Resistance Grounding

Joe Campa
Regional Sales Manager

Post Glover

"The Resistor Specialists"

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- Headquartered in Erlanger, KY (Cincinnati suburb)
  - In business since 1892
  - 105,000 sq.-ft. facility
  - Workforce of 100+ people
  - 13 engineers on staff
- Largest Global Manufacturer of Power Resistors
  - All Fabrication Done on-Site
  - Total Control Exercised Over Processes
- Excellent Reputation for Quality & Service
  - Certified ISO-9001:2015
  - Products certified by CSA and UL

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What we do

- Neutral Grounding
- Motor Control
- Dynamic Braking
- Filter Resistors
- Transit

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Overview

Three Types of System Grounding

- Ungrounded (Capacitive Grounded) Systems
- Solidly Grounded Systems
- Resistance Grounding

System Failures on Industrial Power Systems

Failure Mode	Percentage of Failures
Line to Ground	98%
Phase to Phase	< 1.5%
Three Phase	< 0.5%

Data per CapSchell

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Ungrounded
(Capacitive Grounding)

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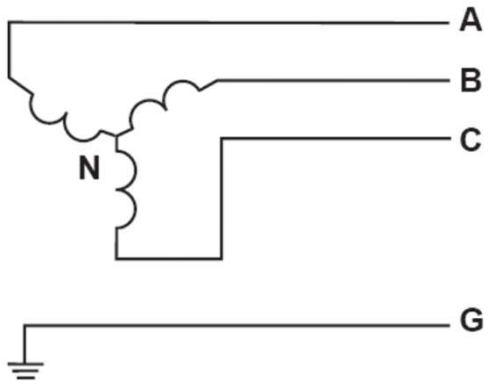
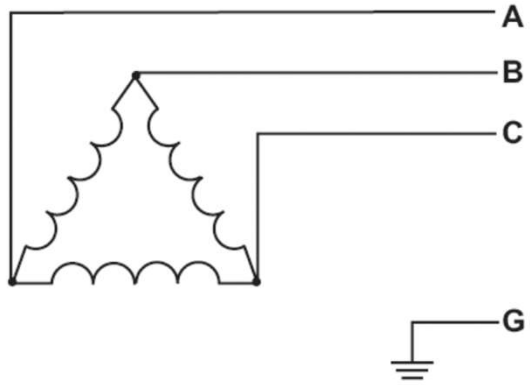
Ungrounded Power Systems

- Allows continuity of power in the event of a line-to-ground fault
  - Fault only grounds the system
  - Very low current would flow
  - Circuit breakers and fuses will not open
- Faults easy to find but time-consuming
- Line-to-ground voltage could exceed line-to-line voltage by several times in an arcing fault condition



Wye Connected System



Delta Connected System

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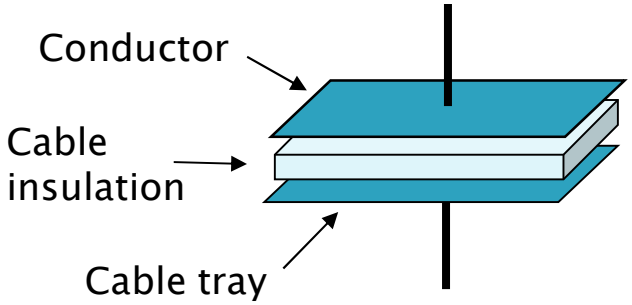
System Capacitance

A capacitor is an electrical device that can store energy in the electric field between a pair of closely spaced conductors

(Thank you, Wikipedia)



- Capacitance re-charges during an arcing fault, creating a larger overvoltage
- Overvoltage stresses insulation, leading to further faults

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Industry Recommendations

IEEE Std 242-2001 (Buff Book)

Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

Ungrounded Systems

8.2.5 **If this ground fault is intermittent or allowed to continue, the system could be subjected to possible severe over-voltages to ground, which can be as high as six to eight times phase voltage**. Such over-voltages can puncture insulation and result in additional ground faults. These over-voltages are caused by repetitive charging of the system capacitance or by resonance between the system capacitance and the inductance of equipment in the system.

Solidly Grounded

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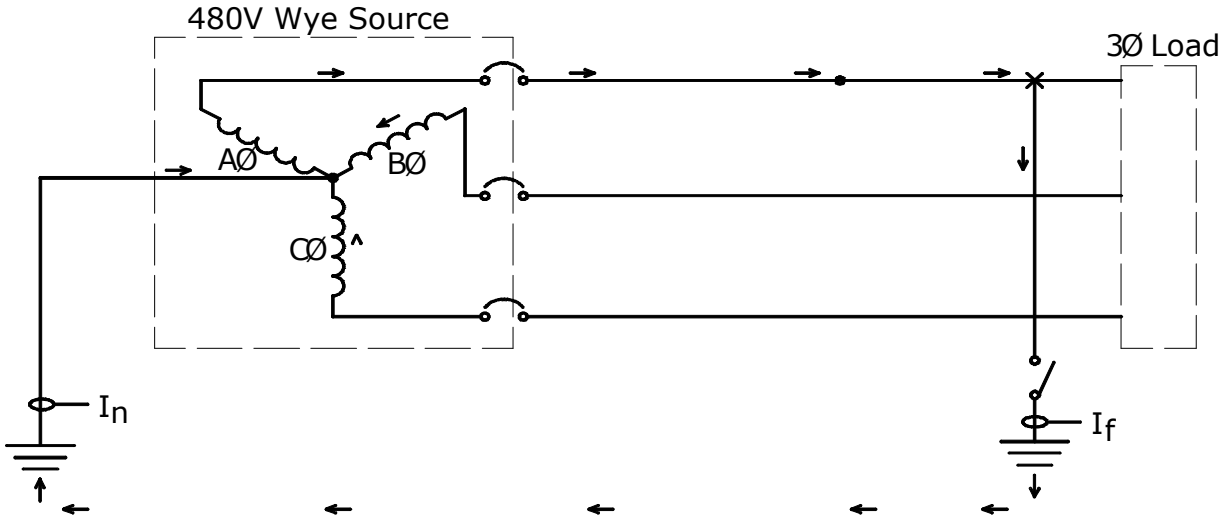
Solidly Grounded Systems



- Advantages
  - Fixed line to ground voltage
  - Diminished overvoltage danger in arcing fault conditions
  - Permit line-to-neutral loads
- Disadvantages
  - Danger from low-level-arcing faults
  - Strong shock hazard to personnel
  - Unscheduled service interruption

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Arc Faults

- Usually caused by insulation breakdown, creating an arc between phase to ground.
- Intense energy is not well contained and can be very destructive.

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IEEE – Arcing Faults

IEEE Std 242-2001
Recommended Practice for the Protection and Coordination of Industrial and Commercial Power Systems
8.2.2

One disadvantage of the solidly grounded 480 V system involves the high magnitude of destructive, arcing ground-fault currents that can occur.

IEEE Std 141-1993
Recommended Practice for Electric Power Distribution for Industrial Plants
7.2.4

The solidly grounded system has the highest probability of escalating into a phase-to-phase or three-phase arcing fault, particularly for the 480 and 600 V systems. The danger of sustained arcing for phase-to-ground fault…is also high for the 480 and 600 V systems, and low or near zero for the 208 V system. A safety hazard exists for solidly grounded systems from the severe flash, arc burning, and blast hazard from any phase-to-ground fault.

