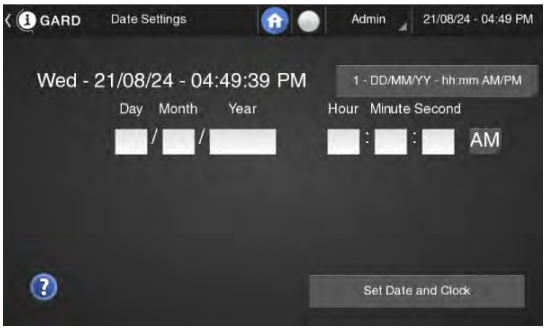


Figure 7.3.3.5.iii: Date Settings Screen

7.3.3.5.iv Fan settings

Figure 7.3.3.5iv: Fan Settings Screen

8. MODBUS COMMUNICATION

The SIGMA3-C supports MODBUS RTU and is equipped with a 4-wire RS-485 communication port for connecting to a remote terminal or network. Use terminals 30 (Rx +), 31 (Rx -), 32 (Tx -), and 33 (Tx +) as shown in Figure 8.1. The preferred connection method is the 4-wire setup (Figure 8.1(a)), with an optional 2-wire setup available (Figure 8.1(b)).

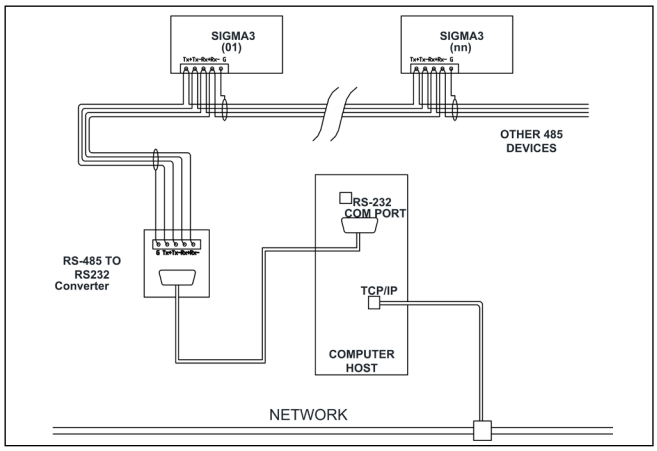


Figure 8.1 (a): Preferred 4-wire
MODBUS Communication Connection

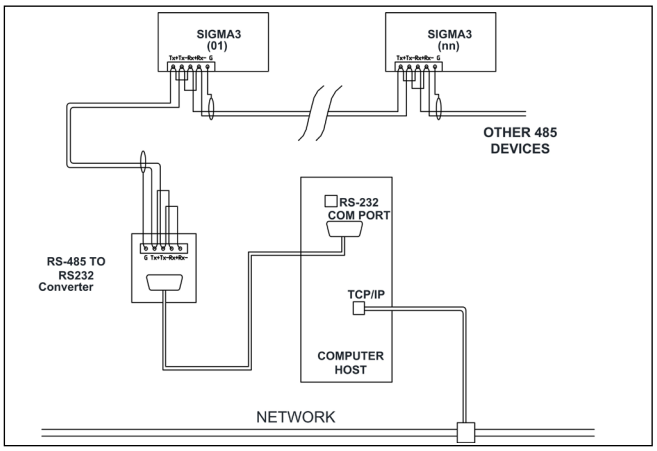


Figure 8.1 (b): Alternate 2-wire
MODBUS Communication Connection

INFORMATION

The SIGMA3-C-TDM supports MODBUS TCP/IP. When using the SIGMA3-C-TDM, communication should be routed through the SIGMA3-C-TDM.

Refer to Section 4.6 SIGMA3-C TDM Connections for TDM connection and setup instructions.

Last Digit of SIGMA 3 Serial Number	MODBUS Slave ID (Hex)
XXX0	0xA
XXX1	0xB
XXX2	0x2
XXX3	0x3
XXX4	0x4
XXX5	0x5
XXX6	0x6
XXX7	0x7
XXX8	0x8
XXX9	0x9

Table 8: MODBUS ID Address Map

WARNING

Use a standard 4-wire cable with two twisted pairs and a grounding shield to prevent electromagnetic interference. Ground the shield at only one end.

The MODBUS ID for the SIGMA3-C is fixed and set according to the serial number (see Table 8). The baud rate is fixed at 38400 BPS with an 8-bit frame setup, no parity, and 1 stop bit.

