SPP ELECTROMAGNETIC TRANSIENT (EMT) MODEL REQUIREMENTS

For Inverter-Based Resource Interconnection

Revision 0

Published: January 21, 2022
By: Research and Development

REVISION HISTORY

VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
Draft	DAB	Initial Draft	For RR 430 approval
Revision 0	DAB	Revised and Finalized for Customer Use	To be implemented in DISIS 2018, Phase 2

SPP Electromagnetic Transient (EMT) Model Requirements

Inverter-Based Resource (IBR) response to a disturbance can be much faster than that which is shown in standard positive sequence dynamic studies. To capture these responses, Electromagnetic Transient (EMT) studies are necessary. SPP's Generator Interconnection (GI) department will be performing these studies using PSCAD™ software when screening studies reveal further analysis is needed.

To perform these studies, EMT models for IBRs are required from the GI interconnection customer. The IBR models shall be compatible with the PSCAD™ simulation tool as described throughout this document and must comply with the listed model requirement features with respect to accuracy, usability, and efficiency. The customer shall adhere to these requirements when constructing, assembling, and submitting the PSCAD™ model. Any deviations shall be documented and explained and will be subject to review.

The GI customer's EMT PSCAD™ model shall be submitted to SPP no later than 15 months prior to the customer's commercial operation date (COD).

Model Accuracy Features

For sufficient accuracy, the model provided for each facility shall:

- Represent in full detail the inner control loops and all fast inner controls of the power electronics as implemented in the installed equipment.
- Utilize actual hardware code in creating the PSCAD™ model. Models which embed the actual hardware code into a PSCAD™ component are currently wide-spread, and this is the type of model required.
- Incorporate a full IGBT representation (preferred) or use an average source representation that approximates the switching but maintains full detail in the inner controls, and maintains DC side protection features.
- Standard blocks in the PSCAD™ master library shall not be used in creating and assembling the model
- Represent all control features as they are implemented in the installed controls (e.g. customized external voltage controllers, phase-locked loop (PLL) systems, ride-through controllers, SSCI damping controllers, etc.). Actual hardware code is recommended to be

used for control and protection features. Operating modes that require system specific adjustment must be user accessible.

- Power Plant Control (PPC) representation must be included which represents the specific controllers used in the plant. Plant controllers must be represented in sufficient detail to accurately represent short term performance, including specific measurement methods, communication time delays, transitions into and out of ride-through modes, settable control parameters or options, and any other specific implementation details which may impact plant behavior. Generic PPC representations are not acceptable unless the final PPC controls are designed to exactly match the generic PPC model. If multiple plants are controlled by a common controller, or if the plant includes multiple types of IBRs (e.g. Hybrid BESS/PV) this functionality must be included in the plant control model. If external or multiple voltage control devices (e.g. STATCOM) are included in the plant, these should be coordinated with the PPC
- Represent capacitor and reactor banks, and dynamic reactive devices, including automatically controlled devices, if applicable.
- Represent all pertinent electrical and mechanical configurations, such as filters and specialized transformers. Mechanical features (such as gearboxes, pitch controllers, etc.) shall be included in the model if they impact electrical performance. Any control or dynamic features of the actual equipment, which may influence simulation behavior but are not represented or are approximated, must be clearly identified.
- Have all pertinent protections modeled in detail for both balanced and unbalanced fault conditions. Typically this includes various over-voltage and under-voltage protections (individual phase and RMS), frequency protections, DC bus voltage protections, overcurrent protection, etc. Any protections which can influence dynamic behavior or plant ride-through in the simulation period must be included. Actual hardware code is recommended to be used for these protection features.
- Accurately reflect behavior throughout the valid MW and MVAr output range from minimum power through maximum power. Represent machine slip of Type III (DFIG) wind generation as appropriate for the power dispatch. This value should be calculated and not require manual entry.
- 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. Default parameters are not appropriate unless they match those in the installed equipment.

Model Usability Features

In order for study engineers to perform system studies and analyze results, the model provided for each facility shall:

- Have pertinent control or hardware options and parameters that are accessible to the user (e.g. adjustable protection thresholds or real power recovery ramp rates, frequency or voltage droop settings, voltage control response times, or SSCI damping controllers). Diagnostic flags (e.g. flags to show control mode changes or which protection has been activated) shall be accessible to facilitate analysis and should clearly identify why a model trips during simulations.
- Be capable of running at time steps in the range of 10 µs or higher. Requiring a smaller time step may mean that the control implementation has not used the interpolation features of PSCAD™ or is using inappropriate interfacing between the model and the larger network. Longer time steps can introduce inaccuracies into the model
- The model must be able to operate at a range of simulation time steps of 10 µs – 20 µs.
- Include documentation and a sample implementation test case. Test case models shall be configured according to the site-specific real equipment configuration up to the point of interconnection. This includes, but is not limited to: aggregated generation model, aggregated generator transformer, equivalent collector branch, main step-up transformers, generator tie line, power plant controller, and any static/dynamic reactive resources. Test case must use a single machine infinite bus representation of the system, configured with an appropriate representative SCR, reflecting approximate N-1 interconnection SCR where possible, especially if the system is expected to be weak. If the system strength is not known, using a relatively low SCR in the test system is required. Access to technical support engineers is desirable.
- Be capable of initializing itself. The model's initial condition variables must be provided such that the models will initialize and ramp to full output without external user input. Any slower control functions which are included (such as switched shunt controllers or power plant controllers) must also accept initial condition variables if required. Note that during the first few seconds of simulation (e.g. 0-2 seconds), the system voltage and corresponding terminal conditions may deviate from nominal values due to other system devices initializing, and the model must be able to tolerate these deviations or provide a variable initialization time.
- Accept external reference values. This includes real and reactive power reference values (for Q control modes), or voltage reference values (for V control modes). The model must accept these reference variables for initialization, and be capable of changing these reference variables mid-simulation, i.e. dynamic signal references.
- Have an identification mechanism for configuration. The model documentation must provide a clear way to identify the specific settings and equipment configuration which will be used in any study, such that during commissioning the settings used in the studies can be checked. This may be control revision codes, settings files, or a combination of these and other identification measures.
- 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. This is distinct from a dispatchable power order, and is used for modeling different plant capacities (e.g. if a portion of the plant is offline) or breaking a lumped equivalent plant into smaller composite models.
- Be dispatchable to values less than nameplate. This is required for testing the plant's behavior at various operating points. This dispatch testing is not to be confused with scaling a plant from one unit to more than one unit.
- Initialize quickly. Model must reach its ordered initial conditions as quickly as possible (<5 seconds) to user supplied terminal conditions

Model Efficiency Features

In order to improve study efficiency and model compatibility the following efficiency features are required. Note that no feature should compromise model accuracy.

- The model must be compatible with Intel Fortran compiler versions 12 (32 bit) and higher.
- The model must be compatible with PSCAD version 4.6.3 and higher.
- The model must support multiple instances of its own definition in the same simulation case.
- The model must support the PSCAD™ "timed snapshot" and "multiple run" features.
- The model must support the PSCAD™ "multiple run" feature.
- The model must not use or rely upon global variables in the PSCAD™ environment
- The model must not utilize multiple layers in the PSCAD™ environment, including "disabled layers"