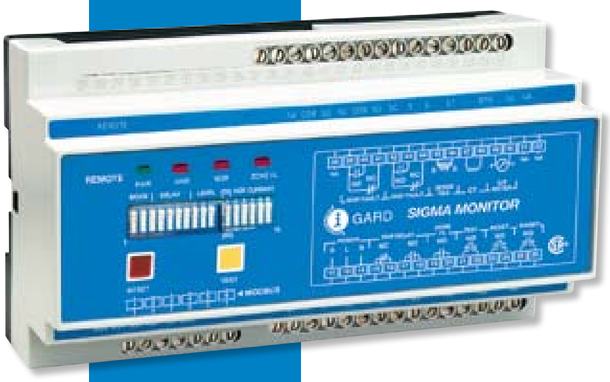
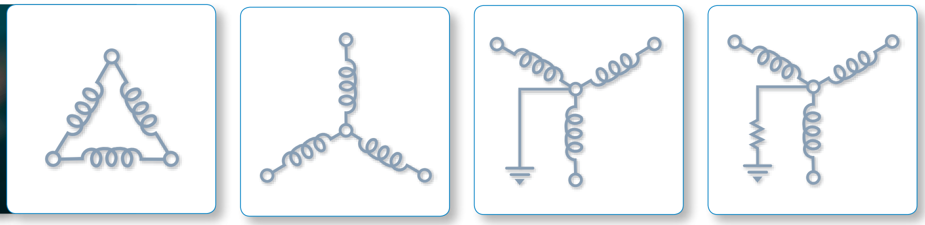
SIGMA MONITOR RELAY



GROUND FAULT RELAY / RESISTOR MONITOR



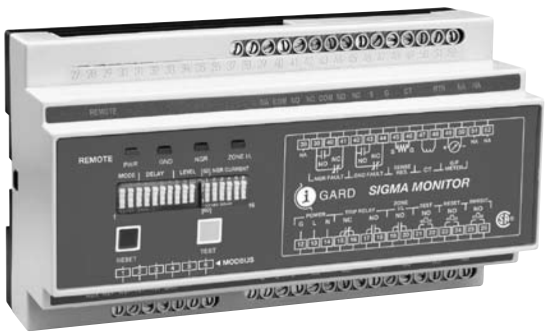
the power to protect

SIGMA

Instruction Manual C-453EM

IPC

SIGMA MONITOR RELAY



Neutral Grounding Resistors (NGR) are an integral and critical component in a grounding protection scheme and in many ways are similar to fuses in that they nothing until something in the system goes wrong. Then, like fuses, they protect personnel and equipment from damage. Damage comes from two factors, how long the fault lasts and how large the fault is. Ground fault relays trip breakers to limit how long a fault lasts. Neutral grounding resistors limit how large the fault is.

The Sigma relay not only monitors the Neutral Grounding Resistor to ensure its functionality and that it is available for use but is also a ground fault relay.

DANGER

Hazard of Electrical Shock, Burn or Explosion

All installation, servicing and testing referred to in this manual must be performed by qualified personnel.

All power should be disconnected prior to removing covers or enclosures and where live conductors may otherwise be exposed.

Failure to observe these precautions may result in death or severe personal injury.

IMPORTANT

Each SIGMA MONITOR RELAY and its auxiliary parts, are carefully inspected before being packed in specially designed cartons. Any unit received should be examined immediately upon receipt. If damage or indication of rough handling is apparent, a claim should be filed with the transport company immediately. I-Gard should be notified promptly if replacements for damaged goods are necessary. If units received are not installed immediately they should be stored in their original containers in an area free of dust and moisture. The Sigma Monitor Relay may not correctly monitor the resistance between the Neutral of a transformer and ground in a configuration where the resistor is coupled to the secondary of a step down transformer. The NGR continuity test applied by the Sigma Monitor Relay may be defeated by the low impedance of the transformer primary winding. In such applications please consult with I-Gard for more economical ways of obtaining ground fault protection.

TABLE OF FIGURES

TABLE OF CONTENTS

TABLES

1 INTRODUCTION

The I-Gard SIGMA MONITOR RELAY is a combination Neutral Grounding Resistor (NGR) monitor and Ground Fault relay. In distribution systems employing High Resistance Grounding the SIGMA MONITOR RELAY protects against ground faults and abnormal resistance values of the Neutral Grounding Resistor (NGR).

The SIGMA MONITOR RELAY is specifically designed for a variety of system voltages and a Neutral Grounding Resistor (NGR) limiting the maximum NGR current to the relay's set Let Through Current.

The SIGMA MONITOR RELAY is designed to operate with a T2A, T3A, TxA or any Rx-yA Zero Sequence Current Sensors, an NGRS-XX Sensing Resistor and a Neutral Grounding Resistor (NGR) sized to limit ground fault current to that stated in the installation's specifications.

The Let-through Current measured by the Zero Sequence Current Sensor will be the vector sum of any leakage currents or charging currents normally in the system and any ground fault currents that may be present.

2 DESCRIPTION

The SIGMA MONITOR RELAY measures the current through the NGR, the transformer neutral-to-ground voltage and the NGR resistance. The relay compares the measured values against the field settings of the relay and provides relay outputs and LED indications when an abnormal condition is detected.

NGR Current is measured using the Zero Sequence Current Sensor (ZSCS). The trip level of the ground fault circuit is DIP Switch selectable as a percentage of the NGR Let-Through Current setting at 5%, 10%, 15%, 20%, 25%, 30%, 40% and 50%. Trip time is DIP Switch selectable from 60 milliseconds to 3.15 seconds.

Transformer neutral-to-ground voltage is measured by means of the NGRS-XX Sensing Resistor (NGRS), connected between the NGR's connection to the transformer neutral and the relay's NGRS input terminal. The NGRS-XX Sensing Resistor is used by the SIGMA MONITOR RELAY as part of a comparator to monitor the NGR resistance. The NGRS-XX Sensing Resistor contains a voltage suppressor which limits its output voltage to a safe level.

When the NGR current measured by the ZSCS is above 1% of the NGR Let-Through Current setting, an NGR fault will be detected if the measured current and voltage indicates that the NGR resistance has increased to more than 150% or has decreased to less than 70% of its nominal value.

When the ZSCS current is below 1% of the NGR Let-Through Current setting, the SIGMA MONITOR RELAY simply monitors the NGR resistance for continuity, i.e. whether the NGR is open or presents some resistance.

The SIGMA MONITOR RELAY has three output relays:

- The Trip Relay can be programmed for shunt operation (not failsafe) or undervoltage operation (failsafe) in a main breaker trip circuit. The Trip Relay will energize on either an NGR Fault or a Ground Fault.
- The NGR Fault Auxiliary Trip Relay can be used to give a door/panel mounted or remote indication of an NGR Fault.
- The Ground Fault Auxiliary Trip Relay can be used to give a door/panel mounted or remote indication of a Ground Fault.

The SIGMA MONITOR RELAY provides a current source output for connection to a 1mA full scale ammeter (either analog or digital). The output signal is proportional to the measured current and is expressed as a percentage of the NGR Let-Through Current.

3 METHOD OF OPERATION

3.1 Components of the System

The Zero Sequence Current Sensor (ZSCS) is an I-Gard type T2A, T3A, TxA or any Rx-yA Zero Sequence Current Sensors.

The NGRS-XX Sensing Resistor is selected to match the line-to-line voltage of the system in which the SIGMA MONITOR RELAY will be used.

The NGR will be sized for a Let-through Current according to the specifications of the system in which it will be installed.

A DIP Switch array on the SIGMA MONITOR RELAY permits selection of Trip Relay Operational Mode, Trip Memory, Ground Fault Trip Time Delay, Ground Fault Trip Current Level and the NGR Let-Through Current.

3.2 NGR MONITORING

The SIGMA MONITOR RELAY is designed to be used with an I-GARD type “A” (TxA Rx-yA) Zero Sequence Current Sensor, an NGRS-XX Sensing Resistor and an NGR sized for a Let-Through Current according to the specifications of the system in which it will be installed.

DIP Switches on the SIGMA MONITOR RELAY are used to set the NGR Let-Through Current to one of thirty two settings as shown in TABLE 5.

