Communications Assisted Islanding Detection

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Communications Assisted Anti-Islanding

**Agenda**

- What is a power system island?
- Islanding detection – Local
- Islanding detection – Communications Assisted
- Direct Transfer Trip & Phase Comparison Analysis
- Phase Comparison Islanding Detection Details and Critical Functionality
- Summary
A power system island occurs when distributed generation becomes isolated from the power system grid and continues to provide power to a portion of the grid.
What is a Power System Island?

Intentional and Unintentional Islands

- **Intentional**
  - Where an island is desired in certain circumstances (example: micro-grids)

- **Unintentional**
  - Where an island is not desired

*Unintentional islands are considered a risk to personnel safety, power quality, equipment, and reliable grid operation.*
What is a Power System Island?

Unintentional islanding risks

- **Personal Safety**
  - Generator may back feed power to disconnected lines
  - Maintenance risk for utility personnel working on lines
  - Public safety risk for downed lines

- **System Coordination**
  - Reclosing into islands can cause issues and also affect coordination between inverters

- **Power Quality**
  - Power regulation may be reduced while islanded
  - Power disruptions and instability more likely

- **Equipment Damage**
  - Resulting voltage fluctuations may cause damage to utility and customer equipment
Islanding Detection - Local

Local Detection - Advantages and Disadvantages

**Advantages**
- Lower equipment cost
- Less maintenance

**Disadvantages**
- Non-detection zone (NDZ)
- Resiliency during system disturbances
Communications Assisted Methods

- **Direct Transfer Trip (DTT)**
- **Phase Comparison**

*Communications assisted methods effectively eliminate the NDZ found in local methods. As a result protection elements may be set less sensitively, reducing false operations during system disturbances.*
Islanding Detection – Communications Assisted

Direct Transfer Trip (DTT)

- Uses teleprotection channel to send signal to generator to open local breaker
- Can be initiated from any device which can cause an island
  - Substation breaker
  - Recloser
  - Switch

![Diagram of DTT system]
Islanding Detection – Communications Assisted

Direct Transfer Trip (DTT)

Communications Channels:
• Direct Fiber
• Digital Network (owned or leased)
• Power Line Carrier (PLC)
• Audio tone circuit (phone line)
• Wireless radio

Communications for DTT should emphasize security.

Advantages
• No NDZ given a good communications channel
• Speed
• Reduced false tripping as a result of system disturbances

Disadvantages
• Initial and/or recurring communications cost
• Requires one comms channel for each interruption device
Islanding Detection – Communications Assisted

Phase Comparison

The complexity of the connection does not matter
Islanding Detection – Communications Assisted

Phase Comparison

**Communications Channels:**
- Direct Fiber
- Digital Network (owned or leased)
- Audio tone circuit (phone line)
- Power Line Carrier (PLC)

**Communications for Phase Comparison should emphasize dependability**

**Advantages**
- No NDZ given a good communications channel
- Simplicity when multiple line interruption sources exist
- Only one communications channel required per generator
- Reduced false tripping as a result of system disturbances

**Disadvantages**
- Initial and/or recurring communications cost
DTT anti-islanding requires separate DTT transmitters and receivers at the Station and at each Recloser in order to trip for each islanding case.
Phase Comparison anti-islanding requires *only one comms channel and one transmitter / receiver pair*, regardless of the number of in-line reclosers.
Multiple comms channels and transmitter/receiver pairs between the Generator and each Station.

Complex logic design to determine the island condition
Phase Comparison anti-islanding requires **only one comms channel** between the Generator and Source Station to determine the island condition, and **no complex logic**.
Phase Comparison Islanding Detection - Details

**Transmit Device**

- Located at the Utility Substation
- System voltage phase input (120VAC)
- Optional DTT input for backup control
Receive Device

- Located at the Generator
- Receives system phase square wave
- Local voltage phase input (120VAC)
- Phase comparison logic for islanding detection
- Optional DTT output for backup control
Phase Comparison Islanding Detection - Details

Receiver – Delay Compensation
• Delay inherent in communications must be compensated for
• Without compensation a fair comparison cannot be achieved

Analog Communications
• Local generator phase square wave is delayed to match received system phase
• Manual adjustment at the time of commissioning
Digital Communications

- Digital circuits do not always have fixed delays as a result of circuit switching and re-routing

Dynamic Delay Compensation

- Local generator phase square wave is delayed by a fixed amount
- Active ping pong delay measurements are used to delay received system phase to match the generator phase
Phase Comparison Islanding Detection - Details

Receiver – Phase Comparison Logic

- Compares the received system phase with the local generator phase
- Negates local generator phase (180° out of phase)
  - Prevents false tripping under loss of communications
- Calculates phase difference by the amount of time in phase (coincidence)
  - Quarter of a cycle or 4.25ms for 90° (60Hz)
What is a Power System Island?

IEEE 1547 Recommendations

**IEEE 1547 – Standard for Interconnecting Distributed Resources with Electric Power Systems, recommends that an island be detected and removed within two seconds of an occurrence**
Receiver – Islanding Detection Time

• Detection time is a function of the difference in frequency at the time of separation and the set trip angle

\[
\text{Detection time} = \frac{\text{Set Trip Angle}}{360} \times \left| \frac{1}{(\text{Sys Freq} - \text{Gen Freq})} \right|
\]

**Example:**
Typical set point = 90° (4.25ms)
Generator frequency sags to 59.5Hz when islanded while the system remains at 60Hz.

\[
\frac{90}{360} \times \left| \frac{1}{(60 - 59.5)} \right| = 0.5 \text{ seconds}
\]
Phase Comparison Islanding Detection - Details

Operate Time

Detection time = \( \frac{\text{Set Trip Angle}}{360} \times \frac{1}{|\text{Sys Freq} - \text{Gen Freq}|} \)

Operate Time vs Delta-F for \( A_r = 30, 60, 90 \)

Graph showing operate time vs difference in frequency for different values of \( A_r \).
Operate Time

\[
\frac{df}{dt} = \left| \frac{Set\ Trip\ Angle}{360^\circ \cdot (T_{operate})^2} \right|
\]

Operate Time vs ROCOF for \( A_T = 30, 60, 90 \) Setpoints
Summary

Communications Assisted Methods

- Eliminates NDZ as found with local methods
- Performance relies on the quality of the communications channel and equipment
- Performance measurements
  - Security
  - Dependability
  - Latency
- Allows passive protection to be less sensitive reducing false tripping during system disturbances
Communications Assisted Methods

**Direct Transfer Trip (DTT)**
- Trip signal initiated by interruption/switching devices
- Requires one communications channel for each interruption device

**Phase Comparison**
- Substation voltage phase information sent to the generator for comparison with the generator phase
- Generator is tripped when phase difference reaches a preset level
- Requires only one communications link per generator
- Requires no complex DTT logic as a result of in-line reclosers, switches or multi-line connections
Q & A