Hybrid Grounding: What It Is And When/Why You Should Use It

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About the Author

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- Been at Post Glover for 12 years

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Today's Topics

- Resistance Grounding Review
- Introducing Hybrid (High) Resistance Grounding (HHRG)
- Why You Use HHRG
- Design Considerations
- Applications
- Economic Analysis

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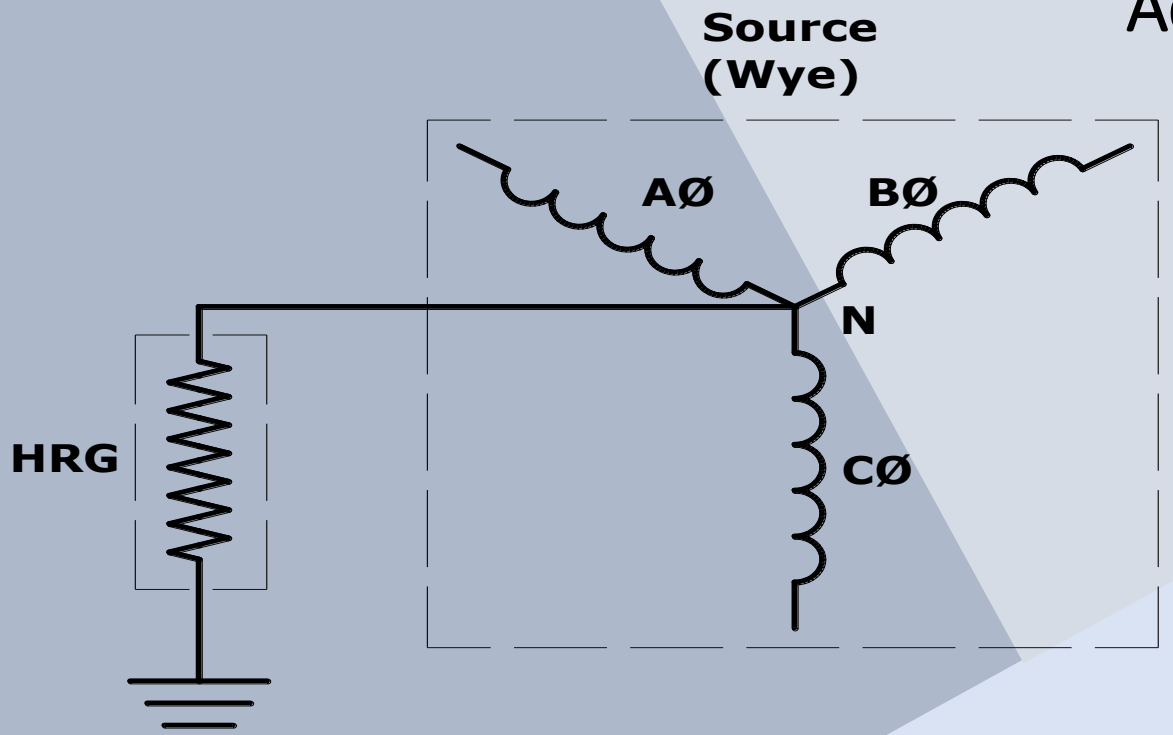
Review: High Resistance Ground



Advantages

- Limits Ground Fault current to 10 Amps or less
- Allows faulted circuit to continue operation
- Eliminates 95% of arc flash potential
- Significantly decreases shock potential

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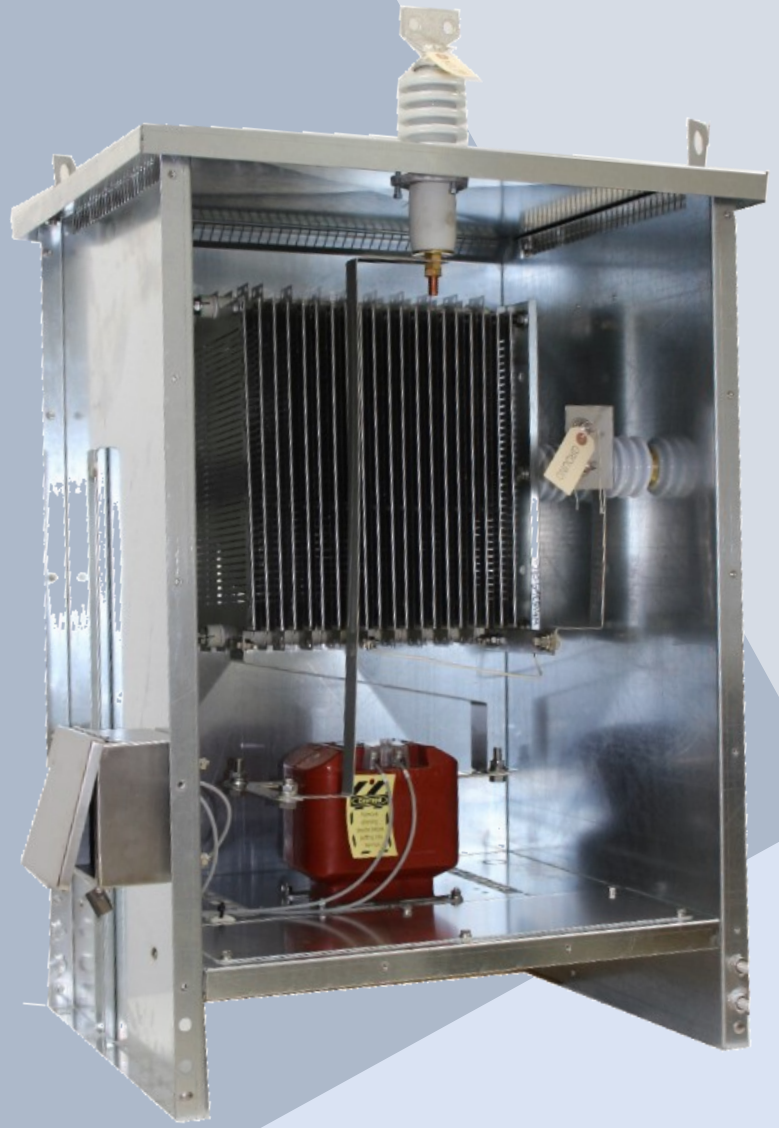
Review: Low Resistance Ground



Advantages

- Relay Coordination
- Limits excessive damage to faulted equipment
- Reduces shock hazard to personnel

Disadvantages

- Some equipment damage may still occur
- Faulted circuit must be segregated

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What is Hybrid Grounding(HHRG)?