Refer to TABLE 9.6 for DIP Switch settings for the NGR Let-Through Current.

The SIGMA MONITOR RELAY monitors the NGR using one of two methods, a Measurement mode of operation where the NGR resistance is measured using the leakage current through the NGR and a Continuity mode of operation where the continuity of the NGR is checked, which is used when the leakage current is too low for the measurement mode to accurately gauge the resistance of the NGR.

The Measurement mode of operation is used when the combination of current through the ZSCS and neutral-to-ground voltage indicates that the resistance of the NGR has increased to more than 150% of its nominal value or has decreased to less than 70% of is nominal value. If these limits are exceeded, the SIGMA MONITOR RELAY will indicate an NGR failure and trip within 3.5 seconds. A fast response is necessary as failure of the NGR implies that there is limited ground fault protection on the system. It also ensures fast tripping when a transformer is energized and the resistor is faulty.

By measuring the leakage values of current and voltage the SIGMA MONITOR RELAY recognizes when the resistance of the NGR cannot be measured accurately. If the NGR current is than 1% of the Let-Through Current the NGR integrity monitor detects whether the NGR resistance is present or the NGR has failed such that it presents an open circuit.

In the event that the NGR opens completely when the SIGMA MONITOR RELAY is in the Measurement mode described above, the appearance of the open circuit will cause the SIGMA MONITOR RELAY to switch from the Measurement mode to the Continuity mode described above. The Continuity mode will recognize that the NGR circuit is open and indicate an NGR failure within 3.5 to 10 seconds.

3.3 Ground Fault Detection

The SIGMA MONITOR RELAY measures Ground faults by measuring the current through the NGR. The relay compares the measured values against the field settings of the relay and provides relay outputs and LED indications when an abnormal condition is detected.

NGR Current is measured using the Zero Sequence Current Sensor (ZSCS). The trip level of the Ground fault circuit is DIP Switch selectable as a percentage of the set NGR Let-Through Current with Ground fault trip settings of: 5%, 10%, 15%, 20%, 25%, 30%, 40% and 50%.

The Ground Fault Trip Time setting defines the length of time a Ground fault must persist before a fault is qualified and reported by the relay by operating the Ground Fault output relay and the Main Trip relay. This setting can also be used to delay the indication by the SIGMA MONITOR RELAY of a Ground Fault. The Ground Fault Trip time is DIP Switch selectable from its minimum setting of 60 milliseconds to 3.15 seconds.

DIP Switches on the SIGMA MONITOR RELAY must be set for the required Ground Fault Time Delay and Ground Fault Trip Current Level.

Refer to TABLE 9.3 for DIP Switch settings for the GROUND FAULT TRIP TIME DELAY.

Refer to TABLE 9.4 for DIP Switch settings for GROUND FAULT CURRENT LEVEL.

4 INSTALLATION INSTRUCTIONS

CAUTION

The G terminal of the SIGMA MONITOR RELAY should be connected to Ground as described BEFORE connecting the R terminal of the NGRS-XX Sensing Resistor to the appropriate terminal on the SIGMA MONITOR RELAY. Similarly, when disconnecting the NGRS Sensing Resistor from the SIGMA MONITOR RELAY, the R terminal of the NGRS Sensing Resistor should be disconnected BEFORE the Ground connection is removed from the G terminal of the SIGMA MONITOR RELAY.

The procedure described above provides a discharge path for static electricity which could damage the SIGMA MONITOR RELAY.

4.1 The Sigma Monitor Relay

4.1.1 Location

The SIGMA MONITOR RELAY should be located as close as possible to the system's isolating device, circuit breaker or contactor.

4.1.2 Mounting

Mount the SIGMA MONITOR RELAY horizontally using 35 mm DIN rail bolted or firmly fixed to flat surface. Allow at least 20 mm of rail to extend beyond each end of the relay. Secure the relay to the DIN rail ensuring the release latches at the bottom of the relay engage the rail. If the relay is to be mounted in any other position take appropriate steps to prevent the relay from disengaging from the DIN rail.

4.1.3 Connections

Refer to Figure 1 for electrical connections to the SIGMA MONITOR RELAY. Terminals on the relay will accept up to #14 AWG wire.

Connect the G terminal on the SIGMA MONITOR RELAY to a suitable grounding point. Connect control power to terminals L and N. An isolation transformer is recommended as the source of supply to prevent excessive voltage being applied to the relay's internal power supply.

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

The SIGMA MONITOR RELAY must be grounded as described above. As the relay's housing is non metallic, no chassis bond is required.

Connect the Sensing Resistor input terminals on the SIGMA MONITOR RELAY to the R terminal of the NGRS-XX Sensing Resistor as shown in Figure 2.

Connect terminals 47 & 48 on the SIGMA MONITOR RELAY to the X1 and X2 terminals of the Zero Sequence Current Sensor as shown in Figure 2.

Refer to the description of the Trip Relay Operating Mode settings for an explanation of the Shunt (not failsafe) and Undervoltage (failsafe) Operating Modes and the relay contact states for each of these operating modes. The connection of field devices to the terminals of the SIGMA MONITOR RELAY must be as specified in the installation specifications. These include the Trip Relay terminals, the Auxiliary Fault Relay terminals, the external Reset, Test and the G/F Meter terminals.

If door/panel mounted or remote Test and/or Reset controls are required, connect momentary single pole single throw (SPST) normally open contact pushbuttons to the appropriate terminals on the SIGMA MONITOR RELAY. Refer to Figure 2. These contacts are to be voltage free.

If a panel/door mounted or remote ground fault meter is required, an I-Gard GM-AM1 type meter or a meter conforming to specifications given in this document can be connected to the appropriate terminals on the SIGMA MONITOR RELAY. Refer to Figure 2. The I-Gard percentage ammeter is designed for use in this application. If a meter other than the I-Gard GM-AM1 is used, observe the polarity shown on the front panel and in Figure 2.

4.2 Zero Sequence Current Sensor (ZSCS)

4.2.1 Location

The Zero Sequence Current Sensor (ZSCS) should be mounted near the system transformer neutral (whether a Transformer or a Generator) along with the NGRS-XX Sensing Resistor and NGR.

4.2.2 Mounting

The overall dimensions of the T2A ZSCS are 104 mm x 104 mm x 44 mm. If another size Zero Sequence Current Sensor is used please refer to Document C-700EM Sensors.

4.2.3 Connections

The neutral point of the system is to be connected to the ungrounded end of the Neutral Grounding Resistor (NGR) such that this conductor passes through the window of the Zero Sequence Current Sensor.

The secondary terminals, X1 and X2, must be connected to the appropriate terminals on the SIGMA MONITOR RELAY as shown in Figure 2.

4.3 NGRS-XX SENSING RESISTOR

The NGRS-XX Sensing Resistor must be selected from those available from I-Gard and must be one that is designed for use in a system with a system voltage in which it will be installed.

4.3.1 Location

The NGRS-XX Sensing Resistor should be mounted in near the system transformer, along with the ZSCS and the NGR.

4.3.2 Mounting

The overall dimensions of NGRS-1 to NGRS-7 (from 140 to 700 volts) Sensing Resistor are 89 mm x 65 mm x 71 mm. A metal mounting bracket extends from one side of the housing. The bracket has two 6 mm mounting holes in it through which bolts or self threading screws can be used to mount the 1 to NGRS-7 Sensing Resistor to a flat surface. Refer to Figure 4.

Dimensions for other NGRS-XX are available upon request or may be updated regularly at www.i-gard.com.

4.3.3 Connections

The Neutral terminal of the NGRS-XX Sensing Resistor must be connected to the ungrounded end of the NGR. This is the same connection point as it is connected to the system neutral. Refer to Figure 2.

The R terminal of the NGRS-XX Sensing Resistor must be connected to the appropriate terminal of the SIGMA MONITOR RELAY as shown in Figure 2. The G terminal of the NGRS-XX Sensing Resistor should be connected to a suitable ground point. This grounding point should be separate from the ground path from the NGR so that the ground path from the NGR is monitored as well as the NGR itself.

