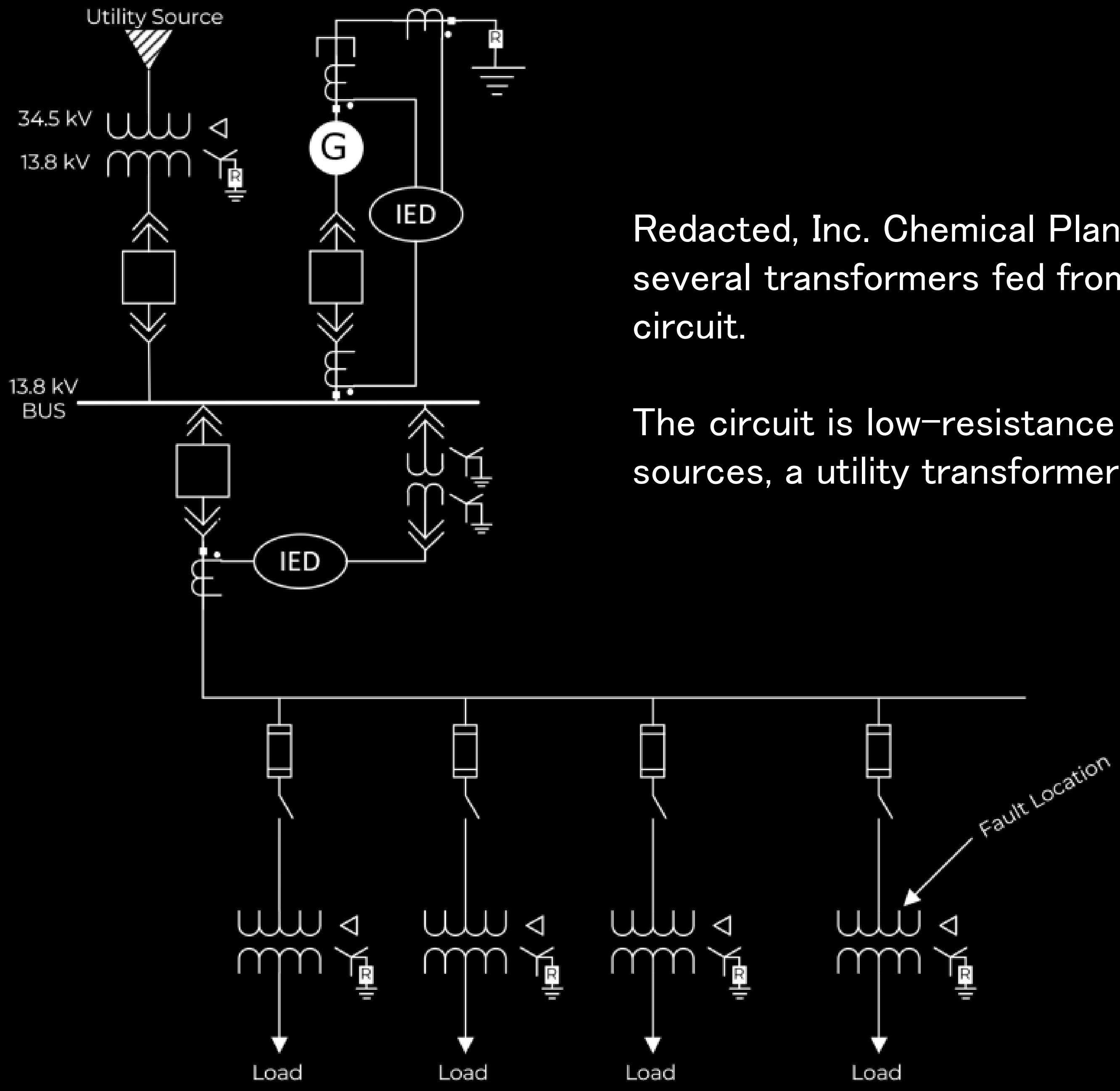
Protection Challenges of a Resistance Grounded Distribution Feeder with Fused Taps

Matt Proctor – Root 3 Power

Texas A&M Protective Relay Conference - 2019



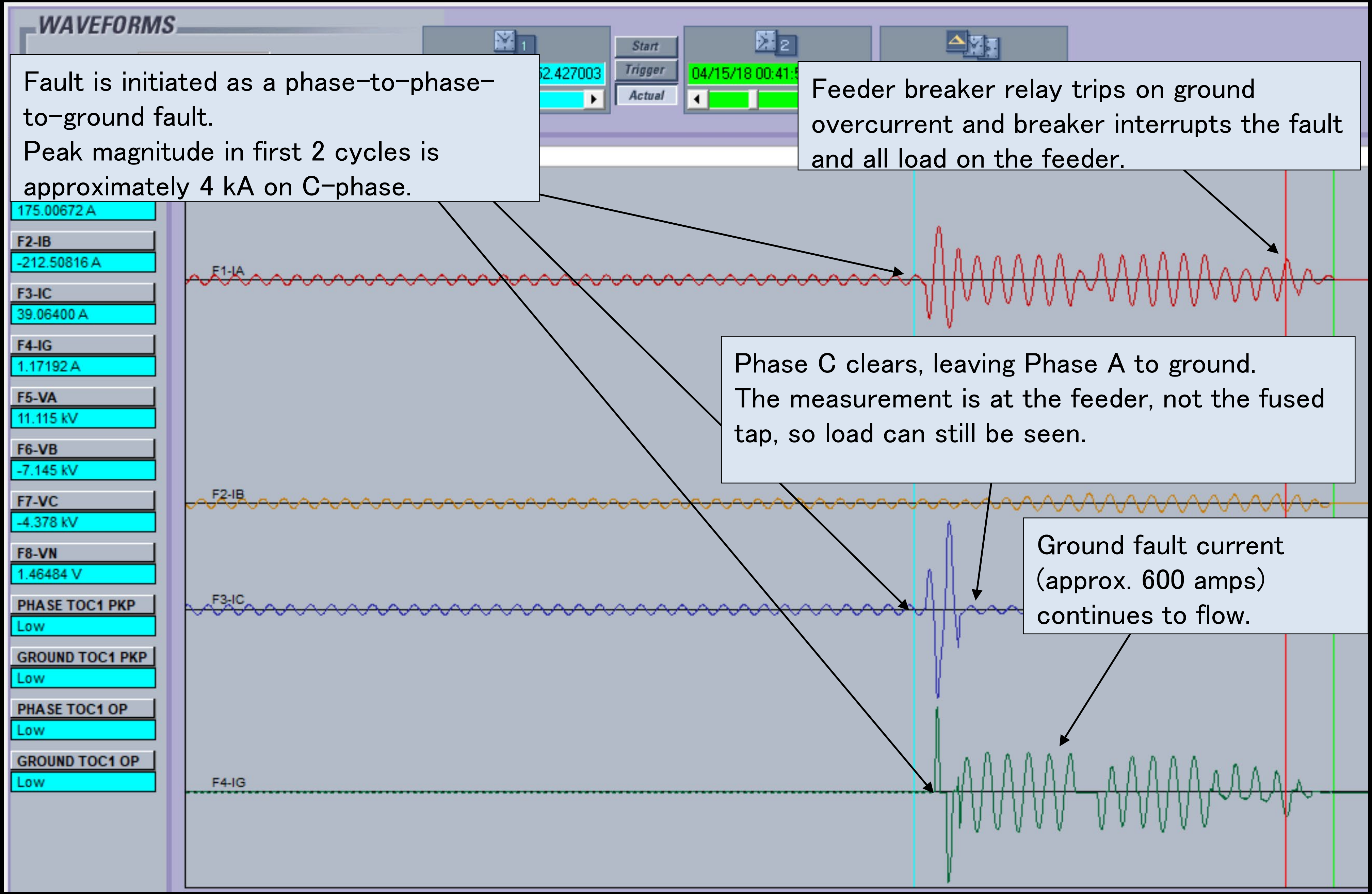
Redacted, Inc. Chemical Plant experiences a fault on one of several transformers fed from a fused tap on a distribution circuit.

