Low Inertia Microgrid Fault Stability and Protection Considerations

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POWER ENGINEERS

Microgrid

The U.S. Department of Energy defines the microgrid as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island mode"

Distributed Energy Resource

IEEE defines a DER as a "*source of electric power that is not directly connected to a bulk power transmission system. DERs include both generators and energy storage technologies*."

NERC defines a DER as *"any resource on the distribution system that produces electricity and is not otherwise included in the formal NERC definition of the Bulk Electric System (BES)."*

Microgrid/DER Planning

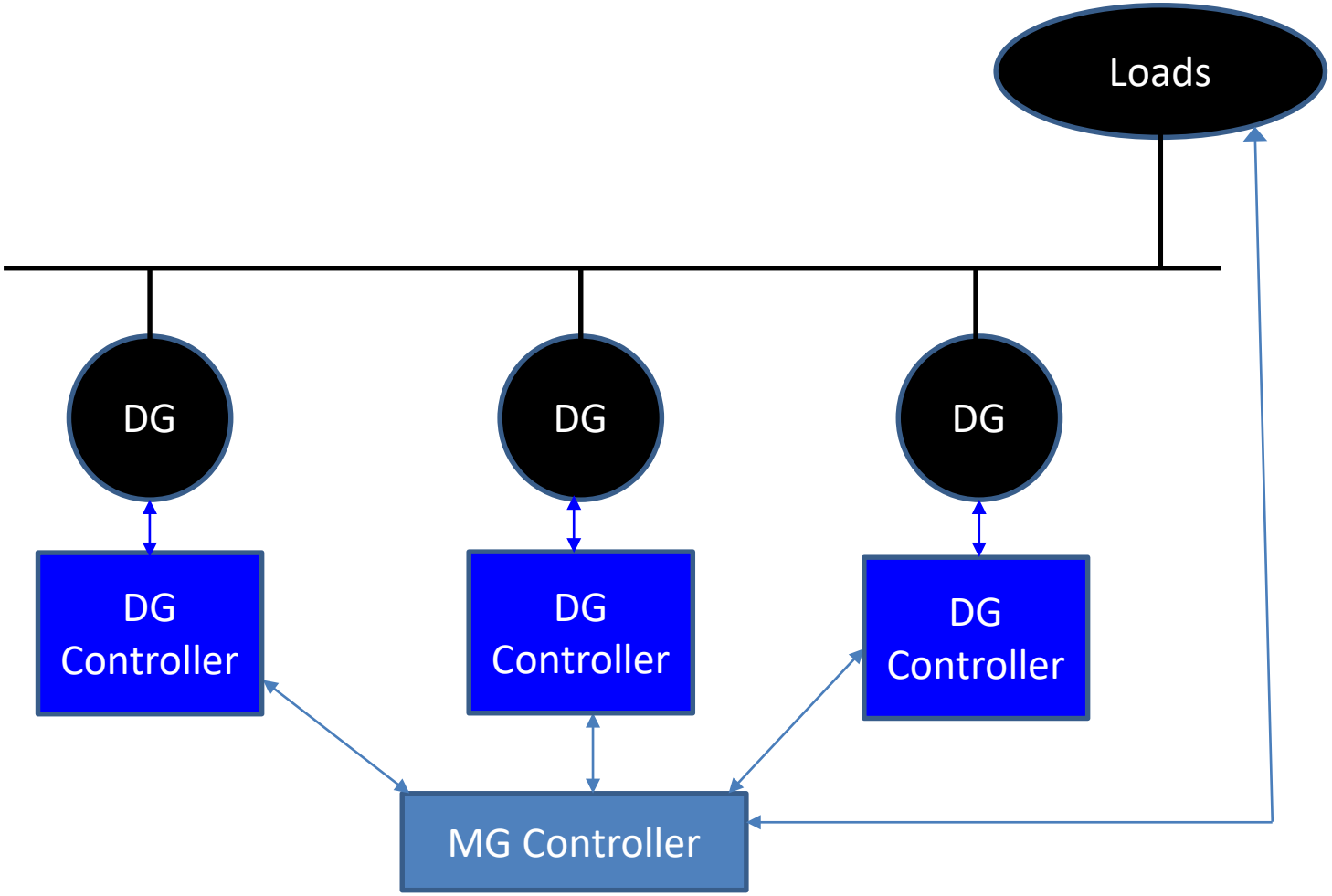
When planning Distributed Energy Resources (DER) in a microgrid, careful consideration must be taken to ensure the DER and microgrid are resilient during both grid-connected and islanded operation.

