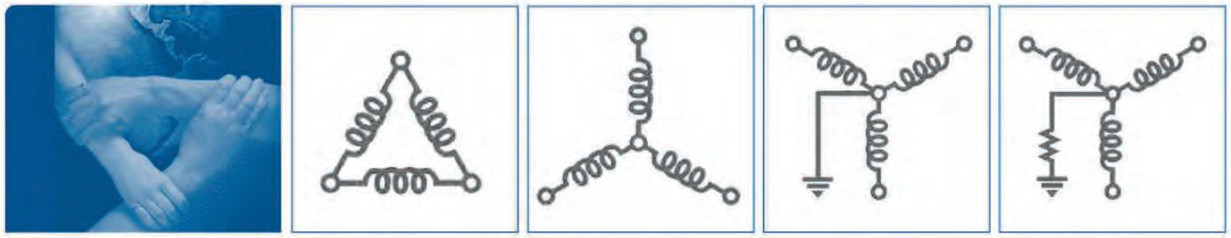
GARD

Unparalleled Protection

Time to Upgrade Your Ungrounded Electrical Distribution System

Speaker: Daleep Mohla



Webinar Agenda

- ✓Historical rationale for the application of ungrounded electrical systems
- ✓Pros and Cons of this technology
- ✓Application of Insulation Monitoring
- ✓Comparison of High Resistance and Ungrounded Systems
- ✓Recent advances in HRG Technology

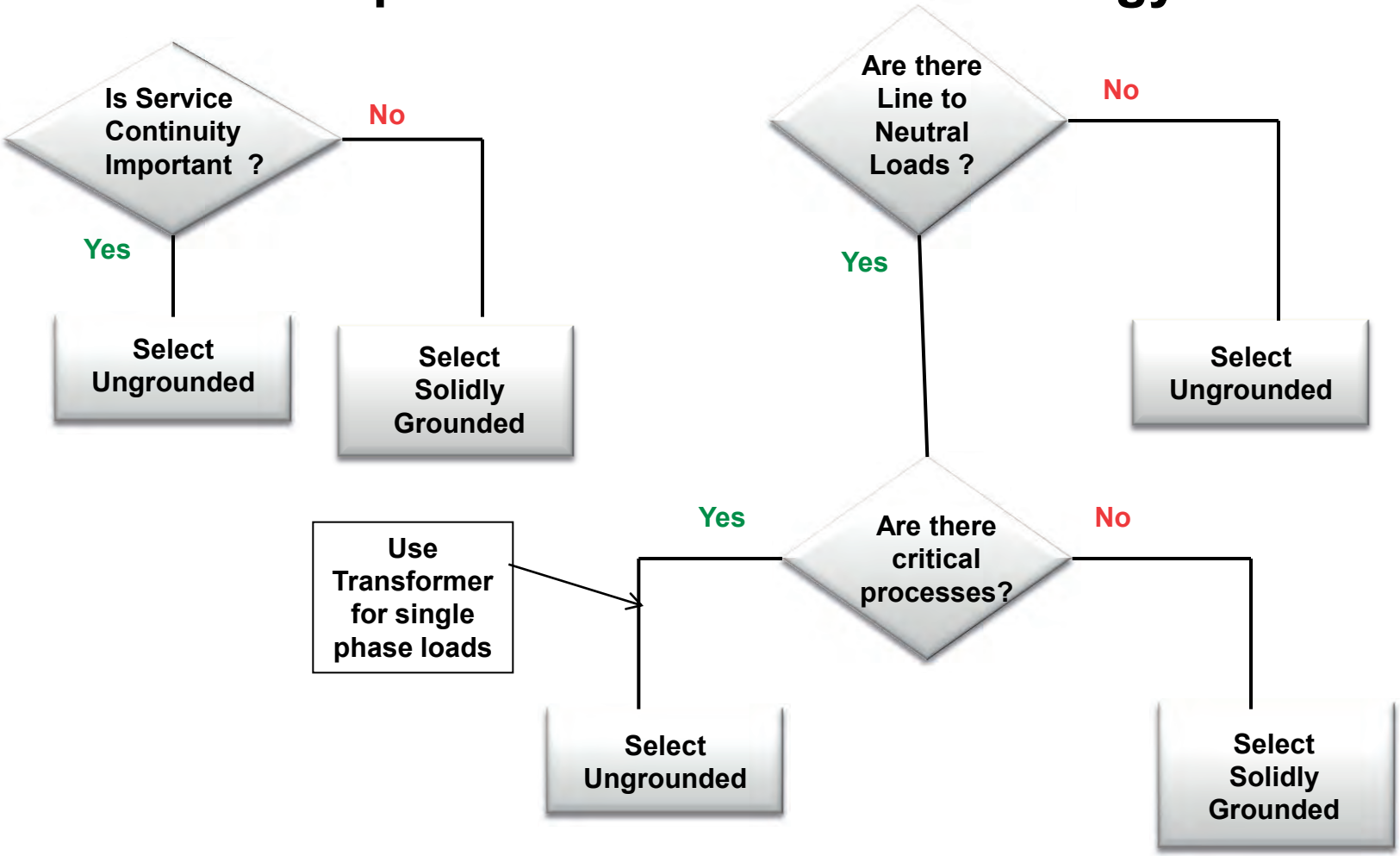
System Grounding Decision

Two Key Questions :

1. How important is service continuity?

2. Are there many line-to-neutral loads?

System Grounding Choices:
Options before HRG Technology

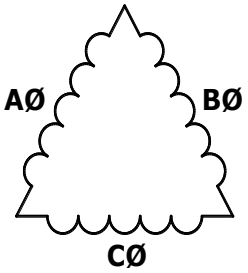


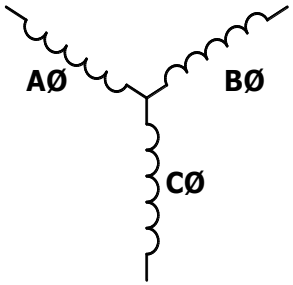
System Grounding Summary

	Ungrounded	Ungrounded with Insulation Monitoring	High Resistance Grounded
Process Continuity			

Ungrounded Systems

- Ungrounded systems do not have an intentional connection from the source generator or transformer to ground
- Typically a three wire delta system
- Can be a four wire system where the source neutral is not connected to ground





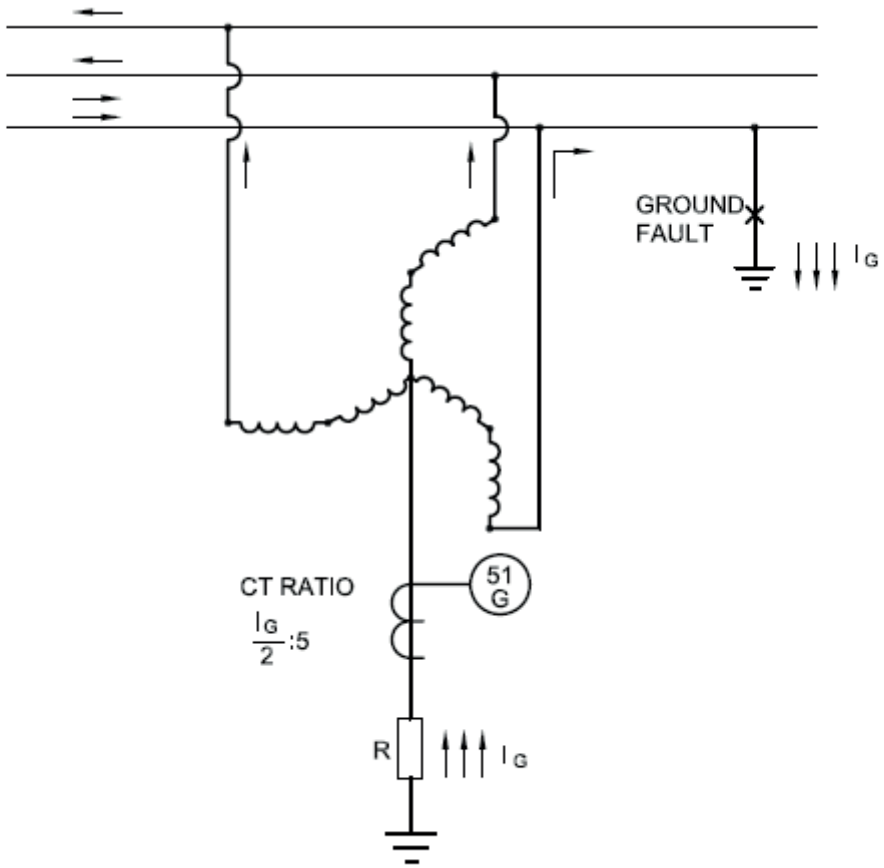
Ungrounded Systems

IEEE Standard 242-2001 (Buff Book)

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

8.2.5 Ungrounded low-voltage systems employ ground detectors to indicate a ground fault. These detectors show the existence of a ground on the system and identify the faulted phase, but do not locate the ground, which can be anywhere on the entire system.

Deriving Neutral for Delta Transformer



Ungrounded Systems

IEEE Standard 242-2001 (Buff Book)