The circuit is low-resistance grounded with two grounded sources, a utility transformer and a generator.

Fused taps are the de-facto standard on overhead utility distribution circuits.

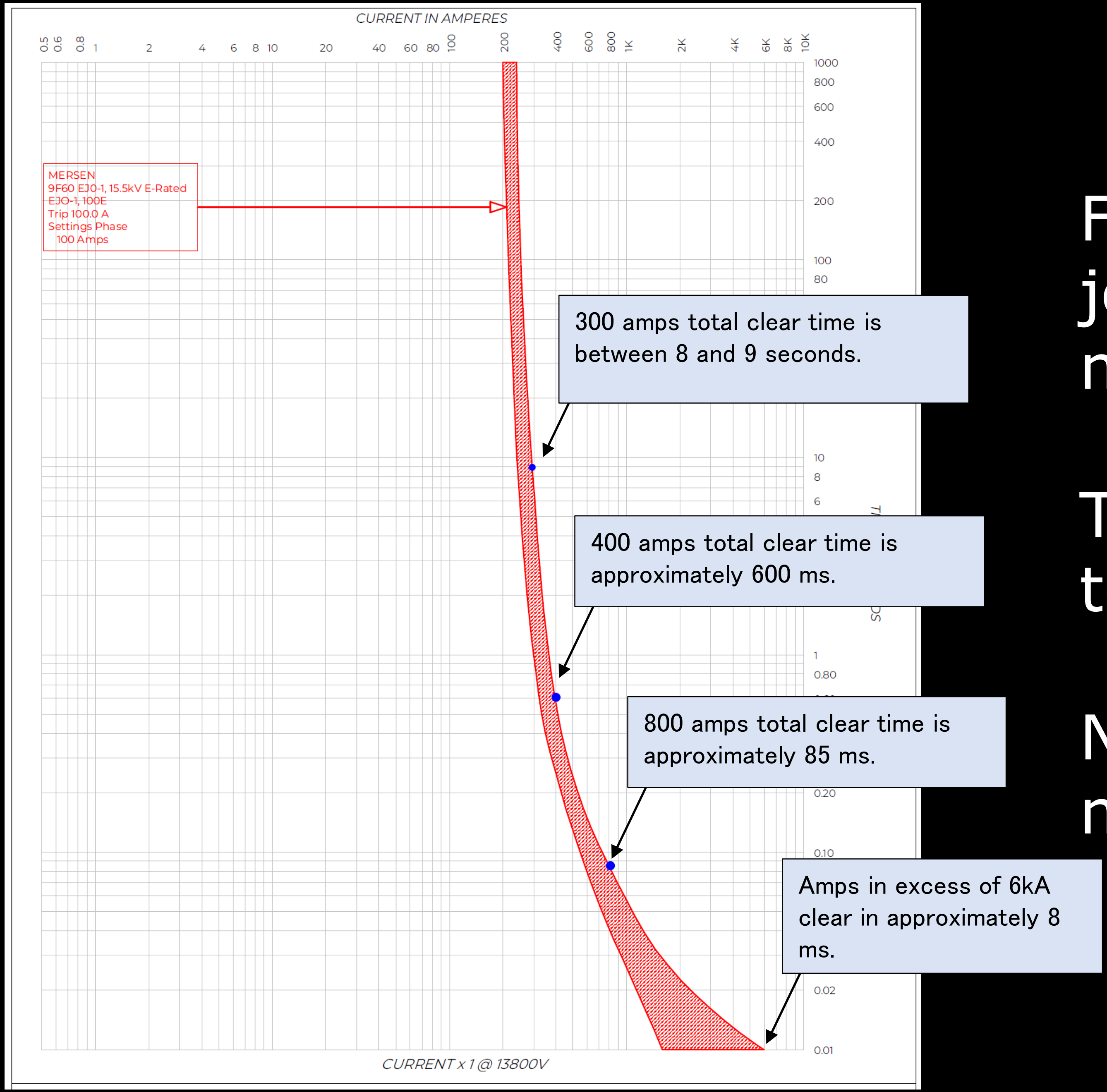
They're fairly common on insulated distribution circuits as well.

Yes, this is a picture of a fused contactor, not a fused switch. It's the best I had without stealing one off the internet.


WAVEFORMS
Start
Trigger
Actual
Fault is initiated as a phase-to-phase-to-ground fault.
Peak magnitude in first 2 cycles is approximately 4 kA on C-phase.
Feeder breaker relay trips on ground overcurrent and breaker interrupts the fault and all load on the feeder.
175.00672 A
F2-IB
-212.50816 A
F3-IC
39.06400 A
F4-IG
1.17192 A
F5-VA
11.115 kV
F6-VB
-7.145 kV
F7-VC
-4.378 kV
F8-VN
1.46484 V
PHASE TOC1 PKP
Low
GROUND TOC1 PKP
Low
PHASE TOC1 OP
Low
GROUND TOC1 OP
Low
F1-IA
Phase C clears, leaving Phase A to ground.
The measurement is at the feeder, not the fused tap, so load can still be seen.
F2-IB
F3-IC
Ground fault current (approx. 600 amps) continues to flow.
F4-IG

“Fuses do a pretty good job…*”