Distributed Generation

Distributed Generation (DG)

- Synchronous Generators
- Induction Generators
- Inverter/Converter-based Generation

Example DG/Microgrid Control

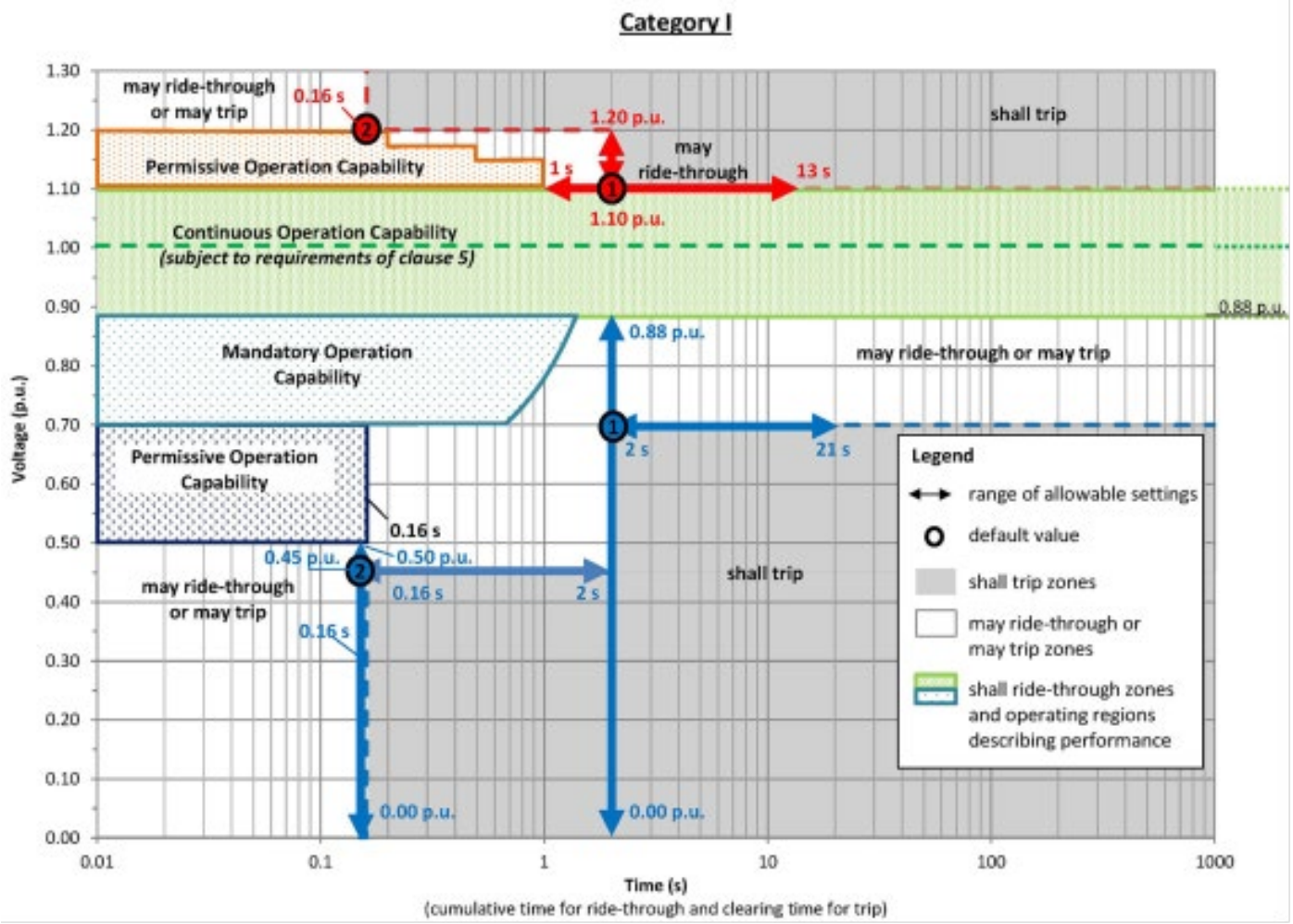


Grid-connected Considerations

Protection & Stability Considerations During Grid-Connected Mode

- DG Fault Current Contribution
- DG Step Response
- Voltage Ride-through, POI Requirements, IEEE1547

IEEE1547 Category 1 DER Voltage Ride-through



Island Mode Considerations

Protection & Stability Considerations During Island Mode

- DG Type
- DG Manufacturer Model Data
- DG Control Modes: P/Q, V/F, Droop
- Existing Equipment, Existing Protection
- Inverter Pos, Neg, Zero Seq Fault Contributions

Microgrid Modeling

- Real-Time Simulator Advantages
  - ✓ Accurate Transient Simulations
  - ✓ Hardware-in-the-Loop (HIL)

Case Study – Hardware/Software

Software:
RTDS® RSCAD® software

Hardware:
Simulated on a NOVACOR RTDS® real-time simulator.