8.1 MODBUS FUNCTIONS

The SIGMA3-C supports the "Read Holding Registers" (03) MODBUS function, providing access to 32 MODBUS registers. Requests from the master are always 8 bytes long, as shown in Table 8.1.1.

In the MODBUS RTU system, the SIGMA3-C can operate in either a client/server model or a master/slave model:

- **Client/Server Model:** The SIGMA3-C acts as the MODBUS server, responding to requests from a MODBUS client.
- **Master/Slave Model:** The SIGMA3-C acts as the MODBUS slave, responding to requests from a MODBUS master.

The data format for MODBUS registers is as follows:

- **nnnnH** for four hexadecimal digits
- **ddddB** for four binary digits
- **dddddddd B** for eight binary digits

Table 8.1.1 provides an example of a request for 2 registers starting from address 02. The CRC checksum is a 16-bit CRC as defined in MODBUS documentation. On a successful request, the SIGMA3-C will return the message shown in Table 8.1.2

INFORMATION
The SIGMA3-C relay processor may occasionally be too busy to respond. To ensure successful communi cation, request the maximum number of registers in a single request.

Unit I/D	Function	Starting Address		No. of Registers Requested		CRC	
		High	Low	High	Low	High	Low
02	03	nn	nn	nn	nn	cc	cc

Table 8.1.1: MODBUS RTU Standard 8 Byte Holding Register Read Function (03)

Unit I/D	Function	No. of Bytes		Data 1		Data N		CRC	
		High	Low	High	Low	High	Low	High	Low
02	03	nn	nn	nn	nn	nn	nn	cc	cc

Table 8.1.2: Returned Information Structure for Holding Register Request

INFORMATION
Register numbers are shown in decimal but must be sent in hexadecimal in the request. For example, register number 40001 is sent as hexadecimal address 0000H, register number 40002 as 0001H, and so on.

MODBUS registers can be read by specifying the starting address in a block and the number of registers required, up to the number available in that block.
Register contents are detailed in Tables 8.1.3 and 8.1.4.

MODBUS TCP			
REGISTER	R/W	NAME	DESCRIPTION
40001	R	N-G VOLTAGE READING	0-511
40002	R	SYSTEM VOLTAGE	***Refer*** TABLE 2
40003	R	DIP SW3(3-10), SW2(1-6), SW1(1-2)	***Refer*** TABLE 3
40004	R	DIP SW1(3-10)	***Refer*** TABLE 4
40005	R	RELAY STATUS	"Bit 0 – Main Relay: 0 – OFF / 1 – ON Bit 1 – Ground Fault Relay: 0 – OFF / 1 – ON Bit 2 – NGR Fault Relay: 0 – OFF / 1 – ON"
40006	R	NGR/RPF STATUS	"Bit 3-0: GND Fault LED status: 0 – OFF / 1 – ON /3- Flashing Bit 7-4: NGR Fault LED status: 0 – OFF / 1 – ON /3- Flashing"
40007	R	PULSING STATUS	"Bit 4 to Bit 0 – Pulsing frequency - (Refer Pulsing Frequency TABLE 1) Bit 5 – Pulsing Status"
40008	R	CONDUCTANCE	0-50,000
40009	R	OPEN CIRCUIT THRESHOLD	0-50,000
40010	R	SHORT CIRCUIT THRESHOLD	0-50,000
40011	R	FAULT CURRENT	0-511
40012	R	NGRX SENSOR ZERO DRIFT	0-50,000
40013	R	LOW PEAK	0-50,000
40014	R	HIGH PEAK	0-50,000
40015	R	ONLINE COUPLING IMPEDENCE	0-50,000
40016	R	LOW FLUCTUATION	0-50,000
40017	R	HIGH FLUCTUATION	0-50,000
40018	R	CALIBRATION MODE	(0-OFF,1-ON)
40019	R	PHI	0-50,000
40020	R	IMPEDANCE MODE (0-OFF,1-ON)	(0-OFF,1-ON)

