
Presented by Alla Deronja
System Protection Engineer
American Transmission Company
Authors

Alla Deronja, ATC (Chair)
Keith Houser, Dominion Energy (Vice Chair)
Abu Bapary, AEP
Jeffrey Barsch, AEP
Randall Cunico, Power Grid Engineering
Will English, Consumers Energy
Dominick Fontana, Eversource
Dale Fredrickson, We Energies
Nathan Gulczynski, ATC
Mike Jensen, PG&E
Gerald Johnson, Dominion Energy (CM)
Yuan Liao, University of Kentucky
Heather Malson, SynchroGrid

Rene Midence, ERLPhase Power Technologies (CM)
Dean Miller, POI Engineering
John Miller, Georgia Transmission Corporation
Adi Mulawarman, Xcel Energy (CM)
Mukesh Nagpal, BC Hydro
Jim O’Brien, Duke Energy
Mahendra Patel, EPRI
Manish Patel, Southern Company
Neftaly Torres, CenterPoint Energy (CM)
Ian Tualla, Duke Energy
Joe Uchiyama, USBR
Joseph Valenzuela, Kiewit Engineering & Design
Solveig Ward, Quanta Technology
Richard Young, Electrical Consultants
Objectives

• Need for industry document
• Scope/purpose of new guide
• Guide contents
• Interconnection protection overview
• Summary
Need for industry document

• Past – vertically integrated utilities
  ▪ Individual electric utilities maintain their own interconnection requirements
Need for industry document (cont.)

- 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
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 power flow

- Generation for local load, no energy export
  - Industrial plant with local generation
- Lost network source, power flowing into transmission system
- Trip 52M
- Trip 52G
Interconnection protection functions
Breaker failure protection (50BF)
Interconnection protection functions
GSU Ground Overcurrent (51TG)

Example in the Guide!
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
- Fast protection response needed
Renewable energy resources
Solar PV inverters

- Current controlled devices
- Fault currents
- Time-delayed protection issue
- Filtering components of the inverter
- Fast protection response required
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
  • Aid protection engineers in interconnection design
  • Document and explain protection principles and best practices
  • Expound on practical application issues