4.4 Configuration of Sigma Monitor Relay and NGR

The SIGMA MONITOR RELAY has settings for the Let-through Current (Neutral Grounding Resistor rated current), Ground Fault Trip Current Level and Ground Fault Time Delay. These settings may be specified in the installation requirements. However, the Let-through Current and Ground Fault Trip Current Level are, in part, dependent on conditions that can only be determined at the time of installation or if and when there are changes to the operating environment.

One of the operating conditions that impact on relay settings is the amount of leakage or charging current in the system. This may vary from one installation to another or, as noted above, when there are changes to the operating environment.

As the Let-through Current measured by the Current Transformer will be the vector sum of any leakage currents or charging currents normally in the system and any ground fault currents that may be present, it is important that the leakage currents or charging currents normally in the system be taken into consideration when setting the relay's ground fault trip points. Failure to take the leakage currents or charging currents into consideration may result in nuissance tripping due to the low Let-through Current settings.

The Ground Fault Trip Current Level is set as a percentage of the Let-through Current through the NGR. The Ground Fault Trip Current Level settings available are: 50%, 40%, 30%, 25%, 20%, 15%, 10% and 5%.

The SIGMA MONITOR RELAY has thirty two settings for the Let through Current setting ranging from 1 A to 400 A with a TxA or Rx-yA ZSCS. For higher rated currents a special 10,000:1 core balanced sensor is required.

Zone Grading is supported on the SIGMA MONITOR RELAY. If voltage free, normally open (NO) contacts connected to the ZONE I/L input terminals are closed, the relay's Ground Fault Trip Time Delay is extended by 750 mSec. This allows a downstream or another protective device to selectively clear the ground fault.

The SIGMA MONITOR RELAY has a Trip Inhibit input. If voltage free, normally open (NO) contacts connected to the INHIBIT input terminals are closed, the relay's Ground Fault Trip and NGR Fault Trip functions are inhibited.

WARNING

Operation of the Trip Inhibit circuit will prevent the SIGMA MONITOR RELAY from tripping on either an NGR Fault or a Ground Fault. Care must be taken to ensure that the Trip Inhibit circuit is operated only for a short time to prevent injury or damage to the system's transformer or circuits connected to the system's transformer secondary.

5 TRIP RELAY AND AUXILIARY FAULT RELAYS

The SIGMA MONITOR RELAY has three output relays:

- The Trip Relay can be programmed for shunt (not failsafe) or undervoltage (failsafe) operation. The Trip Relay will trip on either an NGR Fault or a Ground Fault.

- The NGR Fault Auxiliary Relay can be used to give local (door/panel) or remote indication of an NGR Fault.

- The Ground Fault Auxiliary Relay can be used to give local (door/panel) or remote indication of a Ground Fault.

All relays are electrically held, i.e. when power is off, the relays are always in the de-energized state. The de-energized state of the relay contacts is shown on the front panel of the SIGMA MONTOR RELAY. Note that this is irrespective of the Trip Relay Operating Mode.

All relays can be in one of two states, Idle or Tripped. Whether the Trip Relay is energized or de-energized when in one of these states depends on the Trip Relay Operating Mode.

When the Trip Relay Operating Mode of the SIGMA MONITOR RELAY is set for the Shunt (Non-Failsafe) Mode and no fault condition is present, the Trip Relay is Idle or de-energized. If a fault condition is detected and qualified, the Trip Relay is Tripped or energized.

When the Trip Relay Operating Mode of SIGMA MONITOR RELAY is set for the Undervoltage (Failsafe) Mode and no fault condition is present, the Trip Relay is normally Idle or energized. The Trip Relay is Tripped or de-energized if a fault condition is detected on the system. The Failsafe Mode of operation allows the SIGMA MONITOR RELAY to be configured such that the Trip Relay is de-energized and put into its Tripped state when control power is off.

Refer to TABLE 1, TRIP RELAY OPERATING MODE SETTING, for description of relay states when SIGMA MONITOR RELAY is Idle/Not-Tripped for the Failsafe and Non-Failsafe Operating Modes.

The Auxiliary Fault Relays operate exclusively in the Shunt (Non-Failsafe) Mode. When the SIGMA MONITOR RELAY is operating and no fault condition is present, the Auxiliary Fault Relays are Idle or de-energized. If a fault condition is detected and qualified, the appropriate Auxiliary Fault Relay is Tripped or energized.

The SIGMA MONITOR RELAY uses non-volatile memory to store the states of the Trip and Auxiliary Fault relays in case of a loss of control power.

If the Trip Memory option is ON and the SIGMA MONITOR RELAY is powered down while indicating a fault condition, the Trip, NGR and GND Auxiliary Fault relays are restored to the states these relays were in at the time of the power loss when control power is restored. If an NGR Fault was indicated at the time of the loss of control power, the NGR Fault Relay will be restored to a Tripped state when control power is restored. Similarly, if a GND Fault was indicated at the time of the loss of control power, the GND Fault Relay will be restored to a Tripped state when control power is restored. The Main Trip relay will be set to a Trip State if either of the NGR or GND Auxiliary Fault relays is restored to a Trip State.

If the Trip Memory option is ON and, when control power is restored, if the NGR or GND Fault relays are restored to a Trip State, the LED associated with the fault relay, i.e. NGR Fault or GND Fault LED is set to intermittently flash. The Trip Relay, Auxiliary Fault relays and associated LED and will remain in such condition indefinitely regardless of whether a fault is present on the system and until the conditions which caused the SIGMA relay to trip are cleared and the relay is manually reset.

When SIGMA MONITOR RELAY is manually reset, the states of the Trip Relay and Auxiliary Fault relays are set to their respective Idle states in the relay's operating memory and are then stored in the non-volatile memory.

6 LED INDICATORS AND DIAGNOSTICS

The SIGMA MONITOR RELAY has four Light Emitting Diodes (LEDs) located on its front panel. These LEDs are the Green PWR (Power) LED; the Red GND (Ground) FAULT and NGR FAULT LEDs; and the ZONE GR. (Zone Grading) LED.

6.1 Start-up and Reset Indications

The SIGMA MONITOR RELAY has a start-up sequence where the Red GND FAULT, NGR FAULT and ZONE GR. LEDS flash ON and OFF twice before being turned OFF. The Green PWR (Power) LED may also flash before it is turned ON. These indications will be the same whether the start up is a result of a manual reset or the application of control power.

During a manual reset the Red GND FAULT, NGR FAULT and ZONE GR. LEDs are turned ON for two seconds as an indication that a reset sequence is taking place. During this time the Green PWR (Power) LED will intermittently flash. After these indications the SIGMA MONITOR RELAY resets giving the start-up indications described above.

After The SIGMA MONITOR RELAY has gone through the start-up sequence and is operating normally the Green PWR (Power) LED will turn ON and the Red GND FAULT, NGR FAULT and ZONE GR. LEDS will turn OFF.

6.2 Power on LED (Green)

The Green PWR (Power) LED will turn ON when control power is applied to the SIGMA MONITOR RELAY and the relay is operating normally.

The Green PWR (Power) LED will intermittently flash if control power is applied to the SIGMA MONITOR RELAY but the relay is not operating correctly due to a malfunction in the microprocessor circuit. Control power must be turned off and then restored to reset the SIGMA MONITOR RELAY to clear this indication.

The Green PWR (Power) LED will intermittently flash during a manual reset or power on reset as described above.

6.3 GND Fault LED (Red)

The Red GND FAULT LED will turn OFF when the SIGMA MONITOR RELAY is operating normally and no Ground Fault has been detected and qualified.

The Red GND FAULT LED will turn ON when the SIGMA MONITOR RELAY has detected and qualified a Ground Fault. The RED GND FAULT LED will remain ON until the SIGMA MONITOR RELAY is manually reset even if the NGR fault condition has been corrected.

The Red GND FAULT LED will intermittently flash when the SIGMA MONITOR RELAY is powered up after having been powered down while indicating a Ground Fault. The SIGMA MONITOR RELAY must be manually reset to clear this condition.

The Red GND FAULT LED will turn ON during a manual reset as described above.

6.4 NGR Fault LED (Red)

The Red NGR FAULT LED will turn OFF when the SIGMA MONITOR RELAY is operating normally and no NGR Fault has been detected and qualified.

The Red NGR FAULT LED will turn ON when the SIGMA MONITOR RELAY has detected and qualified an NGR Fault. The RED NGR FAULT LED will remain ON until the SIGMA MONITOR RELAY is manually reset even if the NGR fault condition has been corrected.