- Matt Proctor, former sales manager for ***relays***

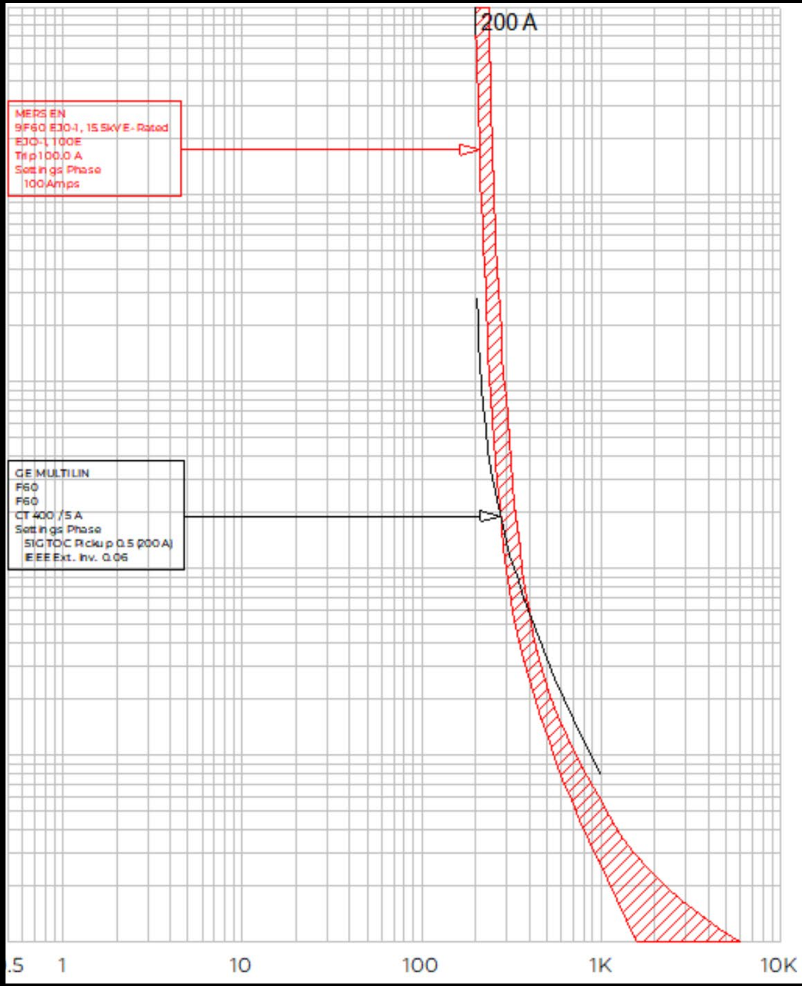


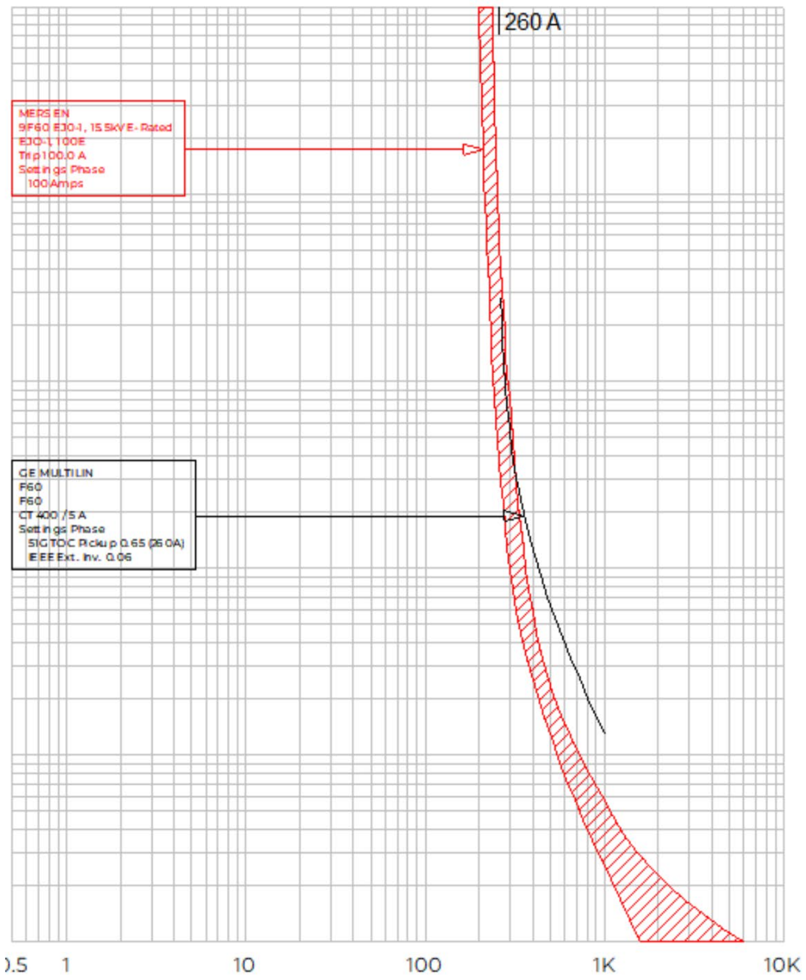
Fuses do a pretty good job when current magnitude is high.

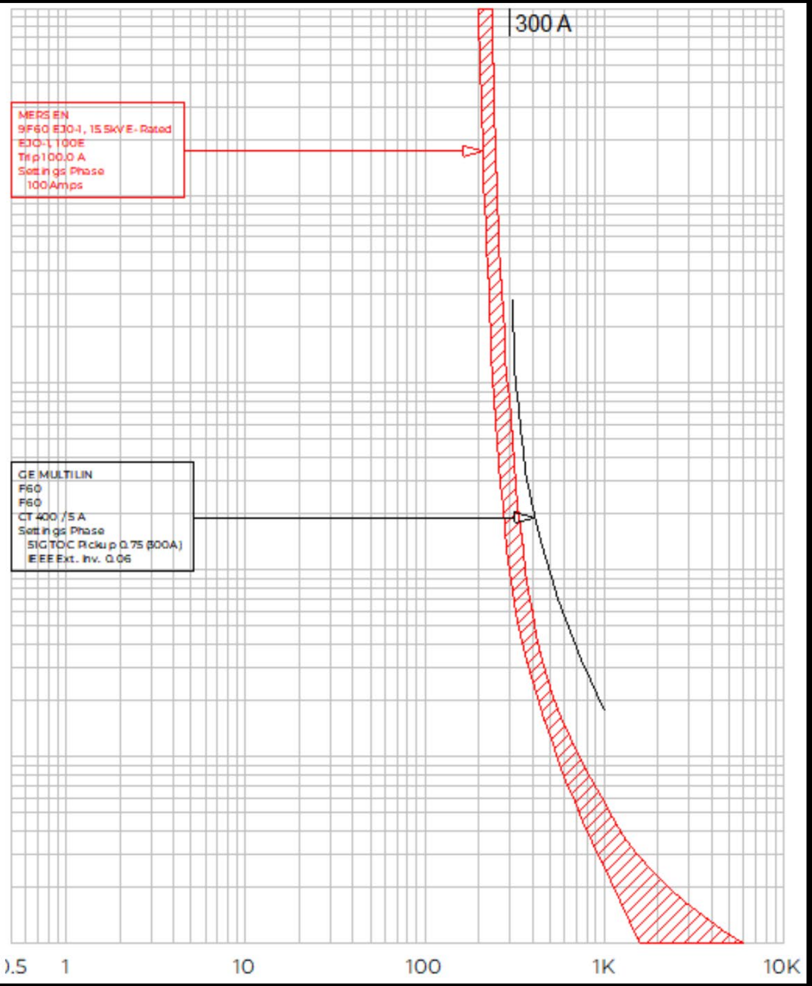
They can limit current too!

Not so great for low magnitudes.

