Exploring IEEE C37.246-2017 Guide for Protection Systems of Transmission-to-Generation Interconnections

Presented by Abu Bapary

American Electric Power

Tulsa, OK

IEEE PES Power & Energy Society®

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Objectives

- Need for industry document
- Scope/purpose of new guide
- Guide contents
- Summary

Need for industry document

- Past – vertically integrated utilities
  - Individual electric utilities maintain their own interconnection requirements
- Present – power industry deregulation
  - Independent power producers and transmission companies
  - Increasing penetration of inverter-based generation
  - Regulatory reliability standards

Guide Scope and Purpose

- **Scope**
  - Document accepted protection practices for transmission-to-generation interconnections
  - Cover protection system applications at transmission-to-generation interconnections greater than 10 MVA
  - Out of scope: distributed energy resources

- **Purpose**
  - Provide guidance to those responsible for the protection of electrical transmission-to-generation interconnections greater than 10 MVA
  - Not intended to supplant specific transmission or generator owner practices, procedures, requirements, or contractual agreements.

Guide contents

Establishing interconnection

- Technical data exchange between transmission and generator owners

Interconnection configurations

- Straight bus
- Dual-terminal bus
- Tapped connections

System studies

- Evaluate proposed transmission-to-generation interconnections
- Power flow, transient stability, short-circuit, and relay coordination

Guide contents (cont.)

Protection system settings for interconnections

- Specific protection system guidelines to be considered when designing new or upgrading existing interconnection substation.
- Interconnection substation protection and control functions
- Issues of autoreclosing near generation and interconnection communication-based transfer tripping
- Tapped connections
- Interconnections with renewable energy sources

Establishing interconnection Role of transmission owner

- Selects relays and protection schemes
- Determines maximum and minimum fault current levels
- Approves generator step-up (GSU) or interconnection transformer winding configurations
- Provides data on:
  - Power system stability
  - Synchronizing practices
  - Autoreclosing practices
  - Grounding coordination

Establishing interconnection Role of generator owner

- Proposes point of interconnection
- Provides design drawings
- Provides data on:
  - Generator
  - Transformer
  - Ride-through capability
  - Reactive power, frequency control
  - Short circuit levels

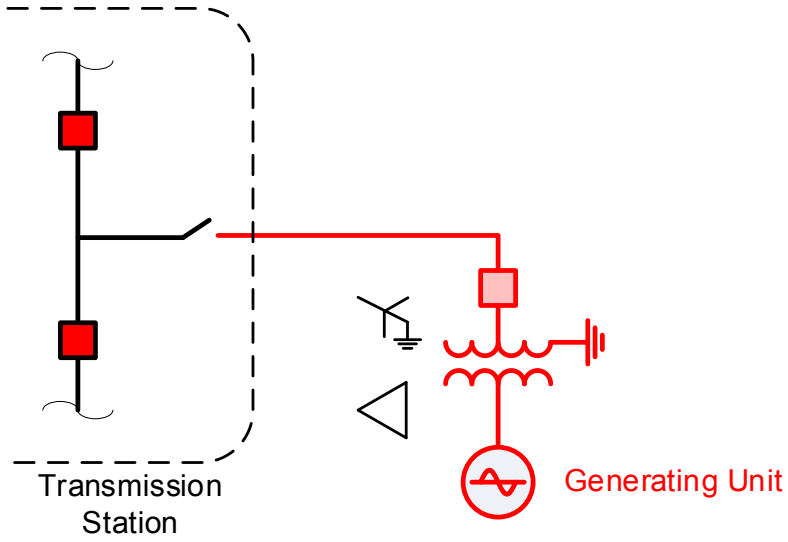
Establishing interconnection Specific considerations

