

Precautions for Working with High Resistance Grounded Systems

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HRG Systems at Major Chip Manufacturer

- **1981 – HRG in Corporate Data Center**
- **1996 - Dallas, Texas Chip Manufacturer desired to improve - 480v System Reliability & Safety**

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TO START

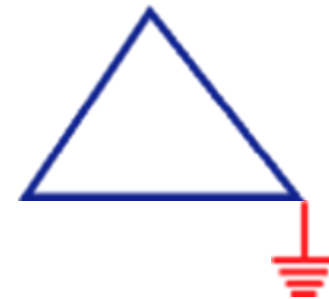
- **Facility Engineering evaluated three types Systems**
 - **Ungrounded**
 - **Solidly Grounded**
 - **High Resistance Grounded**

SYSTEM GROUNDING OPTIONS

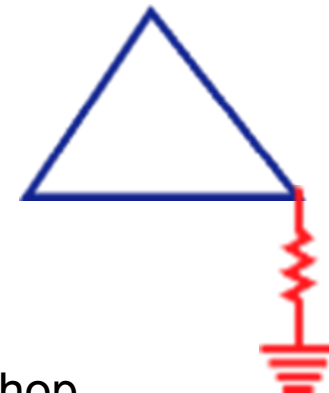
Ungrounded



**Solidly
Grounded**



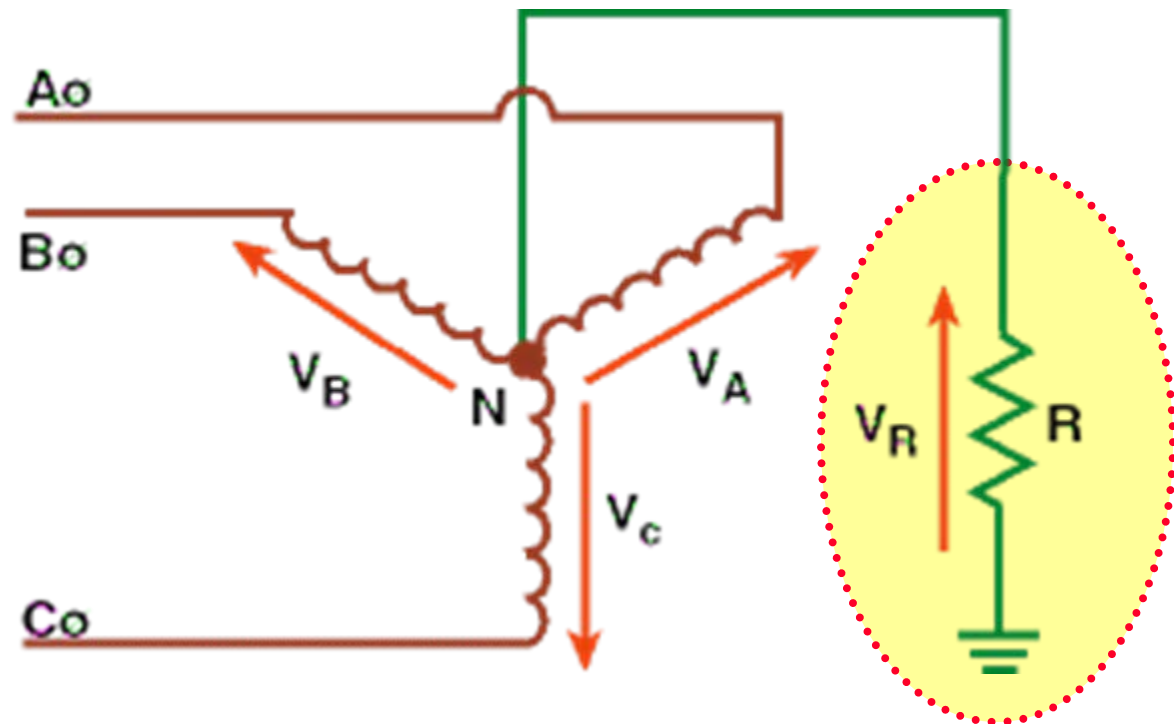
**Resistance
Grounded**



Resistance Grounding

What it is!

