

# E-TRAN

Translator for Power System Simulation

User's Manual  
Version 3.0

**ELECTRANIX**  
SPECIALISTS IN POWER SYSTEM STUDIES

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# 1.0 Introduction

Electranix Corporation was founded in 2000 by two experienced power systems engineers, namely Dennis Woodford who first wrote the EMTDC algorithm in 1975 and Garth Irwin who was the Head of development of PSCAD/EMTDC at the Manitoba HVDC Research Centre for over 10 years. One of the biggest challenges in performing EMT (Electromagnetic Transients) studies is obtaining PSCAD models, since many utilities maintain their network data in PSS/E **.raw** data files. At the beginning of our consulting services we would take PSS/E **.raw** data file and manually translating the data into a PSCAD model. This process takes both a lot of effort and time and is prone to human error. To automate this process we developed E-TRAN to use as an internal tool. When customers saw the power and capability of E-TRAN they started asking for it which in turn gave us the idea to commercialize E-TRAN.

## 1.1 In this Manual

1. **Chapter 1.0: Introduction** to E-TRAN, outlines the contents of this manual, and lists five ways to get help with E-TRAN.
2. **Chapter 2.0: E-TRAN Overview** of the features that E-TRAN offers.
3. **Chapter 3.0: Installation and License Management** step by step guide takes you through the procedure of installing E-TRAN. After the installation it discusses the three different types of licences that can be used to run E-TRAN and how to obtain a license key. Finally, a step by step guide takes you through the procedure of installing a license key.
4. **Chapter 4.0: E-TRAN Tasks** step by step guide takes you through the procedure of translating a basic model from PSS/E to PSCAD. The chapter then explains how to run an E-TRAN translated model in PSCAD. In addition to a basic translation, if you have sequence and dynamics data available this chapter explains how to include this data in a translation.
5. **Chapter 5.0: How to use the Substitution Library** demonstrates how to build your own library (substitution library) with detailed components and use E-TRAN to build models from the substitution library. The chapter first explains the process and follows with four examples that show how to substitute the following: transformer, transmission line, synchronous machine, and a DC Link.
6. **Chapter 6.0: Options and Preferences** describes the parameters that can be set in the Options and Preferences dialog.
7. **Chapter 7.0: E-TRAN PSCAD Library** presents the components that are contained in the E-TRAN PSCAD Library, which comes with E-TRAN and can be downloaded from <http://www.electranix.com/E-TRAN/>. The chapter then goes on to describe the parameters of each component individually.
8. **Chapter 8.0: Theory of E-TRAN** discusses the theory E-TRAN is based on.

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9. **Acknowledgements** gratefully acknowledges the names of people and organizations that have contributed to the development of E-TRAN.
10. **FAQ's and Trouble Shooting** answers frequently asked questions and will help you with trouble shooting in E-TRAN translations.
11. **Technical Support Contact Information** section on the inside back cover and contains the address, e mail, website, phone, and fax number for technical support.

### 1.2 E-TRAN

E-TRAN uses a "Wizard" style, which will guide you step by step through the process of translating a loadflow data to a PSCAD model.

Loadflow programs are the most common tools to study the fundamental frequency behaviour of power systems. They calculate the steady state voltages and power flows in a very large power network. Users keep databases of their entire system (usually in PSS/E .raw format) and religiously update these files every year to document the current and predicted state of their network.

Electromagnetic transients (EMT) simulation is performed to study dynamic power system transients, such as overvoltage's, harmonics, dynamics, power electronics (HVDC, SVC, STATCOM...), resonance conditions etc... EMT programs solve differential equations (not steady state equations) for the entire circuit, including electro-mechanical, electro-magnetic and control systems (note that transient stability algorithms also solve differential equations, but not for the electrical electro-magnetic portions of the circuit). As such, EMT programs often require specialized data for the portion of the network they are studying.

Since EMT programs are generally unable to solve very large networks (> 3000 busses), users must also introduce network equivalents in their model in order to represent the network outside of the study boundaries.

E-TRAN performs the following functions:

- Directly translates power system data from PSS/E for use in the PSCAD simulation program.
- Initializes machines, generators and sources in large PSCAD simulations.
- Creates multi-port network equivalents of large systems.
- Performs sanity checks/data verification/error checks on PSS/E .raw input files.
- Visualization of an electrical network by auto-routing and direct creation of a Single Line Diagram.

## 1.3 PSCAD/EMTDC Electromagnetic Transients Simulation Program

PSCAD/EMTDC is the world's leading commercial Electromagnetic Transients simulation program. The program solves the differential equations for the electrical power system network, as well as for the controls and electro-mechanical portions of the system.

PSCAD ("Power System Computer Aided Design") is the graphical user interface for the EMTDC solution algorithm (EMTDC was originally developed by Dennis Woodford in 1975). PSCAD/EMTDC is now developed and supported by the Manitoba HVDC Research Centre Inc. and is used by all the major manufacturers of power system equipment, as well as consultants, universities and electric utilities.

The E-TRAN Library is compatible with PSCAD Versions 4.2 and x4. For translation from PSS/E .raw files, E-TRAN will directly generate PSCAD Case (.psc, .pscx) files.

For more information on PSCAD, please contact the Electranix Corporation at [info@electranix.com](mailto:info@electranix.com) (see Technical Support Contact Information) or visit the PSCAD www site at <http://www.pscad.com>).

## 1.4 PSS/E Loadflow Program

The PSS/E program solves the steady state phasor equations for the electrical power system network, and solves differential equations for the controls and electro-mechanical portions of the system. The PSS/E .raw file format has become a de-facto standard and many other commercial loadflow programs import and export .raw files.

PSS/E ("Power System Simulator for Engineering") is developed and supported by Power Technologies Inc. (PTI - <http://www.pti-us.com/pti/software/psse/>).

Refer to section 4.1.3 for information on the versions of the PSS/E .raw files supported by E-TRAN.

## 1.5 Where to get Help

The E-TRAN documentation is available in 4 forms:

1. *Hardcopy E-TRAN User's Manual*: A hardcopy of the E-TRAN User's Manual is shipped to commercial customers when they purchase E-TRAN.
2. *Online E-TRAN User's Manual (.pdf file)*: The online manual in .pdf form is available by using the **start** ↗ **Programs** ↗ **E-TRAN\_V3** ↗ **E-TRAN User's Manual (pdf)** shortcut.

**Note:** PDF is a standard viewing format that allows you to view, search, print, hotlink between sections and chapters etc... You require a free PDF Viewer (available for Windows, Unix, Mac etc...). The windows version of the viewer can be downloaded from:

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***<http://www.adobe.com/support/downloads/product.jsp?product=10&platform=Windows>***

3. *Online E-TRAN User's Manual help file (E-TRAN.chm using Microsoft HTML Help):* The E-TRAN User's Manual is available online through the online help system in E-TRAN. Click on any "**Help**" button in E-TRAN (or hit the "**F1**" key) and the most applicable section of the manual will open.
4. *Online fly-by help in PSCAD E-TRAN models:* Fly-by help is available on all E-TRAN models in PSCAD:
  - Point at an E-TRAN model (and stop moving the mouse)
  - Point at an input connection on an E-TRAN model (and stop moving the mouse)

If you require additional help send an e-mail to ***[e-tran@electranix.com](mailto:e-tran@electranix.com)***.



## 2.0 E-TRAN Overview

E-TRAN is a powerful translation tool that allows you to automate the process of drawing PSCAD models from a combination of PSS/E **.raw**, **.dyr**, and **.seq** files. E-TRAN bridges the gap between PSS/E and PSCAD. The sections that follow describe the features that are part of E-TRAN and shown in Figure 2.1.

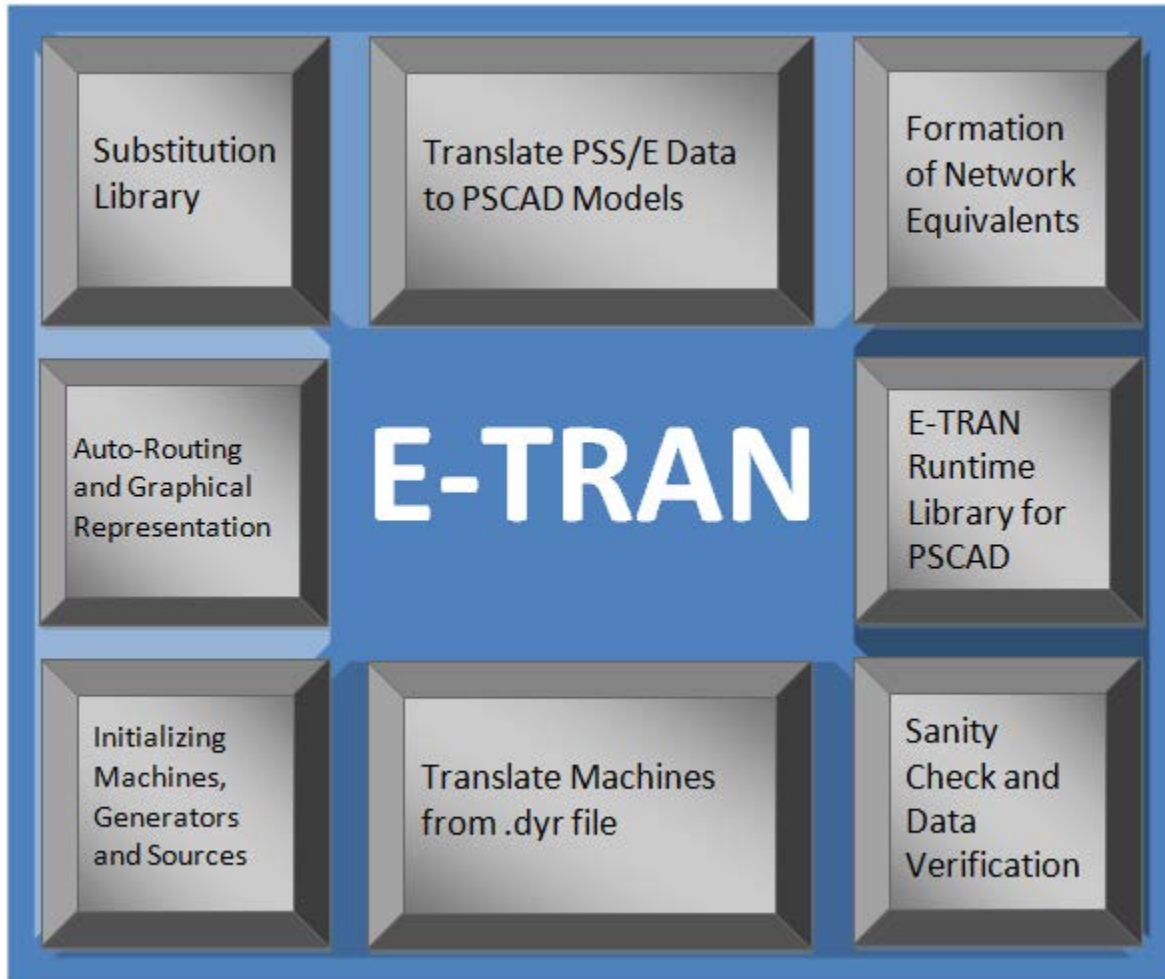


Figure 2.1 Diagram showing a list of E-TRAN features.

### 2.1 Translate PSS/E Data to PSCAD Models

1. Convert a **.raw** file to a **.psc** file with a few clicks.
2. For a more detailed model you can include a **.dyr** and **.seq** file in your translation.

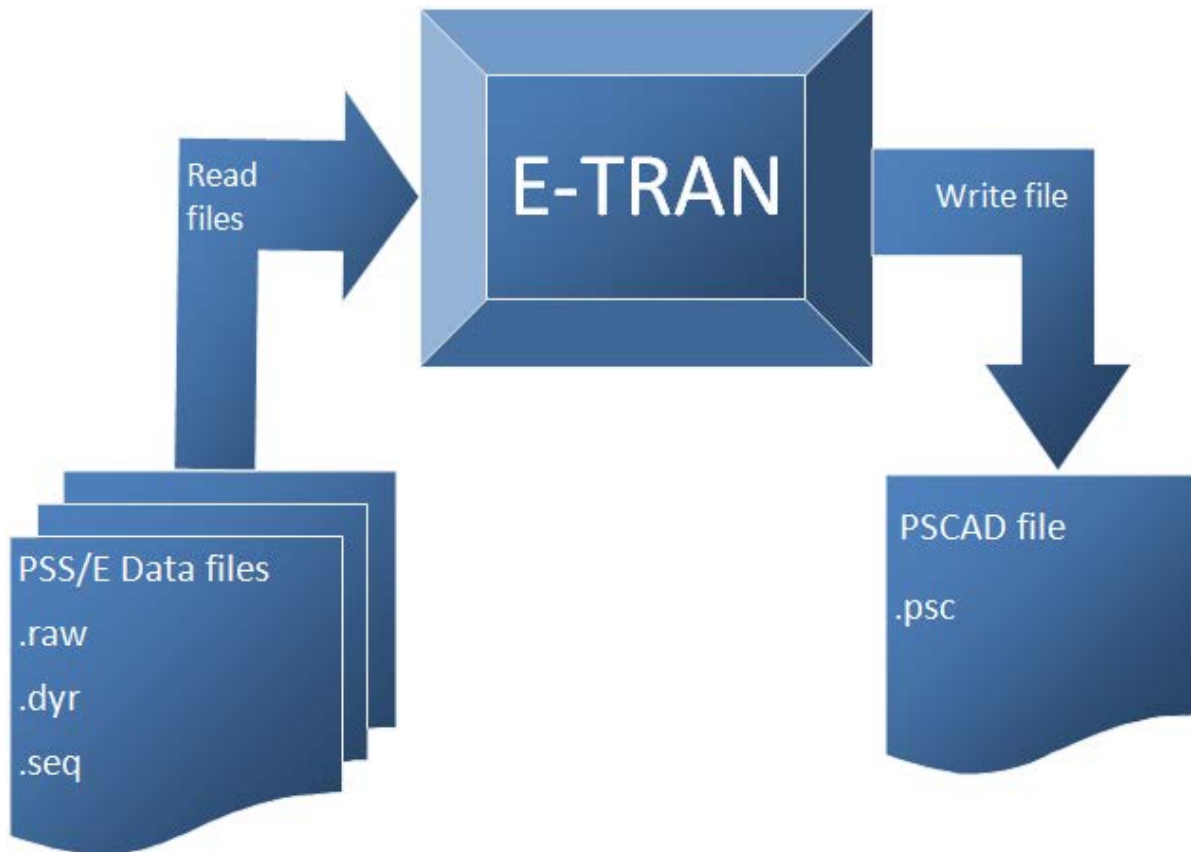


Figure 2.2 Diagram showing the flow of data during an E-TRAN translation.

## 2.2 Auto-Routing and Graphical Representation

E-TRAN will directly create PSCAD .psc files, complete with correct data for all busses, loads, DC links, switched shunt devices, branches, generators, transformers, phase shifters (etc...). All components are correctly drawn and graphically interconnected. Drawings are grouped by location and voltage level, and can be created for a complete network or a portion of a network.

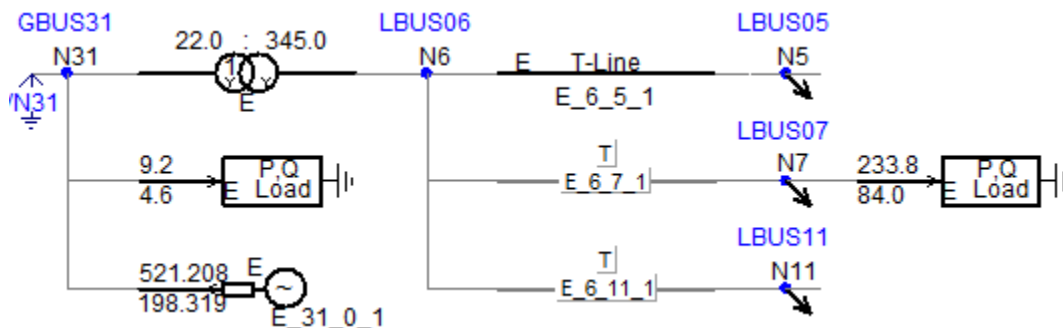


Figure 2.3 The IEEE 39 bus system auto-routed using E-TRAN. Bus 31 was selected as the central bus and 2 busses back.

The auto-routing algorithm in E-TRAN is capable of drawing very large networks (it has been tested

up to 50,000 busses) with no known limitations. E-TRAN will automatically generate sub-pages and sub-sub-pages (if required) etc...

### 2.3 Network Equivalent and Kept Network

You can identify a portion of the network for a direct translation into PSCAD models (i.e. the "kept" network), and E-TRAN creates a network equivalent of the rest of the network based on the available fundamental frequency impedance and powerflow information. The equivalent is multi-port (meaning the representation will be correct for steady state as well as for open circuit and short circuit conditions) and contains voltage sources (to match PQ flow and represent generation in the equivalent network). The kept network can be selected in one of the following ways:

1. Keep all (only useful for smaller networks).
2. Keep an Area in your kept network.
3. Keep a Zone in your kept network.
4. Choose a particular bus and N Busses Back in your kept network.
5. Enter a list of bus number for your kept network.
6. Keep busses with a certain voltages in your kept network (i.e. show only 230 kV and higher, 13.8 kV and lower, or between two kV levels).

### 2.4 Initialization of Machines, Generators and Sources

The bus voltages and angles and PQ loadflow information (from the solved load flow input file) are used to directly initialize sources/generators in PSCAD (and to initialize non-linear loads etc...). The initialization information can be used in simple voltage source representations of generators, or can be used to initialize detailed machines, governors, exciters, multi-mass systems etc... The resulting simulation in PSCAD will exactly match the solved load flow results for any circuit and complex systems with any number of machines can be initialized without startup oscillations.

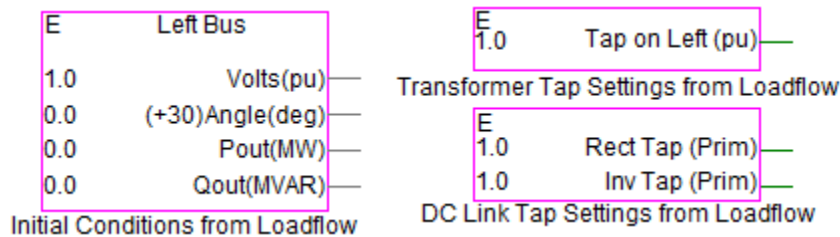


Figure 2.4 Components that can be used in the substitution library to initialize detailed models from loadflow.

## 2.5 Translate Machines from .dyr file

Simply enter the **.dyr** file in E-TRAN, and for all machines in the kept network, E-TRAN will translate the machine into its own sub-page, along with the respective exciters, governors, stabilizers, min/max excitation limiter, and compounding settings.

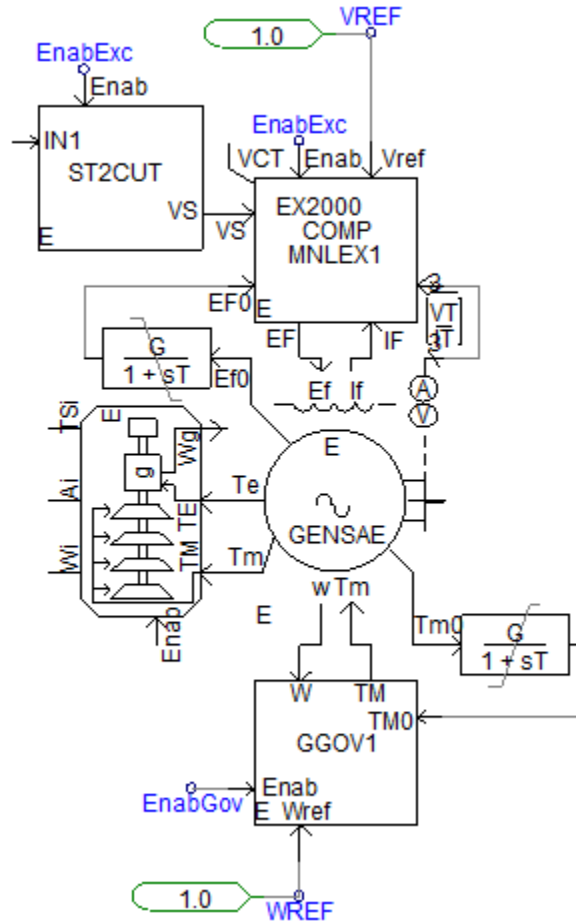


Figure 2.5 This machine model is placed in the sub-page that E-TRAN creates for each generator in the kept network (varies somewhat depending on how much data is in the .dyr file).

## 2.6 E-TRAN Runtime Library for PSCAD

E-TRAN includes a freely downloadable runtime library for use in PSCAD. The E-TRAN Library contains all models used in loadflow programs (including load models, sources, transmission lines, transformers, phase shifters etc...) and has data entry based on the same Per Unit system and data entry standards as used in loadflow programs. PSCAD cases generated with E-TRAN can be freely distributed to other users without license fees.

## 2.7 Substitution Library

If a user has more detailed data available (for example geometrical data for transmission lines

suitable for a frequency dependant line model or a detailed core representation of a transformer with saturation data entered etc.) then the user can maintain this data in a Substitution library and E-TRAN can directly write out this data instead of the simple RXB data. A device in the Substitution Library can also be a custom or page component, in which case it can contain many sub-pages of electrical or control devices (for example a detailed model of an HVDC link or SVC). An initialization feature can be used to define +/- 30 degree phase shifts (due to wye-delta transformers) and to accept the loadflow steady state powerflow, voltage magnitude and phase angles. This can be used to initialize any device.

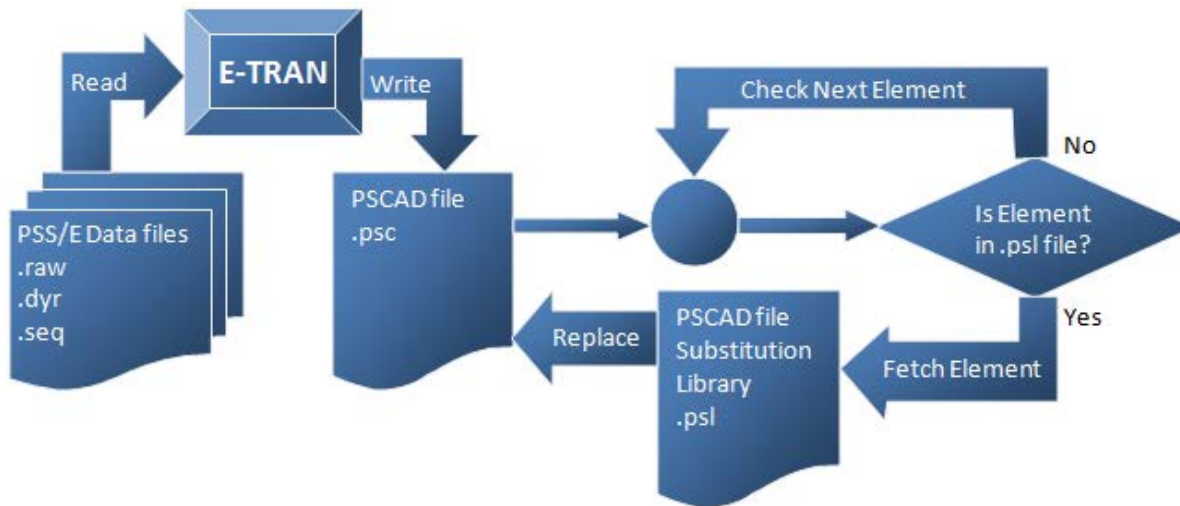


Figure 2.6 State diagram showing at which stage of a translation E-TRAN checks for detailed components in the substitution library.

## 2.8 Sanity Check and Data Verification

E-TRAN generates extensive warnings and error messages when it reads in PSS/E .raw input files. This will inform the user of areas of mismatched voltage levels, inconsistencies in the entry of data, and other possible problems. The result messages are output to the E-TRAN log file.



## 3.0 Installation and License Management

This chapter will guide you through the installation procedure and help you with obtaining a license for E-TRAN. It also contains information about system requirements to install E-TRAN. After this chapter, E-TRAN will be setup and ready to translate loadflow data to PSCAD models. If you require more assistance send an e-mail to [e-tran@electranix.com](mailto:e-tran@electranix.com).

E-TRAN can be installed on any MS-Windows platform from Windows XP and higher (XP, Vista, Windows 7, and Windows 8).

Requirements:

1. E-TRAN uses a single computer licensing model, which will allow E-TRAN to run on only one computer at a time. Licenses are requested from and issued for one specific computer only.
2. It is recommended that your computer has at least a screen resolution of XGA (1024x768) or higher.
3. An html browser (i.e. Internet Explorer (3.02 or later) or Firefox etc.) is required for viewing the online help files. (Internet Explorer 7.0 or better is recommended)
4. The free Adobe Acrobat Reader is required for viewing the **.pdf** version of the User's Manual. Adobe Acrobat Reader can be downloaded from <http://get.adobe.com/reader/>

The E-TRAN program is installed via the installation program setup.exe (see Section 3.1).

To un-install or repair the installation of the E-TRAN program, use Add/Remove Programs from the Windows Control Panel (see Section 3.2).

Finally, a user should customize the E-TRAN **Options and Preferences** (to set the path of the PSCAD.exe program so it can be launched from within E-TRAN), as well as the specific E-TRAN library required by their fortran compiler. See Chapter 6.0 for more information.

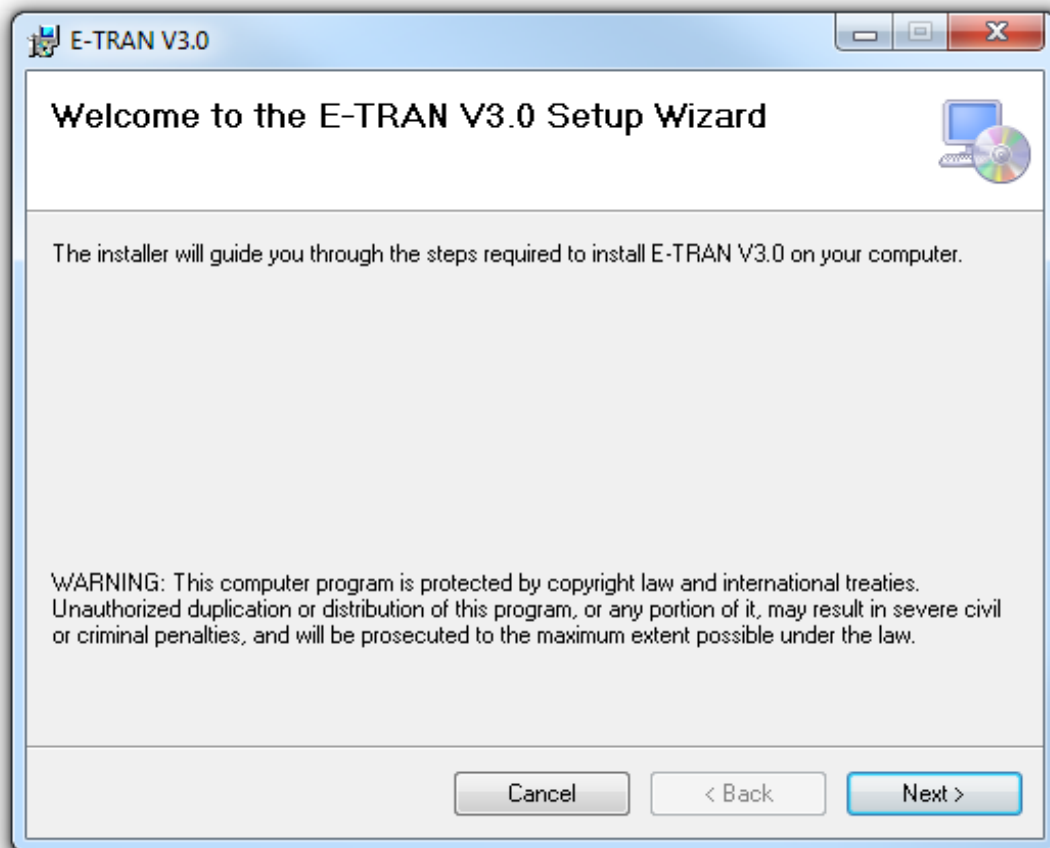
Updates for E-TRAN can be downloaded by going to the web site [www.electranix.com/E-TRAN/](http://www.electranix.com/E-TRAN/) and once there, clicking on **Support/Downloads**. To access this page of the website you will need a username and password. For information about applying for a username and password see section 3.3.

### 3.1 Installing E-TRAN

To install E-TRAN, follow the steps shown below:

1. If you are using the E-TRAN folder downloaded from [www.electranix.com/E-TRAN/](http://www.electranix.com/E-TRAN/) for the installation, extract the files from **E-TRAN\_V3\_x\_x** folder, open it, then double-click the **“Setup.Exe”** file. This will launch the Setup Wizard shown below, which will let you customize and install E-TRAN.

If you are using the CD for the installation, insert the CD and the Setup Wizard shown below will launch automatically.



Click **“Next”** to continue.

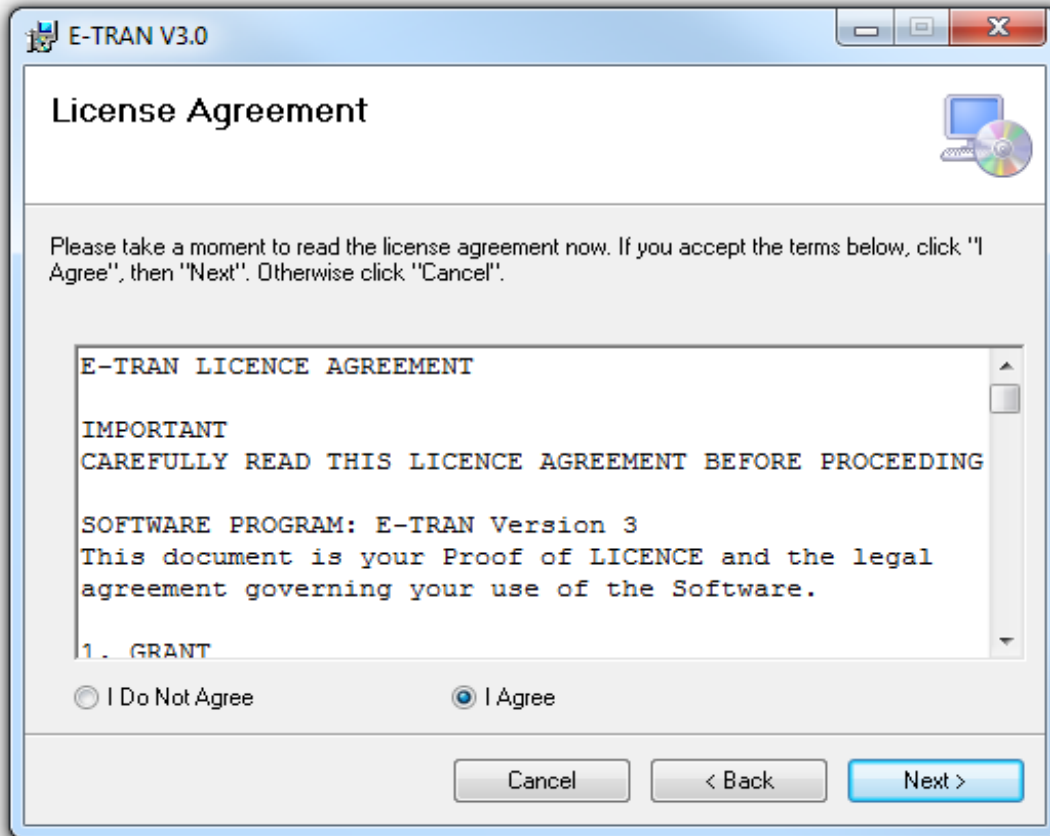
You can click **“Cancel”** at any time to exit the installation.

**Note:** Windows requires the installation to be performed by an Administrator or Power User.

**Note:** If you are using E-TRAN in conjunction with PSCAD, it is recommended that you first install PSCAD.



2. After you click “Next” the dialog shown below will appear on your screen.



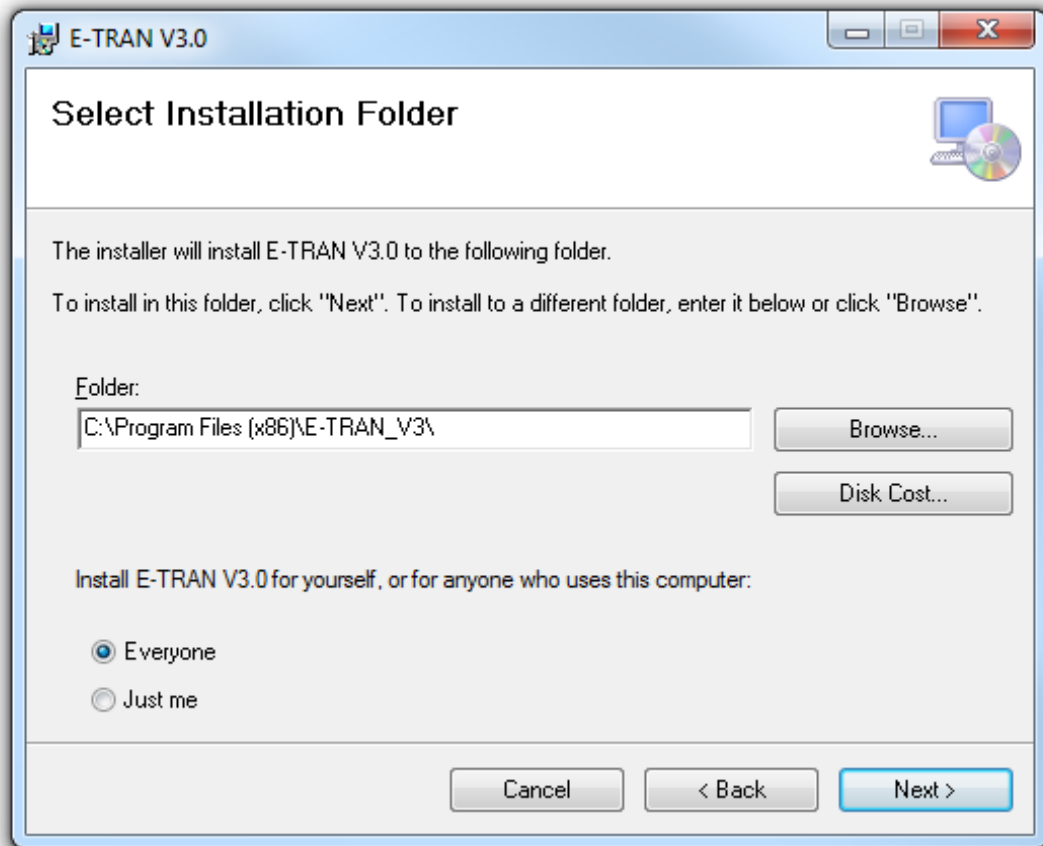
Please read the license agreement carefully; if you agree to the terms and conditions of the installation, check “**I Agree**” and Click “**Next**” to continue.

If you do not agree to the terms and conditions, then click “**Cancel**” to exit the installation.

The “**Back**” button allows you to return to the previous step at any time.

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3. After you click “**Next**” the dialog shown below will appear on your screen.



Select a directory in which you want to install E-TRAN. The default directory is “C:\Program Files (x86)\E-TRAN\_V3” and is already selected for you.

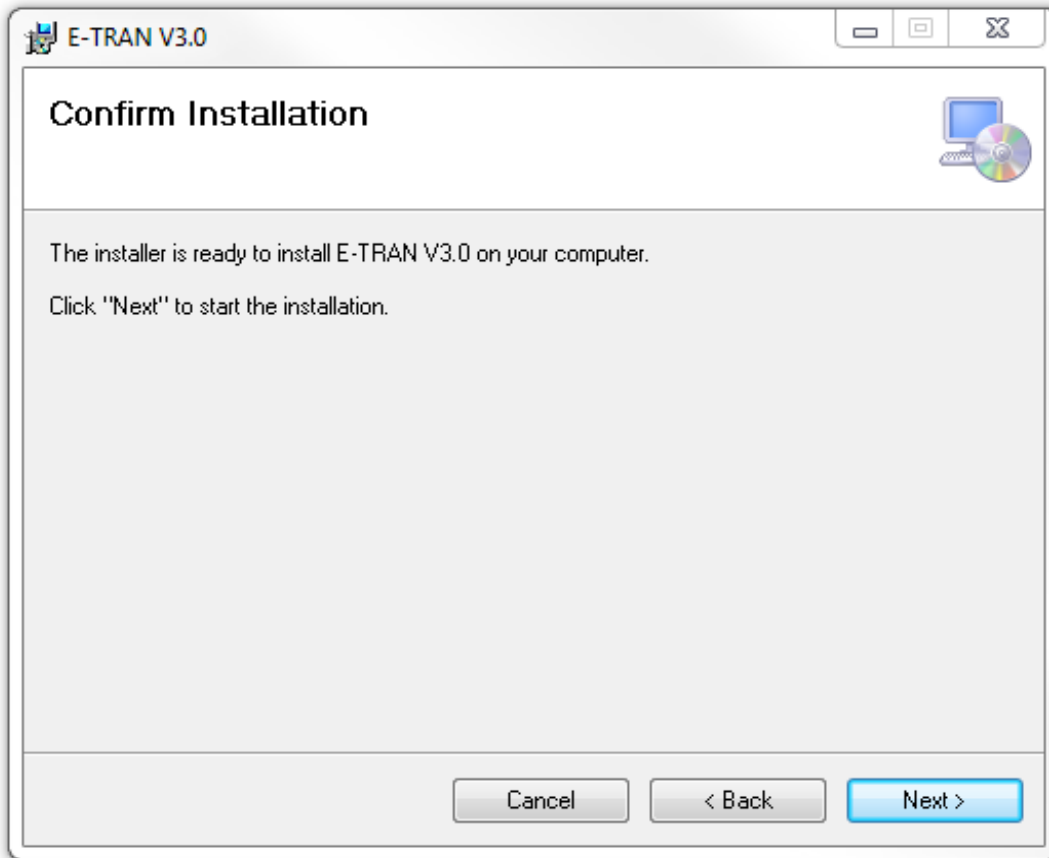
You can type the folder name or use the “**Browse...**” button to select a directory.

The “**Disk Cost...**” button can be used to see how much disk space is available on all your system drives.

**Note:** Program files are installed to only this directory (i.e. files are not copied to system directories).

Click “**Next**” to continue.

4. After you click “**Next**” the dialog shown below will appear on your screen.

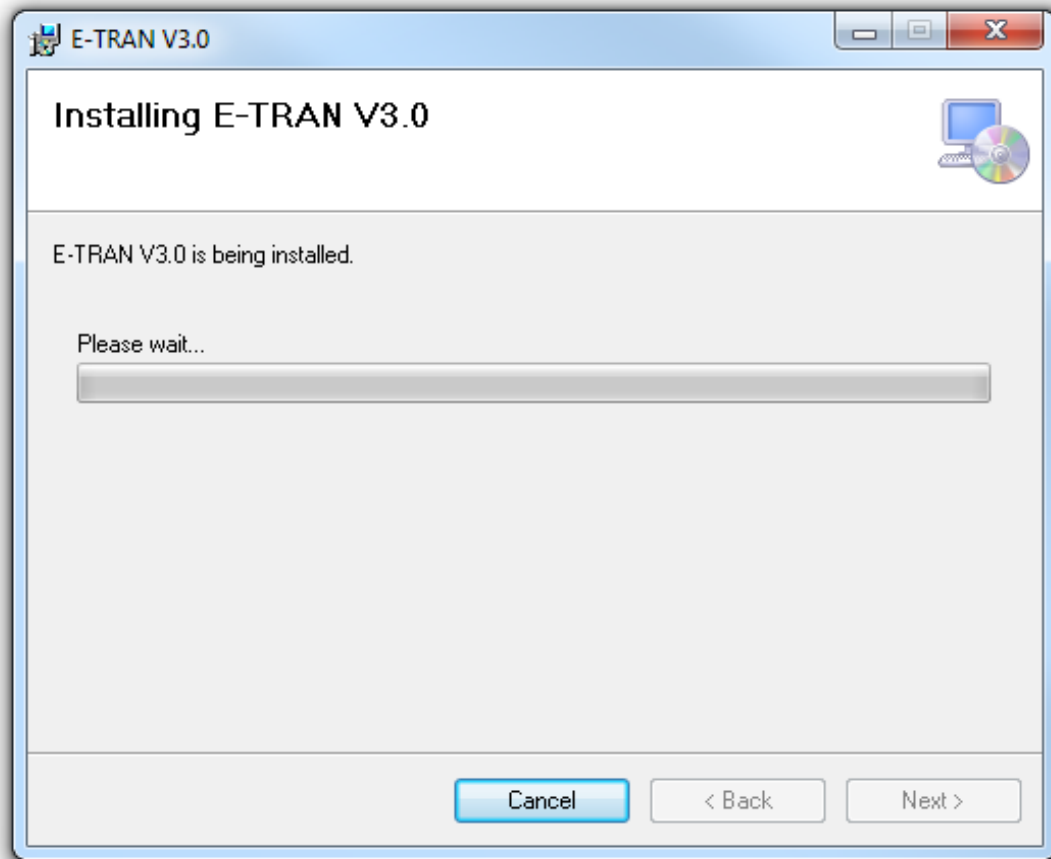


This is the last chance to exit before E-TRAN files are installed.

Click “**Next**” to install E-TRAN, or click “**Back**” to go back and change previous installation settings.

