PSS/E to EMTP Import Tool

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1 Introduction

This document outlines the basic operations of the PSS/E to EMTP Import Tool. This Tool is designed to support user that wish to import networks between PSS/E and the EMTPWorks design environment for EMTP enabling user to rapidly convert networks from PSS/E sources.

PSS/E and EMTP are very different tools designed to provide mathematical solutions for time and frequency domains. Due to their different modeling technics, using a network model from PSS/E in EMTP requires a software tool that is designed to map the devices found in a PSS/E network into an EMTP network. To achieve this, the software performs a two-stage processing of output files coming from PSS/E.

1) The first stage of the process is to parse the input file data and compile the information into a collection of internal data structures that represent the network. This collection is referred to as the network listing or "netlist" for short. Since the PSS/E data is composed of a series of tables and connections between items in the tables, the internal netlist is modelled as database of entities and relationships. This database is then used to generate additional meta-data needed to properly form a circuit design in EMTP.

2) The second stage of the process is to use the netlist database to generate the individual devices into EMTP, thus creating the finished circuit diagram. This involves the creation of the device, addition of the signal connections and then the application of property data for each device. In addition, other devices required to glue the circuit diagram together are also created. These do not have any modelling back-end but are needed to ensure that the network is properly formed.

*Note: PSS/E Networks can be very large and the operation of converted them to a time domain solution requires a lot of additional detail. For this reason, the import tool is focused on smaller networks of up to a **maximum of 500 buses**. Networks beyond this are very difficult to diagnose and so the support for this product is limited to those networks that fall within this range.*

After a network is imported, it is also possible to validate the circuit by comparing the PSS/E and EMTP load-flow results. This is a rapid way to determine if the fundamental import actions resolved correctly.

2 Activation

Two licenses are required to use the PSS/E Import Tool:

- A regular EMTP license with the PSSEtoEMTPTool feature. This license is activated using the EMTP Activation Utility the first time EMTP is started. If the license was activated before PSS/E import tool feature was included, the license file must be updated. Use the EMTP activation Utility in EMTPWorks to request and update the license.

- An Import Tool License Key. Enter the Import tool License Key in the dedicated field of the Tool. See 4.1.3 for more information.

3 Description

PSS/E network information is distributed amongst multiple files. The main file (.RAW) is critical and is thus used as the starting point for the import activity. Other files, the sequence (.SEQ), dynamics (.DYR), location (.LOC) files are optional and are not a requirement for import, but since they contain important information to the behavior, the level of detail in the resulting EMTP network will be directly influence by their inclusion.

If some files are missing, the Import Tool provides various options which will be used to build a proper EMTP design:

- If the .SEQ file is not provided:
    - branches zero-sequence are estimated based on typical data (see 4.1.1).
    - generators are modeled using Thevenin equivalents (ideal voltage sources and impedances). The negative-sequence is equal to the positive and the zero-sequence is estimated with the same ratio used for branches.
- If the .DYR file is not provided:
    - generators are modeled using Thevenin equivalents (ideal voltage sources with sequence impedances). The negative-sequence is equal to the positive. The zero-sequence is provided in the .seq file.
- If the .LOC file is not provided, the device positions are not available which is a problem for circuit-based software like EMTP. The Import Tool will provide several options for how devices are organized (see 4.2).

The importation is started by pressing the **Import** button.

After a network is imported, it is also possible to validate the circuit by comparing the PSS/E and EMTP load-flow results by clicking the **Validate Load-Flow** button.

3.1 The Coordinate System

EMTP GUI is entirely based on circuit representations whereas PSS/E networks are mostly described with tables. For this reason, the software has several steps that it takes to ensure that the connections between devices are properly formed. When provided in the .loc file in PSS/E, the coordinate systems are also different, requiring a scaling between the two software. In order to maintain a best fit, EMTP scaling is based on a mesh using a standard 72-point base unit. To provide higher print resolution, EMTP uses a base unit multiplied by 7 to create a DPI value:

$$72 \times 2 \times 7 = 1008 \text{ Dots Per Inch}$$

The diagram object location files are set using real numbers rather than integers using the extended base divided by 10. To map the devices into EMTP then results in a multiplier of 7*10 = 70 across the schematic.