- **Transformer grounded through a resistor**



High or Low Resistance Grounding

- **Low Resistance**
 - $100A \leq I_{\phi-g} \leq 1000A$
 - **Circuit Interrupts - 1st Ground Fault**
- **High Resistance**
 - $I_{\phi-g} \leq 10A$
 - **No Interruption - 1st Ground Fault**

The Leader

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System Attributes	Grounding Methods		
	Solid Grounded	HRG	Ungrounded
Immediate Isolation of ground faults	●		
No tripping of breakers on first ground fault		●	●
Minimize shock hazard from stray ground currents		●	●
Minimize ground fault arcing		●	●
Suppress transient ground fault over voltage due to arcing	●	●	
Minimize arc flash hazards (1st fault ONLY)		●	●
High Probability of phase to ground fault escalating to phase to phase fault	●		
High probability for sustained arc in phase to ground fault	●		
Voltage dip on initial fault	●		

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- **HRG Design Issues**

- **Sizing Ground Resistor**

- **Suppress Transient Over voltages**

- **Ground Fault Location System**

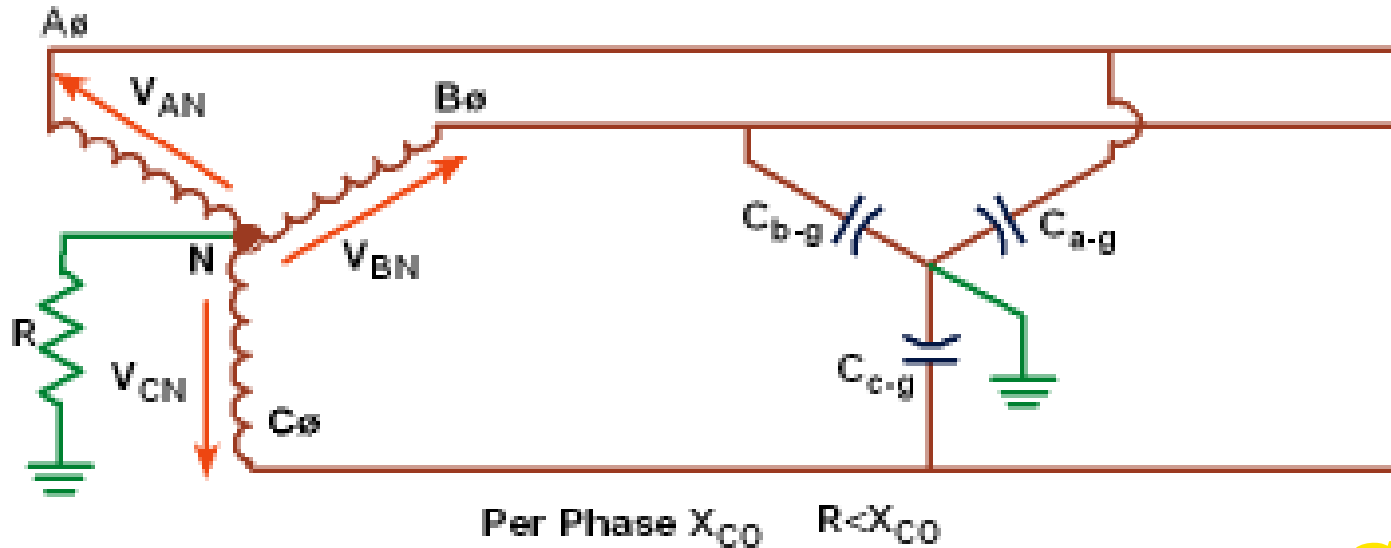
- **Locate Fault Before Shutting Down for Repairs**