Case Studies

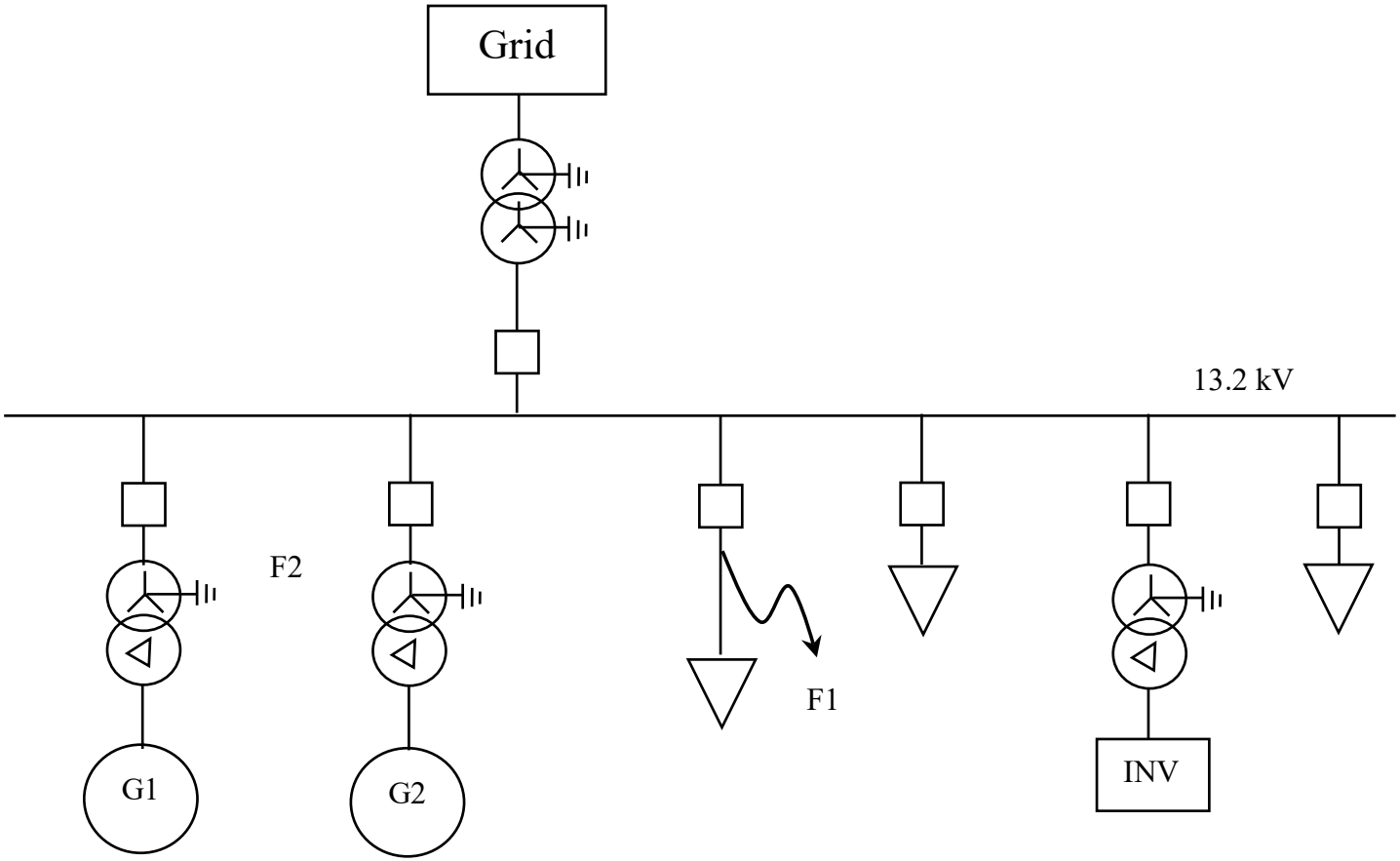
1. Grid-connected, 3 DGs, low impedance 3-phase to ground fault.

2. Islanded, 3 DGs, low impedance 3-phase to ground fault triggered.

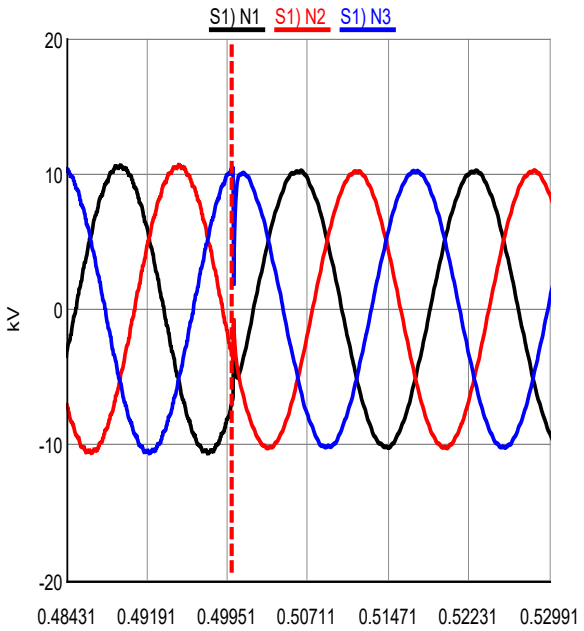
3. Islanded, 1 DG, low impedance 3-phase to ground fault triggered.