- Various items to agree on:
  - Equipment
  - Protection
  - Testing

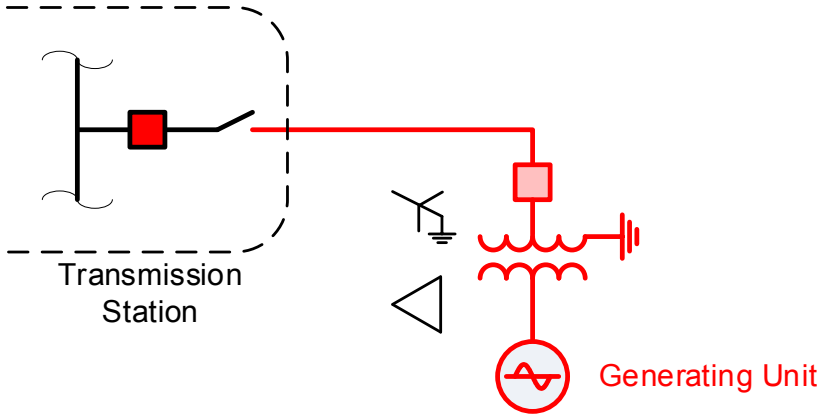
- Voltage transient effect

Interconnection configurations
Tie line

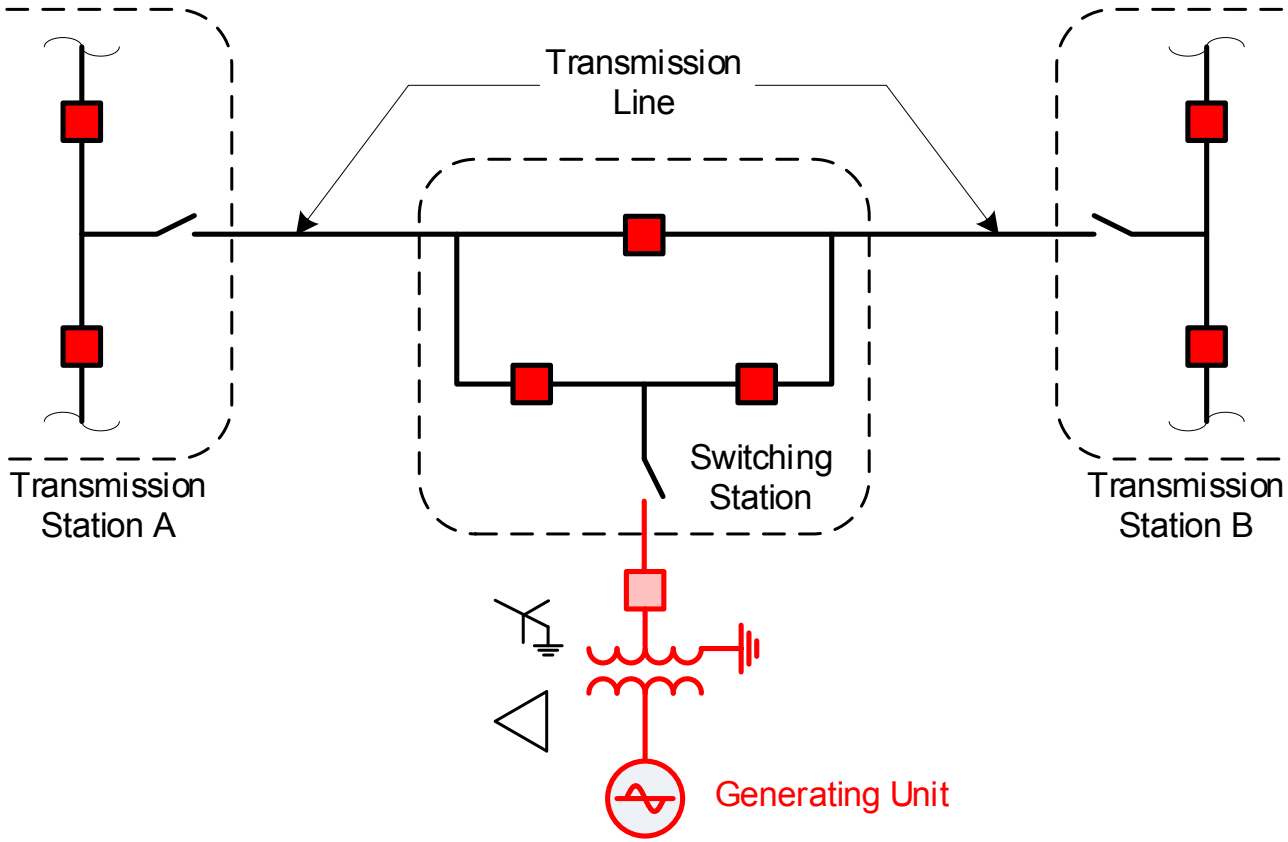
a) Double breaker arrangement



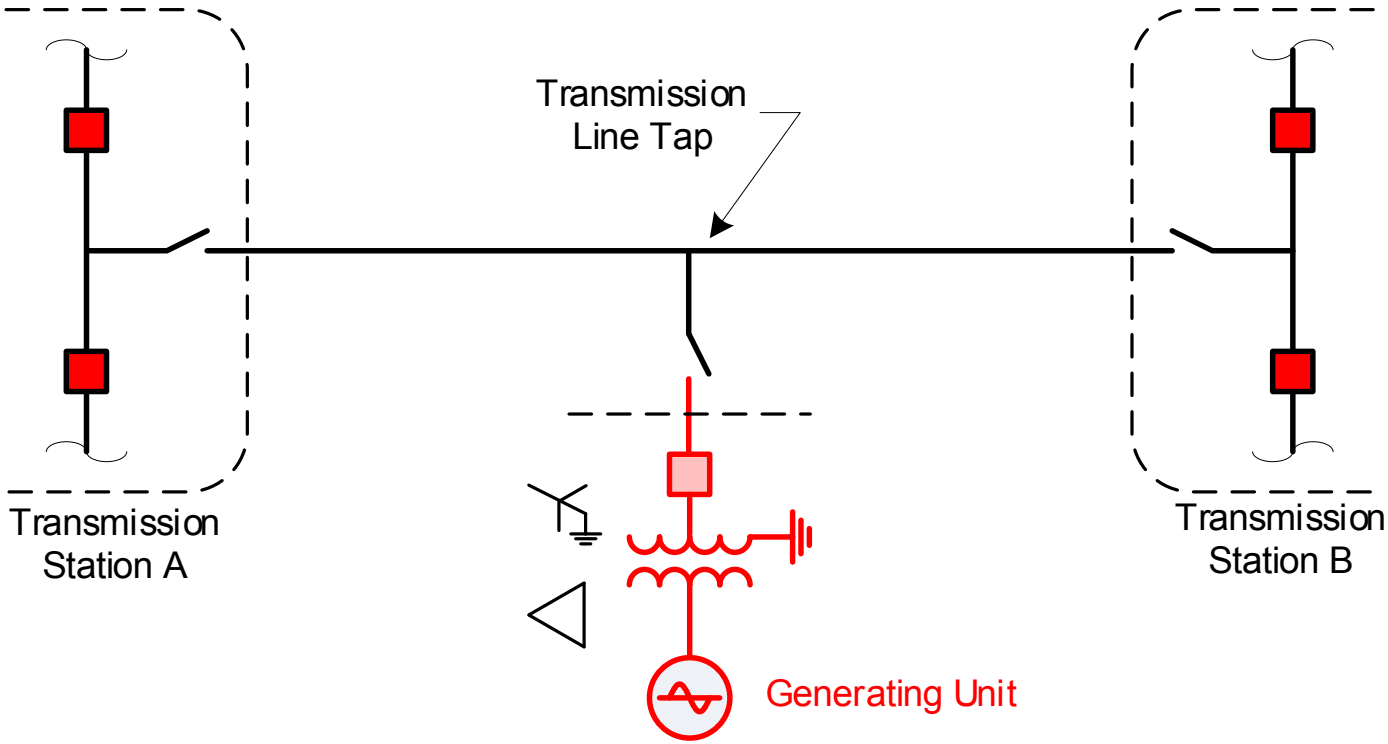
b) Single breaker arrangement



Interconnection configurations