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Resistance Grounding

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Advantages of Resistance Grounding

- Greater safety for personnel and equipment
- Increased service reliability
- Lower operating and maintenance expense
- Reduced magnitude voltage transients
- Simplified ground-fault location

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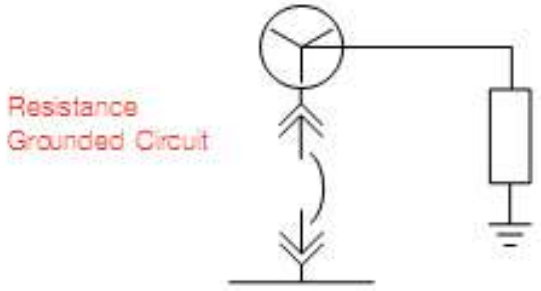
Resistance Grounding

Low Resistance

- Less than 1000 amps for ten seconds
- Safely shutdown
- Less damage than solidly grounded

High Resistance

- Less than 10 amps continuously
- Avoid shutdowns
- Least damage



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Considerations for Grounding Resistors

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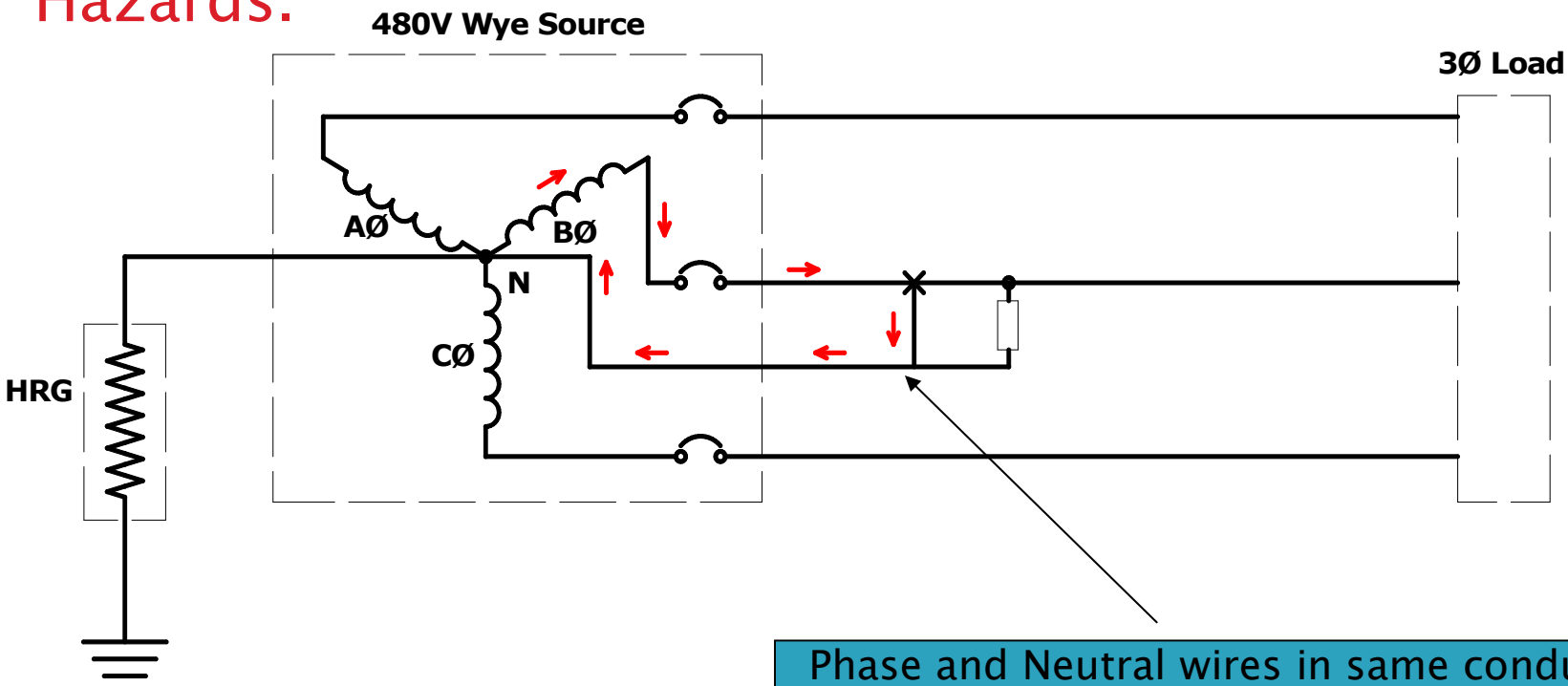
No Single Phase Loads

- No line-to-neutral loads allowed, prevents Hazards.



Phase and Neutral wires in same conduit.
If faulted, bypass HRG, thus, Φ-G fault.

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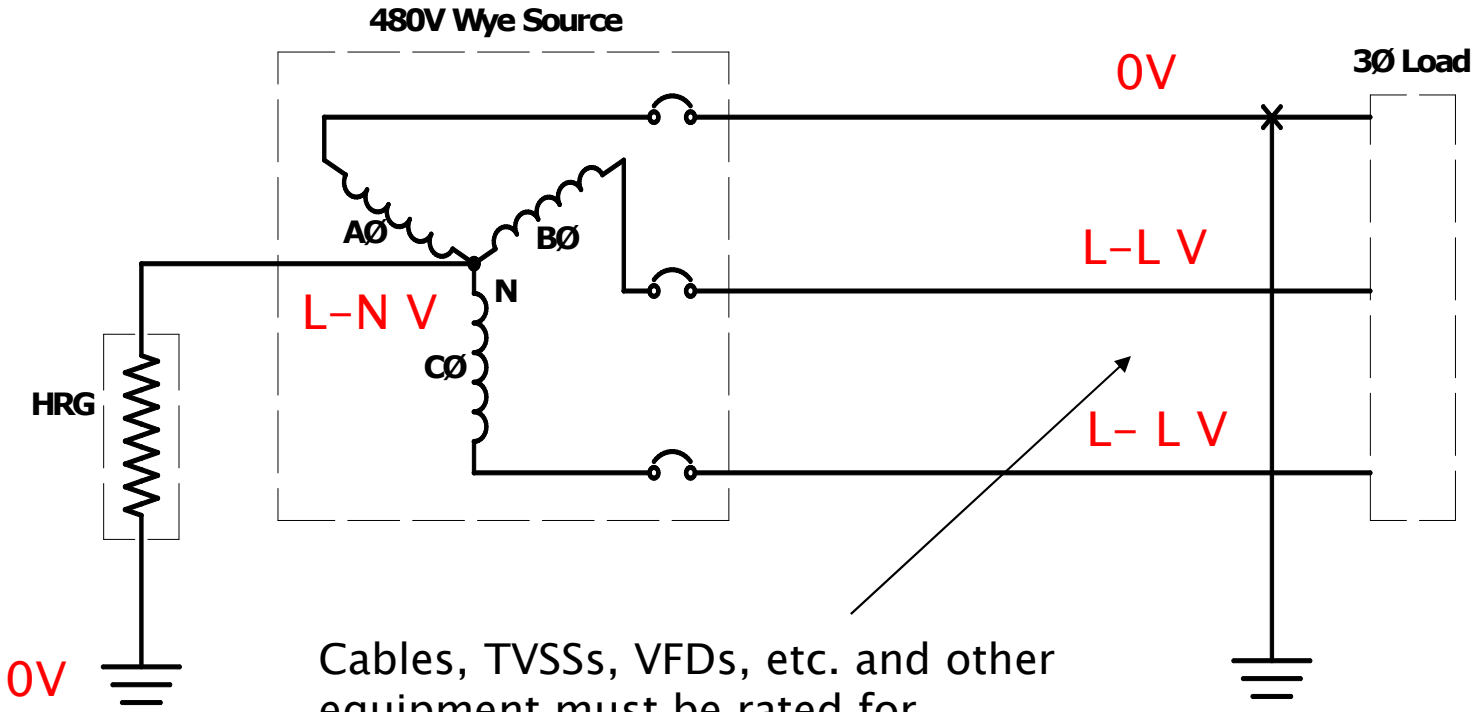
Elevated Voltage Hazard

- Properly rated equipment prevents Hazards.



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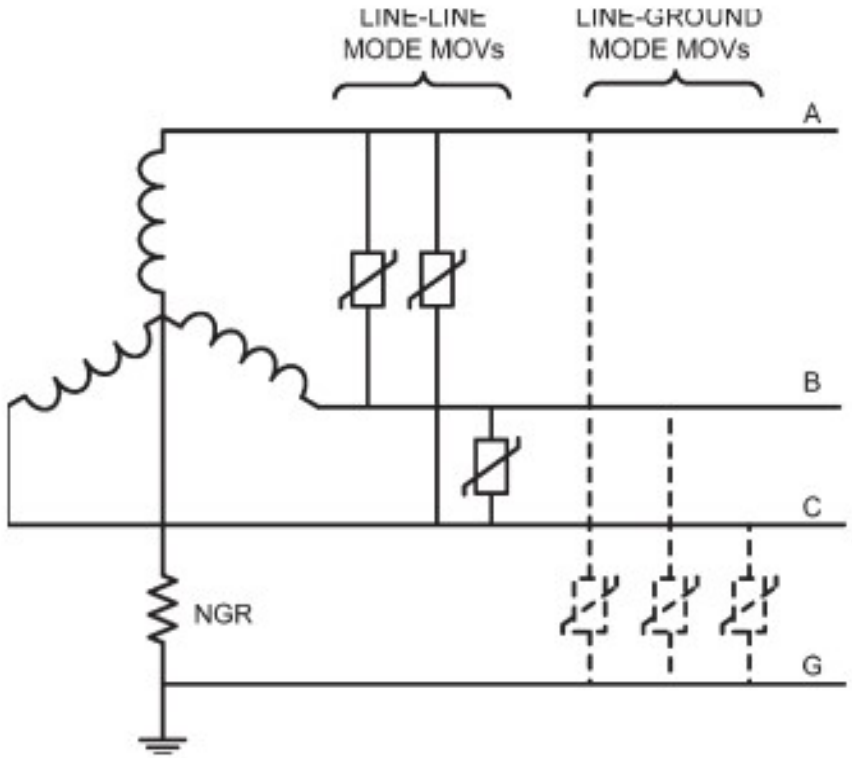
Over-voltage protection selection

