LIM Line Insulation Monitor reference manual

Ground Fault Systems bv

Ground Fault Systems B.V.
Rigtersbleek-Aalten 4B15
7521 RB Enschede
The Netherlands

www.groundfaultsystems.com
info@groundfaultsystems.com
Tel: +31 53 4318628
CofC: 55400914

1. GENERAL DESCRIPTION

Ungrounded systems are commonly called 'floating' or 'IT' electrical systems. 'IT' stands for Isolated Terra. The secondary of a three-phase delta connected transformer is typical of this type of system.

It is generally accepted that on installations using ungrounded electrical supply systems, protection against electrical shock cannot normally be provided by the use of conventional ground fault relays (GFRs) or residual current detectors (RCDs). Leakage currents to ground require a return path. Therefore, when no such path exists, a standard GFR or RCD would be unable to detect a fault when it occurs.

The solution to this problem is the LIM, Line Insulation Monitor. The LIM sequentially monitors each phase of the single- or three-phase ungrounded AC power system, 380 to 600 V on systems with a frequency of 50 – 60 or 400 Hz. If an insulation fault develops anywhere on the system between the source and the load, a small current will flow through the high impedance of the unit. This current is analysed by the LIM and it will alarm or trip depending on the selected settings.
The detection circuitry is based on impedance measurement of the monitored system.

The LIM is NOT designed to discriminate between different circuits fed from the same source of supply. Therefore, it is ideal for monitoring a system supplied by its own isolation transformer with either an ungrounded delta or an ungrounded wye connected secondary.

Because the LIM has high immunity from the effects of voltage transients and cable capacitance, it may be applied in automotive, sub-sea, mobile lighting, portable generators, sensitive equipment and other installations where ungrounded systems are used extensively.

The LIM houses an isolated universal power supply from 24 - 240 V AC or DC and is equipped with two form 'Z' (4 connections) isolated NO and NC contact sets. The System Phase Configuration (3 phased or single phased), the Leakage Current Limit (20, 35 or 50 mA RMS), the Alarm and Trip relay Operating Mode (Failsafe, Non-Failsafe RRPL, Non-Failsafe Latched) and the Reset mode (manual or automatic) are set on two front accessible dipswitch arrays.

Two single turn potentiometers permit the alarm level and the trip level to be individually set from 20% - 80% of the selected maximum leakage current limit of the LIM. Any leakage current above the alarm level will activate the alarm relay and light the yellow 'ALARM' LED. Should the leakage current rise above the trip level, the trip relay and red 'TRIP' LED will activate. The fault current is measured every 70 ms. Once a fault is detected, the sampling is discontinued and the sample rate will go to approximately 2 seconds. One of three yellow LEDs (L1, L2, L3) will light to indicate the faulted phase.

To ensure that the LIM will function in all circumstances, it is encapsulated in polyurethane (PUR) to make sure it is not vulnerable to mechanical shock, vibration nor weather.

2. FUNCTIONALITY

FOR MAXIMUM SAFETY THE SETTINGS DESCRIBED IN THIS SECTION SHOULD BE MADE WITH CONTROL VOLTAGE AND SYSTEM VOLTAGE REMOVED FROM THE LIM.

2.1 Potentiometers

There are two single turn potentiometers extending through the front cover of the LIM, labelled 'ALARM CURRENT %' and 'TRIP CURRENT %'. These are adjustable from 20% to 80% of the selected Leakage Current Limit. See section 2.3 for setting procedure.

2.2 Dipswitch settings

The dipswitches are accessible through the front cover. It is recommended that all of the dipswitch settings are set at one time.

Refer to the picture on the front page of this reference manual. There is one 4–pole and one 6–pole set of dipswitches on the front of the LIM. The factory setting of all dipswitches is up (U).

2.2.1 4-pole dipswitch settings

These four dipswitches are assigned to phase selection and leakage current limit settings.

Refer to table 1 for all settings.

2.2.1.1 System Phase configuration - dipswitch 1

The LIM can be used for a single-phase system or a three-phase system.

- Single-phase System: This is a two wire AC ungrounded power distribution system.
- Three-phase System: This is a three wire AC ungrounded power distribution system.