The Red NGR FAULT LED will intermittently flash when the relay is powered up after having been powered down while indicating an NGR Fault. The SIGMA MONITOR RELAY must be manually reset to clear this condition.

The Red NGR FAULT LED will turn ON during a manual reset as described above.

6.5 Zone Gr. LED (Red)

The Red ZONE GR. LED will turn OFF when the SIGMA MONITOR RELAY is operating normally.

The Red ZONE GR. LED will turn ON when the ZONE I/L input circuit is active, i.e. Normally Open (NO) contacts connected to these inputs are closed.

The Red ZONE GR. LED will intermittently flash when the relay's Self-Test circuit is enabled through the operation of the TEST pushbutton on the front panel.

The Red ZONE GR. LED will turn ON while the installer is adjusting the operational settings on the SIGMA MONITOR RELAY by way of the DIP Switches. When the relay detects that the installer has stopped making adjustments to these settings the Red ZONE GR. LED will turn OFF.

The Red ZONE GR. LED will turn ON during a manual reset as described above.

7 SELF-TEST

The SIGMA MONITOR RELAY has a built-in Self-Test feature.

⚠ WARNING ⚠

Operation of the Self Test circuit will cause the NGR Fault and the Trip Relays to signal a fault and trip the circuit breaker or contactor disconnecting the circuits connected to the system's transformer secondary.

The Self-Test feature in the SIGMA MONITOR RELAY requires that all equipment i.e. the SIGMA MONITOR RELAY, the NGRS-XX Sensing Resistor, the ZSCS and the NGR be connected as described in this manual.

The ideal test condition is with control power applied to the SIGMA MONITOR RELAY and no voltage applied to system transformer's primary winding. Alternatively, the system transformer's primary winding may be powered with the system transformer secondary isolated from the load.

The Self-Test feature is activated pressing the TEST pushbutton on the front panel of the SIGMA MONITOR RELAY. When Self-Test feature is activated the Red ZONE GR. LED will intermittently flash, at the same time a voltage is internally applied at the NGRS Sensing Resistor input. This creates an out-of-range condition on the NGRS input causing the SIGMA MONITOR RELAY to detect an NGR Fault and Trip. This verifies that the NGR monitoring circuitry within the SIGMA MONITOR RELAY and related microprocessor software is functioning correctly.

The SIGMA MONITOR RELAY must be manually reset or control power must be turned off and then restored to reset the relay once the Self-Test feature is enabled.

The Test and Reset functions can be operated by means of the TEST and RESET pushbuttons mounted on the front panel and/or externally connected remote switches.

No additional test equipment is required.

8 RELAY SETTINGS

All settings on the SIGMA MONITOR RELAY are defined by means of a DIP Switch array located on the front panel of the relay.

Refer to:

- TABLE 9.1 for Trip Relay Operating Mode.
- TABLE 9.2 for Trip Memory ON/OFF.
- TABLE 9.3 for Ground Fault Trip Time Delay.
- TABLE 9.4 for Ground Fault Trip Current Level.
- TABLE 9.5 System Frequency Selection
- TABLE 9.6 for Neutral Grounding Resistor Let-Through Current.

In these tables, DIP Switch settings are either Up or Down designated U and D respectively.

8.1 TRIP RELAY OPERATING MODES

The SIGMA MONITOR RELAY can be set for a Shunt Trip Operating Mode (Not Failsafe) or an Undervoltage Trip Operating Mode (Failsafe) operation with the Trip Relay Operating Mode Dip Switch.

Refer to TABLE 9.1 TRIP RELAY OPERATING MODE SETTING.

The Trip Relay is electrically held, i.e. when control power is off, the relay is de-energized. Note that this is irrespective of the Trip Relay Operating Mode setting.

8.1.1 SHUNT TRIP MODE (NOT FAILSAFE)

In the Shunt Trip Mode (Not Failsafe), the Trip Relay remains de-energized (no trip) when control voltage is applied to the SIGMA MONITOR RELAY and the system is operating normally. The Trip Relay is energized (trip) when the measured values of the Ground Fault current or NGR Resistance exceed the threshold settings for the time specified.

The Trip Relay will energize (trip) after a fault is qualified and will remain energized (tripped) until the SIGMA MONITOR RELAY is reset whether or not the fault that caused the trip remains present on the system. The Trip Relay will be de-energized (no-trip) if the control voltage is removed.

When control voltage is applied the Trip Relay will at first be de-energized (no-trip) and the SIGMA MONITOR RELAY will start operating normally. If the Trip Memory option is OFF the Trip Relay will remain de-energized (no-trip). However, if the Trip Memory option is ON and a Trip state is stored in the non-volatile memory, the Trip Relay will energize (trip) approximately 1 second after control voltage is applied and will remain energized (tripped), regardless of whether a fault is present on the system.

The Trip Relay will de-energize (no-trip) if the SIGMA MONITOR RELAY is reset through a local or remote reset. When reset, the SIGMA MONITOR RELAY will resume monitoring of the system and, if a fault remains on the system, will detect the fault and will re-trip, energizing the Trip Relay.

8.1.2 UNDERVOLTAGE TRIP (FAILSAFE) MODE

When programmed for the UNDERVOLTAGE TRIP MODE and the SIGMA MONITOR RELAY is operating normally, the Trip Relay energizes approximately 1 second after control voltage is applied. The Trip Relay de-energizes (trips) under any of the following conditions:

- The measured values of the Ground Fault current or NGR Resistance exceed the threshold settings for the time specified.
- The SIGMA MONITOR RELAY is reset.
- Control voltage is removed.

The Trip Relay remains energized after a trip, providing control voltage is present, until the SIGMA MONITOR RELAY is reset whether or not the fault that caused the trip remains present on the system.

When control voltage is applied the Trip Relay will at first be energized (no-trip) and the SIGMA MONITOR RELAY will start operating normally. If the Trip Memory option is OFF the Trip Relay will remain energized (no-trip). However, if the Trip Memory option is ON and a Trip State is stored in the non-volatile memory, the Trip relay will de-energize (trip) approximately 1 second after control voltage is applied to the relay and will remain de-energized (tripped), regardless of whether a fault is present on the system.

The Trip Relay will energize (no-trip) if the SIGMA MONITOR RELAY is reset through a local or remote reset. When reset, the SIGMA MONITOR RELAY will resume monitoring of the system and, if a fault remains on the system, will detect the fault and will re-trip, de-energizing the Trip Relay.

8.2 TRIP MEMORY SETTING

The SIGMA MONITOR RELAY stores the states of the Trip Relay and Auxiliary Fault Relays in non-volatile memory and can, if programmed to do so by means of the TRIP MEMORY Setting, restore the state of the Trip Relay when control power is applied.

The SIGMA MONITOR RELAY can be set for Trip Memory ON (DIP switch #2 UP) or Trip Memory OFF (DIP switch #2 DOWN).

Refer to TABLE 9.2 TRIP MEMORY SETTING.

When the Trip Memory option is OFF the Trip Relay and Auxiliary Fault Relays are returned to their Idle operating states when control power is applied.

When the Trip Memory is ON the Trip Relay and Auxiliary Fault Relays are restored to the state these relays had prior to the loss of control power. If the SIGMA MONITOR RELAY was indicating a fault condition when control power was lost, the states of the Trip Relay and Auxiliary Fault Relays will be maintained until the relay is manually reset.

The SIGMA MONITOR RELAY retains the states of the Trip Relay and Auxiliary Fault Relays stored in non-volatile memory indefinitely.

8.3 GROUND FAULT TRIP TIME DELAY

The SIGMA MONITOR RELAY can be programmed for Ground Fault Trip Delays ranging from 60 milliseconds to 3.15 seconds.

Refer to TABLE 9.3 GROUND FAULT TRIP TIME DELAY SETTINGS to determine the DIP Switch settings for the application.

8.4 GROUND FAULT TRIP CURRENT LEVEL

The SIGMA MONITOR RELAY 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%.

I-Gard recommends that the Ground Fault Trip Level setting be set as low as possible to provide maximum operating personnel and equipment protection without having the SIGMA MONITOR RELAY report Ground Faults falsely.