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

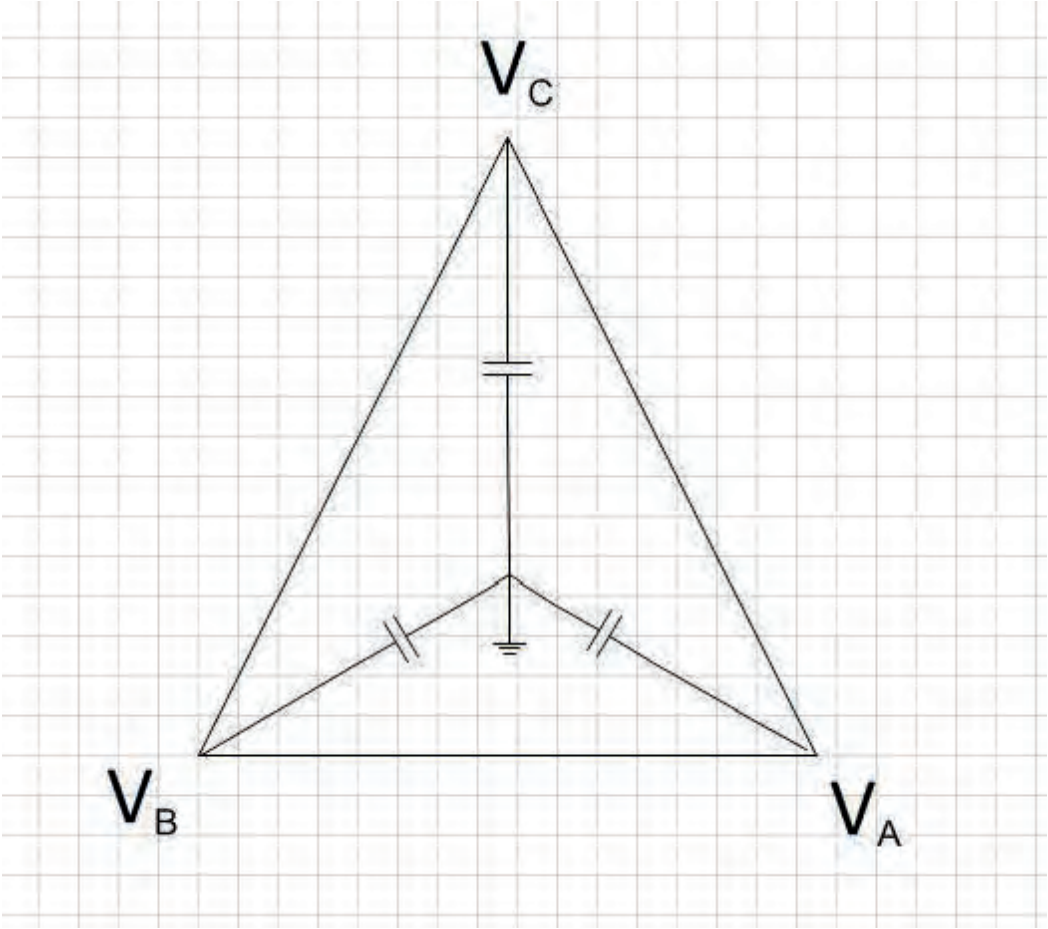
Ungrounded Systems

IEEE Std 141-1993 **(Red Book)**

Recommended Practice for Electric Power Distribution for Industrial Plants

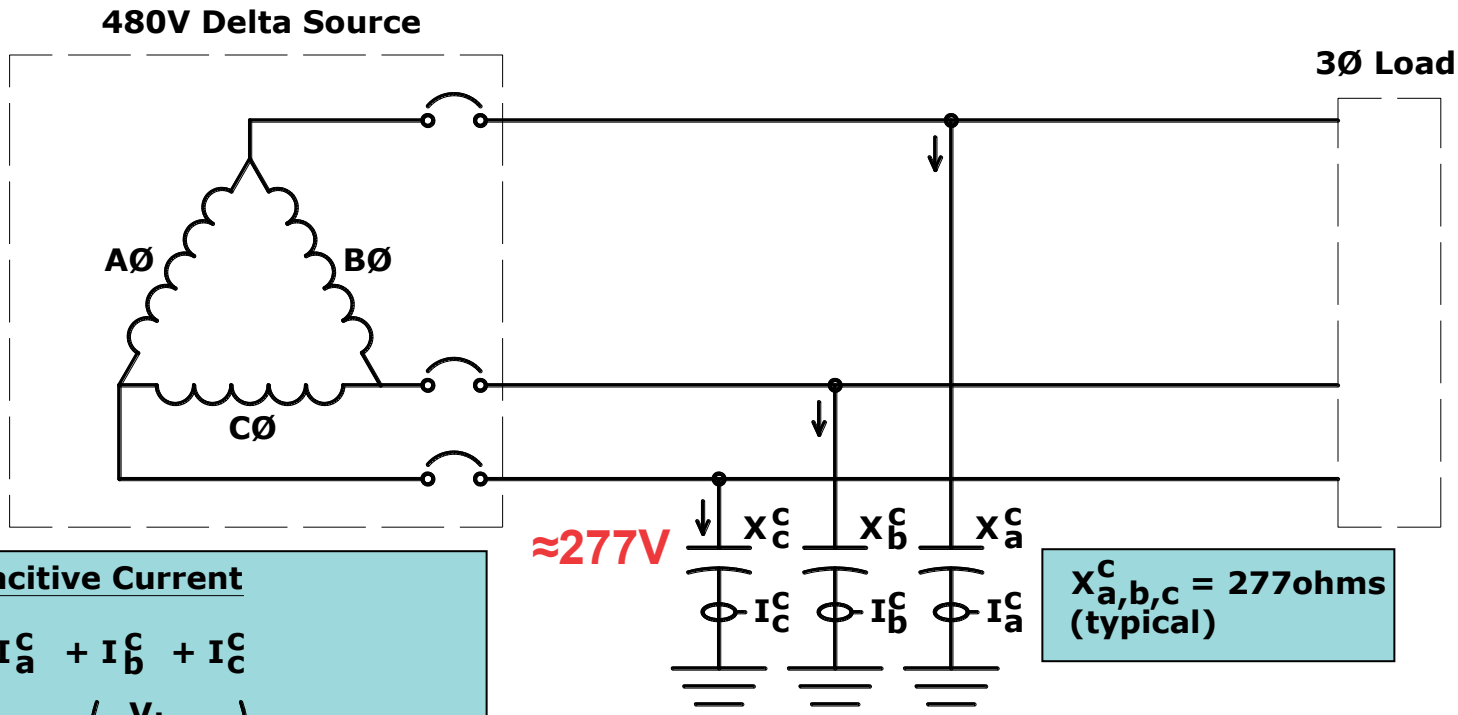
7.2.1 Accumulated operating experience indicates that, in general purpose industrial power distribution systems, **the over-voltage incidents associated with ungrounded operation reduce the useful life of insulation** so that electric current and machine failures occur more frequently than they do on grounded power systems.

Ungrounded?



Ungrounded Systems

- Unintentionally grounded through system capacitance
  - Such as cables, transformers, motors, surge suppressors, etc.



Total Capacitive Current

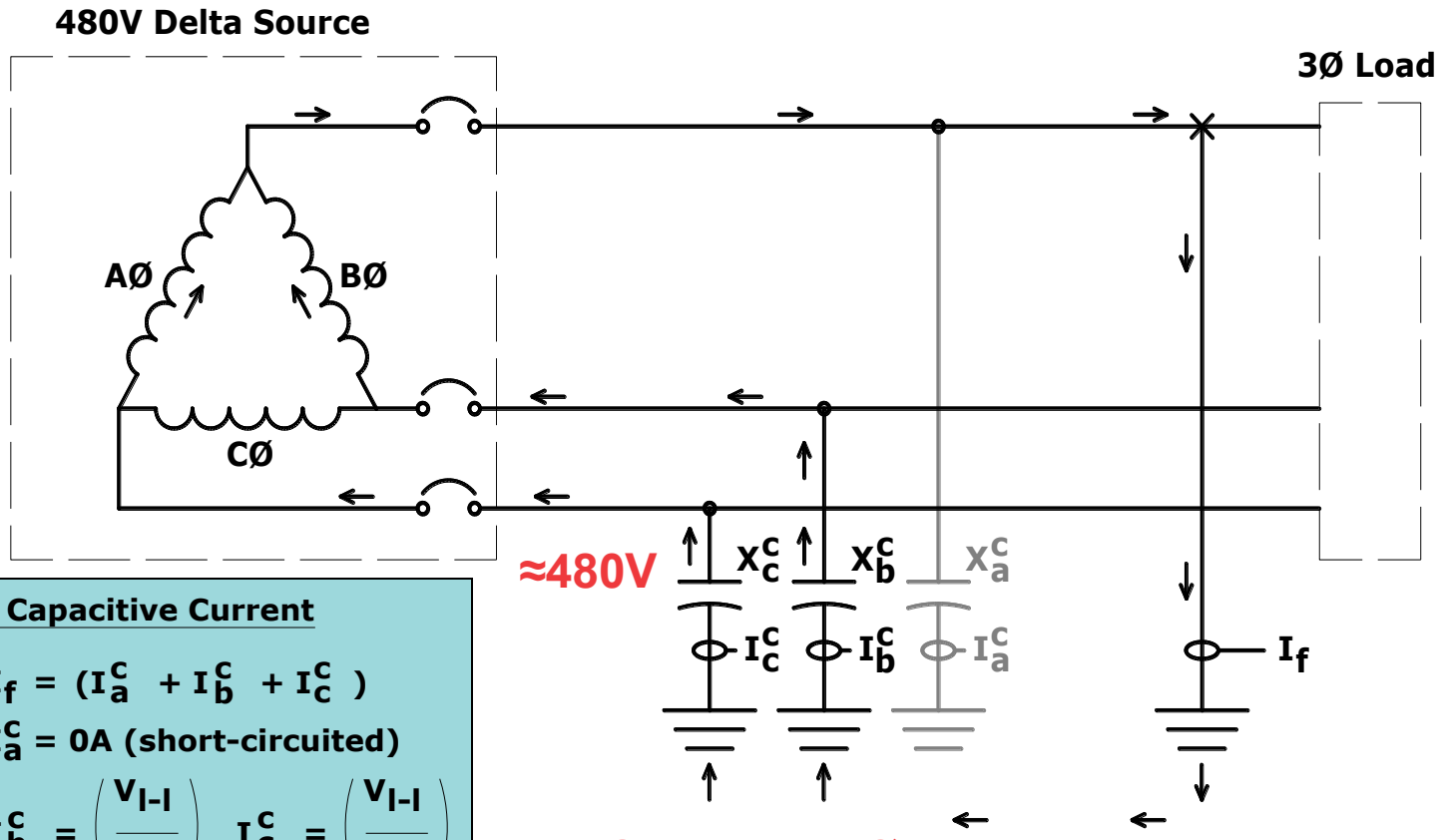
$$0 = I^c_a + I^c_b + I^c_c$$

$$I^c_{a,b,c} = \left(\frac{V_{l\text{-}n}}{X^c_{a,b,c}}\right) \text{ [120° apart]}$$

Ground ≈ 0V

Ground Faults on Ungrounded Systems

- Ground fault current distribution (minimal current)