Switching station



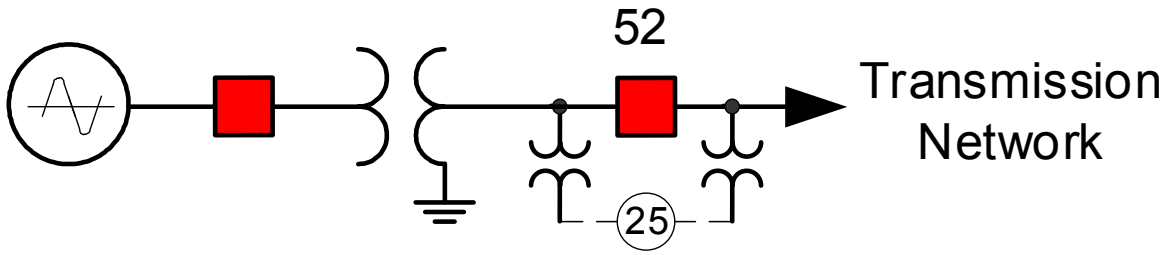
Interconnection configurations
Tapped connection

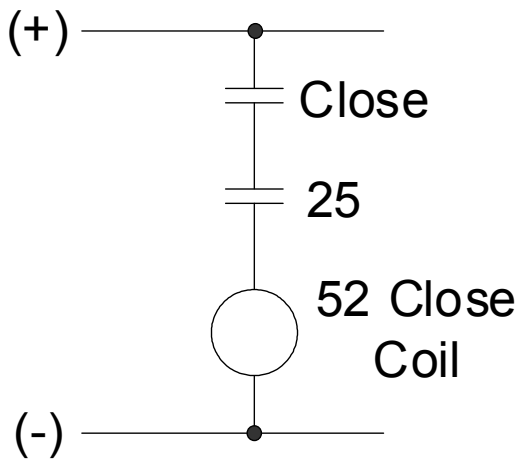


System studies

- System impact study
- Facilities study
- Specific system studies
  - AC power flow analysis
  - Transient stability analysis
  - Short circuit analysis
  - Relay coordination studies
