Electromagnetic Transient Modeling Requirements

October 21, 2020
Due to a shift in resource mix and increasing prevalence of HVDC and FACTS devices, operating characteristics and constraints of the bulk power system are changing.

- Electromagnetic Transient (EMT) studies must be incorporated into planning to assure continued reliability.

- Unlike traditional dynamic models, EMT models can represent the power system at all frequencies as well as individual phase quantities.

- Examples of EMT applications include:
  - Unbalanced fault analysis
  - High frequency transient analysis
  - Sub-Synchronous Oscillation (SSO) analysis
  - Fast control interaction with nearby devices and/or generation
EMT Model Submission Criteria

- Generation facilities which meet the following criteria are required to submit EMT models:
  - a. Connected to facilities 60 kV or greater, and
  - b. Individual resource with nameplate capacity > 10 MVA or Aggregate resource with nameplate capacity > 20 MVA, and
  - c. Meet any of the following interconnection criteria:
    - i. Any synchronous generation interconnected electrically close to series compensated line(s), and/or
    - ii. All asynchronous generation (i.e. inverter-based resources)
- Facilities which utilize legacy Type 1 and Type 2 wind turbines are exempt from the EMT model requirement.
EMT Model Submission Timeline

- The CAISO has been requesting EMT models since the inception of the program in 2018.
- Over 30 models have been received so far, and as a result new issues have been identified, which has helped evolve the CAISO EMT modeling requirements.
- The CAISO has provided submission deadlines to individual generators, including “catch-up” submission deadlines for Phases 1-4 in 2021.
EMT Model Requirements

• The remainder of the presentation will highlight certain EMT model requirements. For complete CAISO EMT Modeling Requirements, refer to the link below:

• All EMT model submissions must comply with the CAISO EMT Modeling Requirements document.
Synchronous & Induction Generators

• The following EMT modeling details should be met for synchronous and induction generators, such as:
  – Combustion Turbine Generators
  – Steam Turbine Generators
  – Hydro Generators
  – Type 1 and 2 Wind Turbines (though not required to submit EMT models)
Synchronous and induction generator models should:

- Include the Multi-Mass Torsional Shaft Interface model. The approximate representation of one stiff shaft used in transient stability modeling is not allowed.

Model should include:
- Inertia constants
- Shaft spring constants
- Torque share between different masses
- Damping

- Include representation of the machine saturation or magnetizing curve, and the transformer magnetizing curves
Synchronous & Induction Generators (cont.)

- Synchronous and induction generator models should:
  - Represent the following as a user-written PSCAD model or as standard PSCAD block models with the model type and data specified:
    - Excitation system
    - Governor
    - Power System Stabilizer
  - Include model parameters which reflect the actual installed settings in the field and not the manufacturer default parameters
  - Represent the generator grounding system
  - Represent all installed protections in detail for both balanced and unbalanced fault conditions
  - Represent dynamic reactive devices including automatically controlled capacitor and reactor banks, if applicable
Inverter-Based Generators

• The following EMT modeling details should be met for inverter-based generators, such as:
  – Solar Photovoltaic
  – Battery Energy Storage Systems (BESS)
  – Type 3 and 4 Wind Turbines
Inverter-Based Generators (cont.)

• Inverter-based generator models should:
  – Include the full detailed inner control loops of the power electronics. This representation should include all fast inner controls, as implemented in the installed equipment.
  – Represent all plant level controllers. This should include:
    ▪ External voltage controllers
    ▪ Plant level controllers
    ▪ Customized phase locked loop (PLL) systems
    ▪ Ride-through controllers
    ▪ Sub-synchronous control interaction damping controllers
  – If multiple plants are controlled by a common controller, this functionality should be included.
  – The model parameters provided should reflect the actual installed settings in the field and not the manufacturer default parameters.
Inverter-Based Generators (cont.)

- Inverter-based generator models should:
  - Represent all installed protections in detail for both balanced and unbalanced fault conditions
  - Represent dynamic reactive devices including automatically controlled capacitor and reactor banks, if applicable
  - Include representation of the transformer magnetizing curves
  - Be configured to match expected site-specific equipment settings. Any user-tunable parameters or options should be set in the model to match the equipment at the specific site being evaluated, as far as they are known.
Model Usability Features

• All EMT models should:
  – Be capable of running at time steps anywhere in the range from 10 μs to 20 μs
  – Be capable of initializing itself. Models should initialize and ramp to full output without external input.
  – Allow the active power capacity of the model to be scaled if using same inverter, collector and/or padmount transformer models
  – Have the ability to dispatch its output to values less than nameplate
Model Usability Features (cont.)

- All EMT models should:
  - Allow protection models to be disabled
  - Have pertinent control or hardware options accessible to the user (e.g., adjustable protection thresholds, real power recovery ramp rates, or Sub-Synchronous Control Interaction damping controllers)
Model Usability Features (cont.)

• All EMT models should:
  – Include documentation and a sample implementation test case. Test case models should be configured according to the site-specific real equipment configuration up to the point of interconnection.
  – Accept external reference values. This includes real and reactive power reference values (for Q control modes), or voltage reference values (for V control modes).
Model Efficiency Features

• All EMT models should:
  – Be compiled using Intel Fortran compiler version 12 and higher
  – Be compatible with PSCAD version 4.5.3 or higher. The model should not be dependent on a specific PSCAD version to run.
  – Initialize as quickly as possible (for example < 5 seconds) to user supplied terminal conditions
  – Support multiple instances of its own definition in the same simulation case
  – Support the PSCAD “timed snapshot” and “multiple run” features
  – Allow replication in different PSCAD cases or libraries through the “copy” or “copy transfer” features
Contact Information

• Comments to be sent to CAISO at GridModelingData@caiso.com. If discussing a specific resource, please use following subject line: [Resource ID] [Generating unit name] BPM Model Submission

• Please cc your interconnecting PTO in your email to CAISO; using the contacts provided below:
  SCE basecase@sce.com
  PG&E GenModel@pge.com
  SDG&E basecase@semprautilities.com
  VEA veaengineering@vea.coop
  Gridliance GLW-planning@gridliance.com