Power Systems Computer-Aided Design (PSCAD™) Modeling Requirements

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I. Introduction

This document provides Generator Owners with modeling requirements, including guidelines for accuracy, usability, and efficiency, to be used for better planning, operation, and improved reliability of the bulk power system. Due to a shift in resource mix (e.g., higher penetrations of inverter-based generation), operating characteristics and constraints of the bulk power system are changing; therefore, Electromagnetic Transient (EMT) studies must be incorporated into planning to assure continued reliability. Specifically, EMT studies include Sub-Synchronous Oscillations (SSO) and fast control interaction with nearby devices or generation. For the EMT models to be usable, they should be in a format usable by the PSCAD™/EMTDC™ simulation tool, for e.g. *.pswx, *.pscx, *.pslx. The entirety of the project (only generator owner facilities) should be modeled up to the point of interconnection and tested in a working PSCAD™/EMTDC™ case. Finally, the working test case that contains the project should be submitted by the Generator Owner to its Planning Coordinator and/or Transmission Planner, as applicable.

II. Modeling Data

2.1. Modeling Requirement Details

a) Synchronous and Induction Generators

The modeling details described in this section should be met for synchronous generators and induction generators, such as combustion turbine generators, steam turbine generators, hydro generators, and Type 1 and Type 2 wind turbines.

- The model should include the Multi-Mass Torsional Shaft Interface model configured for a Synchronous Machine or Induction Machine as appropriate. The model should include the inertia constants, shaft spring constants, torque share between the different masses, and damping. The approximate representation of one stiff shaft used in transient stability modeling is not allowed.
- The model should include representation of the machine saturation or magnetizing curve, and the transformer magnetizing curves.
- Representation of the generator excitation system as a user-written PSCAD model or as standard PSCAD block models with the model type and data specified. If standard PSCAD block models are used, the manufacturer must confirm that the models can represent the accurate excitation system performance in transient simulations (50 micro-second time step).
- Representation of the generator governor model as a user-written PSCAD model or as standard PSCAD block models with the model type and data specified. If standard PSCAD block models are used, the manufacturer must confirm that the models can represent the accurate excitation system performance in transient simulations (50 micro-second time step).

- Representation of the generator power system stabilizer (PSS) as a user-written PSCAD model or as standard PSCAD block models with the model type and data specified. If standard PSCAD block models are used, the manufacturer must confirm that the models can represent the accurate excitation system performance in transient simulations (50 micro-second time step).
- The model parameters provided should reflect the actual installed settings in the field and not the manufacturer default parameters
- Representation of the generator grounding system. The generator grounding will impact the generator fault contribution and represent the imbalance in the three phase system.
- Representation of the generator protection system including overcurrent protection, under or over voltage protection (individual phase and RMS), frequency protection, loss of field protection, under/over-excitation protection, reverse power protection, out of step protection, and any other special protection including the ability to enable and disable.
- Represent the Sub-Synchronous Oscillation (SSO) mitigation and/or protection including the ability to enable and disable SSO mitigation/protection, if applicable.
- Represent dynamic reactive devices including automatically controlled capacitor and reactor banks, if applicable.
- Accurately reflect behavior throughout the valid (MW and MVAr) output range from minimum power through maximum installed capacity.
- Include detailed representation of any hardware or software filters for the wind turbine controllers is necessary as they may act to block the sub-synchronous frequencies.

b) Inverter Based Generators

The modeling details described in this section should be met for inverter based generators.

- The model 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. The approximate representation used in transient stability modeling is not allowed. It is possible to create models by embedding the actual hardware code into a PSCAD™ component. If the model is assembled using standard blocks available in the PSCAD™ master library, a validation against actual hardware performance is required.
- The model should represent all plant level controllers. This also should include external voltage controllers, plant level controllers, customized phase locked loop (PLL) systems, ride-through controllers, sub-synchronous control interaction damping controllers or others. Operating modes that require system specific adjustment should be user accessible. In most cases, plant level voltage control should be represented along with adjustable droop characteristics. The model parameters provided should reflect the actual installed settings in the field and not the manufacturer default parameters.

- Representation of the Sub-Synchronous Oscillation (SSO) mitigation and/or protection including the ability to enable and disable SSO mitigation/protection, if applicable.
- Represent dynamic reactive devices including automatically controlled capacitor and reactor banks, if applicable.
- Represent all pertinent electrical and mechanical configurations, such as filters and specialized transformers. Mechanical features (such as gearboxes, pitch controllers, etc.) should be included in the model if they impact electrical performance.
- Have all installed protection systems modeled in detail. Typically, this includes various over-voltage and under-voltage protection (individual phase and RMS), frequency protection, DC bus voltage protection, and overcurrent protection. There may be others.
- Accurately reflect behavior throughout the valid (MW and MVAr) output range from minimum power through maximum power.
- Detailed representation of any hardware or software filters for the wind turbine controllers is necessary as they may act to block the sub-synchronous frequencies.

2.2. Model Usability Features

The model usability features described in this section should be met.

- Have pertinent control or hardware options accessible to the user (e.g., adjustable protection thresholds or real power recovery ramp rates). Diagnostic flags (e.g., flags to show control mode changes or which protection has been activated) should be accessible to facilitate analysis and should clearly identify why a model trips during simulations.
- Be capable of running at time steps anywhere in the range from 5 µs to 20 µs. Most of the time, requiring a smaller time step means that the control implementation has not used the interpolation features of PSCAD™, or is using inappropriate interfacing between the model and the larger network. Lack of interpolation support introduces inaccuracies into the model at longer time steps.
- Include documentation and a sample implementation test case. Access to technical support engineers is desirable.
- Be capable of initializing itself. Models should initialize and ramp to full output without external input from simulation engineers.
- Accept external reference values. This includes real and reactive power reference values (for Q control modes), or voltage reference values (for V control modes).
- Allow protection models to be disabled. Many studies result in inadvertent tripping of converter equipment, and the ability to disable protection functions temporarily provides study engineers with valuable system diagnostic information.
- Allow the active power capacity of the model to be scaled if using same inverter, collector and padmount transformer models. This is distinct from a dispatchable power order, and is used for modeling different plant capacities or breaking a lumped equivalent plant into smaller composite models.

2.3. Model Efficiency Features

The model efficiency features described in this section should be met.

- Models with dynamic-link library (DLL) files should be compiled using either GFortran 4.2.1 or GFortran 4.6.2.
- 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™ “snapshot” and “multiple run” features.
- Allow replication in different PSCAD™ cases or libraries through the “copy” or “copy transfer” features.