  - Subsynchronous resonance (SSR) studies

Interconnection protection functions
Synch Check (25)

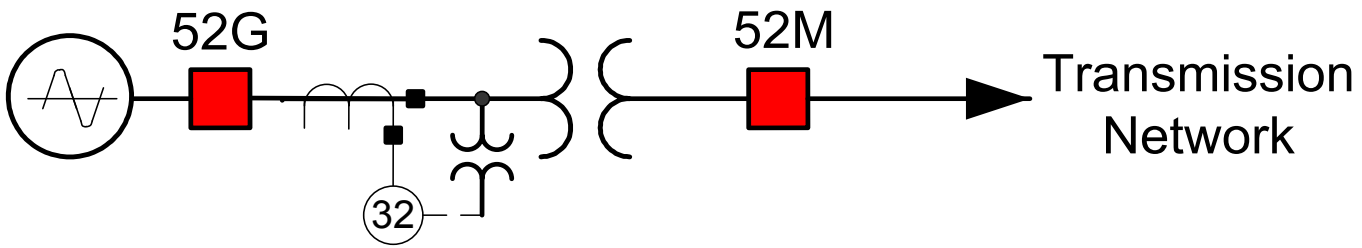




Interconnection protection functions Degraded Grid Voltage (27)

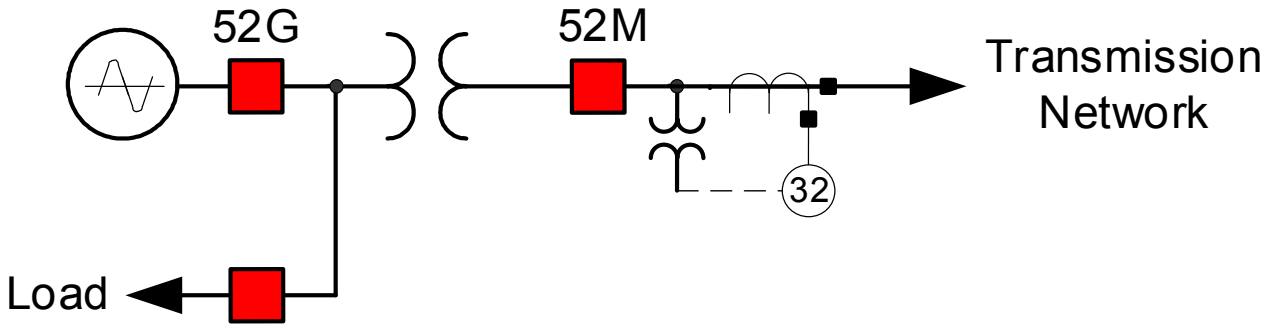
- Generator auxiliary systems
- Specified limits
- Separation
- Multiple elements
- Coordination
- See guide for further details