- **No Single Phase (277V) Loads**

- **Economics**

HRG Design Issues

Sizing Ground Resistor



To Minimize Transient Over Voltages
 $R < X_{CO}$

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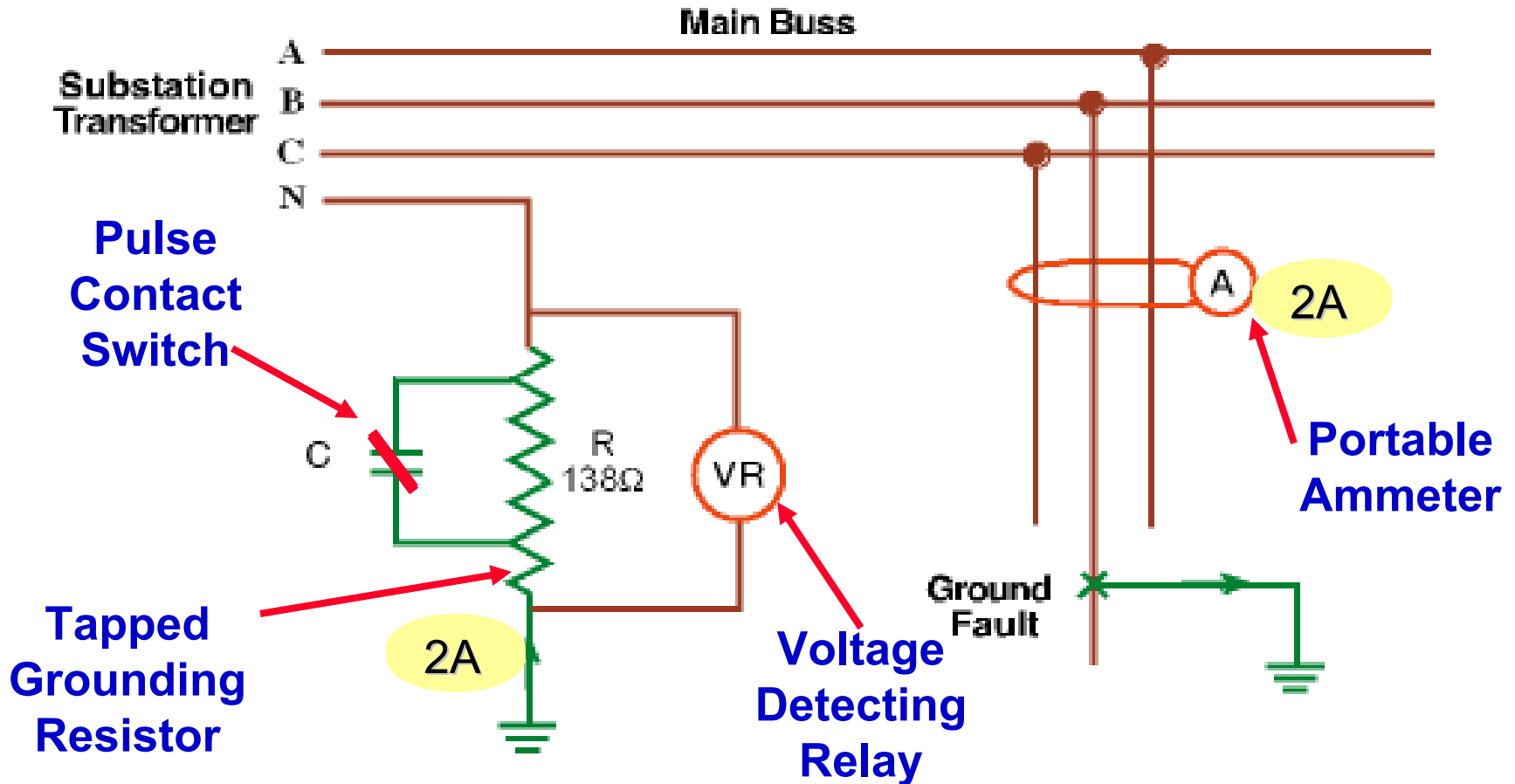
HRG Design Issues

No Single Phase (277V) Loads

- Install 480V Delta to 480V/277V Wye Transformer For Lighting

HRG Design Issues

Ground Fault Locating



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HRG Design Issues

- **Economics**
 - **New**
 - **No Additional Cost**
 - **Retrofit**
 - **\$20K per Substation**

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HRG Was Chosen

The Winner Because

- **Improved Safety**
 - 1st Grd fault – no arc flash or blast
- **Increased Reliability**
 - 1st Grd fault – Non Event
 - Production continues (Scheduled outages – increased revenues)
- **No Added Cost for New Substations**

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Additional Issues To Resolve

- **Safety**
- **Qualifications of Electrical Workers**
- **Training-Employee/Contractor**
- **Culture Changes**