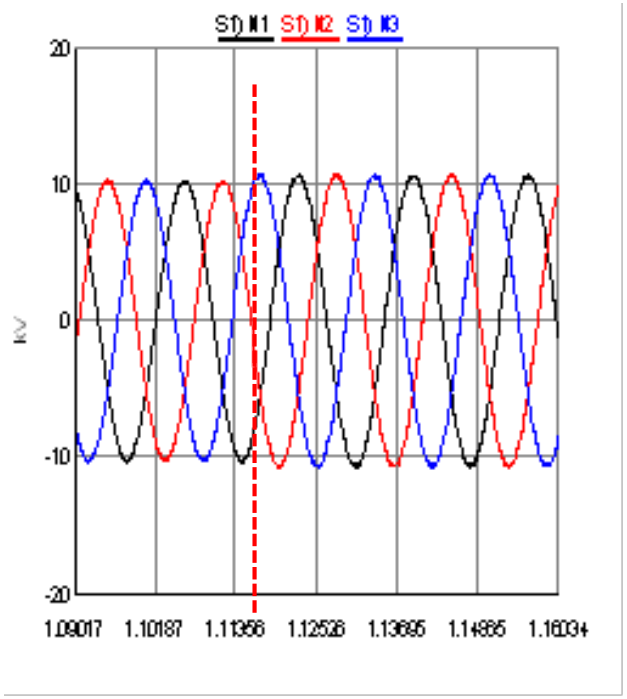
4. Islanded, 1 DG, low impedance 1-phase to ground fault triggered.