- Both a low impedance and a high impedance resistor are installed
- Differential protection is needed to provide isolation in a fault condition
- Low Resistance Ground System for vast majority of faults
- High Resistance Ground for faults located in the protection zone of the generator

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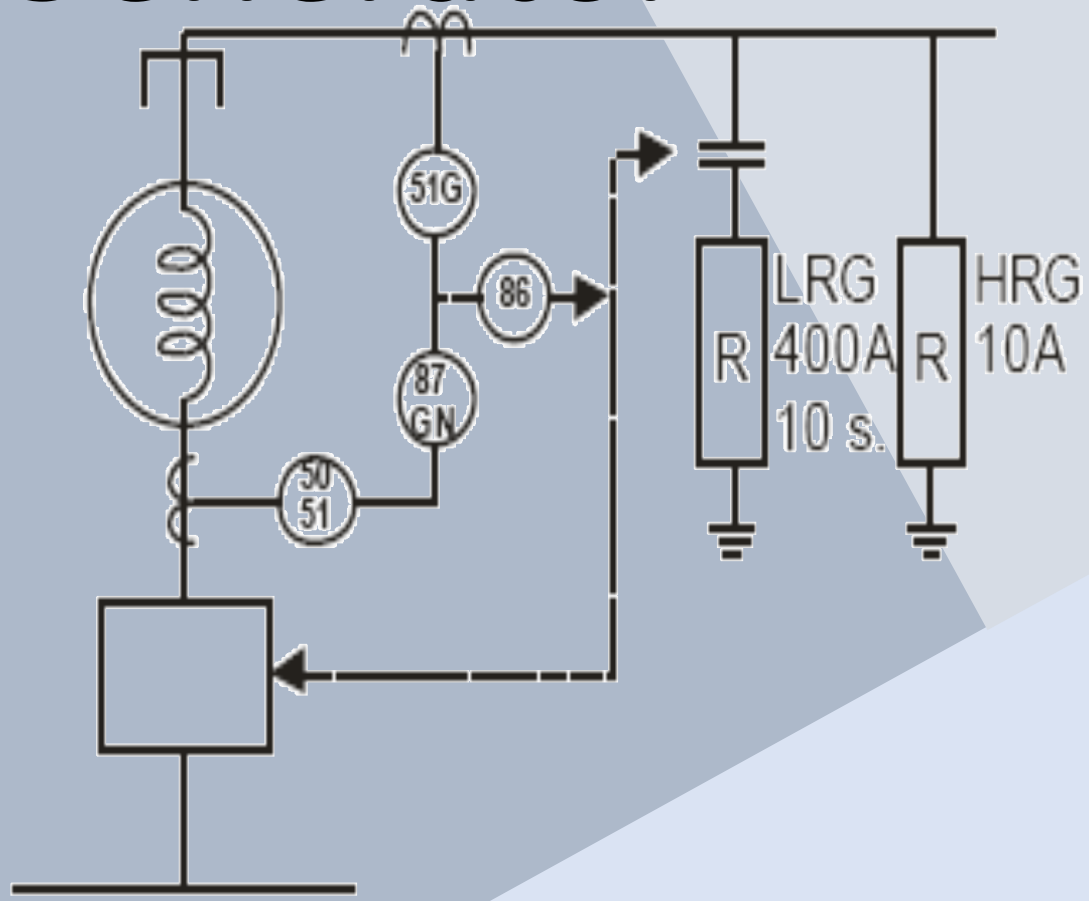
What is Hybrid Grounding – Single Generator



- Typical solution can be put in a single enclosure
- Packaging can include vacuum switch, arrestor, filter and resistors

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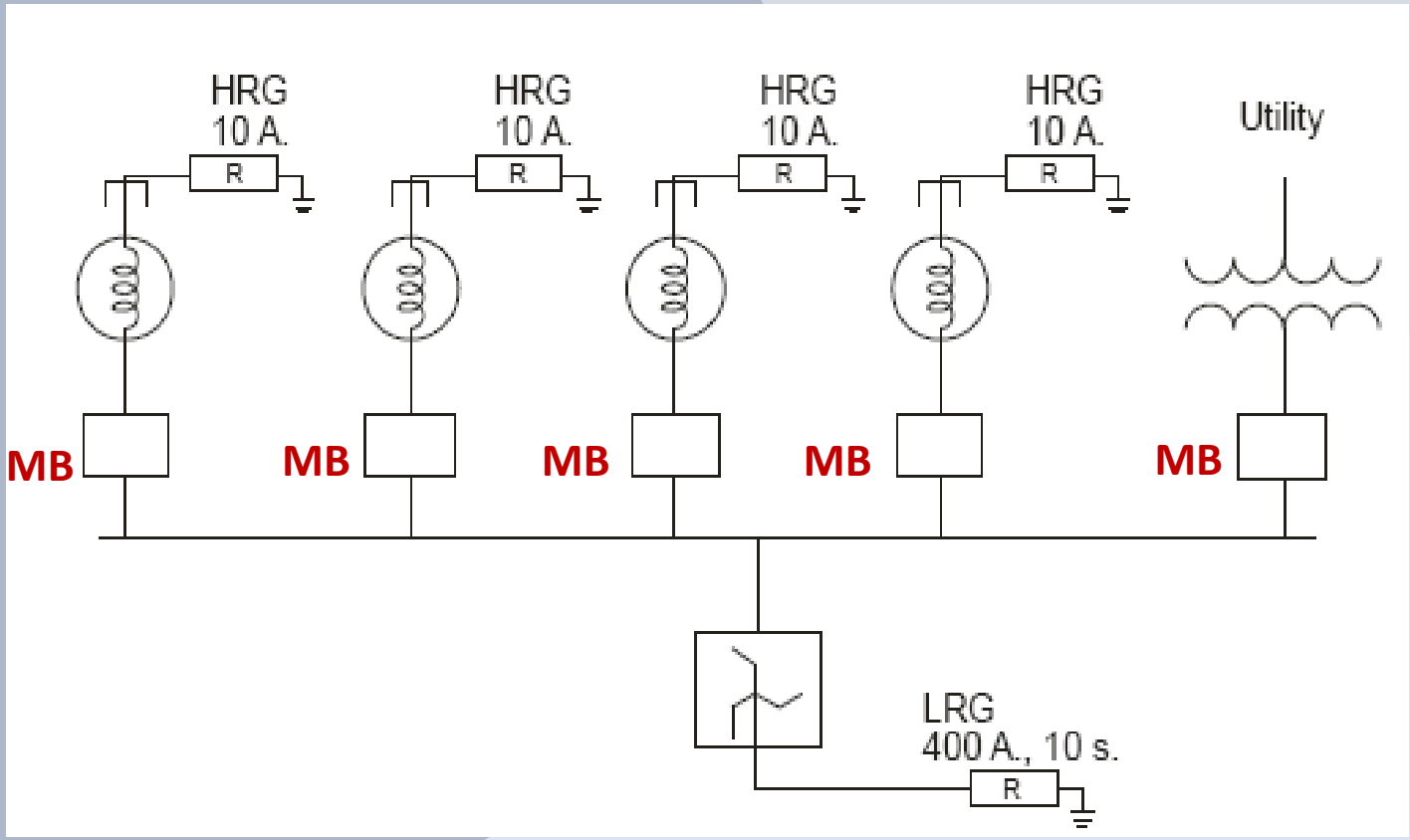
What is Hybrid Grounding – Multiple Generators (Distributed Neutral Grounding)