The factory setting is to a single-phase ungrounded system, where dipswitch 1 is up. To change the LIM unit to a three-phase ungrounded system, set dipswitch 1 down.

2.2.1.2 Dipswitch 2

Not used.

2.2.1.3 Leakage Current Limit - dipswitches 3 & 4

The LIM will limit the fault currents to a preselected maximum value.
There are three current limits to select, 20, 35 and 50 mA.
See table 1 for the settings.
Note that both D – U and U – D will give 35 mA current limit.

2.2.2 6-pole dipswitch settings

2.2.2.1 Operating modes

The six dipswitches are assigned to alarm relay and trip relay operating mode settings.
For both alarm and trip there are three operating modes. Alarm and trip operating modes can be set independently. Refer to table 2 for all settings.
All modes have in common:

- In the 'reset state' of the relay the NO[1] contact is open and the NC[1] contact is closed.
- In the 'tripped state' of the relay the NO contact is closed and the NC contact is open.

The possible operating modes are:

1. Failsafe
   When Control Voltage is removed the relay goes to the tripped state unconditionally, and when Control Voltage is restored, it goes to its pre-power down state, after its power-up time. After an alarm or trip the relay remains in the tripped state and after the return of the Control Voltage the red 'TRIP' LED remains active and the relay stays tripped until a reset button is pressed (manual reset) or the cause of trip has been removed (automatic reset).
   The yellow 'ALARM' LED and alarm relay always auto-resets if the cause of the alarm is below set alarm level.
2. Non-Failsafe Relay Released at Power Loss (RRPL)
   When Control Voltage is removed (and subsequently restored) the relay remains in the pre-power down state.
   After an alarm or trip the unit resets the tripped state with loss of Control Voltage.
   When the trip relay is operating a shunt trip circuit breaker that is supplying the Control Voltage to the LIM, this mode is also referred to as 'One Shot Trip'.
3. Non-Failsafe Relay Latched
   When Control Voltage is removed (and subsequently restored) the relay remains in the pre-power down state.
   After an alarm or trip the relay remains in the tripped state and after the return of the Control Voltage the red 'TRIP' LED remains active and the relay stays tripped until a reset button is pressed (manual reset) or the cause of trip has been removed (automatic reset).
   The yellow 'ALARM' LED and alarm relay always auto-resets if the cause of the alarm is below set alarm level.

2.2.2.2 Alarm relay operating mode - dipswitches 1 & 2

The LIM user can select one of the three alarm operating modes with these dipswitches.
The factory setting is Non-Failsafe Latched.
See table 2.

2.2.2.3 Dipswitch 3

Not used.

2.2.2.4 Trip relay operating mode - dipswitches 4 & 5

The LIM user can select one of the three trip operating modes with these dipswitches.
The factory setting is Non-Failsafe Latched.
See table 2.

[1] (NO = Normally Open, NC = Normally Closed)

2.2.2.5 Relay reset mode - Dipswitch 6

The LIM has two reset options for a trip, manual and automatic.
With the manual mode selected the reset button must be pressed to reset the unit to its normal state. A manual reset will only be granted if the cause of the trip is cleared. Otherwise the unit will remain activated without glitches.
With the automatic reset mode selected the relay will automatically reset to its normal state after the condition that caused the relay to change state has been cleared.

The alarm relay will automatically reset if the leakage current drops below the alarm level.

2.3 Setting procedure

Before setting the potentiometers, establish the following information about the system being monitored:

- The desired insulation fault threshold current in mA at which to alarm.
- The desired insulation fault threshold current in mA at which to trip.
  Note: the trip threshold current is to be greater than the alarm threshold current.
  Note: the levels can not be set below 20% or above 80%.

Multiply the desired trip threshold current by 1,25 and then select the appropriate dipswitch settings on the 4-pole dipswitch array. See Table 1.
Use the following formula to derive the potentiometer settings from the selected Leakage Current Limit and the desired threshold currents:

Potentiometer setting [%] = threshold current [mA] / leakage current limit [mA] x 100

Example 1

- Single-phase system (e.g. 480 V)
- Desired alarm threshold current 10 mA
- Desired trip threshold current 25 mA

Set System Phase configuration to Single-phase Ungrounded System. See table 1.

