ERCOT PSCAD Model Submittal Guidelines



ERCOT requests you submit this completed checklist along with your PSCAD model. Please include this completed sheet in the same zip file when submitting your PSCAD model to your RARF form or RIOO system.

# Introduction

PSCAD models are a specialized type of model used in Electromagnetic Transient (EMT) studies. These models are more detailed than standard dynamic stability models (e.g. PSS/E models) and are necessary for modeling generators in weak grid studies and subsynchronous resonance studies, among others.

Not all PSCAD models are created equal. Some are unreasonably difficult to use and some contain certain modeling approximations. In order to provide better quality control, ERCOT with the help of the Dynamic Model Task Force created this check-sheet. When submitting a PSCAD model to ERCOT, please fill out this check sheet and attach it along with your model (zip the files together). This will facilitate ERCOT providing feedback, and ultimately reduce issues that may occur down the road.

It is expected that all PSCAD models adhere to these guidelines. Any deviations should be documented and explained and will be subject to review. **This form should only be completed by an SME knowledgeable with the inner-workings of the PSCAD black-box model, usually this implies OEM staff**

A picture containing text, clipart

Description automatically generated PSCAD submission checklist:

* Include a Model Quality Test (MQT) report overlaying the PSCAD and PSS/E model response. If utilizing a user-defined-model in PSS/E, then also include the TSAT model response in the overlay.
* PSCAD model inserted into the ERCOT PSCAD Template, available in the “Dynamic Model Templates” package posted at: https://www.ercot.com/services/rq/re
* Include this completed checksheet (check off the items in the below tables).
* Include the PSCAD model manual.
* Include PSCAD files and libraries compiled for both 32-bit and 64-bit Fortran compilers if possible.

The checklist below is applicable for models associated with the following facility (indicate project name and/or GINR# and/or ERCOT Site Code):

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Contact for person completing this form:

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# PSCAD Model Requirement

**Model Accuracy Features**

In order to be sufficiently accurate, the model provided for each facility shall:

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| Item | Description | Check |
| 1 | Represent the full detailed inner control loop 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. |  |
| 2 | Utilize actual hardware code in creating the PSCAD model \*OR\* validate the model by comparing the model to measured device response. Validation should be performed for a standard set of disturbances AND include a small signal frequency sweep to confirm the subsynchronous behavior over 5 to 55 Hz. (Beware that models assembled using standard blocks available in the PSCAD master library introduce unacceptable approximations). |  |
| 3 | Incorporate a full IGBT representation (preferred) or use a voltage source interface that mimics IGBT switching. Average source voltage-like models are acceptable if considered accurate for grid stability studies. Average source models should contain directly connected back-diodes for numerical stability. |  |
| 4 | Represent plant level controllers as they are implemented in the real controls, such as automatic voltage regulation. **Model communication and other delays**. |  |
| 5 | Parameters requiring site-specific adjustment should be made user-accessible. For example, the plant level controller should provide access to regulation gains and droop settings. |  |
| 6 | Represent all pertinent control features as they are implemented in the real controls (e.g. customized PLLs, ride-through controllers, etc.). Incorporate expected site-specific adjustments and settings. |  |
| 7 | Represent Subsynchronous Oscillation (SSO) mitigation and/or protection including the ability to enable and disable SSO mitigation/protection, if applicable. |  |
| 8 | Represent shunt capacitor and reactor banks and any dynamic reactive devices. The controls should be modeled if the equipment dynamically responds to a disturbance within 10 seconds. It is recommended to include an initialization routine, even if the controls are not explicitly modeled, so that the capacitor and reactor banks will be at the correct initial operating position at the start of the simulation. For example, if the plant controller would normally place all shunt capacitors in service for 100% dispatch in real power and no shunt capacitors in service for 50% dispatch in real power, then it is recommended that an initialization routine would include this same logic. |  |
| 9 | 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. |  |
| 10 | Have all pertinent protections modeled in detail. This includes various over-voltage and under-voltage protections (individual phase and RMS), frequency protections, DC bus voltage protections, overcurrent protection, and any other protection which can influence ride-through behavior. Actual code is recommended to model these protection features. Mechanical protections, such as thermal, should be modeled to extent may limit ride through capability. |  |
| 11 | 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. |  |
| 12 | Model main power transformer saturation based upon transformer test reports. Model main power transformer protection system. This feature is not required but recommended to help diagnose ferroresonance for resources locating close to series capacitors. |  |
| 13 | If PLL loss of synchronism protection, phase angle jump protection, or anti-islanding protection is installed, confirm with the OEM that it is necessary protection and it is correctly modeled in PSCAD. If not needed, ERCOT requests that these protections be disabled as they have been linked to ride through failures[[1]](#footnote-1). If needed, please describe why. | (Not installed / modeled & needed because...) |
| 14 | For Type 3 Wind Turbines, include a note, label, flag, or switch in the model indicating clearly whether subsynchronous damping controls are active. |  |
| 15 | Model dynamics of the DC bus in the inverter/converter, including capacitor discharging and protection. |  |