- Line to Ground connected MOV's should be removed
- Line to Line MOV's should be configured similar to Delta connected system



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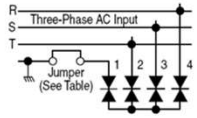
VFD's

- Remove jumpers

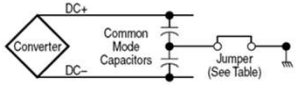
ATTENTION: When installing a drive on an ungrounded, high-resistance or B phase grounded distribution system, disconnect the phase-to-ground MOV circuit and the common mode capacitors from ground.

Phase to Ground MOV Removal



Frame	Jumper	Removes
A, B, C and D	JP3 – JP2	MOV to Ground
E	JP2 – JP1	MOV and Line to Line Capacitors to Ground

Common Mode Capacitors to Ground Removal



Frame	Jumper	Removes
A	N/A	
B	JP6 – JP5	Common Mode Capacitors to Ground
C and D	JP3B – JP3A	Common Mode Capacitors to Ground
E	JP3 – JP4	Common Mode Capacitors to Ground

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No Neutral?

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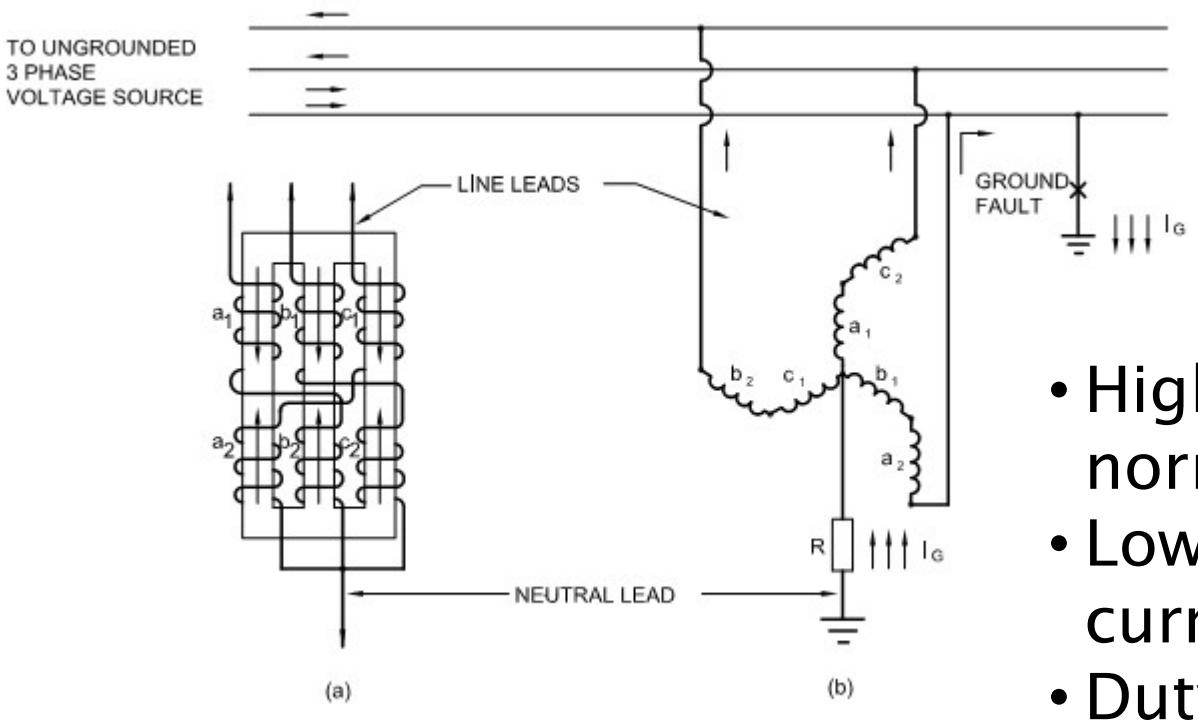
Zig-Zag Transformer



- High impedance to normal phase currents
- Low impedance to fault current
- Duty cycle same as resistor

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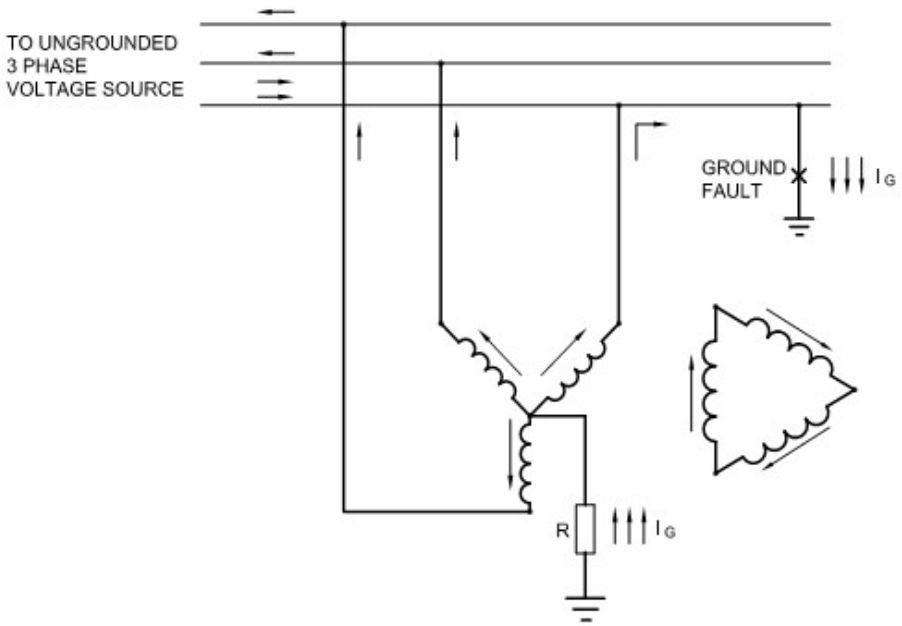
Wye Delta Grounding Transformer



- Uses 3 industrial control transformers
- Connect to create neutral
- Low voltage resistor
- Medium voltage can be done using broken delta configuration

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Resistance Grounding

Low Resistance and High Resistance

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Low Resistance Grounding

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Low Resistance Grounding (LRG)

- Used on Medium Voltage
  - Some 5kV systems
  - Mainly 15kV systems
- System charging current may be too high for High Resistance Grounding (HRG)
- Ground Fault
  - Current typically limited to 25 – 400A
  - Typically Trip within 10 seconds to reduce damage

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Duty Ratings for NGR's

IEEE Std 32

Time Rating and Permissible Temperature Rise for Neutral Grounding Resistors

Time Rating (On Time)	Temp Rise (deg C)
Ten Seconds (Short Time)	760°C
One Minute (Short Time)	760°C
Ten Minutes (Short Time)	610°C
Extended Time	610°C
Continuous	385°C

Increased Fault Time Requires Larger Resistor

Duration Must Be Coordinated With Protective Relay Scheme

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Specifying an LRG

- Technical information required
  - Line-to-neutral voltage for Resistor
    - Line-to-line voltage for Grounding Transformer
  - Rated current
  - Vented Enclosure type (Nema vs. IEC)
    - Resistor must 'breathe'
  - CTs and Relays
    - Neutral or Ground side of Resistor

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Common options

- Enclosure rating
- Enclosure finish
- Current transformer
- Potential transformer
- Disconnect switch
- Entrance/exit bushings
- Elevating stand
- Seismic rating
- Hazardous area classification
- Third party certification