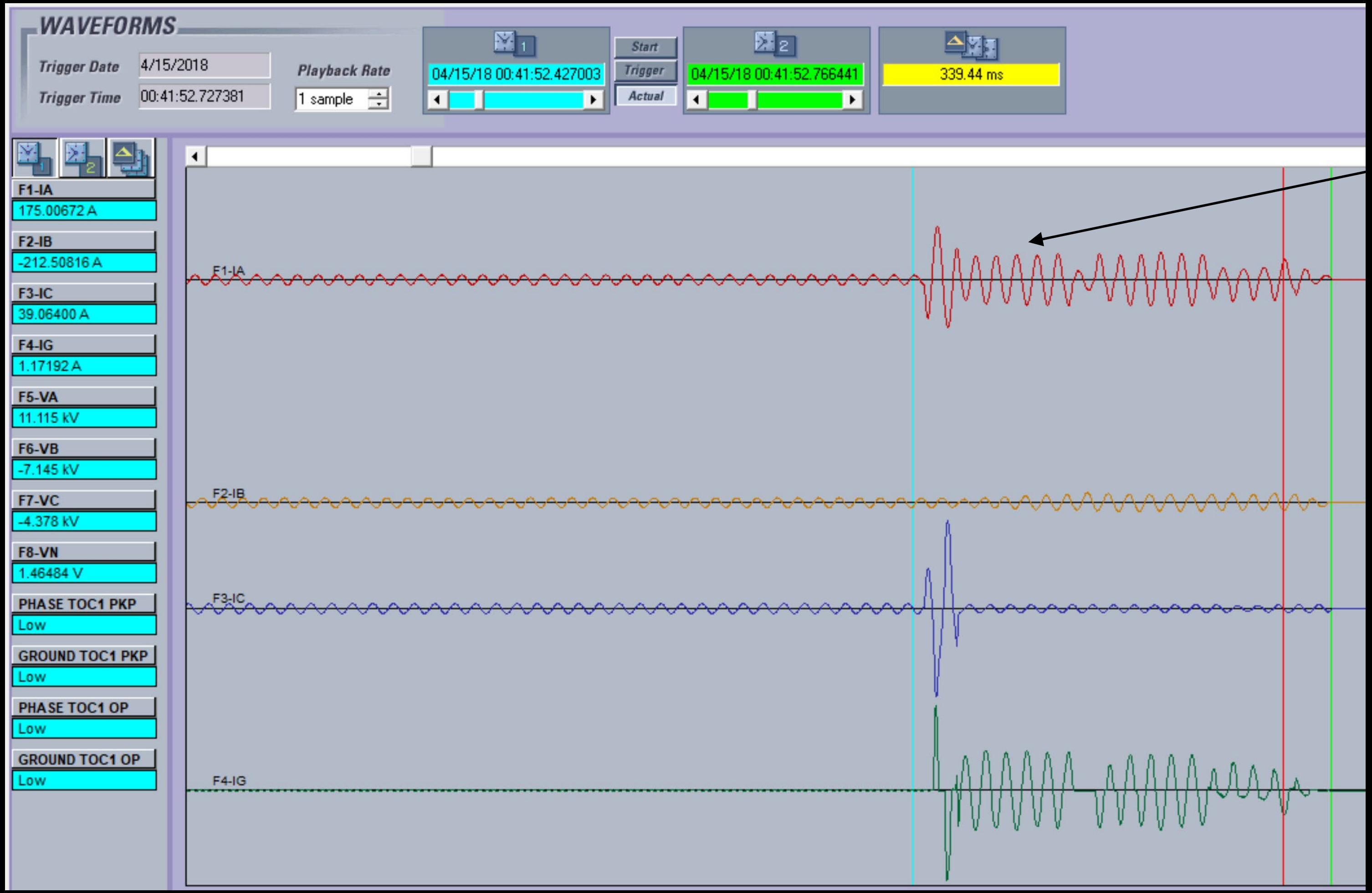
Solution #1 – Fix the Mis-Coordination







Solution #2 – Solidly Ground the System

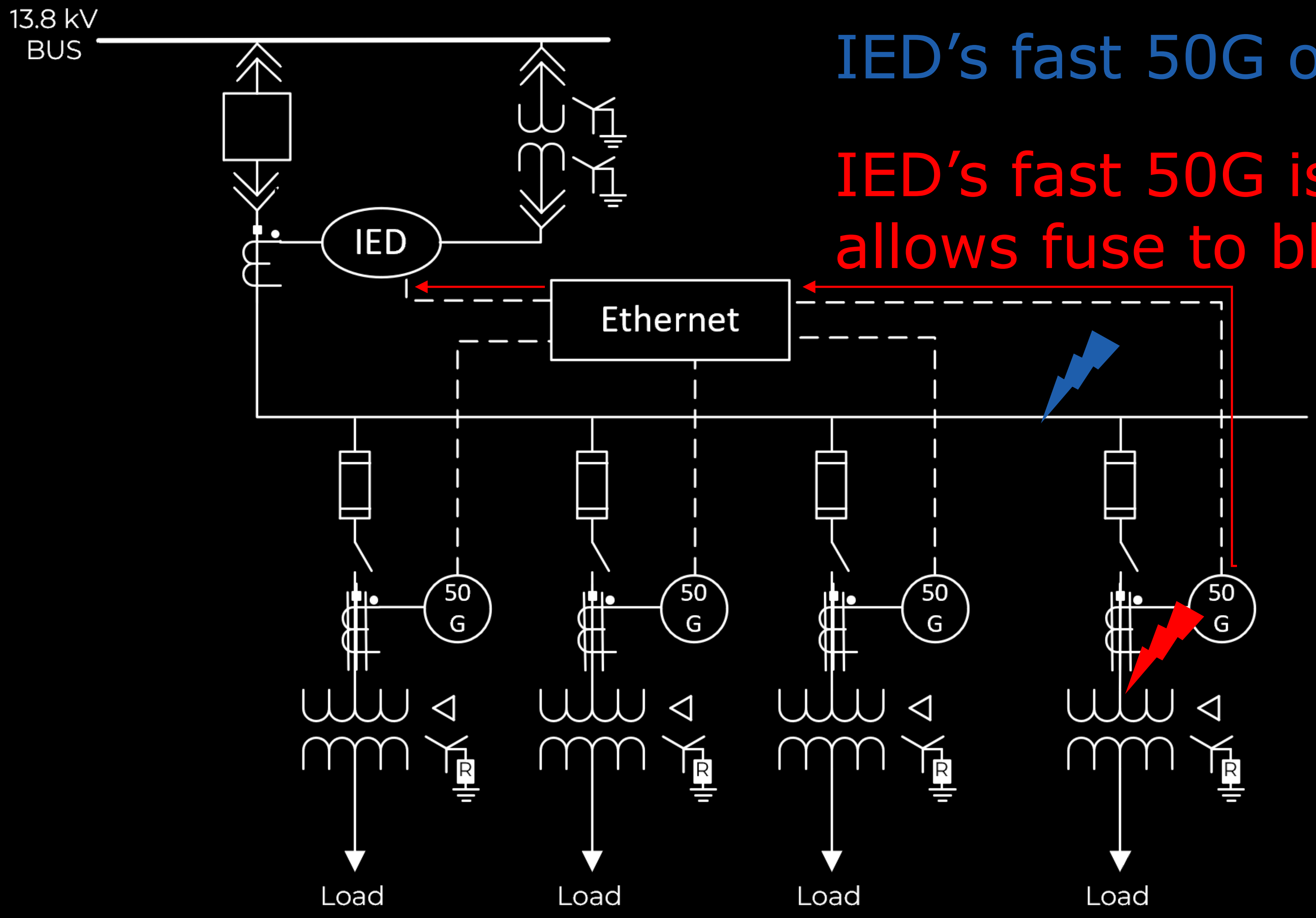


Instead of limiting current magnitude after one fuse blows, the 2nd fuse would have likely blown very fast.

