Recommended PSCAD model requirements Rev. 6

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Introduction

Specific model requirements for a PSCAD study depend on the type of study being done. A study with a scope covering weak system interconnections, ride-through evaluation, short term[1] event response, and fast control interaction with nearby devices (for example) would require a model which has the following characteristics. Some specialty studies may require other features.

Model Accuracy Features

For the model to be sufficiently accurate, it must:

A. *Represent the full detailed inner control loops of the power electronics.* The model cannot use the same approximations classically used in transient stability modeling, and should fully represent all fast inner controls, as implemented in the real equipment. Models which embed the actual hardware code into a PSCAD component are currently wide-spread, and this is the recommended type of model.[2]

B. *Represent all control features pertinent to the type of study being done.* Examples include external voltage controllers, plant level controllers, customized PLLs, ride-through controllers, SSCI damping controllers and others. As in point A, actual hardware code is recommended to be used for most control and protection features. 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.

C. *Represent all pertinent electrical and mechanical configurations*. This includes any filters and specialized transformers. There may be other mechanical features such as gearboxes, pitch controllers, or others which should be modelled if they impact electrical performance within the timeframe of the study. Any control or dynamic features of the actual equipment which may influence behaviour in the simulation period which are not represented or which are approximated should be clearly identified.

D. *Have all pertinent protections modeled in detail for both balanced and unbalanced fault conditions.* Typically this includes various OV and UV protections (individual phase and RMS), frequency

[1] Example analysis periods could be 2 to 10 seconds from fault inception. Some studies could require longer periods.

[2] The model must be a full IGBT representation (preferred), or may use a voltage source interface that mimics IGBT switching (ie. A firing pulse based model). A three phase sinusoidal source representation is not acceptable. Models manually translated block-by-block from MATLAB or control block diagrams may be unacceptable because the method used to model the electrical network and interface to the controls may not be accurate, or portions of the controls such as PLL circuits or protection circuits may be approximated or omitted. Note, however, that Matlab may be used to generate C code which is used in the real control hardware, and if this approach is used by the developer, the same C code may be directly used to create an extremely accurate PSCAD model of the controls. The controller source code may be compiled into DLLs or binaries if the source code is unavailable due to confidentiality restrictions.

It is not recommended to assemble the model using standard blocks available in the PSCAD master library, as approximations are usually introduced, and specific implementation details for important control blocks may be lost. In addition, there is a significant risk that errors will be introduced in the process of manually assembling the model. For this type of manually assembled model, (not using a direct “real code” embedding process), extra care is required, and validation is usually required.

protections, DC bus voltage protections, converter overcurrent protections, and often other inverter specific protections. As in point A, actual hardware code is recommended to be used for these protection features.

E. *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 may not be appropriate.

Model Usability Features

In order to allow study engineers to perform system analysis using the model, the PSCAD model must:

F. *Have control or hardware options which are pertinent to the study accessible to the user.* Examples of this could include protection thresholds, real power recovery ramp rates, or SSCI damping controllers.[3] Diagnostic flags (eg. flags to show control mode changes or which protection has been activated) should be visible to aid in analysis.

G. *Be accurate when running at a simulation time step of 10 µs or higher*. Often, 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 larger simulation time-steps.

H. *Operate at a range of simulation time* steps. The model should not be restricted to operating at a single time step, but should be able to operate within a range (eg. 10 µs – 20 µs)

I. *Have the ability to disable protection models.* 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.

J. *Include documentation and a sample implementation test case.* Test case models should be configured according to the site-specific real equipment configuration. Access to technical support engineers is desirable.

K. *Have an identification mechanism for configuration.* The model documentation should 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.

L. *Accept external reference variables.* This includes real and reactive power ordered values for Q control modes, or voltage reference values for voltage control modes. Model should accept these reference variables for initialization, and be capable of changing these reference variables mid-simulation, ie. dynamic signal references.

M. *Be capable of initializing itself.* Once provided with initial condition variables, the model must initialize and ramp to the ordered output without external input from simulation engineers. Any slower control functions which are included (such as switched shunt controllers or power plant controllers) should also accept initial condition variables if required.

[3] Care should be taken to ensure that any user-settable options are not changed in a way that is not implementable in the real hardware, and that any selectable options are actually available at the specific site being considered. Discussion is recommended with the manufacturer prior to any changes being made in model configuration.

N. *Have the ability to scale plant capacity.* The active power capacity of the model should be scalable in some way, either internally or through an external scaling transformer[4]. This is distinct from a dispatchable power order, and is used for modeling different capacities of plant or breaking a lumped equivalent plant into smaller composite models.

O. *Have the ability to dispatch its output to values less than nameplate.* This is distinct from scaling a plant from one unit to more than one, and is used for testing plant behaviour at various operating points.

P. *Initialize quickly.* Model must reach its ordered initial conditions as quickly as possible (for example <5 seconds) to user supplied terminal conditions.

Study Efficiency Features

In addition, the following elements are required to improve study efficiency, model compatibility, and enable other studies which include the model to be run as efficiently as possible. If these features are not supported, additional discussion is required[5]:

Q. Model should be compiled using Intel Fortran compiler version 12 or higher. Model should not be dependent on a specific Fortran sub-version to run.

R. Model uses PSCAD version 4.5.3 or higher.

S. Model supports multiple instances of its own definition in the same simulation case.

T. Model supports the PSCAD "snapshot" feature.

U. Model supports the PSCAD "multiple run" feature.

[4] A free publicly available scaling transformer suitable for this purpose is available in the E-Tran library.

[5] Electranix has parallelization tools available (E-Tran Plus for PSCAD) which can circumvent compatibility concerns in some cases.