Case Study 1: One-line



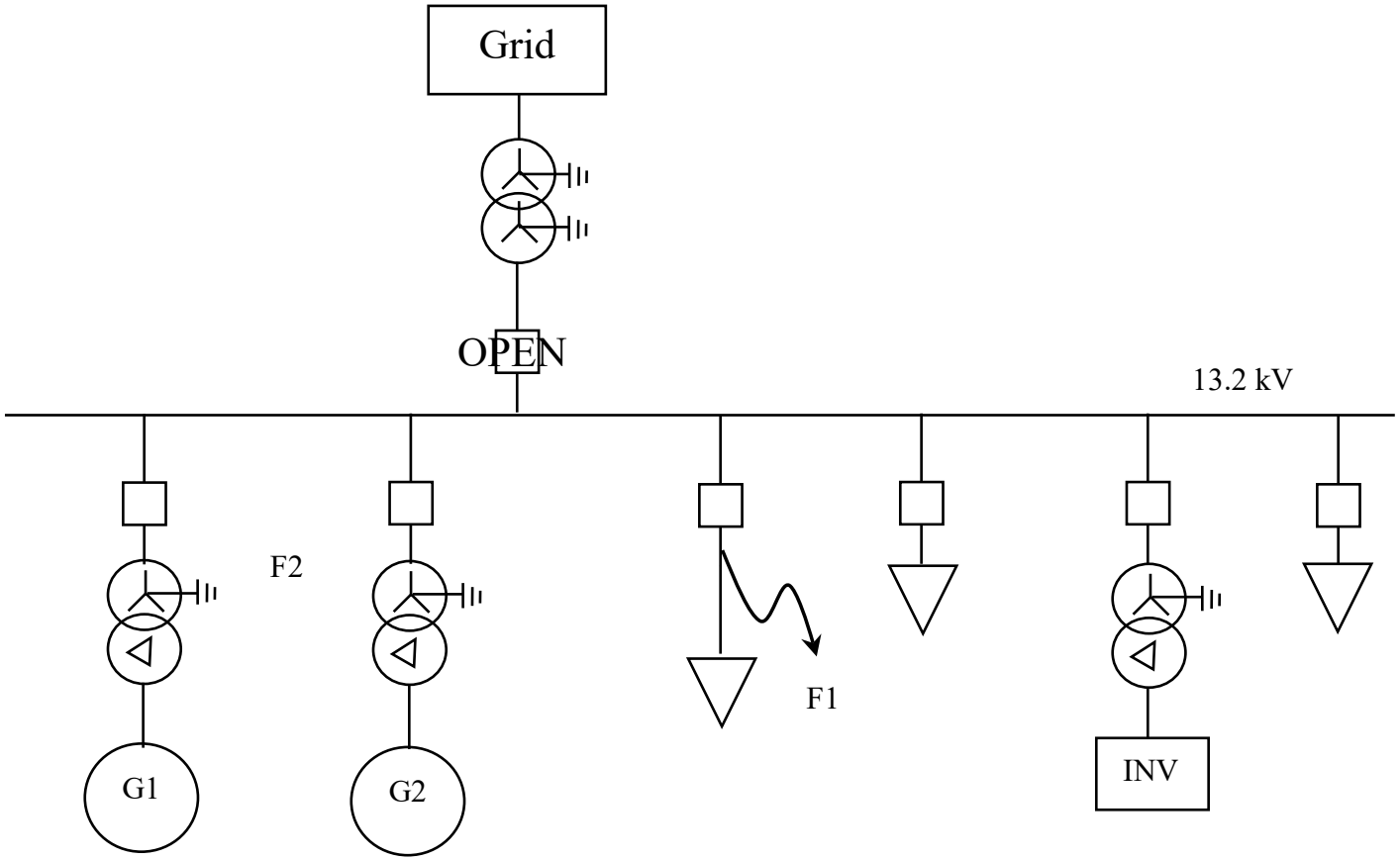
Case Study 1: 13.2kV Fault



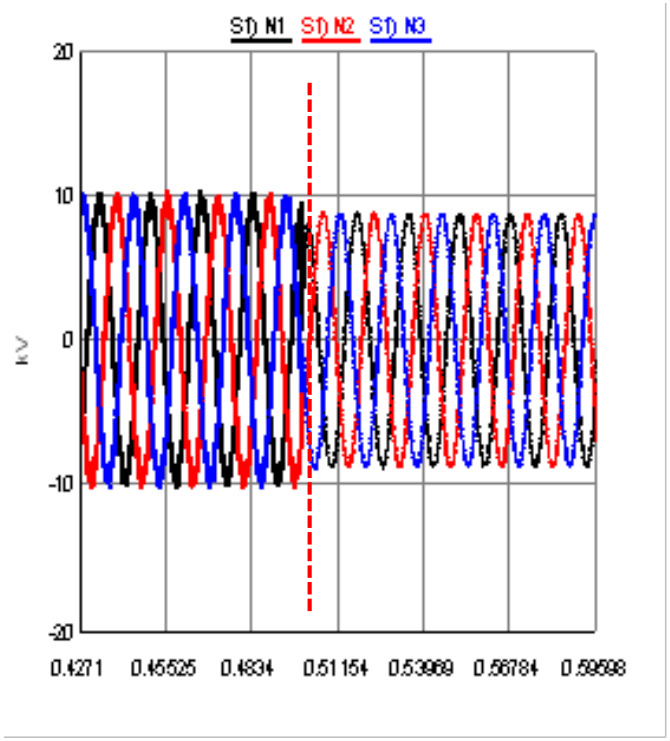


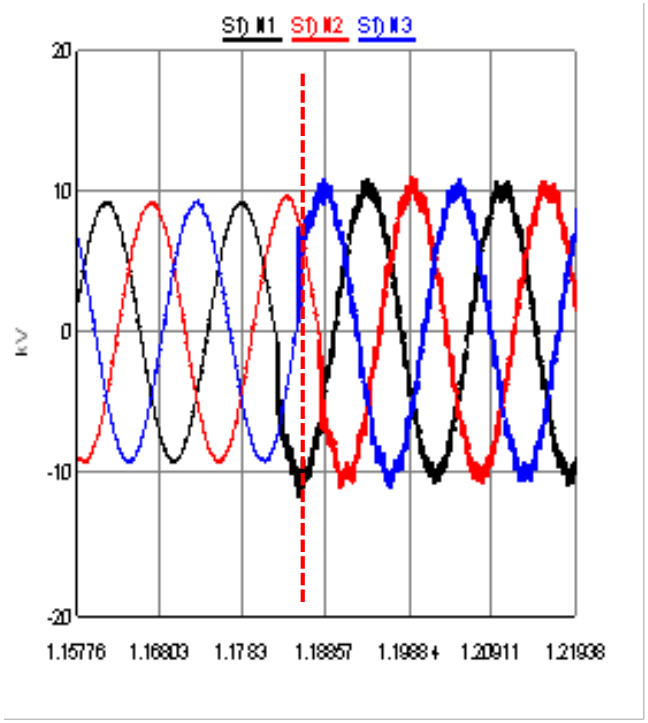
13.2 kV Distribution 0.94 p.u.