Fixes coordination problem.

Increases fault energy, potential catastrophic damage to gen.

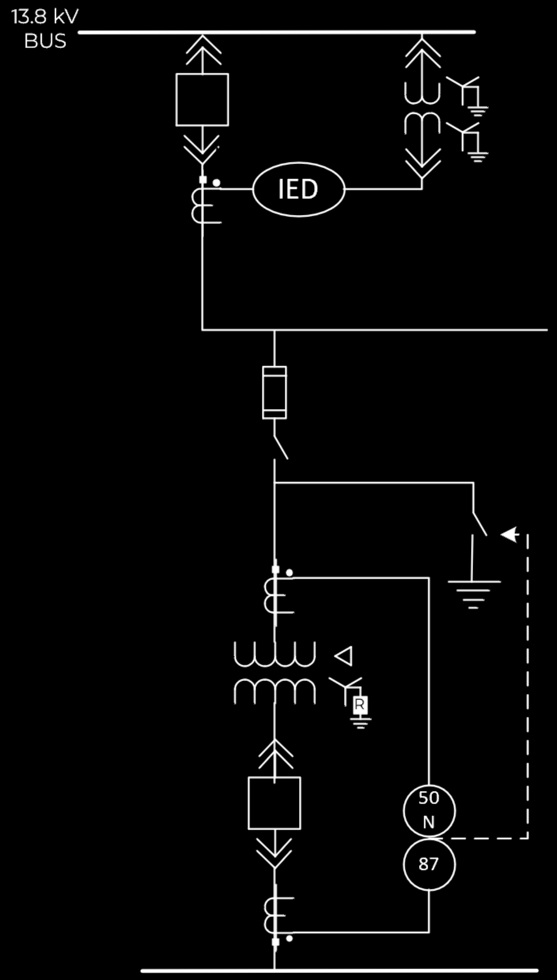
Solution #3 – Use IED’s to Locate Fault



IED’s fast 50G operates.

IED’s fast 50G is blocked. IED allows fuse to blow.

Solution #4 – Use IED's to Trigger Fast Grounding Switch

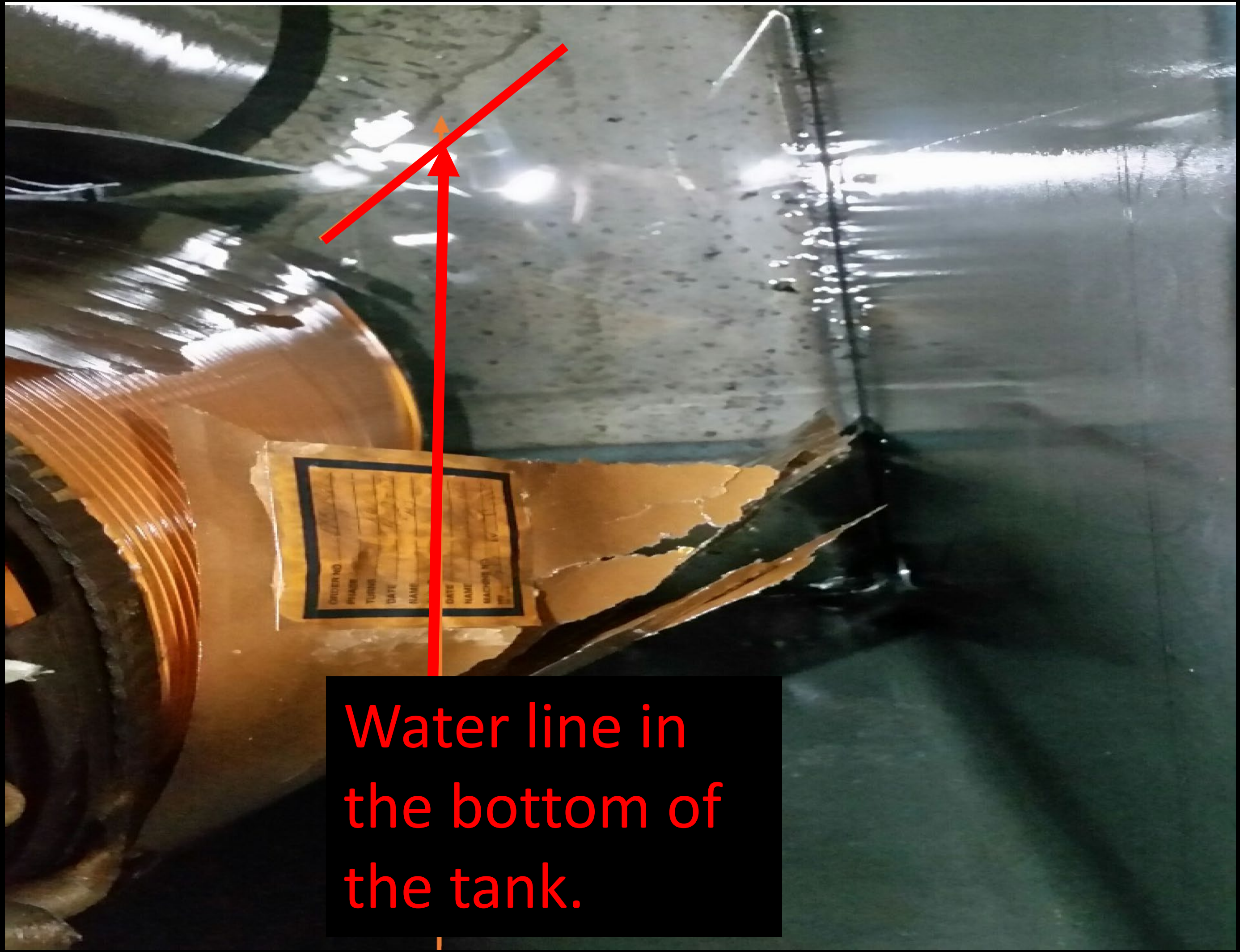


IED protection detects transformer fault and actuates fast ground switch.

Fuses blow for 3LG fault in 8 ms.

Costly, but there's an added benefit of arc flash reduction at LV equipment.

Solution #5 – Use Proactive Transformer Monitoring



Online monitoring might detect moisture in the transformer before a fault occurs.

Solution #6 – Install a breaker (or recloser)

A breaker is the most conventional solution, but there’s a reason a breaker wasn’t used in the first place.

