PSCAD

APPLICATION NOTES

Converting a Solved PSS/E Case to PSCAD for Transient Simulations

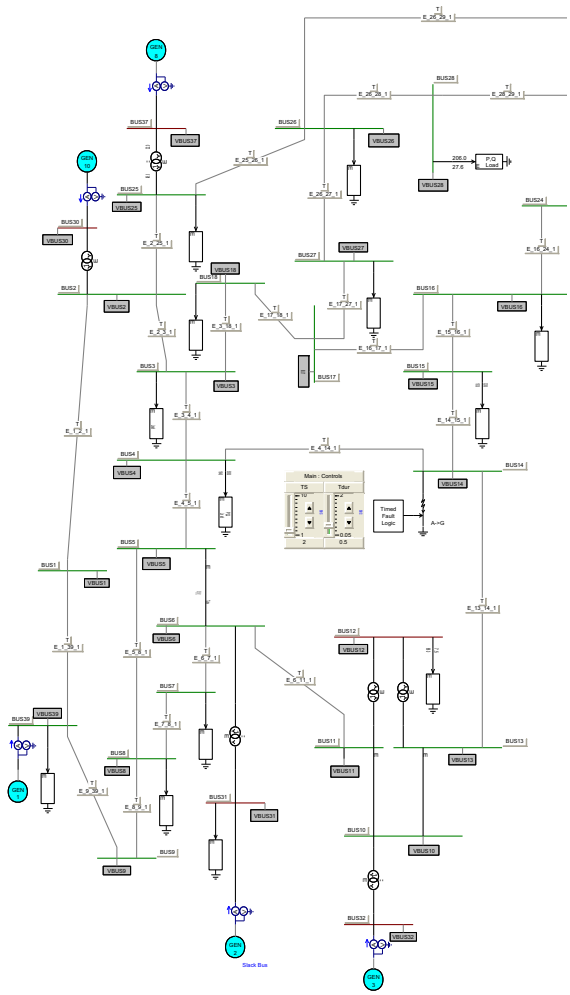

Figure 1 Single line diagram of the IEEE 39 bus system in PSCAD

Many utilities have their power systems modeled in load flow programs. A great deal of effort is required to re-enter network data for transient simulation studies in Electromagnetic Transient (EMT) type programs. This application note describes the use of a new tool that allows for an automated setup of PSCAD simulation cases by directly importing data from solved PSS/E load flow cases, thus maximizing the simulation engineer's productivity. Some helpful tips are also provided on how to ensure the validity of the transient study by effectively selecting the size of the subsystem to be simulated in PSCAD. Some key points addressed are:

- Direct conversion of the PSS/E file - basic steps
- E-TRAN runtime library and custom substitution libraries
- Network equivalences
- Guidelines to determine the extent of the network to be modeled
- Model validation
- Importing dynamic data from the PSS/E *.dyr file

The IEEE 39-bus system in Figure 1 is used as the base case to illustrate the PSS/E to PSCAD conversion process. The IEEE 39-bus system is a standard system used for testing new power systems concepts and simulation methodologies. It was created based on a simplified model of the New England power system. The 39-bus system has 10 generators, 19 loads, 36 transmission lines and 12 transformers.

The conversion of the system into PSCAD is achieved through E-TRAN, a program developed by **Electranix Corporation**. In addition to converting PSS/E data into PSCAD cases, this program offers many powerful features that could be manipulated by the simulation engineer to reduce the time spent on a study. The software's most relevant features are outlined in this document.

This application note describes the use of a new tool that allows for an automated setup of PSCAD simulation cases by directly importing data from solved PSS/E load flow cases, thus maximizing the simulation engineer's productivity.

Converting the Base PSS/E Case to PSCAD

When converting a case from the PSS/E load flow data file (*.raw) and the dynamic data file (*.dyr), E-TRAN allows for several options that provide enhanced flexibility to the final user.

To convert the *.raw/*.dyr files, start the E-TRAN program. The pop-up dialog will prompt the user through the conversion steps.

