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OPERATING MANUAL FOR

4 CHANNEL

EARTH LEAKAGE DETECTOR

RDSO/SPN/256/2002

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INTRODUCTION

The Earth Leakage Detector monitors the insulation resistance of a non-earthed single or three phase AC & DC networks. It can monitor four different AC or DC supplies. Insulation faults are also detected in a network with loads fed via rectifiers or thyristors.

Customer has to specify voltage (AC/DC) of the supply to be monitored.

This ELD has been designed for preventive maintenance of system insulation by monitoring its 'On-line' condition. It monitors and reads the insulation of all the cables and loads connected with power supply AC or DC (bus bar) in the form
Of leakage resistance. It measures 'On line insulation' (Leakage Resistance) directly on LCD meter.
It can also measure actual value of the insulation resistance of the signaling circuit during un-energised (OFF Line) condition through a built-in Cable Insulation Tester.

Design

Construction: The detector has vermin proof sheet metal case with detachable covers. It is suitable for mounting in 19 inch rack and Siemens type 21 inch racks.

The individual detecting circuit is plug in type.
Basic unit comprises of two instruments in 19 inch sub rack:

- 4-Channel ELD for use on signaling circuits of 110V/60V/24V/12V in AC or DC – Online
- Cable Insulation Tester (CIT) - Off line

All channels of ELD and Cable Insulation Tester have a common Meter. If all the 4 channels are not in use then extra channels can be switched off. Switch is provided on rear side of the detector.

For More than 4-channels, say 8, 12 or 16 channels, add-on units of 4-channels can be attached together.

Various control and indications are provided on the front plates of the 'Channel module' and 'Main module' (Cable Insulation Tester), the details of which are under 'Controls and Indications'.
On opening the rear panel of ELD, two types of terminal strips are seen as shown above. The first is an 8way MAIN STRIP which is common for all channels. It has tapings for connecting 110 V or 230 V AC supply. The second terminal strip or the CHANNEL STRIP (7way) is separate for each channel. It has various connections which are shown in fig.

Insulation resistance

Insulation is the property of insulated material and can be measured in off line condition.

Leakage resistance

Leakage is also property of insulated material and can be measured in on line condition.
On line System Insulation of Signaling system with respect to Earth = Insulation of Power Supply + Insulation of Control circuits + Insulation of Cables + Insulation of loads (all in parallel) = Leakage Resistance For example if

Insulation of power supply (w.r.t Earth) =Rp
Insulation of one cable pair (w.r.t Earth) =Rc
Insulation of one load (any) (w.r.t Earth) =Rs
Then total insulation of (pair + load) R1=1/Rc+1/Rs

If we have 'n' such circuits in our system and when all such circuits are working on common power supply (called bus bar), they all are in parallel and equivalent parallel Insulation Resistance, will be given by the formula.

$$1/R=1/Rp+1/R1+1/R2+ \text{----} 1/Rn.$$

Where R is equivalent parallel Insulation Resistance.
This value of Insulation Resistance in parallel is called as On line System Insulation or **Leakage Resistance**.

Principle of operation

Earth Leakage Detector measures on line insulation (Leakage Resistance) directly on LCD meter. Measurement Principle is based on superimposition of a DC measuring voltage. ELD constantly monitors and measures Leakage Resistance of Bus Bar with respect to Earth in online condition. Leakage Resistance can be read on meter.

When Leakage Resistance value drops below preset alarm value, fault is detected; which is either announced as audio and/or visual alarm. Fault can be recorded by counter / Data logger. Preset alarm value can be set anywhere between 2K to 1M (Factory setting on 2K).

Fault Indications

Earth Leakage Detector has twin indicating arrangements:

(i) Through direct display of leakage resistance value on a LCD on main panel equivalent to the resistance in the circuit from 10meg ohms to nearly dead short (about 900ohms) resistance. The meter is common for all channels and Cable Insulation Tester.

(ii) By way of lighting a RED LED on Channel Module front plate, labeled **FAULT** and initiation of an audible alarm which operates as per pre adjusted leakage limit. This arrangement is provided for alerting the maintenance staff to take suitable measures well in advance.

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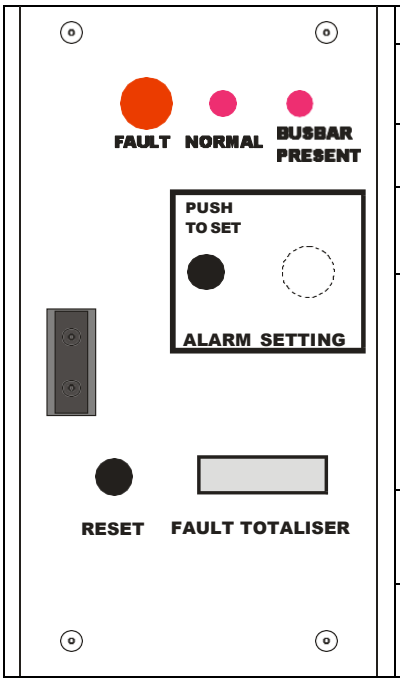
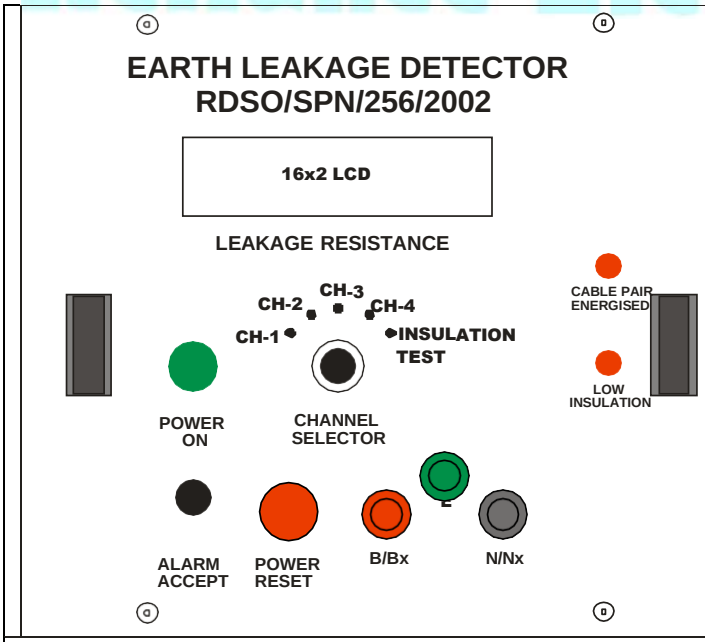
Controls and indications of each Channel Module