Multiply Leakage Current Limit by a factor of 1,25 — 25(mA) x 1,25 = 31,25 mA
Set Leakage Current Limit dipswitches to 35 mA. See table 1

Alarm potentiometer setting: — 10(mA) / 35 x 100 = 30% (rounded)
Trip potentiometer setting: — 25(mA) / 35 x 100 = 70% (rounded)

Example 2

- Three-phase system (e.g. 480 V)
- Desired alarm threshold current 20 mA
- Desired trip threshold current 40 mA

Set System Phase configuration to Three-phase Ungrounded System. See table 1.

Multiply Leakage Current Limit by a factor of 1,25 — 40(mA) x 1,25 = 50 mA
Set Leakage Current Limit dipswitches to 50 mA. See table 1.

Alarm potentiometer setting: — 20(mA) / 35 x 100 = 40% (rounded)
Trip potentiometer setting: — 40(mA) / 35 x 100 = 80% (rounded)

Example 3

- Three-phase system (e.g. 480 V)
- Desired alarm threshold current 5 mA
- Desired trip threshold current 20 mA

Set System Phase configuration to Three-phase Ungrounded System. See table 1.

Multiply Leakage Current Limit by a factor of 1,25 — 20(mA) x 1,25 = 25 mA
Set Leakage Current Limit dipswitches to 35 mA. See table 1.

Alarm potentiometer setting: — 5(mA) / 35 x 100 = 15% (rounded)
Trip potentiometer setting: — 20(mA) / 35 x 100 = 60% (rounded)

The alarm potentiometer cannot be set lower than 20%, so in this case there is no option to choose for 5 mA (15%), the lowest option is 7 mA (20%).

Back to Potentiometers.

2.4 LED indicators

The unit has six LEDs.

- A green 'RUN' LED flashes, alternating one second on and off, to indicate that sufficient Control Voltage is applied to terminals L+ and N- (Power OK).
- A yellow 'ALARM' LED will turn solid on, if the values reach or exceed the preset alarm level.
- A red 'TRIP' LED will turn solid on, if the values reach or exceed the preset trip level.
- For the affected phase the corresponding yellow LED (L1, L2 or L3) will turn on solidly. These LEDs will reset if the measured value drops below the alarm/trip level or, in manual reset mode, a reset is granted.

2.5 Reset pushbutton

The cover mounted pushbutton must be used to reset the trip relay, if manual reset is selected.
A reset will only be granted if the cause of the trip is cleared. Otherwise the unit will remain activated without glitches.

2.6 Functionality test

It is possible to perform a functionality test of the system. Contact info@groundfaultsystems.com for more information.

2.7 Frame Bonding/Chassis Ground

For optimum EMC performance and safety, the FB (Frame Bond/Ground) terminal must be firmly connected to the local frame or chassis ground. The chassis ground must not be more than 50 mm away from the unit.

The ground terminal FB is to be securely connected to the equipment ground in the control panel. This provides the return path for fault current when a line insulation fault occurs.

If the LIM is mounted on a 35 mm DIN rail, a 'DIN rail ground terminal block' can be installed beside the unit to act as the chassis ground point. Use a 2 - 2,5 mm^2 (14 AWG) stranded conductor.

3. CONTROL VOLTAGE

The LIM has a universal, isolated power supply, accepting nominal voltages between 24 and 240 V AC/DC with -20/+10% tolerances. The total range of accepted voltages is therefore 19,2 to 264 V AC/DC. Power consumption is a mere 4 VA maximum with AC voltages.

See 2.7 for Frame Bonding/ Chassis Ground.

Control Voltage is subsequently presented to the L+ and N- terminals. For good EMC behaviour it is important (as in any installation) to run all wiring close along the chassis or in metal ducts, avoiding excess lengths and coiled up wires.

4. CONNECTIONS AND PRECAUTIONS

WARNING: HAZARDOUS VOLTAGES CAN BE PRESENT ON ALL CIRCUITS WITH THE CONTROL VOLTAGE AND/OR THE SYSTEM VOLTAGE APPLIED.

Please consult the following checklist when applying the LIM.