Total Capacitive Current

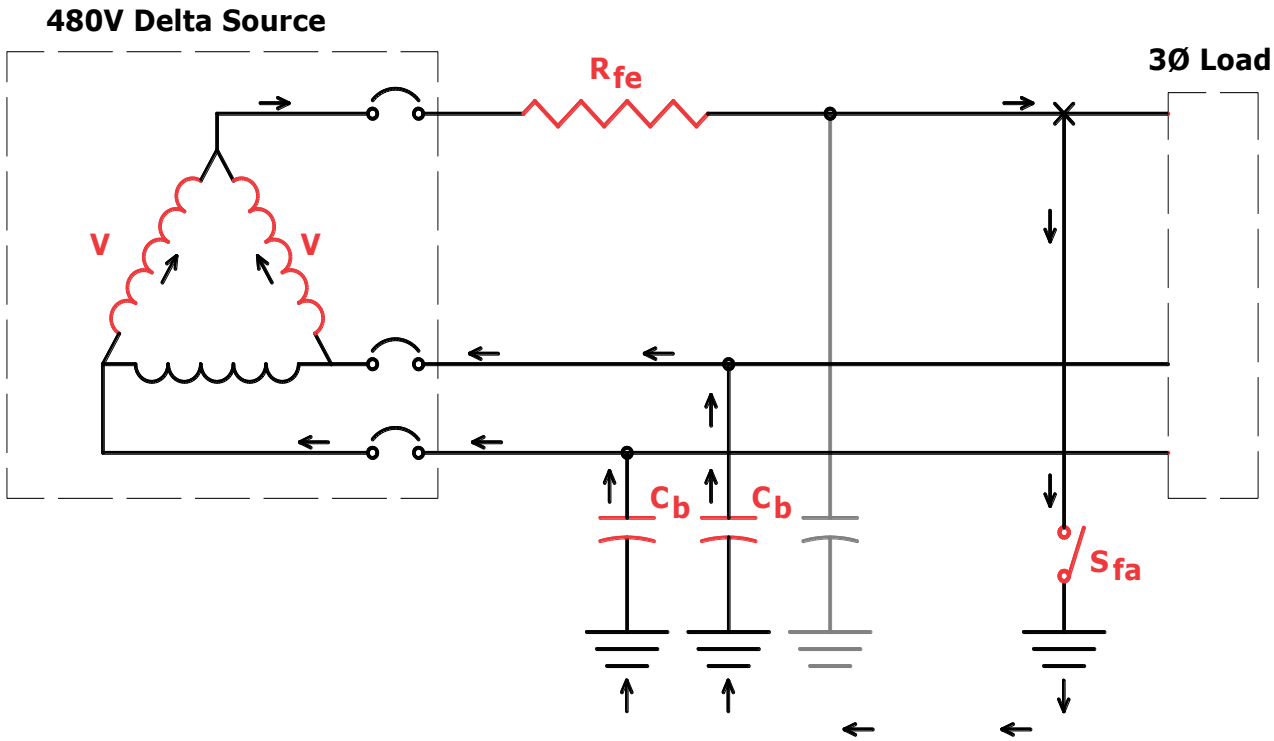
$$I_f = (I_a^c + I_b^c + I_c^c)$$

$$I_a^c = 0A \text{ (short-circuited)}$$

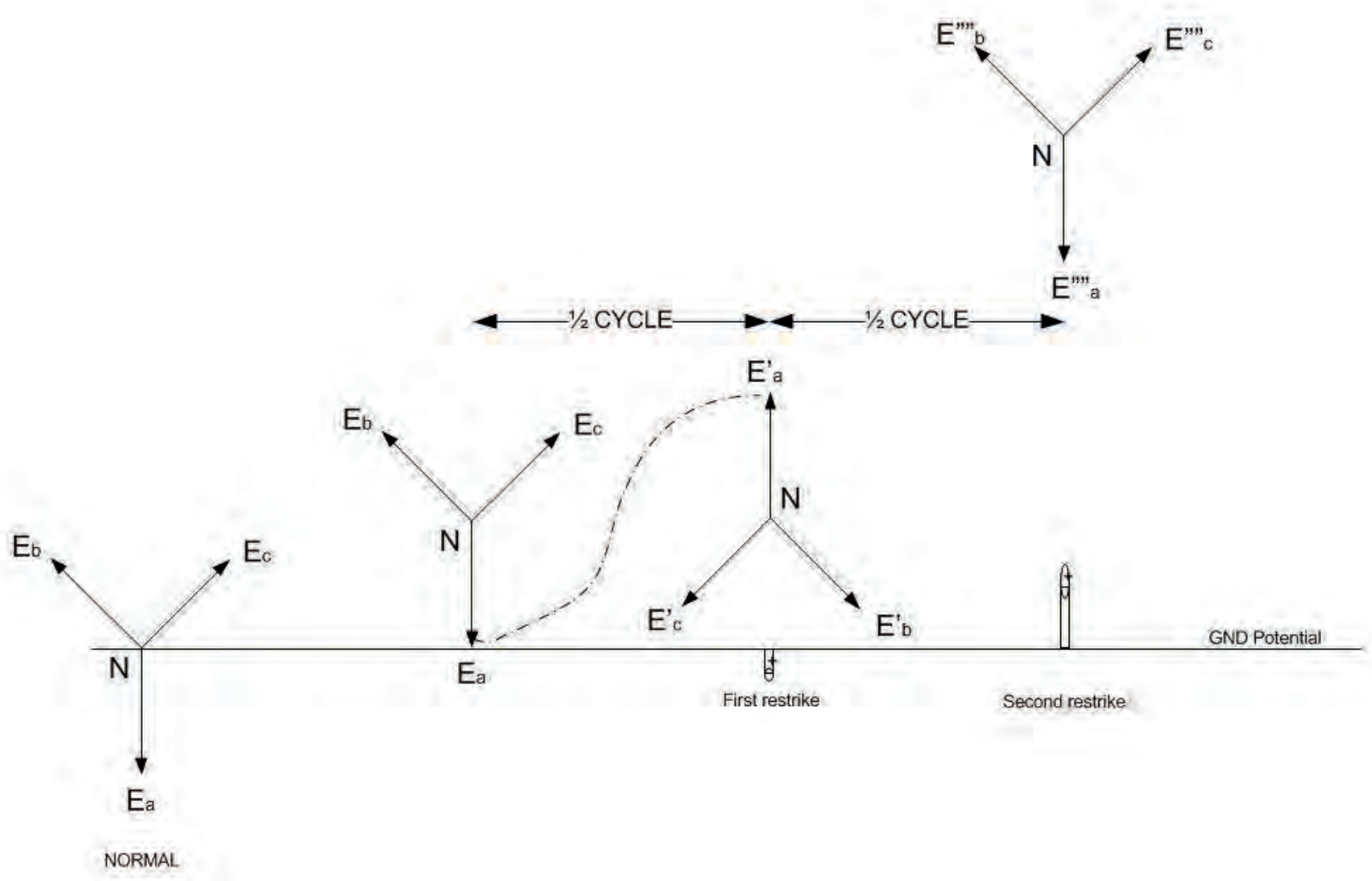
$$I_b^c = \left(\frac{V_{l\text{-}l}}{X_b^c}\right) \quad I_c^c = \left(\frac{V_{l\text{-}l}}{X_c^c}\right)$$

Arcing Ground Faults Intermittent or Re-strike

- **Intermittent ground fault:** A re-striking ground fault can create a high frequency oscillator (RLC circuit), independent of L and C values, causing high transient over-voltages.
  - i.e. re-striking due to ac voltage waveform or loose wire caused by vibration



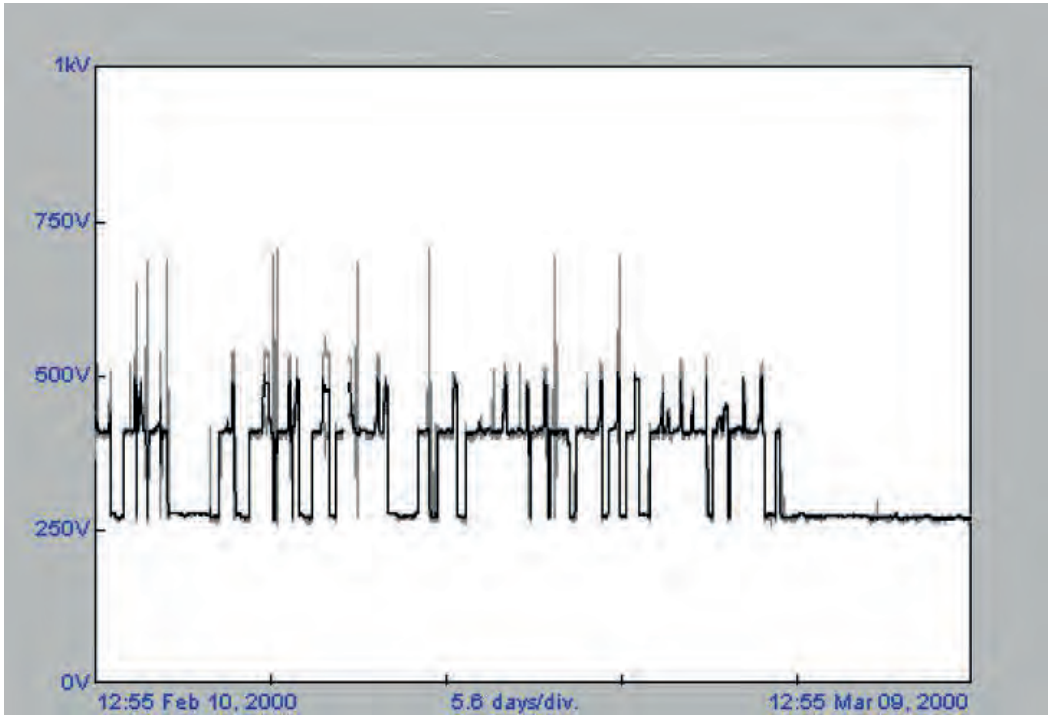
Transient Over-voltages



Case Study

Automotive Facility Troy, Michigan

Phase to Ground voltage monitored for 4 weeks ungrounded and 4 weeks high resistance grounded.



485 events with peak voltage above 700 volts due to intermittent ground faults.

Peak voltage 1050 volts.

Transients lead to insulation failure.

Impact of Transient Over-voltages

Insulation failure resulting in phase to phase fault and equipment damage in excess of $200,000.

Grounding System Summary

	Ungrounded	Ungrounded with Insulation Monitoring	High Resistance Grounding
Process Continuity			
Locate Ground Fault			
Control Transient Over-voltages			

System Grounding Options

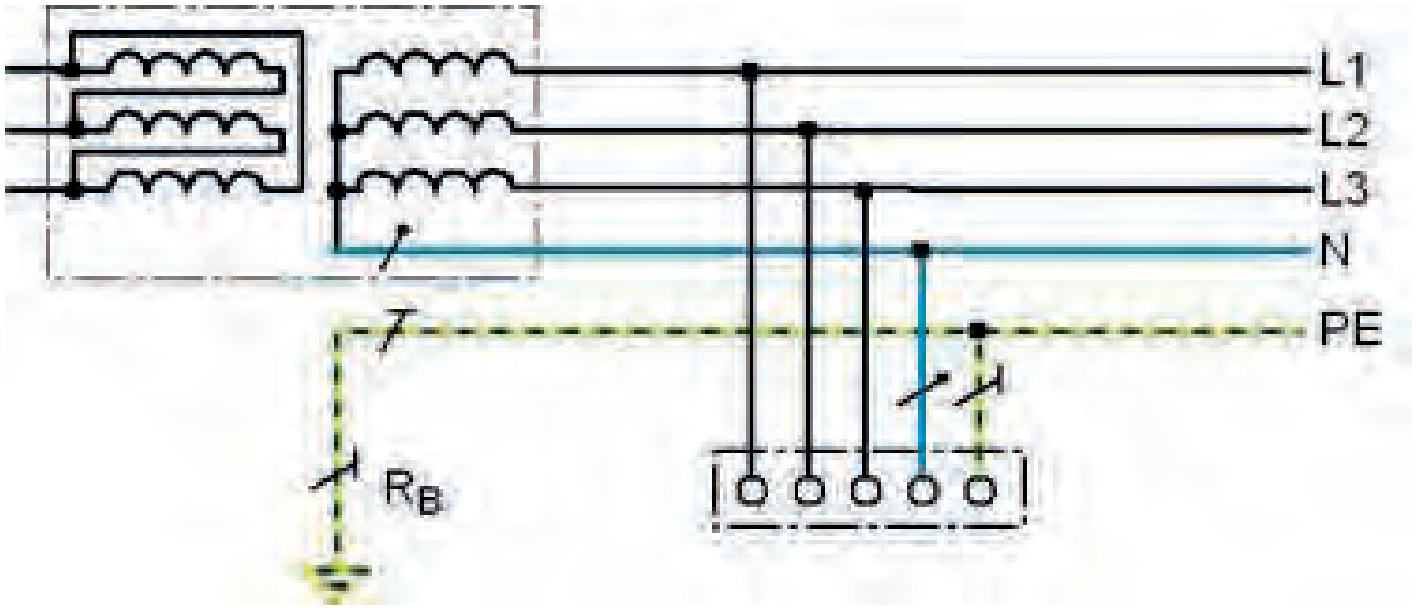
Install Insulation Monitoring

Upgrade to High Resistance Grounded

Insulation Monitoring Device

The Insulation Monitoring Device continuously monitors the impedance to ground (resistance and capacitive and reactance) by injecting both a DC and an AC current through the neutral point of the system.