- Low Resistance installed on the bus (neutral deriving transformer)
- One resistor box per generator
- Assuming no isolation, resistances are additive for ground fault current

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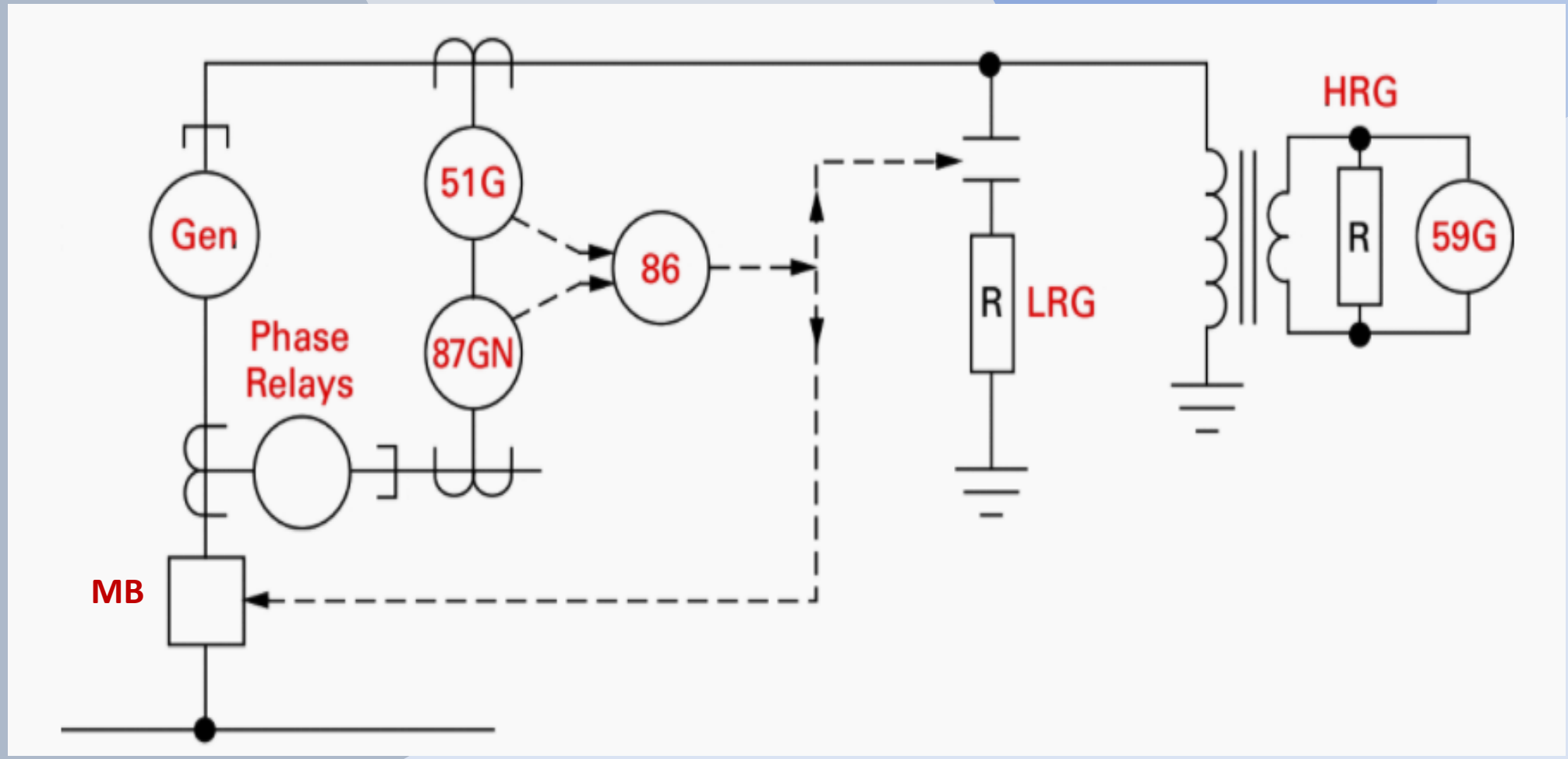
What is Hybrid Grounding - Relays



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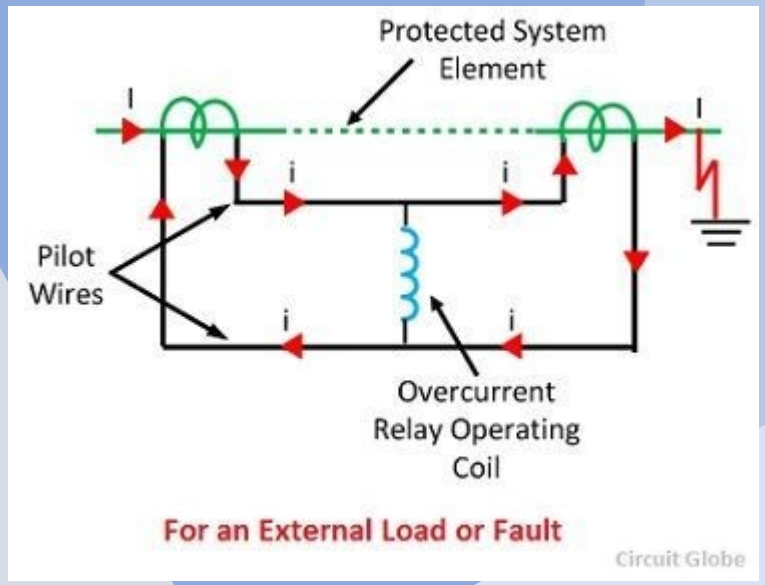
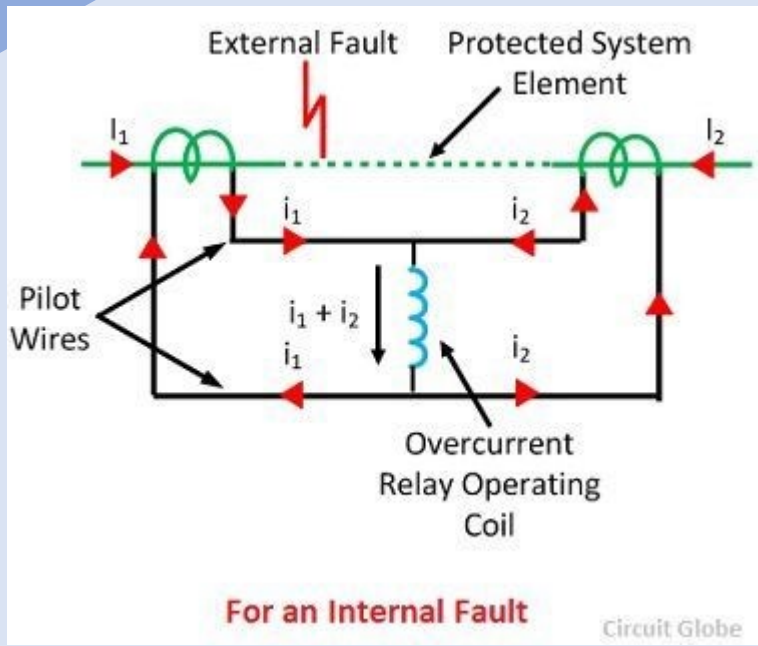
Relays – 87 GN