1. Please review Figure 1 for typical field connections.
2. Place the LIM in a clean dry enclosure. Locate the unit in the vicinity of the isolating device (circuit breaker or contactor) that is protecting the circuit being monitored.
3. All connections to the LIM, except the line voltages, are by means of screw clamp pull-apart terminals rated 10 A, 300 V. Terminals will accept 0,14 - 4,0 mm_2, (26 - 12 AWG) solid or stranded conductors. The user may want to identify the following terminals:
   - L+ for connecting AC Control Voltage's 'hot' side.
   - N- for connecting AC Control Voltage's 'cold' side.
   - 13 and 14 for connecting the normally open (NO) contact of the trip relay.
   - 11 and 12 for connecting the normally closed (NC) contact of the trip relay.
   - 23 and 24 for connecting the normally open (NO) contact of the alarm relay.
   - 21 and 22 for connecting the normally closed (NC) contact of the alarm relay.
4. The connections for the line voltages are via a 4-pole ring-type terminal block, rated 600 V. Terminals will accept 0,34 - 4 mm^2 or 22 - 12 AWG solid or stranded conductors. The user may want to identify the following terminals:
   - FB for providing an absolute ground reference to the system (refer to section frame bonding/ chassis ground), use 2 - 2,5 mm2, 14 AWG stranded wire.
   - L1, L2 and L3 for connecting the power line phases.
5. See National Electrical Code for minimum required wire gauges.
6. In order to meet the Electromagnetic Compatibility (EMC) requirements a firm and short connection is required between terminal FB and the chassis ground point. The chassis ground must not be more than 50 mm away from the unit.
7. If the LIM is mounted on a 35 mm DIN rail, a 'DIN rail ground terminal block' can be installed beside the unit to act as the chassis ground point.
8. For good EMC behaviour it is important (as in any installation) to run all wiring, especially if unshielded, close along the chassis or in metal ducts, avoiding excess lengths and coiled up wires.
9. Integrate the relay contacts into the control circuit. Apply appropriate fusing to protect the contacts (13 A maximum).
10. Secure the unit to the DIN rail ensuring the white release latch at the bottom of the unit engages the rail. If the unit is to be mounted in any other position take appropriate steps to prevent the unit from becoming disengaged from the DIN rail.

5. CATALOGUE NUMBERS

LIM2	Line Insulation Monitor, 24 – 240 V AC or DC Control Voltage, for use on 380 - 600 V, 50 – 60 or 400 Hz power systems.

6. TECHNICAL SPECIFICATIONS

6.1 Ground fault circuit

Leakage Current Limit	20 – 35 – 50 mA RMS
Accuracy of Trip & Alarm settings	5% of Leakage Current Limit
Trip Current Range potentiometer setting	20% - 80% of Leakage Current Limit
Alarm Current Range potentiometer setting	20% - 80% of Leakage Current Limit

6.2 Control Voltage

Voltage range	24 - 240 V AC/DC, -20/+10%
Frequency range on AC voltages	45 – 450 Hz
Power consumption	4 VA @ AC
Isolation voltage	400V RMS, 50–60 Hz 1 min, 2,5 kV impulse
Power-up time	500 ms

6.3 System power

Voltage	380 – 600 V Single- or three-phase ungrounded delta or wye
Frequency range	50 - 60 Hz or 400 Hz

6.4 Field Terminals

6.4.1 Pull-apart Connector

Type	Pull-apart
c-UL-us rating	300 V AC, 10 A
VDE rating	250 V AC, 12 A, pollution degree 3, over-voltage category III
Insulation stripping length	7 mm
Tightening Torque	0,4 – 0,6 Nm
Field wiring *See National Electrical Code for minimum required wire gauges.*	0,14 – 4,0 mm^2 (VDE) 26 - 12 AWG (UL), Cu or Al, solid or stranded

6.4.2 Line Power Connector

Type	Ring-type Line Power Connector
UL/CSA rating	600 V AC
Insulation stripping length	7 mm
Tightening Torque	9 in. lb.
Field wiring *See National Electrical Code for minimum required wire gauges.*	0,34 – 4 mm^2 22 - 12 AWG (UL), Cu, solid or stranded with ring-type crimp
Breakdown Voltage	3 kV