If such impedance decreases below a predetermined value, due to a first fault to ground, an audible/visual alarm will be initiated.



Find a Fault with Insulation Monitoring

✓ Several pieces of hardware required for this:

- Low frequency current injection
- Zero sequence detection equipment
- Zero Sequence CT's around all feeders.

✓A low frequency current signal is injected into the electrical system and detected with zero sequence CT's.

➢Not effective in intermittent faults.

➢Does not limit transient overvoltage's.

➢May interfere with solid state equipment.

Grounding System Summary

	Ungrounded	Ungrounded with Insulation Monitoring	High Resistance Grounding
Process Continuity			
Locate Ground Fault			
Control Transient Over-voltages			

System Grounding Options

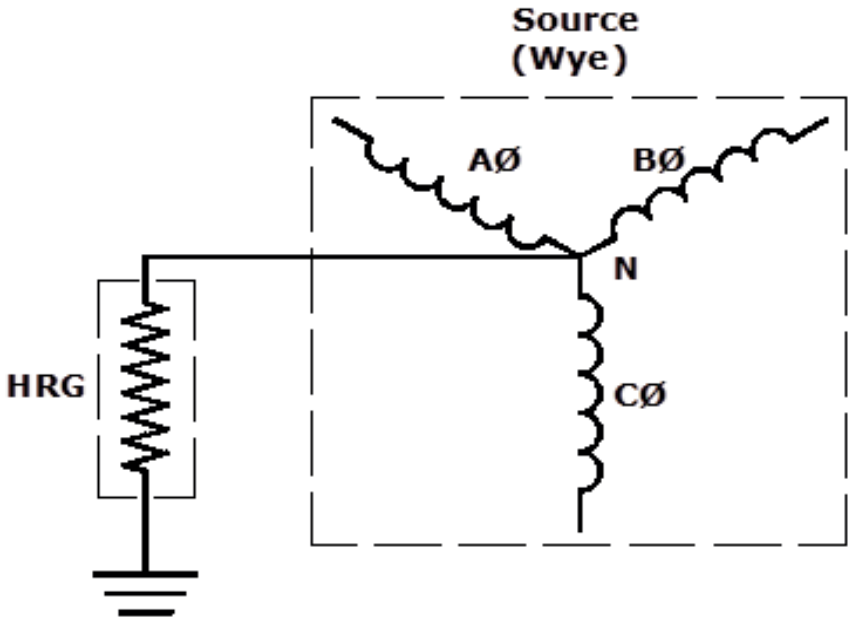
Install Insulation Monitoring

Upgrade to High Resistance Grounded

High Resistance Grounding

High resistance grounding of the neutral limits the ground fault current to a very low level (typically from 1 to10 amps) and this is achieved by connecting a current limiting resistor between the neutral of the transformer secondary and the earth ground and is used on systems, up to 5kV (nominal).

By limiting the ground fault current, the first fault can stay on the system until it can be located and removed quickly.



High Resistance Grounding

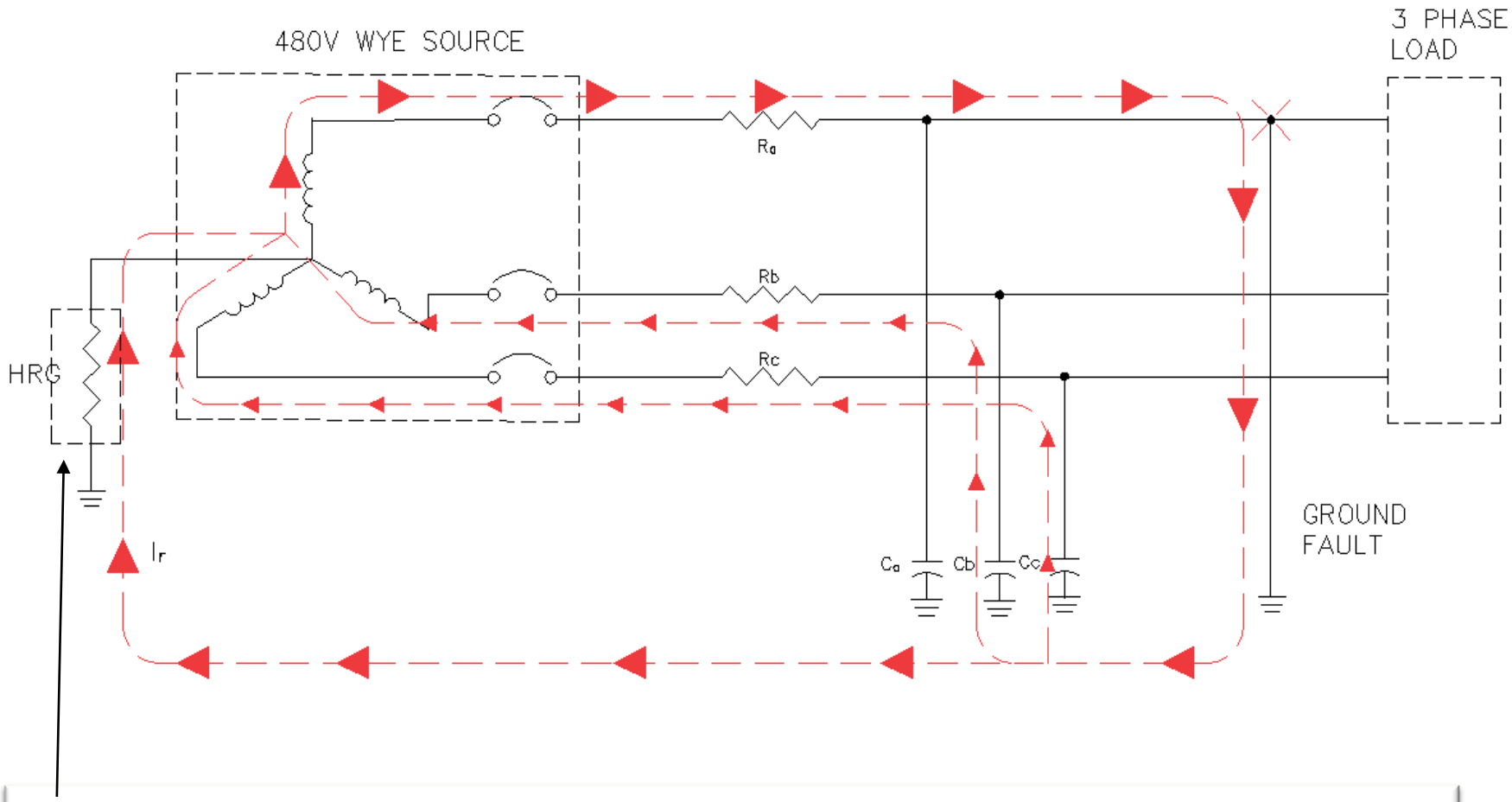
IEEE Standard 141-1993 **(Red Book)**

7.2.2. High-resistance grounding provides the same advantages as ungrounded systems yet limits the steady state and severe transient over-voltages associated with ungrounded systems.

IEEE Std 242-1986 Recommended Practice for the Protection and Coordination of Industrial and Commercial Power Systems

7.2.5. Ungrounded systems offer no advantage over high-resistance grounded systems in terms of continuity of service and have the disadvantages of transient over-voltages, locating the first fault and burn-downs from a second ground fault. For these reasons, they are being used less frequently today than high-resistance grounded systems".

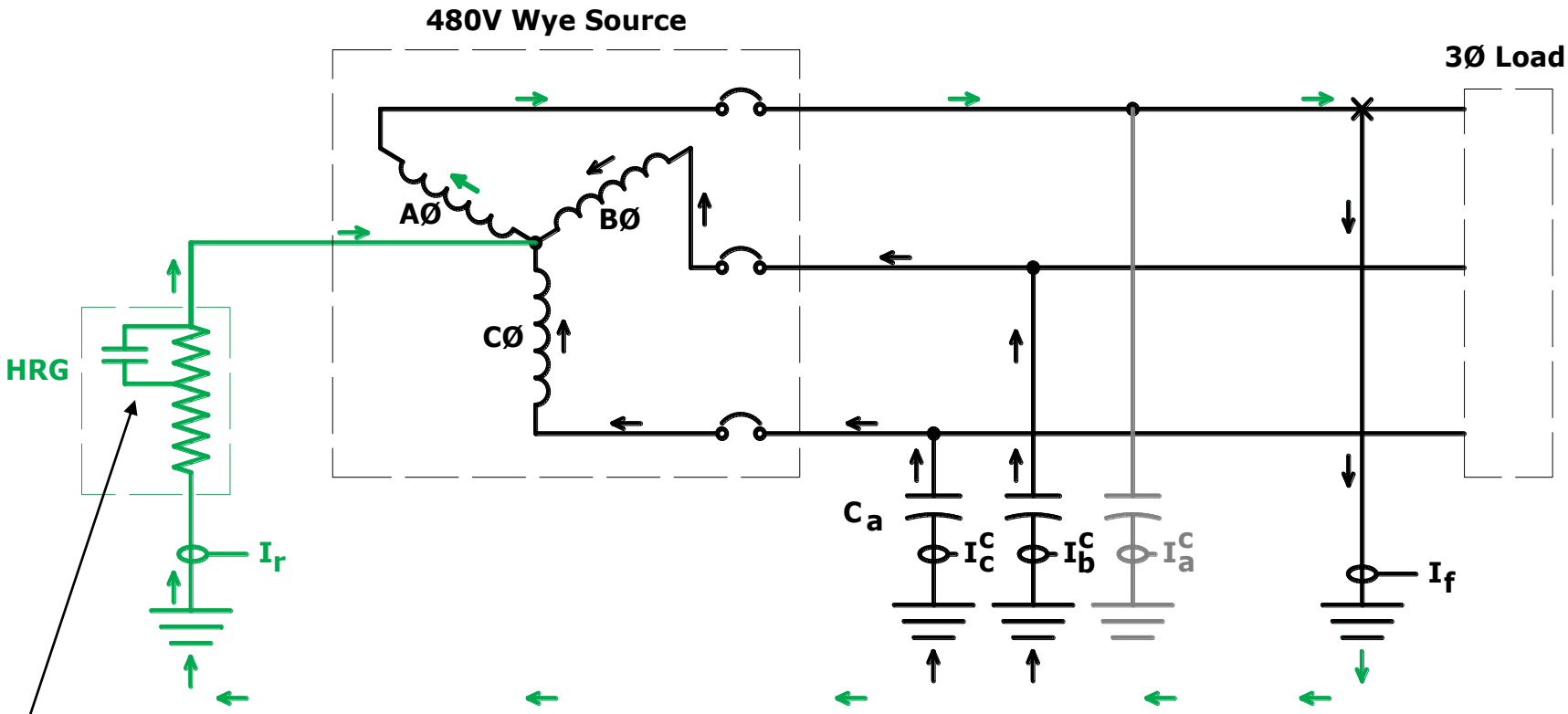
High Resistance Grounding



Resistor (HRG) in lieu of wire adds significant amount of resistance to lower ground fault to a predetermined value preventing destructive fault currents and shut-down!