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Additional Issues

• Safety Continued

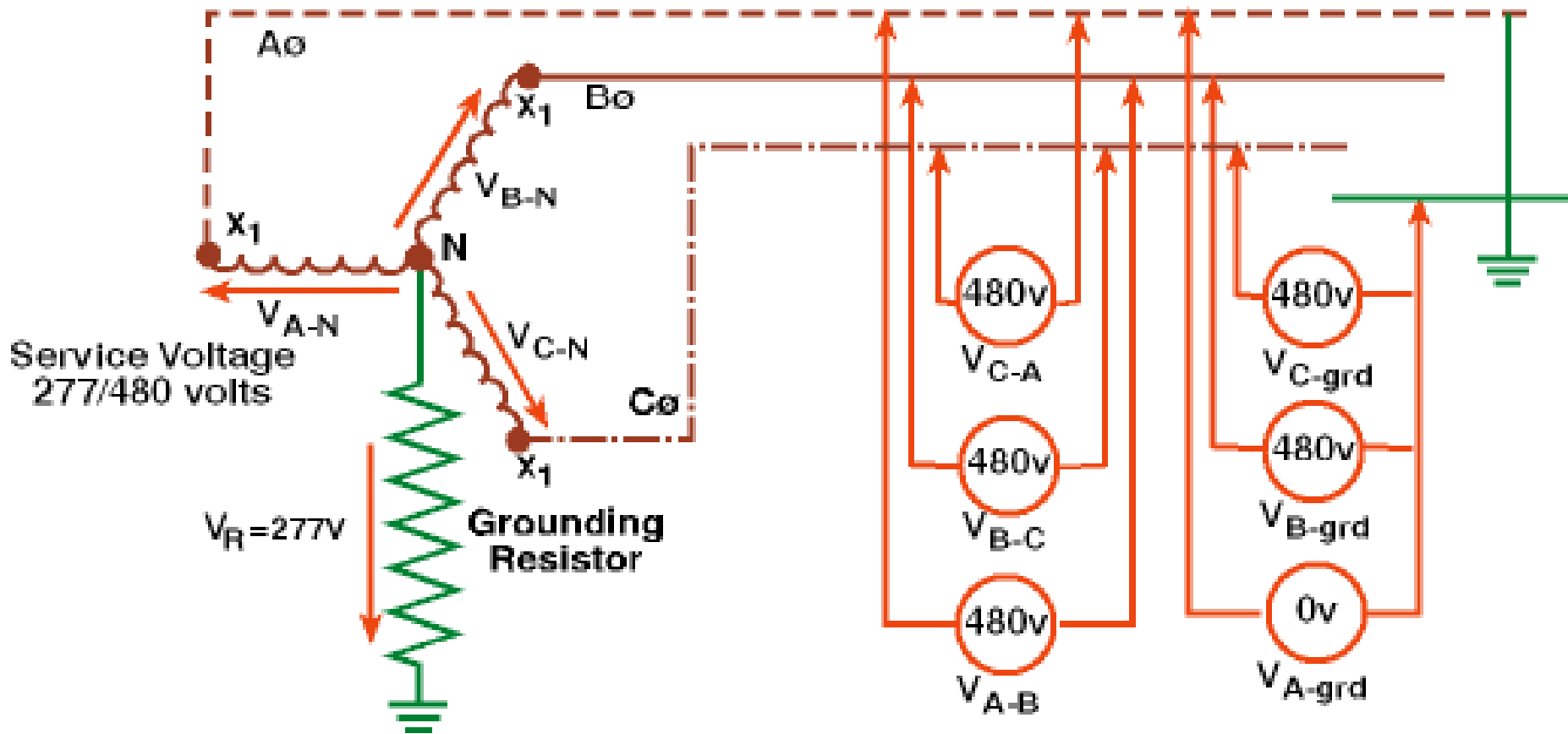
– Assumptions of Workers

- Think they have a free pass for faults
- All short circuits will be non events
- Believe NO flash hazard
- Do not need same level of PPE

ALL FALSE – Why?