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High Resistance Grounding

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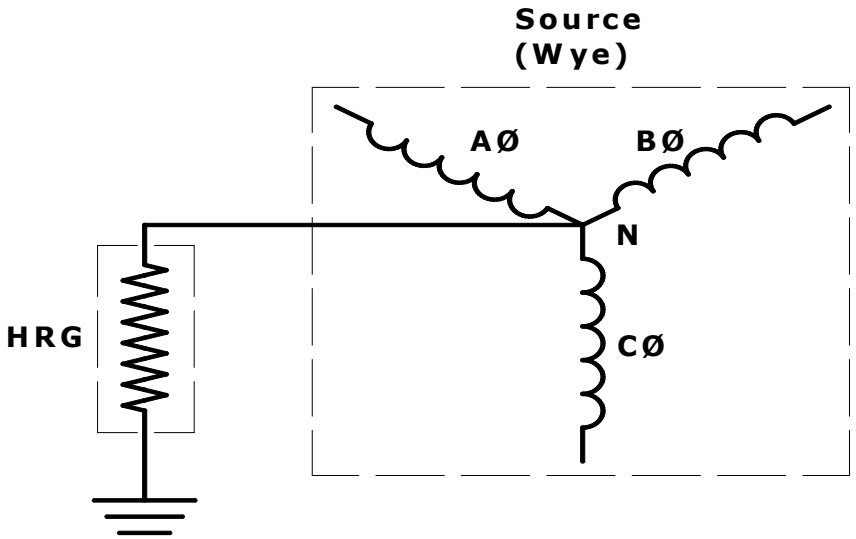
High Resistance Grounding



- Impedance selected to limit line-to-ground fault current (normally < 10A)
- Allows faulted circuit to continue operation
- No transient over-voltages
- Maintenance personnel can easily track the fault

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Specifying an HRG

- Same basic information as LRG

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Low Voltage HRG
PulserPlus.Net

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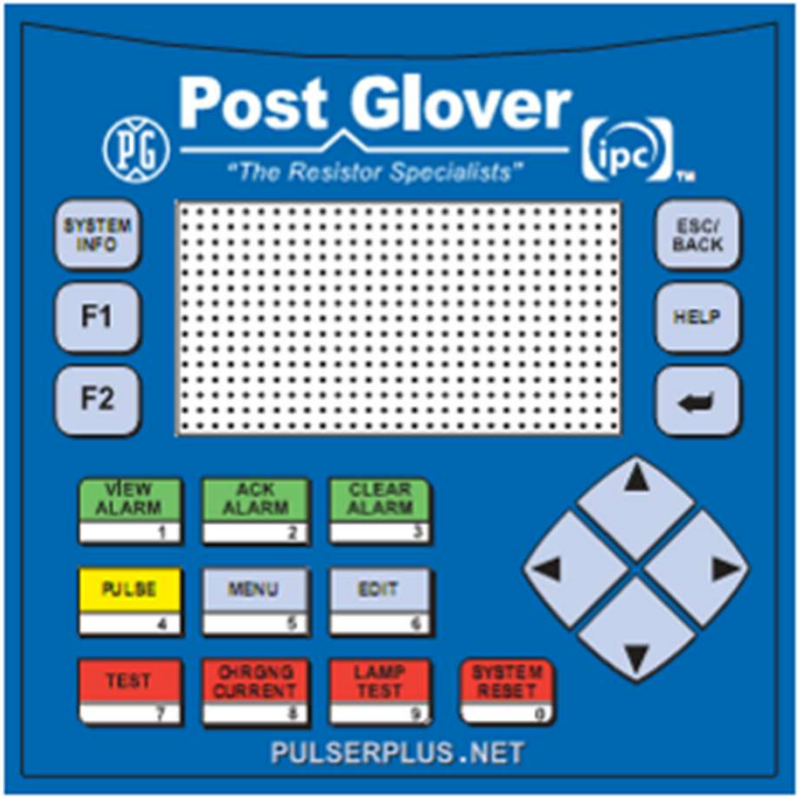
LV HRG Control Features

- Data Logging
- Alarm Settings
- Automated charging current calculation
- Pulsing Capability
- 3-Phase Monitoring
- Available Ethernet communication



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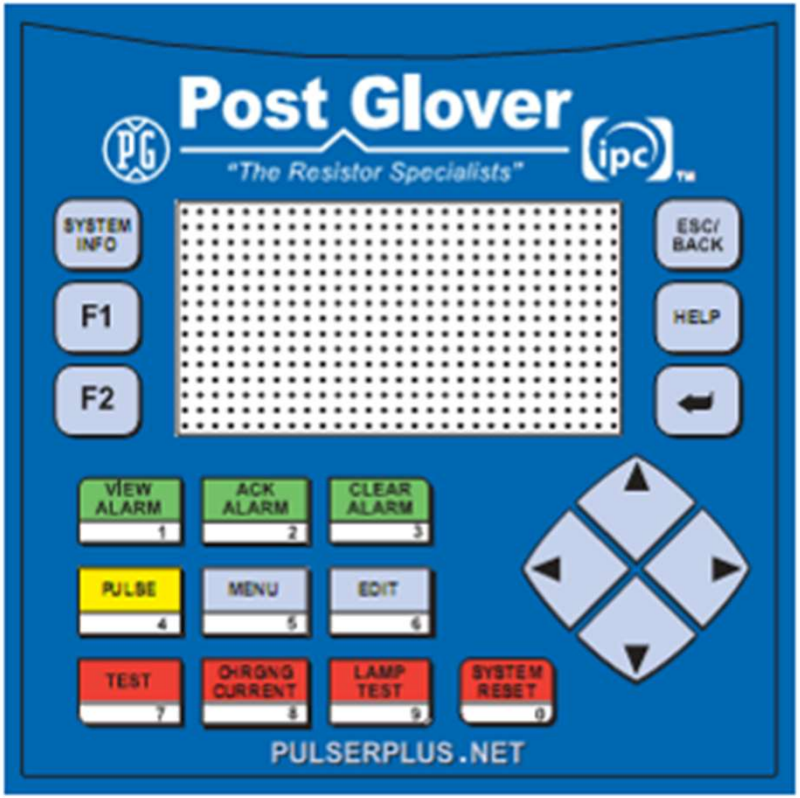
Data Logging

- Records up to 200 alarms with date and time. Helpful in tracking down nuisance alarms.



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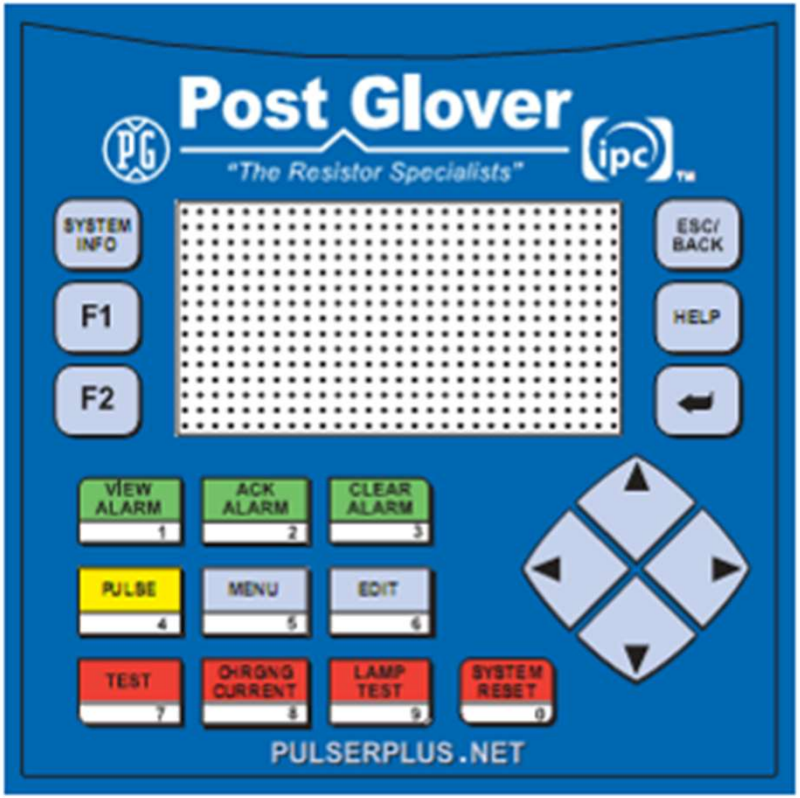
Alarm Settings

- Settings for overvoltage, overcurrent with a time delay setting.
- Ability to allow for customization of alarm settings in order to avoid nuisance alarms.