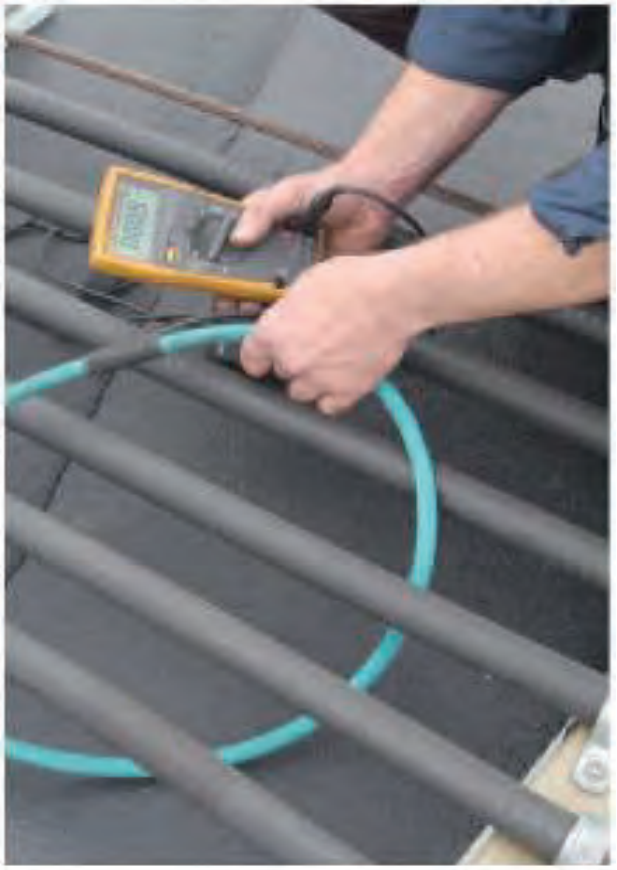
High Resistance Grounding

Advantage of return path - ground fault location



Contactor shorts out part of the resistor changing the resistance, hence, changing the current. Ground fault current now is a pulse signal that allows for detection!

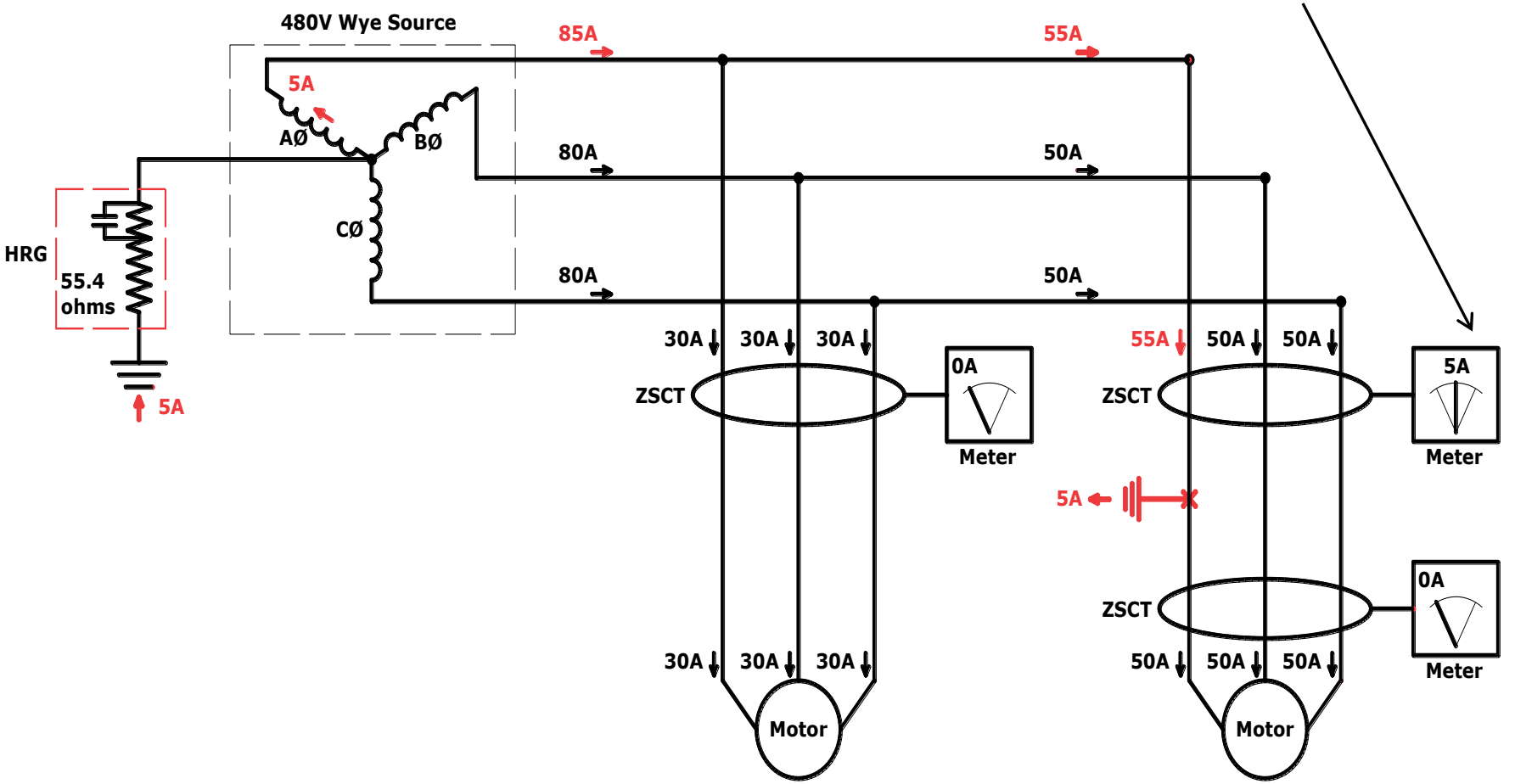
Ground Fault Pulse Locating



High Resistance Grounding

Method to quickly locate ground faults.

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

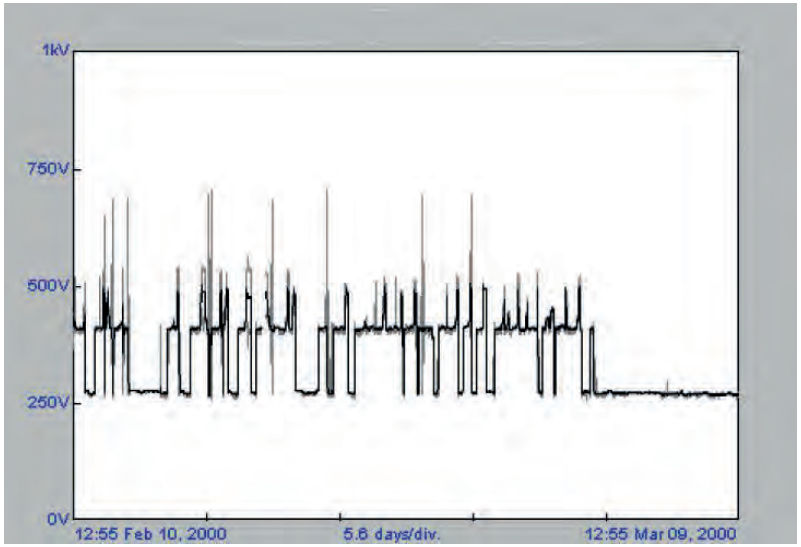


Case Study: Transient Voltage Control

Automotive Facility

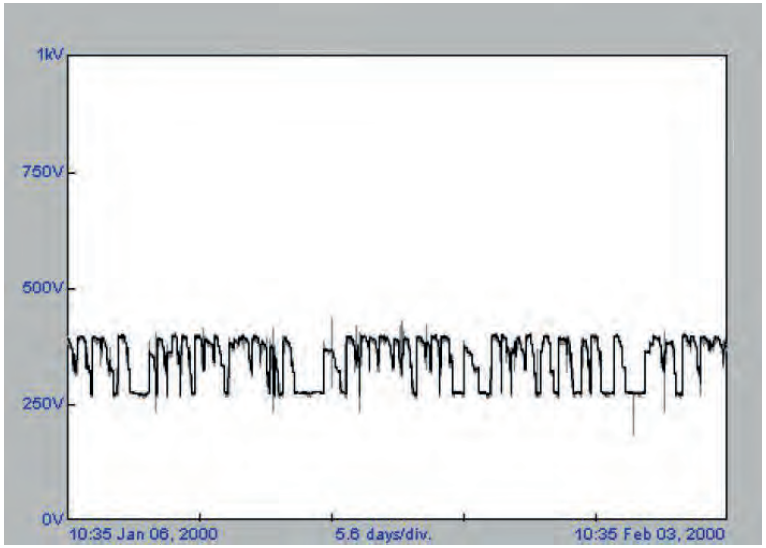
Troy, Michigan

Phase voltage ungrounded



✓High level of transients
✓485 peak events over 700 volts
✓Peak voltage 1050 volts

Phase voltage HRG



✓Transients controlled
✓0 peak events over 700 volts
✓Peak voltage 660 volts

Grounding System Summary

	Ungrounded	Ungrounded with Insulation Monitoring	High Resistance Grounded
Process Continuity	✓	✓	✓
Locate Ground Fault	✗	✓	✓
Control Transient Over-voltages	✗	✗	✓

Top 7 Excuses to Avoid HRG Technology

1. I just don't have room.
2. What if I lose the resistor circuit?
3. It takes too long to locate the fault even with pulsing.
4. What if I don't want the fault to stay on the system indefinitely?
5. What if the fault is intermittent?
6. What if a second fault occurs?
7. My budget can't afford it right now.

High Resistance Grounding:

What if I don't have enough room?