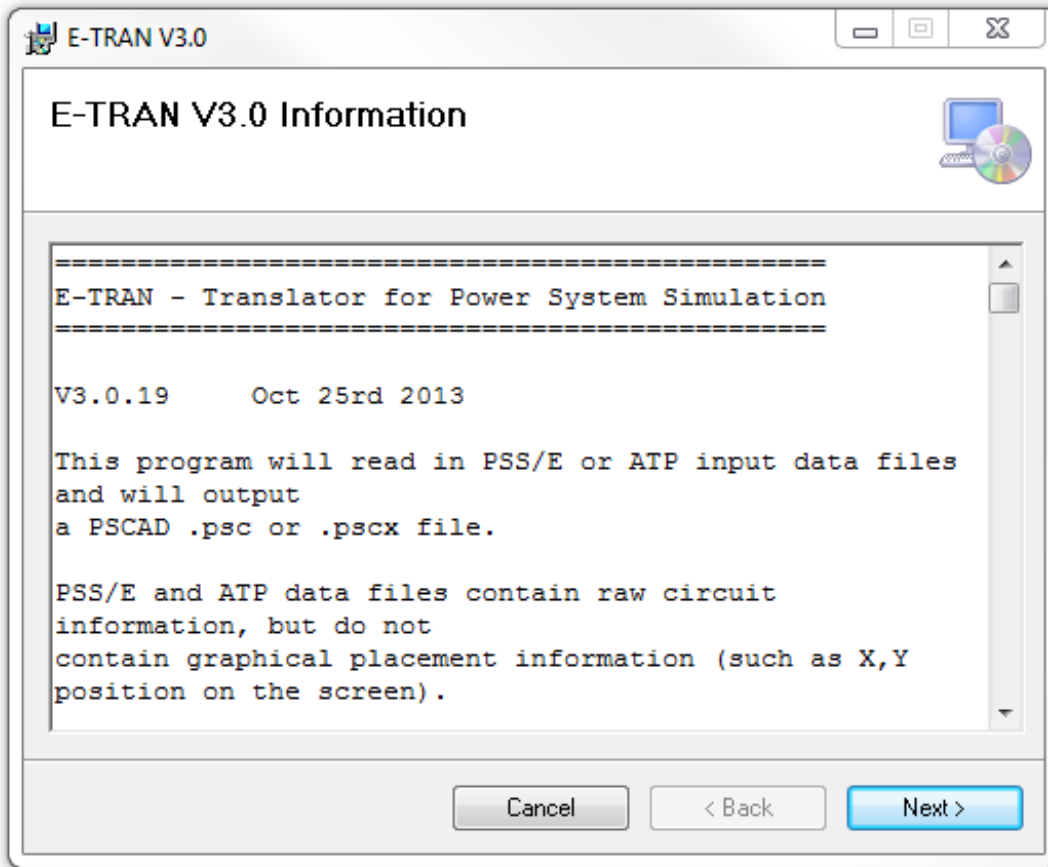
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5. After you click **Next** the dialog shown below will appear on your screen.



E-TRAN is now being installed.

- After the installation is finished the dialog shown below will appear on your screen.



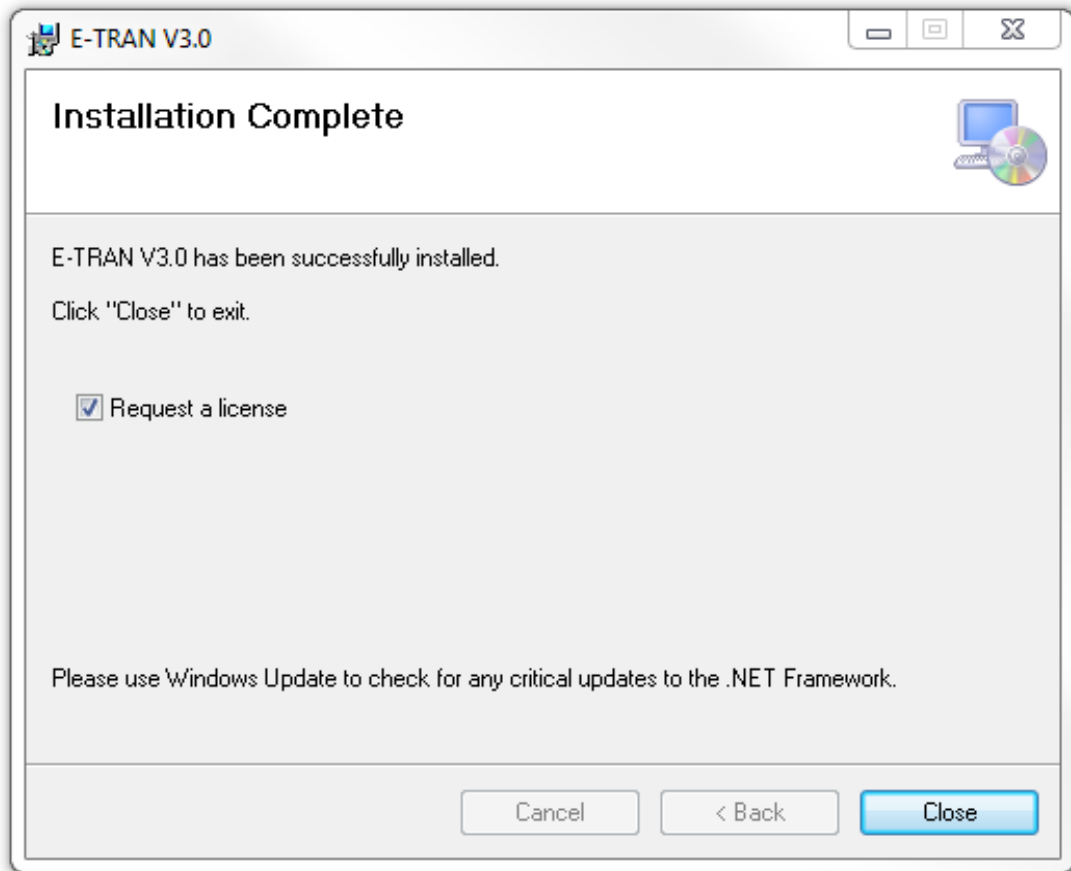
This screen shows the “**readme.txt**” file for this version of E-TRAN. You can review the list of changes in this version by reading the text in this window.

The “**readme.txt**” file will also be installed to the installation directory if you would like to read it later.

Click “**Next**” to continue with the installation.

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7. After you click “Next” the dialog shown below will appear on your screen.



The Installation is now complete. If you don't have a license to run E-TRAN, leave the check in the checkbox on to request a license from Electranix. If you already have a valid license, uncheck the box. To exit the Installation click “Close”.

**Note:** The .NET Framework may recommend you reboot your computer at this point (which you should do).

**Note:** It is recommended that you copy the examples to a directory that you are able to modify, just in case you need to modify the examples. To do this open the “C:\Program Files (x86)\E-TRAN\_V3\” directory (if you entered a different directory in step 3, you will find the Examples folder in this directory) and copy the Examples folder to a directory that you are able to modify. This will give you the ability to change or add files in the examples folder.

You can start E-TRAN by using the **start** ↗ **Programs** ↗ **E-TRAN\_V3** ↗ **E-TRAN\_V3** shortcut. Refer to section 3.3 for license requirements and E-TRAN Tasks in Chapter 4.0.

## 3.2 Un-Installing/Repairing E-TRAN

To un-install E-TRAN, go to **start** / **Control Panel** / **Add or Remove Programs**, in the list of programs select **E-TRAN\_V3** and click "**Remove**". The uninstall program will remove all files that were originally installed onto your system.

**Note:** If you have subsequently created files in the installation directory (i.e. "C:\Program Files (x86)\E-TRAN\_V3\..."), the uninstall program will not delete these files.

It is recommended you use the approach described above and do not simply delete the installation directory (i.e. "C:\Program Files (x86)\E-TRAN\_V3"). The uninstall programs do a better job of cleaning up registry entries etc... which will save room on your disk.

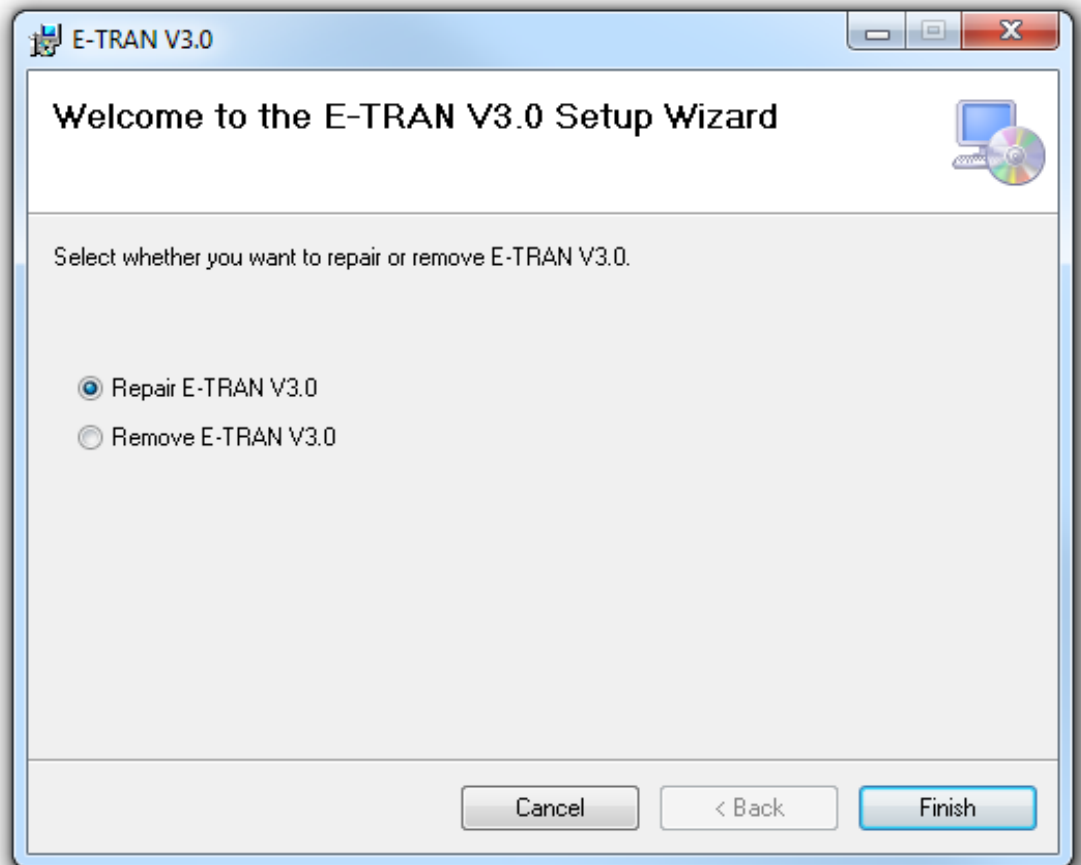
You also have the option of repairing the E-TRAN installation, which will restore the installed files in case they have been edited or have become corrupted.

To repair E-TRAN, follow these steps:

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1. If you are using the E-TRAN folder downloaded from [www.electranix.com/E-TRAN/](http://www.electranix.com/E-TRAN/) for the repair, extract the files from **E-TRAN\_V3\_x\_x** folder, open it, then double-click the “**Setup.Exe**” file. This will launch the Setup Wizard shown below, which will let you repair or remove E-TRAN.

If you are using the CD for the repair, insert the CD and the Setup Wizard shown below will launch automatically.



**Repair E-TRAN V3.0:** To repair E-TRAN check this radial button, then click “**Finish**”.

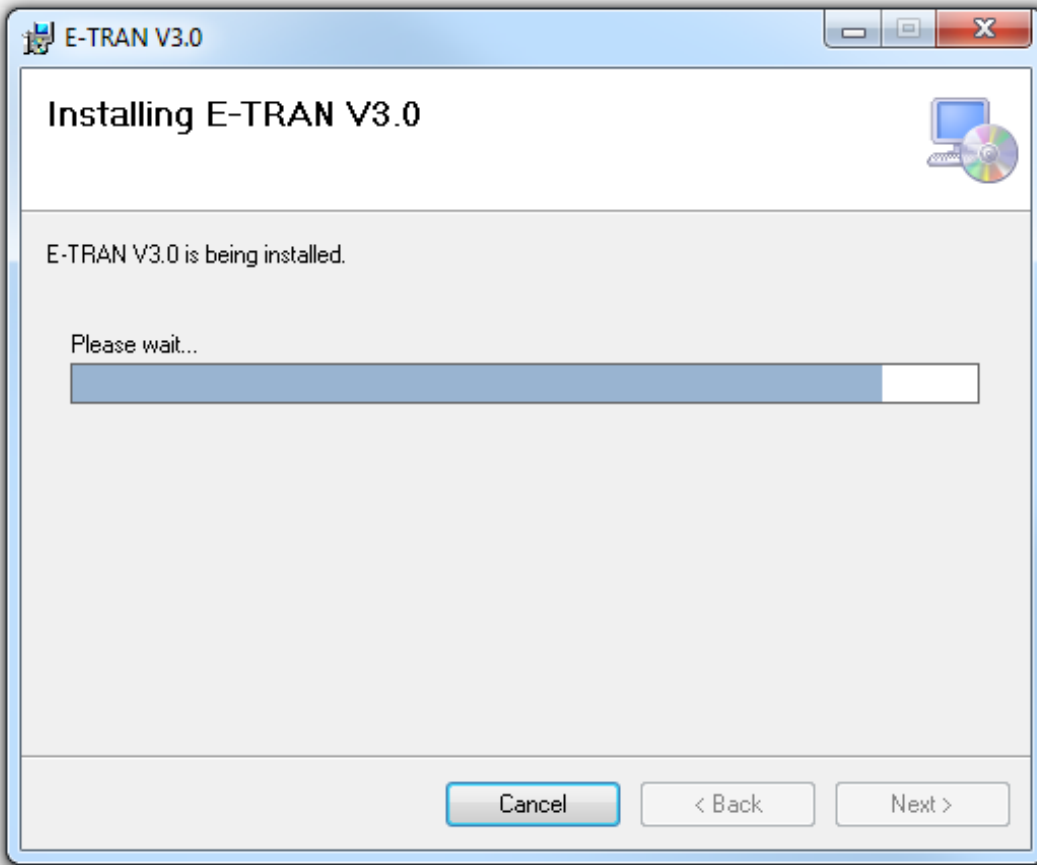
**Remove E-TRAN V3.0:** To remove E-TRAN check this radial button, then click “**Finish**”. Once E-TRAN has been removed, click “**Close**” to exit.

**Note:** This is an alternative to un-installing E-TRAN from the approach described above.

You can click “**Cancel**” at any time to exit the repair.



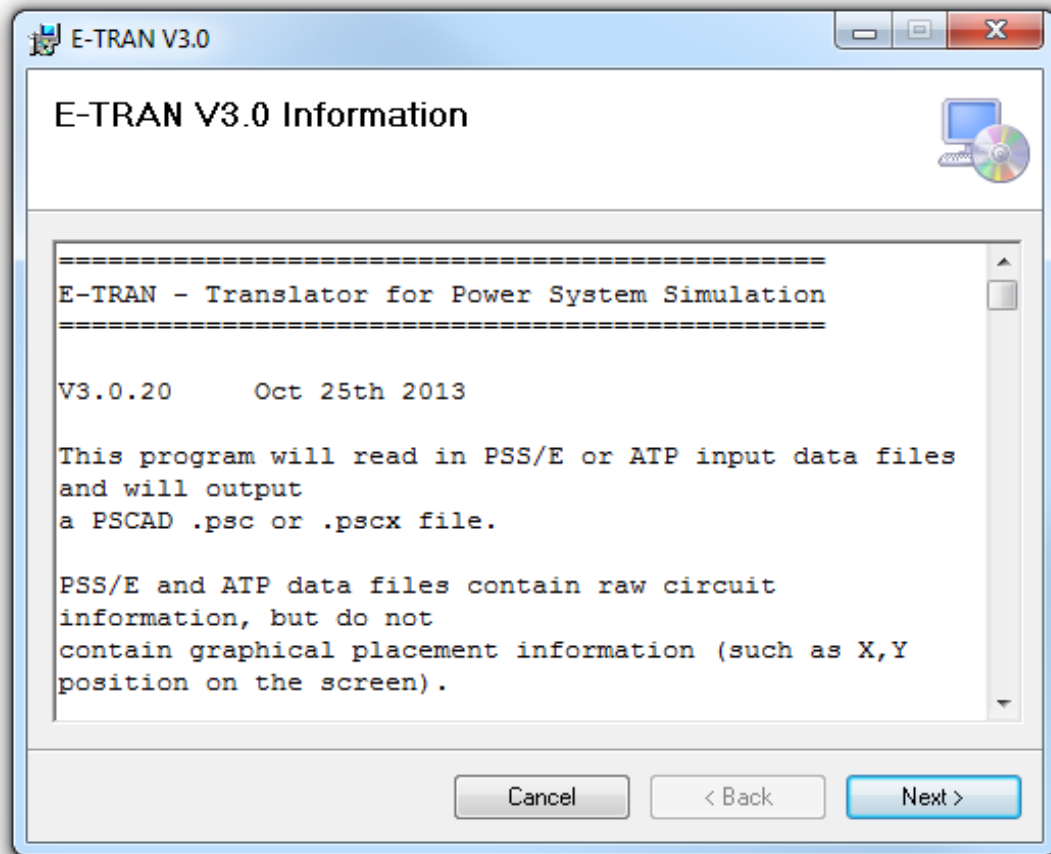
2. After you click “**Finish**” the dialog shown below will appear on your screen.



E-TRAN is now being repaired.

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3. After the repair is finished the dialog shown below will appear on your screen.

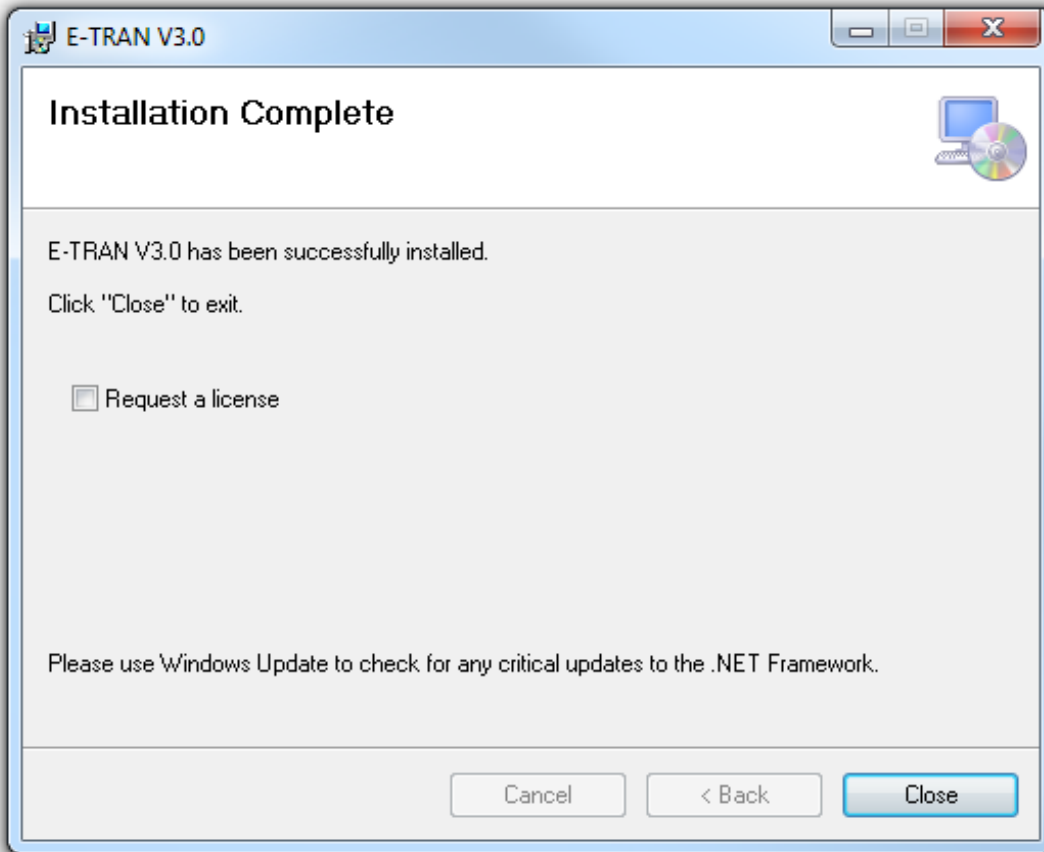


This screen shows the “**readme.txt**” file for this version of E-TRAN. You can review the list of changes in this version by reading the text in this window.

The “**readme.txt**” file will also be installed to the installation directory if you would like to read it later.

Click “**Next**” to continue with the repair.

4. After you click “**Next**” the dialog shown below will appear on your screen.



The repair is now complete. Uncheck “Request a license” and click “**Close**” to exit the repair.

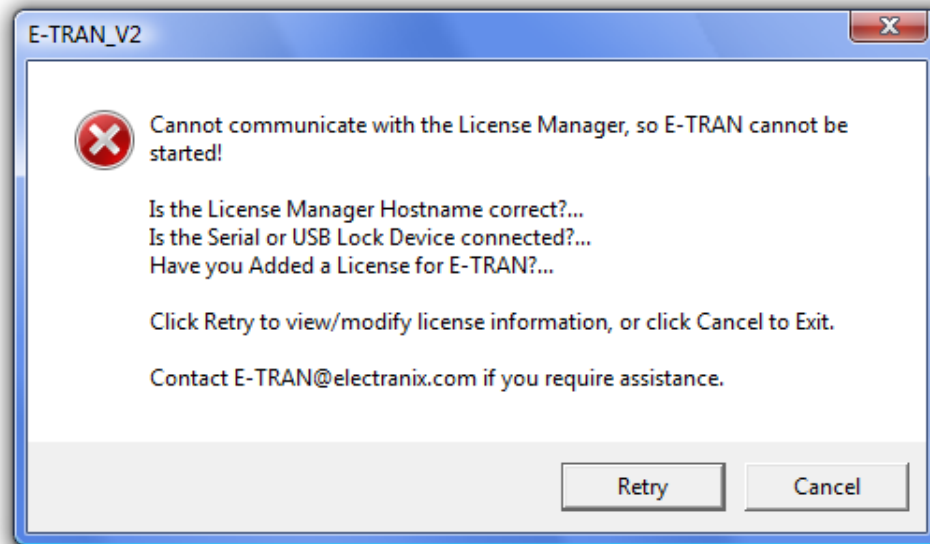
### 3.3 Licensing

If you have not purchased E-TRAN, a 30 day free trial license is available for those interested in getting a firsthand look. To obtain a license key for E-TRAN you should follow the directions below:

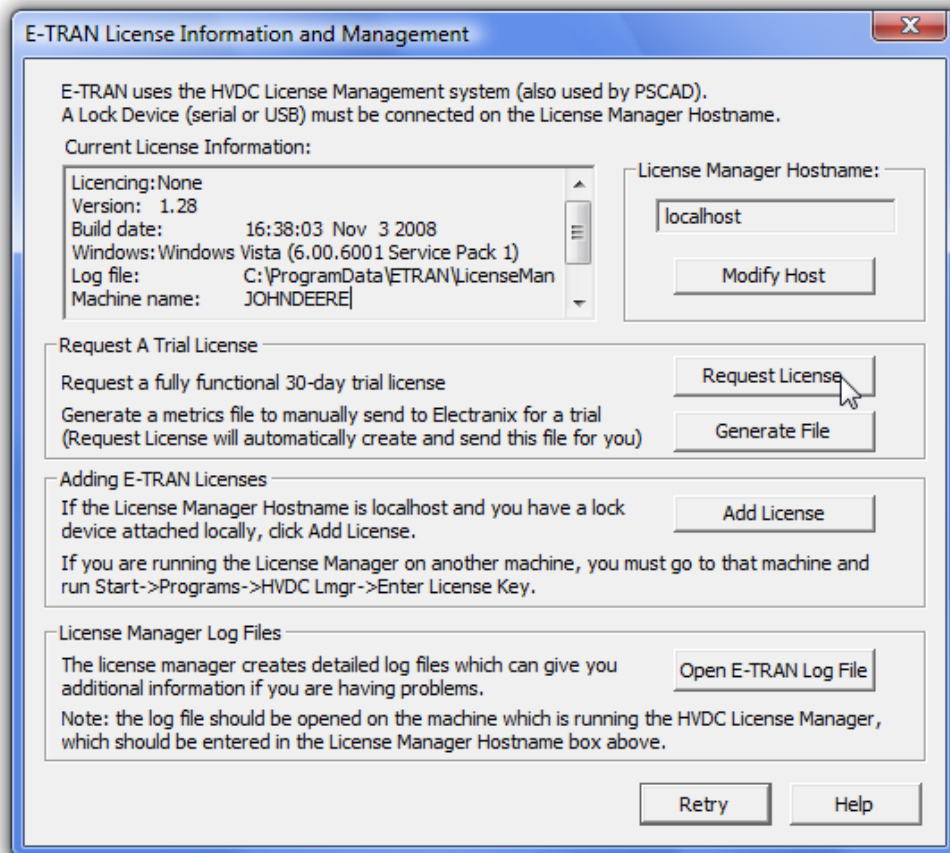
1. Obtain a **username** and **password** by emailing [e-tran@electranix.com](mailto:e-tran@electranix.com). Mention in the e-mail that you are interest in trying out E-TRAN.
2. Go to [www.electranix.com/E-TRAN/Client\\_Downloads](http://www.electranix.com/E-TRAN/Client_Downloads). Then log in.
3. Download the E-TRAN installation.
4. Install E-TRAN, Refer to section 3.1 for instruction on how to install E-TRAN.
5. Start E-TRAN by going to **Start** ↗ **Programs** ↗ **E-TRAN\_V3** ↗ **E-TRAN\_V3**. However, the first time you try to start E-TRAN the dialog shown below will appear with the message indicating that

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you have not yet added a license key for E-TRAN.



6. Click **“Retry”** which will bring up the dialog shown below.



7. In the dialog shown above click “Request License” which will open the Request Mailer dialog shown below.

The dialog box is titled "Request a Trial License" and contains the following text and fields:

To request a free trial, please fill out this form. Upon approval by Electranix Corp. a trial license will be sent to you.

Please select the product you wish to evaluate

- E-TRAN
- E-TRAN Plus - PSCAD Parallel Processing
- E-TRAN Plus - PSSE/E Hybrid Component

If you are purchasing E-TRAN, please enter your purchase order reference number :

P/O :

Name :

Company :

Address :

City :

State / Province :

Postal Code :

Country :

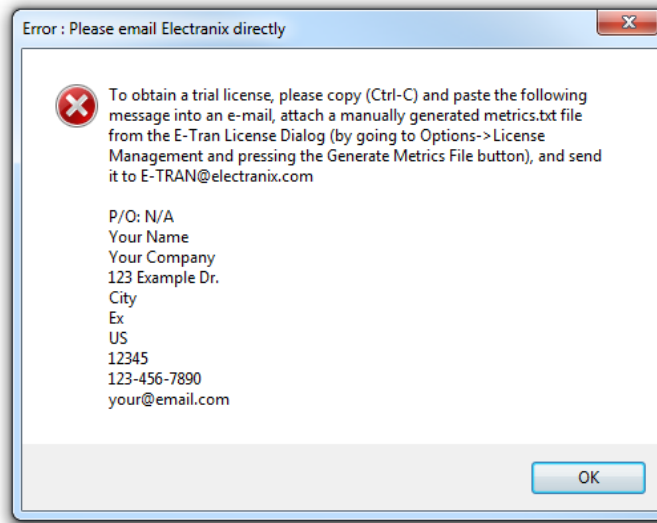
Phone # :

Email :

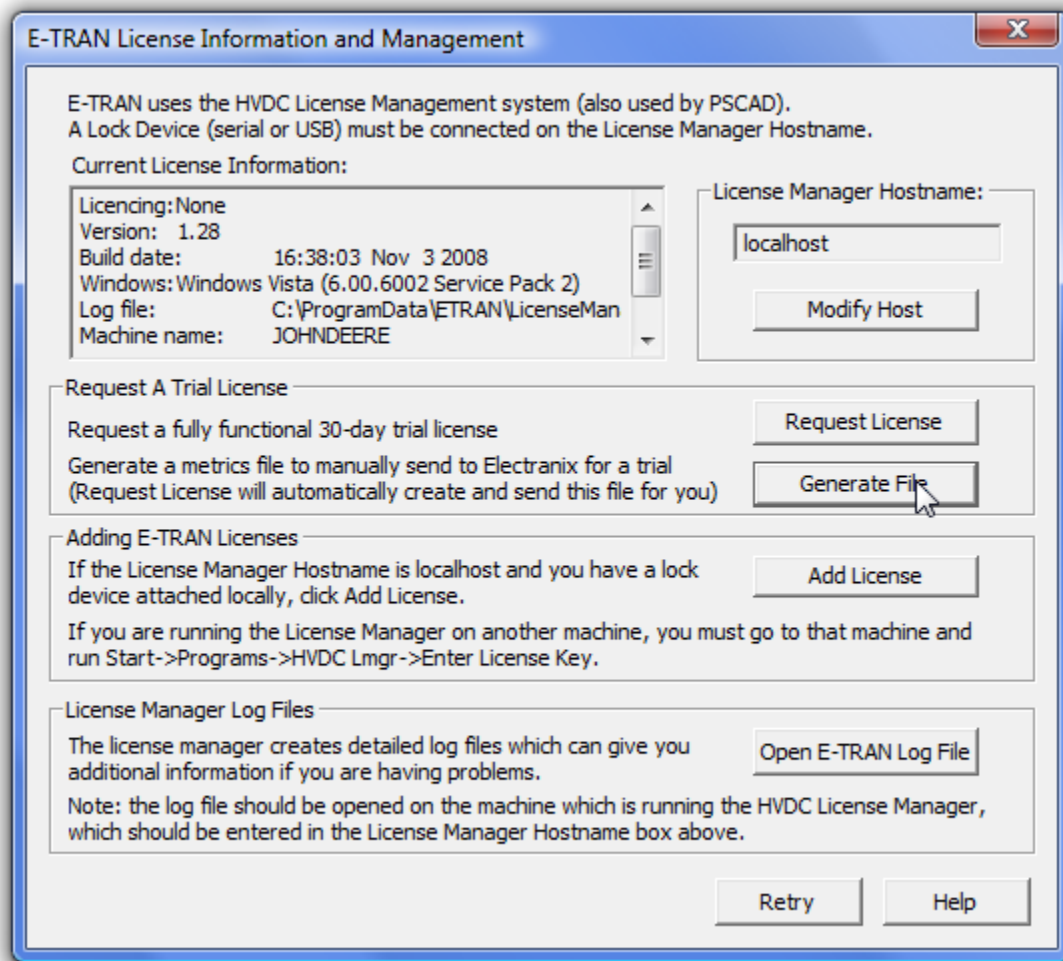
Buttons: Submit, Cancel

8. Fill out the form contained in the dialog above with your information and click “Submit”. This should automatically generate a “metrics.txt” file and send the form and the “metrics.txt” file to us at Electranix Corp when you click “Submit” above.
9. We will send you a trial license key contained “ETRAN.lic” file as soon as possible. Refer to section 3.3.1 for directions on installing a license key.

If the Request Mailer fails to send a license request to us at Electranix Corp. an error message like the one shown below will appear. In this case follow the directions below:



10. The dialog shown below should still be on your screen. In this dialog click “**Generate File**” and save the metrics file to a directory that you have access to and will be able to find later.



11. E mail E-TRAN technical support at [e-tran@electranix.com](mailto:e-tran@electranix.com) and attach the metrics.txt file.

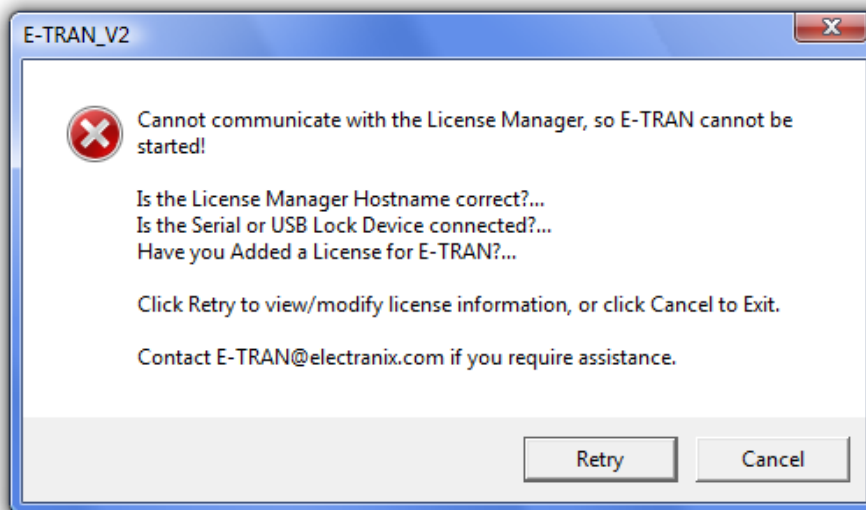
**Note:** If you have windows vista then when you browse for the “**metrics.txt**” file you will have to click on “**Compatibility Files**” to find the files.

12. We will send you a trial license key contained “**Etran.lic**” file as soon as possible. Refer to section 3.3.1 for directions on installing a license key.

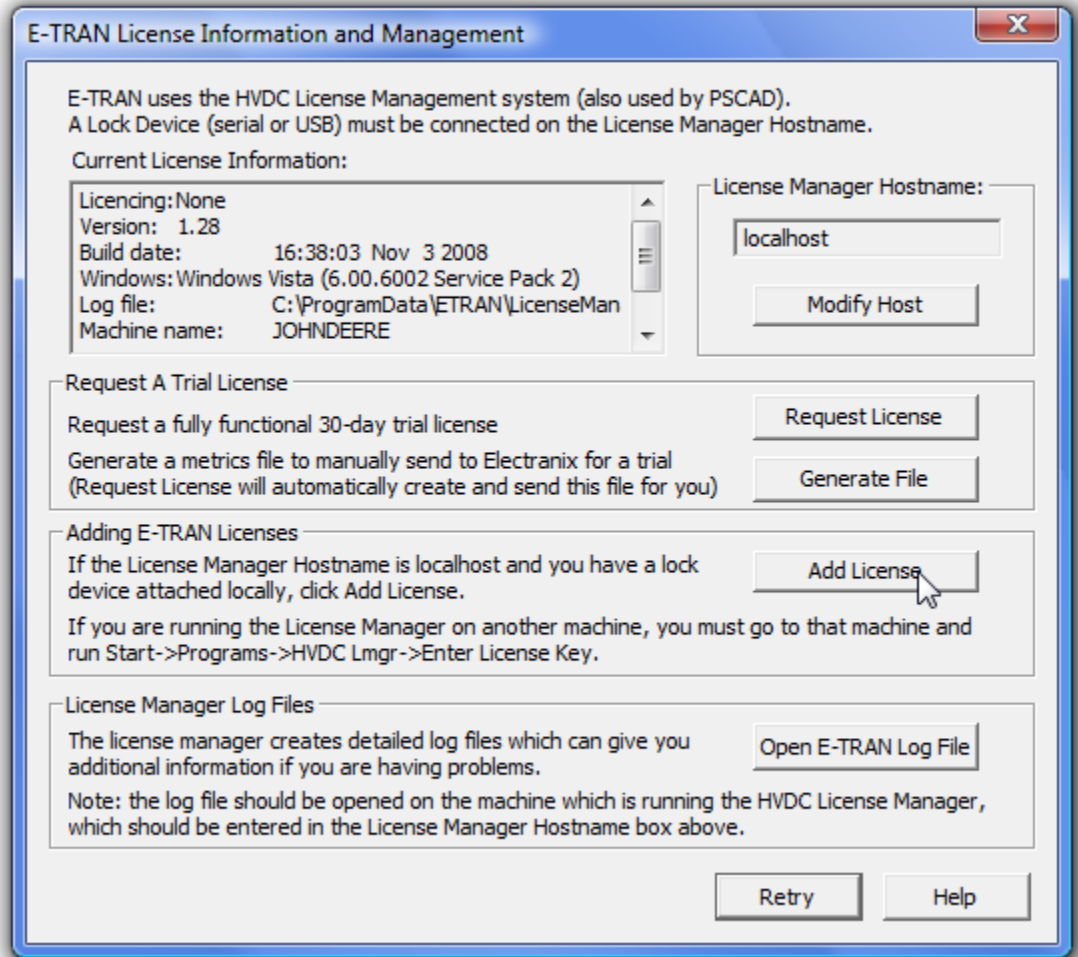
### 3.3.1 Installing a License Key

Installing a license key for a trial license, Save the “**Etran.lic**” or “**license.txt**” file to your hard disk or to a USB storage device.

1. Start E-TRAN by going to **Start** ↗ **Programs** ↗ **E-TRAN\_V3** ↗ **E-TRAN\_V3**. The dialog shown below will appear indicating that you have not yet added a license key for E-TRAN.



2. Click “**Retry**” which will bring up the dialog shown below.



**License Manager Hostname:** In the trial license and Standalone (SUL) Modes the Hostname will always be “localhost”.

3. In the dialog shown above click “Add License” and browse or manually enter the path that contains your “trial.txt” or “license.txt” file.

**Note:** If you are installing a trial license key you will not need to have a lock device attached to your computer. However, if you are installing a standalone (SUL) license key you will need a lock device attached to your computer.

### 3.3.2 License Manager Log File

All licensing errors and warnings are logged to a file contained in the directory “C:\Users\<username>\AppData\Local\E-TRAN\E-TRANlicense.txt”.

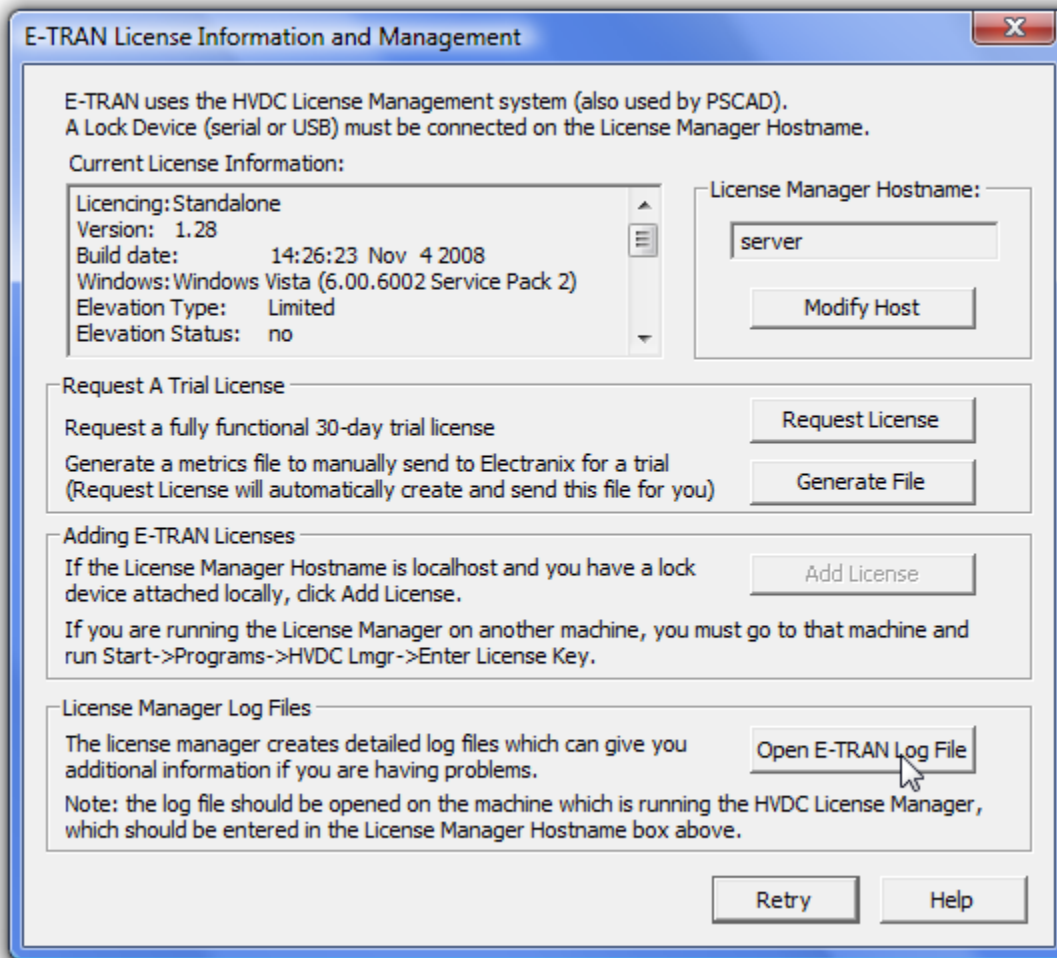
The license log file can be opened with any text editor (such as WordPad or Notepad). Notepad



should be used if the log file is small or if the file is currently being used by another application WordPad can be used to open the file if it is too large for Notepad.

The license log file can also be viewed directly from E-TRAN from the E-TRAN License Information and Management dialog. To open the license log file using this approach follow these directions:

1. In E-TRAN go to **Options** / **License Management** which will bring up the dialog shown below.



2. Click **“Open E-TRAN Log File”** to open the license log file. The dialog shown above is automatically opened if there is a license failure at start-up.

**Note:** If the license log file does not exist (or if Notepad.exe cannot be found) the **“Open E-TRAN Log File”** button will be grayed out and inaccessible.

In the event of a licensing problem, the license log file should be e-mailed to technical support at ***e-tran@electranix.com***.



## 4.0 E-TRAN Tasks

This is a how to chapter; it will take you step by step through the more common tasks that can be performed with E-TRAN. The chapter starts with taking you through the most basic translation called a “free lunch” (the free lunch is the model that E-TRAN generates from loadflow data without using detailed data). Then the last two sections show you how to include sequence impedance and machines data in a translation. A very important and time saving feature of E-TRAN is the substitution library, which has been granted its own chapter. To learn more about the substitution library see chapter 5.0 How to use the Substitution Library.

### 4.1 Translating Loadflow Data to PSCAD Models

This section deals with translating a free lunch. E-TRAN is organized using a “Wizard” style, where you are presented with dialogs prompting for information. After entering the information you then click “**Next**” to proceed to the next step. The following subsections will help you with determining what information is needed, and how to enter the information needed for each step to perform your translation.

#### 4.1.1 Step 1: Starting E-TRAN

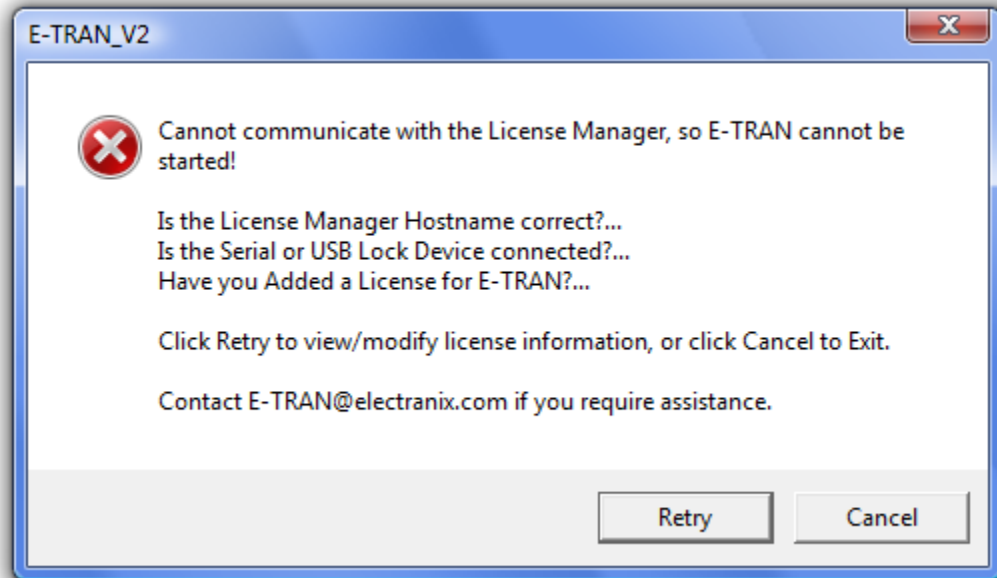
To start E-TRAN, go to **Start** ↗ **Programs** ↗ **E-TRAN\_V3** ↗ **E-TRAN\_V3** or double click on the desktop shortcut. The image shown below will appear for a brief moment:



After a short delay, the dialog shown in the next step should appear.