Description	Function
FAULT LED	Glows in case leakage resistance goes below set value or Busbar absent or any of two Earth open
NORMAL LED	Glows in normal condition without any of above fault
BUSBAR PRESENT LED	Glows in case Busbar supply is present
ALARM SETTING (Push switch & variable device)	Push to check Alarm setting value on LCD. Continuously variable device below circular lid is used to set leakage resistance value below which ELD will announce fault. Press P.B. switch & variable device simultaneously to store alarm setting.
RESET push button	Re-energises detector relay only after fault is rectified
FAULT TOTALIZER	Counter increments after each RESET operation

Controls and indications of Main Module



Description	Function
CHANNEL SELECTOR ROTARY SWITCH	(i) Selects Any one channel from 1 to 4 for meter reading only. (monitoring of system of all 4 channels is continuous irrespective of channel selector position) (ii) Insulation resistance meter
LCD METER	Reads bus bar to earth leakage or insulation resistance as per the position of selector switch
ALARM ACCEPT PB	To stop the buzzer sound
'POWER ON'(RED LED)	Glows when the mains is connected to the instrument
EARTH	To connect cable sheath or earth of selected pair of cable
PAIR ENERGISED (RED LED)	ON when cable pair connected to circuit (Measurement not possible)
LOW INSULATION (RED LED)	ON when insulation resistance is lower than 10Kohms otherwise OFF.

Main terminal strip details (Rear side)

REMOTE ALARM ACCEPT	Parallel to Alarm Accept switch on Main panel
REMOTE ALARM ACCEPT	Parallel to Alarm Accept switch on Main panel
REMOTE BUZZER	+Ve To connect 24V buzzer at a distance away from ELD
REMOTE BUZZER	-Ve To connect 24V buzzer at a distance away from ELD
230V (WORKING AC SUPPLY)	AC Mains supply 230V L
110V (WORKING AC SUPPLY)	AC Mains supply 110V
0V (WORKING AC SUPPLY)	AC Mains supply neutral
GND	Cabinet body

Channel terminal strip details (Rear Side)

CH ON	Channel ON-OFF switch
Bx / +	Busbar of supply to be monitored
Nx / -	Busbar of supply to be monitored
E1	Earth1
E2	Earth2
P	Potential free contact for data logger pole
NO	Potential free contact for data logger normally open
NC	Potential free contact for data logger normally short

Installation

- Open the rear panel
- Loop together all the terminals marked E1 on channel strips with a suitable wire
- Loop together all terminals marked E2 of channel strips
- Mount the ELD on the Relay Rack/ CT Rack in Relay Room
- Connect AC/DC bus bar to Bx/+ and Nx/- terminals of relevant channel strip
- Connect E1 & E2 to separate earths. In case of ring earth connect E1 & E2, with two separate wires. DO NOT SHORT CIRCUIT E1 & E2 on terminals side
- Connect one conductor from instrument ground on main terminal strip to relay rack
- Connect buzzer to REMOTE BUZZER terminals of Main terminal strip with extended buzzer wires
- Connect a simple push switch (door bell type) to REMOTE MUTE terminals on extended wires
- Connect P of each channel to the Data Logger digital common
- Connect NO of each channel to the empty points at Tag Block. (In normal condition of ELD P & NO remain short and in Fault condition P & NO remain open)
- Finally connect the instrument with available power of 230V AC or 110V AC to the terminals marked '230V~' and '110V~' on main terminal strip. '0' is marked for neutral

Operating instructions

- After the instrument is given Power, switch ON the connected channels from the rear side toggle switch near terminal strip.
- Check the Leakage resistance on the Meter panel, one by one for each channel after selecting through the Channel selector.
- In case the meter reading of a channel is below 2K continuously then take action as follows:

For non-IPS type power supply

- Check earth connections. The resistance between two Earths should be < 10 Ohms.
- If this is an AC Channel it should be connected to the Bus-bar.
- The above two conditions also cause FAULT Indication even if the Leakage conditions are alright
- If it is observed that on the panel meter the reading comes down to less than 2K, improves for some time and again falls down to 2K after sometime
- In such cases investigate during operation, for which particular circuit (bus-bar) the Leakage resistance reading becomes < 2K.By ascertaining this we can locate low insulation pair/pairs with the help of Insulation Tester (part of ELD)

  In case the reading remains continuously <2K or 2K, investigate as follows –
- For AC Bus bar remove transformer Earth connection and check ELD meter reading for improvement in Leakage resistance
- For DC BUS BAR remove charger's Earth connection and check ELD meter reading for improvement in Leakage resistance
- If reading remains <2K then remove Battery Bank (Both connections) and check ELD meter reading for improvement in Leakage resistance
- If meter reading remains <2K, (AC or DC busbar) perform all the operations of the associated BUS BAR
- During any operation if leakage reading becomes >2K, note that operation.
- Now with the help of insulation tester find out low insulation pair/pairs

For IPS type power supply

In case the bus-bar supplies are taken directly from the IPS and the leakage is below 2K continuously then change that module of the IPS and check leakage reading on ELD. If it is not possible to change the module, check the current to the load (On IPS Amp meter) and compare it with similar load condition in another same station. If there is a large difference (about 2 times), then be sure that the leakage condition is caused by the IPS system. To ensure this, check all conductor pairs associated with this IPS module with the help of Insulation Tester.