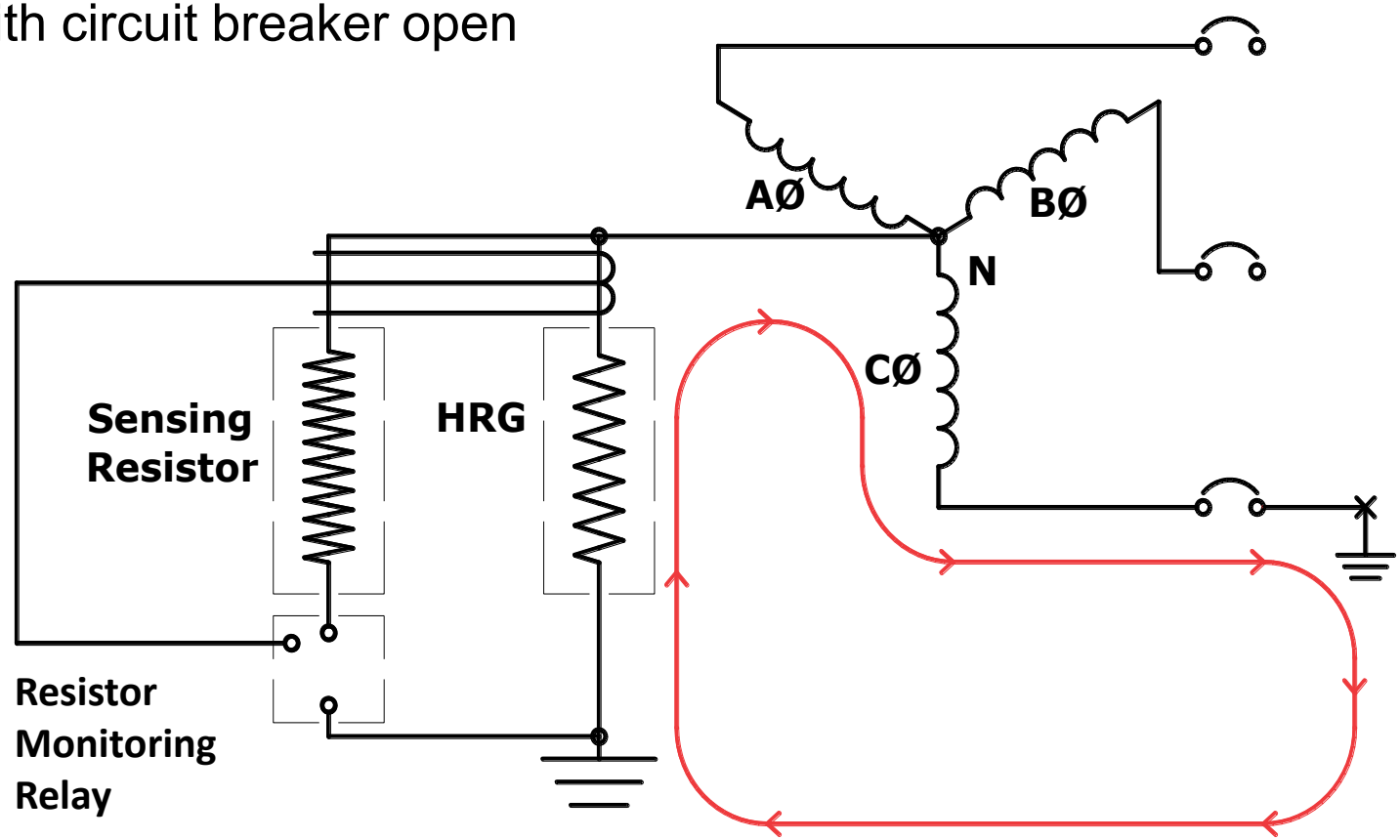
16" x14" x15" (h x w x d)
13 ¼" x 10" (mtg)

14 ½ " x11" x18 ¼ " (h x w x d)

High Resistance Grounding:
What if I lose the Resistor Circuit?

Ground Fault Relay & Sensing Resistor

Detects Open / Short Circuits and annunciates failure of HRG even with circuit breaker open

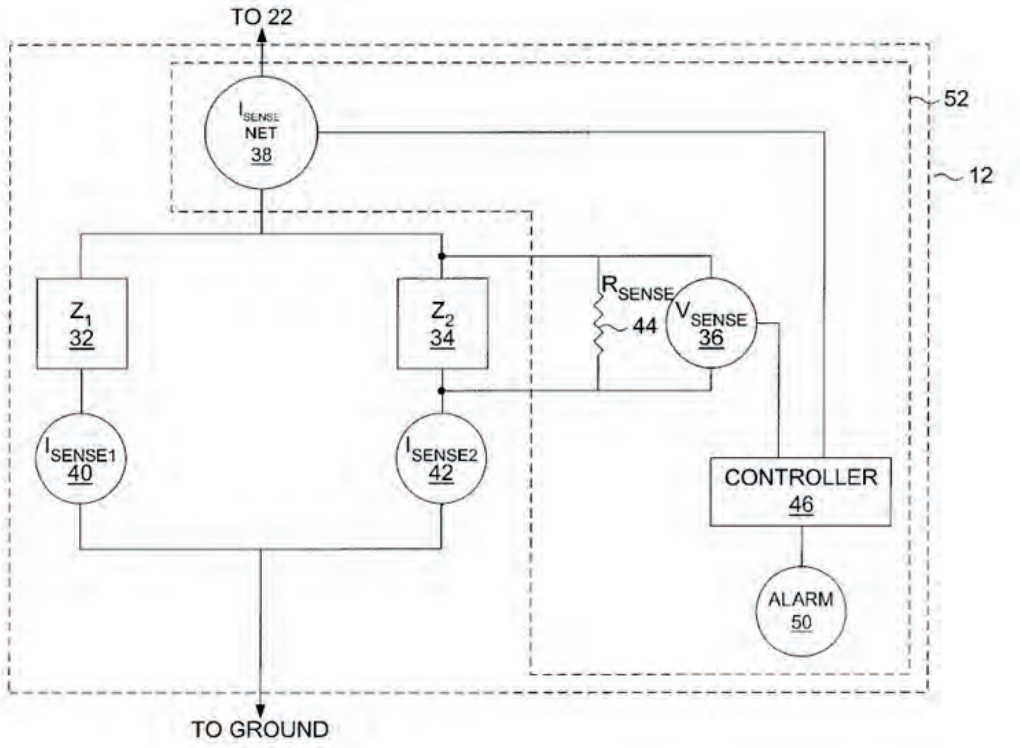


High Resistance Grounding:

What if I lose the Resistor Circuit?

In this monitored and **fail-safe circuit**, there is a parallel resistance circuit comprised of two identical resistor paths connected from the neutral to the ground.

The parallel resistance circuit is sized to limit any ground fault to predetermined levels. In the unlikely event that one resistor path fails, the second resistor path continues to limit the ground fault to half of the predetermined levels and still provides full ground fault protection and an alarm indicating resistor failure.



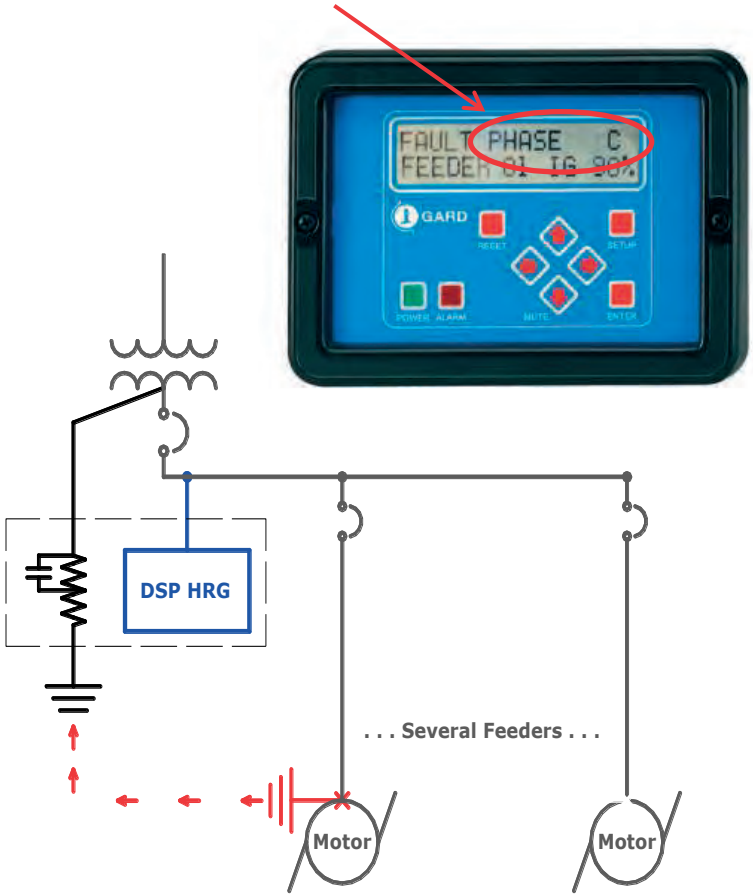
In conjunction with a sensing resistor and a series current transformer, a monitoring relay measures current through the neutral grounding resistor, transformer neutral to ground voltage and NGR resistance for continuity.

This relay has the capability to discriminate between ground faults, resistor failure and open and short circuits. The unit trips in 1.5 seconds when NGR failure is detected. NGR failure is determined when resistance varies to less than 66%or more than 150% of the selected value.

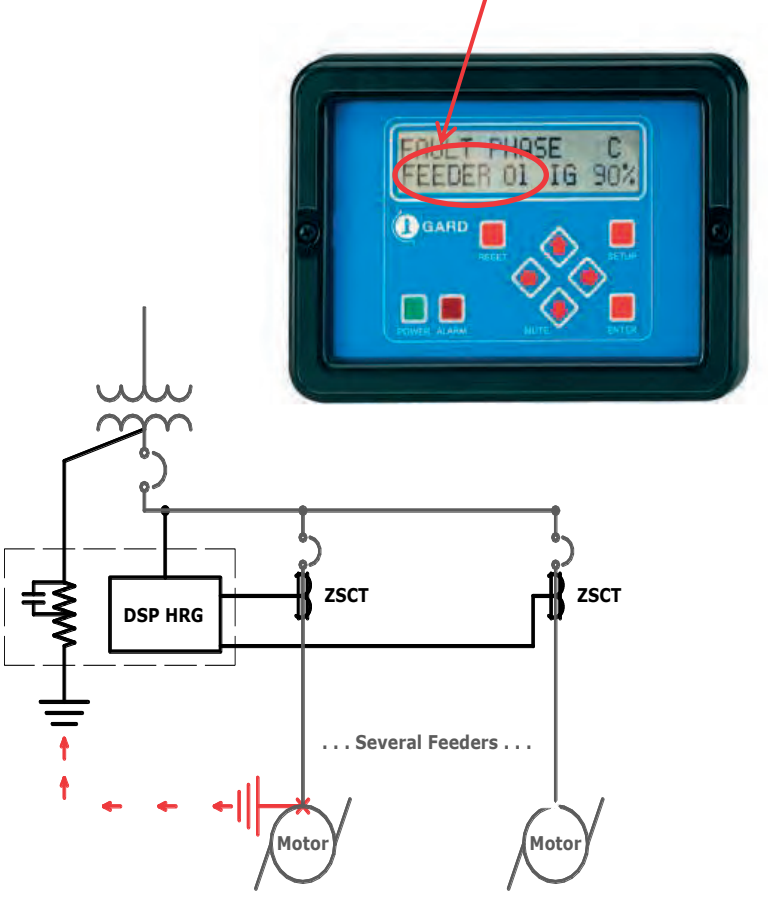
High Resistance Grounding

It Takes Too Long to Find The Fault

Automatically indicates faulted phase



Automatically indicates faulted feeder



High Resistance Grounding:

I Don't Want the Fault to Stay on the System Indefinitely

Feeder module

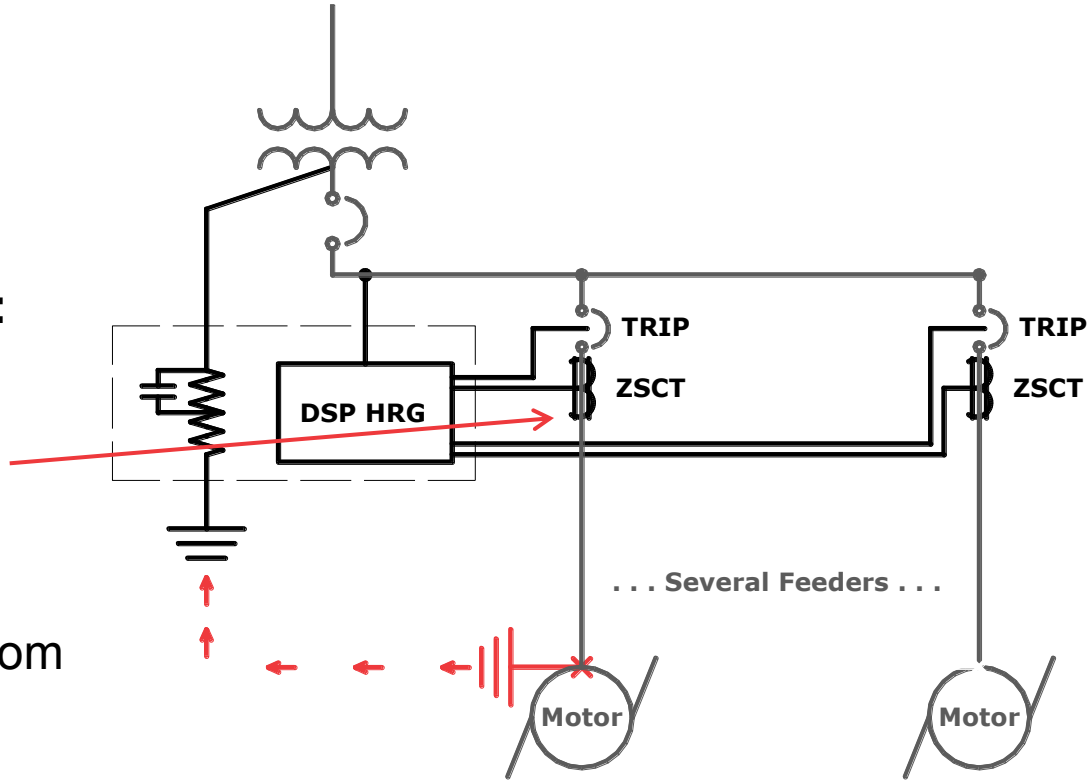
Options for Faulted Feeder:

1) Alarm Only (No Trip)

   OR

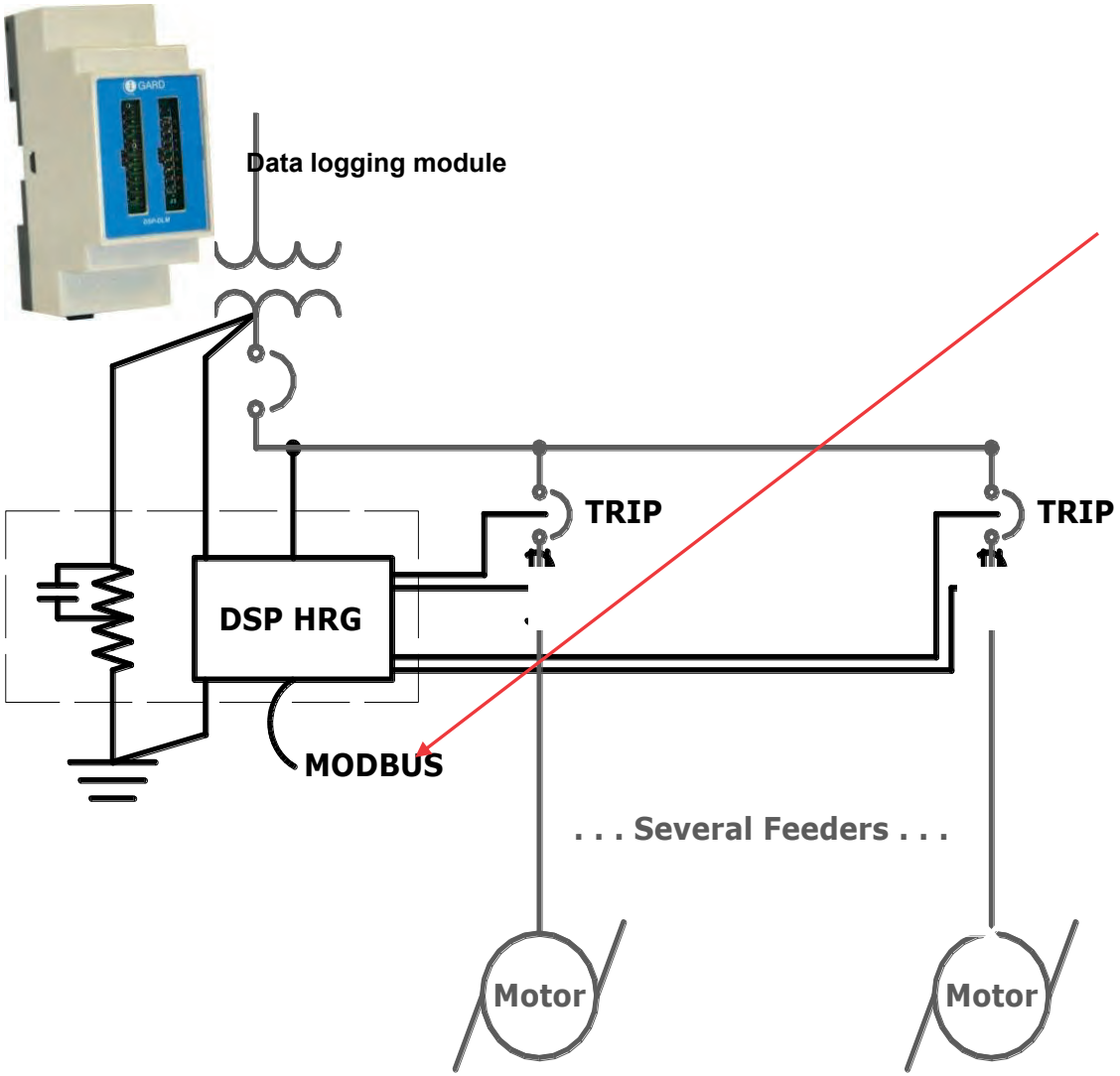
2) Trip with Time Delay

3) You set the Time Delay from 1 second to 99 hours



High Resistance Grounding:

What if the Fault is Intermittent?



1) Feeder Module indicating light latches to indicate intermittent fault.

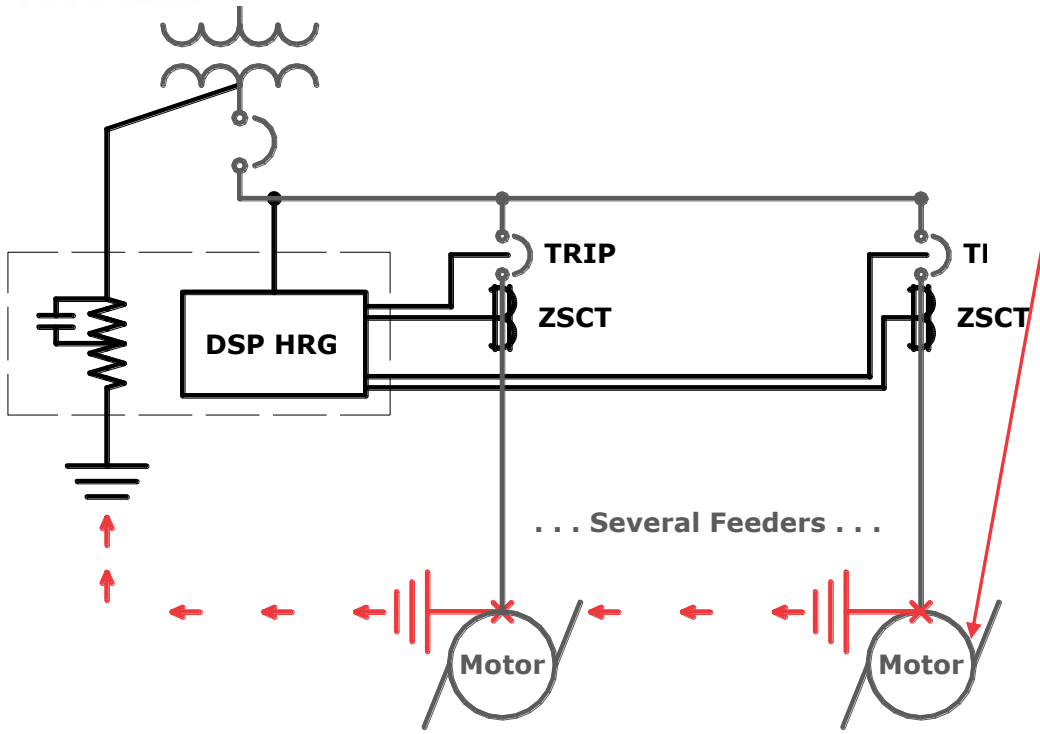
2) Remote Monitoring.

   Use Modbus communication to remote monitor the system and the data logging module for trend analysis.

High Resistance Grounding:

What if a Second Ground Fault Occurs?

Feeder module



2nd Ground Fault:

- Prioritize Feeders
- Trips least important, maintaining operation on most important
- Up to 50 Feeders
- Reduces the risk of arc flash

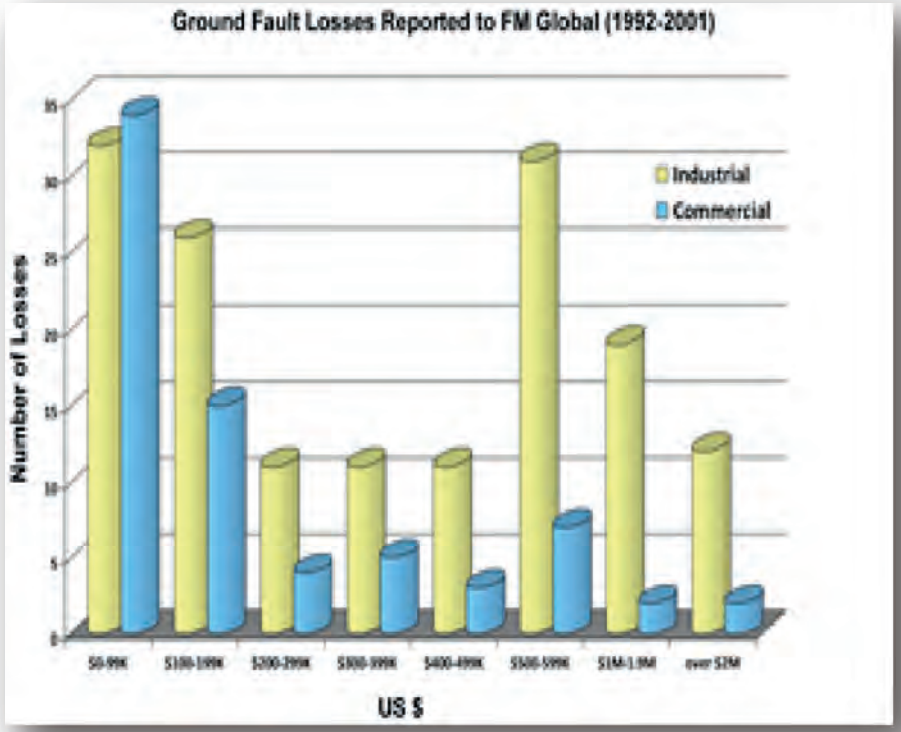
High Resistance Grounding:

Can you afford this?