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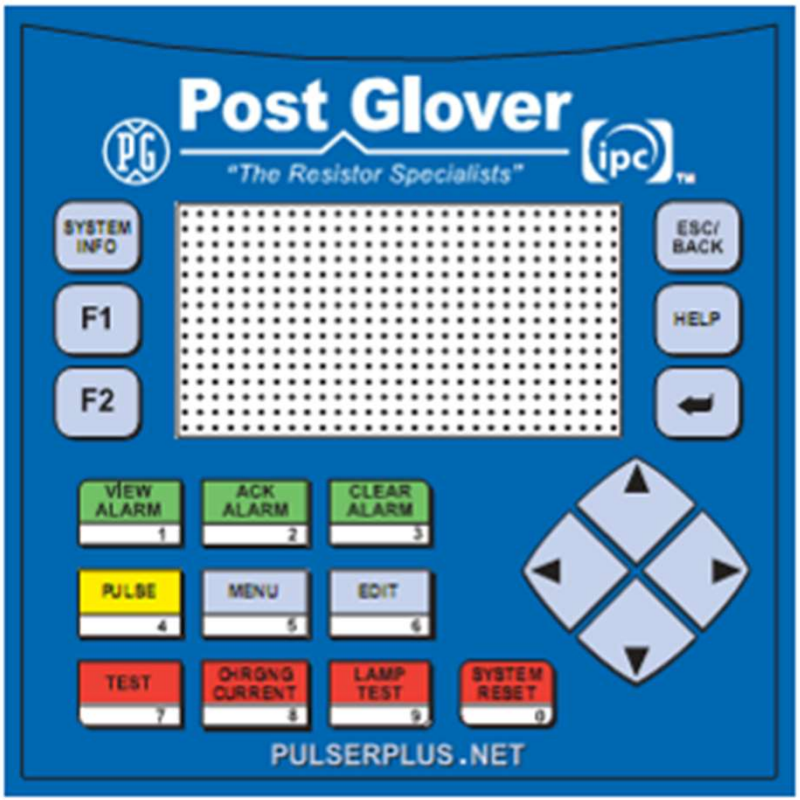
Charging Current Button

- The push of a button automatically calculates the system charging current for you.



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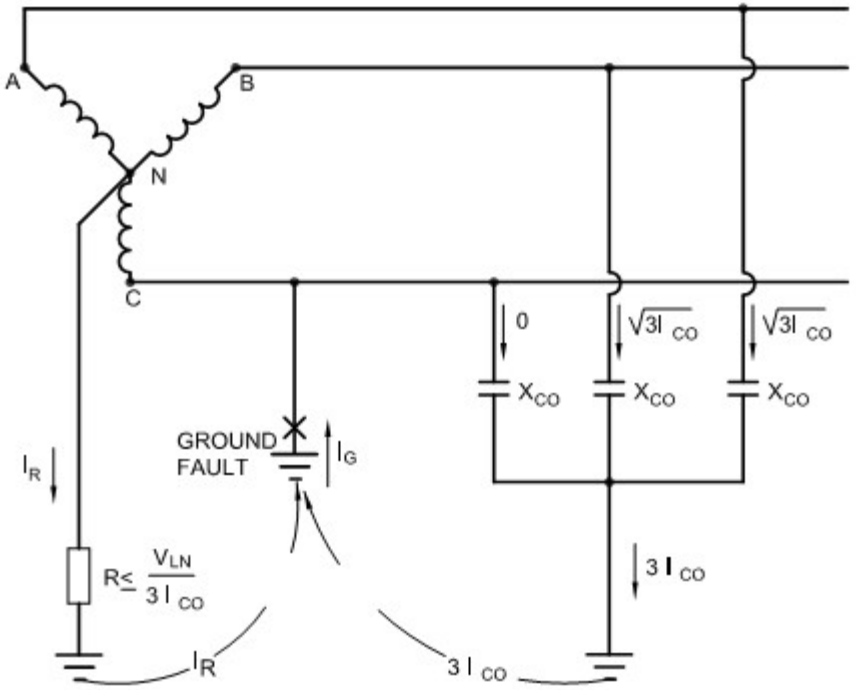
Importance of Charging Current



In a high resistance grounded system, the resistance must be low enough to allow the system capacitance to discharge relatively quickly.

Only discharges if $R_o < X_{co}$, so $I_r > I_{xco}$ (per IEEE142-2007 1.2.7)

That is, *resistor current* must be greater than *capacitive charging current*.

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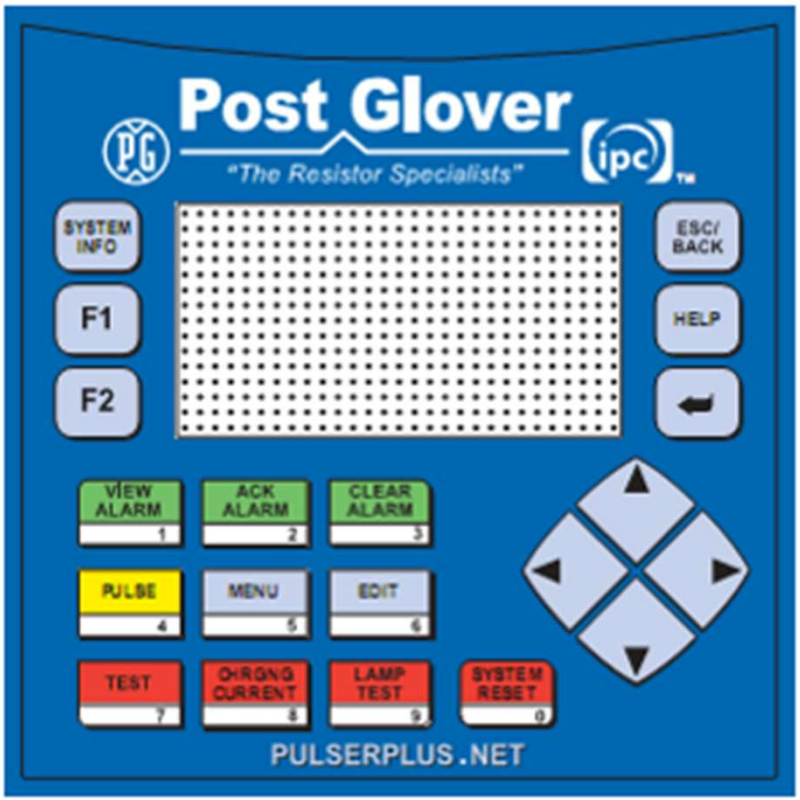
Pulsing Capability

- When activated, contactor alternately shorts the resistor and forces the current to increase to the pulse level
- Use ammeter to track the current fluctuation