Refer to TABLE 9.4 GROUND FAULT TRIP CURRENT LEVEL SETTINGS to determine the DIP Switch settings for the application.

Caution: CAN/CSA-M421-00 Use of Electricity in Mines Paragraph 3.5.5 states, in part, that “Where ground-fault protection is used, the supply shall be … de-energized in less than 1s if ground-fault current exceeds 20% of the prospective ground-fault current”. Therefore, I-Gard recommends that the Ground Fault Trip Level be set as low as possible **and** not higher than 20% when complying with this CSA Mine Safety Standard.

8.5 NGR SET LET-THROUGH CURRENT

The SIGMA MONITOR RELAY has thirty two settings for the NGR Let-Through Current.
Refer to TABLE 9.6 for DIP Switch settings for the NGR Let-Through Current.

The NGR Let Through Current Settings in Table 9.6 show that the Sigma Monitor Relay can be configured for Let Through Currents ranging from 5 Amperes through 400 Amperes using a standard I-GARD TxA zero sequence current sensor.

The NGR Let Through Current Settings in Table 9.6 are intended to show that the Sigma Monitor Relay can be configured for Let Through Currents ranging from 1 Ampere through 4 Amperes using a standard I-GARD TxA zscs with the conductor carrying the NGR current wrapped through the CT’s primary window 10 times to create a primary winding of 10 turns.

The Sigma Monitor Relay can be configured for Let Through Currents over 400 Amperes using an I-Gard zscs sized for the intended application.

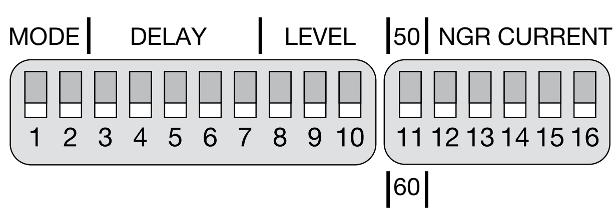
Contact the factory if settings other than those are required in the intended application.

9 SIGMA MONITOR RELAY CONFIGURATION SWITCHES

9.1 SYSTEM FREQUENCY

The SIGMA MONITOR RELAY has two settings for selecting the AC frequency of the system it monitoring for ground faults. Refer to TABLE 9.5 for DIP Switch settings for the AC frequency setting.

Sigma Monitor Relay Configuration Switches



Tables for DIP Switch Array

TABLE 9.1	Operating Mode Settings	DIP switch 1
TABLE 9.2	Trip Memory Selection	DIP switch 2
TABLE 9.3	Ground Fault Trip Time Delay Settings	DIP switches 3,4,5,6,7
TABLE 9.4	Ground Fault Trip Current Level Settings	DIP switches 8,9,10
TABLE 9.5	System Frequency Selection	DIP switch 11
TABLE 9.6	NGR Let-through Current Settings	DIP switches 12,13,14,15,16

TABLE 9.1 TRIP RELAY OPERATING MODE SETTING
DIP SWITCH #1 (LEFT HAND ARRAY) U = UP, D = DOWN

MODE	DIP SWITCH SETTING
FAILSAFE (UNDERVOLTAGE TRIP)	UP
SIGMA Relay is Idle/Not-Tripped:	
Trip Relay is energized	
Aux Fault Relays are not energized	
SIGMA Relay is Tripped:	
Trip Relay is de-energized	
Aux Fault Relays are energized	
NON-FAILSAFE (SHUNT TRIP)	DOWN
SIGMA Relay is Idle/Not-Tripped:	
Trip Relay is not energized	
Aux Fault Relays are not energized	
SIGMA Relay is Tripped:	
Trip Relay is energized	
Aux Fault Relays are energized	

TABLE 9.2 TRIP MEMORY SELECTION
DIP SWITCH #2 (LEFT HAND ARRAY) U = UP, D = DOWN

TRIP MEMORY ON/OFF	DIP SWITCH SETTING
TRIP MEMORY ON	UP
Control voltage off after trip:	
When Control voltage restored	
Trip and Aux relays Idle* then immediately re-trip (within 2 seconds).	
TRIP MEMORY OFF	DOWN
Control voltage off after trip:	
When Control voltage restored	
Trip and Aux relays Idle* but do not immediately re-trip	
Trip and Aux relays will re-trip if a fault is detected after monitoring starts.	

* ***Idle state:*** *See Table 1, Trip Relay Operating Mode Setting for description of relay states when the SIGMA Relay is Idle/Not-Tripped for Failsafe and Non-Failsafe Operating Modes.*

TABLE 9.3 GROUND FAULT TRIP TIME DELAY SETTINGS

DIP SWITCHES #3 - #4 - #5 - #6 - #7 (LEFT HAND ARRAY) U = UP, D = DOWN

G/F TRIP TIME DELAY (in milliseconds)	DIP SWITCH SETTINGS 3	4	5	6	7
60	D	D	D	D	D
150	D	D	D	D	U
250	D	D	D	U	D
350	D	D	D	U	U
450	D	D	U	D	D
550	D	D	U	D	U
650	D	D	U	U	D
750	D	D	U	U	U
850	D	U	D	D	D
950	D	U	D	D	U
1050	D	U	D	U	D
1150	D	U	D	U	U
1250	D	U	U	D	D
1350	D	U	U	D	U
1450	D	U	U	U	D
1550	D	U	U	U	U
1650	U	D	D	D	D
1750	U	D	D	D	U
1850	U	D	D	U	D
1950	U	D	D	U	U
2050	U	D	U	D	D
2150	U	D	U	D	U
2250	U	D	U	U	D
2350	U	D	U	U	U
2450	U	U	D	D	D
2550	U	U	D	D	U
2650	U	U	D	U	D
2750	U	U	D	U	U
2850	U	U	U	D	D
2950	U	U	U	D	U
3050	U	U	U	U	D
3150	U	U	U	U	U

TABLE 9.4 GROUND FAULT TRIP CURRENT LEVEL SETTINGS
DIP SWITCHES #8 - #9 - #10 (LEFT HAND ARRAY) U = UP, D = DOWN

G/F TRIP LEVEL (% of NGR Let-Through Current)	DIP SWITCH SETTINGS 8	9	10
5 %	D	D	D
10 %	D	D	U
15 %	D	U	D
20 %	D	U	U
25 %	U	D	D
30 %	U	D	U
40 %	U	U	D
50 %	U	U	U

TABLE 9.5 SYSTEM FREQUENCY SELECTION
DIP SWITCH #11 (RIGHT HAND ARRAY) U = UP, D = DOWN

SYSTEM FREQUENCY 60/50 Hz	DIP SWITCH SETTING
SYSTEM FREQUENCY 50 Hz	UP
SYSTEM FREQUENCY 60 Hz	DOWN

TABLE 9.6 NGR LET-THROUGH CURRENT SETTINGS
DIP SWITCHES #12 - #13 - #14 - #15 - #16 (RIGHT HAND ARRAY) U = UP, D = DOWN

NGR Let-Through Current (Amperes)	DIPSWITCH SETTINGS 12	13	14	15	16	USE ZSCS
1	D	D	D	D	U	TxA or Rx-yA w/10TurnsThrough Primary
2	D	D	D	U	U	TxA or Rx-yA w/10TurnsThrough Primary
3	D	D	U	D	U	TxA or Rx-yA w/10TurnsThrough Primary
4	D	D	U	U	U	TxA or Rx-yA w/10TurnsThrough Primary
5	D	D	D	D	D	TxA or Rx-yA
10	D	D	D	D	U	TxA or Rx-yA
15	D	D	D	U	D	TxA or Rx-yA
20	D	D	D	U	U	TxA or Rx-yA
25	D	D	U	D	D	TxA or Rx-yA
30	D	D	U	D	U	TxA or Rx-yA
35	D	D	U	U	D	TxA or Rx-yA
40	D	D	U	U	U	TxA or Rx-yA
45	D	U	D	D	D	TxA or Rx-yA
50	D	U	D	D	U	TxA or Rx-yA
55	D	U	D	U	D	TxA or Rx-yA
60	D	U	D	U	U	TxA or Rx-yA
65	D	U	U	D	D	TxA or Rx-yA
70	D	U	U	D	U	TxA or Rx-yA
75	D	U	U	U	D	TxA or Rx-yA
80	D	U	U	U	U	TxA or Rx-yA
90	U	D	D	D	U	TxA or Rx-yA