Testing of insulation with Cable Insulation Tester

- Connect earth lead (GREEN) on EARTH terminal
- Connect measuring leads (RED) to TEST
- Keep Channel Selector switch in INSULATION TEST position
- Touch RED leads to GREEN lead, LCD meter will show ‘poor insulation’ Red LED (Leakage below set value) start glowing. It shows that instrument is working properly
- Now connect earth lead probe (GREEN) to cable sheath or earth.
- Touch measuring lead probes (RED) to outgoing cable pair on CT rack whose insulation is to be tested
- If the pair is energized, Red LED (PAIR ENERGISED) will start glowing and meter will not show any reading. Connect to another pair, if Red LED does not glow and meter shows a reading then this is the insulation resistance of the pair
- By repeating this procedure we can find insulation of all pairs.
- In case any energized pair is to be measured, follow proper procedure for disconnection
- Remove both links and measure the insulation
- After detecting low insulation pair/pairs, Meggering of that pair can be done

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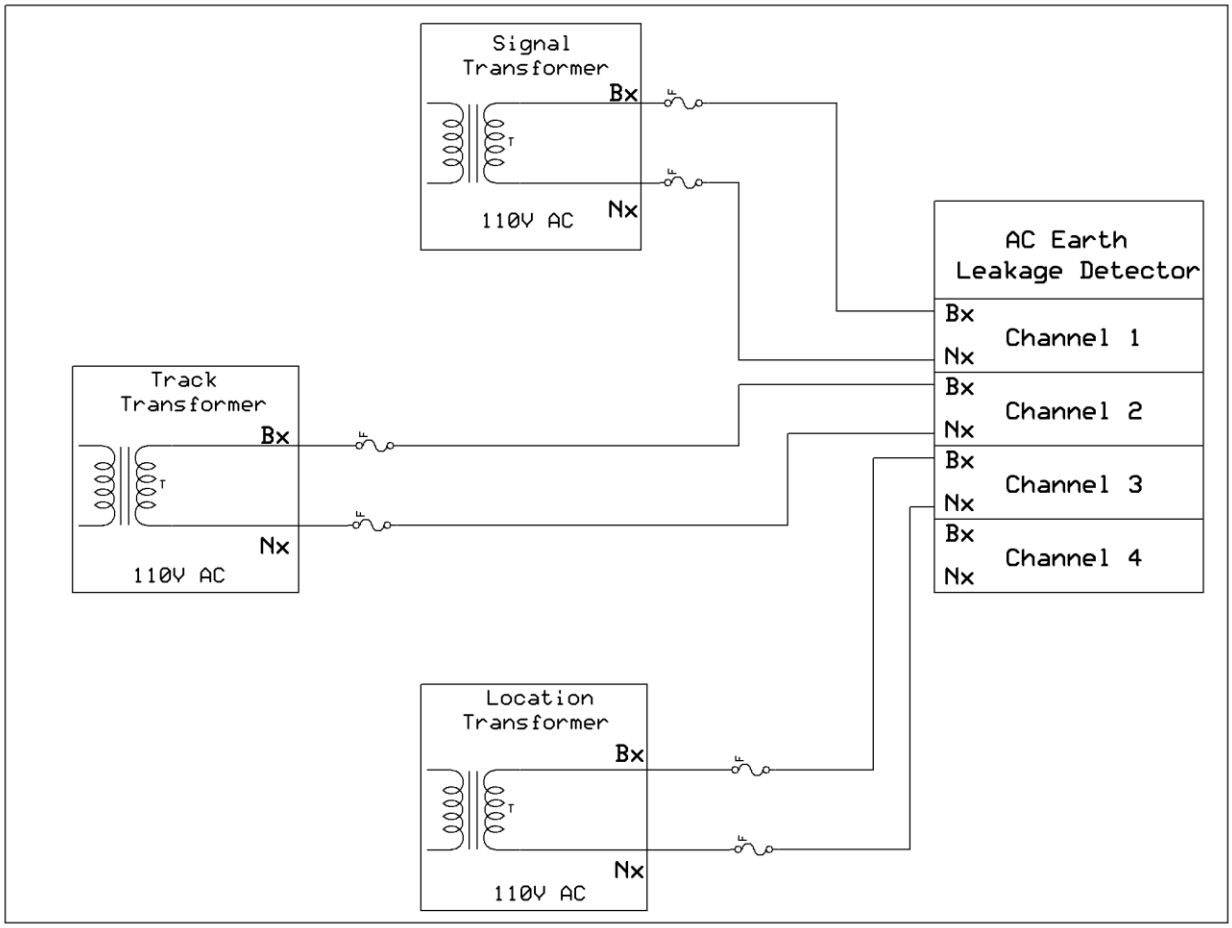
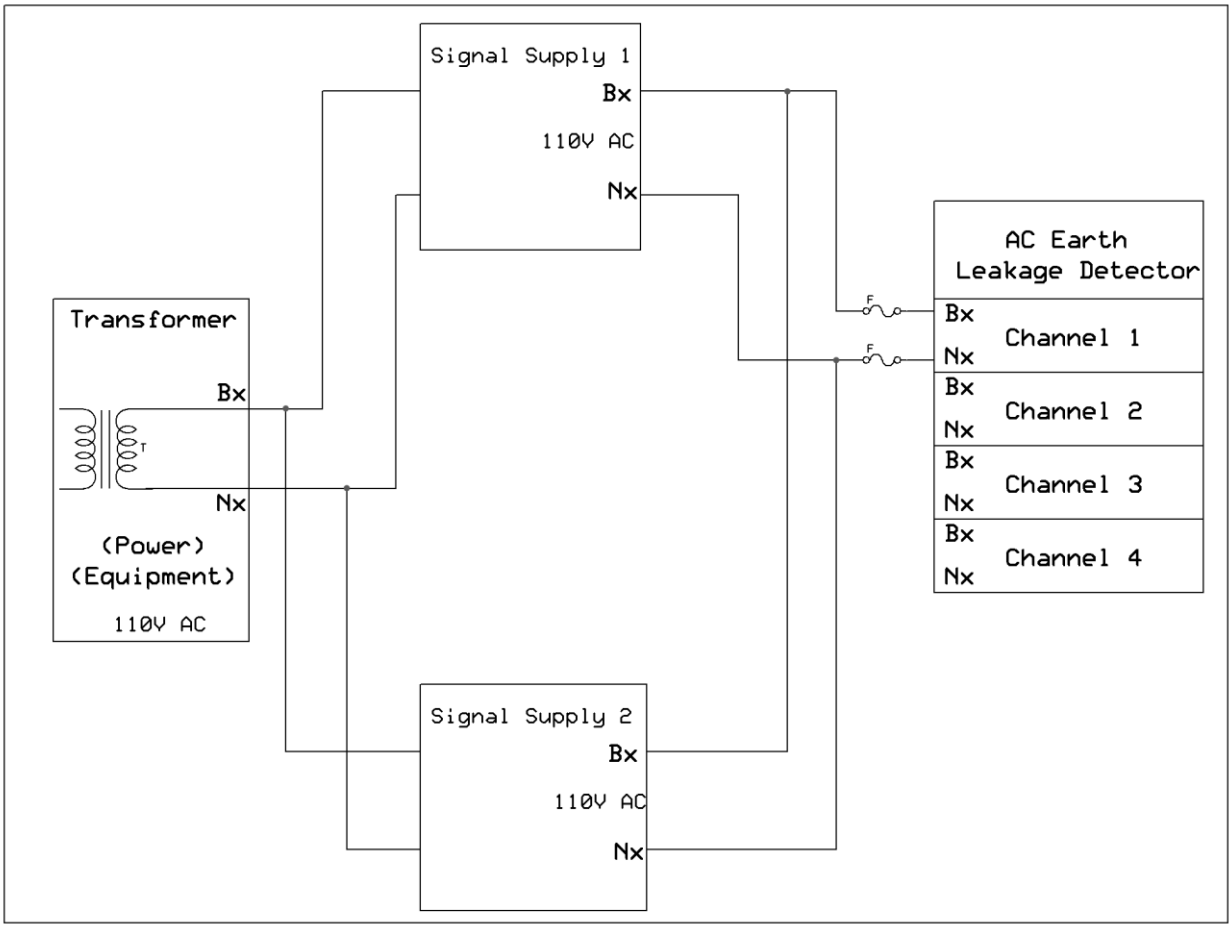
Installation Diagram for AC Channels