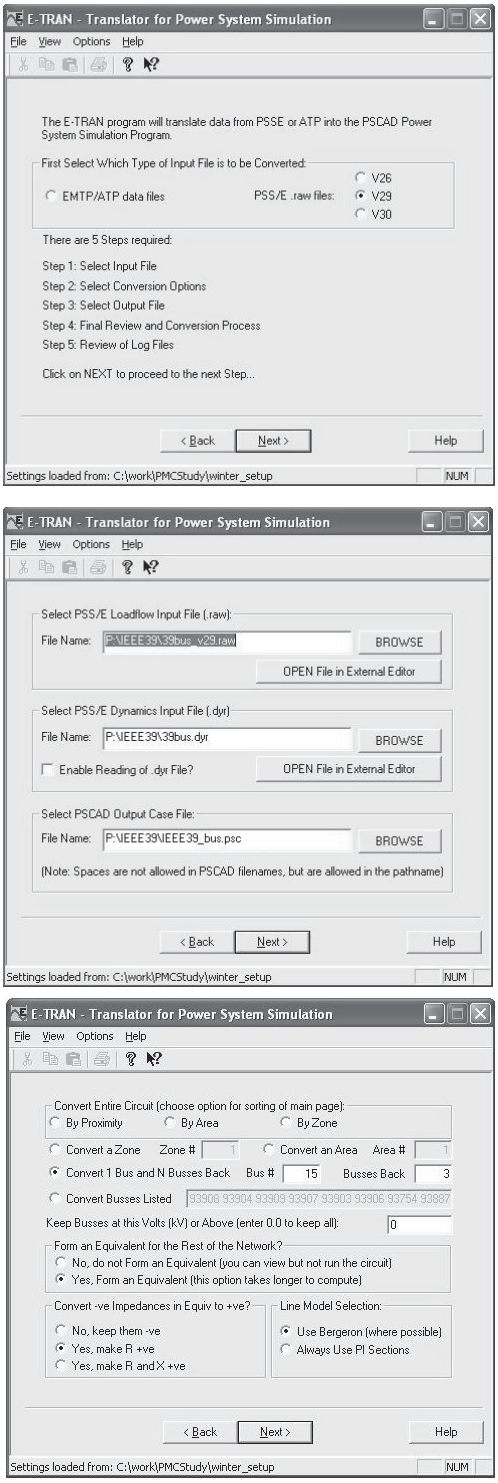

Figure 2 E-TRAN dialog boxes

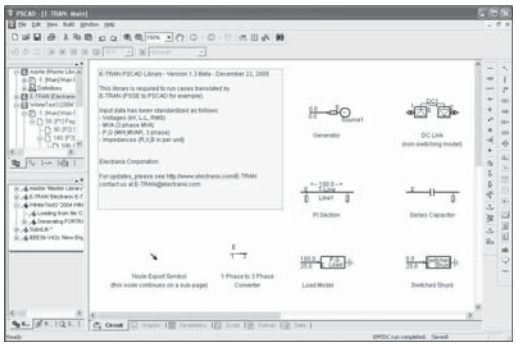

Figure 3 E-TRAN runtime library for PSCAD

The user will have to specify the location of the *.raw/*dyr data files and the target *.psc (PSCAD) file. In the next dialog, the user will specify if the entire network is to be 'kept' or if only a specific part is kept and the rest equivalenced. In most transient studies, there is no added benefit in modeling the details of the network beyond a few buses away from the location of main interest. E-TRAN allows for the system to be partially or fully converted (all its nodes) into PSCAD. The conversion process will generate a PSCAD (*.psc) file in the specified location. The network equivalent sources will have their magnitudes and phase angles automatically set for the same power flow as in the original PSS/E file.

E-TRAN Runtime Library for PSCAD

The E-TRAN Runtime Substitution Library in Figure 3 contains a series of models specially developed for PSS/E-PSCAD conversions that translates PSS/E component information into equivalent PSCAD component information. The E-TRAN Runtime Substitution Library is provided with the program and contains the models that will appear in the converted PSCAD case. To run the converted PSCAD case:

- Open PSCAD
- Load the E-TRAN Runtime substitution library
- Load and run the PSCAD case to ensure correct conversion
- Verify the load flow results

Custom Substitution Libraries and Data Entry

Load flow programs represent the power system network using simplified models consisting of resistances, inductances and capacitances. When converted to a PSCAD case, these components can be replaced by more detailed models to represent the respective unit. Therefore, depending on the user needs, some of the models automatically substituted from the E-TRAN substitution library may require additional data or may have to be replaced by more complex models from the PSCAD master library. Due care must be given to component grounding as this information is not in the PSS/E file. Fortunately, E-TRAN allows the user to create a user substitution library where any additional information will have to be entered by the users only once, when the component is used the first time.