- Two current transformers are placed at each side of the protection zone (Generator)
- For an external fault, the same current will flow through both CT's, therefore not indicating a trip
- For an internal fault, an imbalance of current will be created ($i_1 \neq i_2$), and a trip will be initiated





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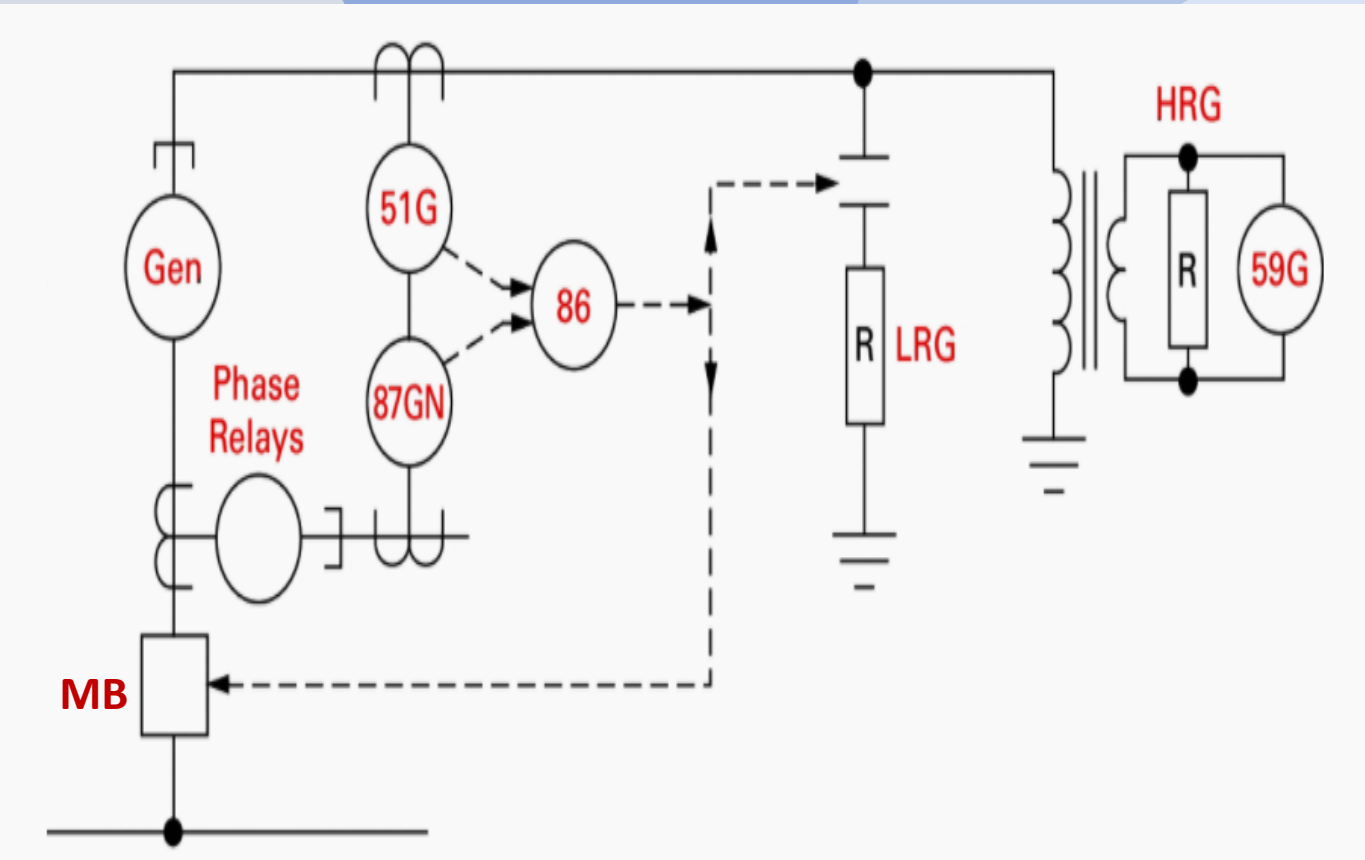
What is Hybrid Grounding - Relays

- 51G Neutral Time Overcurrent – Will trip upon CT receiving a current value above the preset trip condition
- 86 Master Trip Relay – Will trip based on the various inputs it receives which are preprogrammed
- 59G Neutral Overvoltage – Will trip/alarm upon voltage input above the preset trip condition - most likely you will want to alarm only



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Poll Question #1

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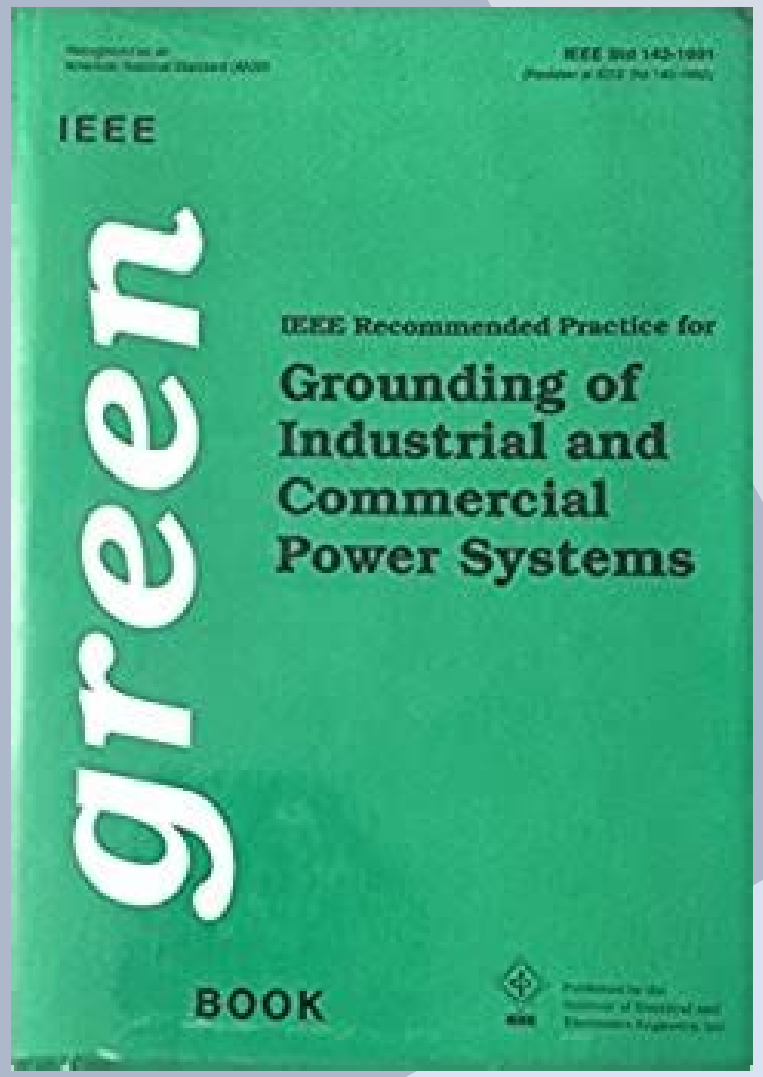
Why use Hybrid Grounding