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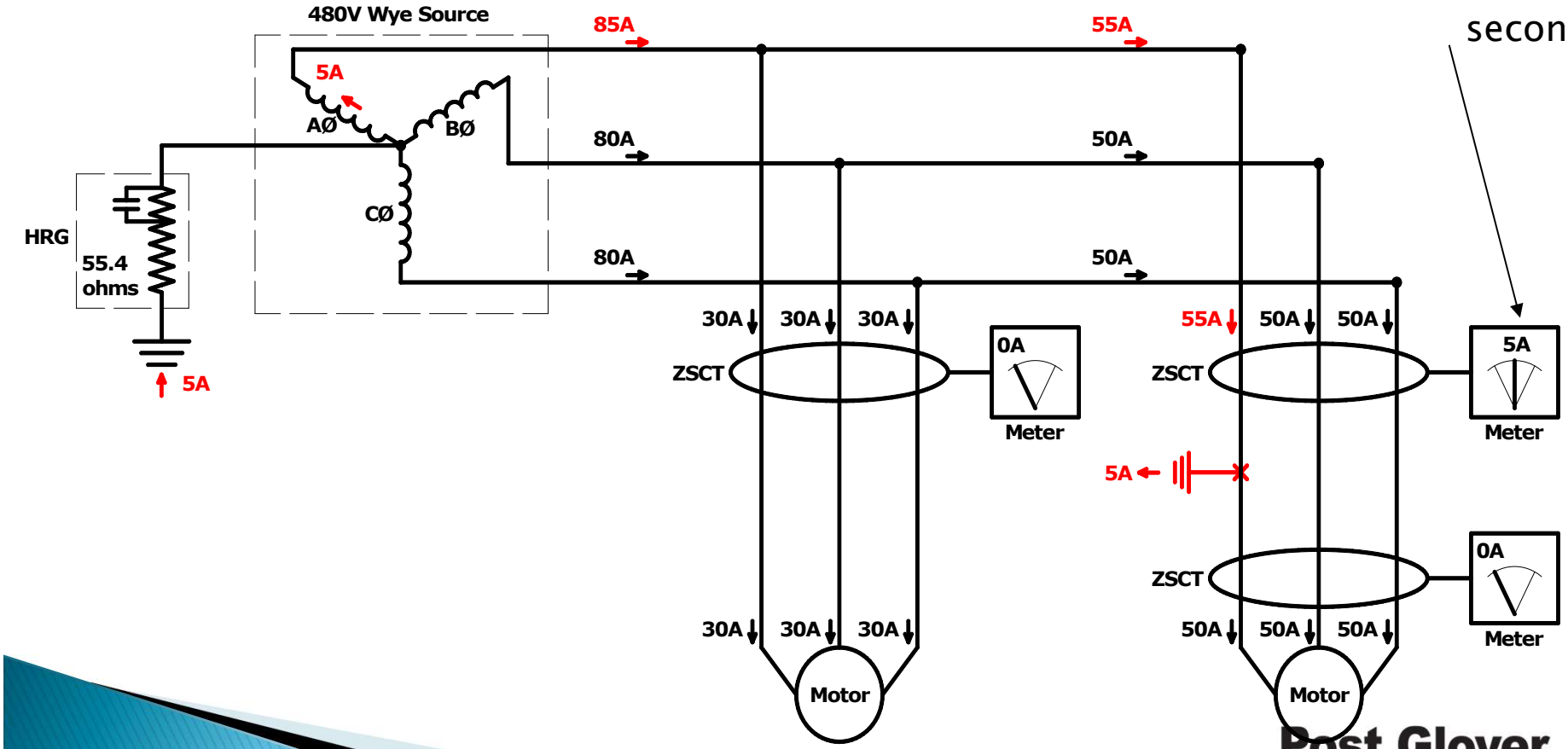
Fault Location

- Method to (relatively) quickly locate ground faults.

Meter reading will alternate from 5A to 10A every 2 seconds.



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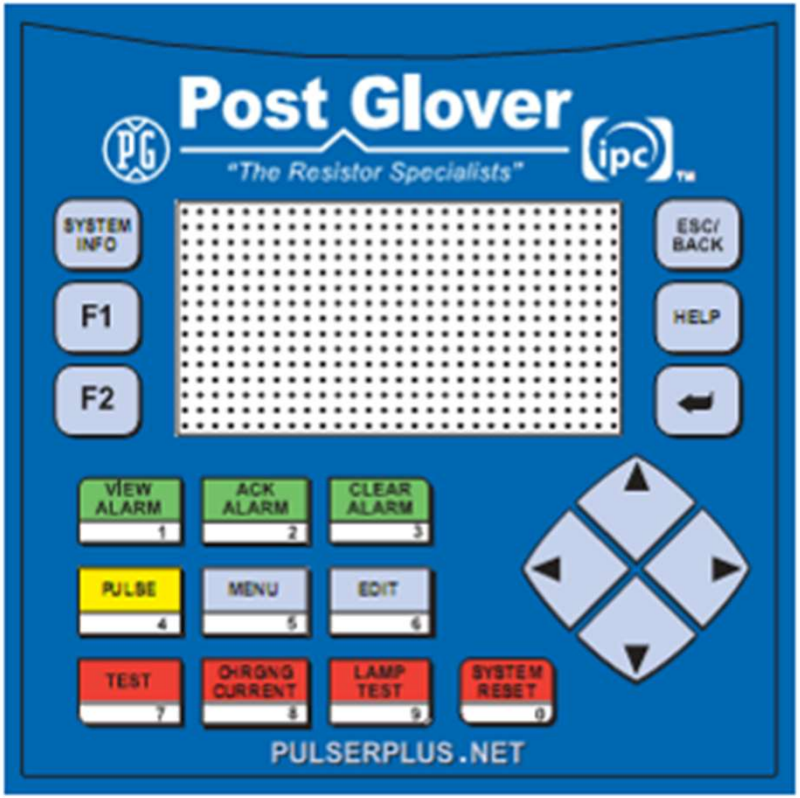
3-Phase Monitoring

- Monitors each phase and indicates which phase is faulted
- Knowing the faulted phase can assist with troubleshooting and repair

Ethernet Communications

- Ethernet communications allows our unit to easily network using TCP/IP.
- Also, includes ports for RS232, RS422 and RS485



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Unit Features

- Tapped Resistor
- Resistor Monitor
- UL Listed
- Switched Neutral is standard with a Solid Neutral available at customer request

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Tapped Resistor Settings

- Choose fault current higher than capacitive charging current with tap settings at 2,3,4, 5, 6 and 8 Amps. The last setting of 10 Amps is save for the pulsing circuit.
- Ex. If charging current is determined to be 1.5 A, choose at least 2 Amps of fault current.

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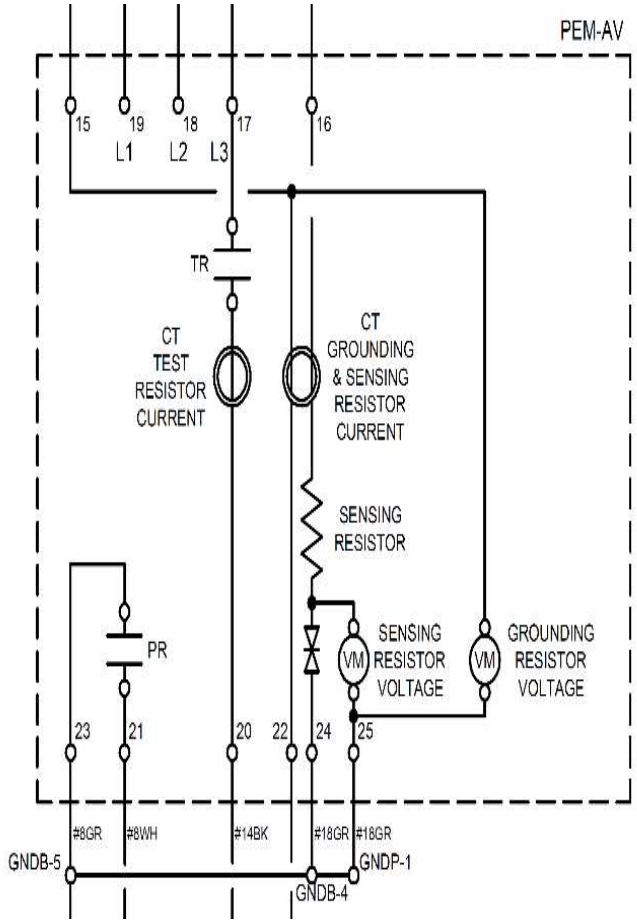
Resistor Monitoring

- Open Circuit Detection
- Active – Checks every 60 seconds, places a voltage across the system and compares to healthy state value



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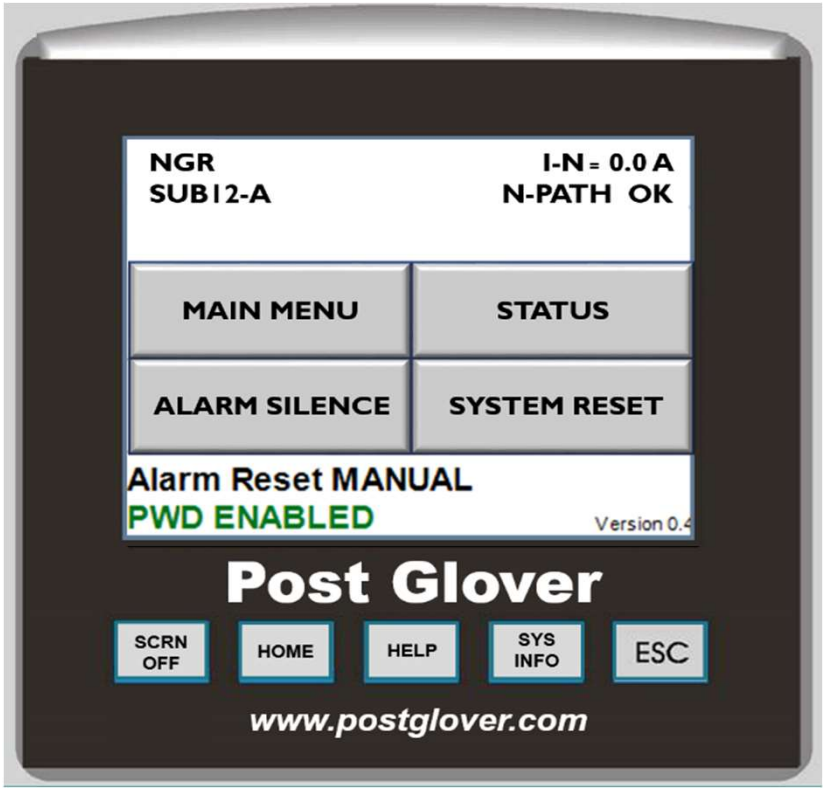
Feeder Monitoring System (optional)

