Keeping your Grid Stable when Units Isolate: A Case Study of Governor Response in Various Situations

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Overview

• Today’s discussion will touch upon:
  • Gaps in available guidance
  • Governor fundamentals and system stability
  • How units isolate and governors respond
  • Case studies
    • U.S. Army Corps of Engineers
    • Pacific Gas & Electric
    • Southern Company
  • Future considerations
  • Guidance
Gaps in Available Guidance

✓ Requirements when connected to the BES
  • NERC Mandatory Standards on setting and modeling

✓ Tuning for isolated operation
  • Countless papers by IEEE and others

✗ Handling transition from connected to isolated/islanded
  • IEEE Governor Standards touch on It
Governor Stability

• $T_m = \text{Machine Starting Time}$
  • Inertia Constant of the system, dependent on the mass and diameter of the turbine/generator and all connected spinning equipment

• $T_w = \text{Water Starting Time}$
  • Inertia Constant of the water, dependent on the penstock/draft tube and proportional to flow/load

• $K_P = \text{Proportional Gain}$ & $K_I = \text{Integral Gain}$
  • Control Gains, which balance stability and responsiveness

• $R = \text{Regulation or Droop}$
  • Feedback which effectively reduces $K_P$ & $K_I$
Governor Stability

\[ \frac{T_w K_p}{T_m} \]

\[ T_w / \left( \frac{K_p}{K_I} \right) \]
Governor Stability

\[
\frac{T_w K_p}{T_m}
\]

Stability Limit

\[
T_m
\]
Machine Starting Time

\[
T_w / \left( \frac{K_p}{K_l} \right)
\]
Governor Stability

\[ \frac{T_w K_p}{T_m} \]

- \( T_m \) Machine Starting Time
- \( T_w \) Water Starting Time

Stability Limit

\[ T_w / \left( \frac{K_p}{K_I} \right) \]
Governor Stability

\[ \frac{T_w K_p}{T_m} \]

- \( T_m \): Machine Starting Time
- \( T_w \): Water Starting Time
- \( K_p \): Proportional Gain
- \( K_I \): Integral Gain

Stability Limit

\[ T_w / \left( \frac{K_p}{K_I} \right) \]
How Units Isolate and How Governors Respond

<table>
<thead>
<tr>
<th>Type of Separation</th>
<th>Known</th>
<th>Unknown</th>
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<tbody>
<tr>
<td>Intentional / Known (Case Study A)</td>
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<tr>
<td>Intentional / Unknown</td>
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<td>Unintentional / Known (Case Study B)</td>
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<td>Unintentional / Unknown (Case Study C)</td>
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Governor Operation When Isolated or Islanded

✓ Mode Change: By Detection or By Operator
✓ Isolated Mode P-I-D Gains
✓ Isolated Mode Droop Setting

Control Mode:

✓ Speed Droop (Gate Control)
× Speed Regulation (Megawatt Control)
× Feedforward Disabled (no fast loading)
Case Study A – Intentional / Known

- USACE - Hills Creek
  - 2 Units – 18.1MW Each
  - Carry town of Oakridge, OR (6MW)
  - Unstable at 6MW and 0% Droop
  - Stable at 6MW and 2% Droop
  - Would have been also stable with different gains or with both units paralleled
Case Study A – Intentional / Known
Case Study A – Intentional / Known
Case Study A – Intentional / Known
Case Study A – Intentional / Known

Paralleling Second Unit Base-Loaded To 0MW Doubles Load Carrying Capacity
Case Study B – Unintentional / Known

• Pacific Gas & Electric - Stanislaus
  • Line Breaker Status Monitored
  • Pre-defined load limits for loss of line
  • Governor configured and tuned for defined situation
  • Automatic Mode/Gain changes
Case Study C – Unintentional / Unknown

- Southern Company (Unplanned Separation – Unknown
  - Mitchell Dam
  - Governor moved between online and isolated control during event

![Graph showing islanded event with gate position and speed data.](image)
Case Study C - Transition

- How do we transition to Unknown/Planned
  - Underfrequency Changes
  - Hold governor in isolated mode
  - Adjust PID gains
Future Consideration

NERC BAL-001-TRE-1: Primary Frequency Response in the ERCOT Region

75% of Droop Response in 46 seconds $\rightarrow K_{i_0}$ of at least 2.0 (vs 0.2)
Guidance

1. Understand possible operating scenarios
2. Plan for these with your governor upgrade
3. Simulate and configure
4. Test if possible
5. Documentation and Training for Operations
Contact

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