An example that calls for the use of the custom substitution library could be a transmission line, where the PI section or the Bergeron models used to represent it may have to be replaced by a more accurate frequency dependant model, which will require specific information on the tower, conductor and right-of-way dimensions.

In the custom substitution library, the user can predefine the substitution of a specific system component to be done with a pre-filled out PSCAD master library component (or a user built component) by referencing the bus number they are connected to as shown in Figure 4.

"You can save detailed device data in this library, and E-TRAN will use this data (substituting it for the simple load flow data) every time a region of the network is converted into PSCAD. The goal is to eventually have all detailed model data entered into this library. Once this is achieved, this library can be used to generate PSCAD cases for any location of your system.

The models in the Substitution Library can also be custom written components, or even page components. A page component can also have as many layers of sub-pages as required. Each page can also contain sliders, plots, graphs, control-panels, etc... When E-TRAN copies the data from your Substitution Library, it will also replace initial condition information. For example, E-TRAN will modify synchronous machine data to replace the data for the terminal voltage, angle, P and Q."

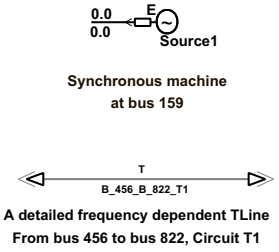

Figure 4 Examples of 'custom substitution library' components

The construction of the custom library will require a significant investment of time for large networks. However, once it is completed, you can convert any part of your network without having to do any manual data entry. This was identified as a key time saving feature by large utilities and consultants who are required to work on different parts of large networks when undertaking different projects.

Deciding on the Part of the Network to be Kept

A transient study would require the detailed modeling of a small part of the network around the main point of interest. Typically, this would be about two or three buses away from this point. E-TRAN allows users to efficiently decide and check if the 'kept' network details are adequate for a given study. The following steps are recommended. This makes use of the '**network frequency scan**' component of PSCAD as shown in Figure 5.

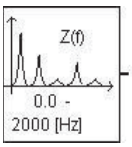

Figure 5 PSCAD frequency scan component

- Convert the PSS/E file to PSCAD, keeping the details of two or three buses away from the main point of interest and equivalencing the rest.
- Use the frequency scan component of PSCAD to plot the impedance vs. frequency characteristic of this system at the bus concerned.
- Reconvert the PSS/E file; this time keeping the details of one more bus away than in the earlier step.
- Plot the impedance vs. frequency characteristics of this system at the bus concerned and compare with the first plot.
- Repeat the process until the differences in frequency characteristics are minor in the frequency range of interest. Adding more details of the network beyond this point is unlikely to improve results.

Figure 6 shows the use of the frequency scan feature. Here, different network equivalents were constructed using E-TRAN for the IEEE 39 bus system at bus No. 15, for 2, 3, … 6 buses away (with 6 buses away comprising the whole network). These network equivalents were created using the load flow data file only (*.raw). It can be observed that the frequency spectrums of the equivalent networks start providing a good approximation for the whole network starting at '4 buses away.'

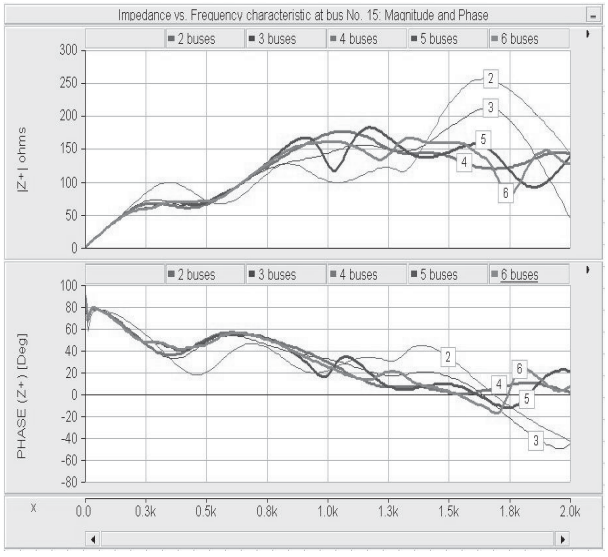

Figure 6 Frequency scans 2, 3 ...6 buses away at bus no. 15 for the system under study