IEEE Std. 142-1991 (Green Book)

1.8.1 Discussion of Generator Characteristics

- …Unlike the transformer, the three sequence reactances of a generator are not equal. The zero-sequence reactance has the lowest value, and the positive sequence reactance varies as a function of time. *Thus, a generator will usually have higher initial ground-fault current than a three-phase fault current if the generator is solidly grounded. According to NEMA, the generator is required to withstand only the three-phase current level unless it is otherwise specified…*

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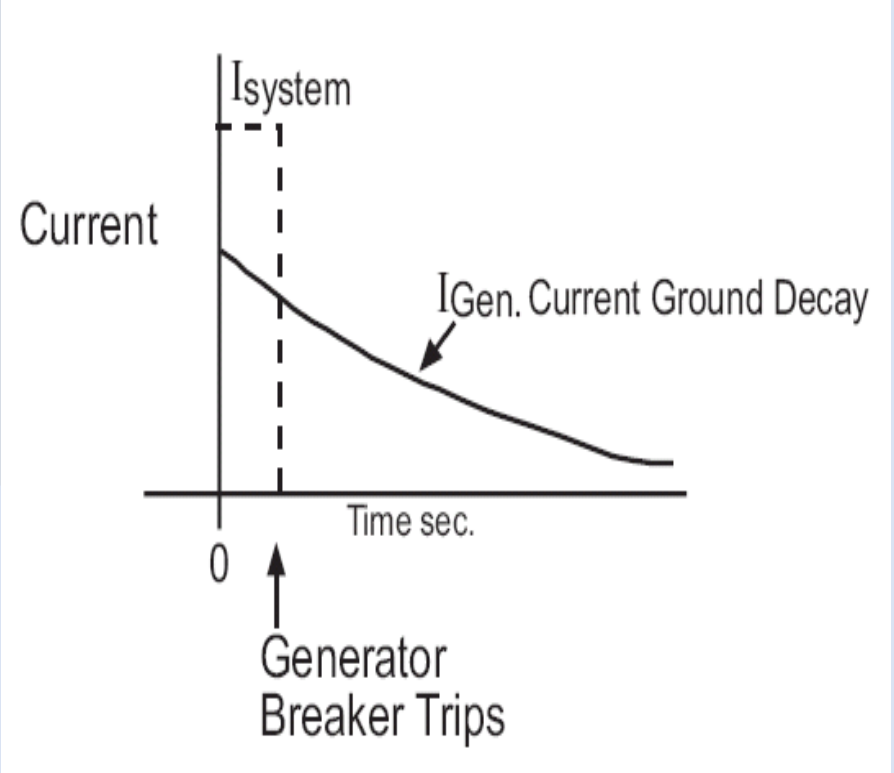
Why use Hybrid Grounding?

- Ground fault current which rises through the neutral of the generator will not be interrupted by tripping the generator circuit breaker
- The fault current will be present in the generator windings until the field is demagnetized, usually several seconds
- Burning damage can occur in a low resistance grounded system/solidly grounded system



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Why use Hybrid Grounding

- Generator fault protection
- Hybrid Grounding assumes you cannot use High Resistance Grounding alone
  - 5kV it is likely (Capacitive Charge Current analysis must be done)
  - 15kv it is less likely
    - Capacitive Charge Current is too high
    - Not enough ground fault current to trip throughout system
- Economic

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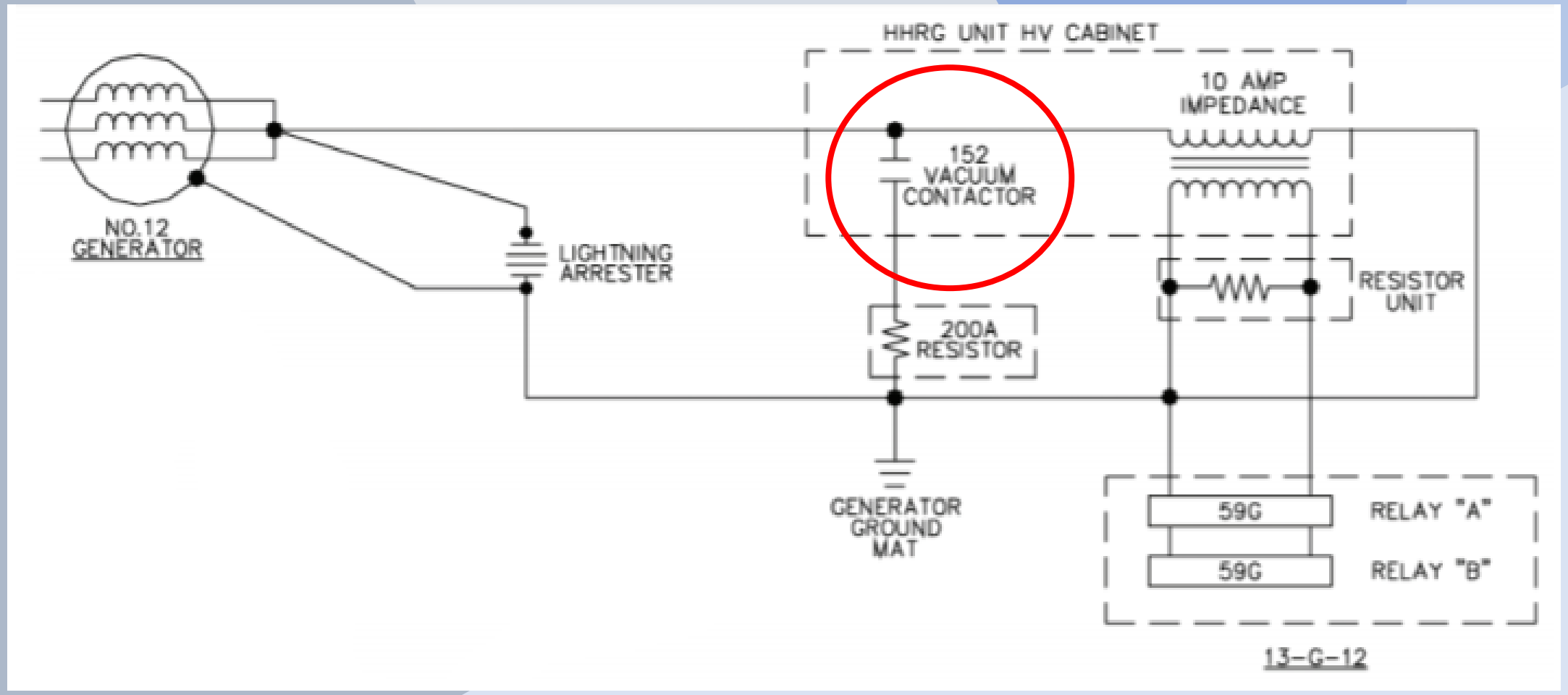
Design Considerations - Vacuum Switch