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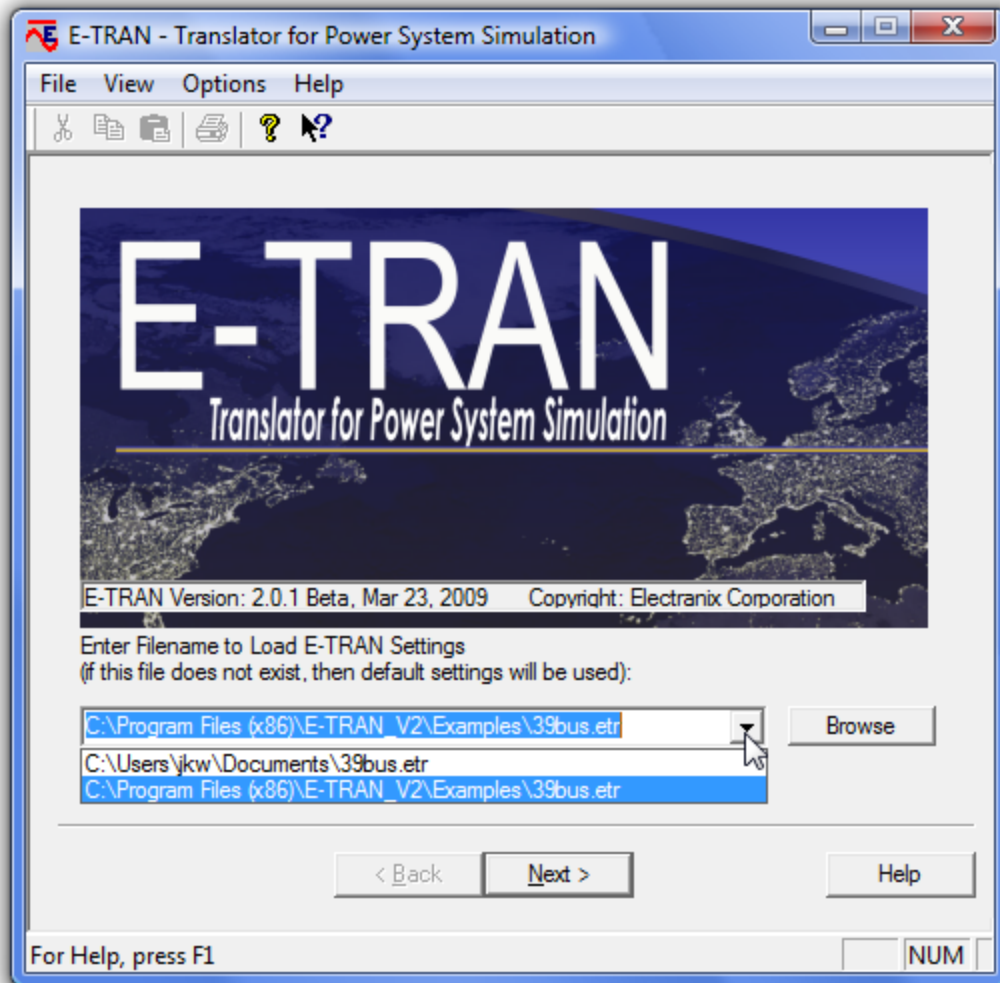
If the program fails to start, you may see the following error message:



If you see the error message above or any other license manager error messages, refer to Chapter 3.0.

### 4.1.2 Step 2: Load E-TRAN Case Settings

If you see the dialog shown below on your screen, E-TRAN has started successfully.



E-TRAN allows you to save your case settings when you translate a case. So that later when you have a case that is similar to the one earlier; you can just simply load the case settings from the earlier case and you will only need to modify a few settings that are different from your earlier case.

This step allows you to load previous saved E-TRAN case settings.

To load a case settings file, select it from the drop-down menu or you can browse for a file name by clicking “**Browse**”.

For information on how to save E-TRAN case settings refer to (section 4.1.9).

Once you have selected an E-TRAN case setting, click “**Next**” to proceed to the next step.

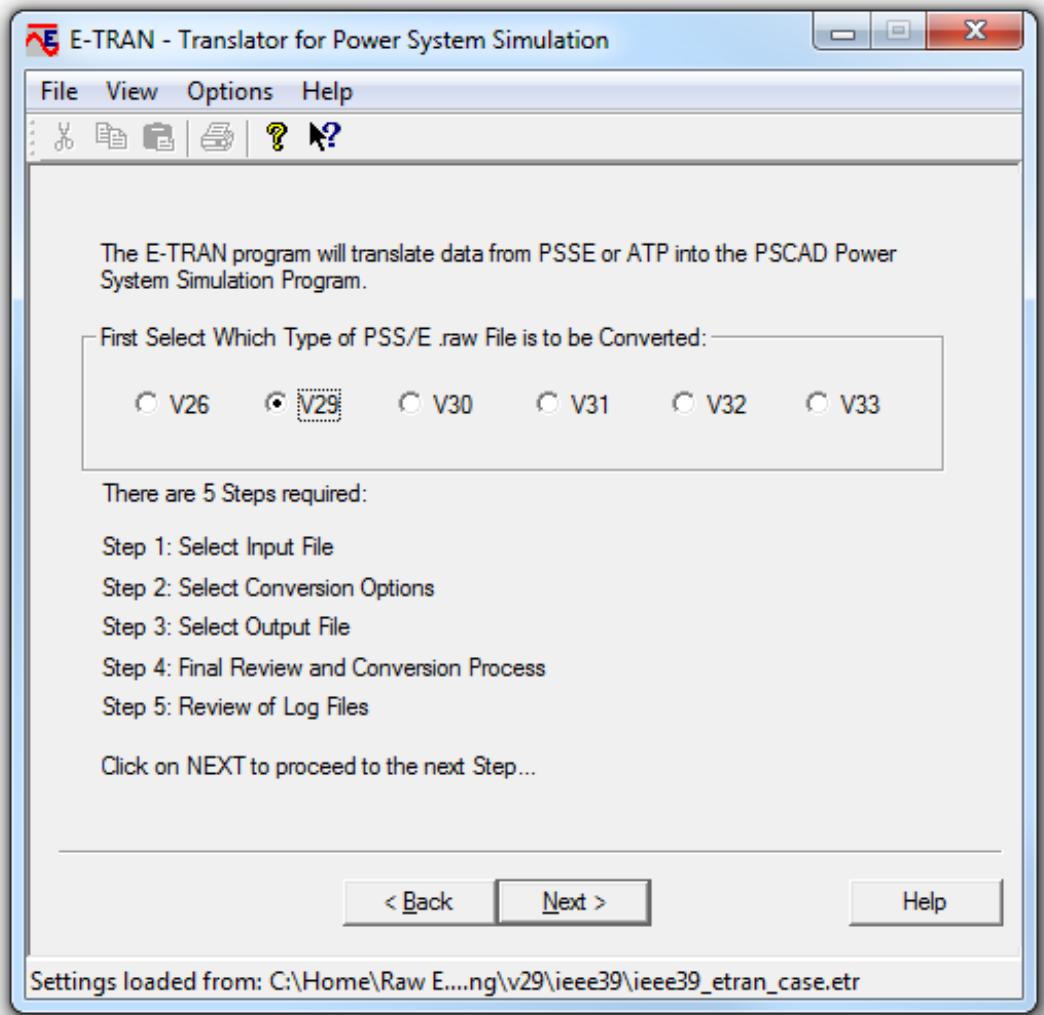
**Note:** If this is your first time translating a case, you will most likely not have any saved E-TRAN

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case settings. In this case just click “**Next**” and use the default E-TRAN case settings (“C:\Program Files (x86)\E-TRAN\_V3\Examples\39bus.etr”) that are already loaded for you.

### 4.1.3 Step 3: Select Loadflow File

After you click “**Next**” the dialog shown below will appear on your screen.



This step allows you to select the version of PSS/E that your loadflow file is in. All of the versions listed in the dialog above are supported by E-TRAN.

**PSS/E .raw files** is where you select which type of loadflow data you want to translate i.e. the version of PSS/E that your loadflow data is stored in.

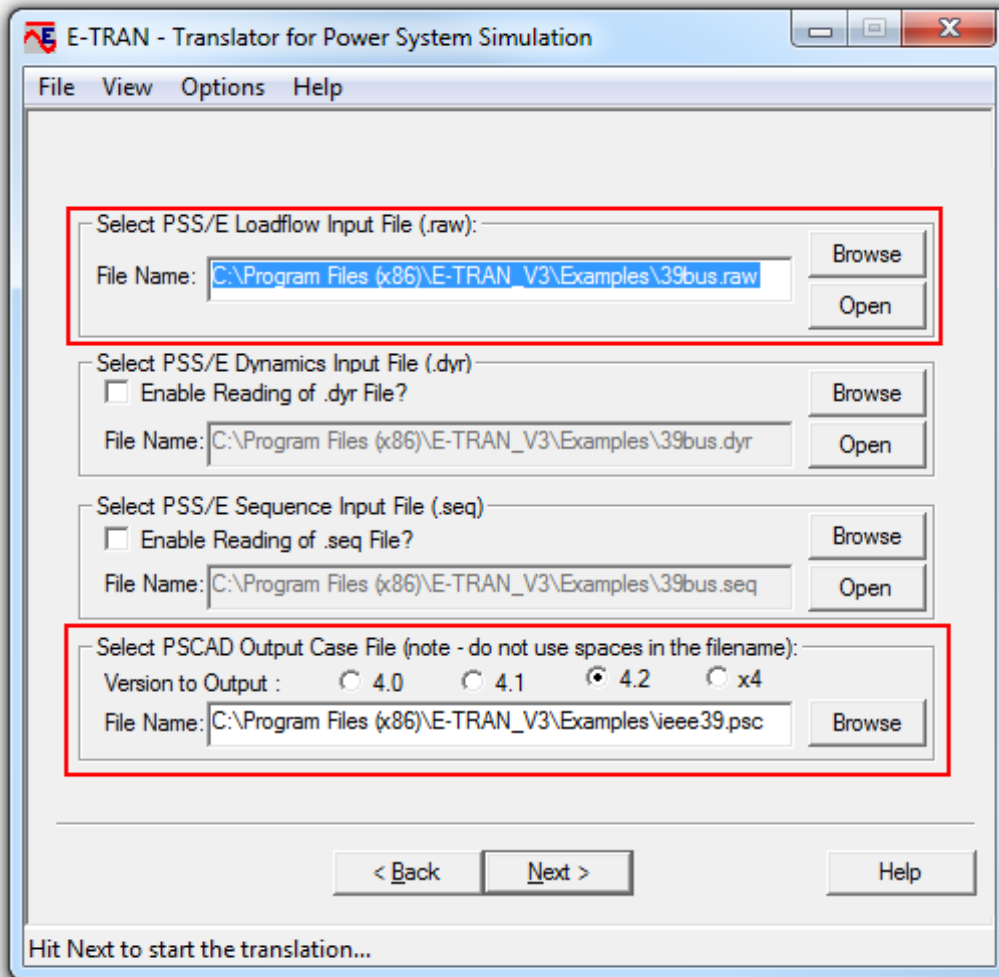
When you have made your selection; click “**Next**” to proceed to the next Step.

If during any one step you need to return to the previous step; click “**Back**”.

**Note:** You can check which E-TRAN case settings you loaded, by looking at the status bar at the bottom of the dialog.

#### 4.1.4 Step 4: Enter Loadflow and Output File

After you click “Next” the dialog show below will appear on your screen.



This step allows you to enter the input and output file paths.

**Select PSS/E Loadflow Input File:** This is where you enter the path to the .raw file that you are translating. The path to the IEEE 39bus system is contained in this box by default.

**Select PSCAD Output Case File:** This is where you enter the path to the PSCAD file. This is the directory that will contain your PSCAD case that E-TRAN will create.

**Note:** PSCAD does not support spaces in its file names. Therefore, you should not use spaces in .psc filenames.

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**Note:** The directories in the dialog above are entered by default. They contain the examples that come with E-TRAN. If you need to modify the examples, you will need to copy the examples folder to a directory that allows you to modify files. To do this open the "C:\Program Files (x86)\E-TRAN\_V3\" directory (if you entered a different directory in step 3 of section 3.1, you will find the Examples folder in the directory you entered in step 3) and copy the Examples folder to a directory that you are able to modify. This will give you the ability to change or add files in the examples folder.

The file names can be entered by typing the pathname or by browsing. To browse for the pathname of a file, click "**Browse**".

If you want to open the PSS/E Loadflow Input File, click "**Open**" next to the filename.

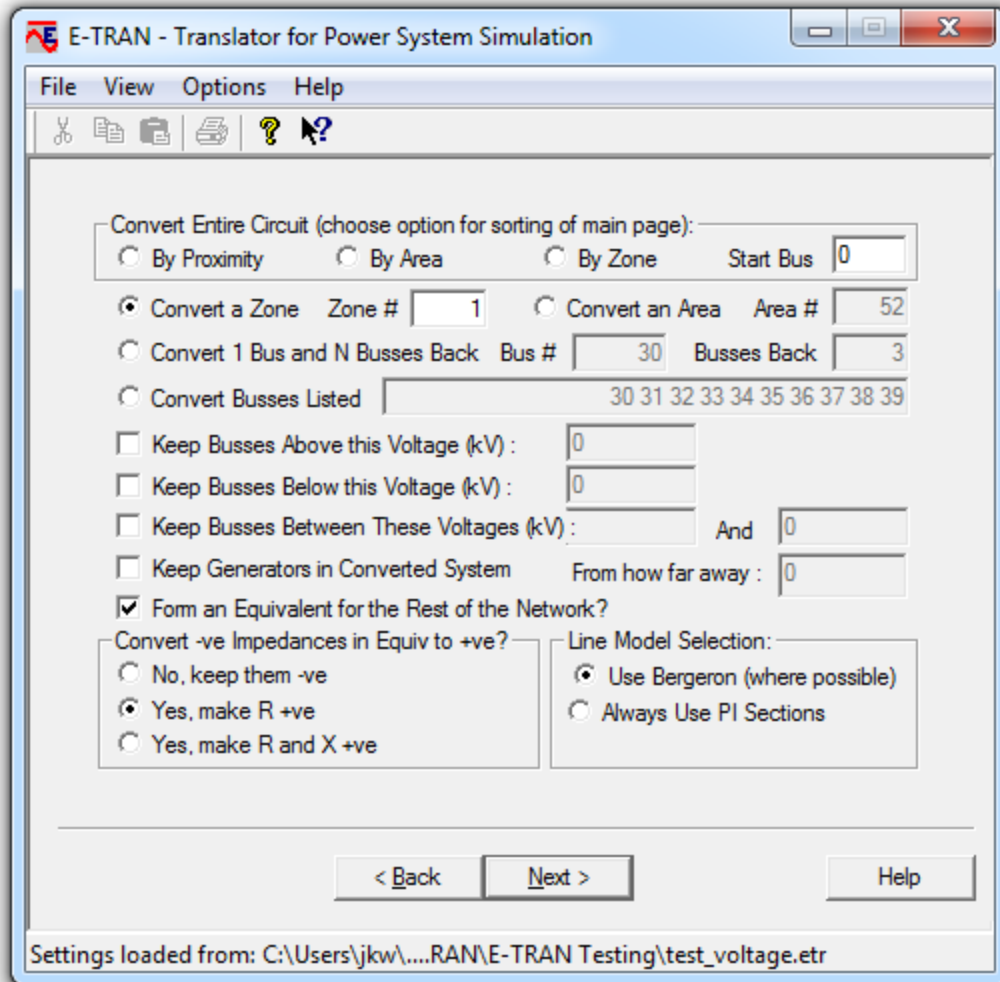
Once you have entered the filenames, click "**Next**" to proceed to the next step.

**Note:** For information on the **PSS/E Sequence Input File** and **PSS/E Dynamics input File** refer to sections 4.2 and 4.3 respectively.



### 4.1.5 Step 5: Select Model Size

After you click “Next” the dialog shown below will appear on your screen.



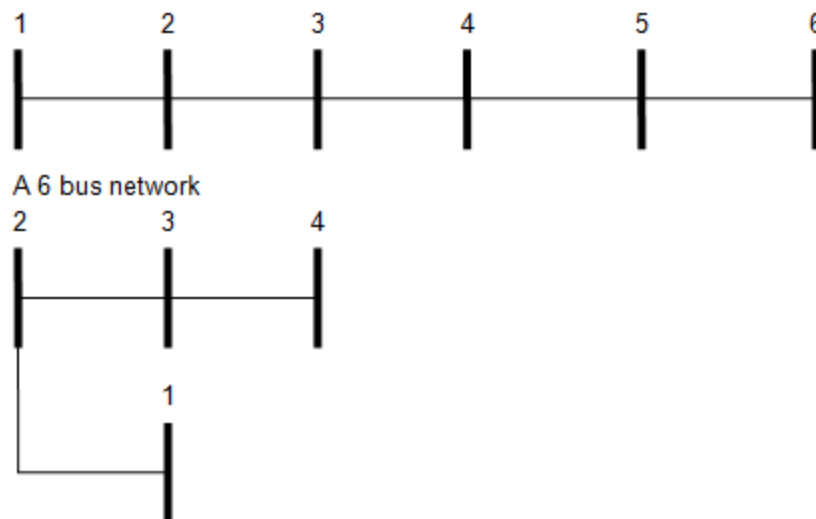
This step allows you to select the model size of your kept network, whether you want to form a network equivalent, how to deal with –ve impedances in the network equivalent, and choose a line model. When selecting a model size for your kept network, there are five options to choose from:

1. **Convert Entire Circuit:** If you choose this option, the entire circuit contained in the loadflow file will be in your kept network. With this option you also have to choose how you want busses on the main page sorted. The choices are as follows:
  - **By Proximity:** If you select this choice, no preference will be given to different areas or zones when auto-routing your network onto one or more pages.
  - **By Area:** If you select this choice, busses of the same area will be auto-routed onto one or more pages.

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- **By Zone:** If you select this choice, busses of the same zone will be auto-routed onto one or more pages.
  - **Start Bus:** If you have a preference
2. **Convert a Zone:** If you choose this option, you also have to enter the zone number you want in the kept network. With this option only busses in the specified zone will be in your kept network.
  3. **Convert an Area:** If you choose this option, you also have to enter the area number you want in the kept network. With this option only busses in the specified area will be in your kept network.
  4. **Convert 1 Bus and N Busses Back:** If you choose this option, you also have to enter which bus number to start the translation at (central bus of interest) and the number of busses away from the central bus. With this option only the central bus and the number of busses back will be in your kept network.

**Note:** **N Busses Back** means N connections away from the central bus. For example, consider a network where 6 busses are connected in series, numbered 1 through 6. If you entered bus number 2 as your central bus and 2 busses back your kept network would consist of busses 1, 2, 3, and 4 as shown in Figure



The 6 bus network with bus 2 selected as the central bus and 2 busses back in the kept network

*Figure 4.1 A 6 bus network translated to a two busses back network with bus 2 elected as the central bus.*

5. **Convert Buses Listed:** If you choose this option, you also have to list the bus numbers that you want in the kept network. With this option, only busses listed will be in your kept network.

If you are uncertain of which option to select to best represent your network refer to section 4.4.

**Keep busses Above this Voltage (kV):** Selecting this option will generate a circuit containing all the

busses above the specified voltage.

**Keep busses Below this Voltage (kV):** Selecting this option will generate a circuit containing all the busses below the specified voltage.

**Keep Busses Between These Voltages (kV):** Selecting this option will generate a circuit containing all the busses between the specified voltages.

**Keep Generators in Converted System:** Selecting this option will include all of the generators in the generated circuit.

**Form an Equivalent for the Rest of the Network?** If you selected one of the options above where your kept network will not contain your entire network, you can instruct E-TRAN what to do with the rest of the network.

1. Do not check this option if you just want to visualize the circuit and don't need to run it in PSCAD.
2. Check this option if you want E-TRAN to form a network equivalent for the rest of the network. The network equivalent is necessary if you need to run the case in PSCAD and to match the loadflow.

**Note:** For large networks, the computation of the network equivalent can be a time consuming process; so you may want to disable the formation of a network equivalent in order to quickly visualize the kept network.

**Convert –ve Impedances in Equiv to +ve?** If you selected to form a network equivalent, you have three options to select from to deal with –ve R or –ve X elements in the network equivalent impedances.

1. **No, keep them –ve:** If you select this option, E-TRAN will not change any of the impedances.
2. **Yes, make R +ve:** If you select this option, E-TRAN will only change the –ve R to +ve R.
3. **Yes, make R and X +ve:** If you select this option, E-TRAN will change both the –ve R and –ve X to +ve R and +ve X.

It is recommended to use the third option if you observe numerically unstable solutions in PSCAD, since –ve elements can occur in complex equivalents. Even though there may be a solution in the loadflow phasor solution, it may be unstable in a time domain differential equation solution (i.e. in PSCAD). See Chapter 8.1 for more information on Network Equivalents and the use of this parameter.

**Line Model Selection:** This is where you select how you want E-TRAN to translated transmission lines and cables.

1. **Use Bergeron (where possible):** If you select this option E-TRAN will use the Bergeron traveling wave line model only if the travel time is greater than the time step (the time step will be entered in next section). E-TRAN calculates the travel time from X and B, using the speed of light as the

propagation velocity.

2. **Always Use PI Sections:** If you select this option E-TRAN will always use the PI sections. This option is beneficial if you don't want to run the case in PSCAD and just need to view the drawing of the kept network with the line lengths. When E-TRAN translates a transmission line or cable and uses PI sections, it checks if the line or cable lengths are entered in the loadflow file and includes them in the drawing.

The Bergeron model has a more realistic frequency response than a PI section does. In fact it is almost the same as using an infinite number of PI sections for a single line. Since the loadflow uses a single PI section (the loadflow program is not concerned with the frequency response) for its solution, the loadflow may not match exactly with the Bergeron model solution in PSCAD (it may have a slight error). Whereas a single PI section in PSCAD would match the loadflow solution.

For both line models, E-TRAN properly handles "long-line correction factors". PSS/E .raw data is assumed to be already corrected for long line effects. For a single PI section in PSCAD the loadflow RXB data can therefore be used directly. When the loadflow RXB data is used to create a Bergeron model, E-TRAN calculates the incremental (per unit length) impedance of the line by un-winding the long line correction inherent in the RXB data. These per unit impedances are then used to create a correct Bergeron model.

The most accurate line model in PSCAD is the Phase Domain Frequency Dependant model. This model represents accurately all frequency dependant effects (whereas the Bergeron and Pi models are based only on the fundamental frequency). This model requires detailed line constants data (i.e. the conductor radius, height, ground resistivity etc...) so that the frequency response can be calculated and curve-fit. Time domain transient simulation (i.e. PSCAD) results depend on impedances at all frequencies, so the RXB loadflow data should be discarded and replaced with the phase domain line model (where possible). You can use the Substitution Library to automate this process in E-TRAN (see Chapter 5.0 How to use the Substitution Library).

Once you finish selecting the model size, click "**Next**" to proceed to the next step.

#### 4.1.6 Step 6: Select PSCAD Properties

After you click “Next” the dialog shown below will appear on your screen.

**PSCAD Time Step ( $\mu$ Sec):** This is where you enter (entered in microseconds) the time step that will be used by E-TRAN to determine if Bergeron or PI section models are used when converting branches from PSS/E (see section 4.1.5). E-TRAN also passes the time step on to the PSCAD file and will be the simulation time step used in the PSCAD simulations.

**Note:** You should not increase the time step in PSCAD, since the time step entered here is used to determine if branches are replaced by Bergeron or PI section models. This is because if you were to increase the time step in PSCAD later, some of the Bergeron models that qualified earlier as having a travel time greater than the time step should no longer be Bergeron models. This in turn could introduce errors in your study results.

**PSCAD Finish Time (Sec):** This is where you enter (entered in seconds) the duration time that the case should run in PSCAD; E-TRAN passes it on to the PSCAD file.

**PSCAD Plot Step (uSec):** This is where you enter (entered in microseconds) the plot step that will be passed onto the PSCAD file and will be the simulation plot step used in PSCAD simulations.

**Fundamental Frequency (Hz):** This is where you enter (entered in hertz) the frequency parameter. The parameter is passed on to all PSCAD/E-TRAN components. PSCAD requires the frequency for all generators and to convert from Per Unit to henries etc... whereas, a loadflow program does not require the frequency, so it must be entered separately. The loadflow solution and the formation of network equivalents will be valid for both 50 and 60 Hz.

**Note:** If your loadflow data is in a version 31 or newer PSS/E .raw file, the fundamental frequency will be contained in this file. In this case E-TRAN will take the frequency from the .raw file and will ignore the frequency that is entered here.

**Eq Admittance Limit (default 1.0E-10):** Enter the equivalent admittance limit parameter. The parameter is used by E-TRAN to ignore some elements in the equivalent network (this is an approximation) so as to reduce the size of network equivalent circuits. If the admittance of a branch is less than this parameter, it is assumed to be 0.0 (i.e. an open circuit) and thus eliminated from the equivalent circuit.

If you don't want to ignore any parts of the network equivalent (recommended), enter a very small number or 0. In this case the network equivalent that E-TRAN generates will be valid for steady state as well as open-circuit and short-circuit conditions.

If you enter a very large number, the equivalent circuit will be generated with only diagonal elements. E-TRAN will correctly calculate the voltage source magnitude and phase to give the correct power flow in steady state, but the use of this option will cause the open-circuit and short-circuit solutions to be approximate.

**Source Initialization Time (Sec):** Enter the (entered in seconds) the time that you want the generators in your simulations to start up. E-TRAN passes this parameter on to the PSCAD/E-TRAN generator models. It is recommended that you enter the same value as what you might be using in custom designed generator models, so that they all start up at the same time when running the case in PSCAD.

**Machine Init Time (sec):** All dynamic machine models in the kept system will release at this time. Ensure that the Machine Init Time is sufficiently long to allow all dynamic elements (such as wind farms) to reach their steady state conditions. If machines are initialized too early, the powerflow quantities in the case may be incorrect, and the machines may go unstable.

**Load Init Time (sec):** The user must enter the time at which loads change from "constant RLC" to the load type specified in the PSSE .raw file. This initial time is intended to provide a more stable start-up period while complex models (such as wind turbines) are initializing.

**E-TRAN PSCAD Data Substitution Library (MyData.psl) Path:** This is where you enter E-TRAN Substitution Library file name. The check box is used to enable or disable the use of the Substitution Library. The use of the Substitution Library allows you to enter more detailed data for a given electrical component and store this detailed data in a PSCAD library (.psl file). E-TRAN then goes into

the Substitution Library during a translation and checks if more detailed data is available for each component in the kept network. If E-TRAN finds more detailed data for a component in the Substitution Library, it will then use the detailed data in the kept network instead of the simple RXB data contained in the loadflow file.

The Substitution Library allows E-TRAN to generate a model, ready for detailed PSCAD/EMTDC studies including frequency dependant transmission lines, transformers with saturation data, detailed machine models etc... Provided the user has entered the detailed component data into the Substitution Library. For more information on how to use the Substitution Library and how to enter detailed component data refer to Chapter 5.0 How to use the Substitution Library.

**Version of PSCAD to Output:** This is where you select which version of PSCAD file to generate. PSCAD versions 4.0, 4.1, 4.2, and x4 (v4.5) are supported.

**Phase Shift All Generator Busses:** This option will shift the generator busses by 30 degrees and adds a wye-delta phase shift to the transformer.

Note: If the generator bus is connected to multiple transformers that are not in parallel, the phase shift will not be performed.

**Phase Shift All Busses on Third Windings:** If selected, E-TRAN will assume all 3-winding transformers have a Delta connected tertiary winding, and apply a 30 degree phase shift to the tertiary winding.

Note: If the circuit connected to the tertiary winding is not islanded, the phase shift will not be applied.

**Use long path optimizations:** This is a feature of E-TRAN that can speed up the translation and make the diagram more presentable.

1. If checked, E-TRAN will determine the longest path in the kept network and draw it first on top of the page, ignoring voltage levels. This also increases the translation speed by about 5%.
2. Unchecked, E-TRAN will determine which components are drawn first by the highest voltage level.

**Show Disabled Items in the Circuit:** This is where you select what you would like E-TRAN to do with disabled components found in the loadflow file when auto-routing the kept network.

1. If checked, E-TRAN will draw any disabled component in your kept network, but it will be highlighted in grey making it easy to tell which components are disabled. Even if you select to draw disabled components, they are not connected to the circuit in any way.
2. Unchecked, E-TRAN will not draw any disabled component in your kept network.

**Play Sound When Complete:** This option allows you to choose if E-TRAN plays a sound when the translation is complete. You can have E-TRAN play two distinctive sounds, one for when the translation completes successfully and a different one for when it completes unsuccessfully. To select

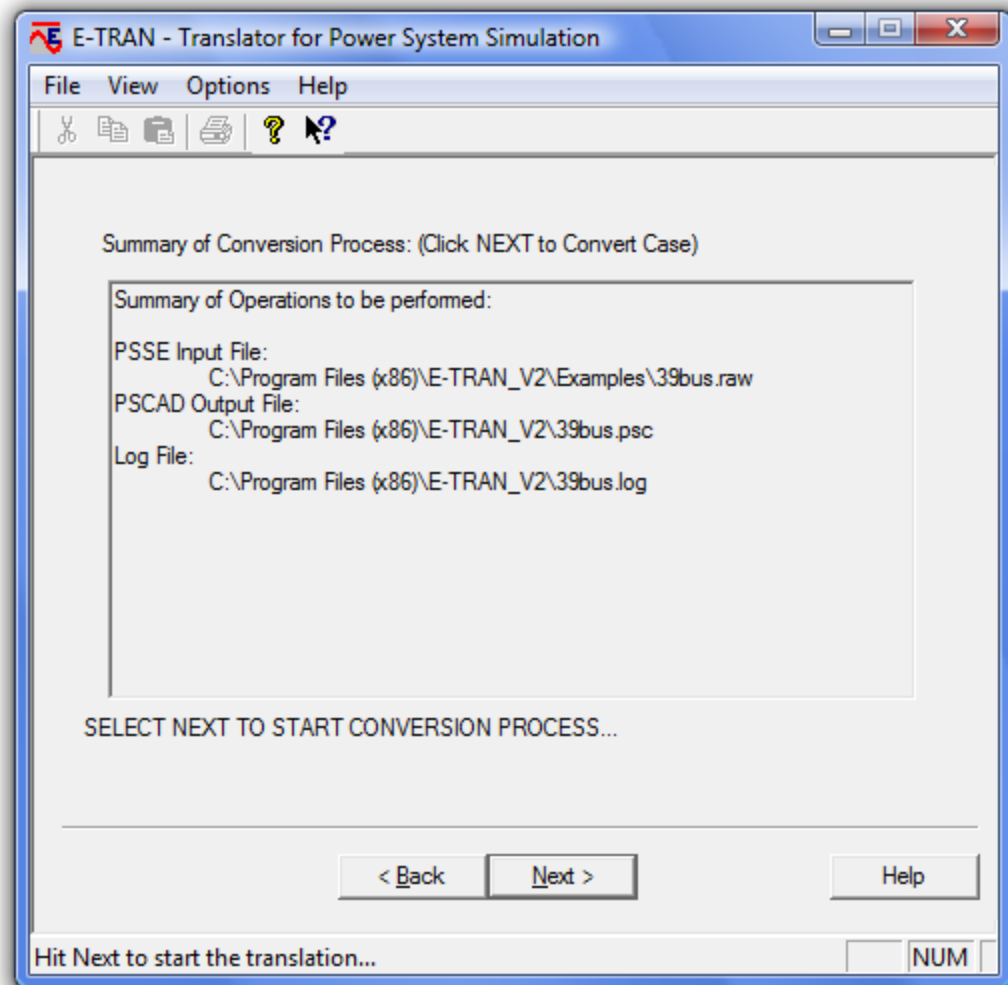
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the file name of a sound piece go to **Options** / **Preferences**.

Once you finish entering the PSCAD properties click "**Next**" to proceed to the next step.

### 4.1.7 Step 7: Check Summary

After you click "**Next**" the dialog shown below will appear on your screen.

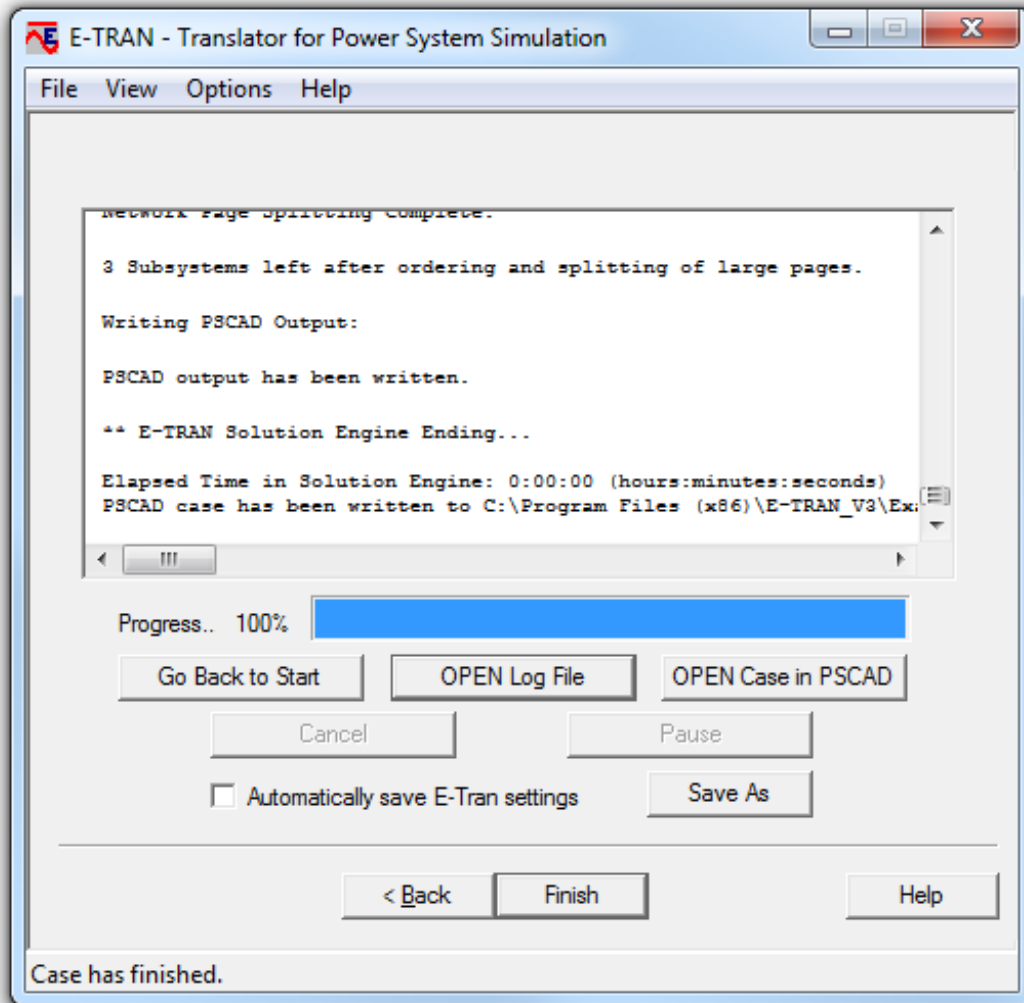


This summary step gives you an opportunity to review the file names that were entered in the previous steps. Once you have confirmed that all the file names are correct you are ready to translate the case. Click "**Next**" to start the translation.



### 4.1.8 Step 8: Check Log File

After you click “**Next**” E-TRAN will start the translation and you will be presented with the dialog shown below while the translation is in progress.



If you want to cancel a translation, click “**Cancel**” or if you want to pause it, click “**Pause**”. If you pause your translation, click “**Continue**” to continue with the translation.

“**OPEN Log File**”: Click this button to open the log file in your web browser.

Note: If the translation hasn't finished, the unformatted log file will be opened in your default text editor.

This step should be taken to review everything that has been logged to the log file.

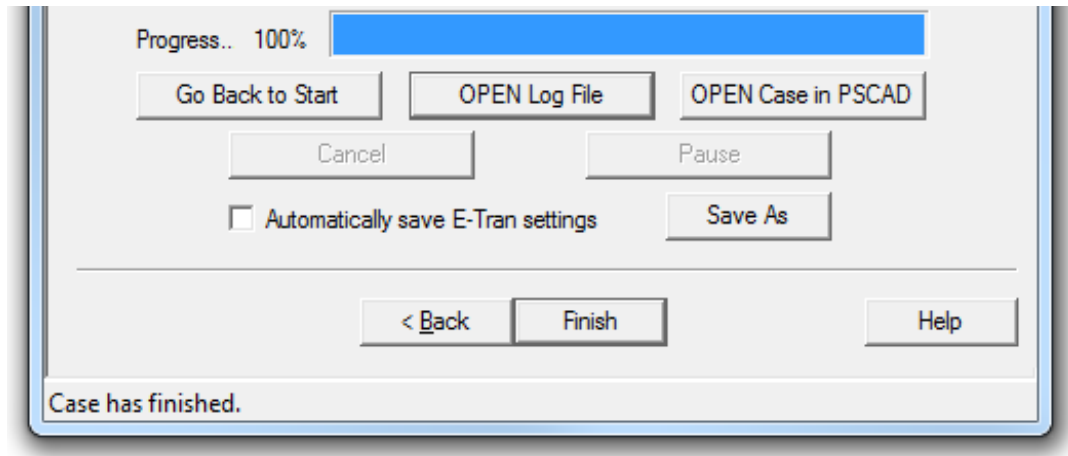
The log file contains extensive warnings and error messages that E-TRAN generates when it reads in PSS/E .raw input files. This will help you in areas of mismatched voltage levels, inconsistencies in the

data etc.

When **warnings** are generated E-TRAN still continues with the translation, but when **errors** are generated E-TRAN aborts the translation.

### 4.1.9 Step 9: Open and Run Circuit in PSCAD

After you have checked the log file for warnings and errors, you are ready to open your case in PSCAD and perform studies.



This is the final step of the translation process. In this step you will find out how to save E-TRAN case settings and how to open the just translated model in PSCAD. After this step you are ready to view and/or study your model in PSCAD.

**“Go Back to Start”**: If you have another case that you would like to translate, you can just click this button and it will take you right back to step 1.

**Automatically save E-Tran case settings**: If you check this of, your E-TRAN case settings from this translation will automatically be saved when you click **“Finish”** to close E-TRAN.

**“Save As”**: If you want to enter a file name that the E-TRAN case settings should be saved as, click this button and enter a file name.

**Note**: You can also go to **File** / **Save E-TRAN Case Settings** to save the current E-TRAN case settings.

**“Finish”**: Click this button to close E-TRAN.

#### 4.1.9.1 Open Model in PSCAD

There are two ways to open your translated model in PSCAD:

1. Open the model directly from E-TRAN: Click “Open Case in PSCAD” which will do the following:

- Start PSCAD
- Load the E-TRAN library
- Load the case just translated

If any of the above three actions fail, refer to FAQ's and Trouble Shooting chapter.

2. **Open the model from inside PSCAD:** To do this, you must first load the E-TRAN library manually (the standard E-TRAN installation locates this file at C:\Program Files (x86)\E-TRAN\_V3\PSCADLib\E-TRAN.psl), and then open the model. The library only needs to be loaded once unless you manually unload it, since PSCAD automatically loads all files that were loaded once unless you manually unload it, since PSCAD automatically loads all files that were loaded when the program was last run.

**To load the E-TRAN library manually,** in PSCAD go to **File** ↗ **Load Project** and use this directory C:\Program Files (x86)\E-TRAN\_V3\PSCADLib\E-TRAN.psl to navigate to the E-TRAN.psl file, unless you have saved the E-TRAN.psl file in a different location. For PSCAD x4 use E-TRAN.pslx.

#### 4.1.9.2 Running Model in PSCAD

If you open the case using “**Open Case in PSCAD**” button in E-TRAN, then no additional steps are required (you can merely hit the green arrow (run) to run the case). E-TRAN creates output channels for all generator voltage magnitudes, phase angles, real and reactive power flows, so you can create plots of these quantities (right click on the output channel component and select **Graphs/Meters/Controls** ↗ **Add as Analog Graph**).

The screen shot show below is the kept network model with bus 30 the central bus and 1 bus back of the IEEE 39 BUS SYSTEM. At the bottom of the screen shot is a 3-Phase Meter with the output channels that E-TRAN creates for all generators in the kept network. The mouse pointer is pointing at one of the output channel components. To the right of the screen shot is the network equivalent component, click on this component to view the network equivalent page(s).