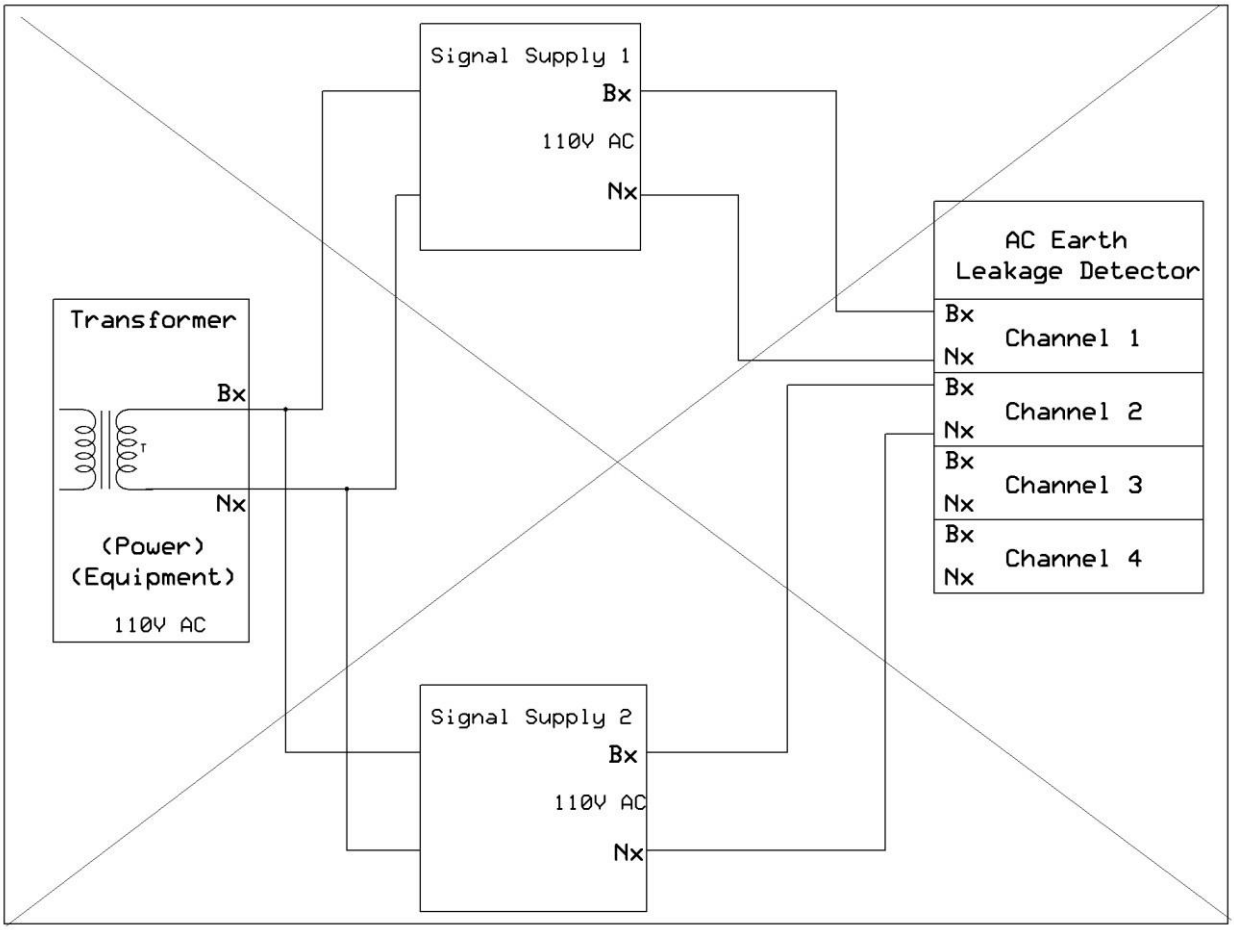
If none of the supplies are in parallel with each other