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Design Considerations - Vacuum Switch

- Fast Switch is Necessary
- Coordinate with your Generator Breaker (<7 cycles)
- Typical control power of 120Vac
- Turbines will potentially coordinate differently

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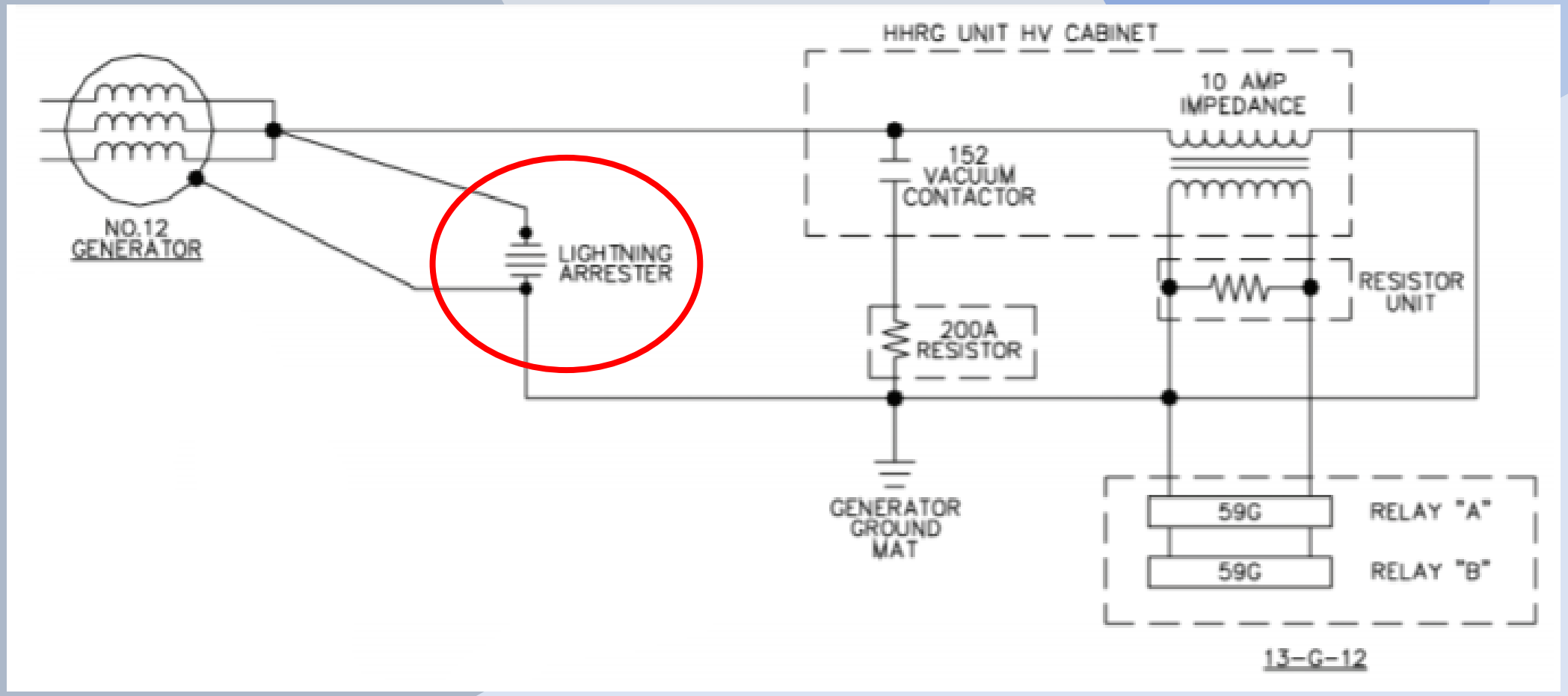
Design Considerations - Lightning Arrestor



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Design Considerations - Arrestor

- This should be considered to protect against transient overvoltages caused by switching
- Install at wye point of generator so that insulation is not compromised

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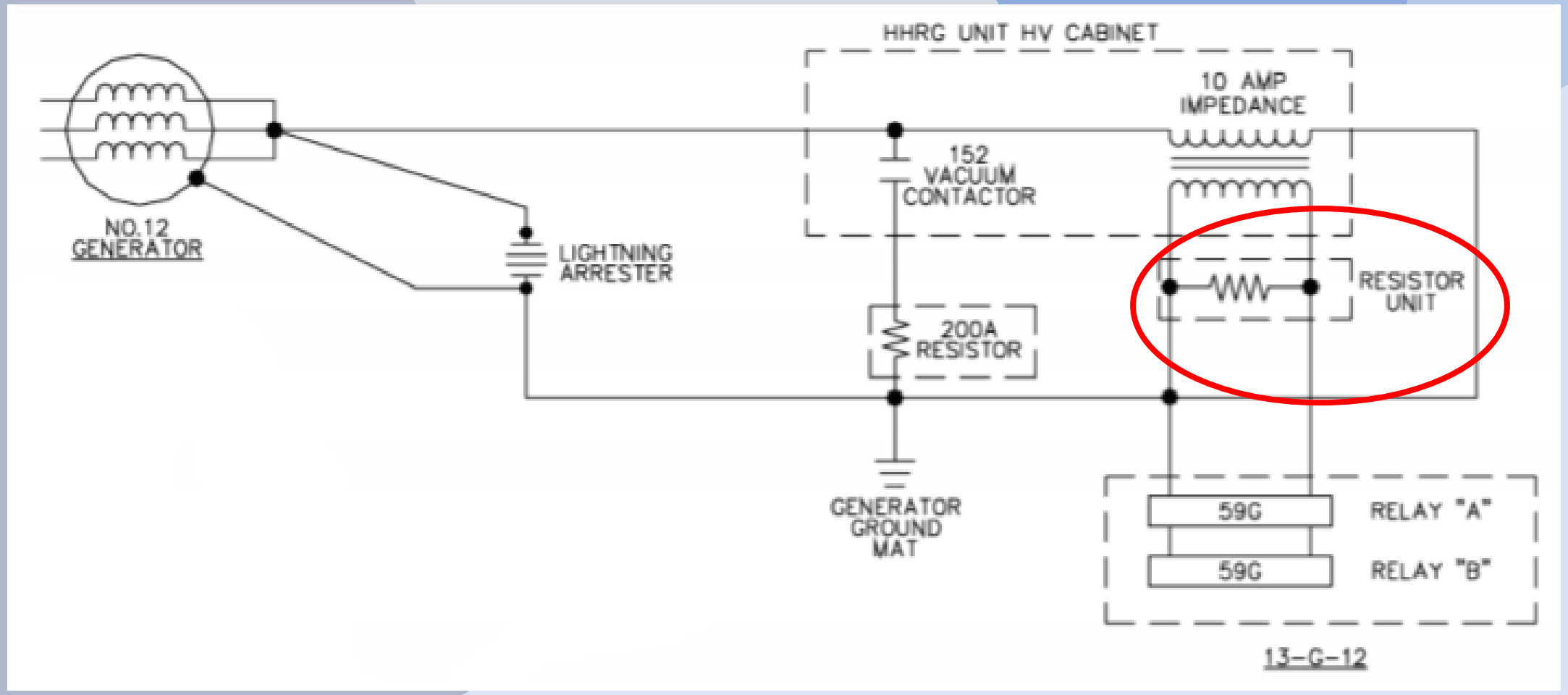
Design Considerations - Harmonic Filter