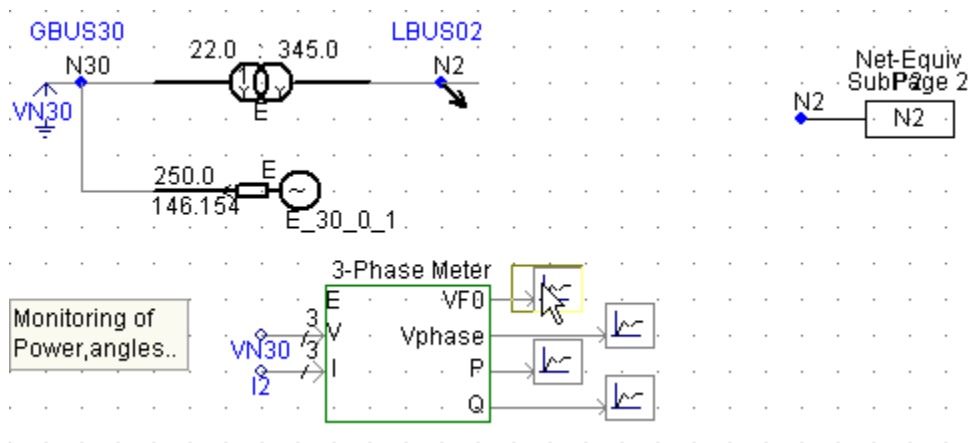


Figure 4.2 Kept network with bus 30 and 1 bus back of the IEEE 39 BUS SYSTEM

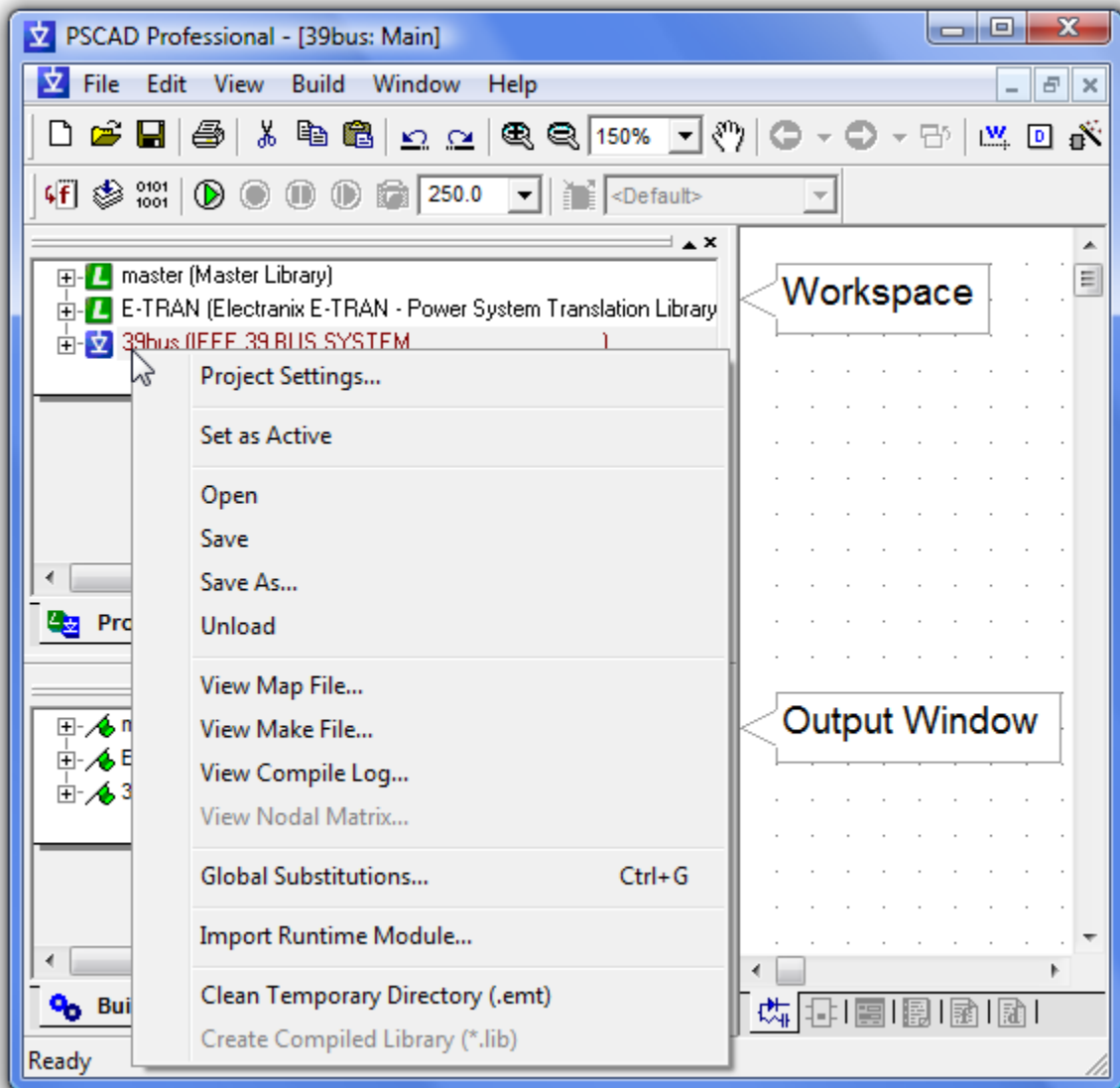
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If you open a case manually from within PSCAD (instead of using E-TRAN to launch PSCAD), then in order to run a case (that E-TRAN has converted), you must first load the E-TRAN Library. Refer to section 4.1.9.1 for instruction on how to load the E-TRAN library.

If you manually construct a case which uses the E-TRAN models (instead of using E-TRAN to generate the case), then this case must have its "Case Properties" modified to instruct PSCAD to include the E-TRAN EMTDC binary object library (found by default at C:\Program Files (x86)\E-TRAN\_V3\EMTDCLib\cf6\E-TRAN.lib) in the link stage when the EMTDC executable is formed:

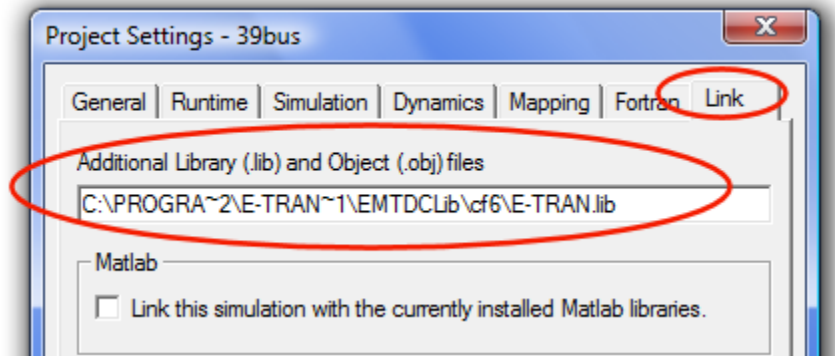
To do this, in PSCAD go to "**Workspace**" and right click on the case name (39bus (IEEE 39 BUS SYSTEM) shown below), select "**Project Settings**", and then go to the "**Link**" tab

Enter the full pathname of E-TRAN.lib in the "**Additional Library (.lib) and Object (.obj) files**" box.



The “cf6” sub-directory should be entered only if you are using the Compaq Visual Fortran 90 compiler (version 6.x) with PSCAD. Use the following list as a sub-directory guide:

- Intel Fortran 9 Compiler ⇒ if9
- Intel Fortran 12 Compiler ⇒ if12
- Compaq Fortran 9 Compiler ⇒ cf6
- GNU/EGCS Fortran 77 or Fortran 95 Compiler ⇒ gnu

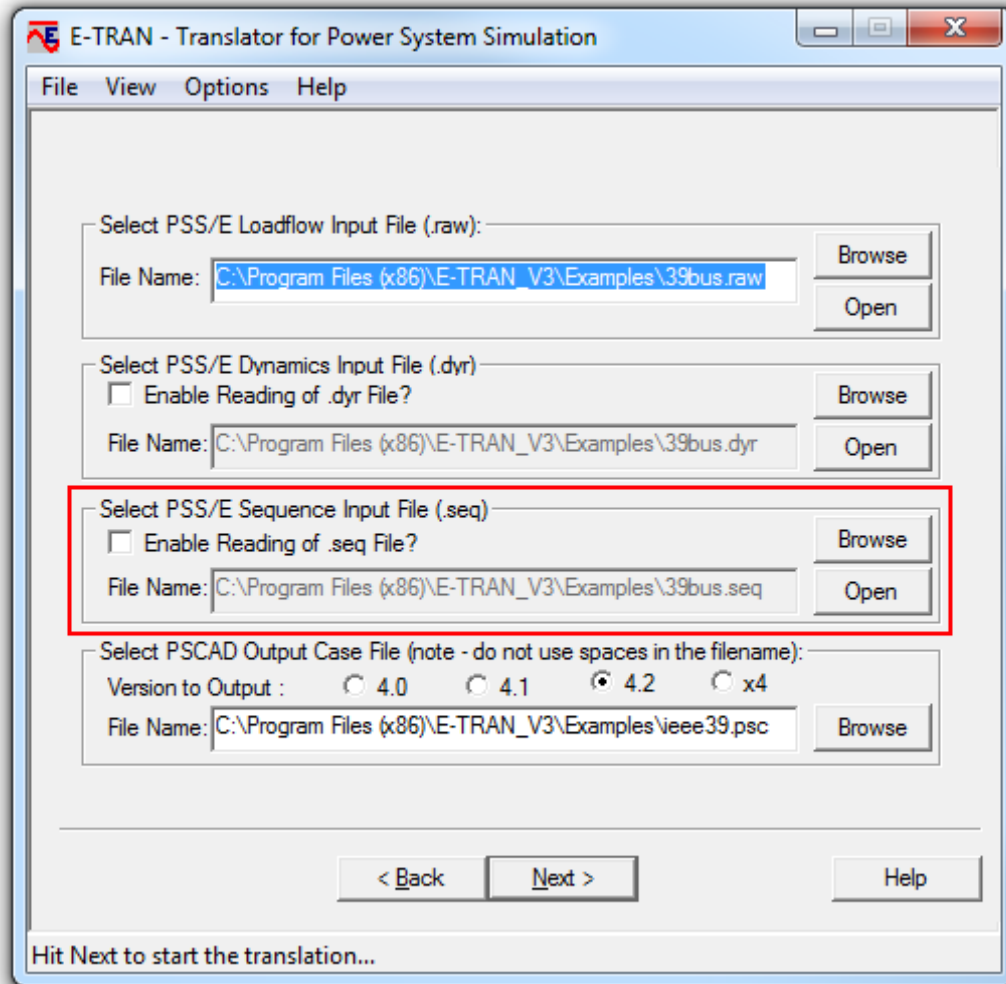


## 4.2 Using Sequence Impedance Data

E-TRAN is also capable of reading sequence impedance data from a .seq file. E-TRAN then takes the 0 sequence impedance data and enters it in the transmission lines. The positive sequence impedance data contained in the sequence file is usually better than the data contained in the raw file. Therefore, for generators and loads, E-TRAN will use the positive sequence impedance data contained in the sequence file instead of the impedance data contained in the raw file when a sequence file is used in a translation.

**Note:** When a dynamics file and a sequence file are used at the same time, E-TRAN will use the impedance data from the dynamics file to enter into machines.

To include data from a .seq file in your translation all of the steps are the same as in the previous section, except for step 4 where you must enter some additional information.



**Select PSS/E Sequence Input File (.seq):** This is where you enter the file name that contains the sequence impedance data and instruct E-TRAN to include it in a translation.

The file name can be entered by typing the pathname or by browsing. To browse for the pathname of the file, click “**Browse**”.

If you want to open the PSS/E Sequence Input File, click “**Open**” next to the filename.

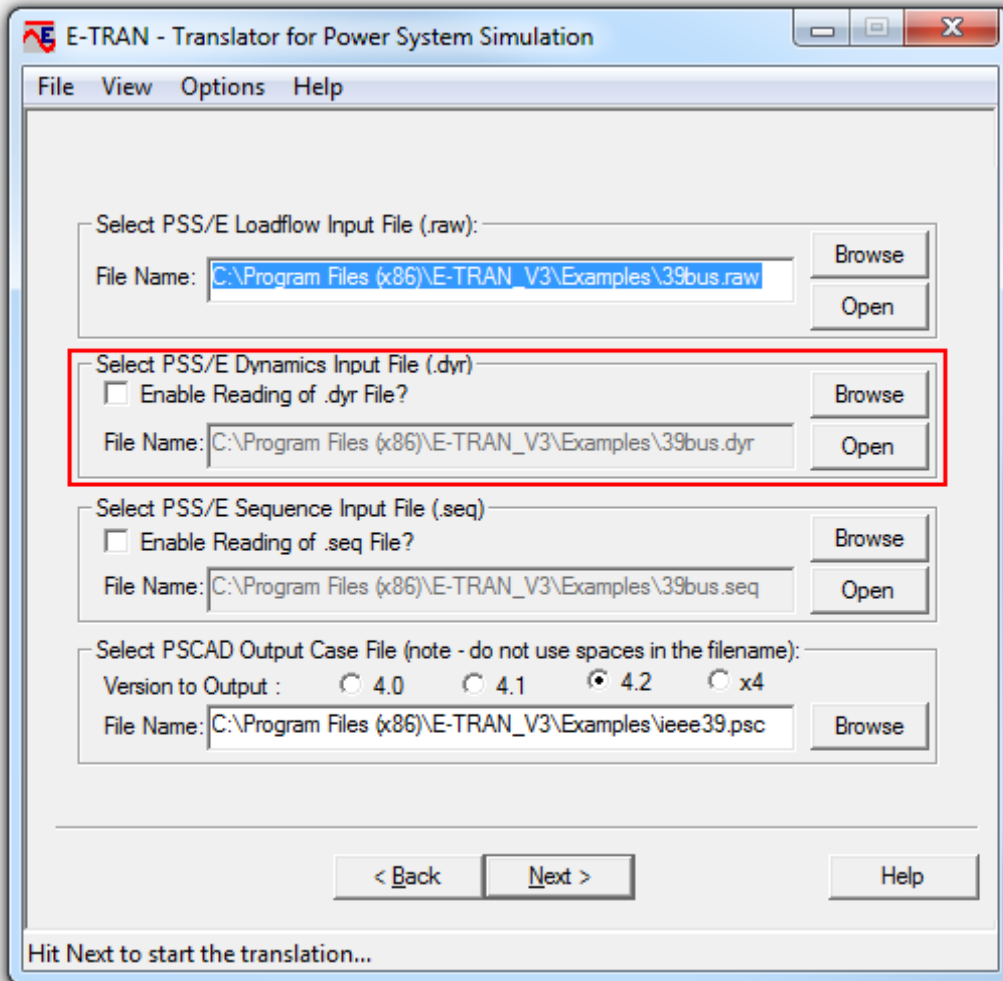
**Enable Reading of .seq File?** This box must be checked of in order for E-TRAN to include the data from a .seq file in your translation.

### 4.3 Translating Machines from Dynamics Data

E-TRAN is also capable of reading dynamics data from a .dvr file. With this data E-TRAN will replace the basic E-TRAN generator models with machine models that will contain the detailed data.

To include data from a .dvr file in your translation all of the steps are the same as in the previous

section, except for step 4 where you must enter some additional information.



**Select PSS/E Dynamics Input File (.dvr):** This is where you enter the file name that contains the dynamics data and instruct E-TRAN to include it in a translation.

The file name can be entered by typing the pathname or by browsing. To browse for the pathname of the file, click “**Browse**”.

If you want to open the PSS/E Sequence Input File, click “**Open**” next to the filename.

**Enable Reading of .dvr File?** This box must be checked of in order for E-TRAN to include the data from a .dvr file in your translation.

#### 4.4 Determine size of Kept Network

One of the challenges faced during an E-TRAN translation is determining how big the kept network should be (i.e. how many buses back from the point of interconnection should be in the kept network,

or which list of buses to use). The following procedure is one method to determine the size to the kept network:

1. Starting from your point of interconnection, translate N Busses away (say 2 busses back).
2. Use the PSCAD harmonic impedance component to plot the harmonic impedance vs. frequency. Save this frequency response.

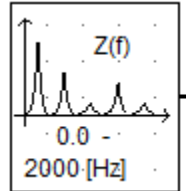


Figure 4.3 PSCAD harmonic impedance component

**Note:** The PSCAD harmonic impedance component outputs a table with frequencies and impedances, which can be used in a graphical analysis tool (such as excel) to produce a plot.

3. Repeat the translation, but translate a larger network (say 4 busses back). Again plot and save the frequency response.
4. Compare the frequency response from 2 busses back to 4 busses back.

**Note:** The larger network will include more shunt capacitors, line capacitance, etc. so will show more resonances.

5. Keep translating larger and larger networks until the frequency response no longer changes. Once the frequency response no longer changes in the range of interest, there is no need to make the kept network any bigger.

This method may produce a very large kept system, and additional effort may be required to reduce the number of kept buses without compromising the accuracy of the solution for the purpose required. There are many tools available in E-TRAN to allow the user to selectively translate a system.



## 5.0 How to use the Substitution Library

This chapter will show you how to use the feature in E-TRAN called “Substitution Library”. This feature saves you time by allowing E-TRAN to read detailed data from a PSCAD library (“.psl” file). Once the data has been entered into a library you can generate countless circuit models using E-TRAN. In other words you only have to manually enter the detailed data once. This chapter starts by describing the process involved in using the substitution library. It will then show how to substitute a transformer, transmission line, and generator into the IEEE 39 bus system. Finally, it contains a section that will describe how to substitute a DC link using the substitution library.

The translation of loadflow data is not always detailed enough for Electromagnetic Transients (EMT) studies. The following is a list of examples for some components where you require more detailed than loadflow data for EMT studies:

1. **Transmission line** RXB data (from loadflow) is only valid at the fundamental frequency and is only suitable for simple PI Section or Bergeron transmission lines. The PI section representation (although accurate at fundamental frequency) will introduce artificial oscillations at higher frequencies. The Bergeron model will be more accurate at higher frequencies (as it is based on the travelling wave concept instead of lumped RLC elements), but does not represent frequency dependent effects. A full frequency dependant line model is required for critical lines in EMT studies.
2. **Transformer** data in the loadflow file does not contain saturation or non-linearity information, which the user will require for EMT studies.
3. **Generators** should be represented with detailed DQ synchronous machine models, complete with exciter, governor, multi-mass, stabilizer data...
4. **Power electronic devices** (HVDC, FACTS devices, SVC...) should be represented in detail.

This process of replacing RXB loadflow data with detailed model data can be automated using the Substitution Library in E-TRAN. The user enters the more detailed model data (for any device) using the model of their choice and saves this data in a PSCAD Library (“.psl” file). You can then enter the name of the pathname of this library into E-TRAN (see section 4.1.6), and E-TRAN will perform this substitution for you.

When the substitution library is used during a translation; for every component that E-TRAN translates from the PSSE “.raw” file it goes into the substitution library and looks if the same component also exists there. If the component exists in the substitution library, E-TRAN will take it to build the circuit model instead of the RXB data component from loadflow. E-TRAN does this in three ways:

1. For **Transmission Lines**, only the “Information Page” should be copied to the Substitution Library. The “Name field” is what E-TRAN reads to identify the component. E-TRAN checks the “from bus”, “to bus” and “circuit number” in the name of the following form “X\_FromBus\_ToBus\_CircuitNumber”. For example, a line name “E\_123\_789\_C1” will be read

as circuit C1 from bus 123 to bus 789.

2. For **Page components**, the name of the page component is what E-TRAN reads to identify the component. Example names of page components are “**E\_289\_0\_G1**” or “**E\_56799\_12345\_C2**”. The page components can contain multiple levels of sub-pages (this is useful for control systems, large electrical networks...).
3. **Custom component definitions** can also be used, but the electrical connections and orientation must match those of the E-TRAN components. In this case a text input parameter called “**Name**” must exist, which E-TRAN reads to identify the component.

### 5.1 Managing Data

The Substitution Library can be used to manage all detailed device data (required by Electromagnetic transients simulation) associated with any given system. For example, a utility called City Hydro may maintain all their data in a PSCAD library called “**CityHydro.psl**”.

The library can contain page components purely for organization (for example a page called Transformers, another called Transmission Lines...). The pages could also be used to separate devices by voltage level or by area/zone.

It is recommended that comments (either with the annotation or sticky note components) be liberally placed in the Substitution Library. The information in the comments should contain the source of the data contained in the model, the date, user who entered the information, perhaps references to any validation studies, device testing...

It is recommended that the Substitution Library be centralized (perhaps on a network drive) and used by all users. It should have a version number (and date/time stamp), and should be maintained by one person perhaps with file system protection (i.e. read only for all users but writeable for users of Group XYZ). File system protection can be put in place on most networks (contact your System Administrator).

### 5.2 Syntax

This section describes the syntax that should be used in component names. This syntax was developed in order to differentiate between components that are connected to the same bus. For example, a load and generator are connected to the same bus 99; say you want to substitute a generator at the bus. In the substitution library you could either name the generator “**E\_99\_0\_1**” or “**G\_99\_0\_1**”, in either case E-TRAN would replace the generator. However, if you use the letter “**E**” in the name, the load connected to that bus would also get replaced by that same generator, since that load could also be named “**E\_99\_0\_1**”. This problem can be avoided by using the letter “**G**” for a generator and the letter “**L**” for a load. Figure 5.1 shows a complete list of the substitution library syntax.

The letter “**E**” that replaces everything connected to the same bus is useful when you want to replace a component with a different component. For instance, if you want to replace a transmission line with

a DC link.

```

Substitution Library Syntax:
E_frombus_tobus_ckt (for example, E_123_456_T1)

E_ General (will substitute anything with anything)
L_ Loads (only substitute shunt loads)
G_ Generator (only substitute generators)
B_ Branch (only substitute series branches (not transformers))

T_ Transformer (only substitute transformers)
S_ SwitchedShunt (only substitute switched shunts)
D_ DC Link (only substitute DC links)

Substition works for:
- Page components (set the page component definition name),
- Tlines (set the tline sub-page to B_frbus_tobus_ckt), or
- any low-level component definition (set the NAME parameter)
    
```

Figure 5.1 List of letters used for different components in a substitution library.

### 5.3 Check that Substitution is Correct

A good way to check whether a substitution was done correctly is by comparing results from a loadflow program and results in PSCAD. The initialization component shown below will read in the results from a solved “.raw” file. The three common quantities that should match within a few units are voltage, real power, and reactive power. For the loadflow results to match with PSCAD results, you should make sure that the substituted component contains the same RXB data as the component in loadflow. For more details on matching loadflow see section 8.2.

Another way of checking whether a substitution was done correctly is by reducing the time step (say from 50 μSec to 10 μSec) and see if the solution in PSCAD changes. If the solution does change with a reduced time step indicates that a characteristic is not represented correctly in the substituted component.

E	Left Bus
1.0234	Volts(pu)
10.991	(+30)Angle(deg)
100.0	Pout(MW)
0.0	Qout(MVAR)

Initial Conditions from Loadflow

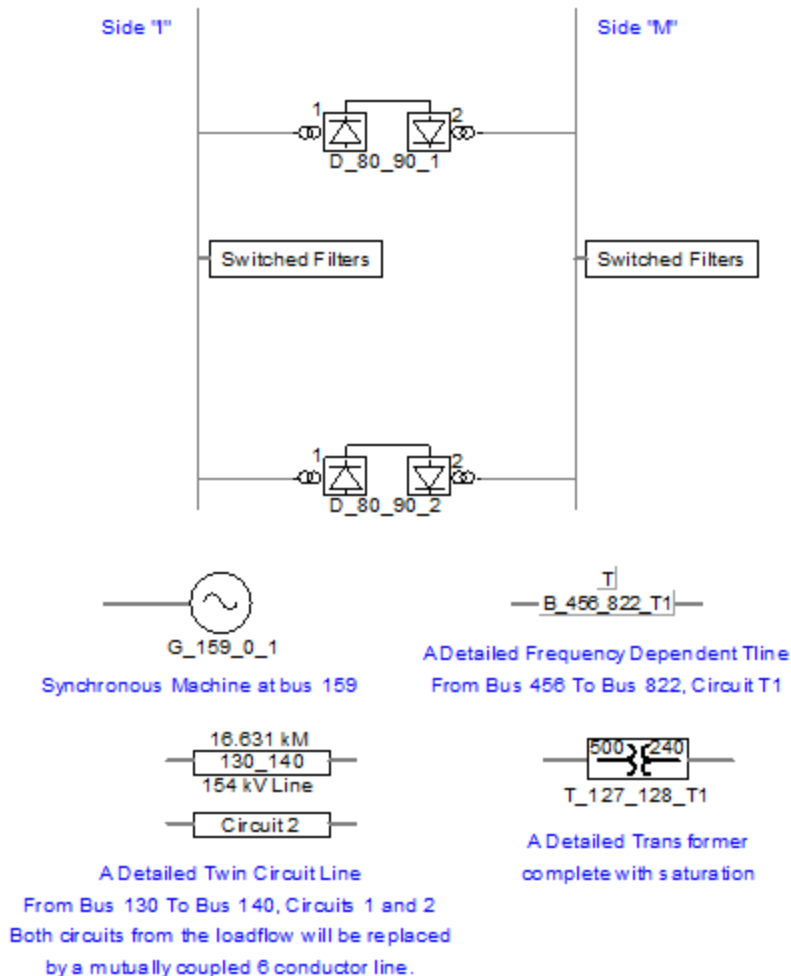
### 5.4 Substitution Examples

This section presents a number of examples substituting detailed data components for simple E-TRAN RXB data components. E-TRAN comes with an example substitution library shown in Figure 5.2 which can generally be found in the following directory “C:\Program Files (x86)\E-

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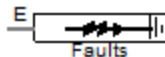
TRAN\_V3\Examples\ Substitution\_Library\_Example\_V4" (directory will depend on where you installed E-TRAN). This section will demonstrate how to modify and build components in the example substitution library so that they can be substituted into the IEEE 39bus system.

DC Link from Bus 80 to Bus 90  
 Note initialization of converter transformer taps , power direction, power order and switchable filters



This is an example of a fault page component.

It is not automatically used in a circuit, but it is convenient to have as it can quickly be manually added in any case.



*Figure 5.2 Detailed data components contained in the example substitution library that comes with E-TRAN.*

A circuit model like the one shown in Figure 5.3 can be generated with E-TRAN from IEEE 39bus system by selecting bus 31 as the central bus and 2 busses back. The “.raw” file for the IEEE 39bus system can generally be found in the following directory “C:\Program Files (x86)\E-TRAN\_V3\Examples\39bus.raw” (directory will depend on where you installed E-TRAN). In the examples that are presented in the following sub-sections, more detailed components will be

substituted in the circuit model shown in Figure 5.3.

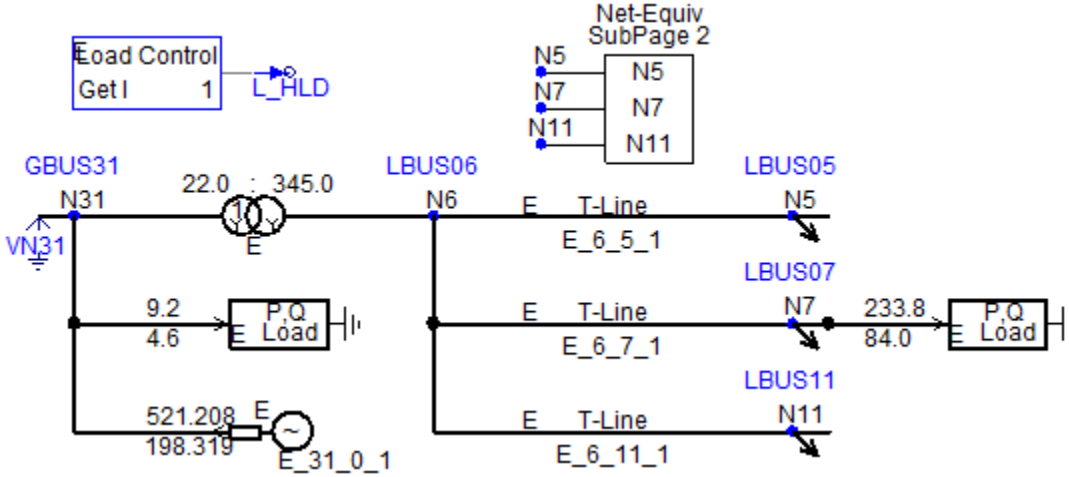


Figure 5.3 Circuit model generated from the IEEE 39bus system with bus 31 selected as the central bus and 2 busses back.

### 5.4.1 Example 1: Transformer Substitution

This is an example suitable for any series connected component. The following steps will demonstrate how to substitute a transformer that contains more detailed data in the IEEE 39bus system from bus 31 to bus 6 (shown in Figure 5.3).

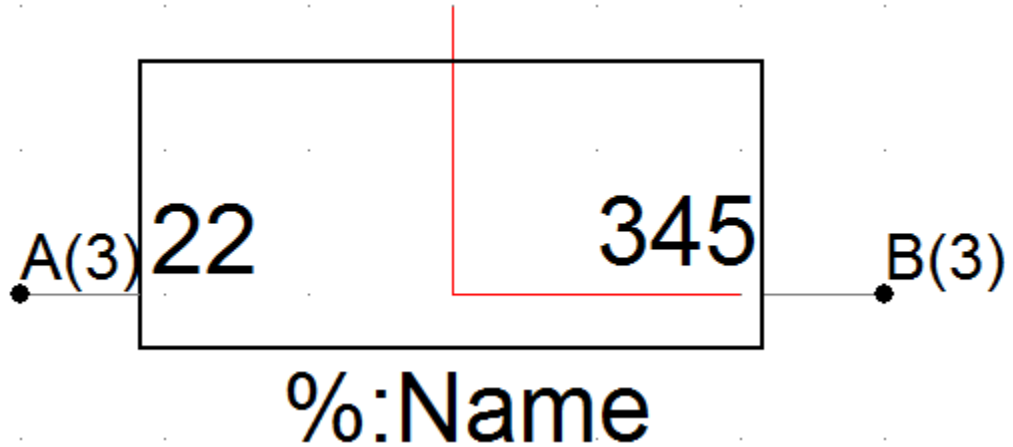
1. In the example substitution library create a page component similar to the transformer model that is already there. When creating the page component you should pay attention to the following:


- The name should be entered “T\_31\_6\_1”, it is critical that bus 31 is on the left and that bus 6 is on the right. E-TRAN uses this orientation to properly connect the transformer with the right voltage levels.

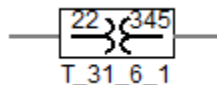
**Note:** If you want to change the component name later, in the workspace window click on “+” to expand the project tree of the substitution library, click on “+” to expand the definitions, right click on the component name, and click “Properties...” to change the component name.

- Enter one connection on the left and one on the right. Also check off the Page Module box.
- For the Left side Connection Name will arbitrarily choose and enter “A”. Enter “22” in the Display Label box for the voltage level on the left. Also check of the Dimension box and enter “3” for three phase circuits.
- For the Right side Connection Name will arbitrarily choose and enter “B”. Enter “345” in the Display Label box for the voltage level on the right.

2. Right click the page component, and then click **"Edit Definition..."** which will bring up the page shown below where you can change the graphics.



- The connection points for this component are three dots away on either side of where the red lines meet.
- In this example connection **"A"** is related to bus 31 (i.e. first bus number in the component name) and connection **"B"** is related to bus 6 (i.e. second bus number in the component name).
- To display the component name in the circuit, left click anywhere on the page, select **"New Graphic"** then click on **"Text"** enter the syntax **"%:Name"** (which will be replaced by **"G\_31\_6\_1"**) and place this label where you want to display the component name.
- Click on  which will return to circuit view, and the graphic of the component shown below looks much like the one already contained in the example substitution library.



3. Double click on the component which will take you to the sub-page of this transformer component. You can copy and paste any one of the transformer models from the master library into this sub-page and connect it to nodes **"A"** and **"B"**.
- It is recommended that you take a few seconds and label the nodes with the voltage level and the bus number that they will be connected to in the circuit. Recall that connection **"A"** corresponds to bus 31 and connection **"B"** corresponds to bus 6. This will be helpful and ensure that you enter the correct voltage levels for the transformer windings later on.

Bus 31 22kV



A

Bus 6 345kV



B

- Once you are finished with the sub-page it should appear similar to the one shown in Figure 5.4.
- If your transformer is oriented similar to the one shown in Figure 5.4, for voltages you would enter “22” for winding #2 and “345” for winding #1.
- When entering detailed data for the transformer it is the user's responsibility to ensure the fundamental frequency impedance and admittance of the device in the Substitution Library will match that in the loadflow input “.raw” file. In this case, the transformer MVA and leakage reactance should match that in the loadflow. E-TRAN does translate loadflow data for E-TRAN components, if you have translated the circuit without using a substitution library retrieving the loadflow data from this circuit can be used as an alternative to getting it directly from the “.raw” file.

**Note:** The use of the optional initial conditions components. E-TRAN will read in 30 degree shifts for the left and right bus from this component (required if one of the windings is a delta), and will output the initial loadflow conditions. For more information on the initial conditions components refer to section 7.14. Also note the use of the transformer tap settings component. When you edit this component you have three choices: Tap on Right, Tap on Left, or no tap changer. If there is a tap changer this component will read in the tap setting from loadflow during the translation.

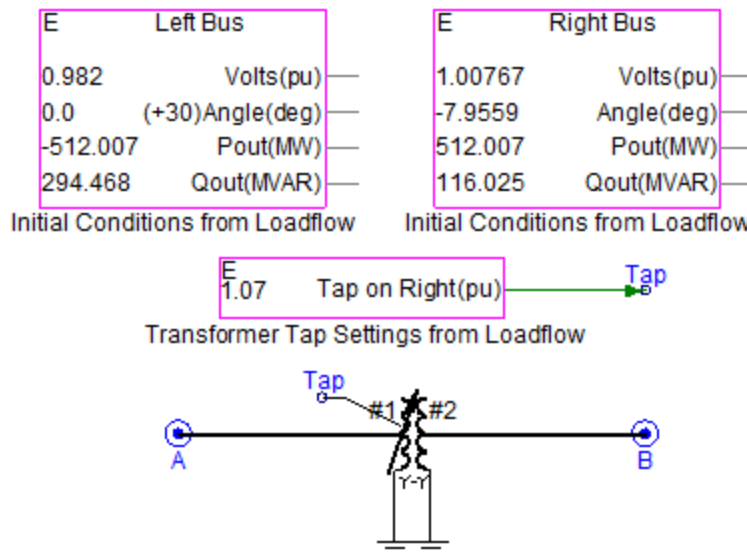


Figure 5.4 The appearance of the sub-page for the substitution transformer created in this example.

4. Run E-TRAN with the substitution library in the translation. To learn how to include the substitution library in a translation refer to section 4.1.6. In Figure 5.5 the IEEE 39bus system is shown after E-TRAN has taken the simple RXB data transformer and substituted the detailed transformer model that was developed in this example.

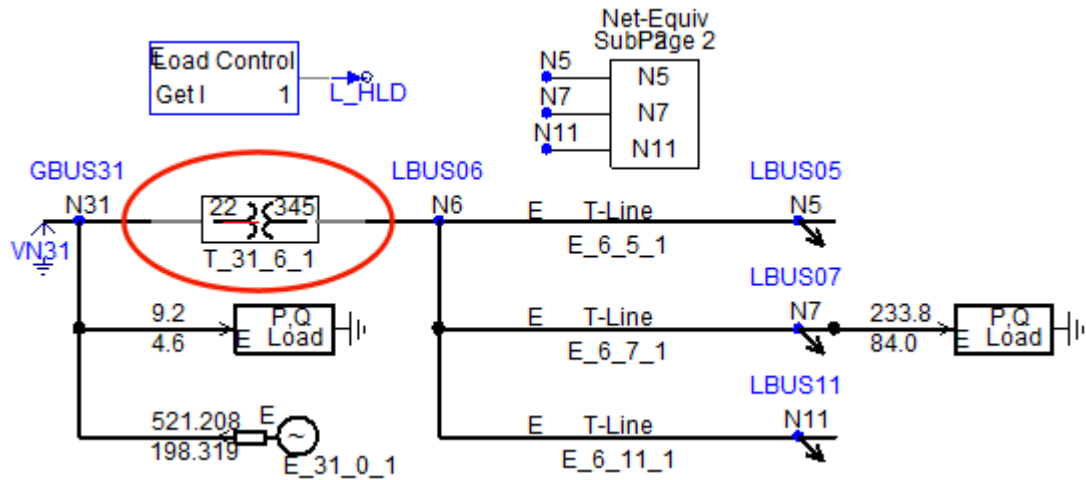


Figure 5.5 A detailed transformer model substituted in the IEEE 39bus system.

In this example, the page component in the Substitution Library is used to substitute detailed transformer data (such as the UMEC model instead of the simple RXB data component). Using a page component in this way is not limited to transformers, but can be applied to replace any model with any other model.

Great care should be taken to ensure that the name of the page component and the graphics of the page component definition have corresponding bus connections. E-TRAN uses this information to ensure the component is connected with the correct orientation (otherwise you would get the 22 kV bus connected to the 345 kV side of the transformer).

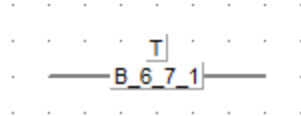
If you have a three winding transformer that you wish to substitute, it is done in a similar way as a two winding transformer. First of all you have to add another bus number to the name. (e.g. “T\_FromBus\_ToBus\_TertiaryBus\_CircuitNumber”). The connection point of the tertiary is one dot below the point of where the red lines meet. Other than these differences the tertiary winding is treated the same as the other windings.

### 5.4.2 Example 2: Transmission Line Substitution

This example demonstrates how to substitute a transmission line that contains more detailed data than RXB loadflow data. Consider the transmission line running from bus 6 to bus 7 in the IEEE 39bus system (shown in Figure 5.3); the following steps will demonstrate how to substitute a more detailed transmission line model (such as the phase domain model instead of the simple RXB data PI section component).

1. In the example substitution library create a transmission line interface component called “B\_6\_7\_1”. The line interface should use the “Direct Connection” and should be exactly 6 dots wide as shown below.





- You can change the name of the component by double clicking on it, and then enter the name in the segment name box.
2. Double click the transmission line interface, then click “Edit...” to go to the sub-page. Enter the line geometry and parameters in the sub-page. The sub-page may appear as shown in Figure 5.6.

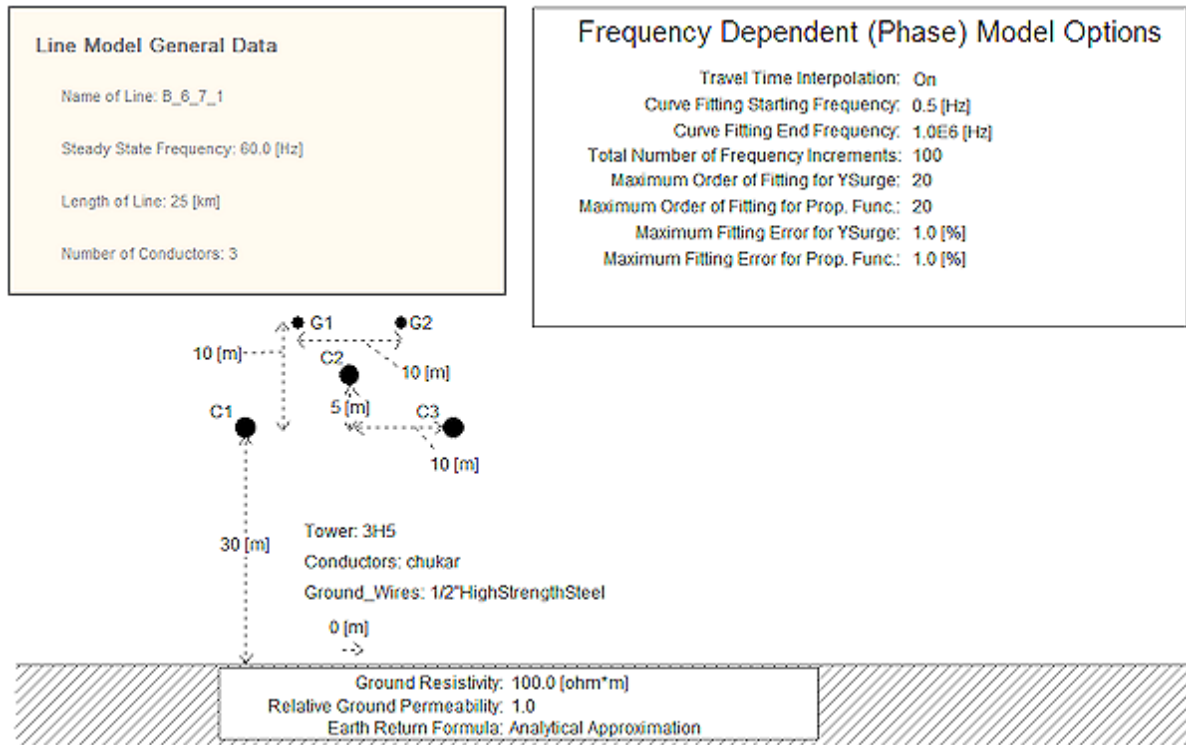


Figure 5.6 The sub-page of a Frequency Dependent (Phase) Model Options.

3. Run E-TRAN with the substitution library in the translation. To learn how to include the substitution library in a translation refer to section 4.1.6. In Figure 5.5 the IEEE 39bus system is shown after E-TRAN has taken the simple RXB data transmission line and substituted the detailed transmission line model that was created in this example.

**Note:** The transformer substitution model that was created in the example 1 was left in the substitution library for this translation; therefore, it was also replaced in this translation. If we had only wanted to replace the transmission line in the circuit model, we should have removed the transformer from the substitution library. For any component in a circuit model that E-TRAN finds a component in the substitution library, E-TRAN will replace.

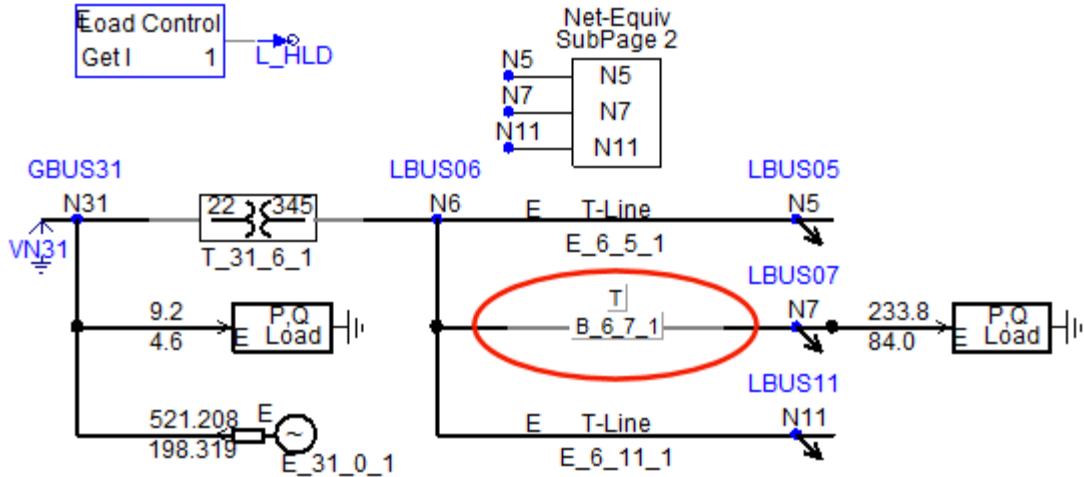


Figure 5.7 A detailed transmission line model and transformer model substituted in the IEEE 39bus system.