Interconnection protection functions
Reverse Power (32) – generator motoring



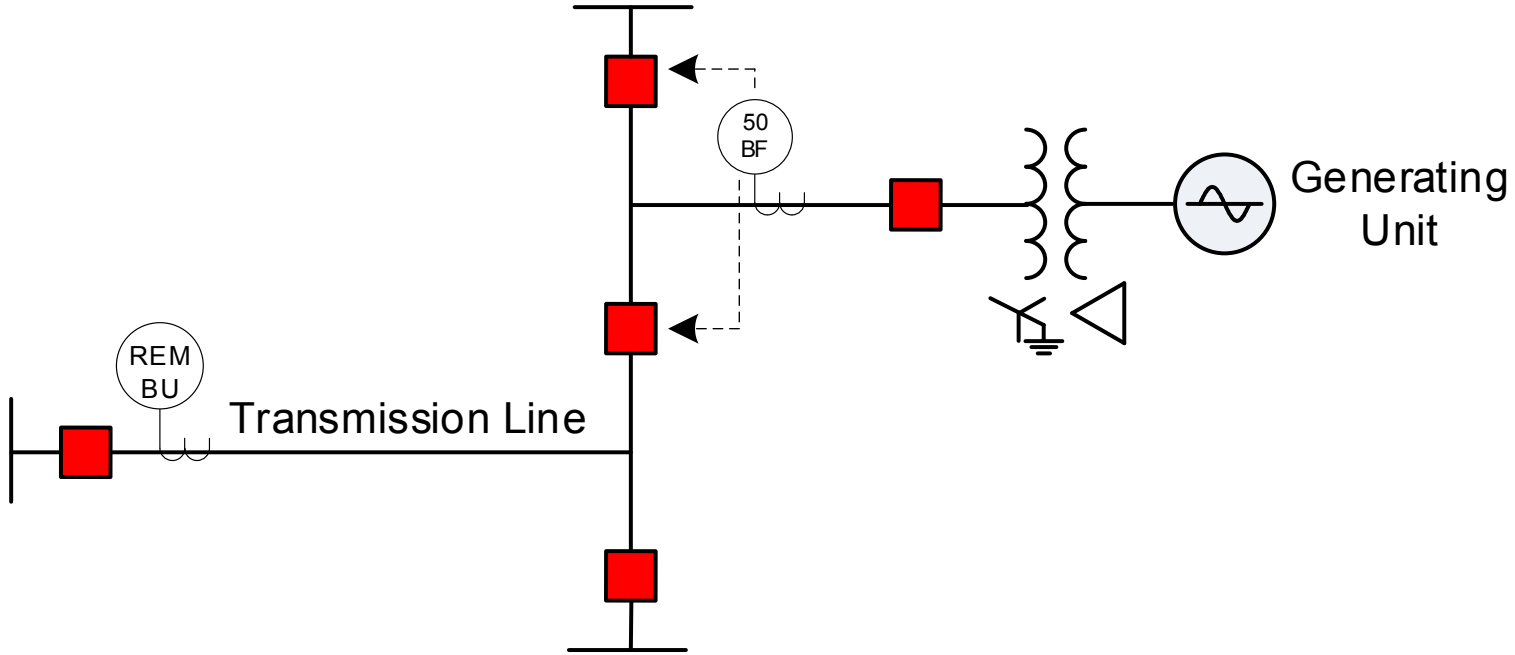
- Typically, part of generator protection
- Applied with loss of prime mover energy
- Trip 52G for power flow into the generator

