Application of Direct Transfer Trip for Prevention of DG Islanding

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Background

• Most distribution systems have radial topology
  – DG can become easily islanded
  – Operation of any upstream breaker, recloser, fuse, or switch can establish an islanded subsystem

• Widely accepted that DG should not continue to energize an island
  – Safety
  – Overvoltages
  – Lack of utility control; potential liability
  – Potential for out-of-phase reclosing

• IEEE 1547 requires DG to cease energization of island in 2 sec
  – Active anti-islanding (AAI) algorithms
  – Direct transfer trip (DTT)
Limitations of Active Anti-Islanding

- AAI schemes have a non-detection zone (NDZ)

\[ Q_{DG} - Q_{Load} \]

\[ P_{DG} - P_{Load} \]

NDZ
Limitations of Active Anti-Islanding

- Decreasing NDZ requires increasing sensitivity
  - Increased potential for false trips
  - Potential bulk grid reliability impact for high penetration
Limitations of Active Anti-Islanding

- Some AAI schemes act as a Power System Destabilizer
  - The entire grid is an island, what about high penetration?
  - These schemes are contrary to the PSS functions required of conventional power plants

\[ f(\text{frequency}) \]

DG

AAI Transfer Function

Voltage, frequency
Limitations of Active Anti-Islanding

- Some AAI schemes are based on perturbing system or injection of a probing signal
  - Speed and effectiveness depend on amount of perturbation
  - Tradeoff between sensitivity and power quality impact

- Different AAI schemes may counteract each other
  - E.g., one DG biased to drift frequency up, another biased to drift frequency down
Direct Transfer Trip

• Direct transfer trip (DTT) communicates a trip signal to a remote location
  – Example: substation relay detects fault on feeder
  – Trip signal communicated to DG location
  – DG breaker tripped by DTT signal

• Advantages
  – Positive avoidance of long-duration island
  – Avoids negative impacts of AAI schemes

• Disadvantages
  – Traditionally viewed as costly
  – Complicated to implement where feeders can be reconfigured
  – Generally does not avoid a short-duration island
DTT Communications

• Communication media
  – Leased telephone lines
  – Dedicated fiber
  – Radio

• Packaged radio systems can make DTT less costly and thus more practical

• Can use “smart grid” comm infrastructure if channels are available with:
  – Low latency
  – Protection-grade security

• Loss of communications needs to be considered
  – Redundancy (expensive)
  – Make DG operation contingent on comm availability
### Simple Auto-Loop Scheme

**Normal Configuration**

- B1: n.c.
- R1: n.c.
- B2: n.c.
- R2: n.c.
- R3: n.o.
- W: Wind plant

**Post-Fault Configuration**

- B1: closed
- R1: closed
- B2: open
- R2: open
- R3: closed
- W: Wind plant

#### Reconfigurable Feeders

- **DTT must be received from any interrupting device that can island DG**
- **In normal configuration**
  - DG (W) must receive DTT from both B2 and R2
- **Fault on Section 22 causes B2 and R2 to open, R3 to close**
- **In backup configuration**
  - DG must receive DTT from B1, R1, and R3
- **Logic to implement DTT on an automated feeder can be complex**
Temporary Island with DTT

- If substation breaker and DG breaker have the same operating time, DG is disconnected after island already occurs.

- Duration of island equals communication latency.
The Case for **Preventing** Islands

- AAI takes from a few cycles to a few seconds to identify islanded state
- Islanding can cause overvoltages
  - Abrupt change in driving point impedance seen by a current-regulated DG inverter
  - Loss of ground reference
- Islanded system has very low short-circuit ratio
  - Outside of typical inverter spec
  - Control instabilities may occur
- Delayed reclosing can affect power quality
**Coordinated Direct Transfer Trip - CDTT**

- Intentional delay between relay operation and energization of substation breaker trip coil
- If interruption times are equal, delay \( \approx \) latency

![Diagram](image)

- Much shorter delay needed if CDTT is direct to inverter
Conclusions

• AAI based on local measurements can have adverse impacts
• Local AAI can only detect island after it has already been created
• Direct transfer trip can provide more reliable islanding protection
• CDTT can avoid island if protection delays are used
• DTT / CDTT can be complex in feeders with multiple possible sources
Thank You!