TABLE 9.6 - NGR LET-THROUGH CURRENT SETTINGS (CONTINUED)
DIP SWITCHES #12 - #13 - #14 - #15 - #16 (RIGHT HAND ARRAY) U = UP, D = DOWN

NGR LET-THROUGH CURRENT (Amperes)	DIPSWITCH SETTINGS					USE ZSCS
	12	13	14	15	16	
95	U	D	D	U	D	TxA or Rx-yA
100	U	D	D	U	U	TxA or Rx-yA
125	U	D	U	D	D	TxA or Rx-yA
150	U	D	U	D	U	TxA or Rx-yA
175	U	D	U	U	D	TxA or Rx-yA
200	U	D	U	U	U	TxA or Rx-yA
225	U	U	D	D	D	TxA or Rx-yA
250	U	U	D	D	U	TxA or Rx-yA
275	U	U	D	U	D	TxA or Rx-yA
300	U	U	D	U	U	TxA or Rx-yA
325	U	U	U	D	D	TxA or Rx-yA
350	U	U	U	D	U	TxA or Rx-yA
375	U	U	U	U	D	TxA or Rx-yA
400	U	U	U	U	U	TxA or Rx-yA
500	D	U	D	D	U	10,000:1
600	D	U	D	U	U	10,000:1
800	D	U	U	U	U	10,000:1
1000	U	D	D	U	U	10,000:1
1250	U	D	U	D	D	10,000:1
1500	U	D	U	D	U	10,000:1
2000	U	D	U	U	U	10,000:1
2250	U	U	D	D	D	10,000:1
2500	U	U	D	D	U	10,000:1

10 MODBUS COMMUNICATIONS

The SIGMA relay has 4-wire RS-485 communications port to allow communications to a remote terminal or network, a 4-wire RS-485 communications port is provided at the bottom left of the SIGMA Relay. The 6-slot terminal block supplied has screw terminals. Terminal # 1 must not be used. Only terminals 2, 3, 4, 5 and 6 are to be used as shown in Figure 2.

The protocol supported is MODBUS RTU. The Modbus I/D number for the SIGMA Relay is not programmable and is set at 2. The baud rate is not programmable and is set to 9600 BPS. The frame set-up is 8 bit, No Parity and 1 Stop Bit.

The communications cable should ideally be standard 4-wire with two twisted-pairs, and a grounding shield to prevent electro magnetic interference. The shield of the cable between nodes should not be continuously grounded but should be grounded at one end. The cable may be grounded at the Sigma Relay using the ground connection provided on terminal # 6.

10.1 SIGMA MODBUS Functions

One Modbus function is supported, Read Holding Register (03). The Sigma Relay provides access to 32 Modbus registers available. This document summarizes the format and function of these registers. The request from the master is always 8 bytes long and are as shown in the Table below.

In the Modbus RTU system the SIGMA Relay operates in a Client/Server communications model or Master/Slave communications model. In the Client/Server communications model the Sigma Relay is the Modbus server and will respond to requests sent to it by a Modbus client. In the Master/Slave communications model the SIGMA Relay is the Modbus slave and will respond to requests sent to it by a Modbus master.

The Modbus requests sent to the Modbus master or client are 8 bytes long as shown in Table 1 below.

TABLE 10.1 MODBUS RTU STANDARD 8 BYTE HOLDING REGISTER READ FUNCTION (03)

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

The data format of the modbus registers is nnnnH for four hexadecimal digits, ddddB for four binary digits and ddddddddB for eight binary digits. Numbers above are, for example, a request for 2 registers only, starting from address 02. CRC checksum is 16 bit CRC as described in MODBUS information.

If successful the SIGMA will return the message shown in Table 2.

TABLE 10.2 RETURNED INFORMATION STRUCTURE FOR HOLDING REGISTER REQUEST

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

Register contents are shown in Tables 1 to 3 as follows.

NOTE: *Register number is shown in decimal but must be sent in hexadecimal form in the request.*

The Modbus Register number is translated in the request such that Register Number 40001 is sent as hexadecimal address 0000H, Register Number 40002 is sent as hexadecimal address 0001H, Register Number 40003 is sent as hexadecimal address 0002H and so on.

The Modbus registers can be read using the starting address in a block and the number of registers required up to the number of registers available in a given block.

There are times when the SIGMA Relay processor will not be able to respond to a request since it is busy with other tasks and no response will be returned. For this reason it is recommended to request the maximum number of registers used by the system in a single request.

TABLE 10.3 SIGMA RELAY REGISTER DEFINITIONS

Register #	Contents	Format	Register #	Contents	Format
40001	2 ASCII characters	nnnnH	40021		nnnnH
40002		nnnnH	40022		nnnnH
40003		nnnnH	40023		nnnnH
40004		nnnnH	40024		nnnnH
40005		nnnnH			
40006		nnnnH			
40007		nnnnH			
40008		nnnnH			
40009		nnnnH			
40010		nnnnH			
40011		nnnnH			
40012		nnnnH	40030	Relay Status	nnnnH
40013		nnnnH	40031	NGR Status	nnnnH
40014		nnnnH			
40015		nnnnH	40040	internal measurement of the GF current as measured by the CT	nnnnH
40016		nnnnH	40041	reserved (always 0000h)	nnnnH
40017		nnnnH	40042	internal measurement of the NGR+NGRS resistance	nnnnH
40018		nnnnH	40043	internal measurement of the NGR+NGRS resistance	nnnnH
40019		nnnnH	40044	The measurement of the Let Through Current expressed as a percentage, 0-100 decimal, of the set Let Through Current.	nnnnH
40020		nnnnH	40045	The measurement of the Let Through Current expressed as a percentage, scaled to 0-1ffH of the set Let Through Current.	nnnnH

Registers 040040 to 040045

	CTavg	Nresv	NGR1	NGR2	Pct1	Pct2
40040:	0000H	0000H	0000H	0000H	0000H	0000H

40040:	CTavg	0 to 0ffH	internal measurement of the GF current as measured by the CT
40041:	resv		reserved (always 0000h)
40042:	NGR1	0 to 0ffH	internal measurement of the NGR+NGRS resistance
40043:	NGR2	0 to 0ffH	internal measurement of the NGR+NGRS resistance
40044:	Pct1	0 to 064H	The measurement of the Let Through Current expressed as a percentage, 0-100 decimal, of the set Let Through Current
40045:	Pct2	0 to 1ffH	The measurement of the Let Through Current expressed as a percentage, scaled to 0-1ffH of the set Let Through Current

TABLE 10.4 RELAY STATUS REGISTERS

Register 40030

The status of the Sigma Relay's output relay are bit mapped register 40030. The Main Trip relay is mapped to Bit 0 which is 1 when the relay is tripped otherwise this bit is 0. The GND Fault relay is mapped to Bit 1 which is 1 when the relay is operated otherwise this bit is 0. The NGR Fault relay is mapped to Bit 2 which is 1 when the relay is operated otherwise this bit is 0.

40030: 0000H or xxxx-xxxx-xxxx-0bbbB	
X - don't care	
b - bit mapped relay status:	0 = all relays off 3 = main & gnd fault relays ON 5 = main & ngr fault relays ON 6 = main gnd fault & ngr fault relays ON

Register 40031

The status of each of the Sigma Relay's three Red LEDs is mapped to individual hexadecimal digits in Modbus register 400031 as shown below.