Care should also be taken when selecting which line model to be used. The travelling wave line models (Bergeron, Mode or Phase Domain frequency dependent models) can only be used if the travel time of the line is at least 1 time step long (if you are using a time step of 50 uSec, this corresponds to 15 km lines or longer). An easy way to determine which lines are at least 1 time step long for any time step, is by generating a circuit using E-TRAN and in Step 5 for **Line Model Selection:** check of “**Use Bergeron (where possible)**” and in Step 6 for “**PSCAD Time Step (uSec)**” enter the time step for which you want to determine if a line is longer than 1 time step. Then open the circuit in PSCAD and observe which transmission lines were put in as Bergeron models and which were substituted as PI Sections. The lines that were put in as Bergeron models are longer than 1 time step and the lines that were put in as PI Sections are shorter than 1 time step.

It is the user’s responsibility to ensure the fundamental frequency impedance and admittance of the device in the Substitution Library will match that in the loadflow input .raw file. For example, you should extract the +ve sequence fundamental frequency RXB from the PSCAD Line Constants program and update your .raw loadflow file so that they match. If this is not done, then the EMT simulation will not match the loadflow (see Chapter 8.2).

Another component that is contained in the example substitution library is a mutually couple transmission line. In loadflow data mutually coupled lines are treated as two separate lines which is sufficient for loadflow studies. However, for some studies (such as EMT studies) the lines need to be modeled as mutually couple which may be accomplished by using the mutually coupled transmission line component contained in the example substitution library. When used in a translation the component replaces one of the lines with a mutually coupled line and the other line is replaced by a dummy line (dummy line has a sub-page that is empty).

### 5.4.3 Example 3: Synchronous Machine Substitution

This example is suitable for any shunt connected component. Substituting a shunt component is similar to a series component, the only difference is the name where you enter 0 for the “**to bus**” since there is only one bus (e.g. “G\_FromBus\_0\_CircuitNumber”). The following steps will

demonstrate how to substitute a generator that contains detailed data in the IEEE 39bus system at bus 31 (shown in Figure 5.3).

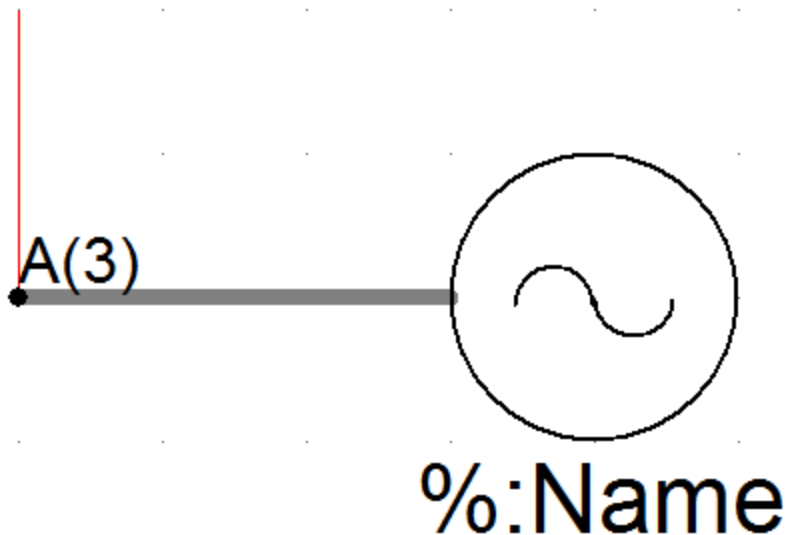
1. In the example substitution library create a page component similar to the machine model that is already in there. When creating the page component you should pay attention to the following:

- The name should be entered “**G\_31\_0\_1**”, since there is only one bus for the component to connect to the second bus number is entered as 0.

**Note:** If you want to change the component name later, in the workspace window click on “+” to expand the project tree of the substitution library, click on “+” to expand the definitions, right click on the component name, and click on “**Properties...**” to change the component name.


- Enter one connection on the left. Also check off the Page Module box.
- For the Connection Name we will arbitrarily choose and enter “**A**”. Also check of the Dimension box and enter “**3**” for three phase circuits.

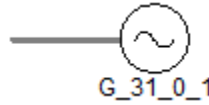
2. Right click on the page component, and then click on “**Edit Definition...**” which will bring up the page shown below where you can change the graphics.



- The connection point for this component is at point (0,0) where the red lines meet.
- To display the component name in the circuit, left click anywhere on the page, select “**New Graphic**” then click on “**Text**” enter the syntax “**%:Name**” (which will be replaced by “**G\_31\_0\_1**”) and place this label where you want to display the component name.

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- Click on  which will return to circuit view, and the graphic of the component shown below looks much like the one already contained in the example substitution library.



3. Double click on the component which will take you to the sub-page of this generator component. You can copy and paste any one of the machine models from the master library into this sub-page and connect it to node “A”. For the purpose of this example, I will just copy and paste the components contained in the sub-page of the generator that already exists in the example substitution library and then enter the parameters.
  - The sub-page for the generator appears as shown in Figure 5.9. Note the use of the optional initial condition component. E-TRAN will read a 30 degree shift for this bus from this component, and will output the initial loadflow conditions (to the machine as well as the initial conditions component). If other devices are used, then the outputs from the initial conditions component can be used to set the operating point of the device (these signals are unused in this case as the initial conditions are directly transferred to the machine model).
4. Run E-TRAN with the substitution library in the translation. To learn how to include the substitution library in a translation refer to section 4.1.6. In Figure 5.5 the IEEE 39bus system is shown after E-TRAN has taken the simple RXB data generator and substituted the detailed generator model that was developed in this example.

**Note:** When I generated the circuit model in Figure 5.8 the transformer and the transmission line developed in examples one and two respectively, were removed from the example substitution library and that is why they did not get substituted into this circuit. Alternatively I could have left them in the substitution library and E-TRAN would have replaced the transformer from bus 31 to bus 6 and the transmission line from bus 6 to bus 7.

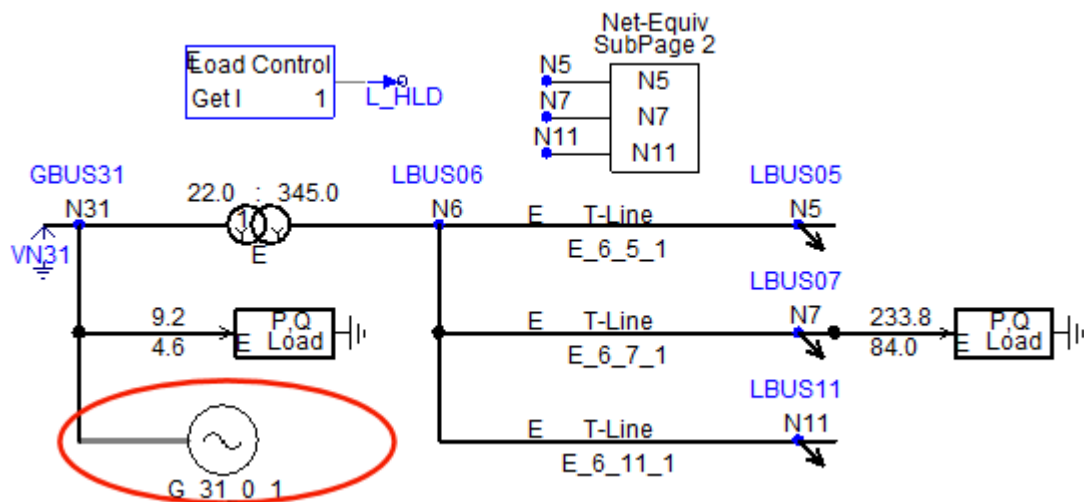


Figure 5.8 A detailed transformer model substituted in the IEEE 39bus system.

In this example, this page component in the Substitution Library is used to substitute detailed generator data (such as the sync\_machine DQ model instead of the simple RXB E-TRAN source component), but can be applied to replace any model with any other model.

E-TRAN will automatically substitute the initial condition information of the machine model (and the initial condition component) based on the loadflow solution. If this machine is connected via a delta winding transformer (perhaps on another page), then the initial conditions component should have the 30 degree shift specified (the machine bus angle will then have the 30 degree shift automatically added by E-TRAN).

It is the user's responsibility to control the timing of the release of the machine (and the connection of initial condition information between the machine, exciter, governor, multi-mass models etc...).

557.66 MVA, 22 kV Machine with Exciter/Governor

The "Initial Conditions from Loadflow" component is used in 2 ways:

- 1) E-TRAN will automatically set its parameters to the loadflow solution for this device. This can be used to set initial conditions for anything on this sub-page
- 2) If this page contains a machine, E-TRAN will read in the Shift parameter (-30, 0, or 30 degrees) and will add this shift to the bus angle and copy it to the machine model (along with other initial condition data). The number of parallel machines is also read in and the PQ info in the machine model will be divided by N.

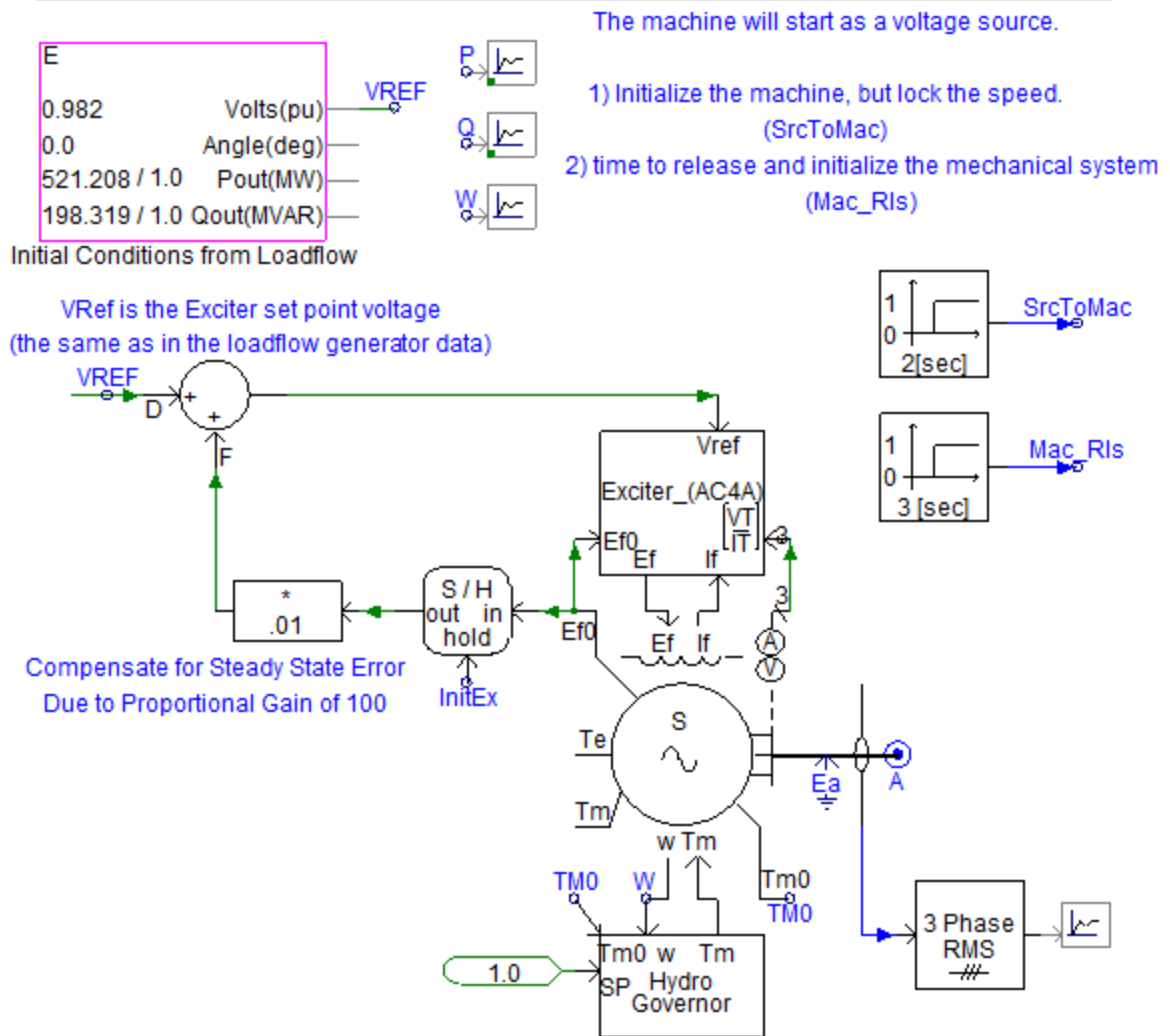


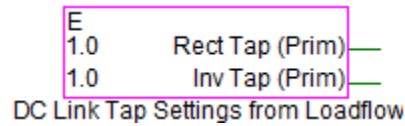
Figure 5.9 Sub-page for the machine in this example may appear as shown in this figure.

### 5.4.4 Example 4: DC Link Substitution

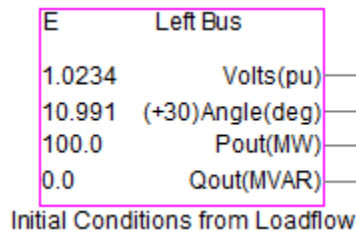
A detailed DC link can be substituted the same way as a transformer by placing a page component in the substitution library and then enter the DC link into that sub-page. The example substitution library contains a very detailed DC link model where the components discussed below have been utilized.

This example will point out a number of components that can be very useful when substituting a DC link.

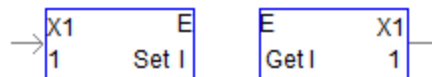
1. **DC Link Tap Settings from Loadflow:** When this component is used during a translation, E-TRAN will calculate the powerflow and update this component. It should be connected to the Rectifier and Inverter Tap settings so that the taps will get set automatically.



2. **Initial Conditions from Loadflow:** When this component is used during a translation, E-TRAN will calculate the powerflow and update this component. In a DC link this component can be used to determine the direction of power flow.



3. **Transfer Information Between Pages:** This component can be used to transfer information between two different pages. When a bipole is modeled in loadflow each monopole is modeled as a separate DC link. The DC link in the example substitution library is a way to substitute a bipole modeled as one DC link. In the example substitution library the bipole has been placed in the sub-page of one of the DC links. The other DC link also gets substituted but only contains some circuitry to determine the state of the negative pole. The transfer of information component (shown below) can be used here to communicate information about the state of the negative pole to the main DC link containing the bipole.



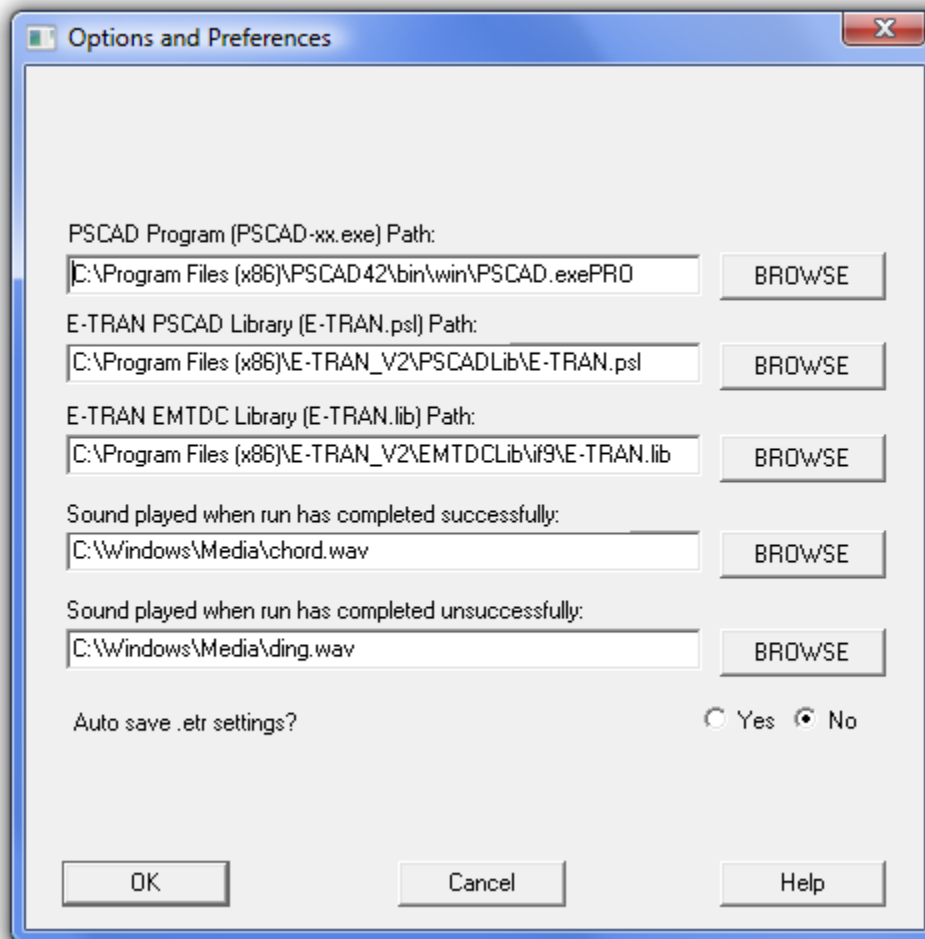




## 6.0 Options and Preferences

To bring up the Options and Preferences dialog, go to **Options** / **Preferences** inside E-TRAN.

All optional parameters are described below. To close the **Options and Preferences** dialog, click “**OK**” to keep changes that you make or click “**Cancel**” without keeping your changes.



**PSCAD Program (PSCAD-xx.exe) Path:** The PSCAD Program Path should be entered here. The path is used by E-TRAN to open PSCAD when you open a model directly from E-TRAN (see section 4.1.9.1). The executable is always PSCAD.exe, but you should add “PRO” for the Professional version, “EDU” for the Educational version. If you do not specify an additional extension (or use “STU”), the Student Edition will be started (the Student Edition does not support multiple pages so is not very useful for converted cases).

**E-TRAN PSCAD Library (E-TRAN.psl) Path:** The pathname to the E-TRAN PSCAD Library is automatically derived from the E-TRAN installation directory and is shown here. This file is not directly needed by E-TRAN, but is used by PSCAD to find the correct components when generating and

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launching the circuit in PSCAD.

**E-TRAN EMTDC Library (E-TRAN.lib) Path:** The pathname to the E-TRAN EMTDC Library is automatically derived from the E-TRAN installation directory and is shown here. This file is not directly needed by E-TRAN, but is used by PSCAD to find the correct libraries when generating and launching the circuit in PSCAD.

See section 4.1.9.2 to see how these libraries are set and used by PSCAD. The if9 portion of the EMTDC Library should only be entered if you are using the Intel Fortran compiler with PSCAD. Use the following list as a sub-directory guide:

- Intel Fortran 9 Compiler ⇒ if9
- Intel Fortran 12 Compiler ⇒ if12
- Compaq Fortran 9 Compiler ⇒ cf6
- GNU/EGCS/GFortran Compiler ⇒ gnu

**Sound played when run has completed successfully:** This is where you enter the path to the sound that you want to play when E-TRAN completes a translation successfully.

**Sound played when run has completed unsuccessfully:** This is where you enter the path to the sound that you want to play when E-TRAN completes a translation unsuccessfully.

**Auto save .etr settings?** If you check “**Yes**” your E-TRAN case settings will automatically be saved each time that you click “**Finish**” to close E-TRAN. If you check “**No**”, E-TRAN case settings will not be saved when you click “**Finish**”.

## 7.0 E-TRAN PSCAD Library


The E-TRAN PSCAD Library contains models for all power system devices required for loadflow studies. It is freely available to all users and can be downloaded from:

***<http://www.electranix.com/E-TRAN/>***

When you use E-TRAN to generate a PSCAD case and then start PSCAD from within E-TRAN (see section 4.1.9.2 Running Model in PSCAD), the required libraries will automatically be loaded and the PSCAD case setup as required.

If you start PSCAD manually (i.e. not from E-TRAN) and want to load a case that uses components from the E-TRAN PSCAD Library (or if you build a case from the beginning and would like to use models from the E-TRAN PSCAD Library), then refer to the following section to see how to load the E-TRAN PSCAD Library and run the case.

### 7.1 Using the E-TRAN PSCAD Library

The E-TRAN Library can be manually loaded from PSCAD by going to **File**  **Open**, and then navigating to the E-TRAN installation directory. For example: "C:\Program Files (x86)\E-TRAN\_V3\PSCADLib\E-TRAN.psl".

If you manually construct a case which uses the E-TRAN models (instead of using E-TRAN to generate the case), then this case must have its "Case Properties" modified to instruct PSCAD to include the E-TRAN EMTDC binary object library ("C:\Program Files (x86)\E-TRAN\_V3\EMTDCLib\cf6\E-TRAN.lib") in the link stage when the EMTDC executable is formed.

To do this, in PSCAD go to "**Workspace**" and right click on the case name, select "**Project Settings**", and then go to the "**Link**" tab.

The "cf6" sub-directory should be entered only if you are using the Compaq Visual Fortran 90 compiler (version 6.x) with PSCAD. Use the following list as a sub-directory guide:

- Intel Fortran 9 Compiler ⇒ if9
- Intel Fortran 12 Compiler ⇒ if12
- Compaq Fortran 9 Compiler ⇒ cf6
- GNU/EGCS/GFortran Compiler ⇒ gnu

### 7.2 PU System and Data Entry

All E-TRAN components ask for data in a Per Unit system that is consistent with PSS/E (regardless of whether the model is used in a single phase or three phase application). The standard data entry system is as follows:

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- Rated Voltages are Line to Line, kV, RMS
- Voltage Initial Conditions in Per Unit
- Power Flow is three phase MW and MVAR
- MVA Rating is 3 phase
- Frequency in Hz
- RXB is entered in PU on 100 MVA base (note RXB for sources/machines are entered on the MVA base).
- Angles in Degrees

Each E-TRAN model (and most PSCAD models) has a NAME field. This field is used by the Substitution Library to determine the from bus, to bus and circuit number (see Chapter 5.0, How to use the Substitution Library for more information).

### 7.3 Loads

The E-TRAN load model supports the following load types:

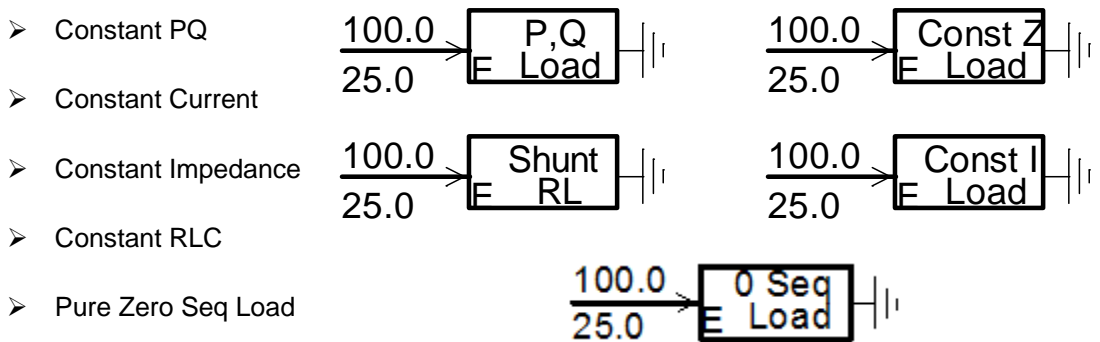


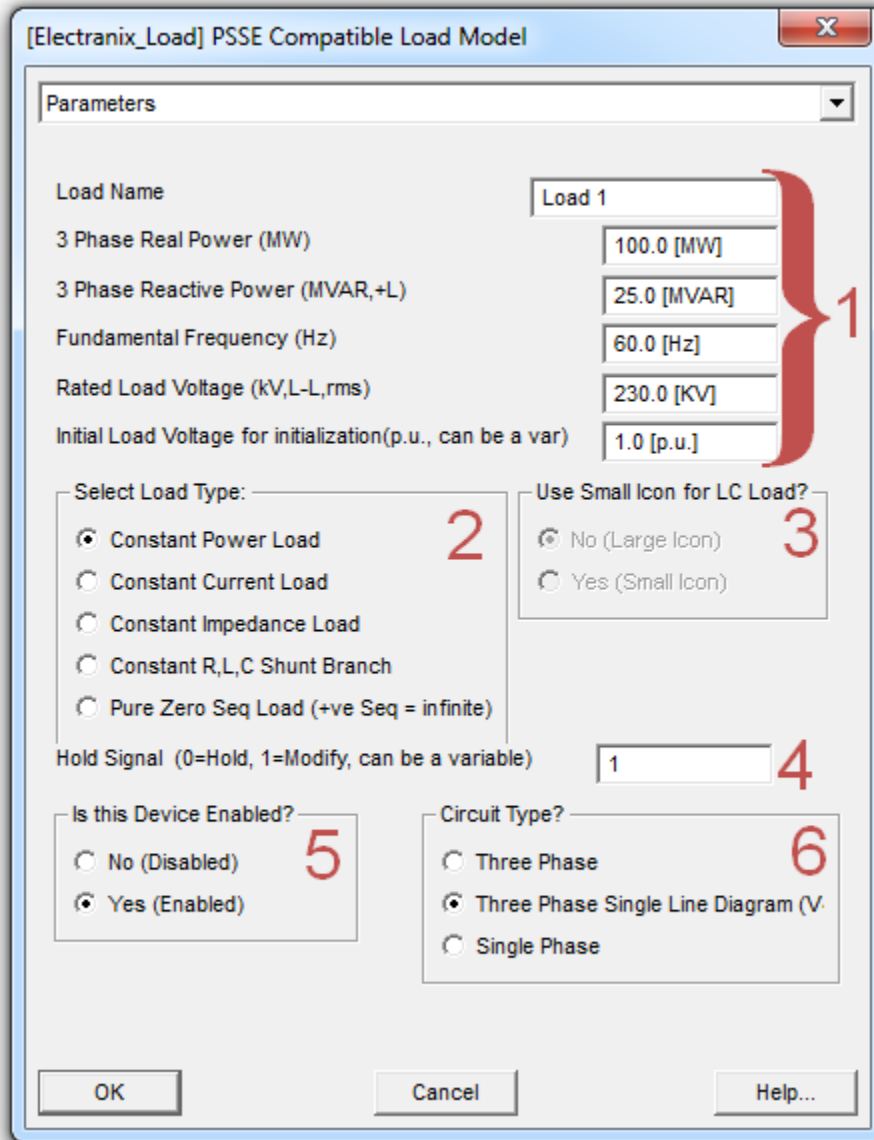
Figure 7.1 Five different Symbols of the five different E-TRAN load models.

The model interfaces to a variable RLC branch, and the RLC parameters are switched (once a cycle) to match the given load characteristic.

The load model measures the +ve sequence fundamental frequency voltage (see Measurements in Chapter 7.11) and then varies the RLC load to match the selected characteristic. The measured voltage has a minimum limit of 0.8 PU and a maximum limit of 1.25 PU, which determines the state of the load during faults and overvoltages.

The text shown on the model (100 +j25 above) is the power flow at the rated voltage set point (see more on this below).

The dialog shown below appears when you edit the **Parameters** page of this model:



1. Refer to section 7.2 for an explanation on the standard system of units for data entry.
  - The PQ load values are entered for the rated voltage (1pu) operating point. The actual load PQ flow will vary according to the loadflow and the load type selected.
  - The Initial Load Voltage parameter is the load voltage from a solved loadflow (read from the bus data of the PSS/E “.raw” file). This is used to set the initial RLC values of the load. The initial load RLC values are held for 0.2 seconds to give the EMTDC simulation time to reach steady state.
2. The E-TRAN load model will represent the selected load type as a variable RLC branch whose

RLC parameters are switched (once a cycle) to match the given load characteristic.

3. If you choose the LC load type you can choose whether you want the symbol in the diagram to appear as a big icon or a small icon.
4. The Hold Signal parameter (this can be a variable) can be used to hold the RLC values at their current levels:
  - If a "1" is entered, the dynamic load model will change the RLC values once per time-step to match the selected load characteristic.
  - If a "0" is entered, the load model will hold its RLC values at the previous level (or at the initial condition based on the Initial Load Voltage).
  - If a variable name is entered (such as "Hold") then the user can create a signal which dynamically changes from 0 to 1 etc... This is useful if you want to prevent the RLC values from changing during a fault.
5. If you disable this device, then the component will appear as "grayed out" and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E ".raw" file.
6. The "Circuit Type" can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase circuit (V3 or V4).

**Note:** The load parameters always ask for 3 phase PQ and the line to line voltage, even if the device is operating in a single phase circuit (see Chapter 7.2).

### 7.4 Generator/Source

This model is a fixed frequency voltage source (either an infinite bus or a source behind impedance). This model does not represent the changing frequency or exciter characteristics of a machine or generator (use the standard PSCAD Master Library models for this).

This model has a convenient option, which makes it easy to initialize. The user can enter the terminal voltage (magnitude and phase) and the PQ flow into the source. This model can then internally compute the "E behind Z" (note the standard PSCAD Master Library sources always require entry of the "E behind Z" directly and you must perform the complex arithmetic yourself).

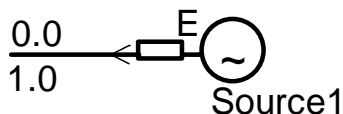
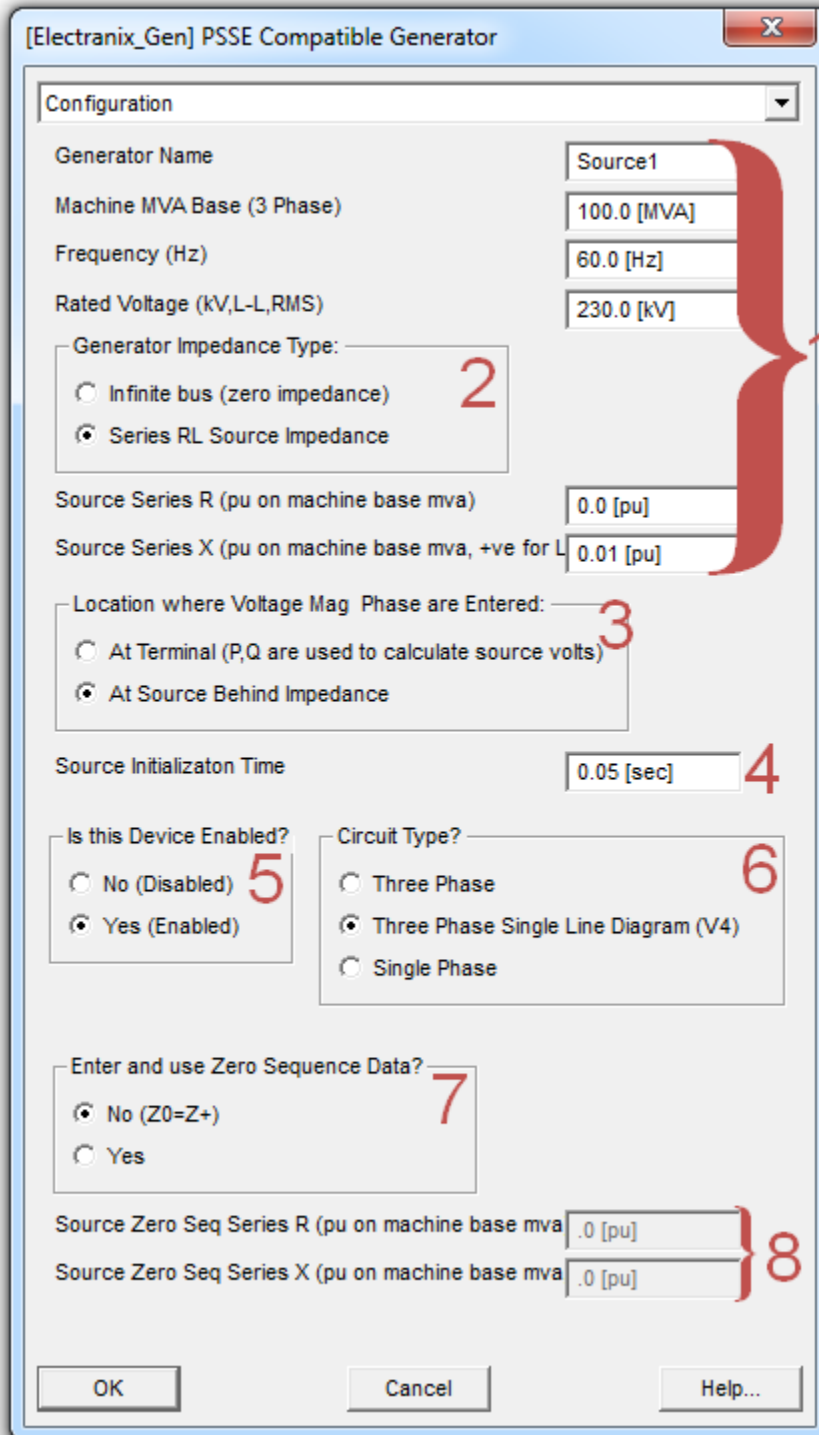


Figure 7.2 Symbol for the E-TRAN generator/source model.

The dialog shown below appears when editing the **Configuration** page of this model:



1. Refer to section 7.2 for an explanation on the standard system of units for data entry.

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2. The Generator Impedance Type can be set to:
    - Infinite Bus, in which case the source voltage is directly fed into the EMTDC solution and will directly appear as the measured voltage on the bus. This is equivalent to a source impedance of zero.
    - Series RL, in which case the source voltage source will contain an impedance, with an associated voltage drop.
- Note:** Data for this generator model is often translated from generator data of a loadflow program. The ZR, ZX ZSORCE parameters are often not required nor used in the loadflow solution, but they do play a critical role in short circuit and transient studies. If the ZR, ZX generator data is not available, then you should consider modifying your loadflow program data files before translating the circuit using E-TRAN. See section 8.3 for more information.
3. If a source impedance is entered in #2 above, then the user can enter the voltage at the bus terminals (magnitude and phase) and the PQ flow into the source, and the model will internally compute the “E behind Z” so as to give the desired terminal conditions based on the loadflow. Alternatively the user can directly enter the “E behind Z” magnitude and phase.
  4. This is the time that the source starts up during a simulation in PSCAD. During an E-TRAN translation, (see 4.1.6 Step 6: Select PSCAD Properties) you enter the Source Initialization Time which will then be forwarded to all sources that are in your network.
  5. If you disable this device, then the component will appear as “grayed out” and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E .raw file.
  6. The “Circuit Type” can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase circuit (V3 or V4). Note the load parameters always ask for 3 phase PQ and the line to line voltage, even if the device is operating in a single phase circuit (see Section 7.2).
  7. This is where you select whether you want to enter and use zero sequence data. If you select “**No**” positive sequence data will be used in place zero sequence data. If you select “**Yes**” enter the zero sequence data in the next step.
  8. This is where you enter the zero sequence series R and X for this source.

The next page of the data entry (**Initial Conditions and Outputs**) is where the initial source voltage (or terminal voltage) and initial loadflow PQ flows are entered, and where you can measure the instantaneous current out of the source. To monitor the source current:

1. Enter a unique name at the desired parameter (such as “lmeas\_Gen1”)
2. Go back to your PSCAD circuit and place a “datalabel” (with the same name as above)





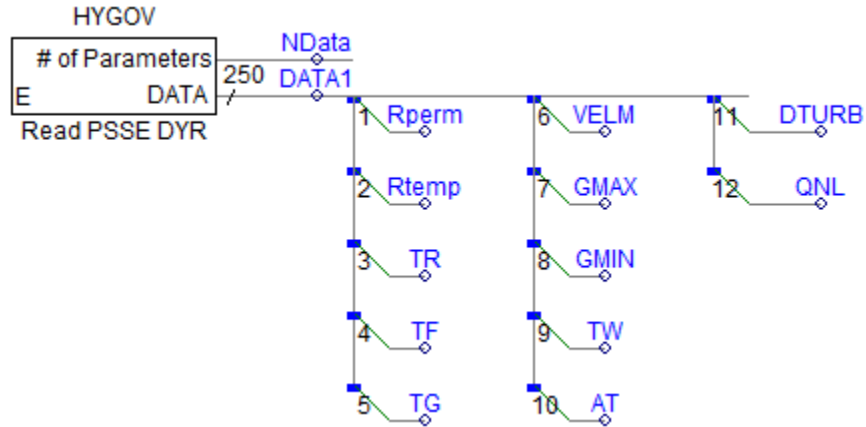


Figure 7.4 Symbol of a system that can be used to read in any PSS/E .dyr file.

## 7.6 Transmission Lines

The E-TRAN PI section component is used for very short lines.

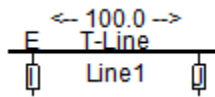


Figure 7.5 The E-TRAN PI Section Component.

When you have a longer transmission line (whose travel time is longer than one time step), then you can use the Bergeron traveling wave line model (consult the PSCAD help system).

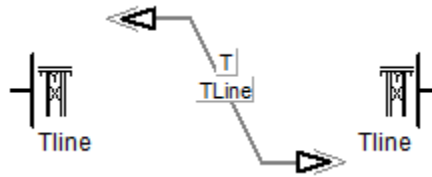


Figure 7.6 The PSCAD Bergeron Line Model (using the Line Constants Interface).

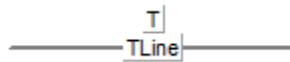
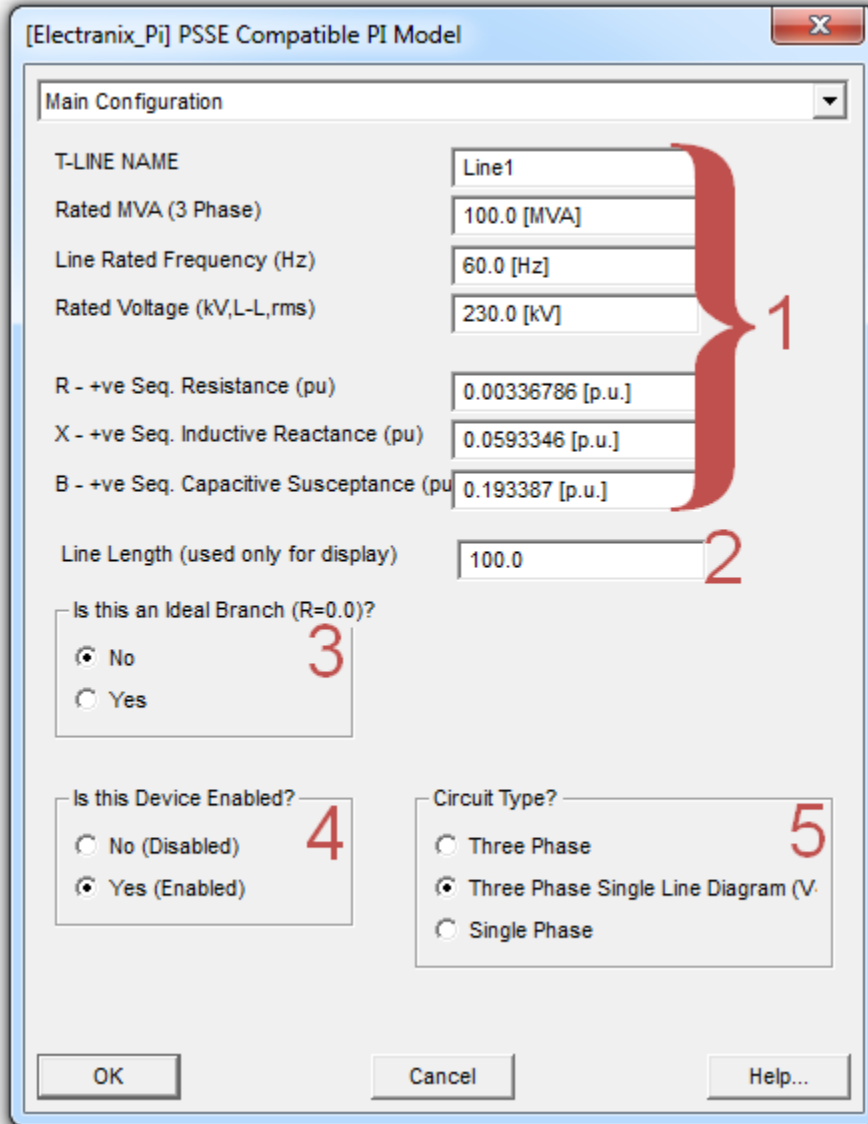


Figure 7.7 The PSCAD Bergeron Line Model (using the Single Line Diagram Line Constants Interface).

The dialog shown below appears when editing the **Main Configuration** page of the E-TRAN PI section model:



1. Refer to section 7.2 for an explanation on the system of units for data entry.

The RXB data entry should already be “long line corrected” and is the same data as required in the PSS/E .raw data format.

2. The line length is used only for display, since the RXB values are entered in PU for the entire length of line.
3. The branch can be made to be Ideal, in which case there is a direct short between the “from” and “to” busses. If the absolute value of the PSS/E reactance is less than 0.0001 PU, PSS/E internally treats the branch as an ideal branch (to improve convergence properties). E-TRAN also will make

the device Ideal if the absolute value of the PSS/E .raw branch reactance is less than 0.0001 PU.

4. If you disable this device, then the component will appear as “grayed out” and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E .raw file.
5. The “Circuit Type” can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase circuit (V3 or V4). Note the load parameters always ask for 3 phase PQ and the line to line voltage, even if the device is operating in a single phase circuit (see section 7.2).

Single Phase PI sections are represented as a series RL impedance (from the sending end to the receiving end) as well as capacitors to ground at each end of the line.

Three phase transmission lines are represented with a three phase mutually coupled transformer. This method gives the correct +ve and zero sequence impedances of the line, yet does not require a separate “zero sequence network” and associated neutral connections at each end of the line. The “separate zero sequence network” method is an old way of representing pi lines on analog simulators (as it can be realized with physical connections) and should be avoided.

The next page of the data entry (Shunt Admittances) allows you to enter shunt admittances at either end of the line. These are represented by constant RLC branches to ground (as per the PSS/E .raw format standard). When the transmission line is disabled, the shunts at each end of the line are also disabled.

Click “OK” to save your changes and exit to PSCAD or click “**Cancel**” to exit without saving your changes.