One leading US based insurance company notes that over a 7 year period their clients reported 228 losses that were attributed to ground faults resulting in payments of $180 million.

On the direct side are the costs associated with equipment repair and replacement as well as the direct medical costs associated with injuries.

On the indirect side we see the cost of business interruption in terms of unscheduled delays, employee training and redeployment, accident investigation, legal costs and possible fines etc.



Average Impact on Industrial Companies

$769,000

Grounding Systems Summary for Process Continuity

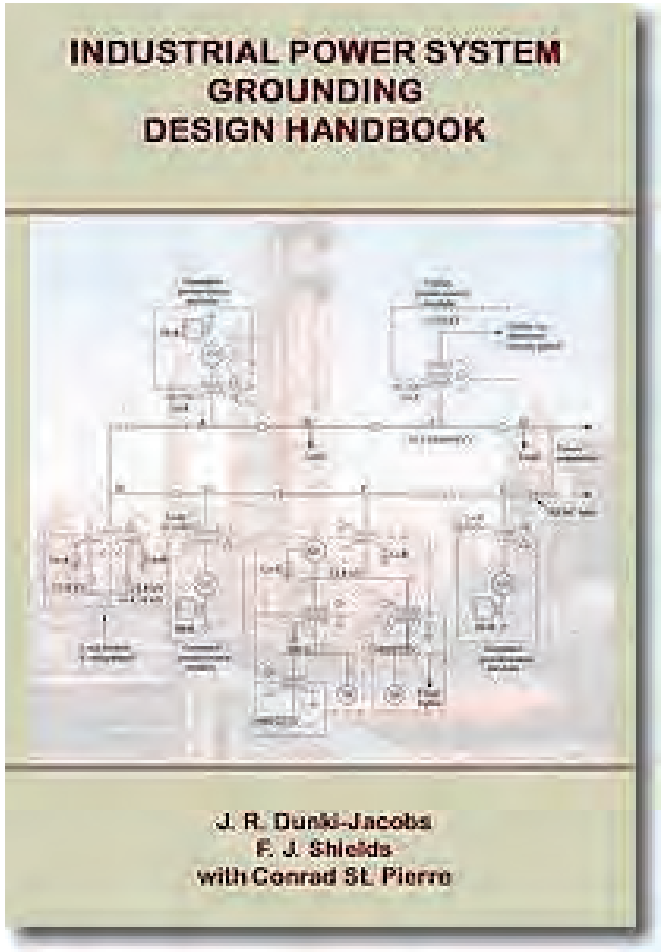
	Ungrounded	Ungrounded with Insulation Monitoring	High Resistance Grounded	Advanced High Resistance Grounding
Process Continuity	✓	✓	✓	✓
Locate Ground Fault	✗	✓	✓	✓
Control Transient Over-voltages	✗	✗	✓	✓
Mitigates Arc Flash	✗	✗	✓	✓
2nd Fault Protection				✓
Latch on Intermittent Faults				✓
Feeder Indication				✓
Monitor Resistor (online & offline)				✓

High Resistance Grounding

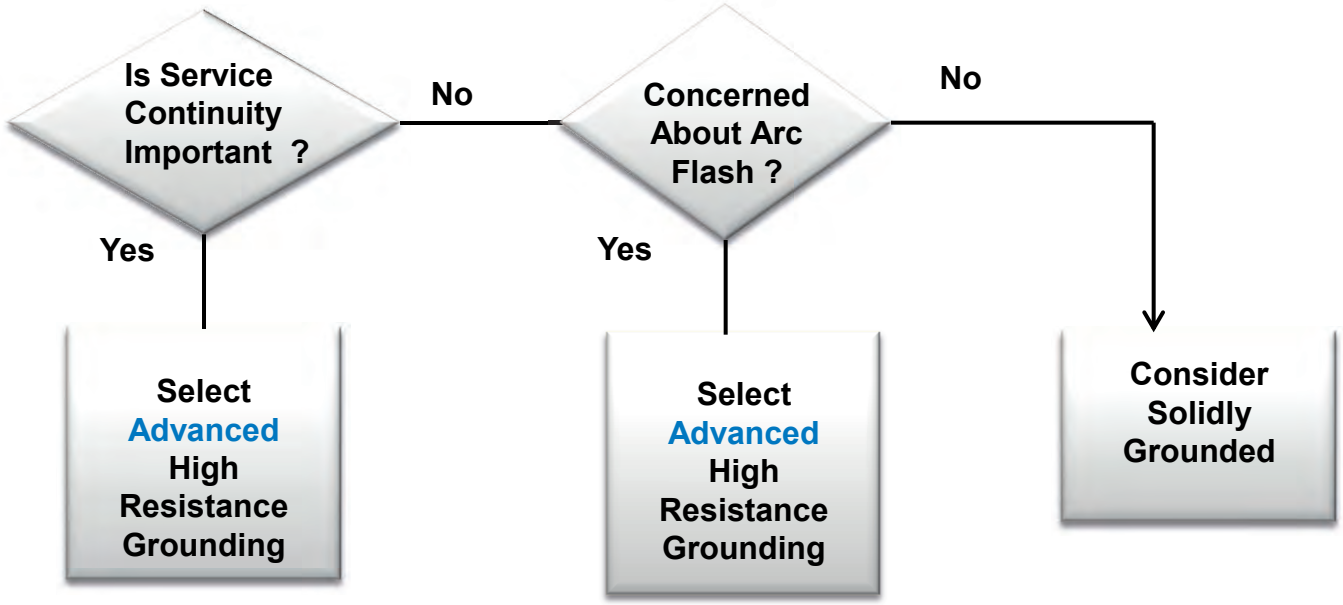
How Does HRG reduce the risk of Arc Flash?

90-98% of all electrical faults are phase to ground faults.

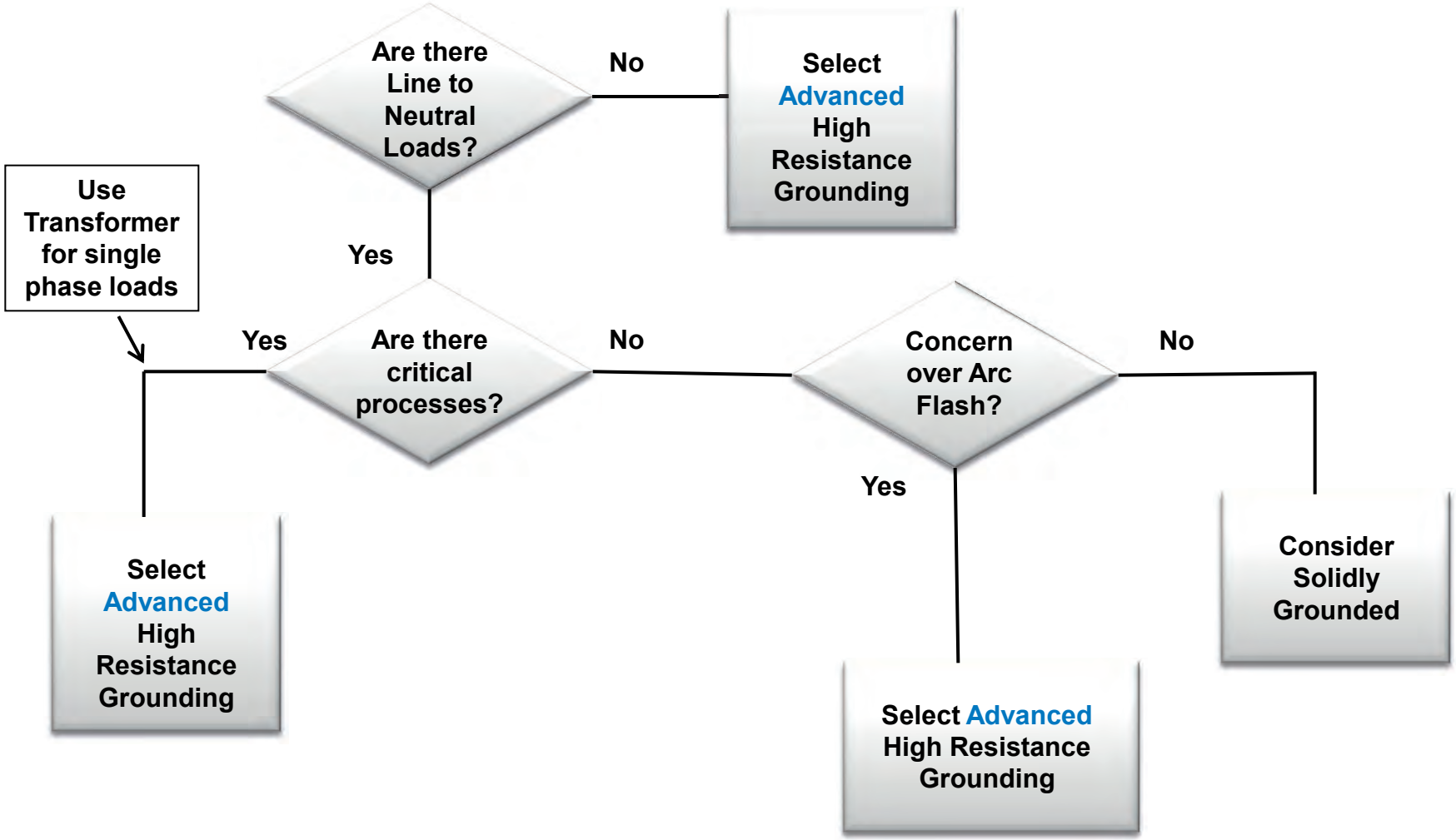
By limiting the fault current to a low level, 10 amps or less, there is insufficient current for the arc to re-strike and it self-extinguishes.



System Grounding Choices:
Options ~~Before~~ with HRG Technology



System Grounding Choices:
Options ~~Before~~ with HRG Technology



High Resistance Grounding

IEEE Std 242-2001 (Buff Book)
8.2.4. High-resistance grounding helps ensure a ground-fault of known magnitude, helpful for relaying purposes. This makes it possible to identify the faulted feeder with sensitive ground-fault relays.

High Resistance Grounding

IEEE Std 141-1993 (Red Book)
7.2.2. High-resistance grounding provides the same advantages as ungrounded systems yet limits the steady state and severe transient over-voltages associated with ungrounded systems. There is no arc flash hazard *[for LV ground faults]*, as there is with a solidly grounded system, since the fault current is limited to approximately 5A.

High Resistance Grounding

IEEE Std 242-1986 Recommended Practice for the Protection and Coordination of Industrial and Commercial Power Systems
7.2.5. Ungrounded systems offer no advantage over high-resistance grounded systems in terms of continuity of service and have the disadvantages of transient over voltage's, locating the first fault and burn downs from a second ground fault. For these reasons, they are being used less frequently today than high-resistance grounded systems".

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Thank You

Q & A

Please contact marketing@i-gard.com or
call us at 1-888-737-4787
with any questions or comments.