Table 8.1.3: MODBUS TCP

MODBUS RTU			
REGISTER	R/W	NAME	DESCRIPTION
40010	R	FAULT CURRENT	0-511
40011	R	LOW FLUCTUATION	0-50,000
40012	R	ONLINE COUPLING IMPEDENCE	0-50,000
40013	R	RESERVED	
40014	R	RESERVED	
40015	R	CALIBRATION MODE	(0-OFF,1-ON)
40016	R	CONDUCTANCE	0-50,000
40017	R	OPEN CIRCUIT THRESHOLD	0-50,000
40018	R	SHORT CIRCUIT THRESHOLD	0-50,000
40019	R	SYSTEM VOLTAGE	TABLE 1
40020	R	N-G VOLTAGE READING	0-511
40021	R	NGRX SENSOR ZERO DRIFT	0-50,000
40022	R	DIP SW3(3-10), SW2(1-6), SW1(1-2)	TABLE 2
40023	R	DIP SW1(3-10)	TABLE 3
40024	R	RELAY STATUS	"Bit 0 – Main Relay: 0 – OFF / 1 – ON Bit 1 – Ground Fault Relay: 0 – OFF / 1 – ON Bit 2 – NGR Fault Relay: 0 – OFF / 1 – ON"
40025	R	NGR/RPF STATUS	"Bit 3-0: GND Fault LED status: 0 – OFF / 1 – ON /3- Flashing Bit 7-4: NGR Fault LED status: 0 – OFF / 1 – ON /3- Flashing"
40026	R	PULSING STATUS	"Bit 4 to Bit 0 – Pulsing frequency - (Refer Pulsing Frequency table, page 39) Bit 5 – Pulsing Status"
40027	R	LOW PEAK SETTING	0-50,000
40028	R	RESERVED	
40029	R	HIGH PEAK SETTING	0-50,000
40030	R	PHI	0-50,000
40031	R	IMPEDANCE MODE (0-OFF,1-ON)	(0-OFF,1-ON)

Table 8.1.4: MODBUS RTU

Table 1

PULSING FREQUENCY	
MODBUS OUTPUT(DEC)	Hz
0	1
1	1.25
2	1.5
3	1.75
4	2
5	2.25
6	2.5
7	2.75
8	3
9	3.25

Table 2

SYSTEM VOLTAGE	
MODBUS OUTPUT(DEC)	(L-L) V
0	120
1	240
2	380
3	400
4	415
5	480
6	600
7	690
8	1050
9	2.2K
10	2.4K
11	3.3K
12	4.2K
13	6.6K
14	7.2K
15	11K
16	13.8K
17	23K
18	34.5K

Table 3

GF DELAY							
MODBUS OUTPUT(DEC)	BIT 8-13						mSEC
	13	12	11	10	9	8	
0	0	0	0	0	0	0	60
1	0	0	0	0	0	1	150
2	0	0	0	0	1	0	300
3	0	0	0	0	1	1	450
4	0	0	0	1	0	0	600
5	0	0	0	1	0	1	750
6	0	0	0	1	1	0	900
7	0	0	0	1	1	1	1050
8	0	0	1	0	0	0	1200
9	0	0	1	0	0	1	1350
10	0	0	1	0	1	0	1500
11	0	0	1	0	1	1	1650
12	0	0	1	1	0	0	1800
13	0	0	1	1	0	1	1950
14	0	0	1	1	1	0	2100
15	0	0	1	1	1	1	2250
16	0	1	0	0	0	0	2400
17	0	1	0	0	0	1	2550
18	0	1	0	0	1	0	2700
19	0	1	0	0	1	1	2850
20	0	1	0	1	0	0	3000
21	0	1	0	1	0	1	3150
22	0	1	0	1	1	0	3300
23	0	1	0	1	1	1	3450
24	0	1	1	0	0	0	3600
25	0	1	1	0	0	1	3750
26	0	1	1	0	1	0	3900
27	0	1	1	0	1	1	4050
28	0	1	1	1	0	0	4200
29	0	1	1	1	0	1	4350
30	0	1	1	1	1	0	4500
31	0	1	1	1	1	1	4650
32	1	0	0	0	0	0	4800
33	1	0	0	0	0	1	4950
34	1	0	0	0	1	0	5100
35	1	0	0	0	1	1	5250
36	1	0	0	1	0	0	5400
37	1	0	0	1	0	1	5550
38	1	0	0	1	1	0	5700

39	1	0	0	1	1	1	5850
40	1	0	1	0	0	0	6000
41	1	0	1	0	0	1	6150
42	1	0	1	0	1	0	6300
43	1	0	1	0	1	1	6450
44	1	0	1	1	0	0	6600
45	1	0	1	1	0	1	6750
46	1	0	1	1	1	0	6900
47	1	0	1	1	1	1	7050
48	1	1	0	0	0	0	7200
49	1	1	0	0	0	1	7350
50	1	1	0	0	1	0	7800
51	1	1	0	0	1	1	7950
52	1	1	0	1	0	0	8100
53	1	1	0	1	0	1	8250
54	1	1	0	1	1	0	8400
55	1	1	0	1	1	1	8550
56	1	1	1	0	0	0	8700
57	1	1	1	0	0	1	8850
58	1	1	1	0	1	0	9000
59	1	1	1	0	1	1	9150
60	1	1	1	1	0	0	9300
61	1	1	1	1	0	1	9300
62	1	1	1	1	1	0	9300
63	1	1	1	1	1	1	9300