## 7.7 Transformers/Phase Shifters

The transformer and phase shifter are modeled as a mutually coupled branch element in PSCAD/EMTDC. The three phase transformer is comprised of three single phase units (more detailed models are possible in the PSCAD Master Library).

This component assumes a wye-wye grounded configuration, which matches the assumptions in loadflow programs. Consult section 5.4.1 for more information on how to substitute more detailed transformer models.

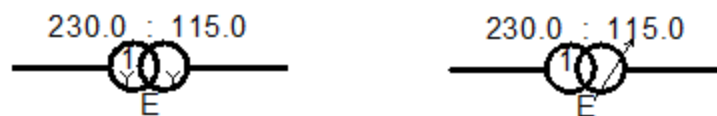
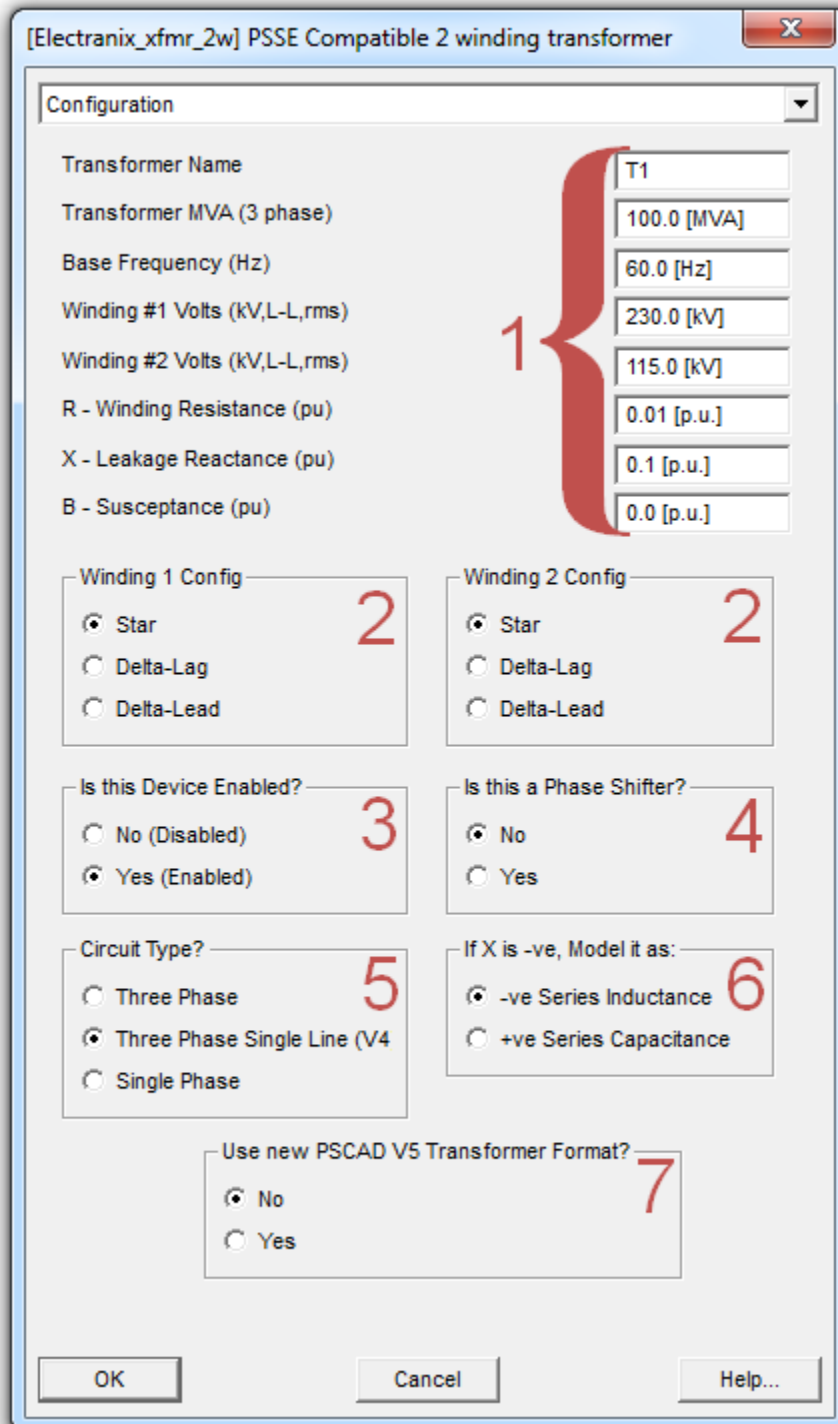


Figure 7.8 Symbols of the E-TRAN Transformer and Phase Shifting Transformer models respectively.

The dialog shown below appears when editing the **Configuration** page of the two winding transformer/phase shifter model:



1. Refer to section 7.2 for an explanation on the system of units for data entry.

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2. Winding 1 and Winding 2 can be Star, Delta-Lag, or Delta-Lead. Use the radial buttons to select the required winding configuration.
3. If you disable this device, then the component will appear as “grayed out” and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E .raw file.
4. This device can also be a phase shifter (the model graphics will change accordingly).
5. The “Circuit Type” can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase circuit.

Three phase transformers are represented with a three single phase mutually coupled transformers. This representation is valid if the actual transformers are built from single phase units, and will be reasonable accurate for 5 limb core transformers. If the transformer is a 3 limb core transformer, then the UMEC transformer model in the PSCAD Master Library should be used (this model requires more detailed data, such as the core geometry).

6. When  $X$  is negative, this component can be modeled as negative series inductance or positive series capacitance. Use the radial buttons to select.

The dialog shown below appears when editing the **Tap, Shunt Phase Shifter Data** page of the two winding transformer/phase shifter model:

The dialog box is titled "[Electranix\_xfmr\_2w] PSSE Compatible 2 winding transformer". It has a dropdown menu at the top set to "Tap, Shunt Phase Shifter Data".

Under "Select Tap Winding:", there are three radio buttons: "None", "Winding 1" (selected), and "Winding 2".

The "Tap Setting (=  $V_{tap} / V_x$ ,  $0.8 < Tap < 1.2$ , can be a variable) [pu]" field contains "1.0 [pu]".

The "Phase Shifter Angle (Winding 1 - Winding 2) (Deg,  $-80 < X < 80$ )" field contains "0.0 [°]".

The "Impedance Correction Table #" field contains "0".

The "Impedance Correction Factor (obtained from Tables for a given Tap/Angle) [p.u.]" field contains "1.0 [p.u.]".

There are four fields for shunt admittance on bus I and bus J:

- GI - Real Shunt Admittance on bus I (pu): 0.0 [p.u.]
- BI - Imag. Shunt Admittance on bus I (pu, -ve for L): 0.0 [p.u.]
- GJ - Real Shunt Admittance on bus J (pu): 0.0 [p.u.]
- BJ - Imag. Shunt Admittance on bus J (pu, -ve for L): 0.0 [p.u.]

Buttons at the bottom: OK, Cancel, Help...

1. A Tap Changer Winding can be specified.
2. Enter the tap setting in PU. The Tap Setting can be a constant or a variable. If you have a 230/115 kV transformer (where winding 1 is 230 kV), and you enter a tap of 0.9 PU on winding 2, this is effectively a  $230/(115 \cdot 0.9)$  kV transformer.
3. Enter the phase shift angle in Degrees. The phase shift is achieved with a near-quadrature voltage source connected in series with the transformer and shunt current injections. The voltage and current sources are dynamically calculated to give the correct phase shift angle based on the measured bus conditions and frequency.
4. The Impedance Correction Factor is used as a multiplier to the series leakage reactance.

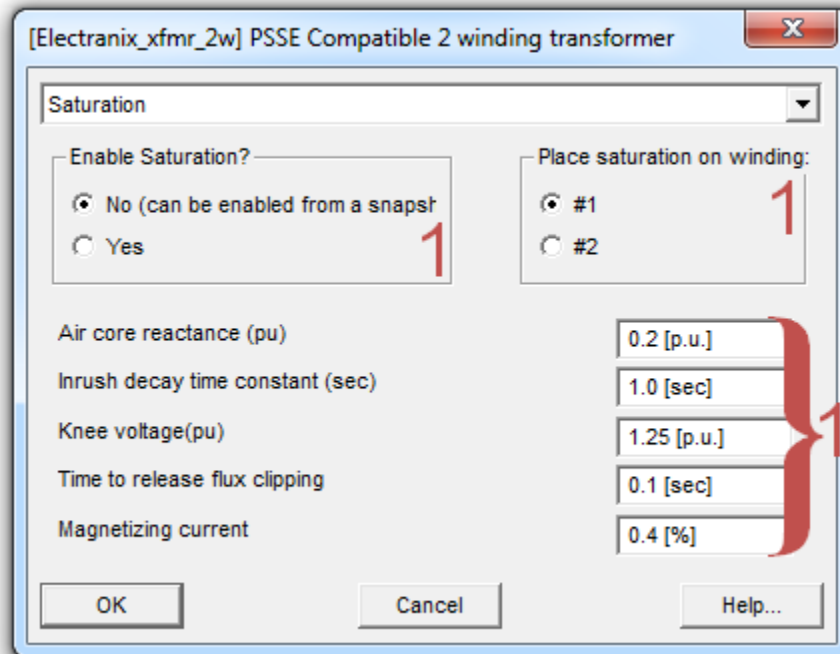
E-TRAN computes the correction factor based on the tap (or phase angle) and the appropriate Impedance Correction Table # that is available in the PSS/E .raw input file. If the tap setting or

phase angle is changed in PSCAD (i.e. not in the PSS/E .raw file and via E-TRAN), then you will have to manually consult the Impedance Correction Table, derive the Impedance Correction Factor, and re-enter it in this component.

Currently the Impedance Correction Table # is not used, but is transferred from the PSS/E .raw file for convenience. Future versions of PSCAD may allow the Impedance Correction Table to be entered directly into the Tap Changer subroutine, in which case the Impedance Correction Factor can be automatically updated to give the effect of the leakage reactance changing as a function of a phase shift or tap change.

5. Shunt Admittances can be entered at each end of the transformer to be consistent with the PSS/E .raw format. These are represented by constant RLC branches to ground. When the device is disabled, the shunts at each end are also disabled.

The dialog shown below appears when editing the **Saturation** page of the two winding transformer/phase shifter model:



1. Saturation is represented in the PSCAD transformer models by use of the TSAT21 subroutine (consult the PSCAD User's Manual for more information on the theory of saturation).

The last page of the data entry (**Monitoring of Currents and Fluxes**) lets the user measure the following quantities:

- Name for winding #1 line currents (kA, into winding, not including inrush current)
- Name for winding #2 line currents (kA, into winding, not including inrush current)



- Name for magnetizing currents (kA)
- Name for flux linkages (kWb-N)

To monitor these quantities:

1. Enter a unique name at the desired parameter (such as "I meas\_T1\_W1")
2. Go back to your PSCAD circuit and place a "datalabel" (with the same name as above i.e."I meas\_T1\_W1")
3. Connect the datalabel to a "channel" component
4. Right click on the channel component to select a plot for this signal

Click "**OK**" to save your changes and exit to PSCAD or click "**Cancel**" to exit without saving your changes.

### 7.7.1 Three Winding Transformer

Three winding transformers are translated by E-TRAN as follows:

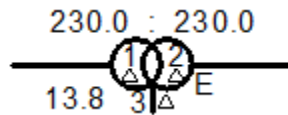
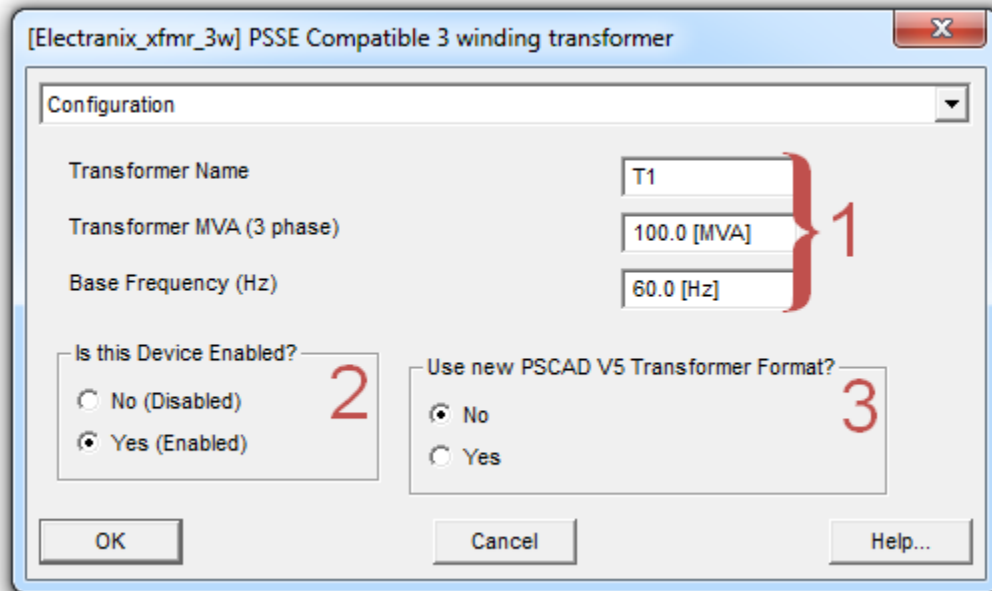


Figure 7.9 Symbol of the E-TRAN three winding transformer model.

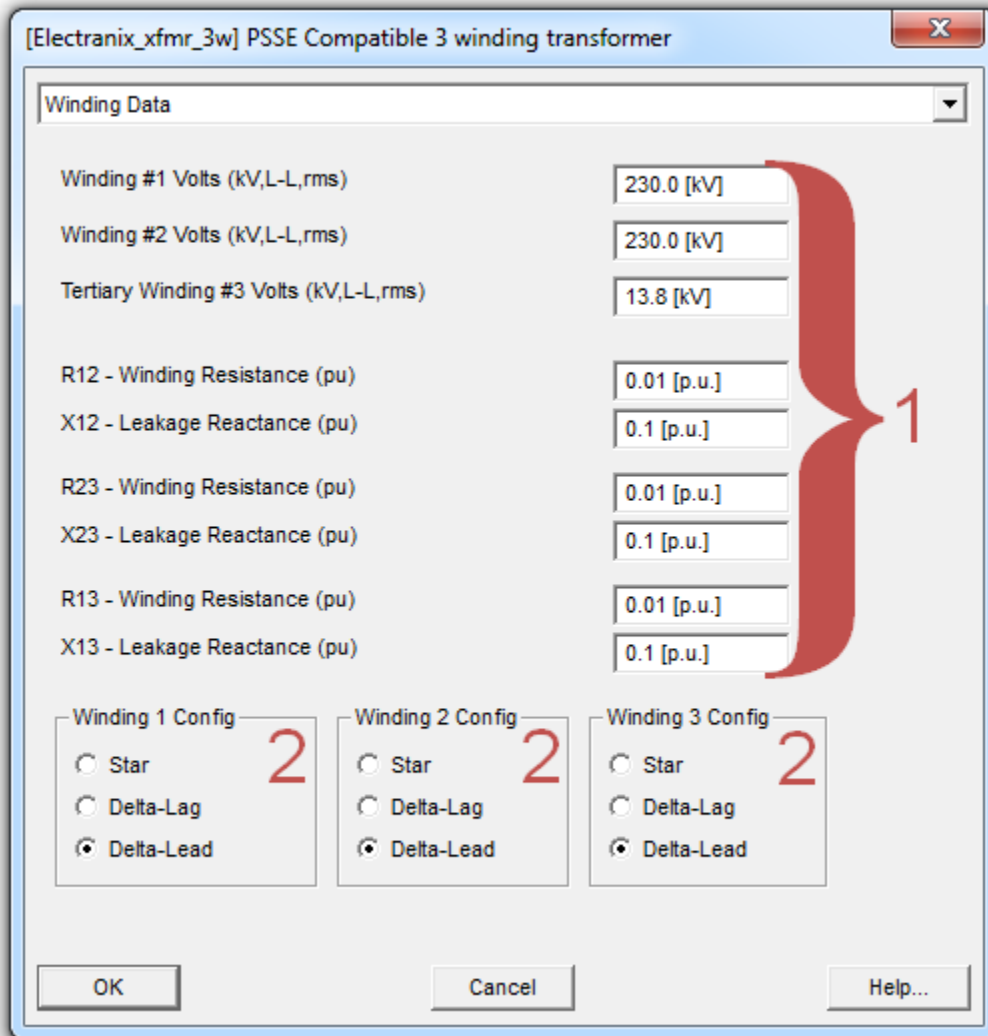
## E-TRAN User's Manual

The dialog shown below appears when editing the **Configuration** page of the three winding transformer model:



1. Refer to section 7.2 for an explanation on the system of units for data entry.
2. If you disable this device, then the component will appear as “grayed out” and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E .raw file.
3. The new PSCAD v5 transformer format can be selected.

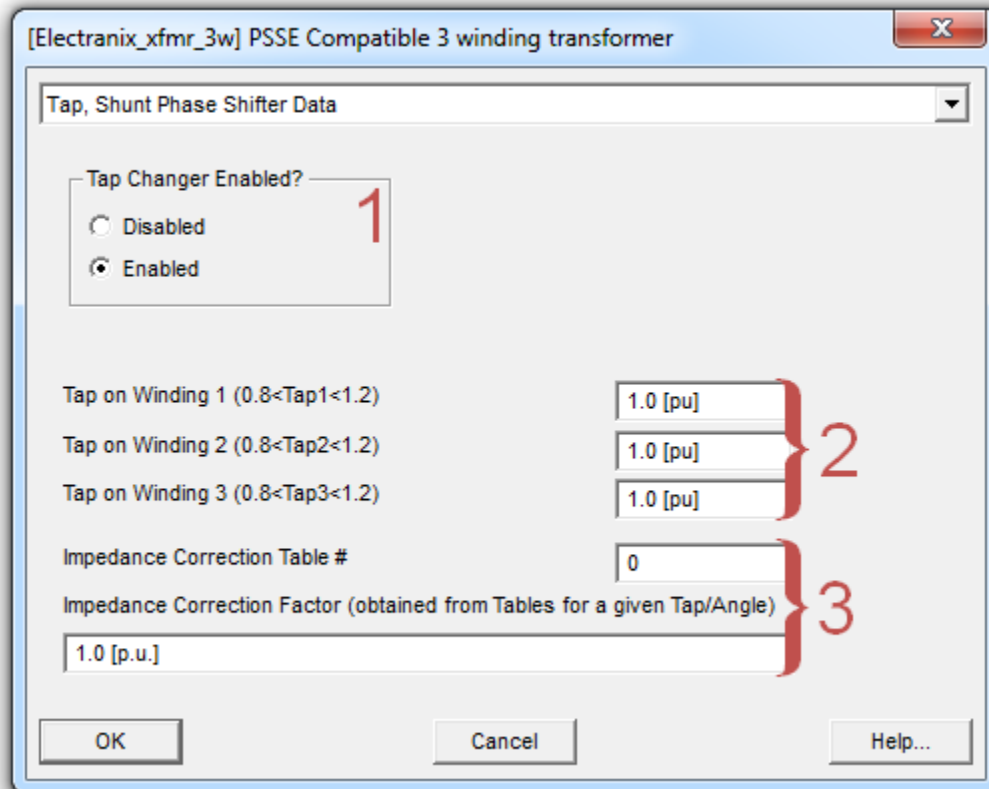
The dialog show below appears when editing the **Winding Data** page of the three winding transformer model:



1. Refer to section 7.2 for an explanation on the system of units for data entry.
2. Winding 1, Winding 2, and Winding 3 can be Star, Delta-Lag, or Delta-Lead. Use the radial buttons to select the required winding configuration.

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The dialog shown below appears when editing the **Tap, Shunt Phase Shifter Data** page of the three winding transformer model:

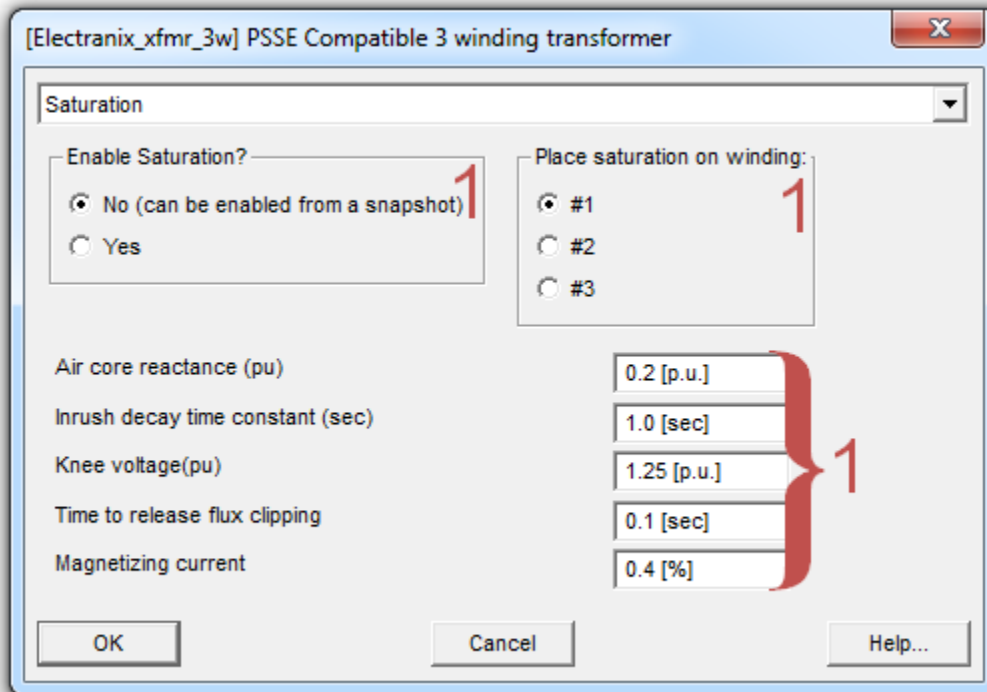


1. This transformer can have the tap changer enabled or disabled. Use the radial buttons to enable or disable the tap changer.
2. Taps will be initialized based on the configuration in the .raw file.
3. The Impedance Correction Factor is used as a multiplier to the series leakage reactance.

E-TRAN computes the correction factor based on the tap (or phase angle) and the appropriate Impedance Correction Table # that is available in the PSS/E .raw input file. If the tap setting or phase angle is changed in PSCAD (i.e. not in the PSS/E .raw file and via E-TRAN), then you will have to manually consult the Impedance Correction Table, derive the Impedance Correction Factor, and re-enter it in this component.

Currently the Impedance Correction Table # is not used, but is transferred from the PSS/E .raw file for convenience. Future versions of PSCAD may allow the Impedance Correction Table to be entered directly into the Tap Changer subroutine, in which case the Impedance Correction Factor can be automatically updated to give the effect of the leakage reactance changing as a function of a phase shift or tap change.

The dialog shown below appears when editing the **Saturation** page of the three winding transformer model:



1. Saturation is represented in the PSCAD transformer models by use of the TSAT21 subroutine (consult the PSCAD User's Manual for more information on the theory of saturation).

The last page of the data entry (**Monitoring of Currents and Fluxes**) lets the user measure the following quantities:

- Name for winding #1 line currents (kA, into winding, not including inrush current)
- Name for winding #2 line currents (kA, into winding, not including inrush current)
- Name for winding #3 line currents (kA, into winding, not including inrush current)
- Name for magnetizing currents (kA)
- Name for flux linkages (kWb-N)

To monitor these quantities:

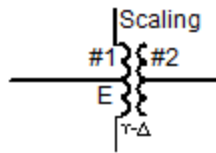
1. Enter a unique name at the desired parameter (such as "lmeas\_T1\_W1")
2. Go back to your PSCAD circuit and place a "datalabel" (with the same name as above i.e."lmeas\_T1\_W1")

3. Connect the datalabel to a "channel" component
4. Right click on the channel component to select a plot for this signal

Click "**OK**" to save your changes and exit to PSCAD or click "**Cancel**" to exit without saving your changes.

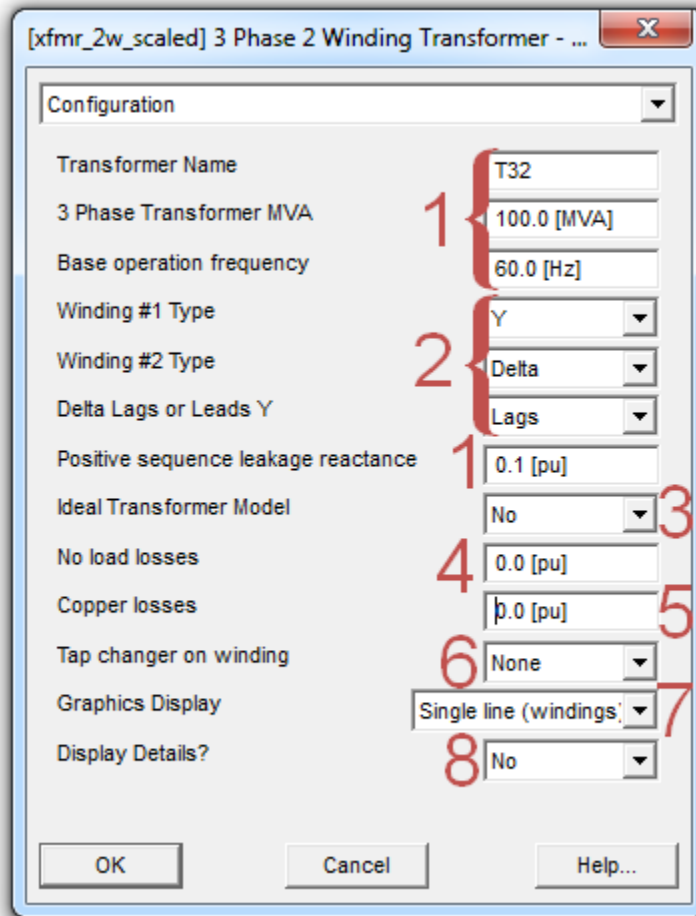
### 7.7.2 Current Scaling Transformer

The scaling transformer component can be used to scale electrical quantities (For example, scaling a wind plant from one turbine to represent an entire plant.) Quantities should be entered on the "pre-scaled" base.



*Figure 7.10 Symbol of the Transformer Current Scaling Component.*

The dialog show below appears when editing the **Configuration** page of the current scaling transformer model:



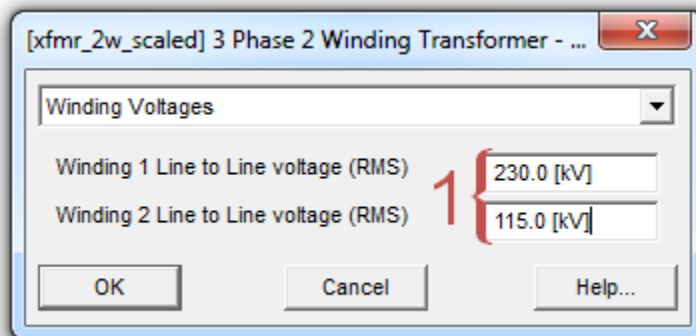
1. Refer to section 7.2 for an explanation on the standard system of units for data entry.
2. Winding #1 and Winding #2 can be of type Y or type Delta. Then you can select whether Delta **Lags** or **Leads** Y.
3. You can choose for this to be an ideal transformer model. Use the down arrow to either select yes or no.
4. No load losses.
5. Copper losses.
6. This component can have the tap changer placed on one of its windings. Use the down arrow to select which winding to place the tap changer on.
7. The “Graphics Display” can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase

circuit.

Three phase transformers are represented with a three single phase mutually coupled transformers. This representation is valid if the actual transformers are built from single phase units, and will be reasonable accurate for 5 limb core transformers. If the transformer is a 3 limb core transformer, then the UMEC transformer model in the PSCAD Master Library should be used (this model requires more detailed data, such as the core geometry).

8. Select Yes to this question then the transformer MVA and winding voltages will be displayed on the diagram.

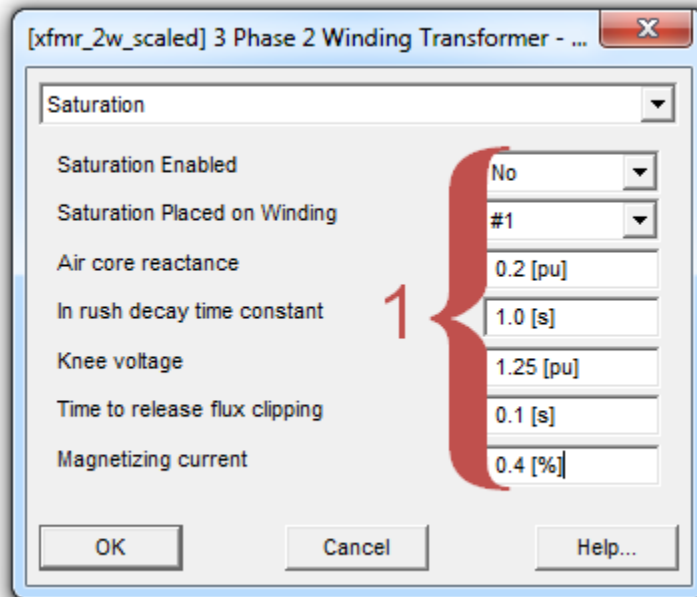
The dialog shown below appears when editing the **Winding Voltages** page of the current scaling transformer model:



1. Refer to section 7.2 for an explanation on the system of units for data entry.



The dialog shown below appears when editing the **Saturation** page of the current scaling transformer model:



1. Saturation is represented in the PSCAD transformer models by use of the TSAT21 subroutine (consult the PSCAD User's Manual for more information on the theory of saturation).

The last six pages of the data entry (Monitoring of Currents and Fluxes) lets the user measure the following quantities:

- Instantaneous winding currents (kA)
- Magnetizing current (kA)
- Flux (kWb-N)

To monitor these quantities:

1. Enter a unique name at the desired parameter (such as "lmeas\_T1\_W1")
2. Go back to your PSCAD circuit and place a "datalabel" (with the same name as above i.e."lmeas\_T1\_W1")
3. Connect the datalabel to a "channel" component
4. Right click on the channel component to select a plot for this signal

Click **"OK"** to save your changes and exit to PSCAD or click **"Cancel"** to exit without saving your changes.

## 7.8 Switched Shunts

The model interfaces to the electrical network as a constant RLC branch. The model does not represent the switching actions of adding/removing various stages of the switched shunt nor does it represent a reactive power controller.

The initial PQ values are taken from the loadflow file based on the number of device stages currently in operation at the loadflow set point.

The text shown on the model in Figure 7.11 (0.0 +j25 above) is the power flow at the rated voltage set point.

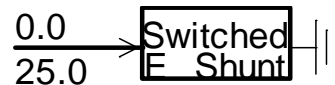
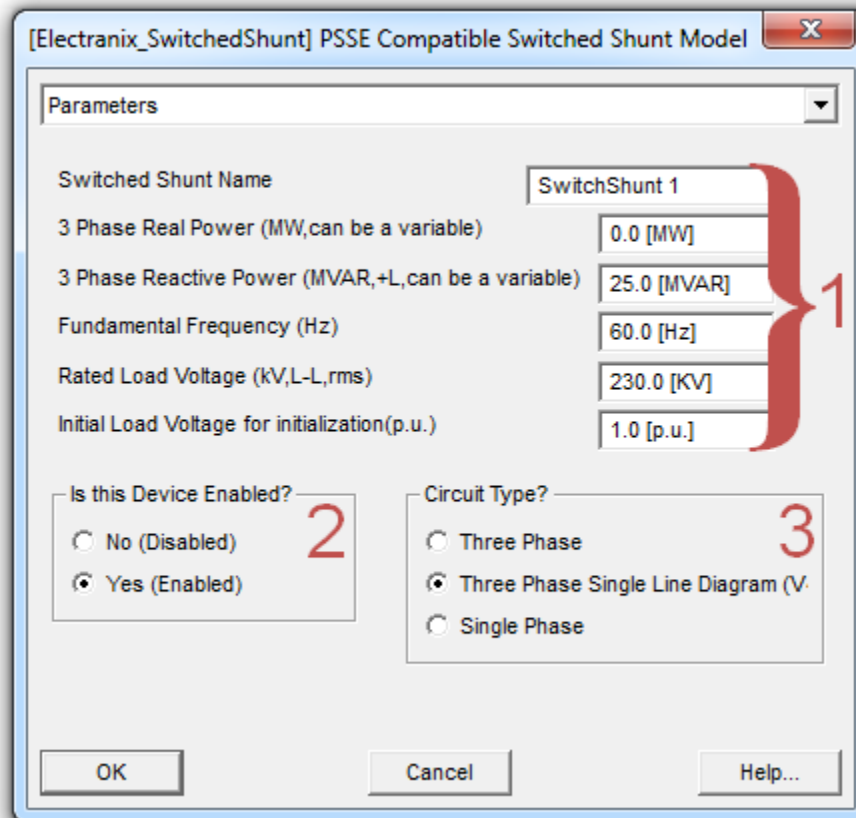


Figure 7.11 Symbol of the E-TRAN Switched Shunt model.

The dialog shown below appears when editing the **Parameters** page of the switched shunt model:



1. Refer to section 7.2 for an explanation on the standard system of units for data entry.
2. If you disable this device, then the component will appear as “grayed out” and the circuit

simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E .raw file.

3. The "Circuit Type" can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase circuit (V3 or V4). Note the parameters always ask for 3 phase PQ and the line to line voltage, even if the device is operating in a single phase circuit (see section 7.2).

The next page of the data entry (Outputs) lets the user measure the actual PQ flow into the device as well as the instantaneous current. To monitor these quantities:

1. Enter a unique name at the desired parameter (such as "Pmeas\_SwSh1")
2. Go back to your PSCAD circuit and place a "datalabel" (with the same name as above i.e. "Pmeas\_SwSh1")
3. Connect the datalabel to a "channel" component
4. Right click on the channel component to select a plot for this signal

Click "**OK**" to save your changes and exit to PSCAD or click "**Cancel**" to exit without saving your changes.

## 7.9 Switched Shunt Capacitor or Reactor Control

E-TRAN provides a custom component for simulating a simple voltage controlling switched shunt device. This component may be used in conjunction with an SVC (for example).

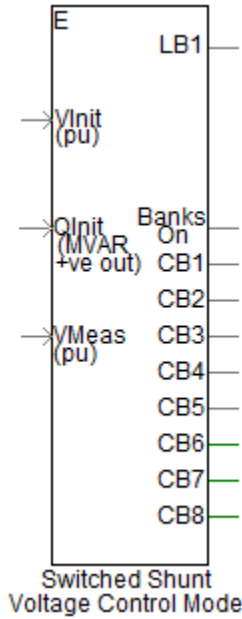


Figure 7.12 Symbol for the E-TRAN switched shunt capacitor or reactor control.

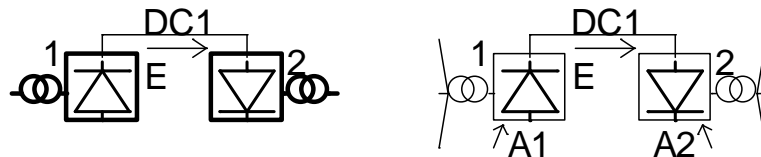
### 7.10 DC Links

This model is a simple version of a DC link based on the steady state phasor equations of a DC link (also what is used in loadflow programs), which is:

$$|V_{dcR}| = \left( 3 \cdot \frac{\sqrt{2}}{\pi} \cdot E_{vR} \cdot \cos(\alpha_R) - \frac{3 \cdot X_{cR} \cdot I_{dcR}}{\pi} \right)$$

Where:

- $V_{dcR}$  = DC Voltage across 1 six pulse group (kV)
- $E_{vR}$  = Converter Transformer Secondary (i.e. Valve Side) Rated Voltage (kV, L-L, RMS)
- $\alpha_R$  = Converter Firing Angle
- $X_{cR}$  = Converter Transformer Leakage Reactance (converted to ohms on the valve side)
- $I_{dcR}$  = DC Current (kA)



*Figure 7.13 Symbol of the E-TRAN DC link single phase and three phase view respectively.*

The Rated DC Voltage should be divided by the total number of six pulse valve groups before this equation is applied.

A more detailed representation of a DC link is possible in PSCAD/EMTDC by using commutation-based models (such as the G6P200 valve group model in the PSCAD Master Library) or by constructing the valve group from individual thyristors.

The commutation models will be more accurate, but require more expertise in the design and implementation of the firing controls etc... If you are primarily interested in getting the correct fundamental frequency power flow and control response (or if you do not have any more detailed information available), then the E-TRAN DC Link model is suitable.

This simple DC link model interfaces to the ac electrical network as a voltage source at each end of the DC link. The model internally computes and outputs the DC Voltage and DC Current [the current is computed via an integration of the voltage across the DC line using the DC Resistance and the total DC inductance (Line inductance plus the Smoothing Reactors at each end)].

The model has internal DC controls (described below) but can accept firing angles from external DC controls.

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The dialog shown below appears when editing the **Configuration and DC Data** page of the DC link model:

[Electranix\_DCLink] DC Link

Configuration and DC Data

DC Link Name: DC1

Rated DC Line Voltage (kV for all groups): 100.0 [kV]

Rated DC Current (kA): 1.0 [kA]

DC Line Resistance (ohms - may be 0.0): 1.0 [ohm]

DC Line Inductance (Henries - may be 0.0): 0.0 [Henries]

Run Control (0 to Block, 1 to Run, can be a variable): 1

Direction of Power (1 for 1-->2, -1 for 2-->1, can be a variable): 1

Are Ratings Specified at Rect or Inv?

Rectifier

Inverter

Use Fast Initialization?

No (use Initial Firing Angles After Di)

Yes (Auto-calc of Initial Firing Angle)

Use Internal or External Controls?

Use Internal Controls

Use External Controls

Infinite Bus at Each AC Terminal

Circuit Type?

Three Phase

Three Phase Single Line Diagram (V)

Single Phase

Is this Device Enabled?

No (Disabled)

Yes (Enabled)

Input Alpha in Degrees or Radians?

Degrees

Radians

OK Cancel Help...

1. The Rated DC Voltage should be entered for all six pulse groups (i.e. it is the DC Line Rated Voltage). For example:
  - If this is a 500 kV monopolar DC link with 2 six pulse valve groups (one star and one delta), then enter 500 kV (and enter 2 for the Number of Valve Groups in the next parameter section).
  - If this is a +/- 500 kV bipolar DC link with 2 six pulse valve groups in each pole, then enter

1000 kV (and enter 4 for the Number of Valve Groups in the next parameter section).

- A twelve pulse valve group should be considered as 2 six pulse valve groups (one star and one delta).

The DC Line Resistance and Inductance should be entered as the equivalent value for the normal mode of operation. If you have a bipolar DC Link, enter the DC Resistance and Inductance of a single pole.

2. Run Control: Enter 1 to always run the DC link (0 to Block). Typically this is a variable name (such as "RunDC"), which lets you construct a 0,1 signal with any standard PSCAD component (perhaps the manual switch). You should then connect a datalabel (to the output of the component) with the same variable name entered.
3. The Direction of Power can be entered as an integer (i.e. 1 or -1), or it can be a variable name. A value of 1 indicates a +ve DC Power Flow from Converter 1 to Converter 2 (the converter numbers 1 and 2 are shown on the model).
4. The ratings can be specified at the Rectifier or the Inverter. The DC Voltage can change (due to the line drop due to the DC resistance) so the ratings must be specified at one end (usually the Rectifier).
5. Use Fast Initialization is a feature to force the DC link to reach steady state sooner. It will calculate the firing angles at each converter in order and initialize the DC link controls.

If the Fast Initialization feature is not used, then each converter will have its controls initialized to the "Initial Firing Angle After Deblock" value (on the Rectifier or Inverter Control Parameters page), usually 90 degrees. The normal control gains and time constants will then be used to reach an operating point (in much the same way as a recovery from a fault or block).

6. Use Internal or External Controls – This DC link model has an internal built-in control system (see the Rectifier or Inverter Control Parameters page) which can be used, or the user can model the controls with their own models and then pass the firing angle to this model.

A third option (Infinite Bus at Each AC Terminal) will result in an ideal voltage source (i.e. 0.0 resistance) at each converter. The voltage source magnitude and phase are taken directly from the loadflow file and entered in the "Converter 1(2) Data" parameter page.

This feature is useful if a DC link does not start up properly and you would like to debug the case to see if the problem is due to the DC control system or if the problem is elsewhere in the network.

7. The "Circuit Type" can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (PSCAD V4 only) or a Single Phase circuit (V3 or V4).
8. If you disable this device, then the component will appear as "grayed out" and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is

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directly obtained from the status of this device in the PSS/E .raw file.

9. Input Alpha in Degrees or Radians – This parameter is only used if you select the “Use External Controls” option above. Many of the standard PSCAD Master Library HVDC Control system models output radians.

