
Presented by Abu Bapary
American Electric Power
Tulsa, OK
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

Transmission Station A

Transmission Line

Switching Station

Transmission Station B

Generating Unit
Interconnection configurations
Tapped connection

Transmission Station A

Transmission Line Tap

Generating Unit

Transmission Station B
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)

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

• 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