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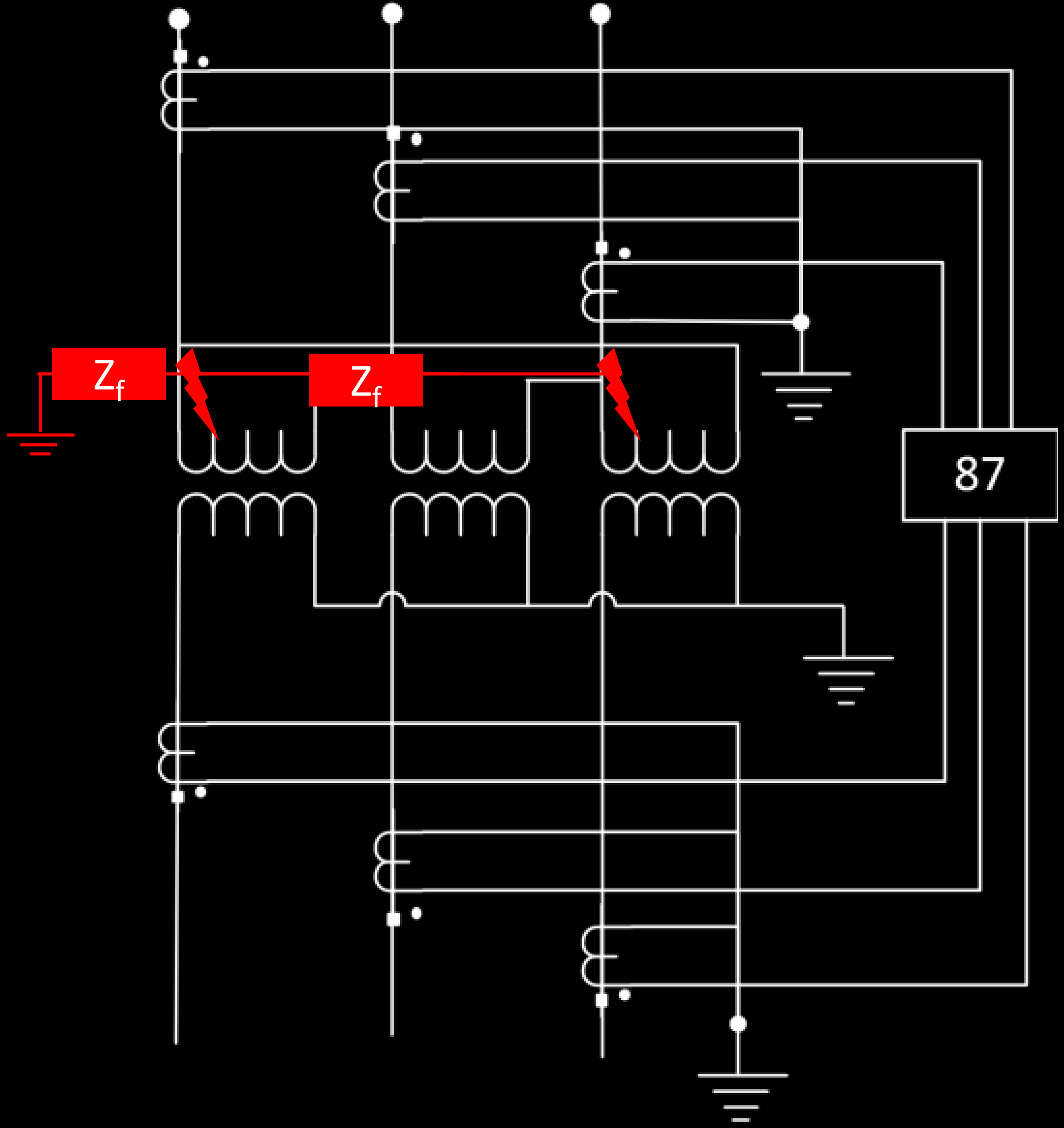
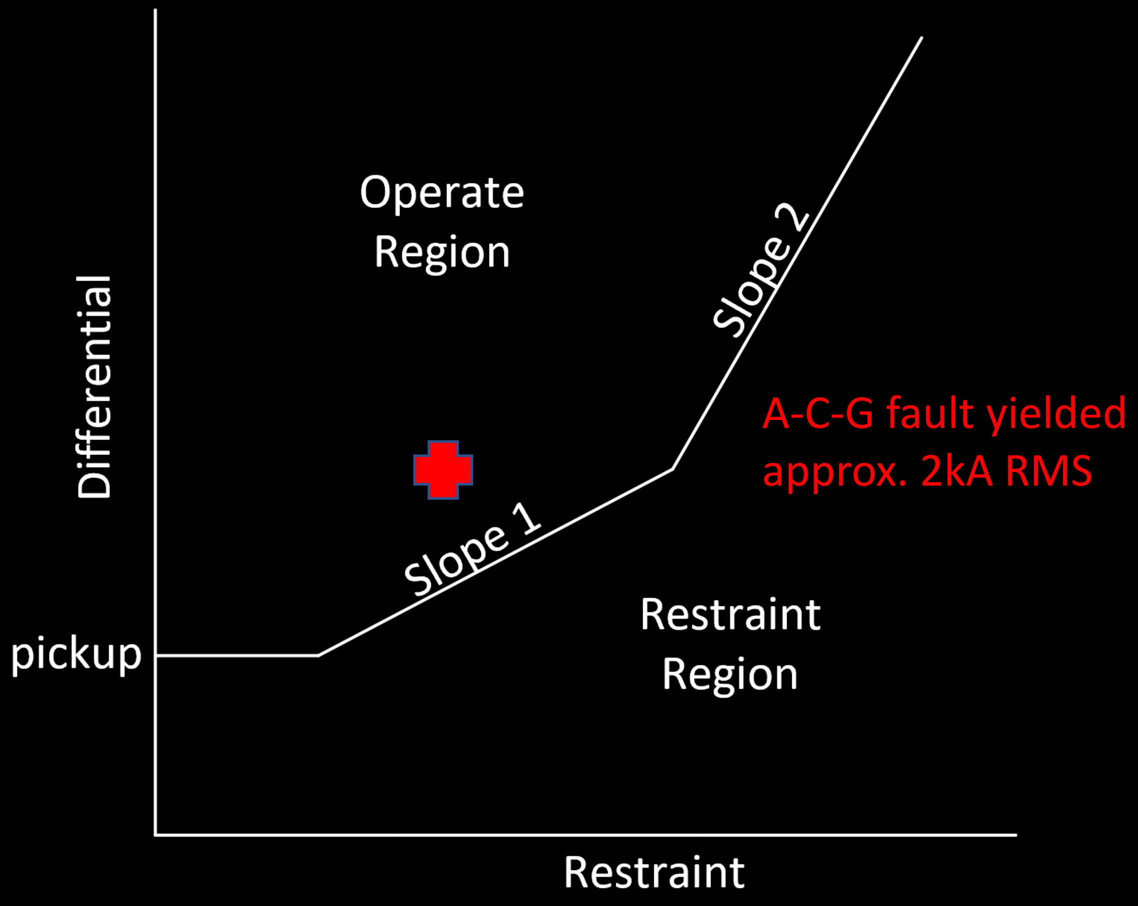