40031: 0000H
0zng

hex. digit 0: g - gnd fault led status: 0 = OFF, 1 = ON, 2 = FLASHING
hex. digit 1: n - ngr fault led status: 0 = OFF, 1 = ON, 2 = FLASHING
hex. digit 2: z - zone led status: 0 = OFF, 1 = ON, 2 = FLASHING
hex. digit 3: always zero

TABLE 10.5 MODBUS REGISTER FORMAT CONVENTIONS

nnnnH	four decadecimal digits	where n can be 0-9 or A - F
ddddB	four binary digits	where d can be 0 or 1
ddddddddB	eight binary digits	where d can be 0 or 1

11 TECHNICAL SPECIFICATIONS

Electrical Ratings

Control Power:	110-240V AC/DC	50/60 Hz
	5VA ac or 5W dc	
	Maximum:	-45% to +10% (60-264V AC/DC)

Output Relay Contacts

Main Trip Relay

Type: Form Z (NO and NC pair)

Rating: 10A @ 240V ac,
10A @ 30V dc,
1/2HP @ 240V ac

Auxiliary Ground Fault Relay

Type: 1 Form C (NO/NC)

Rating: 10A @ 240V ac,
8A @ 24V dc,
1/2HP @ 240V ac

Auxiliary NGR Fault Relay:

Type: 1 Form C (NO/NC)

Rating: 10A @ 240V ac,
8A @ 24V dc,
1/2HP @ 240V ac

All relays are electrically held and are de-energized when control power is OFF.

Failsafe: When the Failsafe option is ON the Trip Relay is normally energized when control power is ON and is de-energized in a Trip state. When the Failsafe option is OFF the Trip Relay is normally de-energized when control power is ON and is energized in a Trip state.

Memory: When the Memory option is ON and control power is restored after a loss of control power, the Trip Relay and Auxiliary Fault Relays are returned to the state these relays had prior to the loss of control power. The state of the Trip Relay and Auxiliary Fault Relays are maintained in memory until the relay is manually reset. When the Memory option is OFF and control power is restored after a loss of control power, the Trip Relay and Auxiliary Fault Relays are returned to their normal operating state when control power is applied.

Electrical Tests

Surge test:	@ 3kV
Dielectric test:	@ 2kV for 1 minute

Temperature Range

Operating:	-40˚C to +60˚C
Storage:	-50˚C to +70˚C

Physical

Dimensions	Length:	157 mm (6.18 in.)
	Width:	86 mm (3.39 in.)
	Height:	58 mm (2.28 in)
	Weight:	344 g

Ground Fault Circuit

CT Input: Non-Isolated. One side of the ZSCS input, terminal 22, is internally grounded. T2A, T3 A or any TxA or Rx-yA ZSCS for NGR rated up to 400 Amperes of let through current. For NGR rated 500 Amperes and above a special core balanced ZSCS 10,000:1 is required.

DIP Switch Settings:

Trip Level:	8 settings: 5%, 10%, 15%, 20%, 25%, 30%, 40%, and 50% of the set NGR current setting		
Trip Time:	32 settings, 0-60 msec., 150 msec. to 3.15 sec. in 100 msec. steps		
Accuracy:	Repeat:	±1%	
	Trip Time:	±10%, ±10 msec.	
	Trip Current:	±10%	
	Meter Output:	±2% at full scale	
Thermal Characteristics:		Short Time Withstand	400 A for 1 sec.

NGR Fault Circuit

NGR Let-Through Current:	DIP switch settings from 1 A to 400 A with any I-Gard Tx-A (T2-A, T3-A ...) or Rx-yA (R4-17A...) type ZSCS or 500 A to 2500 with an I-Gard core balanced ZSCS rated 10000:1. (See Table 9.6)
NGR Trip Resistance: (when the NGR current is high enough to allow measurement of the NGR)	An increase to more than 150% or a decrease to less than 70% of the NGR nominal resistance.

NGR Trip Resistance: (when the NGR current is too low to allow measurement of the NGR)	Simple continuity, i.e. Determines whether the NGR circuit is open or presents some resistance.
Trip Time:	Less than 60 seconds per CAN/CSA-M421-00. Typically 3.5 seconds -0 +100 msec. Up to 10 seconds under certain conditions.
Accuracy:	NGR Trip Resistance limits in Ohms ±20%

NGRS-XX Sensing Resistor (Various versions are available)

Voltage:	various system voltages
Resistance:	as determined by the system voltage
Dimensions:	Typical for electrical systems below 700 Volts: 89 mm (3.5 in.) x 65 mm (2.56 in.) x 71 mm (2.85 in.)

Analog Meter GM-AM1

Movement:	0-1 mA
Scale:	0-100%
Impedance:	200 Ohms Max.
Size:	65 mm (2.56 in.)

The meter display is proportional to the measured current expressed as percentage of the set NGR Let-Through Current.

Note: *A digital meter may be connected to instead of the I-GARD GM-AM1, however it may required a separate power supply.*

Applicable Standards

CSA	CSA C22.2 No. 0 CSA C22.2 No. 14 Industrial Equipment CSA C22.2 No. 144 Ground Fault Interrupters CSA Polymeric Enclosures CSA-M421-00 Use Of Electricity In Mines

I-Gard Corporation reserves the right to change specifications of its products without notice.

12 CATALOGUE NUMBERS

Sigma Monitor Relay	Ground Fault Relay & Neutral Grounding Resistor Monitor (Special Order)
GM-AM1	Analog Meter, 3 ½ in. 0-1 mA with Scale 0-100%
NGRS-XX Sensing Resistor	Sensing Resistor
TxA ZSCS:	T2A, T3A, T6A or T9A zero sequence current sensors.
Rx-yA ZSCS:	R4-17A, R7-13A or R8-26A zero sequence current sensors.

APPENDIX A: HIGH-POT AND DIELECTRIC TESTING OF THE SYSTEM

As the SIGMA MONITOR RELAY, NGRS-XX Sensing Resistor and ZSCS have undergone and passed High-Pot testing at the factory, field testing of the relay is unnecessary and may damage these components. For any High-Pot tests or Dielectric Withstand tests on the system conducted in the field, the SIGMA MONITOR RELAY, NGRS-XX Sensing Resistor and ZSCS must be prepared as described below to avoid damaging this equipment.

1) Ensure all control circuits are disconnected and insulated.
2) Disconnect the conductor on terminal R of the NGRS-XX Sensing Resistor from the SIGMA MONITOR RELAY and ensure the conductor is insulated.
3) Disconnect the conductor on terminal G of the NGRS-XX Sensing Resistor from Ground and ensure the conductor is insulated.
4) Disconnect the conductors between the X1 and X2 terminals of the ZSCS and the SIGMA MONITOR RELAY and ensure these conductors are insulated.
5) Disconnect the control power leads from the SIGMA MONITOR RELAY and ensure these conductors are insulated.
6) Connect short conductors between the L, N and G terminals of the SIGMA MONITOR RELAY ensuring that the G terminal remains connected to Ground.
7) Perform the High-Pot or Dielectric Withstand tests required.
8) Reconnect the conductors between the X1 and X2 terminals of the CT and the SIGMA MONITOR RELAY.
9) Reconnect the conductor between terminal G of the NGRS-XX Sensing Resistor and the appropriate terminal on the SIGMA MONITOR RELAY. Refer to Figure 2.
10) Reconnect the conductor from the G terminal on the NGRS-XX Sensing Resistor to Ground.
11) Remove the conductors added between the L, N and G terminals of the SIGMA MONITOR RELAY ensuring that the G terminal remains connected to Ground.
12) Reconnect the conductor from the R terminal of the NGRS-XX Sensing Resistor to the appropriate terminal of the SIGMA MONITOR RELAY. Refer to Figure 2.
13) Reconnect all control circuits which were disconnected in step 1.
14) Reconnect the control power to the L and N terminals of the SIGMA MONITOR RELAY.

APPENDIX B: CAN/CSA M421-00 USE OF ELECTRICITY IN MINES (EXCERPTS)

3.5.5 Ground-Fault Protection

Where ground-fault protection is used, the supply shall be

a) grounded through a neutral-grounding device that limits ground-fault voltage to 100V or less; and
b) de-energized in less than 1 s if ground-fault current exceeds 20% of the prospective ground-fault current.

3.6.2 Neutral-Grounding Devices

A neutral-grounding device shall be

a) continuously rated, except when ground-fault tripping is provided;

b) monitored so as to de-energize the supply in less than 60 s if the neutral-grounding device opens; and

c) connected as close as practical to the supply neutral.