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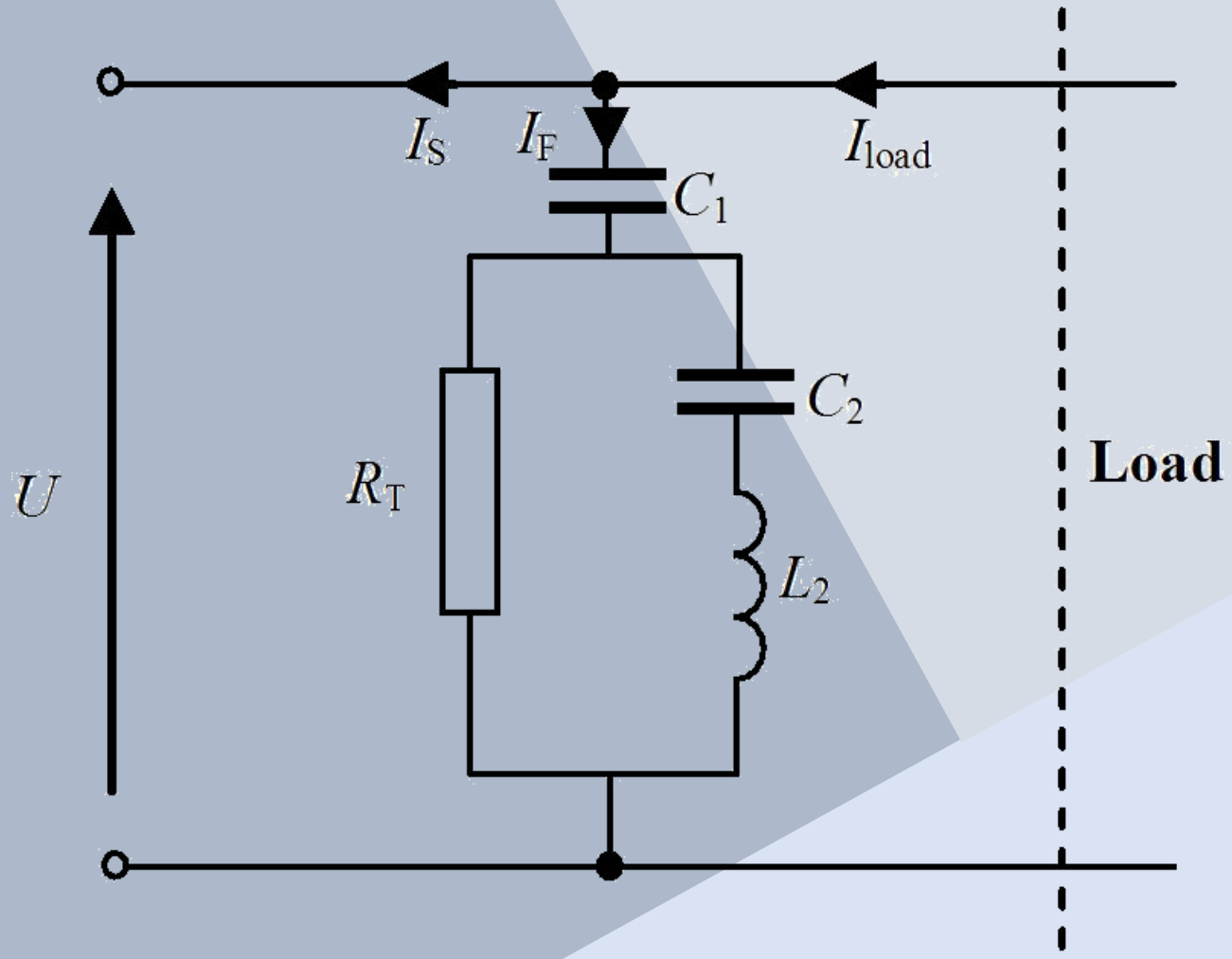
Design Considerations - Harmonics



- 3rd Harmonic Voltages can prompt nuisance alarming on a 51G overvoltage relay
- Filtering is used to prevent this and measure only the fundamental voltage

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Design Considerations - Resistor

- 10A Ground Fault Let Through Current or Less
- 30 second rated resistor or longer, should be longer than longest possible wind down with some safety factor included
- Resistor only is needed. May need Current Transformer to accommodate 51G requirement

