SYMPHOM
SYnchronphasor-based Model calibration for Power systems and conTrol OptiMization

PhD project
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Why “Model Validation”?

- The quality of the models used by off-line and on-line tools will affect the result of any analysis for planning and operation
  - *Good model*: approximates the simulated response as “close” to the “measured response” as possible

- Validating models helps in having a model with better accuracy:
  - increasing the capability of reproducing actual power system behavior

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BAD Model for Dynamic Security Assessment!!!

WECC Break-up 1996

\[ \Delta P \text{ (pu)} \ vs \ Time \text{ (sec)} \]
Near RT Model Calibration App

- **Real-Time Measurements**
  - Pre-processing
  - Mode Estimation
  - Performance Indicator
  - Critical Modes
  - Simulation
  - Pre-processing
  - Mode Estimation
  - Linear Analysis Tools
    - Parameter Variation
    - Parameter Selection
    - Criteria for parameter selection
  - Optimization of Controller Settings and Control Actions
  - Real-time alarms from mode estimation

- **PMU / WAMS**
- **SCADA / EMS**
- **CIM Harmonized Model**
- **Initialization**
Near RT Model Calibration

- Source of information
  - PMU measurements (live or archived)
  - Harmonized model from SCADA snapshot and dynamic components definitions
- Calibration based on small signal response (mode and mode shapes)
- Calibrated models:
  - Validated representation of the power system at any instant for further use
Model Calibration Criterion

• The matching between estimated and model modes is measured by the distance between the estimated modes and model modes (performance criterion):

\[
\min f = \sum_{i=1}^{N} \left\| \lambda_i' - \lambda_i \right\|^2 \\
s.t.
\quad P_{\text{min}} \leq P \leq P_{\text{max}}
\]

(Parameters ranges)
Near RT Control Redesign/Retuning

• Control optimization:
  - Model reduction for control redesign
  - Tuning/optimization of control schemes toward small signal stability
  - Control always optimized for the current operating conditions

→ Better overview of the actual health conditions
First Step: Real-Time Mode Estimation

• Implementation with Statnett’s Synchrophasor SDK

• Implementation of two algorithms to increase precision
  - Ambient data (general case)
  - Ring-down data (post fault case)
First Step: Real-Time Mode Estimation

• Switch logic between the two algorithms:
  - Detection of the presence of Ring-down data
  → Detection of large discontinuities in the measurements

• Investigate the usage of the monitoring tool application developed previously
  - Capable of detecting oscillatory “activity” within a predefined frequency range

• Combination of the different results?