GF TRIP LVL			
MODBUS OUTPUT(DEC)	BIT 0-2		
	2	1	0
0	0	0	0
1	1	0	0
2	0	1	0
3	1	1	0
4	0	0	1
5	1	0	1
6	0	1	1
7	1	1	1

MAIN TRIP DELAY			
MODBUS OUTPUT(DEC)	BIT 3-5		
	5	4	3
0	0	0	0
1	1	0	0
2	0	1	0
3	1	1	0
4	0	0	1
5	1	0	1
6	0	1	1
7	1	1	1

MAIN TRIP DELAY(MIN/HR)	
MODBUS OUTPUT(DEC)	BIT 6
0	0
1	1

FREQUENCY	
MODBUS OUTPUT(DEC)	BIT 7
0	0
1	1

MODE	
MODBUS OUTPUT(DEC)	BIT 14
0	0
1	1

MEMORY	
MODBUS OUTPUT(DEC)	BIT 15
0	0
1	1

Table 4

FAULT CURRENT SETTING							
MODBUS OUTPUT(DEC)	BIT 0-5						Amps
	5	4	3	2	1	0	
0	0	0	0	0	0	0	1
1	0	0	0	0	0	1	2
2	0	0	0	0	1	0	3
3	0	0	0	0	1	1	4
4	0	0	0	1	0	0	5
5	0	0	0	1	0	1	6
6	0	0	0	1	1	0	7
7	0	0	0	1	1	1	8
8	0	0	1	0	0	0	9
9	0	0	1	0	0	1	10
10	0	0	1	0	1	0	15
11	0	0	1	0	1	1	20
12	0	0	1	1	0	0	25
13	0	0	1	1	0	1	30
14	0	0	1	1	1	0	35
15	0	0	1	1	1	1	40
16	0	1	0	0	0	0	45
17	0	1	0	0	0	1	50
18	0	1	0	0	1	0	55
19	0	1	0	0	1	1	60
20	0	1	0	1	0	0	65
21	0	1	0	1	0	1	70
22	0	1	0	1	1	0	75
23	0	1	0	1	1	1	80
24	0	1	1	0	0	0	85
25	0	1	1	0	0	1	90
26	0	1	1	0	1	0	95
27	0	1	1	0	1	1	100
28	0	1	1	1	0	0	125
29	0	1	1	1	0	1	150
30	0	1	1	1	1	0	175
31	0	1	1	1	1	1	200
32	1	0	0	0	0	0	225
33	1	0	0	0	0	1	250
34	1	0	0	0	1	0	275
35	1	0	0	0	1	1	300
36	1	0	0	1	0	0	325
37	1	0	0	1	0	1	350
38	1	0	0	1	1	0	375

39	1	0	0	1	1	1	400
40	1	0	1	0	0	0	450
41	1	0	1	0	0	1	500
42	1	0	1	0	1	0	550
43	1	0	1	0	1	1	600
44	1	0	1	1	0	0	650
45	1	0	1	1	0	1	700
46	1	0	1	1	1	0	750
47	1	0	1	1	1	1	800
48	1	1	0	0	0	0	850
49	1	1	0	0	0	1	900
50	1	1	0	0	1	0	950
51	1	1	0	0	1	1	1000
52	1	1	0	1	0	0	1000
53	1	1	0	1	0	1	1000
54	1	1	0	1	1	0	1000
55	1	1	0	1	1	1	1000
56	1	1	1	0	0	0	1000
57	1	1	1	0	0	1	1000
58	1	1	1	0	1	0	1000
59	1	1	1	0	1	1	1000
60	1	1	1	1	0	0	1000
61	1	1	1	1	0	1	1000
62	1	1	1	1	1	0	1000
63	1	1	1	1	1	1	1000

NGR MONITOR	
MODBUS OUTPUT(DEC)	BIT 6
0	0
1	1

NGR TOLERANCE	
MODBUS OUTPUT(DEC)	BIT 7
0	0
1	1

9. TESTING & COMMISSIONING

9.1 HI-POT AND DIELECTRIC TESTING WARNING

If high-pot or dielectric withstand tests are conducted in the field, the SIGMA3-C monitor relay, NGRXS sensing resistor, and ZSCS must be prepared as described below to prevent damage.