The next 2 parameter pages (for Converter 1 and 2) appear as follows:

The dialog shown below appears when editing the **Converter 1 Data** and **Converter 2 Data** pages of the DC link model:

Parameter	Value	Order
Converter 1 Frequency (Hz)	60.0 [Hz]	1
Converter 1 Rated Primary AC Voltage (kV,L-L,RMS)	230.0 [kV]	2
Converter 1 Rated Valve Side AC Voltage (kV, L-L, RMS)	40.0 [kV]	3
Converter 1 Number of Series Valve Groups	2	4
Converter 1 Leakage Reactance (pu on Transformer Base MVA)	0.1 [pu]	5
Converter 1 Transformer Base MVA (3 phase MVA)	60.0 [MVA]	6
Converter 1 Tap Setting (pu, valve side/primary side)	1.0	7
Converter 1 DC Voltage Transducer Time Constant (sec) - Suggest 0.01	0.01 [sec]	1
Converter 1 DC Current Transducer Time Constant (sec) - Suggest 0.01	0.01 [sec]	2
Converter 1 Smoothing Reactor (Henries - may be 0.0)	0.1 [H]	3
Converter 1 Initial AC Bus Volts (pu)	1.0 [pu]	4
Converter 1 Initial AC Bus Phase (deg)	0.0 [°]	5

1. Refer to section 7.2 for an explanation on the standard system of units for data entry.
2. The Number of Series Valve Groups parameter should be the total number of six pulse valve groups. For example:
  - If this is a 500 kV monopolar DC link with 2 six pulse valve group (one star and one delta six pulse group), then enter 2 for the Number of Valve Groups (and 500 kV for the Rated DC Voltage in the previous parameter section).
  - If this is a +/- 500 kV bipolar DC link with 2 six pulse valve group in each pole, then enter 4 for

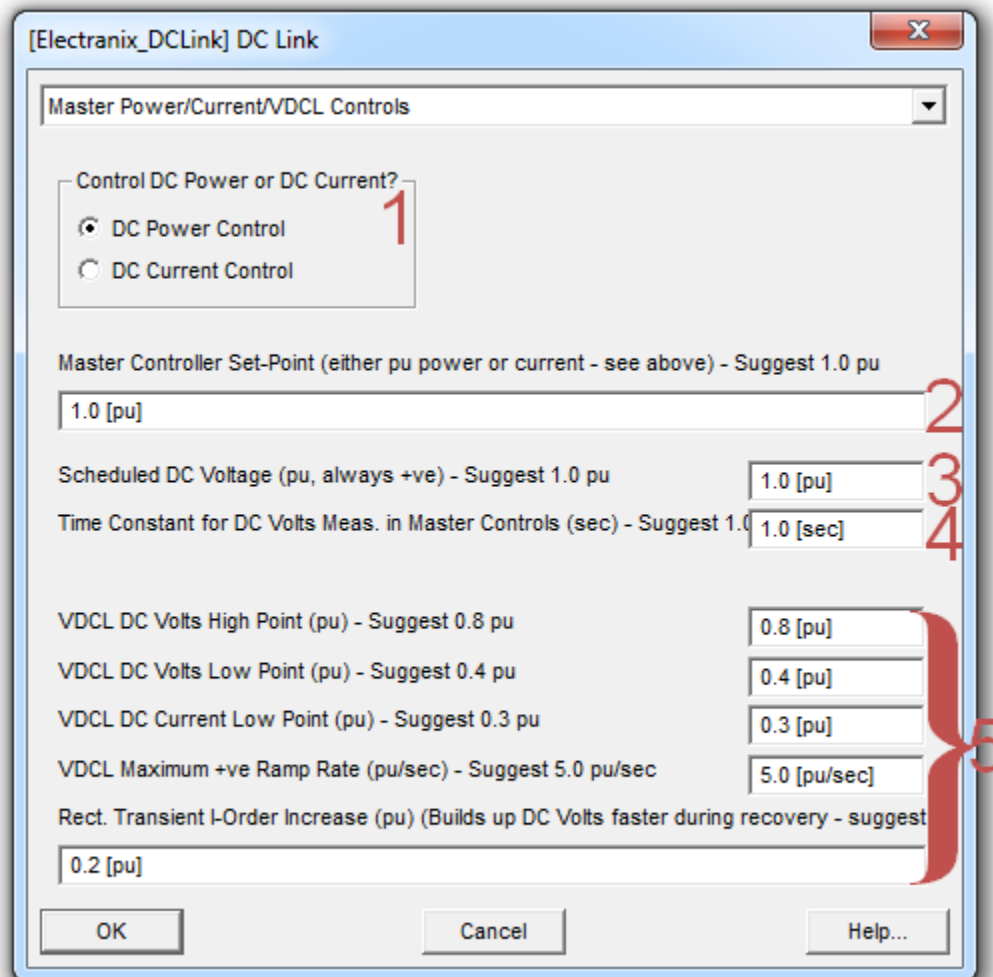


the Number of Valve Groups (and enter 1000 for the Rated DC Voltage in the previous parameter section).

- A twelve pulse valve group should be considered as 2 six pulse valve groups (one star and one delta).
3. The Transformer Leakage Reactance is entered in PU on the Transformer Base MVA (which is a three phase MVA rating). These parameters are used to convert the leakage reactance in PU into Henries.
  4. The Tap Setting (pu) is based on the Valve Side Voltage / Primary Side Voltage. A Tap Setting greater than 1.0 will result in a larger voltage applied on the DC side of the valve group.
  5. The DC Voltage and DC Current Transducer Time Constants are used in a simple measurement of the DC quantities. The transducer response is implemented as a simple first order lag (real pole).
  6. The Smoothing Reactor value should be entered at each end (enter 0.0 if this scheme does not have a smoothing reactor).
  7. The Initial AC Bus Volts and Angle are used in the Fast Initialization feature and when each converter is represented as an Infinite Bus (see the previous parameter page).

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The dialog shown below appears when editing the **Master Power/Current/VDCL Controls** page of the DC link model:

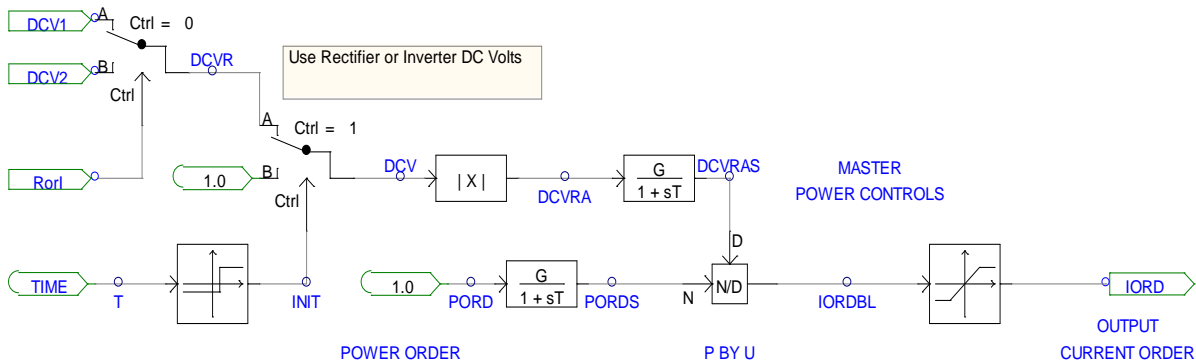


1. The Master Controls can either control the DC Power or the DC Current.
2. The Master Controller Set-Point can be either a power order (pu) or a current order set point (pu), depending on the parameter above.
3. The Scheduled DC Voltage is used by Fast Initialization feature (main parameter page) and is also used as the Set-Point for the DC Voltage Control Mode (see the Main Control circuit on the following pages).
4. Time Constant for DC Volts Measurement in Master Controls is used to smooth or low-pass filter the measured DC Voltage before being applied to the "P by U" (Power divided by Voltage) so as to avoid oscillations in the DC Current Order output of the Master Controls.
5. The Voltage Dependant Current Limit control block diagrams are shown on the next page.

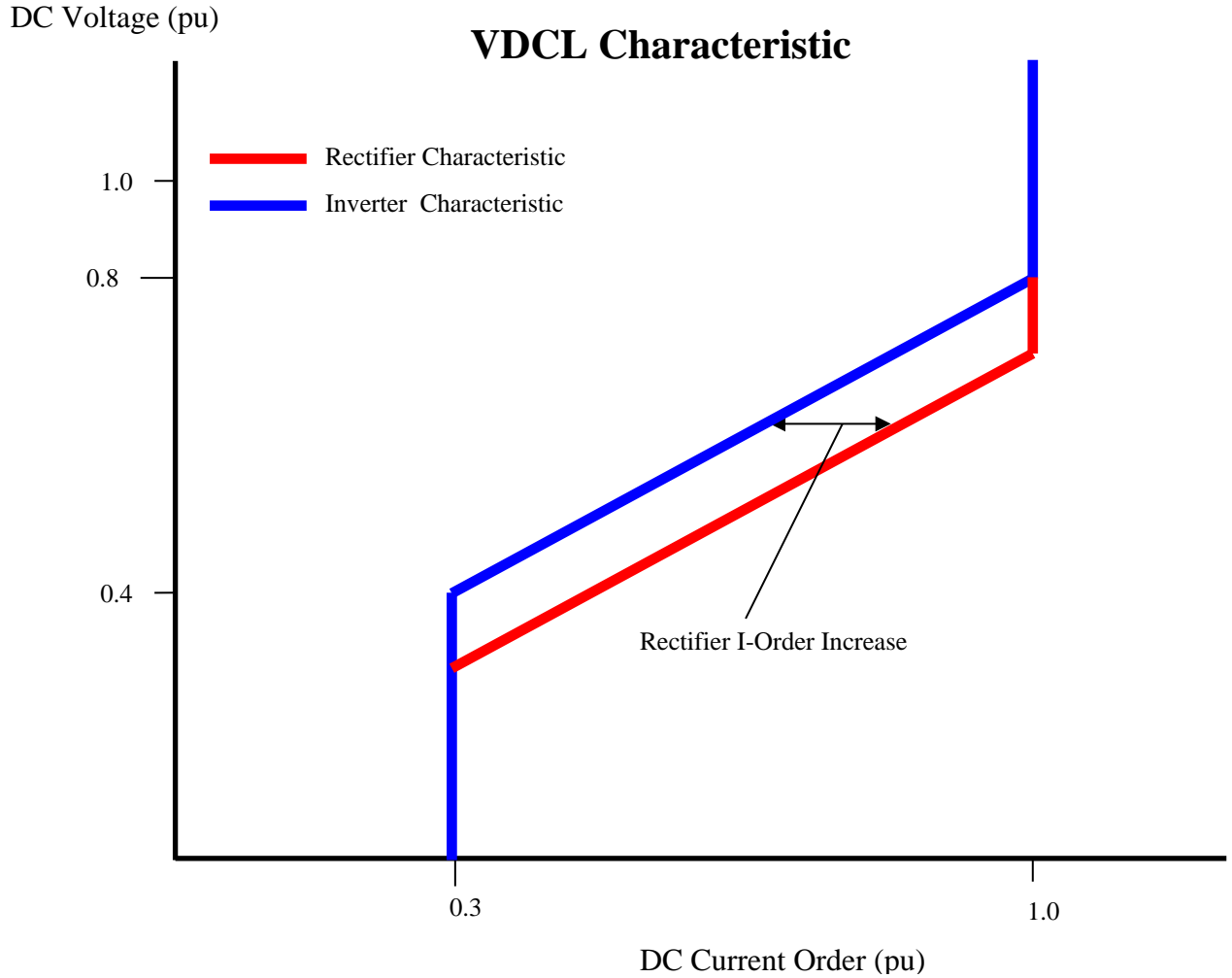
The Rectifier I-Order Increase parameter is used to transiently create a higher current order at the Rectifier than at the Inverter (this is achieved by effectively using a different VDCL characteristic at the Rectifier). This will build up the DC Voltage faster during recovery from faults (since both the Rectifier and Inverter can be in current control mode). In the internal controls, this effect is implemented as a dynamic current margin.

Not shown on the VDCL VI diagram is the parameter “VDCL Maximum +ve Ramp Rate (pu/sec)”. The output of the VDCL (the current order) is rate-limited in the +ve direction to prevent fast set-point changes in the DC link (which can often result in commutation failures and oscillations).

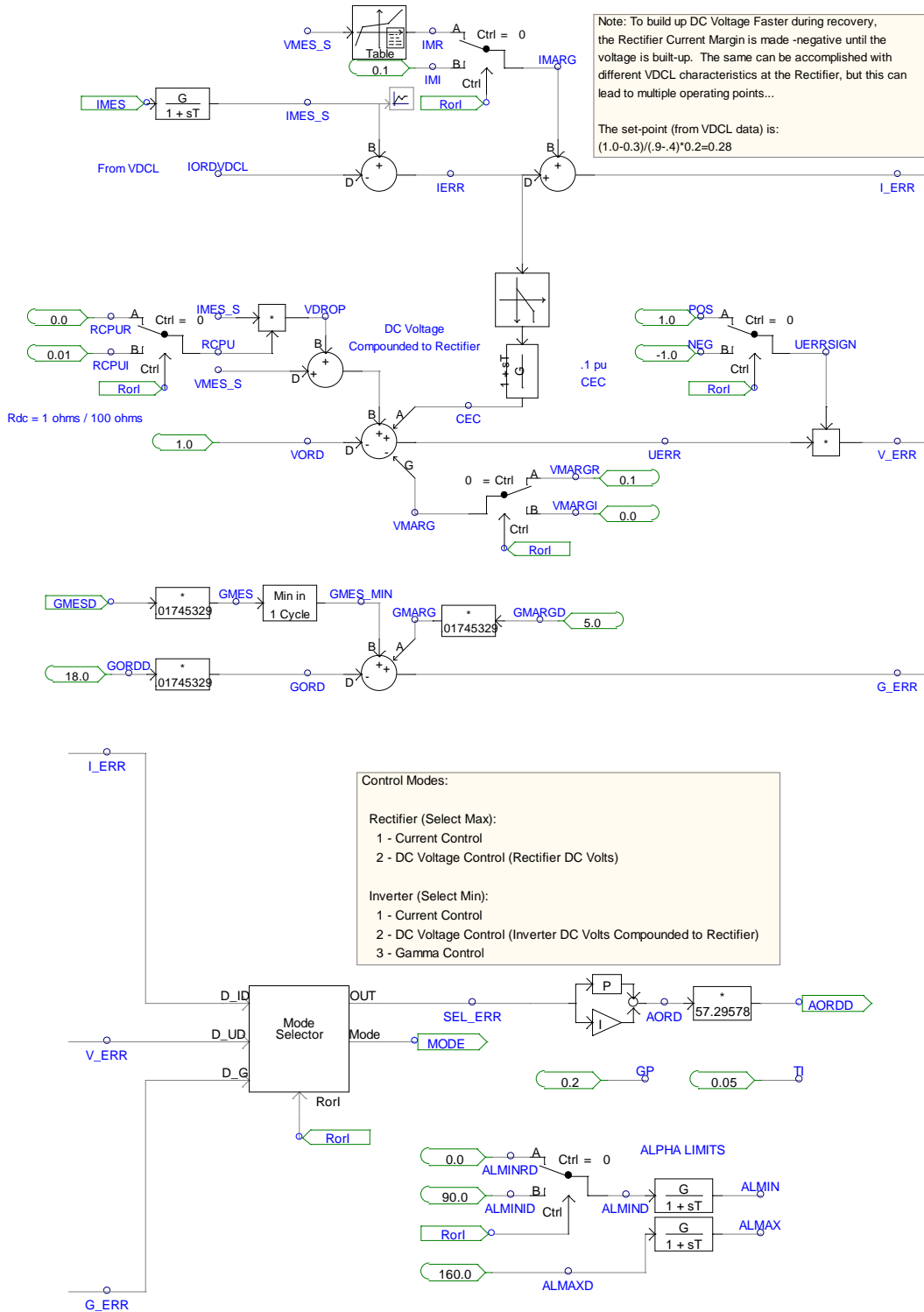
The internal Master Power Controls are based on the following diagram:



A Voltage Dependant Current Limit (VDCL) is used to lower the DC Current Order when the DC Voltage is low. The block diagram for the internal VDCL Controls is based on the following VI diagram:



The Rectifier and Inverter have a nearly identical control circuit as shown below:



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The dialog shown below appears when editing the **Inverter Control Parameters** page of the DC link model:

Parameter	Value	Group
Proportional Gain (Input-pu or rad, Output-rad) - Suggest 0.2	0.2	1
Integral Time Constant (Input-pu or rad, Output-rad) - Suggest 0.05	0.05	
Minimum Alpha (deg) - Suggest 90 Deg	90.0 [°]	2
Maximum Alpha (deg) - Suggest 160 Deg	160.0 [°]	
Nominal Inverter Extinction Angle (deg) - Suggest 18 deg	18.0 [°]	3
Current Margin (pu) - Suggest 0.1 pu	0.1 [pu]	4
DC Voltage Margin (pu) - Normally 0.0 for DC Voltage Control	0.0 [pu]	
Gamma Margin (deg) - Suggest 5 deg	5.0 [°]	
Initial Firing Angle After Deblock (deg) - Suggest 90 deg	90.0 [°]	5
Relative Gain of DC Current Controller - Suggest 1.0 or 0.0 to disable	1.0 [pu]	6
Relative Gain of DC Voltage Controller - Suggest 1.0 or 0.0 to disable	1.0 [pu]	
Relative Gain of Gamma Controller - Suggest 1.0 or 0.0 to disable	1.0 [pu]	

1. The PI controller has a proportional gain and an integral time constant which must be entered. This model also accepts variables (instead of constants) which allows the user the ability to make the PI gains non-linear (perhaps changing with the mode of operation). The input to the PI controller is PU (for DC voltage and current) and radians (for gamma control). The output of the PI controller is radians (this will be scaled later to Degrees for output).
2. The minimum and maximum firing angles are entered here (either as constants or variables). These are used internally in the PI controller (to prevent integrator wind-up) as well as applied to the final output of the controller. A good trick to initialize the PI controller is to set the min and max limits to the same value (this allows the user to perform ramps, etc. for deblocking and fault recovery).
3. The Nominal Extinction Angle (degrees) should be entered here (either as a constant or as a variable). This is the Gamma Order of the gamma control loop. Note the Gamma Margin will be added to the ordered value.

4. The Current, Voltage and Gamma Margins are entered next (either as constants or variables). One of these should be 0.0 in order to set the steady state operating point. The margins ensure that the different modes of operation do not conflict and “fight” each other.
5. The Initial Firing Angle After Deblock should be entered (in degrees, either as a constant or as a variable) to define the initialization of the control system after a blocking action. At the beginning of a run, this variable is used if the “Fast Initialization” feature is turned off.
6. The Relative Gains of each of the three control loops is used to allow the user to enter different gains and time constants for each loop. It is used as a multiplier in the errors of each control mode before it is used in the PI controller. If 0.0 is entered, then this disables that control mode.

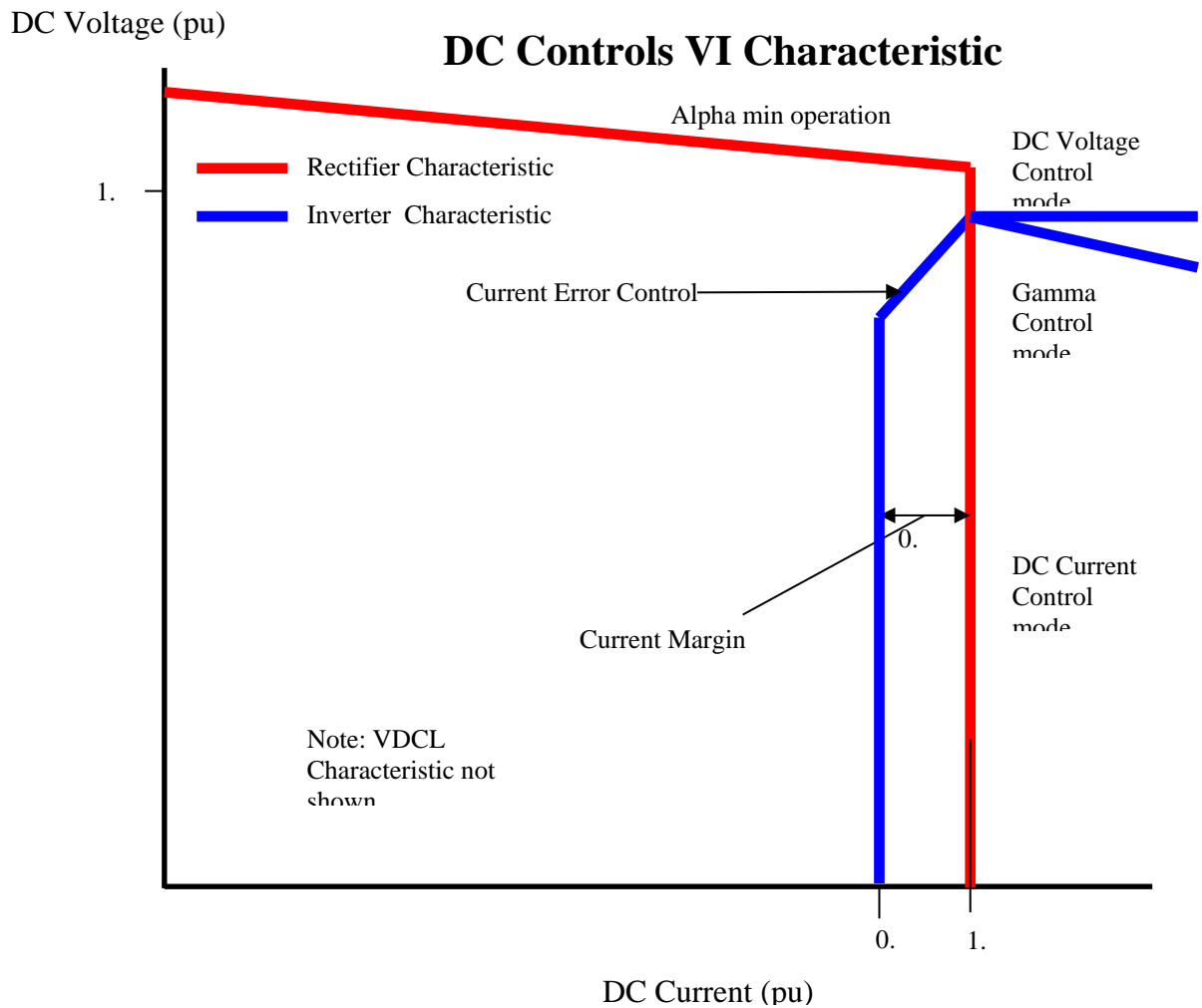
The Relative Gains allow each control mode to have a different gain, but does not allow the ratio of the Proportional Gain to the Integral Time Constant to be modified. If this is required, then you should enter variable names for the PI gain and time constant, and then modify these gains depending on which control mode is currently in use. It is recommended to use a realpole or lowpass filter to smooth changes in the proportional gain (otherwise a step in the output firing angle will result).

The last page of the data entry (Outputs) lets the user measure quantities internally calculated by the DC Link Model (including AC P,Q, DC Voltage and Current Measured, Gamma Measured, Alpha Ordered, Overlap Angle, Current Order and Control Mode).

To monitor these quantities:

1. Enter a unique name at the desired parameter (such as “IDC1”)
2. Go back to your PSCAD circuit and place a “datalabel” (with the same name as above)
3. Connect the datalabel to a “channel” component
4. Right click on the channel component to plot this signal

The DC Controls (shown earlier) effectively provide for DC Voltage, DC Current and Extinction Angle (Gamma) control modes of operation. This results in a VI diagram as shown below:



The control mode used at any instant is determined by a Select Min (at the Inverter) and a Select Max (at the Rectifier). The output of the selection component is the controller error, which is finally fed to the Proportional Integral controller (PI).

The Rectifier control circuit utilizes DC Voltage and DC Current control modes, whereas the Inverter adds a third control mode (Gamma Control).

The mode of operation (current control, voltage control or gamma control) is determined by the intersection of the Rectifier and Inverter control characteristics (in steady state this is determined by the margins).

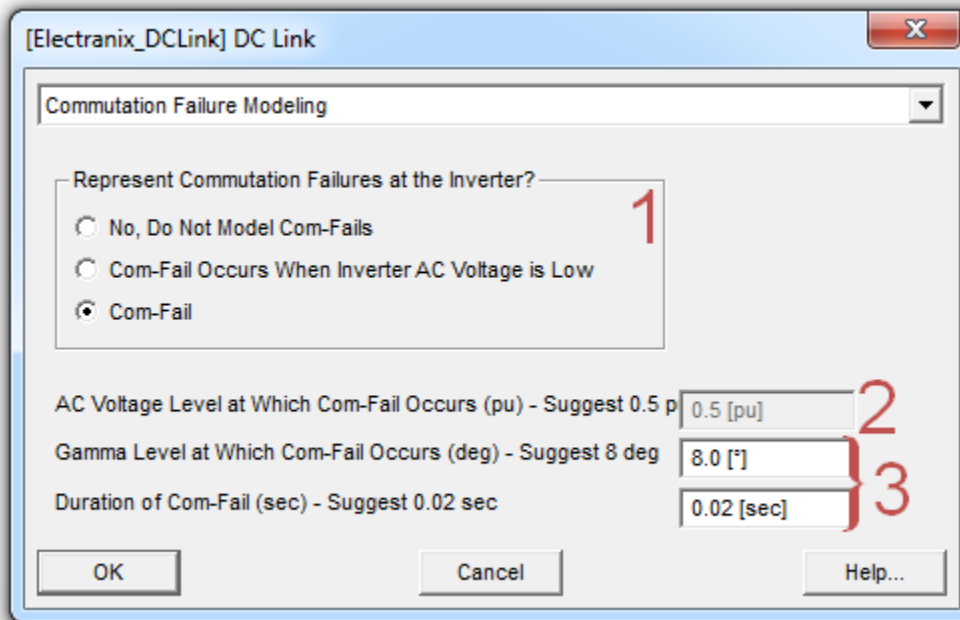
The Current Error Control will generate the “notch” characteristic (as shown above) to smooth the transition between DC Voltage and DC Current control modes. It operates in the current margin region and reduces the ordered DC Voltage by the same PU value as the current error (i.e. the slope



is 1.0).

The VDCL (see the previous section) control circuit will prevent the converter operating in a low voltage high current condition (it reduces the current order when the DC Voltage is too low).

The dialog shown below appears when editing the **Commutation Failure Modeling** page of the DC link model:



1. The Inverter can often suffer from a Commutation Failure (or Com-Fail) whenever there is an AC fault, large transient increase in DC Current or fast phase shift in the AC voltages. The Com-Fail occurs when 2 thyristors in the same phase or a valve group (i.e. Valve 1 and 4 for example) conduct at the same time.

Com-Fails are best represented by Commutation/Switching based models (such as the G6P200 valve group model in the PSCAD Master Library). In this DC link model, the instantaneous valve voltages are not available, so the true Com-Fail criteria cannot be reproduced. However, it is possible to approximate the Com-Fail based on the measurement of AC Voltage or based on the measured Gamma Extinction Angles.

In this phasor based DC link model, the com-fail will result in the Inverter DC Voltage being set to 0.0 and the AC Currents being injected into the Inverter bus being ramped to 0.0. The 0.0 DC voltage will cause the DC Current to quickly increase (as it is the integral of  $V_R - V_I$ ) until the Rectifier DC Current controls increase the firing angle to reduce the current back to its set-point (the set-point will no longer be 1.0 since the VDCL will have operated).

2. If the second option is selected (Com-Fail Occurs When Inverter AC Voltage is Low), then the AC Voltage Level can be entered. A Com-Fail will occur whenever the measured AC bus voltage is lower than the set-point, and the Com-Fail will clear once the AC Voltage rises above the entered

level.

This representation of Com-Fail is sometimes used in transient stability simulations.

3. If the third option is selected (Com-Fail Occurs When Inverter Extinction Angle is Low), then the measured Extinction Angle (not the Nominal Extinction Angle Order!) will be compared to the entered level.

This representation is based on the turn-off characteristics of a thyristor... When a thyristor turns off (at a current zero), the voltage across the thyristor must stay reverse biased for some period of time (known as the Minimum Extinction Time) or else the thyristor will re-fire.

Note in this phase based DC link model, the measured Gamma is calculated based on the DC link equations, whereas in the real system (or commutation models) the measured Gamma is based on a direct measurement of the time period in which the thyristor remains reverse-biased.

If this option is used, the Com-Fail will be held for a fixed duration (which the user enters, typically one cycle).

Click “OK” to save your changes and exit to PSCAD or click “Cancel” to exit without saving your changes.

### 7.11 Measurements

All AC measurements in E-TRAN are designed to extract +ve sequence, fundamental frequency quantities (corresponding to the output of loadflow/stability programs). This is challenging in a transients program in which the instantaneous calculation algorithm can produce distorted waveforms (due to harmonics etc...), DC offsets, changing frequencies etc... (these challenges are identical to those faced in the real system).

The E-TRAN measurements are performed using a recursive Discrete Fourier Transform (DFT) technique. The method developed:

- Eliminates all the effects of characteristic harmonics
- Outputs the RMS magnitude and phase angle of the fundamental frequency
- Reacts to transients over 1 period of the fundamental
- Uses minimum storage and uses a very efficient algorithm

Additional notch filtering is performed to eliminate non-characteristic harmonic distortions and DC offsets (the magnitude and gain effects introduced by the filtering functions are corrected for both magnitude and phase angle including frequency changes). The model also tracks changes in the fundamental frequency (as occurs when used with machine/generator models) and uses the measured frequency to update the filtering magnitude and phase correction terms...

The DFT algorithm has an inherent response delay of one cycle (the time period over which the Fourier Transformer is performed), so the corresponding voltage, P and Q measurements will have a corresponding delayed response time.

The PSCAD Master Library contains other measurement models (based on other techniques such as RMS etc...) which can be used as required.

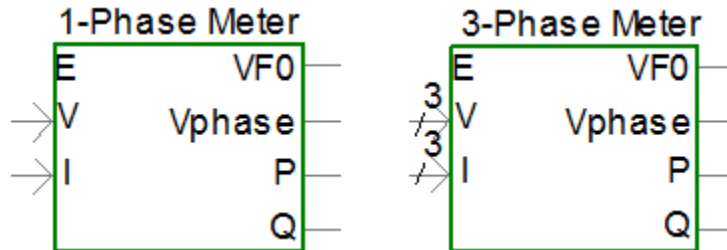


Figure 7.14 Symbols of the E-TRAN 1-phase and 3-phase Meters respectively.

## E-TRAN User's Manual

The dialog shown below appears when editing the **Main Configuration** page of the single or three phase meter:

[Electranix\_meter\_1phase] +ve Sequence Fundamental Frequency ...

Main Configuration

Monitor P and Q? **2**

No

Yes (requires current in)

Outputs in pu or kV,kA,MW,MVAR? **3**

kV,kA,MW,MVAR

pu

Base Voltage (kV,L-L,rms) 230.0 [kV]

Base MVA (3 phase) 100.0 [MVA]

Initial Frequency (Hz) 60.0 [Hz]

Name for Output Frequency (Hz)

Name for +ve Seq Fundamental Current Magnitude (kA,rms)

Name for +ve Seq Fundamental Current Phase (Deg)

Connection Type? **4**

Three Phase

Single Phase

OK Cancel Help...

1. Refer to section 7.2 for an explanation on the standard system of units for data entry.
2. This model can measure +ve sequence, fundamental frequency voltages as well as PQ flow (which requires voltage and current inputs).
3. Outputs can be in kV, kA, MW and MVAR or in Per Unit.
4. The "Circuit Type" can be selected so the component can measure Three Phase quantities (requires entry of array dimension 3 quantities), or Single Phase quantities.

A phase-locked loop (PLL) component is also provided by E-TRAN.

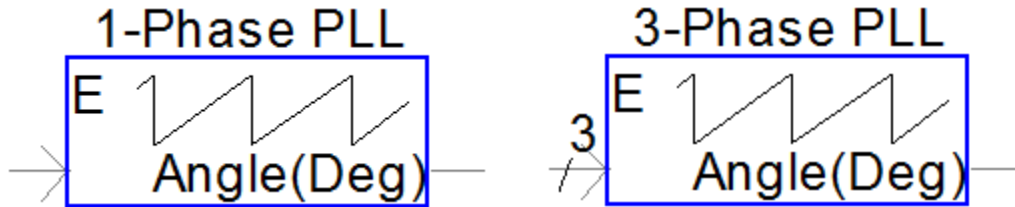


Figure 7.15 Symbols of the E-TRAN 1-phase and 3-phase locked loop respectively.

## 7.12 Series Capacitors

The Series Capacitor model in PSCAD outputs a fixed capacitance value into the PSCAD circuit.

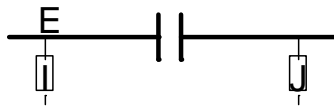


Figure 7.16 Symbol of the E-TRAN Series Capacitor model.

Note in PSS/E .raw format, a –ve X can also be entered in branches which are between busses of a different bus voltage or as part of an equivalent circuit for a 3 winding transformer.

When the bus voltages at each end of the branch are different (and the branch has not been identified as a transformer), E-TRAN will convert the branch to a transformer (not a series capacitor).

There is not enough information in the PSS/E .raw file format to distinguish between –ve reactance used as part of a 3 winding transformer equivalent circuit and –ve reactance for series capacitors.

For this reason, users should check the E-TRAN log file and also check all instances of Series Capacitors in the translated circuit to ensure the representation has been interpreted correctly.

The frequency response of a –ve inductance and a capacitance are very different even though they share the same fundamental frequency impedance!

## E-TRAN User's Manual

The dialog shown below appears when editing the **Main Configuration** page of the series capacitor model:

[Electranix\_SeriesCapacitor] Series Capacitor

Main Configuration

BRANCH NAME: Br1

Rated MVA (3 Phase): 100.0 [MVA]

Line Rated Frequency (Hz): 60.0 [Hz]

Rated Voltage (kV,L-L,rms): 230.0 [kV]

R - +ve Seq. Resistance (pu): 0.00336786 [p.u.]

X - +ve Seq. Reactance (pu - enter -ve for capacitor): 0.0593346 [p.u.]

Is this an Ideal Branch (R=0.0)?

No

Yes

Is this Device Enabled?

No (Disabled)

Yes (Enabled)

Circuit Type?

Three Phase

Three Phase Single Line Diagram (V4)

Single Phase

OK Cancel Help...

1. Refer to section 7.2 for an explanation on the standard system of units for data entry. Note the series X should be entered as –ve for capacitor values (as per the PSS/E format).
2. The branch can be made to be Ideal, in which case there is a direct short between the “from” and “to” busses. E-TRAN will make the device Ideal if the absolute value of the PSS/E .raw branch reactance is less than 0.0001 PU.
3. If you disable this device, then the component will appear as “grayed out” and the circuit simulation will ignore this component. The initial status of the device (i.e. enabled or disabled) is directly obtained from the status of this device in the PSS/E .raw file.
4. The “Circuit Type” can be selected so the component can be used in a Three Phase circuit (with 3 separate electrical connections), a Three Phase SLD (V4 only) or a Single Phase circuit (V3 or V4).

The next page of the data entry lets the user enter shunt admittances (similar to the line model) to

adhere to the PSS/E branch data format.

Click “OK” to save your changes and exit to PSCAD or click “Cancel” to exit without saving your changes.

### 7.13 Get/Set Common Component

The Common Get and Set models in PSCAD allow up to 1000 real quantities and 1000 integer quantities to be directly transferred between pages or sub-pages in a PSCAD circuit. They are designed to be “stacked” so multiple variables can be entered/retrieved at one time.

This component is used to control the E-TRAN load model. By default the load model is initialized to the values determined by the loadflow, and released after 10 seconds.



Figure 7.17 Symbols of the E-TRAN Common Get and Set components.

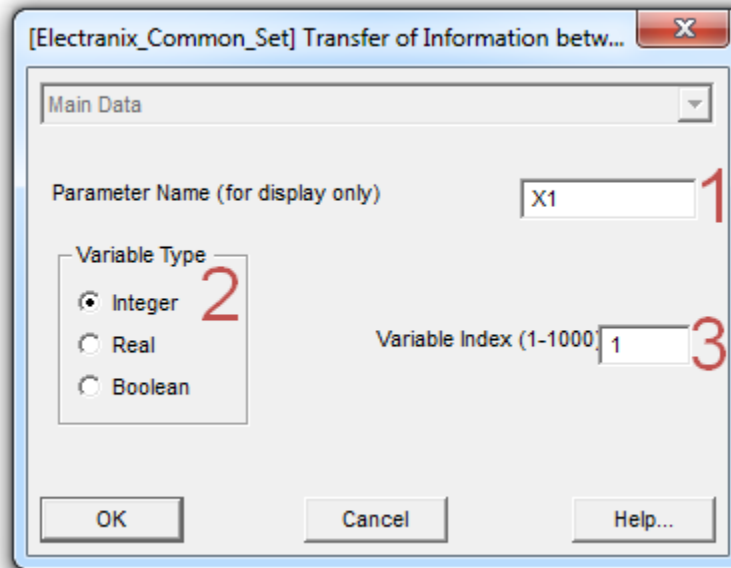
The normal way of transferring control signals from one page to another in PSCAD is to use the Import and Export features to transfer the signals from the current page to a higher/lower level page. This requires modifying the page component definition and can be very time consuming (particularly if you have multiple levels of page components).

This component transfers the information between pages using a Common Block. This method has the advantage that it can transfer a variable from any page directly to another page, but it does not control the order in which the Set and Get operations are performed. For this reason, it is suggested that this model only be used for constants or for variables which do not depend critically on the order of the Get/Set operation.

The normal Import/Export method is more difficult to use, but it ensures that the Set operation is always performed before the Get in the same time step...

## E-TRAN User's Manual

The dialog shown below appears when editing the **Main Data** page of the get/set common component model:



1. The parameter name is used only on the graphical display in PSCAD. You can enter a single space if you do not want a label to appear.
2. Select either an Integer, Real or Boolean (logical true or false) variable type.
3. Enter the Variable Index, which is the array element to transfer. This is what separates one real number from another, as they will read/write to a unique element of an array in the Common block.

Click **“OK”** to save your changes and exit to PSCAD or click **“Cancel”** to exit without saving your changes.

### 7.14 Initialization Components

The Initialization components should be placed on a sub-page of a model in the Substitution Library (see Chapter 5.0 How to use the Substitution Library).



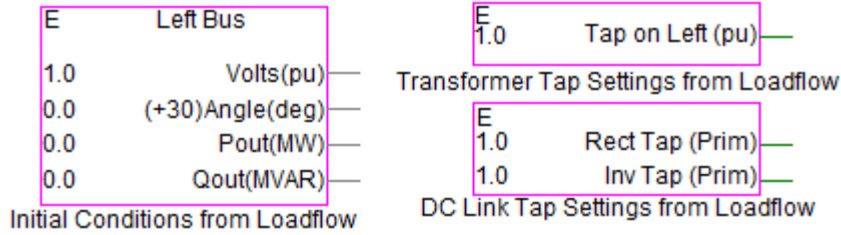


Figure 7.18 Symbols of E-TRAN components for reading initial conditions, Transformer Tap Settings, DC Link Tap Settings from loadflow data in a “.raw” file.

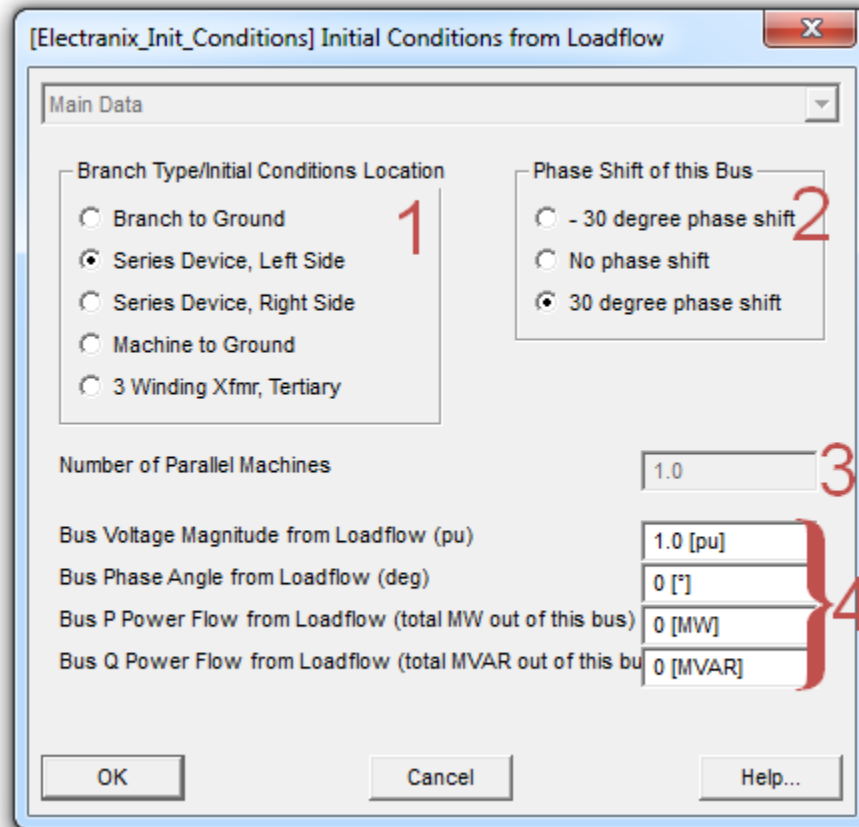
If E-TRAN encounters the initial conditions component in a sub-page in the Substitution Library, it will automatically replace its data with the initial terminal voltage, phase angle, real power and reactive power (calculated based on the loadflow solution). This information can be used to initialize any device contained on the sub-page.

If the device in the Substitution Library is a shunt device (such as a load or generator...), then this component should only appear once on the sub-page. If it is a series device (transformer, dc link...) then 2 copies (one for the left bus and one for the right bus) should be used. See the next section for more information.

E-TRAN also uses this component to determine if a 30 degree phase shift should be added or removed from the loadflow phase angle... The total calculated angle (the loadflow angle with or without the 30 degree shift added/subtracted) will also be transferred to the synchronous machine component for its initialization. See the next section for more information.

## E-TRAN User's Manual

The dialog shown below appears when editing the **Main Data** page of the initial conditions from loadflow model:



1. The Branch type should be set according to the type of device. Branch to Ground should be used for generators, loads, switched shunt devices (anything that has a single bus connection). For Series Devices, this initialization component should be copied and used twice on the sub-page, once for the left side bus, and once for the right side bus. Left is defined based on the name of the page (such as E\_123\_789\_C1, in which case the left bus would be 123, the right bus would be 789 and this is for circuit "C1"). See Chapter 5.0 How to use the Substitution Library for more information on how to use page components in the Substitution Library.
2. Select the phase shift angle of this bus. Loadflow data is quite often entered ignoring the 30 degree shift resulting from delta windings of transformers. If the 30 degree shift is entered in the transformer branch data in the loadflow (or if this is for a wye-wye transformer), then this parameter should be left as "No phase shift". If the 30 degree shift is not entered in the loadflow and there is a wye-delta transformer, then you should select either -30 or +30 degrees.

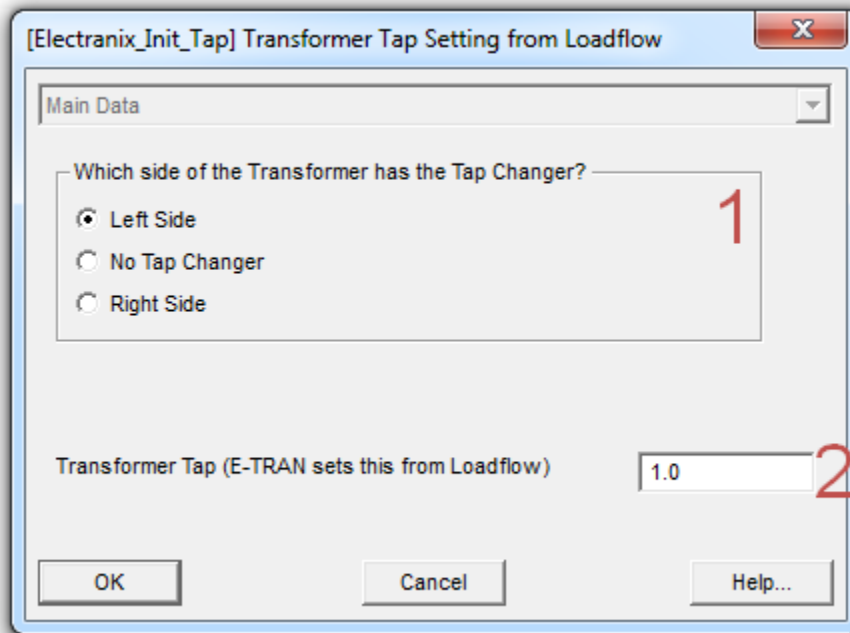
The phase shift angle (-30 or +30) will be added to the phase angle of the bus voltage and output from this component. This information is also read in by E-TRAN and transferred to the synchronous machine initial phase angle.