Interconnection protection functions Reverse Power (32) – one way

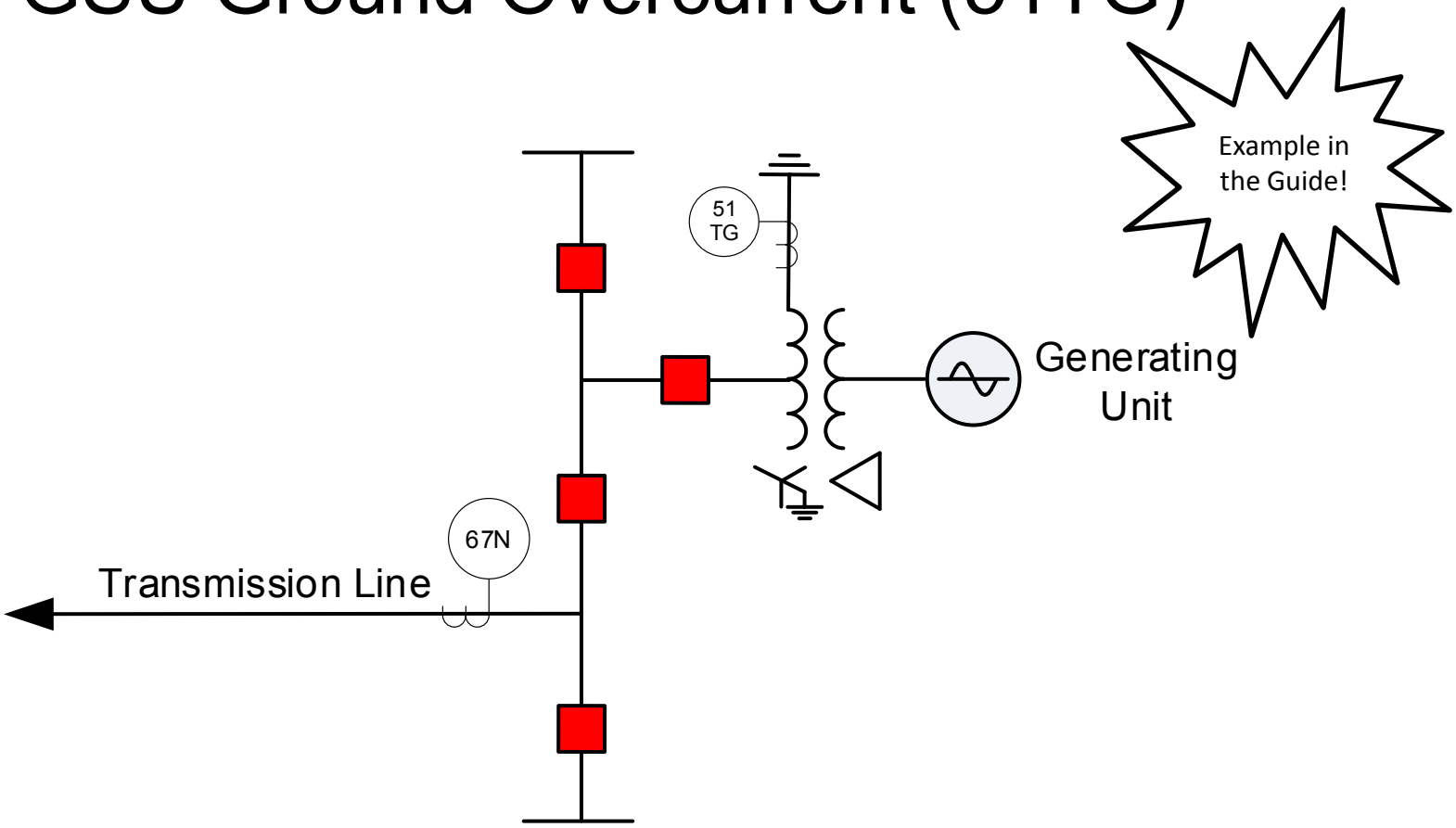


- Industrial plant with local generation
- Generation for load offset, no energy export
- Lost network source, power flowing into network
- Trip 52M
- Trip 52G

Interconnection protection functions
Breaker failure protection (50BF)



Interconnection protection functions
GSU Ground Overcurrent (51TG)



Interconnection protection functions Frequency protection (81)

- Typically applied at generation
- Anti-islanding protection
- Manufacturer recommendations
- Regional requirements
- Backup

Interconnection protection functions Bus Differential Protection (87B)

- When is interconnection a bus?