1. **Disconnect and Insulate Control Circuits:** Ensure that all control circuits are disconnected and insulated.
2. **Disconnect and Insulate NGRXS Terminal R:** Disconnect the conductor from terminal R of the NGRXS sensing resistor from the SIGMA3-C monitor relay, and ensure that the conductor is insulated.
3. **Disconnect and Insulate NGRXS Terminal G:** Disconnect the conductor from terminal G of the NGRXS sensing resistor from the ground, and ensure that the conductor is insulated.
4. **Disconnect and Insulate ZSCS Terminals X1 and X2:** Disconnect the conductors between terminals X1 and X2 of the ZSCS and the SIGMA3-C monitor relay, and ensure that these conductors are insulated.
5. **Disconnect and Insulate Control Power Leads:** Disconnect the control power leads from the SIGMA3-C monitor relay, and ensure that these conductors are insulated.
6. **Short L, N, and G Terminals:** Connect short conductors between the L, N, and G terminals of the SIGMA3-C monitor relay, ensuring that the G terminal remains connected to the ground.
7. **Conduct Hi-Pot/Dielectric Tests:** Perform the necessary high-pot or dielectric withstand tests.
8. **Reconnect ZSCS Terminals X1 and X2:** Reconnect the conductors between terminals X1 and X2 of the ZSCS and the SIGMA3-C monitor relay.
9. **Reconnect NGRXS Terminal G to SIGMA3-C:** Reconnect the conductor between terminal G of the NGRXS sensing resistor and the appropriate terminal on the SIGMA3-C monitor relay (refer to Figure 3.1).
10. **Reconnect NGRXS Terminal G to Ground:** Reconnect the conductor from terminal G of the NGRXS sensing resistor to the ground.
11. **Remove Temporary Conductors:** Remove the conductors added between the L, N, and G terminals of the SIGMA3-C monitor relay, ensuring that the G terminal remains connected to the ground.
12. **Reconnect NGRXS Terminal R to SIGMA3-C:** Reconnect the conductor from terminal R of the NGRXS sensing resistor to the appropriate terminal of the SIGMA3-C monitor relay (refer to Figure 3.1).
13. **Reconnect Control Circuits:** Reconnect all control circuits that were disconnected in step 1.
14. **Reconnect Control Power:** Reconnect the control power to the L and N terminals of the SIGMA3-C monitor relay.

9.2 COMMISSIONING

The commissioning of the SIGMA3-C involves the following steps:

- **Review of Installation and Unit Condition:** Ensure that the unit is properly installed and in good condition.
- **Verification of Connections:** Confirm that all connections are secure and correct.
- **Verification of Settings:** Check that all settings are configured as required.
- **Energization of SIGMA3-C:** Power on the SIGMA3-C unit.
- **Functional Verifications:**

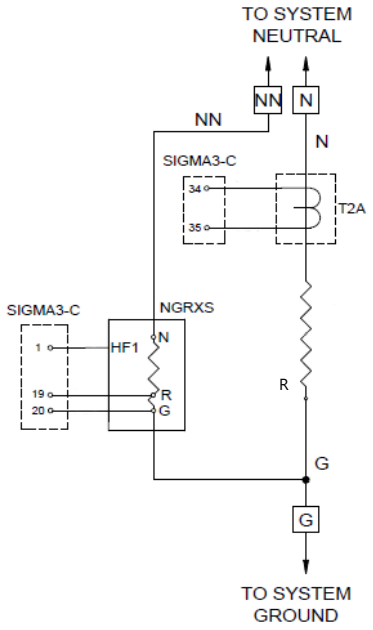
    1. Perform Test and Reset functions.
    2. Test the Pulsing feature.
    3. Verify communication with the SIGMA3-C-TDM.

- **Current Injection:** Perform primary or secondary current injection to verify the Ground Fault functionality.
- **NGR Short Circuit Test:** Conduct a test to check for short circuits in the Neutral Grounding Resistor (NGR) by shorting N and G in de-energized state.
- **NGR Open Circuit Test:** Conduct a test to check for open circuits in the NGR by removing the Neutral connection in de-energize state.
- **Energization of System:** Power on the entire system.
- **Online Calibration:** Perform online calibration if the system's zero-sequence impedance changes noticeably during operation.