**Model Usability Features**

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

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| 15 | 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. |  |
| 16 | Accurately simulates for a timestep between 10 μs and 20 μs. Requiring a smaller time step may mean that the control implementation has not used the interpolation features of PSCAD or has used inappropriate interfacing between the model and the larger network. It is preferable if the model can operate accurately for *any arbitrary* timestep between 10 μs and 20 μs, however ERCOT may accept plant models that require a different time-step if the model simulates reasonably fast per ERCOT’s sole discretion. |  |
| 16.1 | Completes a 10-second simulation in PSCAD in under approximately 300 seconds using a typical computer set up (under 180 seconds ideal). If taking more than 300 seconds, subject to further discussion. |  |
| 17 | Include documentation and a sample implementation test case. Access to technical support engineers is desirable. |  |
| 18 | Be capable of initializing itself. Models shall initialize and ramp to full output within without external input from simulation engineers. |  |
| 19 | Accept external reference values. This includes real and reactive power reference values (for Q control modes), or voltage reference values (for V control modes) and utilize a single parameter for adjusting real power, and separately, a single parameter for adjusting voltage setpoints. Adjustments should be easy to identify, such as using memo markers or a slider control (preferred). |  |
| 20 | 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. |  |
| 21 | Provide a switch to disable saturation on the main power transformer and the inverter or turbine local transformers for investigation of ferroresonance. |  |
| 22 | 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). |  |
| 23 | Have a simple means to represent curtailed operation for a power response to a frequency dip versus uncurtailed operation for no response to a frequency dip. |  |
| 24 | Avoid using PSCAD simulation sets, as these are difficult to incorporate into much larger cases. Use of ETRAN+ is okay. (ETRAN+ version 5 recommended.) |  |
| 25 | Project PSCAD model should accept real power dispatch and voltage reference commands as a variable (not a Fortran constant) for external dispatch initialization. |  |
| 26 | Project PSCAD model should accept reactive power initialization to seed the initial Power Plant Controller reactive state variable at the start of the simulation, rather than requiring the PPC to ramp up from zero. |  |

**Model Efficiency Features**

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

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| 25 | Model is embedded into the PSCAD Template published at: <https://www.ercot.com/services/rq/re> |  |
| 26 | Model is correctly connected to the Template and inputs real power reference (Pref), voltage setpoint (Vref), and initial reactive reference (Qref). Model exports trip signals. |  |
| 27 | Be compiled using Intel Fortran compiler and capable of running in Intel Fortran version 15 and higher and Microsoft Visual Studio 2015 and higher. Should not require a specific version of Intel Fortran and should support the new Intel OneAPI HPC free Fortran compiler. |  |
| 28 | Provide 32-bit and 64-bit versions of libraries. As of 2025, Intel has discontinued their 32-bit Fortran compiler. |  |
| 29 | Compatible with PSCAD version 5.0.1 and higher. |  |
| 30 | Initialize quickly under 5 seconds to user supplied terminal conditions. |  |
| 31 | Support multiple instances of its own definition in the same simulation case for situations where the same inverter resource is used at multiple sites. |  |
| 32 | Support the PSCAD “snapshot” feature. |  |
| 33 | Support the PSCAD “multiple run” feature. |  |
| 34 | Allow replication in different PSCAD cases or libraries through the “copy” or “copy transfer” features. |  |

1. NERC 2022 Odessa Report page 8 (page 17 of pdf): <https://www.nerc.com/comm/RSTC_Reliability_Guidelines/NERC_2022_Odessa_Disturbance_Report%20%281%29.pdf> [↑](#footnote-ref-1)