If the supplies are in parallel with each other, ensure that they are connected in the <u>same channel</u>



Wrong Installation



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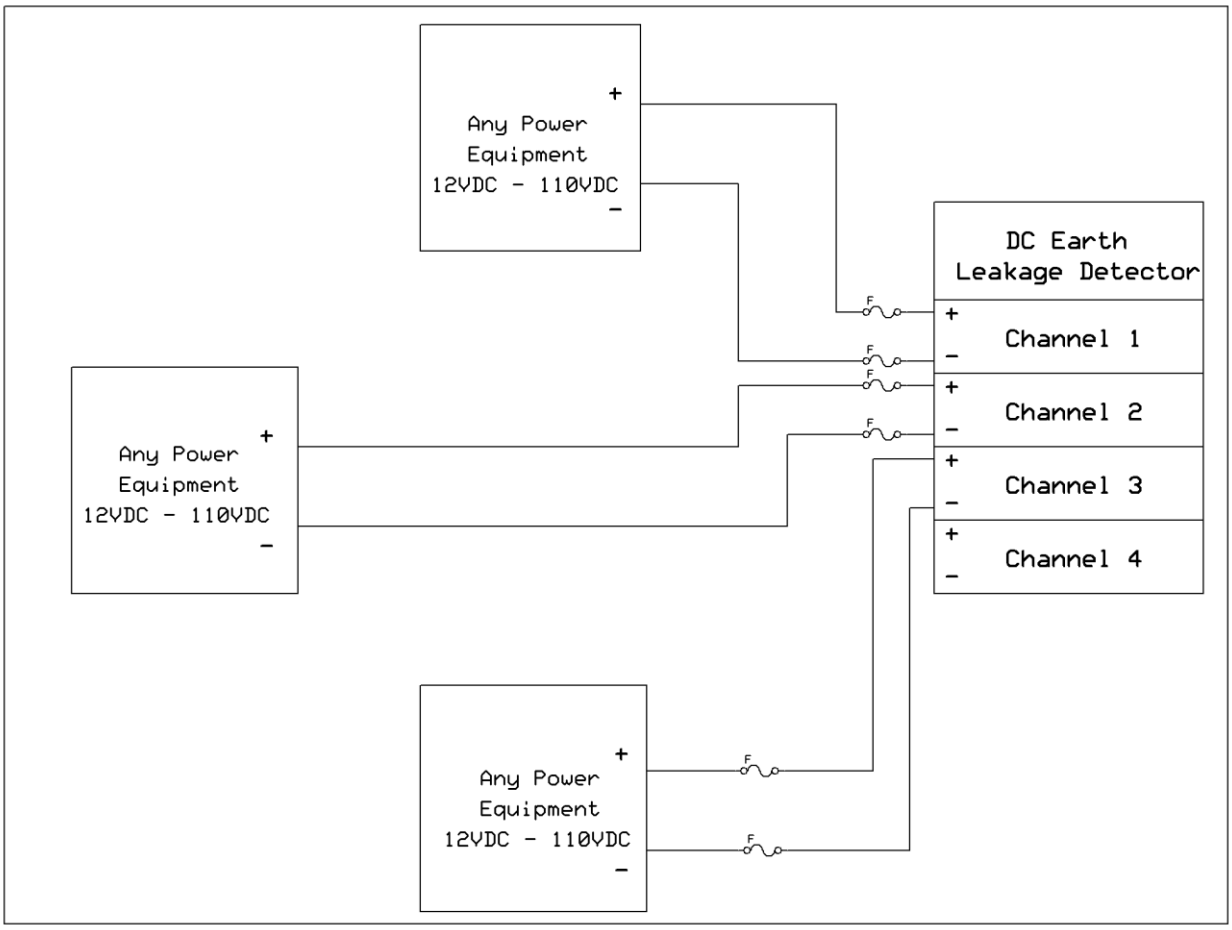
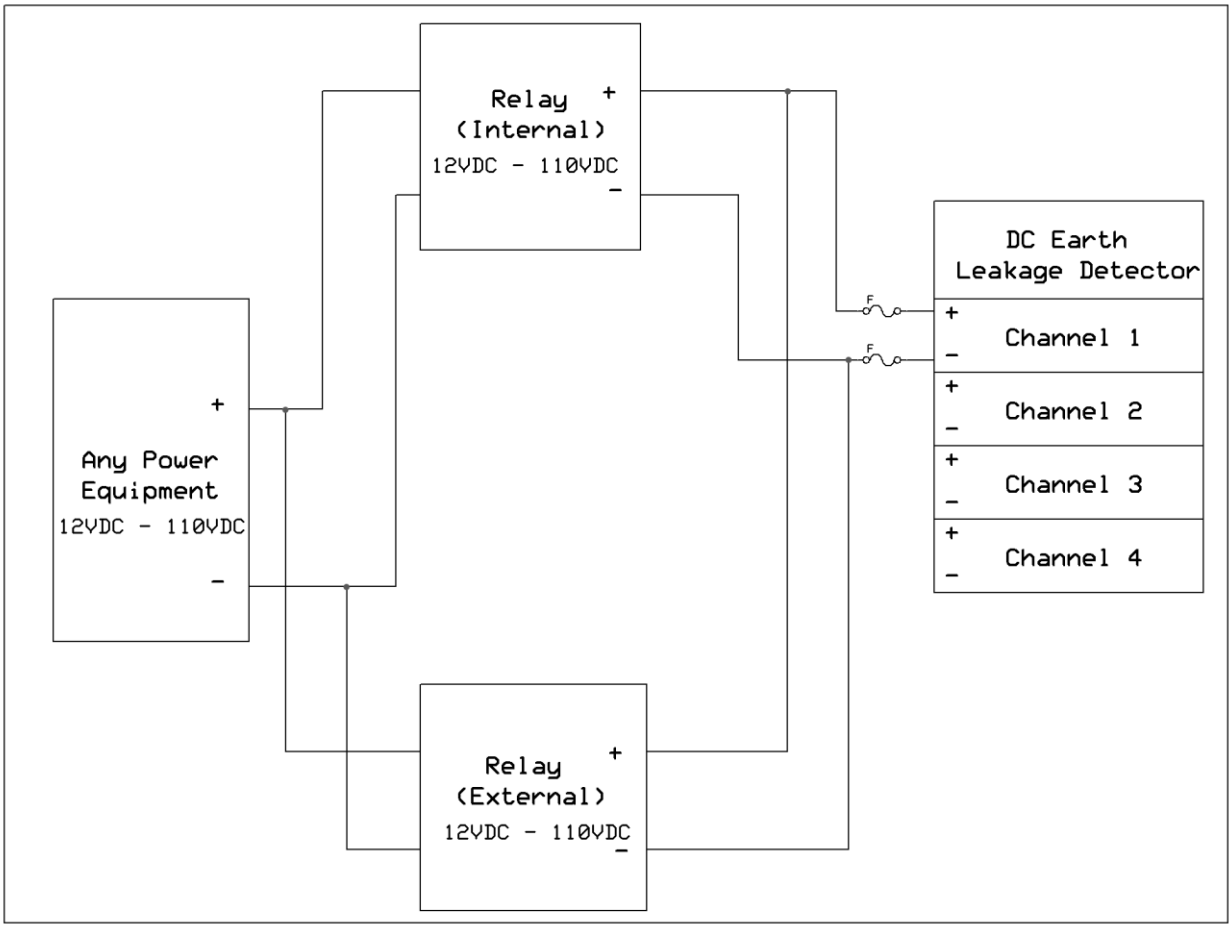
Installation Diagram for DC Channels