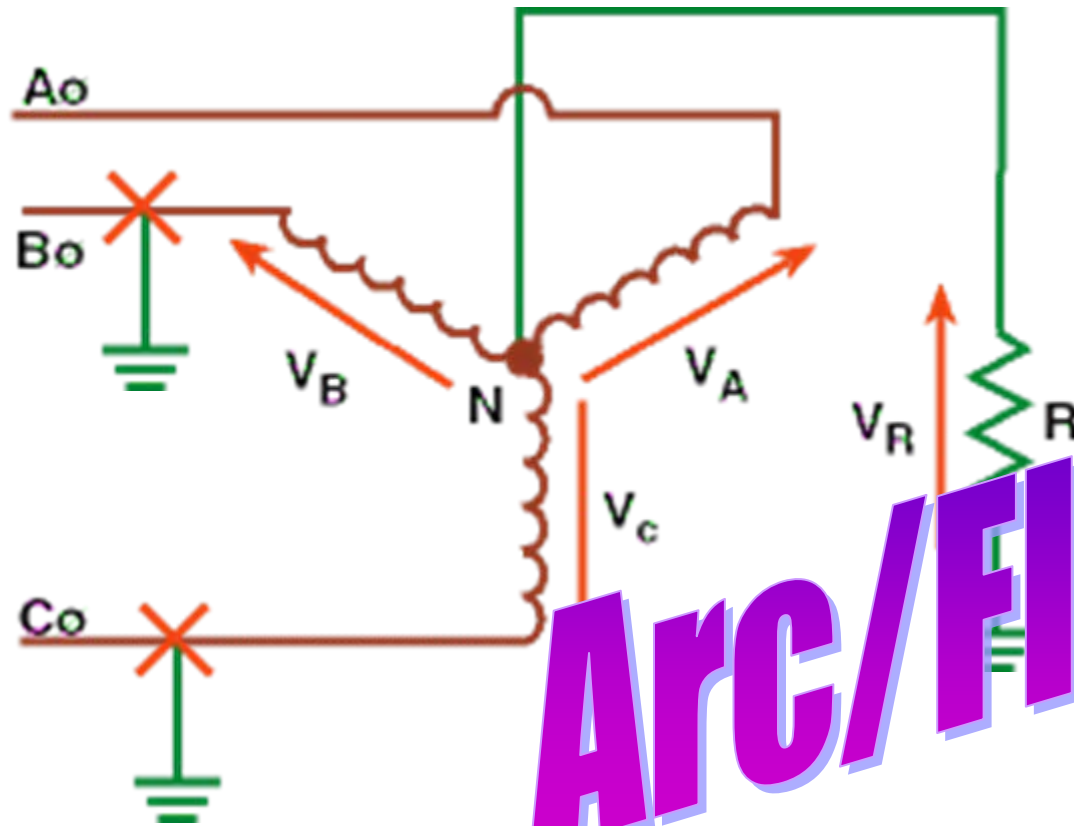
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HRG Operation



Phase "A" to Ground Bolted Fault

HRG Operation



- Bolted faults on different phases

SO SORRY LIGHTS OUT

**Second Fault On Different Phase
Before First Fault Was Cleared**

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Additional Issues

Continued

- **Electrical Worker Qualification**
 - **Average Electrical Worker Unqualified**
 - Required by 2005 NEC 250-36
 - OSHA requires workers understand systems
 - **The Following Incident is What Happens When a Worker Is Not Qualified**

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One of the worlds largest chip manufacturers corporate data center was undergoing renovation to become a 24/365 operation capable of standing alone if all surrounding infrastructure went away.

During the work numerous temporary electrical feeds to keep the center operational were utilized. At one point a technician from an air handler supplier was in to commission some new raised floor units. He reported we had a "weird" electrical system.

When questioned, he replied that C-phase to ground was zero volts and A and B phases to ground was 480V. He had not a clue what was going on. He was told there was a ground fault on the system and he needed to stay out of the equipment until the problem was resolved.

When checked the ground fault voltmeter relay showed a ground fault but no alarm. A failure in the relay portion of the voltmeter relay was determined to be the cause.

The ground fault was traced to a defective inline cable splice in a cable tray.

After this event company began using a second ground fault detection relay so one failure would not leave a system without an alarm.