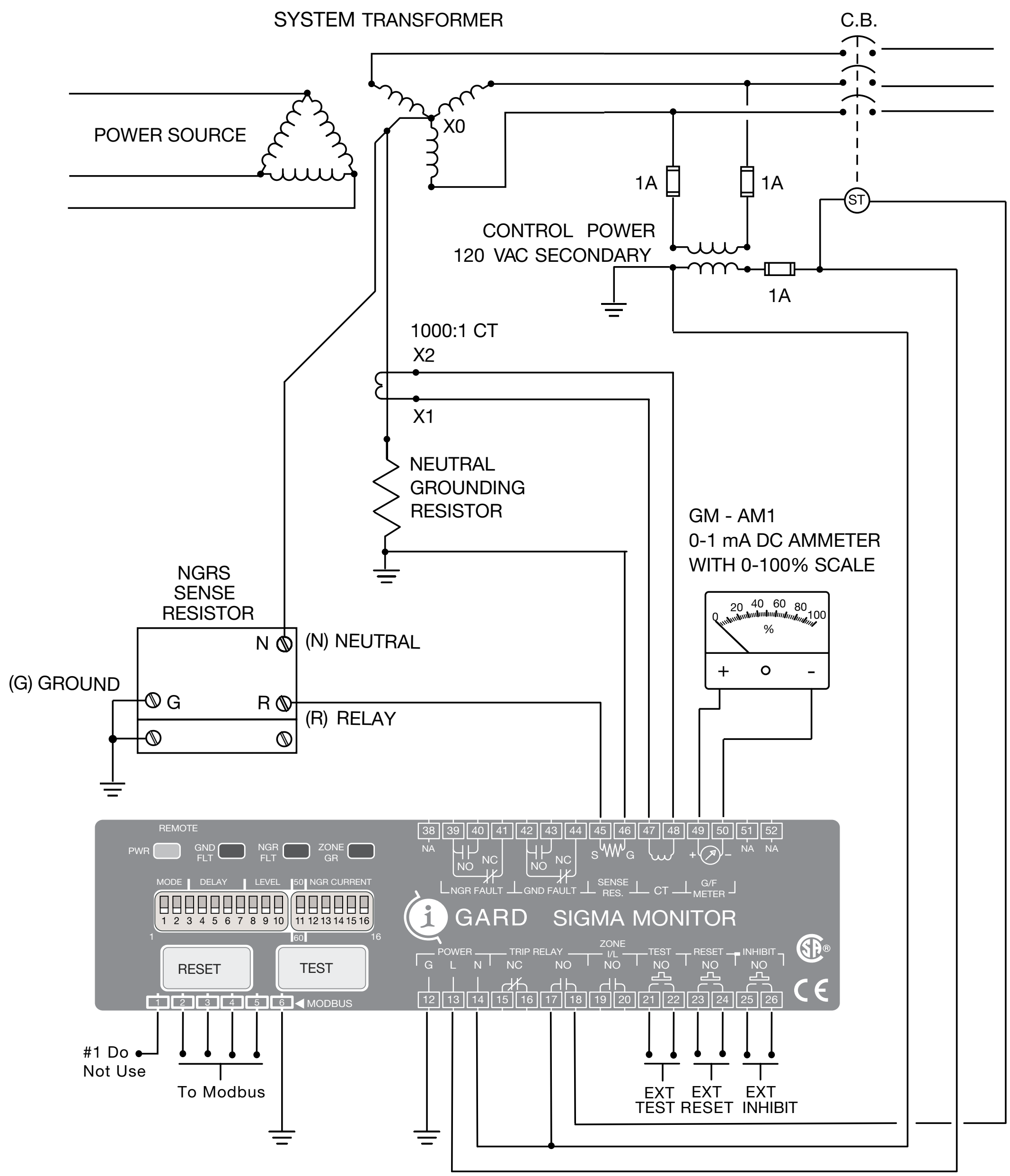


Figure 1 Sigma Monitor Relay Typical Installation Detail

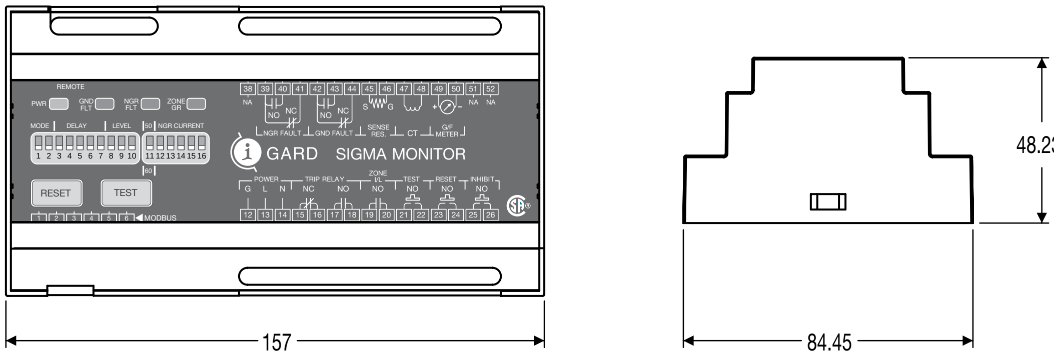


Figure 2 Sigma Monitor Relay Detail

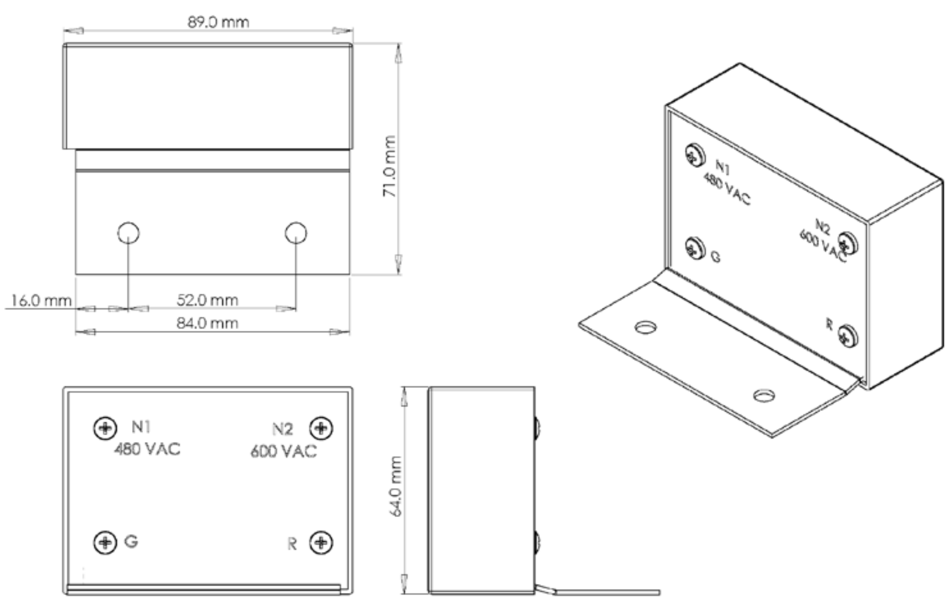


Figure 3 NGRS-Sensing Resistor

A Typical NGRS-Sensing Resistor. NGRS-6 (dual voltage) model shown.

INSTRUCTION MANUALS

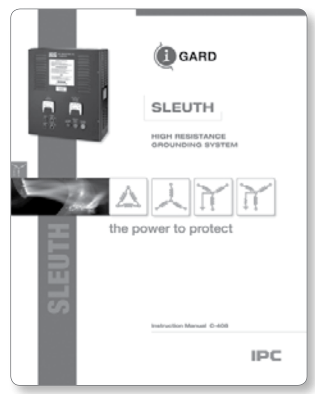
C-101 StopLight
High Resistance Grounding
System Manual

C-102 Gemini
High Resistance Grounding
System Manual

C-105 Fusion
Ground Fault Protection
System Manual

C-322 MGFR
Ground Fault Relay Manual

C-407 GCHK-100 Mining Relay
Ground Fault Protection
System Manual



C-408 Sleuth
High Resistance
Grounding System Manual

C-409 DSP Ohmni
High Resistance
Grounding System Manual

C-403 GFR-RM Sigma
Resistor Monitoring
and Ground Fault Relay

C-107 Sentinel
High Resistance
Grounding System

the power to protect

GARD

7615 Kimbel St., Unit 1
Mississauga, Ontario
Canada L5S 1A8

Phone 905-673-1553
Toll Free 1-800-737-4787
Fax 905-673-8472
e-mail: sales@i-gard.com
www.i-gard.com