USES TOUCH SCREEN PLC FOR EASE OF OPERATION



- Touch Screen control for ease of additional inputs
- User programmable alarm levels
- Same communication capabilities of PulserPlus.Net

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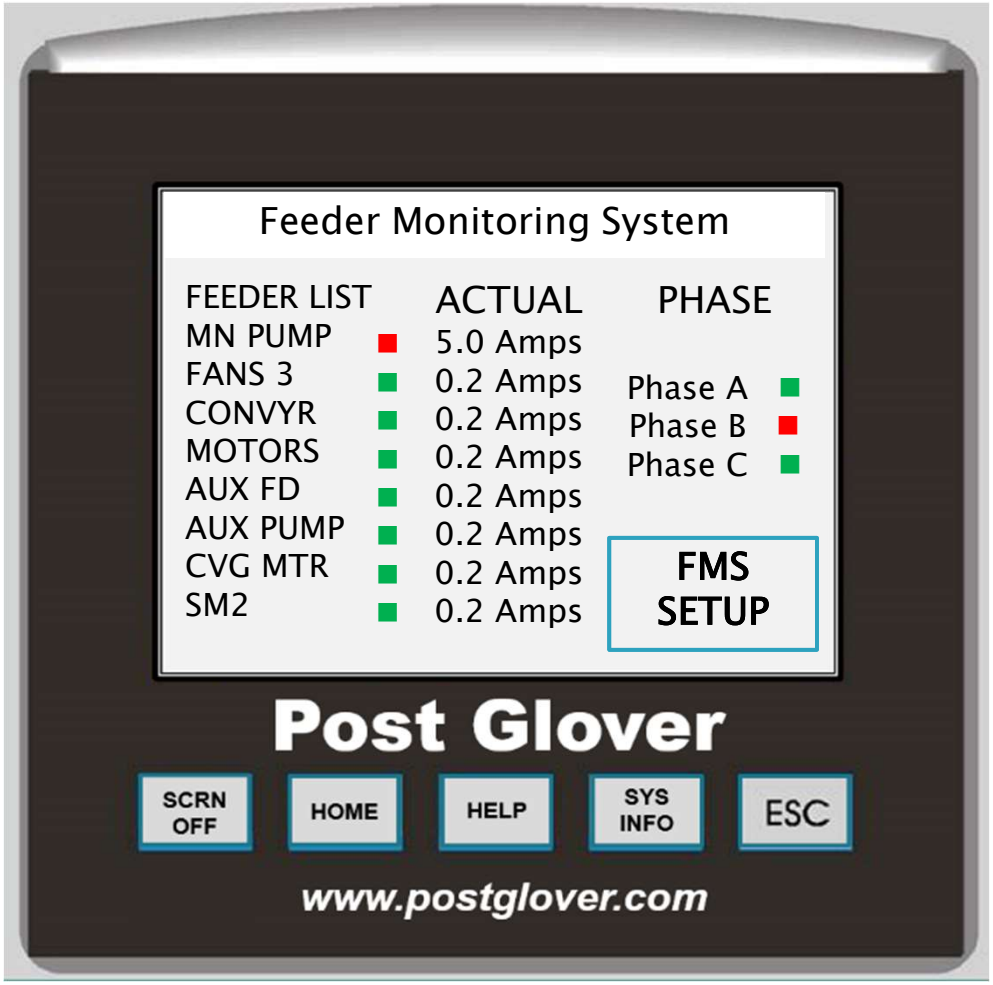
Feeder Monitoring System

MONITOR STATUS OF UP TO EIGHT FEEDERS

- Each feeder name can be up to 8 characters in length
- Displays real-time status of each phase and feeder during a fault.
- Provides relay outputs identifying faulted feeders for customer use.



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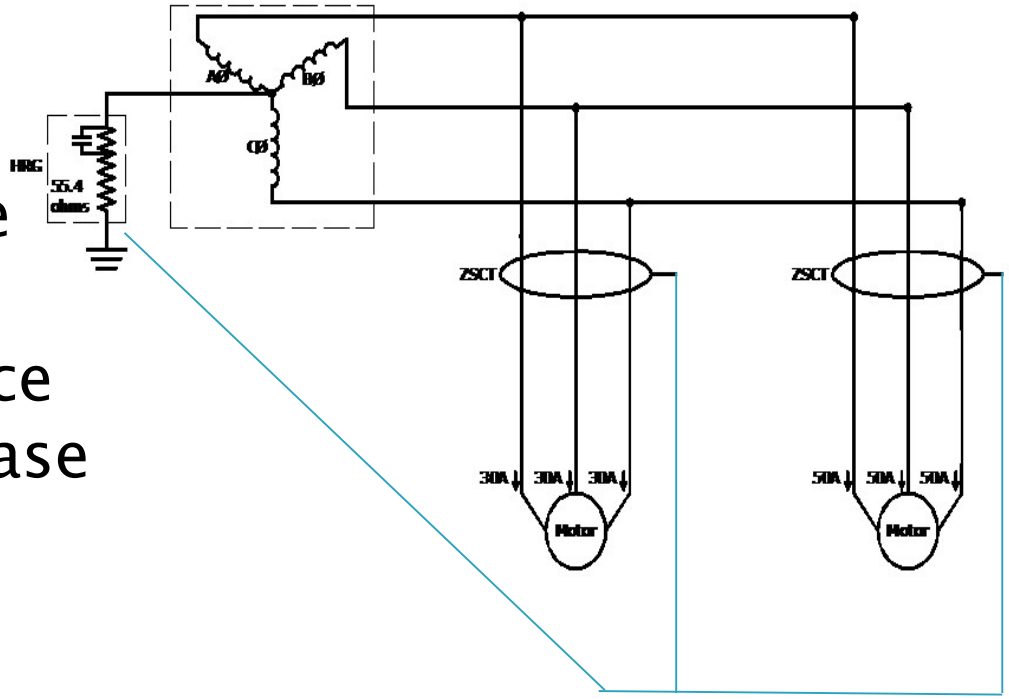
Communication with Feeder relays

- Feeder CT's detect fault current
- Allows for selective tripping
- Assists with advance fault location for ease of maintenance



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Unit Availability

- NEMA 1
- NEMA 3R
- OEM Kit
- Wall-Mounted

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Free Standing

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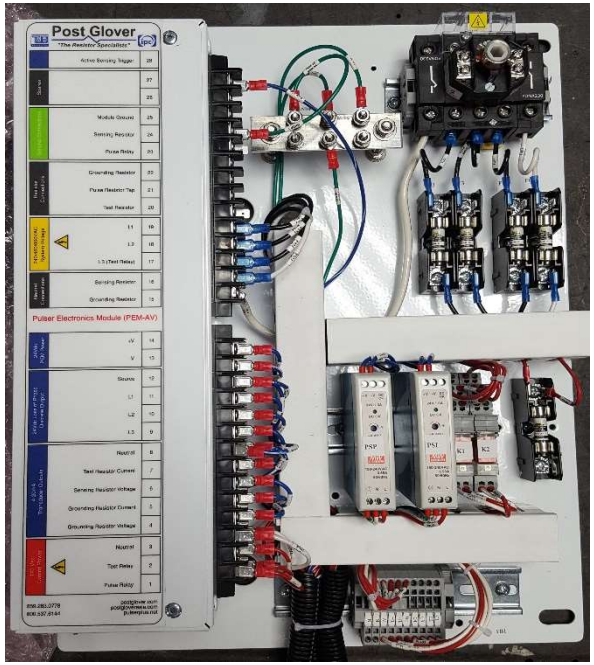
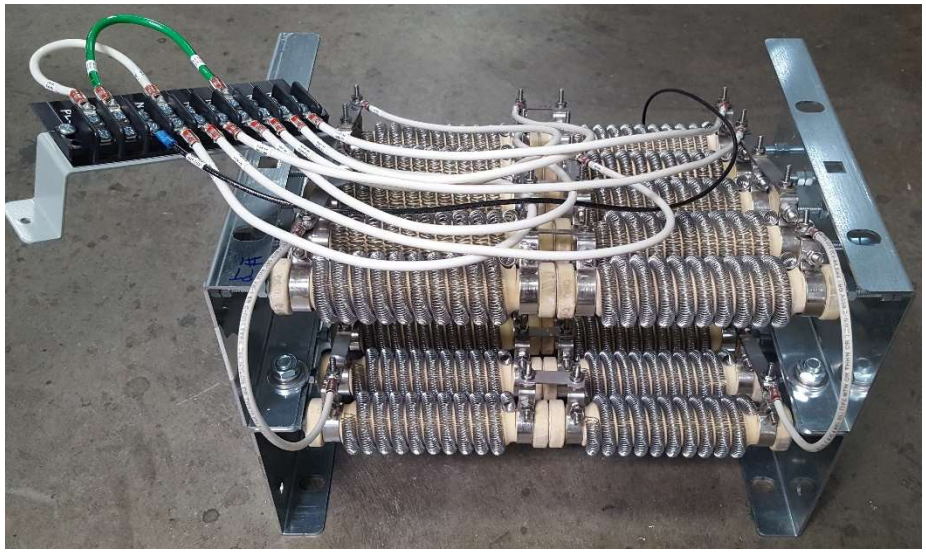
OEM Kit