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Additional Issues

Continued

- **Training**
 - **Classroom**
 - **HRG Circuit Analysis**
 - **Simulator “Hands On” Fault location**
 - **Pass Online Test Bi-Annually or Go Back To Class**

Real World Fault Simulation

3 Load
Indicating
Lights

$\emptyset - \emptyset$
Voltmeters

$\emptyset - \text{Grd}$
Voltmeters

Grd. Resistor
Voltmeter

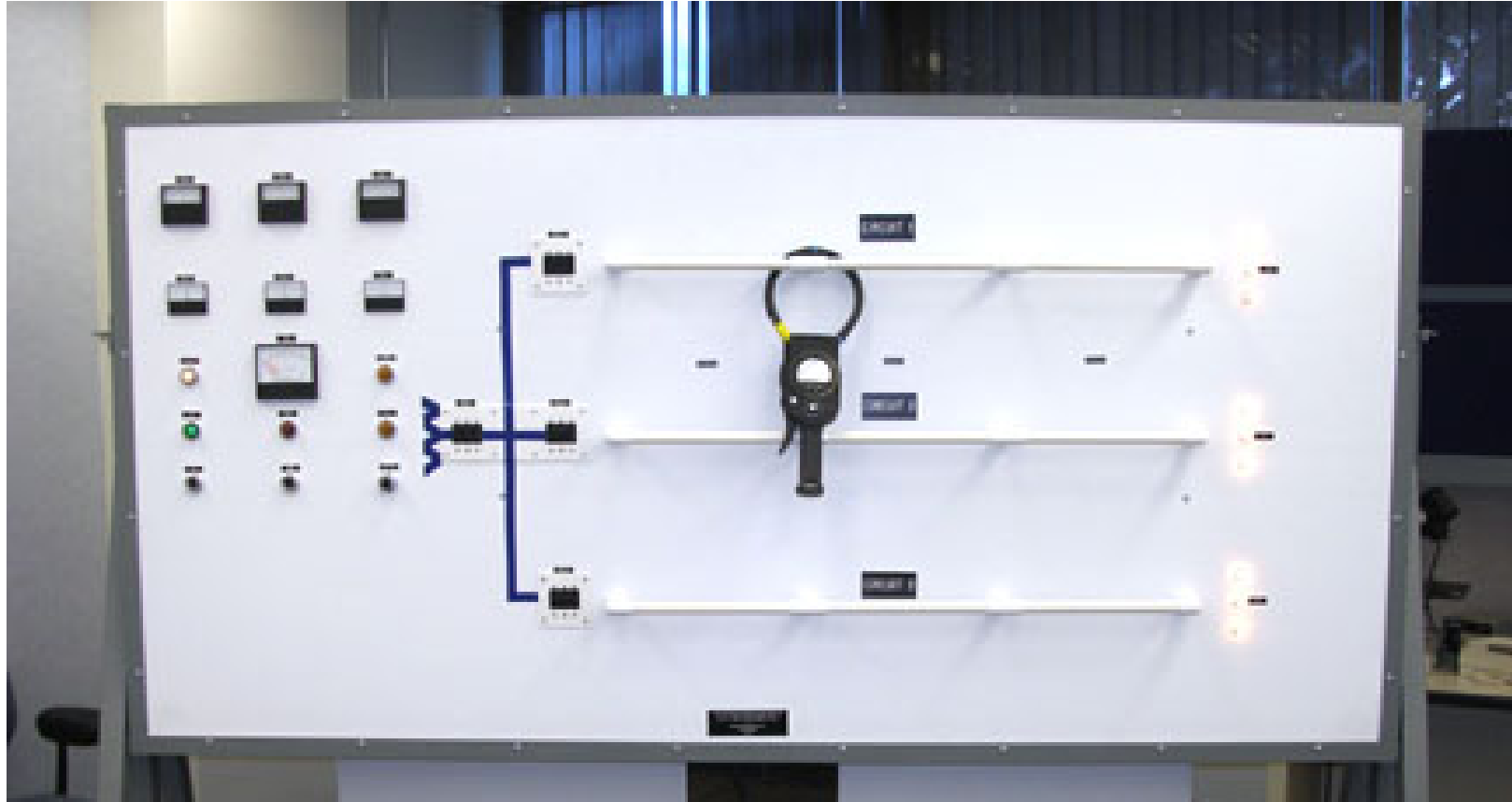
Alarm
Reset



Breakers

Provides Hands-On
Fault Location Training

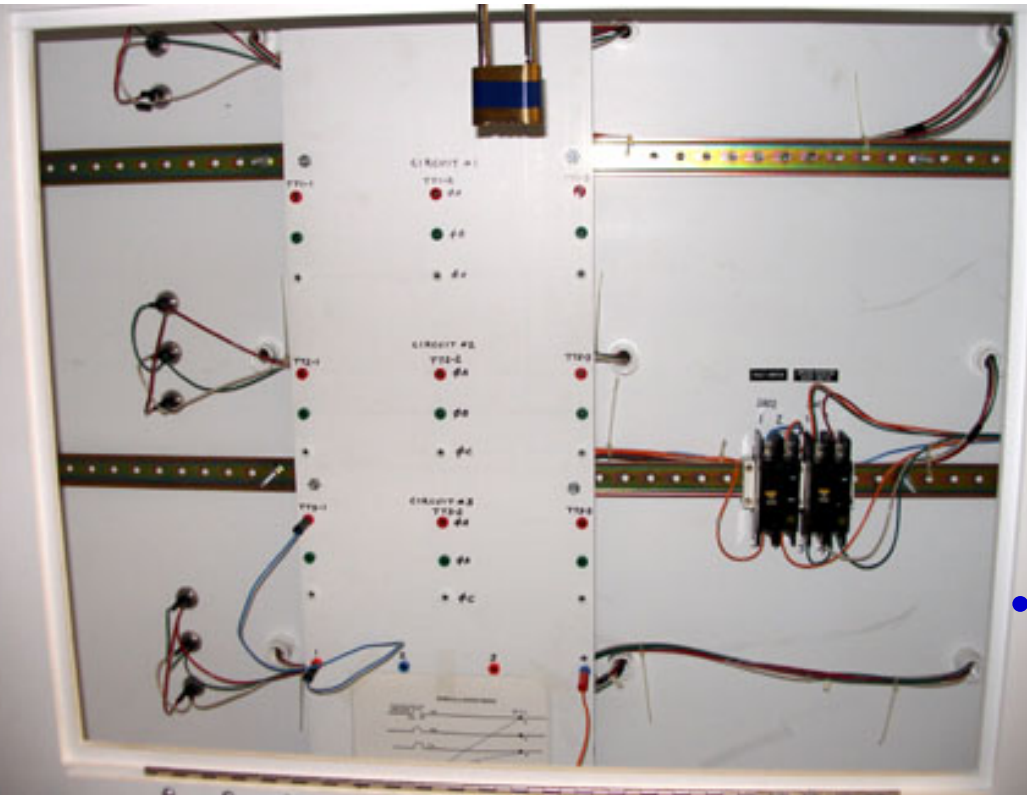
Real World Fault Simulation



Using Volt Meters & Ammeters Participants Identify Faulted Phase & Locate Faults

- Bolted Fault
- High Resistance Faults
- Bolted & High Resistance Faults Same Phase

Simulator Patch Panel



- **Unique Patch Panel Allows Instructor to Simulate**
 - **High R to Ground Faults**
 - **Low R to Ground**
 - **Bolted Faults**
 - **Variable Resistance Faults**
 - **Phase to phase Faults**
 - **High R on “A” Phase, Low on “B”**
- **With three circuits participant gets “real world” experiences**
 - **Real Alarms**
 - **Real Pulse Operation**
 - **Real Current Readings**

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Additional Issues Continued

- **Culture Changes**
 - **Verify No Ground Fault Prior To Energized Work**
 - **Required On Energized Work Permit**
 - **No Energized Work On System W/Grd Fault**
 - **Responding To Ground Faults**
 - **IEEE Standard 141-1993**
 - **Company Requires Shutdown and Clear Within 24 Hours**

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Additional Issues Continued

- **Culture Changes**
 - **Management Understanding Risks Of Extended Operation With a Grd Fault**
 - **Safety**
 - **Equipment Damage**
 - **Unplanned/Extended Interruption**

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TI's HRG System Conclusions

- **Eliminates Arc/Flash/Blast Hazard for 1st Ground Fault**
- **Improves Service Reliability**
- **No Additional Cost – New Installation**
- **Requires Culture & Training Change**

In Conclusion Thanks for Listening to our Presentation

Are there
Questions?

For additional information please contact

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