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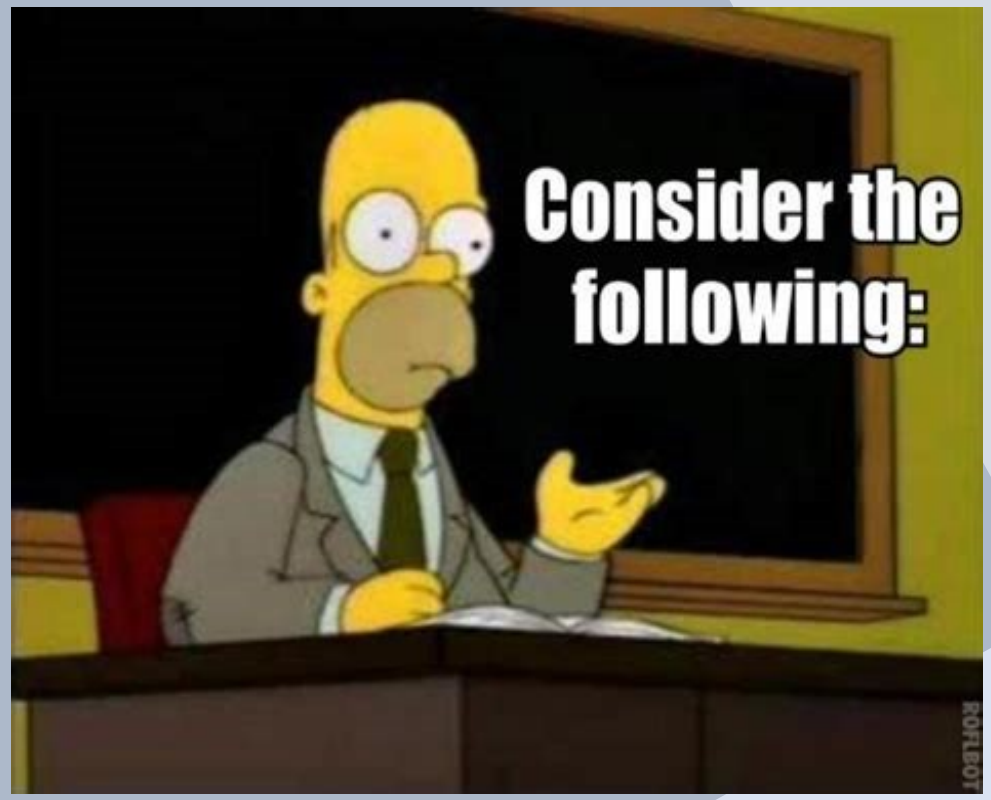
Design Considerations - Others



- Make sure if you get a Generator Fault you train/warn your technician from a reset/restart or lock it out from happening. This can cause major additional damage to your generator.

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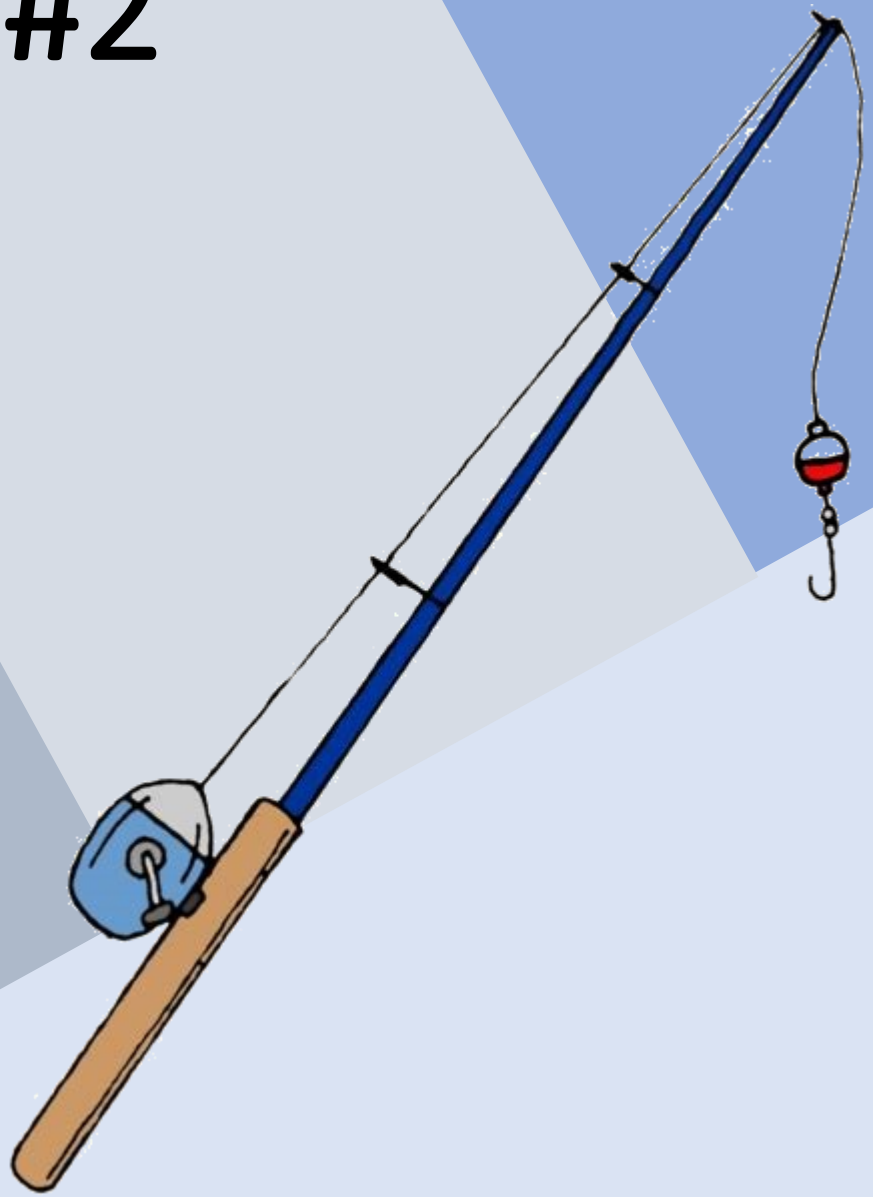
Poll Question #2



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Application

- Medium Voltage only
- Generator operation is critical (Critical Infrastructure, Co-gen)
- Expensive Generators
- Complete protection is important
- Older Generators
- Elongate rewind maintenance schedule (Should do additional testing, i.e. partial discharge testing)

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Economic Analysis

- HHRG Single Generator Solution is ~$25K+
- Average 15kV generator repair is $50K*
- Average turnaround 6 weeks
- Replacement can be up to 6 months or more

*Avg. price history of generator repair facility

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Conclusion

"Do you mind if I put you on hold for a minute?
I have a really short attention span."

- HHRG is a viable MV solution for added protection against stator faults
- More complicated than standard resistance ground solution, but very doable
- Good option depending on your application/ system cost

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Any Questions?

Email : chris.small@postglover.com

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- We can also send a .pdf version of the presentation if you would like.
- Please reply if there are concerns with the format of the certificate of participation pertaining to your continuing education credits.

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References

- Prafulla Prallai (2003), Grounding and Ground Fault Protections of Multiple Generator Installations on Medium Voltage Industrial and Commercial Power Systems Parts I-IV, IEEE/IAS Working Group
- David Shipp, Switching Transient Analysis and Specifications for Practical Hybrid High Resistance Grounded Generator Applications, IEEE/IAS Working Group
- Doug Moody (2003), Application of a Hybrid Grounding Scheme to a Paper Mill 13.8kV Generator, IEEE/IAS Working Group