6.5 Relay contacts for alarm and trip relay

Configuration	Voltage free, 1 NO and 1 NC contact, 4 terminals (each)
c-UL-us rating	5 A @ 250 V AC, general use 5 A @ 30 V DC, resistive 1/6 hp, 250 V AC 2 A, 250 VA, @ 125 V AC, pilot duty 1 A, 250 VA, @ 250 V AC, pilot duty 0,88 A, 26,4 VA, @ 30 V DC, pilot duty B300: 30 A, 3600 VA make, 3 A 360 VA break @ 120 V AC 15 A, 3600 VA make, 1,5 A 360 VA break @ 240 V AC
EN 60947 rating	5 A @ 250 V AC utilization category AC-12 4 A @ 250 V AC utilization category AC-13 3 A @ 250 V AC utilization category AC-14 3 A @ 250 V AC utilization category AC-15 5 A @ 30 V DC utilization category DC-12 3 A @ 24 V DC utilization category DC-13 Maximum fuse rating 13 A (EN 60947-5-1)
Isolation voltage between contacts and coil	3 kV RMS, 50 – 60 Hz, 1 minute
Breakdown voltage between open contacts	1 kV RMS, 50 - 60 Hz, 1 minute
Between contact sets	2 kV RMS, 50 - 60 Hz, 1 minute

6.6 Mechanical properties (installed)

See figure 4.

Height	70 mm
Width	150 mm
Depth	114 mm
DIN rail if DIN rail mounted	35 mm
Screws if screw mounted	M5 x 20 (2 needed)

Weight (open)	1,14 kg
Weight (packaged)	1,41 kg

6.7 Environment

Operating temperature	-35°C to 66°C
Storage temperature	-40 °C to +80 °C
Humidity	85% max (no condensation)
Ingress protection	IP20
Mechanical shock resistance (no malfunction)	10 G
Vibration resistance (no malfunction)	10 G, 10 – 55 Hz at 1,5 mm double amplitude

The LIM is encapsulated in polyurethane (PUR) to keep the exposure to mechanical shock and vibration to a minimum.

7. APPLICABLE STANDARDS

EN 61000-6-3	Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential (=lowest levels). 30- 230 MHz 30 dBμV at 10 m distance 230-1000 MHz 37 dBμV at 10 m distance
EN 61000-6-4	Electromagnetic compatibility (EMC) Part 6-4: Generic standards - Emission standard for industrial environments.
EN 61000-6-8	Electromagnetic compatibility (EMC) – Part 6-8: Generic standards – Emission standard for professional equipment in commercial and light-industrial locations.
EN 61000-6-2	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments (=highest levels) 80-1000 MHz with 80% AM modulation up to 10 V/m at 3 m distance from source.
EN 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test.
EN 61000-4-3	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test.
EN 61000-4-4	Electromagnetic compatibility (EMC) Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test.
EN 61000-4-5	Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques - Surge immunity test.
EN 61000-4-6	Electromagnetic compatibility (EMC) Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields.
EN 61000-4-11	Electromagnetic compatibility (EMC) Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase.
EN 60947-5-1	Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices.
IEC 60755	General requirements for residual current operated protective devices
CE	CE mark – Declaration of Conformity

8. TABLES AND FIGURES

8.1 Dipswitch settings

8.1.1 Table 1 - 4-pole array

'D' denotes right and 'U' denotes left.

Switch no.	Parameter	Set to	Meaning
1	System Phase configuration	D U ♦	Three-phase Ungrounded System Single-phase Ungrounded System
2	Not used	U ♦	
3 4	Leakage Current Limit (100%)	D D D U U D U U ♦	50 mA 35 mA 35 mA 20 mA
♦ Factory settings			

Back to dipswitch settings. Back to Setting Procedure.

