POWERMAX® [ˈpou (ə)r ˈmaks] noun: a system designed to maintain stability

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Agenda

- POWERMAX – Power Management System Introduction
- POWERMAX – Functionalities (IDDS, LSP, GCS, A25A)
- POWERMAX – Simulators
- MOTORMAX – LV Motor Management System Introduction
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- POWERMAX – Power Management System Introduction
- POWERMAX – Functionalities (IDDS)
- POWERMAX – Simulators
- MOTORMAX – LV Motor Management System Introduction
POWERMAX Functions

- HMI / SCADA
- IDDS
- GCS
- A25A and Tie Flow
- High-Speed Load Shedding
- Engineering Management
What Is an IDDS?
Islanding Detection and Decoupling

- Islanding detection – detects islanding condition when microgrid disconnects from utility power system

- Decoupling – microgrid capability of detecting an ongoing utility disturbance and intentionally islanding microgrid
IDDS Schemes

- Direct transfer trip
- Local-area-based
  - Rate-of-change of frequency (81R) and fast rate-of-change of frequency (81RF)
  - Undervoltage / overvoltage and underfrequency / overfrequency
- Wide-area-based
  - Angle-based
  - Slip and acceleration-based
81RF Characteristic

DFDT (Hz per second)

+81RFRP

Trip Region 1

−81RFDFFP

+81RFDFFP

DF (FREQ – FNOM) (Hz)

−0.1

0.1

0.2

−0.2

Trip Region 2

0.1

0.2

−0.1

−0.2

−81RFRP
Wide-Area-Based Schemes

\[ \text{Angle} = \delta_k = \angle V_k^{(1)} - V_k^{(2)} \]

\[ \text{Slip frequency} = S_k = (\delta_k - \delta_{k-1}) \frac{\text{MRATE}}{360} \]

\[ \text{Acceleration} = A_k = (S_k - S_{k-1}) \frac{\text{MRATE}}{} \]
Slip Acceleration Characteristic
Detecting an Islanding Event

- Islanded
- Connected

Acceleration
Slip Frequency

Islanded
Connected
Example Industrial Power System
Case A
IDDS Blocked
Loss of 1,200 MW of generation followed by load shedding
### Utility Disturbance

**Desired Condition:** Detect and Decouple

<table>
<thead>
<tr>
<th>Case</th>
<th>Frequency Rate (Hz / s)</th>
<th>Export (MW)</th>
<th>Detection Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B3</td>
<td>1.5</td>
<td>260</td>
<td>900</td>
</tr>
<tr>
<td>B5</td>
<td>-1.8</td>
<td>800</td>
<td>720</td>
</tr>
<tr>
<td>B6</td>
<td>0.6</td>
<td>800</td>
<td>1,380</td>
</tr>
</tbody>
</table>
Utility Disturbance
Desired Condition: Detect and Decouple

IDDS Trip
Positive Threshold
Start of Event
X: –1.164
Y: –1.803

Rate of Change of Frequency (Hz per second)

Frequency Difference (Hz)

–2
–1
0
1
2
3

–1.5 –1.0 –0.5 0.0 0.5 1.0 1.5

Microgrid frequency returns to stable point

Positive Threshold
X: 1.218
Y: 1.456

IDDS Trip
X: 1.392
Y: 0.3503

IDDS Trip
X: –1.164
Y: –1.803

Case B6
Case B3
Case B5
81RF Element

IDDS Trip

Start of Event

Negative Threshold

Microgrid frequency returns to stable point
## Angle-Based IDDS
**Desired Condition: Detect and Decouple**

<table>
<thead>
<tr>
<th>Case</th>
<th>Export / Import (MW)</th>
<th>Detection Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>520</td>
<td>160</td>
</tr>
<tr>
<td>D2</td>
<td>70</td>
<td>300</td>
</tr>
<tr>
<td>D3</td>
<td>0</td>
<td>500</td>
</tr>
</tbody>
</table>
Angle-Based IDDS

Desired Condition: Detect and Decouple

Angle Difference Element

Samples (each equal to 20 milliseconds)

Case D1 (P ~ 520 MW)  Case D2 (P ~ 70 MW)  Case D3 (P ~ 0 MW)
Case D1
Slip and Acceleration Characteristic

IDDS Trip Due to Angle Difference Element
X: 0.1695
Y: 1.971

Start of Event

Negative Threshold

Positive Threshold

Microgrid Frequency Returning to a Stable Point After IDDS Trip and Generation Shedding

Rate of Change of Frequency (Hz per second)

Frequency Difference (Hz)

Limit 1
Limit 2
Case D1
81RF Element
Case E1
IDDS Rides Through (No Decoupling)

Single-phase fault and fault isolated by opening Line 1
## Lessons Learned
### Relative Effectiveness of Schemes

<table>
<thead>
<tr>
<th>Criterion</th>
<th>DTT</th>
<th>Local-Area</th>
<th>Wide-Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote communications available</td>
<td>Effective</td>
<td>Effective</td>
<td>Effective</td>
</tr>
<tr>
<td>Remote communications not available</td>
<td>Not effective</td>
<td>Effective</td>
<td>Not effective</td>
</tr>
<tr>
<td>Local generation matches local load during unintentional islanding</td>
<td>Effective</td>
<td>Not effective</td>
<td>Effective</td>
</tr>
<tr>
<td>Several remote side breakers that can create islanding</td>
<td>Not effective</td>
<td>Effective</td>
<td>Effective</td>
</tr>
<tr>
<td>Utility disturbances and no breaker opening</td>
<td>Not effective</td>
<td>Effective</td>
<td>Partially effective</td>
</tr>
</tbody>
</table>
Summary

- Sustainable electrical grids require fast and reliable IDDS combined with load and generation balancing.
- DTT provides fastest speed for islanding detection.
- Local-area-based 81RF provides reliable decoupling for utility disturbances.
- Wide-area-based synchrophasor schemes detect islanding condition during very low power flow conditions.
Questions?