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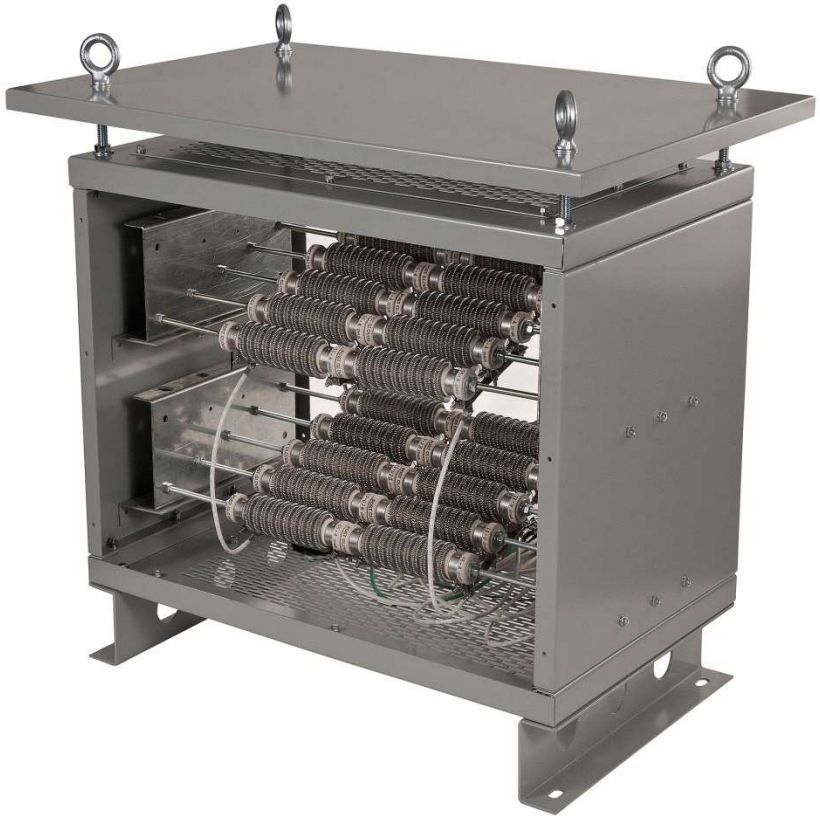
Wall Mounted Unit



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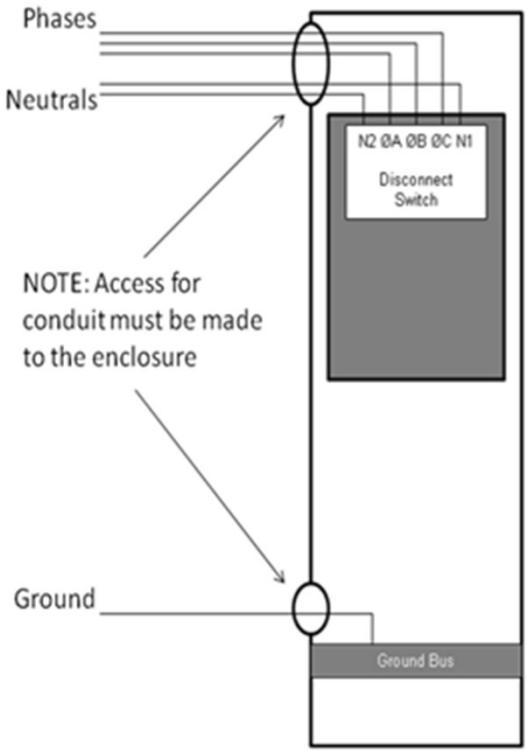
Connections:



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MV HRG

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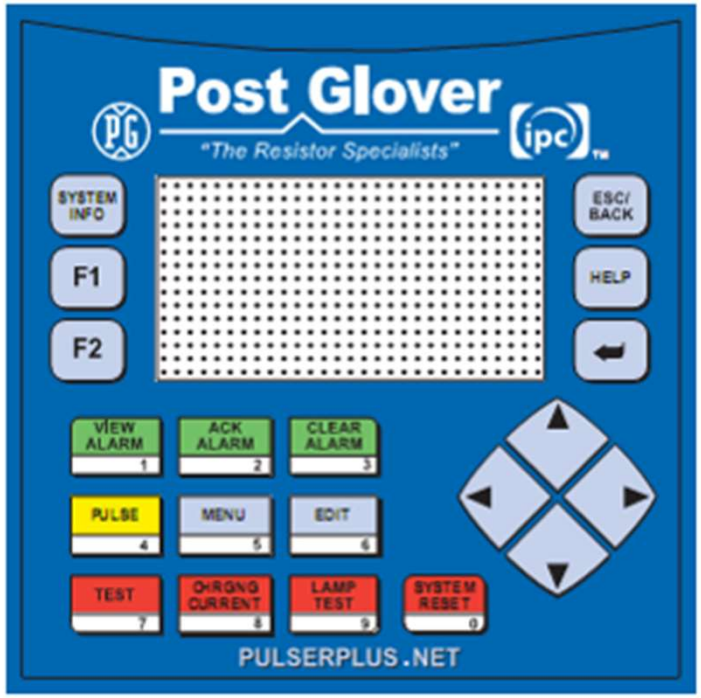
MV Digital Control

- Data Logging
- Alarm settings
- Pulsing
- Available Ethernet



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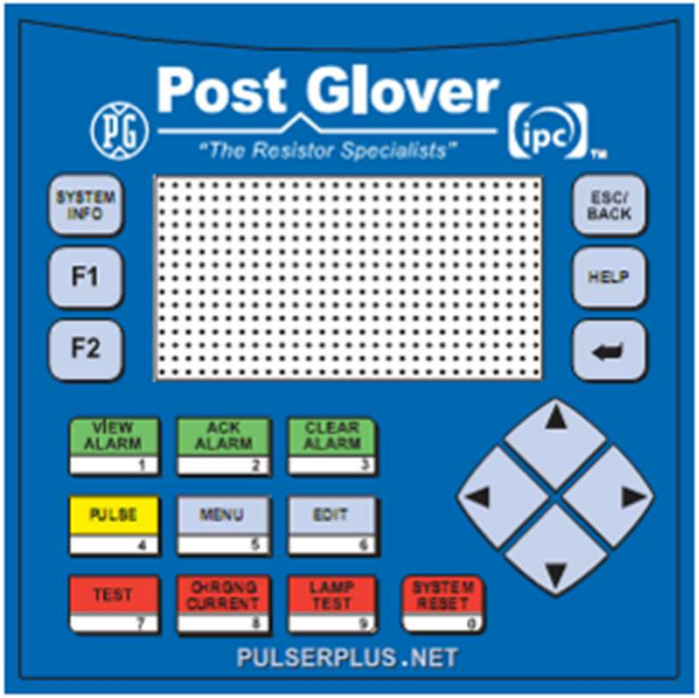
Summary

- Know your system before converting to resistance grounding
- Ask questions – “what we always do” might not work
- Let us help!



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