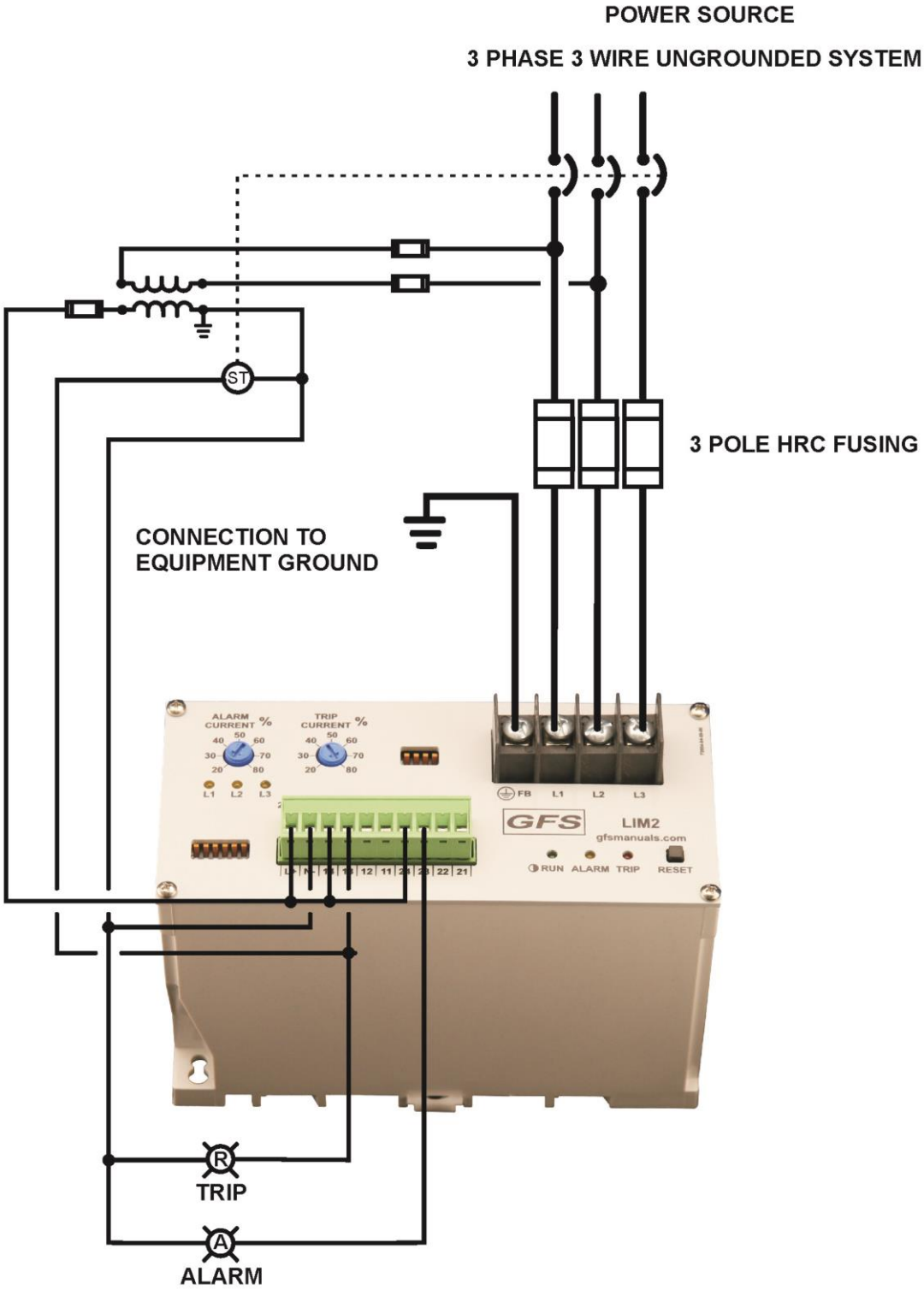
8.1.2 Table 2 - 6-pole array

'R' denotes right and 'L' denotes left.

Switch no.	Parameter	Set to	Meaning
1 2	Alarm relay Operating Mode	D D D U U D U U ♦	Do not use this setting Failsafe operation Non-Failsafe operation RRPL* Non-Failsafe operation Latched
3	Not used	U ♦	
4 5	Trip relay Operating Mode	D D D U U D U U ♦	Do not use this setting Failsafe operation Non-Failsafe operation RRPL* Non-Failsafe operation Latched
6	Trip relay Reset Mode	D U ♦	Manual reset Automatic reset
♦ Factory settings			*RRPL = Relay Release at Power Loss

Back to 6-pole dipswitch settings.

8.2 Figure 1 Typical Field Connection



8.3 Figure 2 – Dimensions LIM