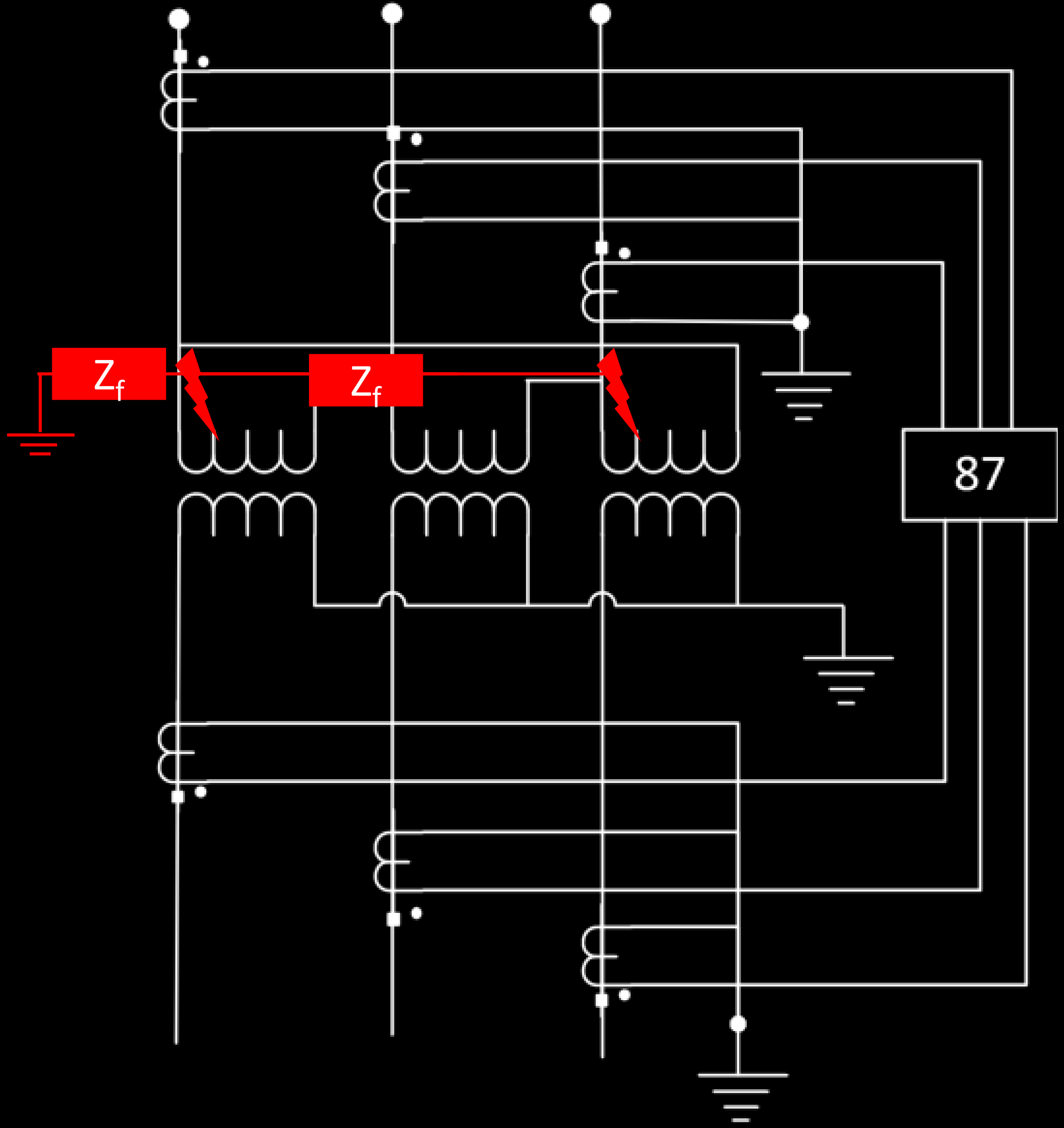
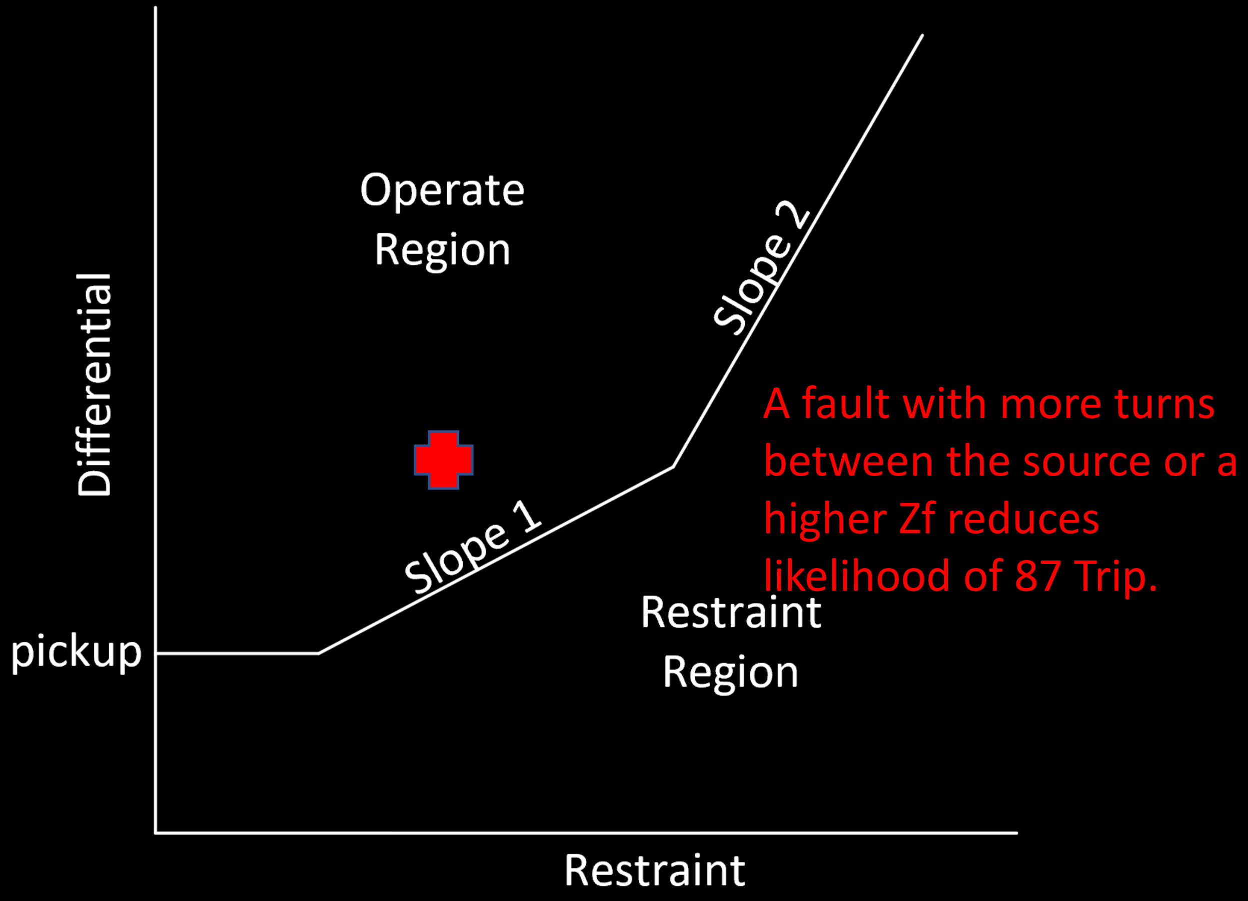
Inference About Transformer Differential Pickup Setting