Case Study 2: One-line



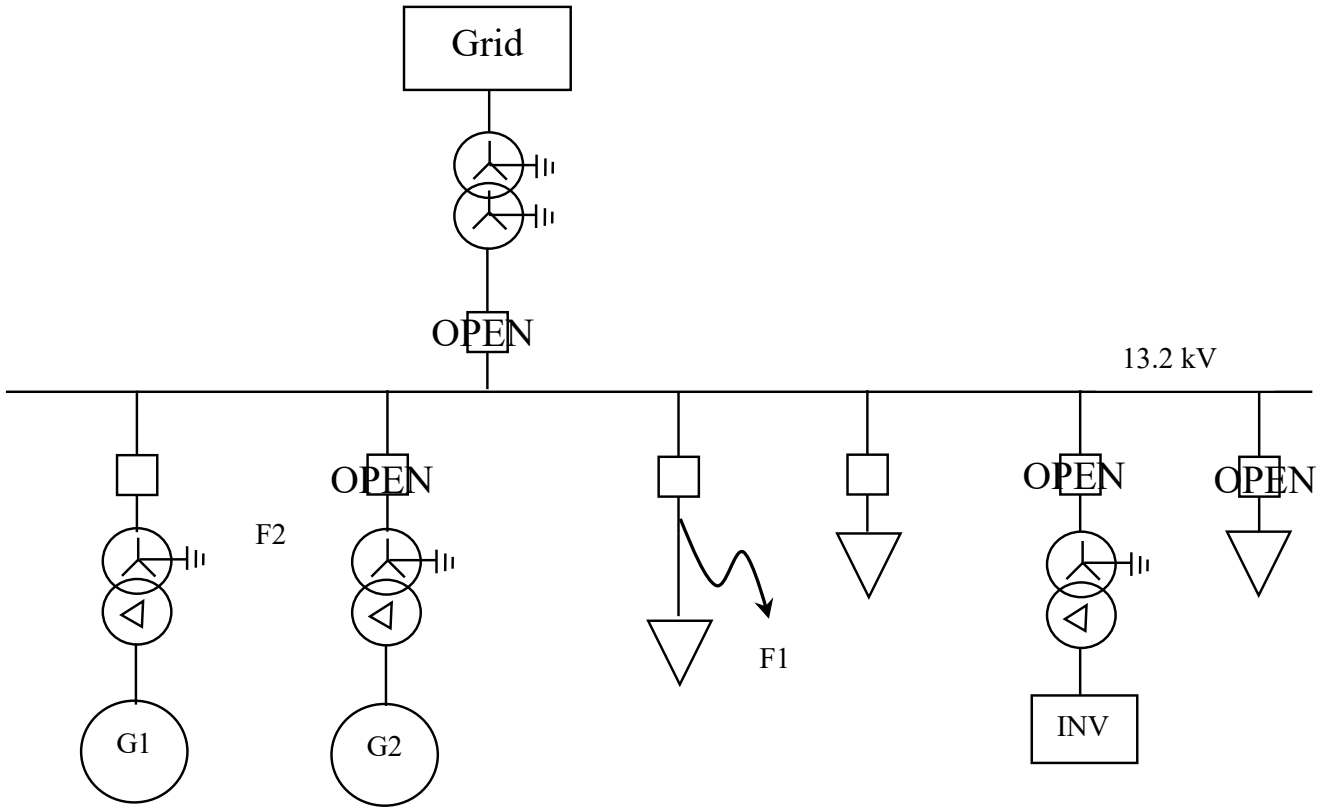
Case Study 2: 13.2kV Fault



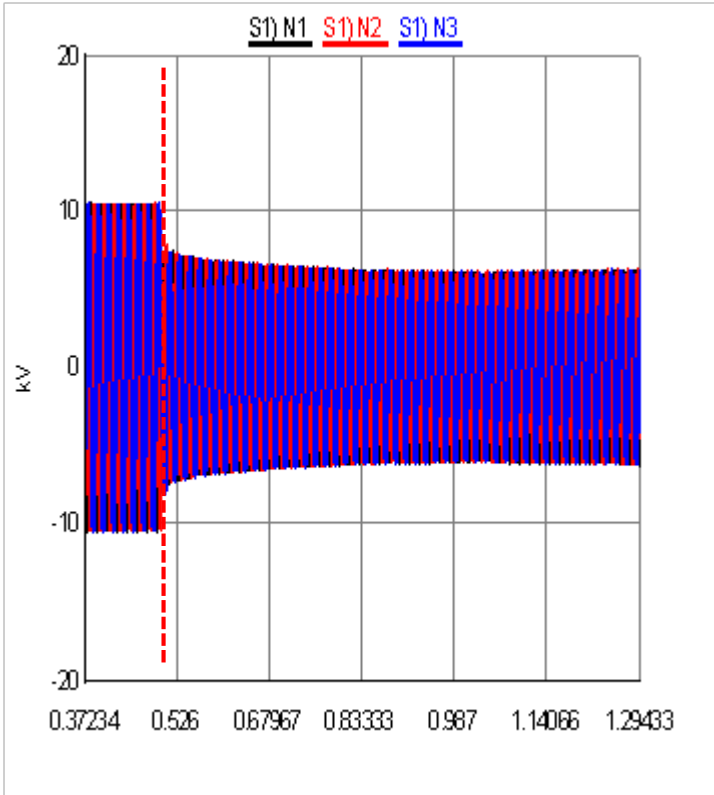


13.2 kV Distribution 0.81 p.u.