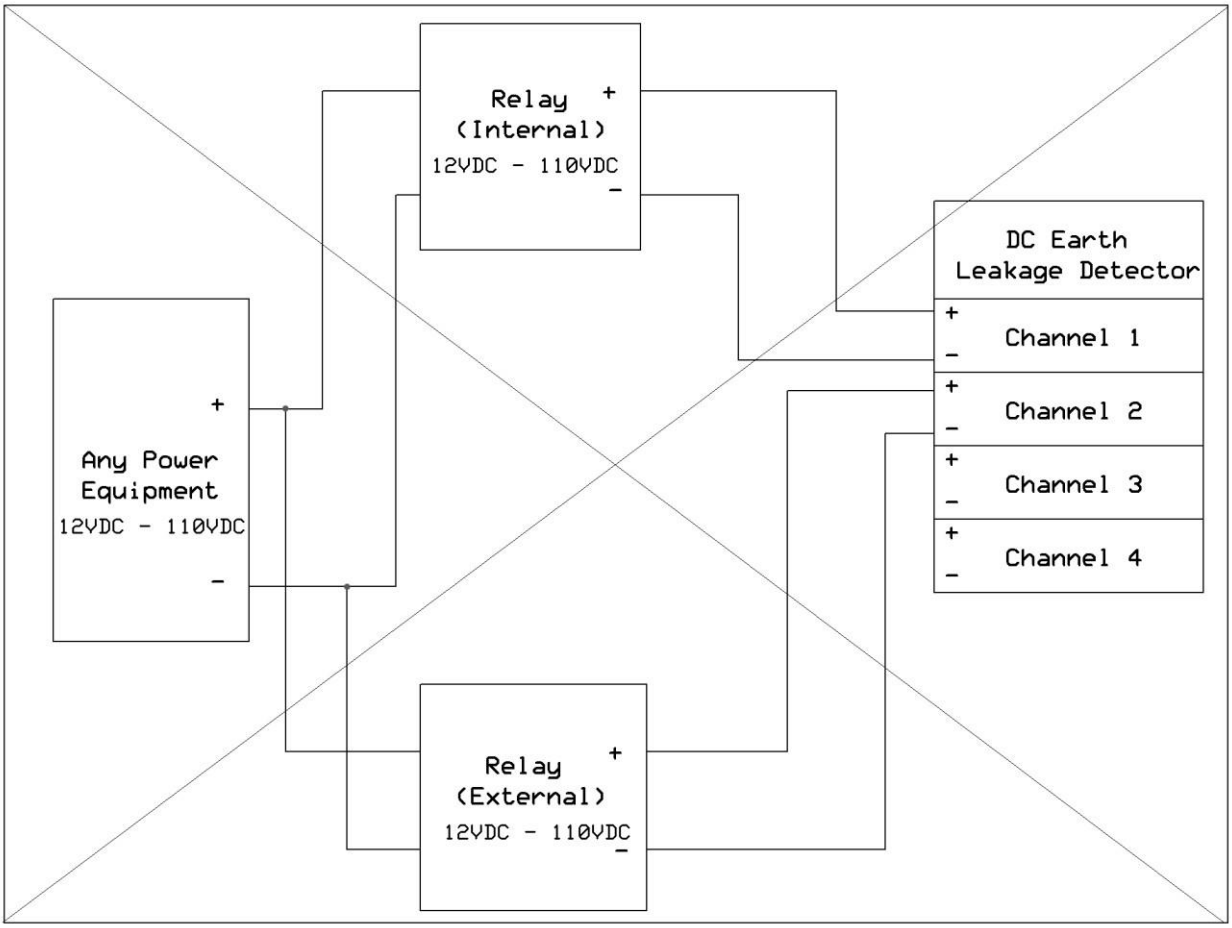
If none of the power equipments and their supplies are in parallel with each other



If the power equipments or their supplies are in parallel with each other, ensure that they are connected in the <u>same channel</u>