Ultra-conservative pickup = 2 x maximum loading





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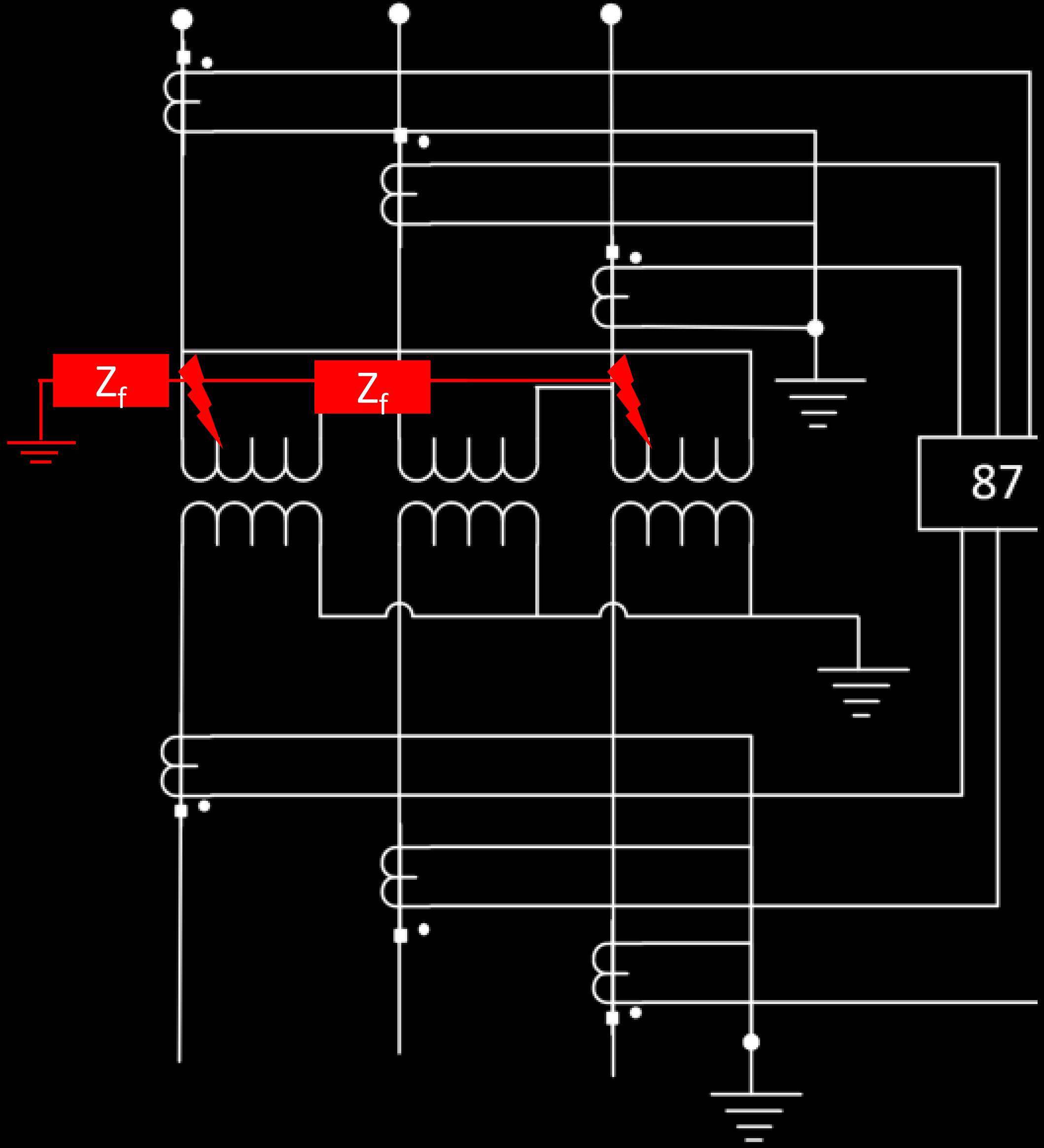

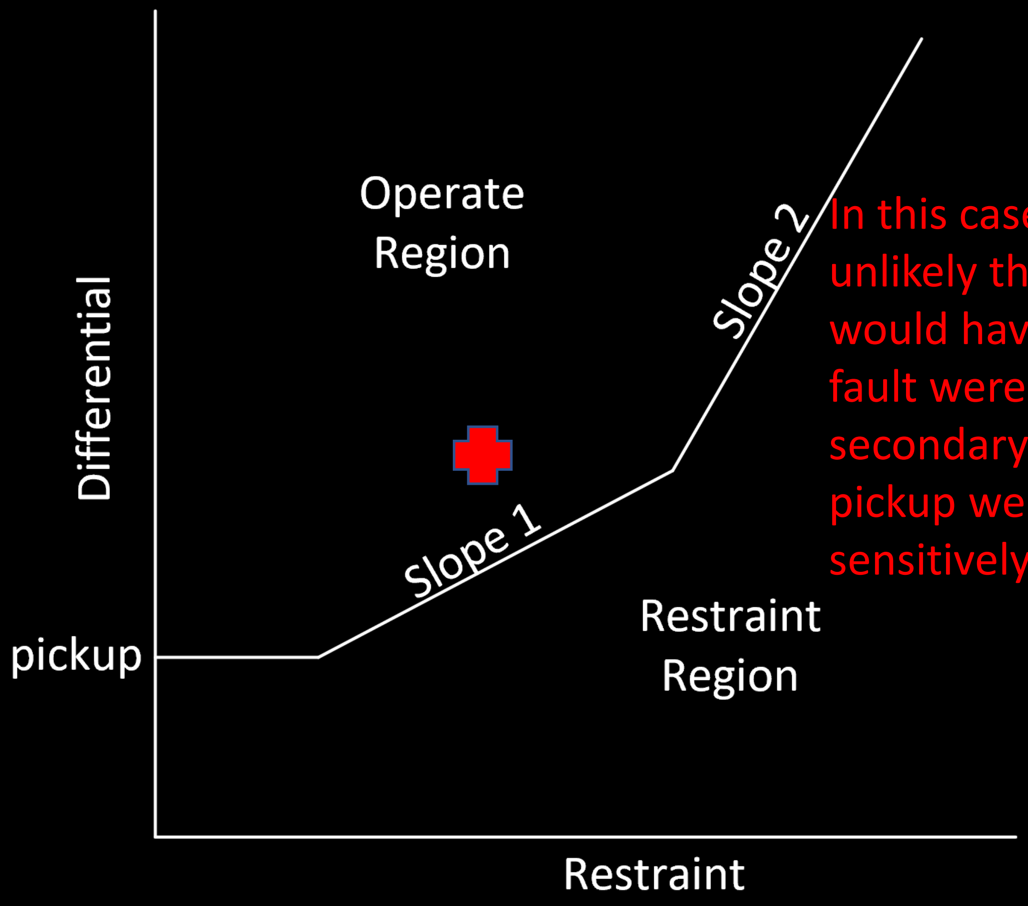

In this case, it is highly unlikely that the 87 would have tripped if the fault were in the secondary winding unless pickup were set sensitively.

Ultra-conservative pickup = 2 x maximum loading

Conclusions

- Fuses can be very fast and effective at clearing faults but are prone to partially clearing.
- Coordinating 51G elements with fuses can require extremely long time delays on resistance grounded systems.
- With multiple sources, multiple scenarios must be considered in coordination.
- Setting an 87 sensitively does not always sacrifice reliability.
- Predictive maintenance is the closest thing we have to zero-cycle protection.

THANK YOU.
QUESTIONS?