3. If you selected **Machine to Ground** in step 1 above, then enter here the number of machines that

this machine is in parallel with.

4. This data will be automatically updated by E-TRAN (based on the loadflow solution) during a translation.

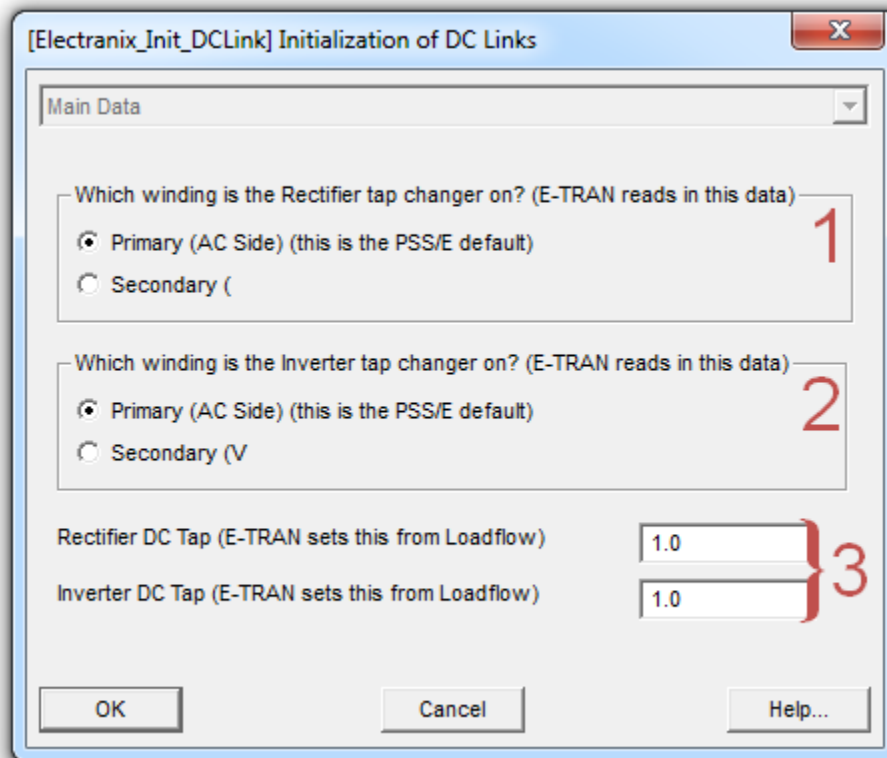
The dialog shown below appears when editing the **Main Data** page of the transformer tap settings from loadflow model:



1. When using this component in the sub-page of a substitution library select here which side the tap changer is on or you can select tap changer. Use the radial buttons to make your selection.
2. This data will be automatically updated by E-TRAN (based on the loadflow solution) during a translation.

## E-TRAN User's Manual

The dialog shown below appears when editing the **Main Data** page of the DC link tap settings from loadflow model:



1. E-TRAN automatically enters the winding for the rectifier tap changer.
2. E-TRAN automatically enters the winding for the inverter tap changer.
3. This data will be automatically updated by E-TRAN (based on the loadflow solution) during a translation.

Click “**OK**” to save your changes and exit to PSCAD or click “**Cancel**” to exit without saving your changes.

## 7.15 Miscellaneous

### 7.15.1 Arrow

During an E-TRAN translation, if the arrow show in Figure 7.19 is placed at a bus means that additional components are connected to this bus on another page.



Figure 7.19 Symbol for the E-TRAN arrow, which indicates that a bus continues on another page.

### 7.15.2 Single to Three Phase Converter

E-TRAN provides components to convert single phase to three phase representation in PSCAD, and to change the interface type from a current injection to a voltage source, and vice versa.

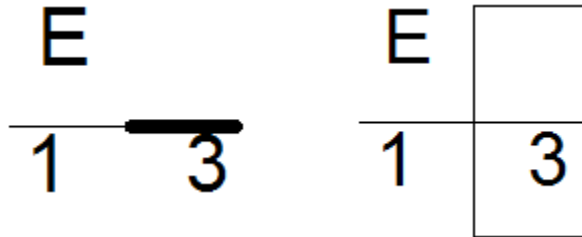


Figure 7.20 Symbols for the E-TRAN single phase to three phase converter, single line and three lines respectively.

## E-TRAN User's Manual

The dialog shown below appears when editing the **Main Configuration** page of the single to three phase converter model:

[Electranix\_1to3] Single Phase to 3 Phase Converter

Main Configuration

Frequency (Hz, can be a variable): 60.0 [Hz] 1

Type of Interface? 2

- Voltage Source on 1 side, Current Injection on 3 side
- Current Injection on 1 side, Voltage Source on 3 side

Phase Advance on 1 Phase Side? 3

- No
- Yes

Phase Advance on A,B,C Side? 4

- No
- Yes

Source Res. on 1 Phase Side (ohms): 1.0 [ohm] 5

Source Res. on A,B,C Side (ohms): 1.0 [ohm] 6

Three Phase Side Connection Type? 7

- Three Phase Individual Connections
- Three Phase Single Line Diagram (V4)

OK Cancel Help...

### 7.15.3 Numerical Instability Detector

A component is provided which identifies the location at which a specified voltage or current is first exceeded, then stops the simulation. This can be used to identify where in a circuit a numerical instability may be coming from. All messages regarding the location of the high quantities will be placed in the PSCAD “non-standard messages”.

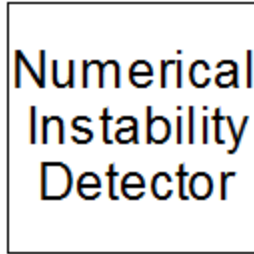
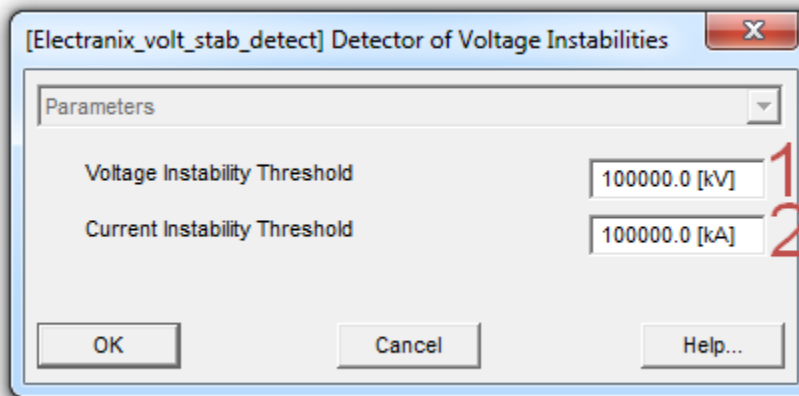


Figure 7.21 Symbol for the E-TRAN numerical instability detector.

The dialog shown below appears when editing the **Parameters** page of the numerical instability detector model:



1. If any voltage in the case is or goes above this threshold this component will generate an error and stop the run.
2. In any current in the case is or goes above this threshold this component will generate an error and stop the run.

Click **“OK”** to save your changes and exit to PSCAD or click **“Cancel”** to exit without saving your changes.

#### 7.15.4 Error/Warning Message Writer

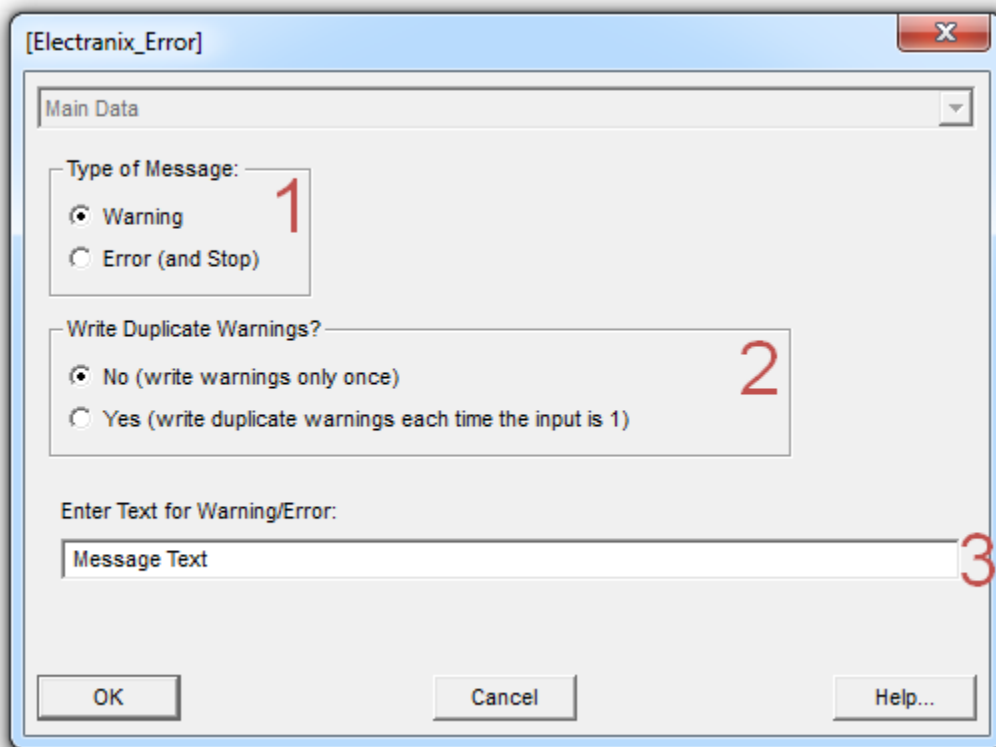
This component can be used to stop the run when a certain quantity becomes 1 or you can use it to write a warning message each time a certain quantity is equal to 1.

Messages are written to the PSCAD “non-standard messages”



Figure 7.22 Symbol for the E-TRAN error/warning message writer.

The dialog shown below appears when editing the **Main Data** page of the error/warning message writer model:



1. Select whether you want this component to output a Warning or Error message. When a warning message is selected your case keeps running after outputting a message. However, when an Error message is selected your case will stop running after outputting a message.
2. If you selected Warning above, you can select here whether you want this component to write a message each time that the input is 1 or just the first time the input is 1.
3. Enter the message that you want this component to output in this textbox.

Click **“OK”** to save your changes and exit to PSCAD or click **“Cancel”** to exit without saving your changes.



## 8.0 Theory of E-TRAN

E-TRAN bridges the gap between phasor based loadflow and stability simulation tools and electromagnetic transient (EMT) tools.

E-TRAN internally solves the steady state phasor equations and uses this information to initialize a PSCAD/EMTDC circuit, as well as to form network equivalents to reduce the network so it is suitable for transient analysis.

The steady state solution in PSCAD/EMTDC is based on the solution of instantaneous differential equations (of either single phase or three phase circuits), whereas the solution in PSS/E or loadflow programs is based on phasor based complex variable calculations at the fundamental frequency. The steady state solutions for the two methods match to a very high degree of accuracy, which gives the user confidence that the conversion process and network equivalents has been done properly.

The loadflow information (obtained from the loadflow input files) is used by E-TRAN to directly initialize the circuit in PSCAD/EMTDC (including sources in the network equivalents and generators).

Finally, E-TRAN will auto-route the circuit (based purely on the raw connection and bus information) so as to create a PSCAD graphical circuit which can be visualized on the screen.

The theory behind each of these E-TRAN technologies is discussed in the following sections in this chapter.

### 8.1 Network Equivalents

E-TRAN can be used to translate very large systems (defined in loadflow .raw files) into PSCAD, suitable for electro-magnetic transient analysis. Although the PSCAD EMT tool is capable of simulating very large systems (3,000 busses and higher, limited only by memory), practically users must limit their study scope and introduce network equivalents at the boundaries of their simulation network.

One decision a user must make is where should a network equivalent be placed (i.e. how many busses away from the area of interest)? The system represented in detail (i.e. the "kept" network) will give a more accurate frequency response (particularly if the data is updated with detailed frequency dependant transmission lines, transformers with saturation etc...) compared to the system in the network equivalent (which is based on fundamental frequency). It is difficult to define the system equivalent boundary, but be sure to represent all the "dominant" electrical devices in the "kept" network (such as machines, non-linearities...) and try to place the system equivalent at least 2 or more busses away from the area of interest. The more of the system that is represented in detail, the more accurate the representation will be.

A commonly used simple method of generating network equivalents is to insert a voltage source behind impedance at every boundary bus to represent the PQ flow into the portion of the network at that bus (this is known as a 1 port equivalent). The sources are often represented with series RL source impedances (based on the fundamental frequency short circuit capacity or short circuit

## E-TRAN User's Manual

impedance). This method will give the correct power flow in steady state, but will not give the correct open circuit or short circuit response. What is missing in this simple form of a network equivalent is the “off-diagonal” impedance terms which represent the interconnections in the non-kept portion of the network (i.e. from one boundary bus to another). What is required (to get steady state, short circuit and short circuit impedances correct) is an N-port equivalent.

E-TRAN calculates an N-port network equivalent based on the fundamental frequency impedances of the system. The equivalent includes both diagonal and off-diagonal terms, and is valid for steady state, open circuit and short circuit conditions.

In order to create the most accurate network equivalent possible, E-TRAN recommends that the “Machine impedance ZSORCE” data be entered for all generators. This data is not used nor required for normal loadflow studies, but it is essential to create accurate network equivalents.

- If the ZR, ZX generator data is entered:
  - If the generator is in the network to be equivalenced, then it will be reflected in the impedance elements of the equivalent that E-TRAN creates.
  - If the generator is in the kept network, this impedance will be used in the series impedance of the generator voltage source.
- If the ZR, ZX generator data is not entered:
  - If the generator is in the network to be equivalenced, then the network equivalent will not contain the most accurate impedance information. In this case, the generator fundamental frequency PQ flow information will be represented entirely in the voltage source magnitude and phase terms of the network equivalent.
  - If the generator is in the kept network, the generator will be represented as an infinite bus at its terminals.

E-TRAN forms the N-port network equivalent using the following steps:

- Form  $Y_{full}$ , the complex Admittance Matrix (Y) of the entire system.  $Y_{full}$  includes all branches, generators, loads (all types), switched shunts, dc links, shunt admittances... at the correct operating point based on the loadflow solution.
- Compute the solution PQ miss-match. The loadflow bus voltage magnitude and angle are used to calculate the voltage and current flow at all generation/load busses, and to determine the PQ flow miss-match. Since the loadflow program uses an iterative process to determine the steady state bus voltage magnitudes and angles, the result is never 100% correct and a small mismatch always exists. E-TRAN calculates the mismatch to ensure the loadflow solution read in is valid. The top 6 busses with the maximum PQ mismatch is written to the translation log file (see Note 1 below).
- Calculate  $Y_{reduced}$ , which is  $Y_{full}$  reduced down to the N kept nodes that the user has defined. The reduction process is performed by a complex, sparse LDU decomposition

routine. The matrix algebra used in E-TRAN includes:

- Support for ideal branches (i.e. 0.0 resistance branches), including series combinations and loops...
  - Non-symmetric admittance matrices (which will occur when phase-shifters are included in a network to be equivalenced).
  - System matrices of any size (the algorithm is 100% auto-dimensioning and automatically allocates and de-allocates system memory as it requires).
- Form  $Y_{kept}$ , which is the partial admittance matrix for system defined within the N kept busses.
- Calculate  $Y_{equiv}$ , which is  $Y_{reduced} - Y_{kept}$ . This admittance matrix represents all network branches and impedances in the network equivalent.
- $Y_{kept}$  is then decomposed into actual circuit elements in the PSCAD page:
- Off-diagonal elements are represented with PI sections (if the busses at each end are equal) or as transformers (if the bus voltages at each end are different).
  - Diagonal elements (formed after the off-diagonal admittances have been removed) are represented by voltage sources behind impedances (the voltage source magnitude and phase are also automatically calculated as described below).
  - The admittance elements are processed by comparing them to a user selectable limit (which optionally can be used to reduce the size of the meshed network equivalent) and are checked for negative impedance values (see Notes 2 and 3 later in this section).
- Calculate the PQ flow in all the diagonal source impedance elements in the network equivalent. These are used to automatically set the voltage source magnitude and phase in the network equivalent (which represents the quasi-diagonal elements).



- The “Eq Admittance Limit” parameter (to set this parameter see section 4.1.6) can optionally be used to ignore very small admittances (which represent very weak connections between busses in the equivalent). If this option is used, then the equivalent can ignore off-diagonal terms whose admittance is less than the limit. The PQ flow in the network equivalent (which is used to calculate the equivalent voltage source magnitudes and phases) is adjusted accordingly so the system steady state solution will be correct.

Note that using the “Eq Admittance Limit” option is an approximation and will result in a circuit that will not yield the correct open circuit and short circuit powerflows. In an extreme case, the “Eq Admittance Limit” parameter can be set very large, in which case all off-diagonals in the network equivalent are ignored, and the result is N simple 1 Port equivalents (discussed earlier).

This feature may be useful where limited size network equivalents must be realized for use in real-time applications.

- During the execution of E-TRAN, the user is presented with an option entitled “Convert –ve Impedances in Eq Network to +ve” (see section 4.1.5). Negative impedances can occur in the equivalent network and are perfectly valid (and stable) in a phasor solution, but may not be realizable or stable in time domain EMT simulation. For example, in the time domain, a +ve R and –ve L in series will produce an exponentially growing unstable current if excited by a current source, but in the phasor domain will produce a steady state solution in a phasor solution. These options can be used to convert the –ve X to a +ve X, which is stable and valid in the time domain. The PQ flows and voltage source terms that represent the network equivalent diagonals are automatically adjusted when this option is applied.

## 8.2 Matching the Loadflow in PSCAD

The loadflow solution is based on complex linear algebra involving the fundamental frequency phasor solution of an electrical network (i.e.  $V(\omega) = I(\omega)(R + j\omega L)$ ). The solution is obtained by iteration, with a given convergence criteria.

Electromagnetic Transients (EMT) programs (such as PSCAD/EMTDC) solve differential equations for the electrical network (i.e.  $V(t) = RI(t) + L(dI/dt)$ ). The EMT solution method solves these differential equations by applying trapezoidal integration, which converts the differential equation into a difference equation (i.e.  $Y(t)$  is a function of  $X(t)$ ,  $X(t-\text{delta})$ ,  $Y(t-\text{delta})$ ...). This integration process results in a direct matrix solution (i.e. no iterations and no iterations), but introduces an integration error (which can show up at very high frequencies). The error can be minimized by selection of an appropriate time step which depends on how high of a frequency response the simulation results will be required. A general rule of thumb is that a 50  $\mu\text{Sec}$  time step is suitable for frequencies up to 2 kHz.

The solution at 50 Hz (or 60 Hz) will be quite accurate and the two solution methods should match to within 3 or 4 decimal points. If there is a discrepancy, this is generally due to an error in the representation of the device in one of the programs (such as a wrong load characteristic etc...) rather than due to an error in the solution method. An easy test in EMT programs is to reduce the time step

(say from 50  $\mu$ Sec to 10  $\mu$ Sec) and see if the solution has changed.

The E-TRAN library of components in PSCAD has been extensively tested by direct comparison against solved loadflow solutions. Each component has been first verified individually, and then the entire electrical network solution is compared to the loadflow solution.

If you do see differences in the two solutions, ensure your measurements are extracting fundamental frequency, +ve sequence quantities. The EMT program can generate distorted waveforms (due to transformer saturation, DC links, resonances...), which can result in differences. The EMT program transmission line models can also introduce -ve and 0 sequence quantities due to non-transposed conductors, which can also generate differences. The E-TRAN measurement models (see Section 7.11) extract the +ve sequence fundamental frequency quantities, so these results should compare well. If you use your own measurement components (such as RMS etc...) then you may get different results.

Finally, the transmission line data in the loadflow file contains only RXB information, which is not suitable for using the frequency dependant transmission line models in PSCAD/EMTDC. If more detailed line models are required, the user must re-enter detailed line constants information (such as the line geometry, ground resistivity...). The PSCAD/EMTDC line constants routine may not generate exactly the same +ve sequence impedances and admittances (as the RXB entered in the original loadflow), which can introduce a steady state error.

It is therefore recommended that the loadflow RXB data (in the .raw file) be updated based on the PSCAD/EMTDC Line Constants solution at the fundamental frequency (this information is output in the linename.out file and accessed by the View->Output File command on a Tline sub-page. The PSCAD/EMTDC line data is output for an incremental length of line, in ohms or mhos (i.e. not PU) and is not corrected for longline effects. In PI sections (or loadflow) representations of lines, the line RXB data should be corrected for longline effects, in which case you must perform the following calculations:

**Enter RXB (+ve and 0 Seq), not corrected for longline effects:**

$$R_1 = \frac{3.50440834}{Z_{base}} \quad X_1 = \frac{42.4153077}{Z_{base}} \quad B_1 = \frac{.000272598288}{Y_{base}} \quad Z_1 = R_1 + X_1j$$

$$R_0 = \frac{30.0353808}{Z_{base}} \quad X_0 = \frac{114.340136}{Z_{base}} \quad B_0 = \frac{.000193555082}{Y_{base}} \quad Z_0 = R_0 + X_0j$$

**Perform longline corrections:**

$$\gamma_1 = \sqrt{(R_1 + X_1j)B_1j} \quad \gamma_0 = \sqrt{(R_0 + X_0j)B_0j}$$

$$Z_{1LL} = Z_1 \frac{\sinh(\gamma_1)}{\gamma_1} \quad Z_{0LL} = Z_0 \frac{\sinh(\gamma_0)}{\gamma_0}$$

$$B_{1LL} = B_1 \frac{\tanh\left(\frac{\gamma_1}{2}\right)}{\frac{\gamma_1}{2}} \quad B_{0LL} = B_0 \frac{\tanh\left(\frac{\gamma_0}{2}\right)}{\frac{\gamma_0}{2}}$$

$$\text{Where: } Z_{base} = \frac{VLL * VLL}{100}$$

$$Y_{base} = \frac{1}{Z_{base}}$$

$R_1, X_1, B_1 \dots$  (calculated above are ohms/mhos for the entire length of line)

### 8.3 Initialization of Generators/Machines in PSCAD

E-TRAN directly initializes the circuit model (and network equivalent) in PSCAD/EMTDC so that the bus voltages, angles, PQ flow ... match the loadflow. The source/generator component (see section 7.4) is by default a fundamental frequency voltage source and does not model machine swings or electro-mechanical oscillations.

In order to model the machine in more detail, you must perform the following steps:

1. You should add a page component to the Substitution Library containing a detailed machine component (from the PSCAD Master Library).
2. Copy the initial conditions component onto the sub-page. E-TRAN will transfer the terminal voltage magnitude, angle and PQ flow from the loadflow to both the machine model and the initial condition component. Note the PSCAD Master Library synchronous generator model requires the line to ground voltage (LL voltage / sqrt(3)) to be entered. The bus voltage angle is also entered in radians (not degrees) (this conversion is automatically done by E-TRAN).
3. Check the generator transformer. All E-TRAN generated transformers are wye-wye, but often generator transformers are wye-delta. If this is the case, you should replace the E-TRAN transformer with the PSCAD Master Library transformer (enter the wye-delta winding configuration, either leading or lagging delta). Also be sure to modify the initial conditions component in the Substitution Library to instruct E-TRAN that there should be a 30 degree phase shift in the bus angle.
4. Enter exciter, governor, turbine, stabilizer data etc... (refer to the PSCAD Master Library Machines sub-page). If you do not find the control circuit component you require, then contact ***e-tran@electranix.com*** to see if the required model is available.
5. A good example of a machine/exciter/governor sub-page in the Substitution Library is contained in section 5.4.3.

The initialization process of machine models/controls in PSCAD/EMTDC is automated once the initial bus voltage magnitude and phase angle is available (which E-TRAN generates). The machine initialization process in PSCAD/EMTDC is summarized below:

---

#### PSCAD Machine Model - Initialization

---

1. From your loadflow program (or E-TRAN output), you require:

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- The voltages at each machine terminal (magnitude and phase)
  - The PQ flow into the machine terminals
2. Enter the V mag, phase into the Machine component. If your machine uses a wye-delta transformer (this is usually the case), then you have to take the load flow angles and subtract 30 degrees (if the delta lags the wye) or add 30 degrees (if the delta leads the wye) before you enter it into the machine (this is because the loadflow treats all transformers as wye-wye without phase shifts) (also be careful as the machine component initial conditions data requires entry of the machine angle in radians).
  3. Have the machine component start as an ideal voltage source. This is done by using the machine parameter called "Source to Machine Transition". Enter a variable here (such as "S2M"), and then create a controls signal on the same page which creates an integer which is 0 until 0.5 seconds, and then switches to 1 for the duration of the run. This will force the EMTDC machine model to start as a voltage source (it is ramped to avoid transients), thus bypassing the mechanical and electrical dynamics.

At 0.5 seconds the AC system should have stabilized and you should see the loadflow voltages and PQ flow matching everywhere in your system (you should get 4 decimal points matching if everything is correct). Matching the loadflow gives you a lot of confidence in the large amounts of data you have entered. If the loadflow does not match, then either the loadflow was not solved, or the PSCAD representation of each device is not the same as the loadflow representation.

Common problems are:

- The transformer impedance in the loadflow is entered in PU on a 100 MVA base, whereas you may be using a different MVA base when you enter the data into PSCAD
- Check the fundamental positive sequence impedance of transmission lines and cables and see if they match the RXB from the loadflow. You may want to first run your system with pi sections (with manual entry of RXB from the loadflow) and then switch to the fre-dep phase domain model later.
- The PSS/E program assumes all RXB data is long-line corrected (as it uses it directly in a PI section formulation in its Y matrix). For short lines, the correction is a very minor effect and can be ignored. If you use this same data in a single PI section in PSCAD, then this should give the identical result. If you use the RXB data in a Bergeron model, then check the option that says the data is long-line corrected.
- Check load models - most loadflows have constant power, current, impedance or RLC loads (see comments on load models available with E-TRAN below) so if you are using a constant RLC load representation you have to calculate the RLC values based on the solved loadflow voltage level...

When the S2M signal becomes 1, this forces the machine to measure the PQ flow into its terminals and to initialize the electrical circuitry internal to the machine. You should not see a bump during this transition. If you have power electronics in your circuit (such as HVDC etc...)



then you may want to run for longer than 0.5 seconds until the entire system has reached steady state.

The machine at this point is running with full electrical dynamics, but it is still ignoring the field input (from the exciter) and the torque input (from the governor) and is locked at steady state frequency (but at the correct rotor angle).

4. The next step is to get the exciter, governor, turbine, multi-mass models (if used) etc... to initialize and fully release the machine. This is done by using the "Lock Rotor to Normal Machine Transition" variable in the machine component. You can enter a variable here (such as "L2N") and then create a controls signal on the same page which creates an integer which is 0 until 0.6 seconds, and then switches to 1 for the duration of the run. This will force the EMTDC machine model to fully initialize and release all dynamics at 0.6 seconds.

Note that the exciter requires a voltage reference set-point. The generator data in the loadflow file often is specified to as to control a bus voltage to a set-point. If your exciter uses a pure proportional gain (not a PI or PID controller), then you will have to slightly increase the set-point to compensate for the steady state error (due to the proportional gain). Chapter 5.0 How to use the Substitution Library contains an example that automatically calculates the exciter set-point voltage (including the compensation for the proportional gain error).

At the S2M transition, the machine model will:

- Calculate and output the electrical torque + damping torque (which is the initial mechanical torque) and pass this to the governor/turbine/multi-mass models. The governor/turbine/multi-mass models will use the initial mechanical torque and will back-initialize its control systems.

You may see a small bump at this point if your system has any -ve sequence components of voltage or current. This can occur when you have unbalanced (non-ideally transposed) transmission lines or unbalanced loads. The -ve sequence component results in a small second harmonic on the field, which will show up on the electrical torque. Thus the initialization time point-on-wave might introduce a small second harmonic oscillation (which will be there in steady state) which cannot be avoided.

5. The machine is fully released at this point and the system should be ready for faults etc... You can look at your circuit and adjust the times for the source to machine transition (0.5 sec) and lock rotor to normal mode transition (0.6 sec) to suit your circuit.
6. If you do not have a loadflow program (so you do not know the voltage magnitude and angles), then you can run the PSCAD circuit once for a very long time (maybe 10-20 seconds or until all mechanical oscillations damp out), and then use the measured steady state information at the end of the run to set up the initial conditions.

---

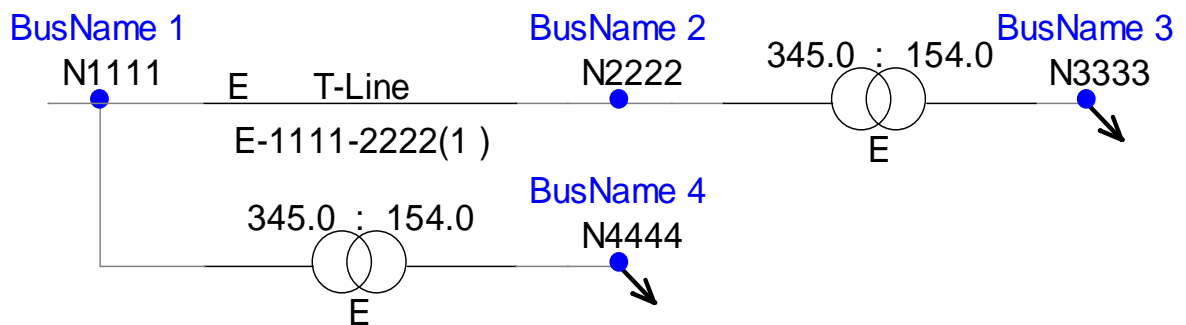
## 8.4 Auto-Routing of PSCAD .psc files

E-TRAN translates loadflow .raw file information into a PSCAD/EMTDC .psc file, which contains data as well as graphical coordinate information (to control how the circuit picture looks). This section describes how the graphical coordinate information is calculated.

The auto-routing algorithm in E-TRAN is capable of drawing very large networks (it has been tested up to 50,000 busses) with no known limitations. E-TRAN will automatically generate sub-pages and sub-sub-pages (if required) etc...

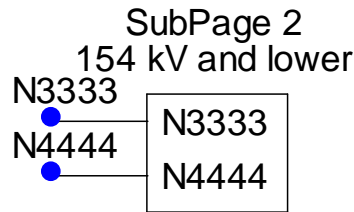
The auto-routing steps E-TRAN uses are:

1. It determines the lowest voltage level so that the entire circuit of this voltage (and higher) will fit on a page (say the 500 and 230 kV voltage level will fit on a page).
2. It auto-routes the circuit at the selected voltage levels onto the page. Drawing preference is given to the highest voltage portions on a given page. If a circuit with a single bus at a lower voltage is also connected (such as a generator transformer and generator bus), then it keeps the circuit connected at the current voltage level page. Transformers connecting to a lower voltage level are kept on the main page (to inform the user that the portion of the network continuing on a sub-page is at a lower voltage level).
3. The auto-routing algorithm is a custom (near optimum) method based on Graph Theory (a formal discipline in mathematics). The method used guarantees no misconnections or undesired cross-over points, even for large heavily meshed networks.
4. At all locations where there are connections to other portions of the circuit at lower voltage levels, E-TRAN places the "nodeexport" component (from the E-TRAN PSCAD Library - it looks like an arrow) at the bus to signify that there are more connections at this bus. An example of exported busses are N3333 and N4444 as shown below:

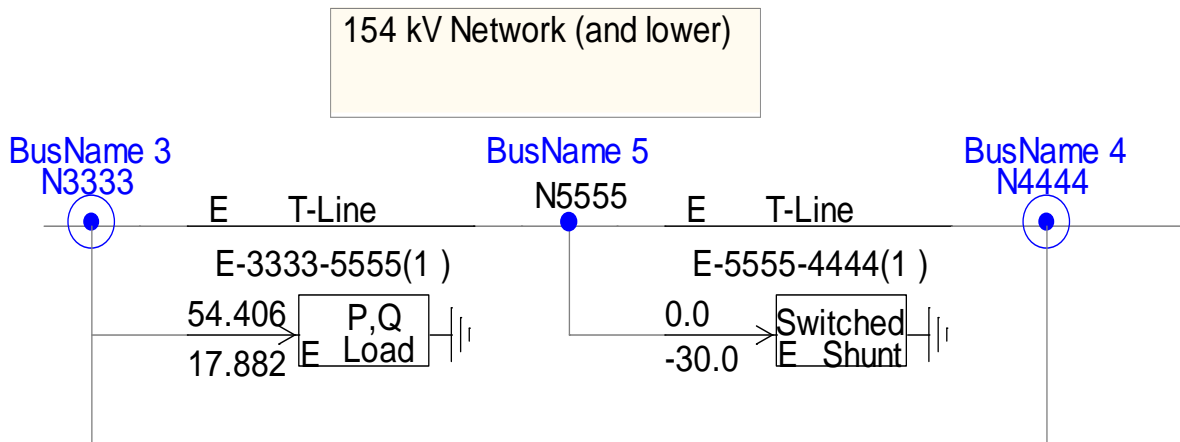


5. It moves the remainder of the circuit to new sub-pages. The number of sub-pages are determined by connectivity, so if 10 busses of a low voltage portion of the network are to be moved, and the first 5 busses are inter-connected with each other but not inter-connected with the remaining 5 busses, then they will be moved to a separate sub-page.

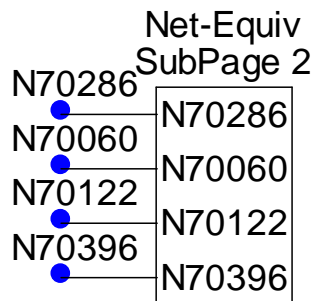
The “parent page” will have the bus nodelabels duplicated and entering into a page component:



The sub-page will connect to the parent page using the xnode component to signify that this is a connection to a higher level:

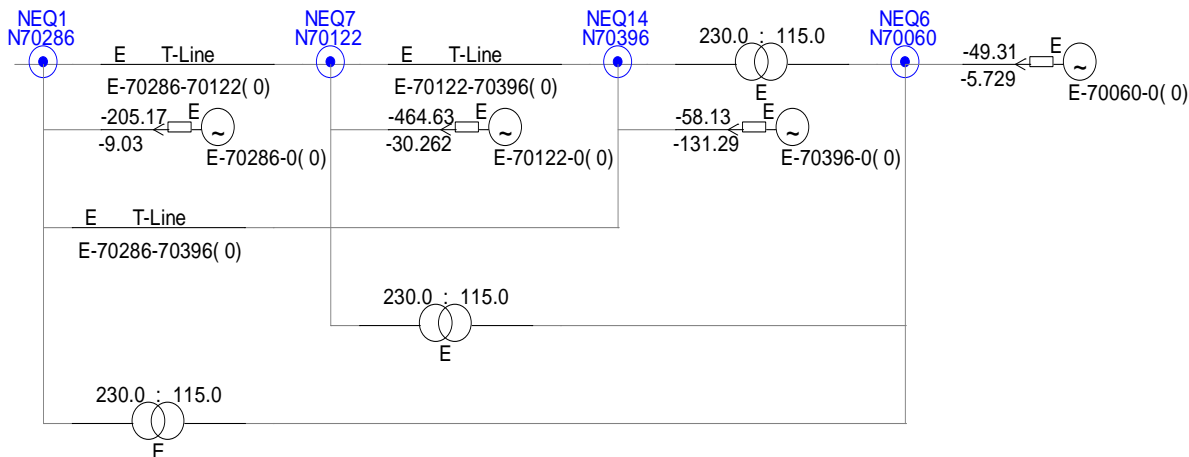


6. Steps 1-4 are repeated for all remaining sub-pages (recursively) until all busses and branches are placed.
7. Network equivalent sub-pages are initially grouped onto a single sub-page (in order to keep the network equivalent separated from directly translated circuits). The network equivalent pages will be given a name “Net-Equiv” to distinguish them from other sub-pages.



8. The network equivalent sub-page is directly translated from diagonal and off-diagonal admittance elements computed from a network reduction process (see section 8.1). An example network equivalent is shown below:

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**Note:** that the bus names are identified as NEQ1... The numbers relate to the log file output of the reduced matrix (Yeq) row and column numbers. PI section T-Line components are used in the network equivalents where the equivalent connection nodes are at the same bus voltage, otherwise transformer components are used. The source PQ and initial voltage conditions are computed based on the total generation PQ flow that flows into the portion of the network that the equivalent is based on.

9. If the highest voltage level does not fit entirely on 1 page, then it is broken up geographically, meaning the circuit will be drawn starting from the top left, and portions of the circuit exceeding the page size X coordinate on the right (or circuits drawn exceeding the bottom Y coordinate) will be moved to a sub-page.
10. The starting bus of a page is determined by the bus with the highest voltage, or it will be the central bus if the "Convert 1 Bus and N Busses Back" option is used (see section 4.1.5).

## 9.0 Acknowledgements

E-TRAN was developed at the Electranix Corporation by Garth Irwin, Dennis Woodford, Nathan Kroeker, and Joel Dyck.

The assistance of the Manitoba HVDC Research Centre Inc. is gratefully acknowledged.



## FAQ's and Trouble Shooting

### Q. What versions of PSS/E .raw file formats are supported?

A. At the time of writing this manual, PSS/E versions 26, 29, 30, 31, 32, and 33 are supported.

### Q. What versions of PSCAD are supported?

A. E-TRAN can generate PSCAD three phase Single Line Diagram circuit .psc files for PSCAD V4.x and VX4. The E-TRAN library is compatible with both versions.

### Q. When I performed a translation, E-TRAN output a log file with a lot of errors. When I went to open the .psc file I discovered that E-TRAN had not generated one. What went wrong?

A. During step 3 of the translation you selected a different version of “.raw” file then the version of file that you entered in step 4. Also, double check that your “.raw” file that you entered in step 4 is not an empty file and/or is not corrupted.

### Q. When I run a translated circuit in PSCAD the loadflow does not match. Why?

A. Check that the .raw file being used is “solved” and has the updated loadflow solution saved in it. Also check that fundamental frequency behaviour of any models in the E-TRAN Substitution Library matches that of the standard E-TRAN components (if you turn off the Substitution Library, does the solution then match?). Finally, check DC Links to see if they are operating correctly. The DC Link controls may have to be adjusted to work in very weak systems. A good test is to see if the loadflow matches when you use the “Infinite Bus” option in the DC Link component.

### Q. Electro-magnetic transients simulations require detailed data (such as transformer saturation, surge arresters, line geometry for frequency dependent transmission lines)... This data is not available in loadflow programs, so is the case generated by E-TRAN useful for EMT studies?

A. Detailed EMT models (such as transformers with saturation, frequency dependent transmission lines...) are essential for any meaningful study (especially for overvoltage, harmonic studies...). E-TRAN supports a Substitution Library (see chapter 5.0 How to use the Substitution Library) which allows a user to enter the detailed model data (and maintain/manage the data in a PSCAD Library) and will automatically use the detailed data if it is available.

The fundamental frequency impedances from the loadflow file are used to generate multi-port network equivalents, and to determine the steady state powerflow. The powerflow is used to initialize all machines, sources and generators (or any device). E-TRAN will automatically modify the initial condition information of machines found in the Substitution Library (which in turn will initialize any exciter, governor, multi-mass system), and in general can provide initial conditions for any device.

This means E-TRAN can directly generate a circuit ready for EMT studies, complete with frequency dependent lines, detailed generator/exciter/governor models, detailed

HVDC/SVC/FACTS devices, *provided the user has entered this data once in a library.*

**Q. I am measuring V and Q flow using the E-TRAN components and it does not give me the same answer as the PSCAD Master Library measurements. Why?**

- A. The PSCAD Master Library models perform RMS or instantaneous PQ measurement (basically the sum of  $V_A.I_A + V_B.I_B + V_C.I_C...$ ), which includes the effect of all sequence components and the effect of harmonics.

The E-TRAN PQ measurements devices (or voltage measurements) measure the +ve sequence, fundamental frequency quantities (because this is what is used in loadflow programs), not the instantaneous or RMS quantities.

This effect is particularly obvious at locations where there are significant harmonics (such as near a commutating model of a DC link).

If the instantaneous quantities being measured are sinusoidal, distortion free and balanced (i.e. only +ve sequence), the results should match.

**Q. During a translation I used the substitution library and when trying to run the case I get the following error message “Signal dimension mismatch”. What did I do wrong?**

- A. The substituted component is connected to a source that has a different dimension, as in a three phase line connected to a single phase component. Use a 3 phase breakout component to interface your custom component to the circuit.

**Q. Where can I get technical support or updates for E-TRAN?**

- A. You can visit <http://www.electranix.com/E-TRAN/> and go to the download page or you can send e-mail to the Electranix Corporation. See Technical Support Contact Information at the end of this manual on the inside cover for more information.

**Q. Where can I get technical support or updates for PSCAD?**

- A. PSCAD is developed and supported by the Manitoba HVDC Research Centre Inc (<http://www.hvdc.ca>). You can visit <http://www.pscad.com> or you can send e-mail to the PSCAD Support team at [support@pscad.com](mailto:support@pscad.com).



## Technical Support Contact Information

The E-TRAN product is a direct outcome of the study requirements from consulting services at the Electranix Corporation. A team who has experience in performing all types of power system simulation studies (they were among the primary developers of the PSCAD/EMTDC program) developed the program, and the same experienced staff is available to answer your questions.

For technical support, sales or pre-sales information, please contact:

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**WWW: <http://www.electranix.com/E-TRAN/>**

E-TRAN is an evolving product, and future updates and revisions are always underway (check the website for the latest information and updates). As you use the program, please be sure to send us your comments, suggestions and to report any bugs.

The Electranix Corporation is also available to perform studies, or to work with your team to help you do the work. Please contact us if you would like information on courses or would like assistance with your studies.