Wrong Installation



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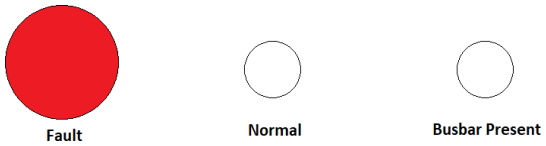
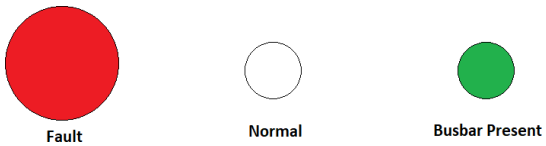
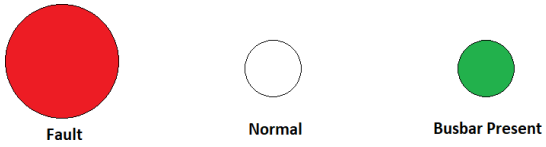
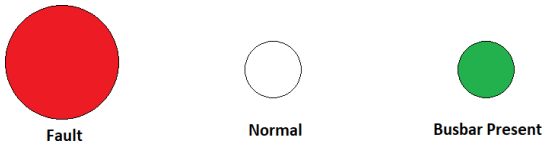
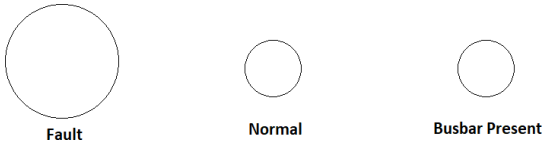
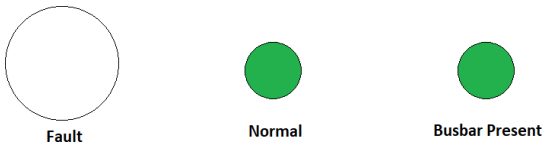
RDSO/SPN/256/2002 Earth Leakage Detector: Usual Faults & How to Solve Them

Visual Representation of Channel CARD LED indications	Status of LED indications & Display Readings	Probable cause of the fault	How to find/solve the problem
	Fault LED – ON Normal LED – OFF Busbar LED – OFF	Busbar is not connected properly	Check if the Busbar is connected properly to the unit & is getting proper voltage. For DC ELD, also check the polarity of the Busbar.
	Fault LED – ON Normal LED – OFF Busbar LED – ON LCD Display Reading – Normal, more than 2K Ohms	Earth Open Fault	Loop E1 (Earth1) & E2 (Earth2) terminals on the channel card. If the fault disappears on Reset, then it is confirmed as Earth Fault. Check the wiring of E1 & E2.
	Fault LED – ON Normal LED – OFF Busbar LED – ON LCD Display Reading – Normal; More than 2K Ohms	Alarm Setting too high	If the Alarm setting is higher than the Leakage resistance, the unit will be in fault condition. Reduce the alarm setting to a value lesser than the display reading to solve the problem.
	Fault LED – ON Normal LED – OFF Busbar LED – ON LCD Display Reading – Fluctuating	Mixing in Supply	Check the supplies attached to the channel cards via a TEST LAMP. If there mixing in supplies, unit will not work. Attach only ONE of the mixed supplies & remove the rest.
	Fault LED – OFF Normal LED – OFF Busbar LED – OFF LCD Display Reading – OFF	No Supply / Channel Card Switched OFF	Check the Power Supply to the unit & the channel cards. If all is correct, check if the Channel ON/OFF switch behind each of the channels is in ON position.
	Fault LED – OFF Normal LED – ON Busbar LED – ON LCD Display Reading – Backlight ON but no Readings	Wiring problem of Power Supply	Check if the connections of Power supply of the units are correctly made. If 110V supply is used, it has to be connected in 110V terminal ONLY. Check the same if 230V supply is used. Also, try to RESET the unit when required.

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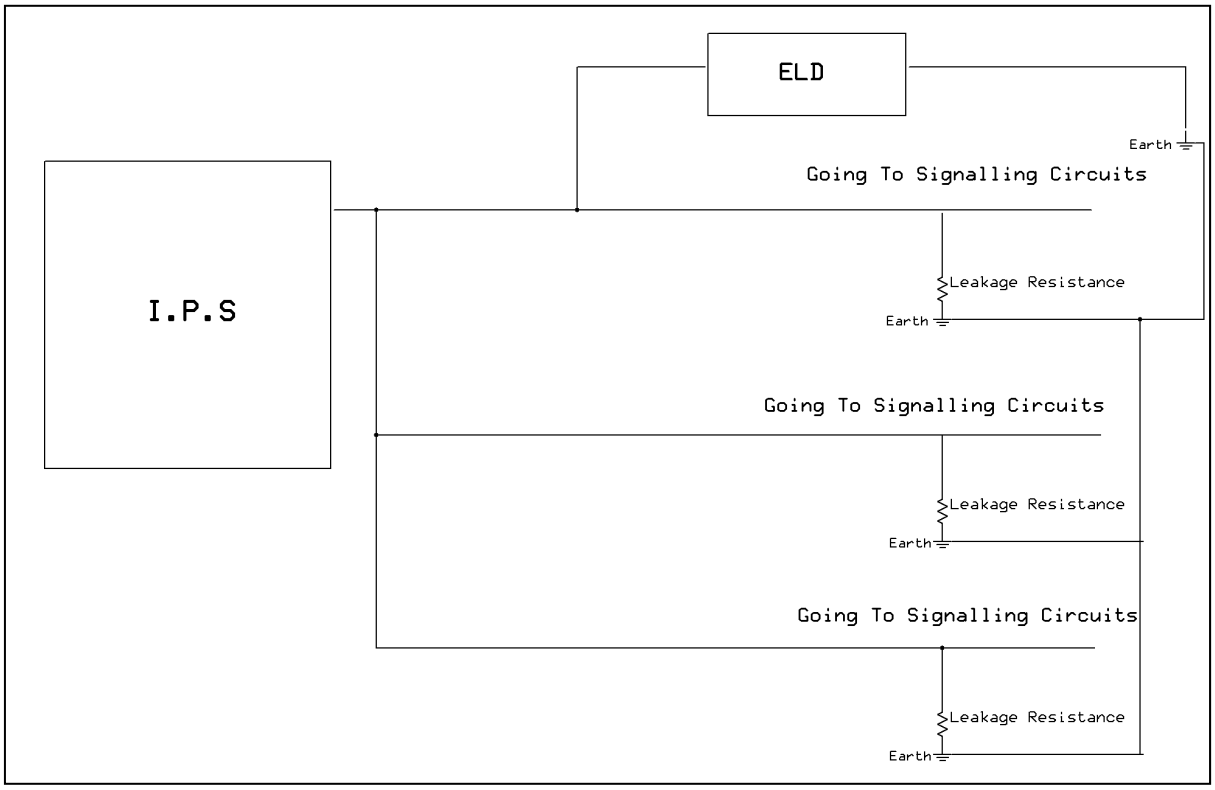
Fault Finding with Earth Leakage Detector