Case Study 3: One-line

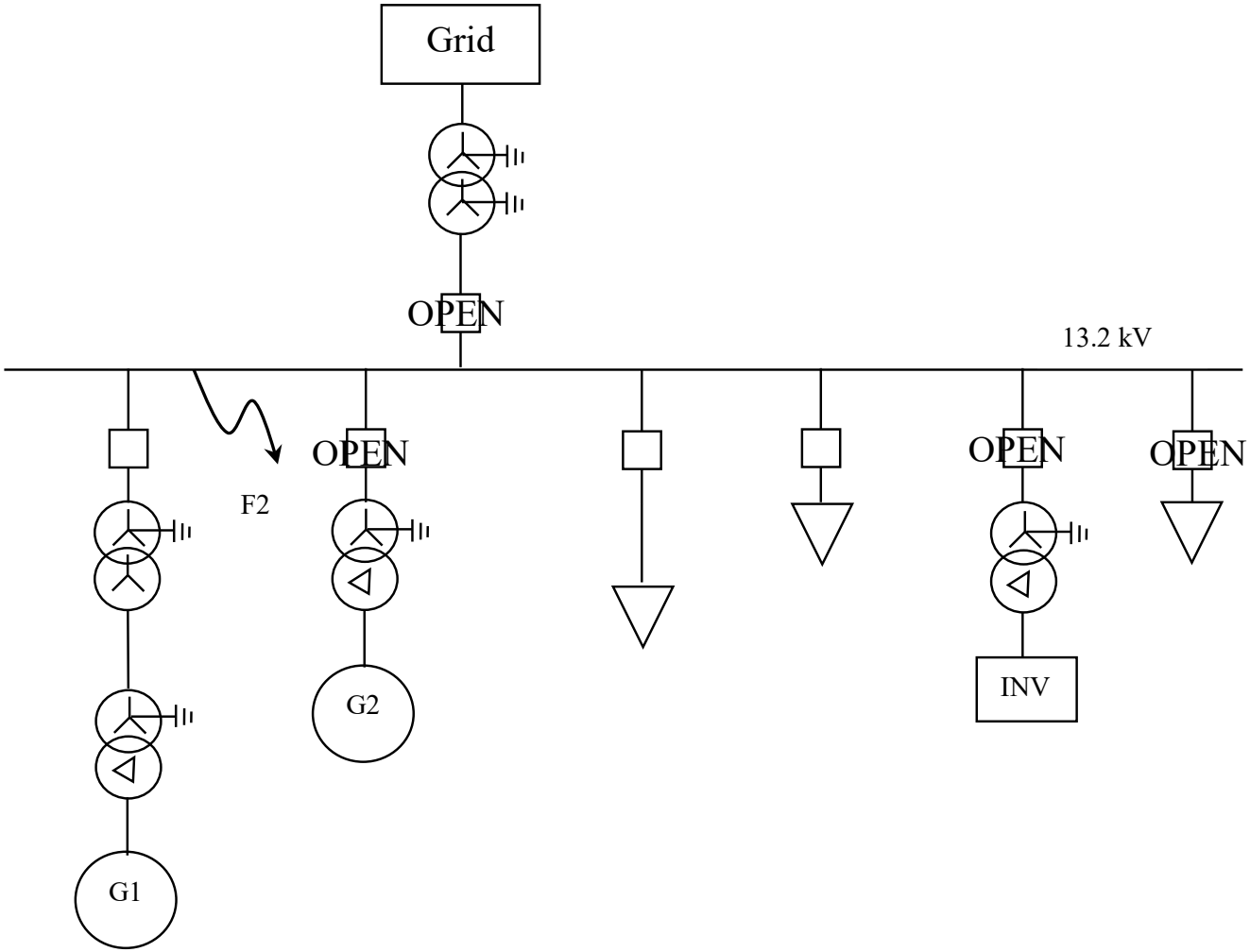


Case Study 3: 13.2kV Fault

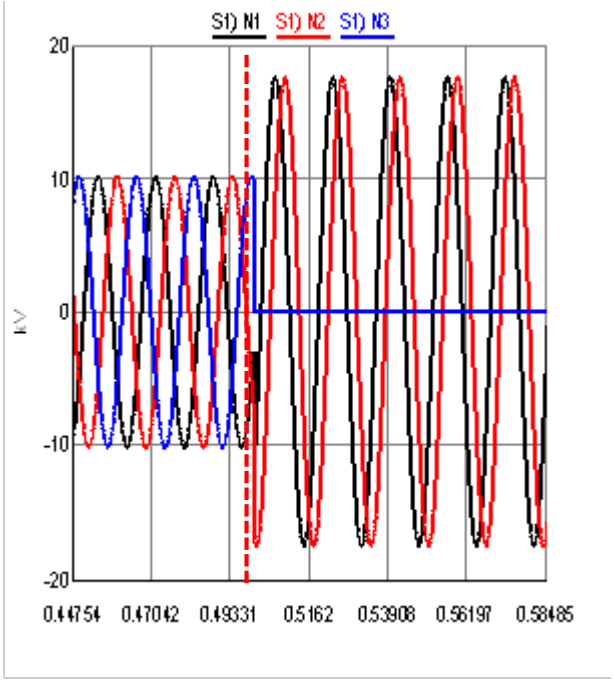


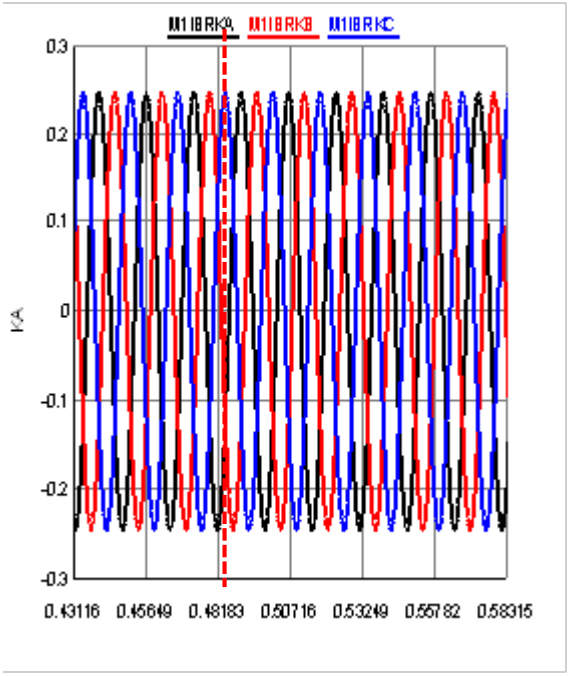
13.2 kV Distribution 0.56 p.u.

Case Study 4: One-line



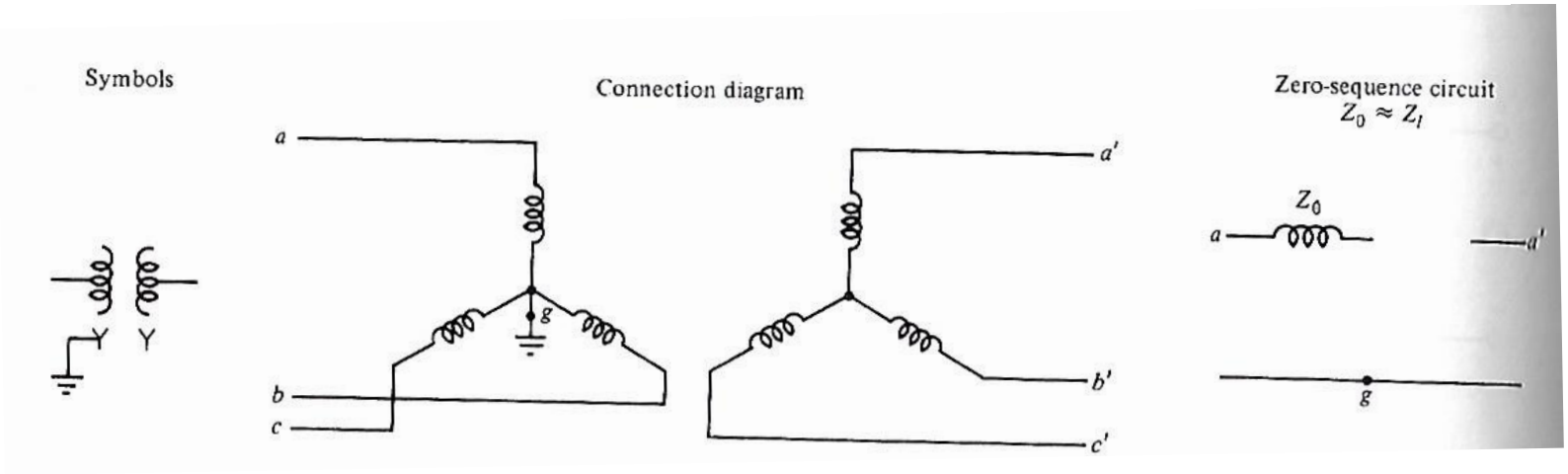
Case Study 4: 13.2kV Fault





13.2 kV Distribution

Wye-Wye Gnd Zero Seq Diag.



Review existing transformer winding configurations

IEEE PES-TR71

- New Technical Report Released *July 2019*
- Protection Scheme Solutions
- Appendix Examples

Conclusion

- ✓ Careful Planning
- ✓ Accurate Simulations
- ✓ Vendor Model Data

References

- D. Ton, M. Smith, “The U.S. Department of Energy Microgrid Initiative” *www.energy.gov/sites/prod/files/2016/06/f32/The US Department of Energy's Microgrid Initiative.pdf*, 2012.
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- Working Group JWG C4/B5.61CIGRE. “Impact of Low Inertia Network on Protection and Control” (DRAFT 2017)
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- 2030-2011 – IEEE Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads. September 10, 2011.
- NERC Distributed Energy Resources Task Force Report – Connection Modeling and Reliability Considerations. February 2017

Questions?

Thank You!

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