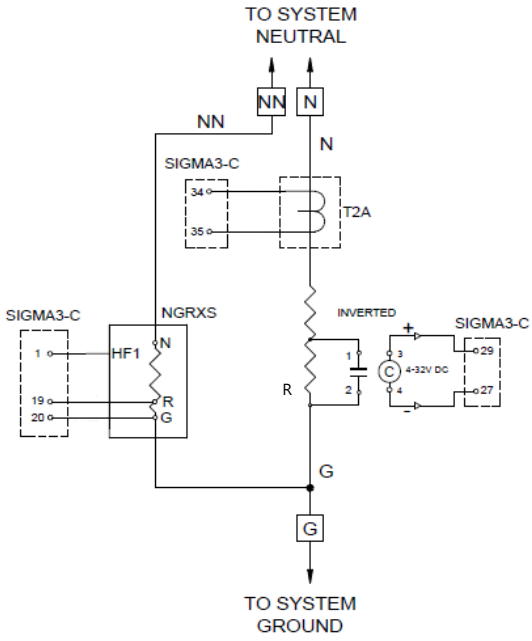
10. CONNECTION DIAGRAM

10.1 STAR CONNECTED

Without Pulsing



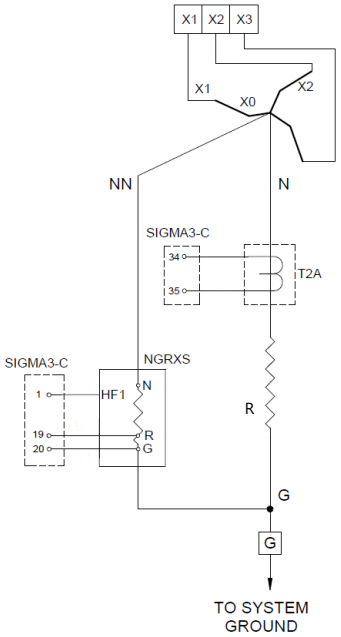
With Pulsing



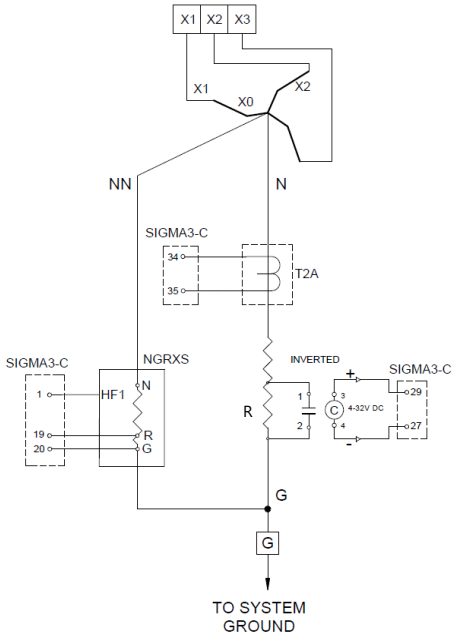
10.2 ARTIFICIAL NEUTRAL (DELTA CONNECTION)

If no star point is available, the following circuit can create an artificial neutral.

Without Pulsing



With Pulsing



11. TROUBLESHOOTING

Troubleshooting Guide		
Status	**Possible Cause**	**Solution**
LCD is blank	Control supply voltage is not connected.	Check if supply voltage is present on terminals 1 and 2. If voltage is present, an overvoltage may have caused the power supply to shut down. Cycle the supply voltage. If the POWER LED remains off, return the unit for repair.
Status LED on TDM is Flashing	Fault in the system	Check the LEDs on the home screen to identify the cause of the fault.
GND fault LED Solid Red	Ground fault detected.	Verify the fault and locate its source.
	Changing DIP Switch settings while power is ON	Manual reset the SIGMA3-C.
RPF LED Solid Red	NGR is open or shorted.	Check the conductance value on the Calibration screen. Low conductance indicates an open circuit, while high conductance indicates a short circuit.
	Voltage may be present across the NGR with no current.	Check the zero drift value on SIGMA3-C-TDM and ensure that it meets the following condition: Zero Drift < (Online Coupling Impedance * 255)
Communication error	Incorrect SIGMA3-C ID.	Verify that the SIGMA3-C ID matches the last digit of the SIGMA3-C serial number. If needed, un-check the Active box, select the correct SIGMA3-C ID, and recheck the Active box.
PWR LED ON SIGMA3-C is Flashing	Malfunction due to microprocessor issue.	Reset by cycling the Control Power

Table 11: Troubleshooting Guide

NOTES

GARD

Unparalleled Protection

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