- IEEE Std C37.234 - Protective Relay Applications to Power System Buses.

Interconnection protection functions
Tie line current differential protection (87L)

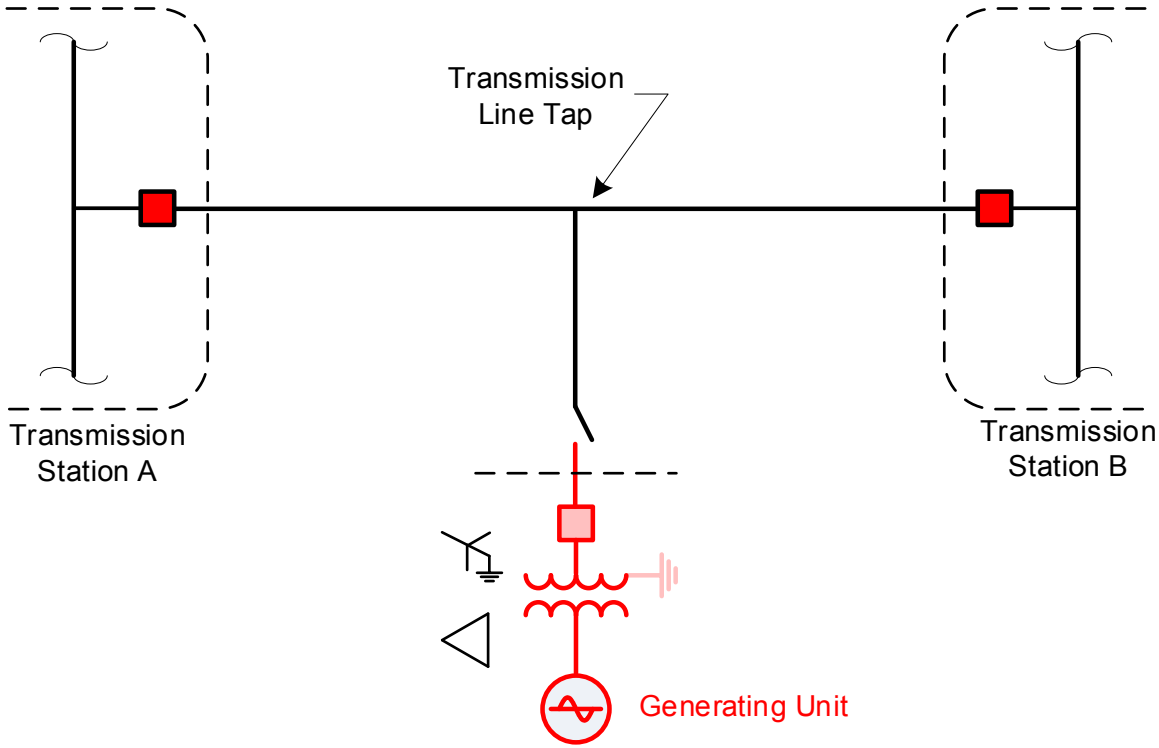
- When is interconnection a line?
- Current differential scheme
  - Not affected by weak infeed conditions
  - Only requires line currents
  - Setting simplicity

Line autoreclosing

- Intermittent faults
- Consider possible damage to generation
- Mitigating options

Tapped connections
Design issues

- Tap adds exposure for line faults to the existing circuit
- Loss of the transmission line results in a loss of generator



Tapped connections
Protection issues

- More complex multi-terminal protection schemes
- May require communication assisted schemes
- Relay coordination issues
- Zone 1 distance protection
- Infeed effects

Renewable energy resources
Wind plants

- Fault current contribution
- Varying fault currents
- Protection basics

Renewable energy resources
Solar PV inverters

- Current controlled devices
- Fault currents
- Time delayed elements
- Filtering components of the inverter
- Protection basics

Summary

- Engineering transmission-to-generation interconnection
  - Design reliable interconnection for dependable system operation during normal or abnormal system conditions.
  - Collaborate between transmission and generator owners during interconnection design

- Role of IEEE C37.246 guide
  - Developed to aid protection engineers in interconnection design
  - Documents and explains protection principles and best practices
  - Expounds on practical application issues