Electromagnetic Transient Modeling Requirements

October 21, 2020

Background

- 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:

  http://www.caiso.com/Documents/CaliforniaISOElectromagneticTransientModelingRequirements.pdf

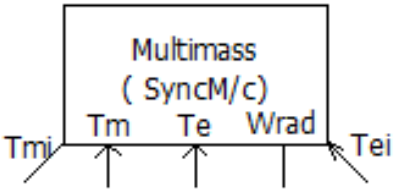
- All EMT model submissions must comply with the CAISO EMT Modeling Requirements document

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 & Induction Generators (cont.)

- 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.)

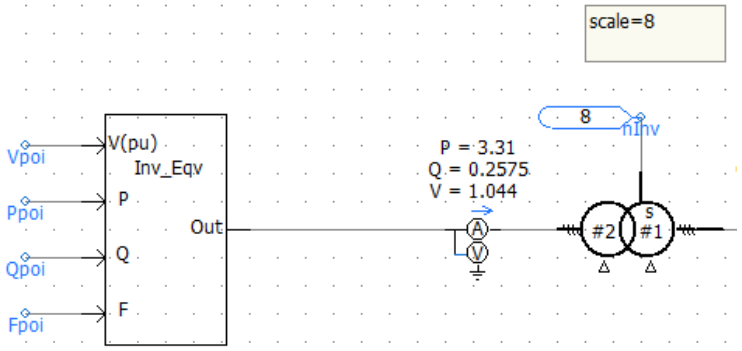
- Inverter-based generator models should:
  - Include the full detailed inner control loops of the power electronics. This representation should include all fast inner controls, as implemented in the installed equipment.
  - Represent all plant level controllers. This should include:
    - External voltage 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.

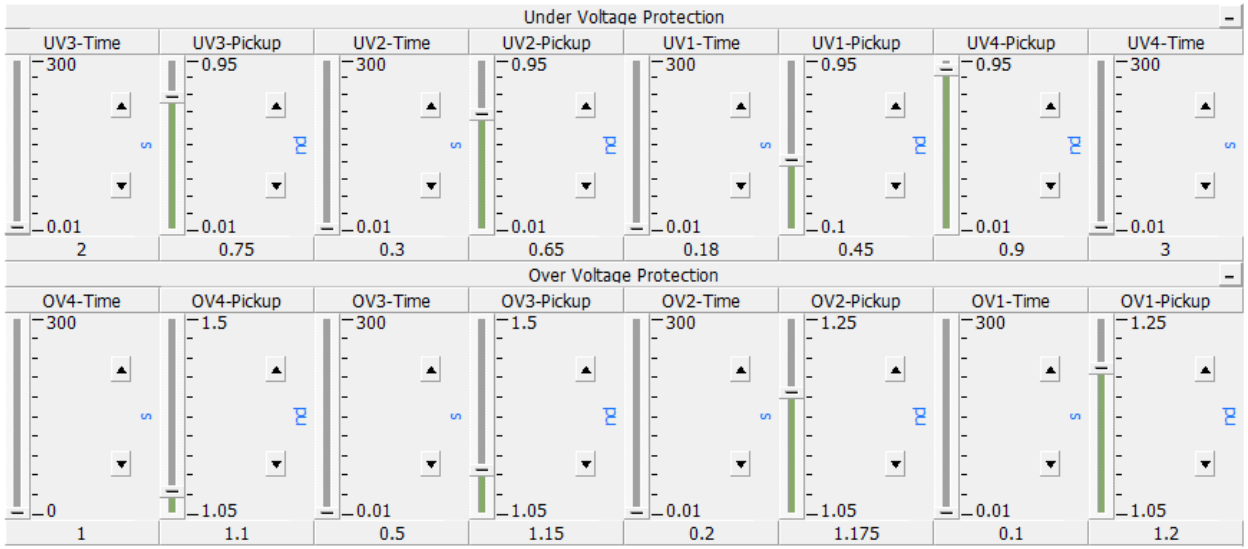
Model Usability Features

- 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



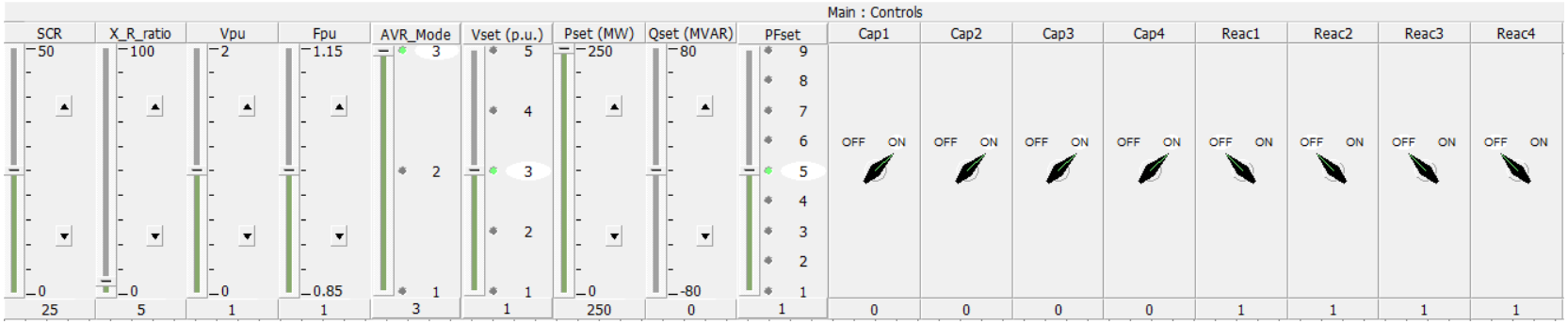
Model Usability Features (cont.)

- 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