Earth Leakage Detector measures the insulation resistance of a non-earthed AC & DC **networks in online condition.**

The insulation of a signaling system withrespect to Earth	=	Insulation of Power Supply	+	Insulation of Control circuits	+	Insulation of Cables	+	Insulation of loads (allin parallel).

Therefore, it is crucial to note that Earth Leakage Detector does not only measure the leakageof the cables, but of **the entire network**.



All conductors of the same supply are in parallel with each other from the point of view of ELD for measuring Leakage Resistance

Example 1 -

Suppose, Network A has only 2 cable pairs with Insulation Resistance R1 & R2 respectively.Then the total Leakage Resistance displayed on the ELD will be –
1/R = 1/R1 + 1/R2 (Because all cables are in parallel with each other)
Let us suppose that the conductors are in good condition. In such cases, their insulationresistance will around 8MΩ.
Therefore, the Leakage Resistance displayed on the ELD will be –
1/R=1/8M + 1/8M
R = 4MΩ

Example 2 -

Suppose, Network B has 20 cable pairs with Insulation Resistance R1, R2..R10 respectively.Then the total Leakage Resistance displayed on the ELD will be –
1/R = 1/R1 + 1/R2 + 1/R3+ 1/R4 + ….. + 1/R20 (Because all cables are in parallel with eachother).
Let us suppose that the conductors are in ideal condition without any damage. In such cases,their insulation resistance will around 10MΩ.
Therefore, the Leakage Resistance displayed on the ELD will be –
1/R=1/10M + 1/10M + ….. + 1/10M
R = 500KΩ

Note that in both the above cases, the conductors in Network B are in perfect condition, yet the Leakage Resistance is drastically less simply because of the additional number of conductors in Network B.
Just by looking at the readings, it can be mistakenly interpreted that health of Network A isbetter than Network B. However, it is clear that is not the case.

Example 3 –

Suppose, Network C has 5 cable pairs with Insulation Resistance R1, R2..R5 respectively.Then the total Leakage Resistance displayed on the ELD will be –
1/R = 1/R1 + 1/R2 + 1/R3+ 1/R4 + 1/R5 (Because all cables are in parallel with each other) Let us suppose that all but one conductors are in ideal condition without any damage. In suchcases, their insulation resistance will around 10MΩ. However, one conductor (R3) hassuffered damage and it's insulation resistance is only 1KΩ
Therefore, the Leakage Resistance displayed on the ELD will be –
1/R=1/10M + 1/10M + 1/1K + 1/10M + 1/10M
R = 999.60Ω

Therefore, it is clear that if the insulation of even 1 cable pair is low, it will reduce the effective leakage resistance of the entire network.

To add to this, remember ELD measures the Leakage Resistance of the entire network. This includes the power supply & the loads (in parallel).

Example 4 –

Suppose, Network D has 3 cable pairs with Insulation Resistance R1, R2..R5 respectively.
The Insulation resistance of Power supply Rp. It is connected to a load with Insulationresistance RL.
Then the total Leakage Resistance displayed on the ELD will be –
1/R = 1/Rp + 1/R1 + 1/R2 + 1/R3+ 1/RL (Because all cables are in parallel with each other) Let us suppose that all but one conductor is in ideal condition without any damage. In suchcases, their insulation resistance will around 10MΩ. Let us suppose the power supply hasproper earthing and also has Insulation Resistance of 10MΩ, However, there is a problem atthe Load (RP) and it's insulation resistance is only 1KΩ
Therefore, the Leakage Resistance displayed on the ELD will be –
1/R=1/10M + 1/10M + 1/10M + 1/10M + 1/10M + 1/1K
R = 999.60Ω

With the above examples, it is clear that even of the health of all the cables are perfectly fine, if there is problem in the load, then effective resistance of the entire network comes down. Hence, while finding faults, it is essential to check the entire network & not just cables.

What further complicated matters is that not all conductors are in the circuit at the same time.

Example 5 (Intermittent faults)–

Suppose Network E has 5 cable pairs number 1,2,3,4 & 5 with Insulation Resistance R1, R2,R3, R4 & R5 respectively.
Cable Pairs 1-4 are in good health (their IR = 10MΩ). Conductor 5 has some damage it's IR is 1KΩ.
Assume that when the aspect is Green, Cable Pairs 1,2,3 & 4 are present in the circuit.In this case, Leakage Resistance displayed on the ELD will be –
1/R=1/10M + 1/10M + 1/10M + 1/10M
R = 4M Ω

Now, assume that the aspect changes to yellow, and in this case, Conductor No.5 is alsointroduced in the circuit for just few seconds.
Therefore, the Leakage Resistance displayed on the ELD will be –
1/R=1/10M + 1/10M + 1/10M + 1/10M + 1/10M + 1/1K
R = 999.60Ω

In the above case, the ELD will give an Alarm whenever conductor no.5 enters the circuit. Ifan engineer checks the ELD when the Aspect is Green, network works properly. However, as soon conductor no.5 enters the circuit, the readings will change and ELD will enter fault condition because of low Leakage Resistance.

Moreover, after few seconds when the conductor is removed from the circuit after the aspect is changed, the ELD can also be reset because at the moment, there is no fault in thecircuit. These conditions sometimes give the impression that ELD is faulty and showing unnecessary alarms. However, as the above clearly shows, there is a faulty conductor and ELD can only detect the same when it enters the circuit.