MANITOBA·HVDC
RESEARCH
CENTRE

Manitoba HVDC Research Centre Inc.
244 Cree Crescent
Winnipeg, Manitoba, Canada R3J 3W1
T +1 204 989 1240 F +1 204 989 1277
info@pscad.com

www.pscad.com

PSS/E Load Flow output											
BUS	15	LBUS15	345	AREA	CKT	MW	MVAR	MVA	%I	1.0154PU	-7.75 DEG
					1					350.31KV	
TO	16	LBUS16	345	1	1	-314.7	-151.7	349.3			

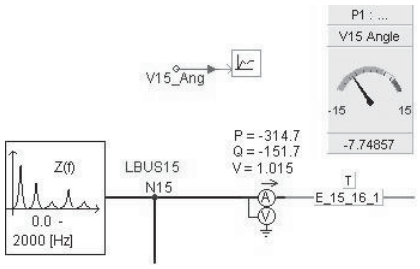

Figure 7 Comparison of load flow results between PSCAD and PSS/E

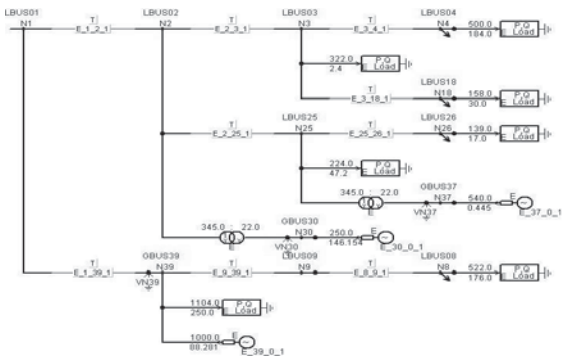

Figure 8 IEEE 39 bus system converted to PSCAD (bus no. 1 and 3 buses away)

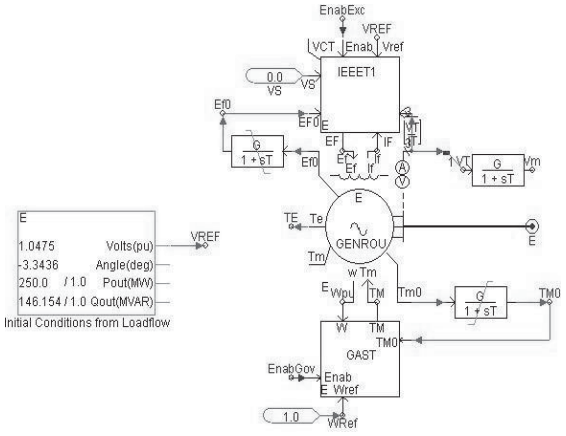

Figure 9 Detailed synchronous machine model automatically generated by E-TRAN with parameters taken from the PSS/E *.dyr and *.raw files

Validation

A quick method to validate the simplified equivalent system provided by E-TRAN is to compare the values calculated by PSCAD for node voltages, transmission line load flows or P, Q flows at generation busses with the ones previously calculated by PSS/E. For such purposes, use the multi-meter to display the voltage at the bus and the P and Q flows in the respective transmission line. The converted PSCAD case will have auto generated labels that display the P, Q flows at generation buses. Figure 7 shows the PSS/E and PSCAD results for the voltage magnitude and angle at node 15, as well as the P and Q flows along the transmission line connected to nodes 15 and 16.

Three-phase short-circuit level calculation at selected buses for the converted PSCAD case is also recommended. The short-circuit results can be compared to those from the PSS/E study or utility system data for validation purpose. Once the PSCAD system has been validated, it is ready to be used for transient studies. This PSCAD case is shown in Figure 8.

Importing Dynamic Data from the .dyr File

During the conversion process, the user can specify to import dynamic data from the PSS/E *dyr file. If this option is selected, all generators in the 'kept' part of the network will be replaced by detailed machine models as shown in Figure 9. The machine controls and related models (exciter, governor, PSS, turbine) will also be included in the PSCAD model. All information necessary to initialize these models will either be imported from the *raw/*dyr files or be computed by E-TRAN. Thus, the simulation will automatically come to the specific steady state after a few cycles of simulation time.

Note: This feature available in the next release of E-Tran.

References

[1] Electranix Corporation "E-TRAN V1.1: Electrical Translation Program for Power Systems. User's Manual" February 2003.

Prepared by Juan Carlos Garcia, Dharshana Muthumuni and Pei Wang. Please email info@pscad.com if you have an article you would like to submit on the use of PSCAD™.