4 Import Tool Tabs

The Import Tool has multiple tabbed views. This is done to break apart the functionality into a proper context and separate the input fields from the output results.

4.1 General Tab View

The main view is the primary presentation for the import tool. Its role is to present the user with the key information fields to enable the process of importing a PSS/E collection of files into EMTP. The program will start with default value installed so that not every field must be entered. The following are the key groups:

4.1.1 Input Files

In the first tab, you must provide the general data. Initially all the fields are left blank. Each field provides free form editing, allowing you to specify the file path or paste a file path from elsewhere. Alternatively, there is a [Select…] button that brings up a file browsing dialog so that the file can be selected from the folder browse tool.

There could be many files in a set that represent all the data that needs to be imported to the network diagram, however, on the .RAW file is critical, while the remaining files provided specific configuration and parametric data that is needed to get a complete representation. The software will import only those files that are selected for import to the network. In addition to the selector, there is an addition check box that tells the import tool if the files should be included as part of the import activity. In general, if the file is available, it should be included for completeness. If, for any reason the accessory file should not be included, or does not exist, the box can be unchecked.

Color borders act to aid the view so that items that are not properly configured stand out. The fields used for the import activity are shown below:

Figure 1: File input controls

- The .RAW file is mandatory.

- The EMTP Output file is mandatory. It specifies the .ecf file that will be generated are after the completion of the import.

- If the .**SEQ** file is available, check the Use .seq file and load it. If not available: Specify the zero sequence and positive sequence ratio. The branch zero-sequence values are estimated based on typical data and generators are modeled using Thevenin equivalents (ideal voltage sources and impedances). The negative sequence is estimated with the same ratio used for branches.

- If the .**DYR** file is specified, the available models are represented using a synchronous machine, exciters and governors. If not available or the model does not exist in EMTP: Generators are modeled using Thevenin equivalents (ideal voltage source and impedance). The negative sequence is equal to the positive and the zero sequence is provided in the .SEQ file.

- The .**LOC** file allows to get the coordinates of the buses for the design display. It is easy to generate the .LOC file in PSSE from the SLD. When the .LOC file is not available, the display can be set in multiple ways on the Advanced tab.

4.1.2 Auto-Populate

Whenever a PSS/E (.raw) file is chosen from the file dialog, the application will use the root path and title of the file to create expected paths for the corresponding associate files. If the other files exist in the system, the checkbox will be enabled indicating that the import action will use those files in the process. If any file path does not exist, that field will be set with a red border and the checkbox will be disabled.

The first step is to select a .RAW file are the basis for the collection of associated files used in the import activity. Using the [Select] button a file dialog is opened, and you can browse to a folder where the collection of files is contained.

When you choose a file, the software will take the directory path and the file name of the input file to construct new file paths to other associated files, form expected paths to sequence (.SEQ), dynamics (.DYR), and finally a graphics location (.LOC). Once this is done, the software will verify the newly created paths to determine if the associated files exist. If the file exists, the check box above each will be enabled, indicating that it will be used in the import activity. Using an example, this view shows an import where associated files are available.

The location file does not have the expected name and as such is not found in this example. For this reason, the field remains unchecked and with a red border to draw attention. Prior to import, you can correct this if desired by clicking on the select button and choosing the file directly. Once this is done it will recheck the file and enable the checkbox if correctly found as shown:

In this example the path to the (.LOC) file was corrected, but if it does not exist then the box can remain unchecked. At this point you are ready to import the set of files previous generated by PSS/E.

4.1.3 Version and License Control

Under tab "General" you can see the version currently in use and the state of your license. Before you can import any networks, a valid license must be installed on the computer.

Tool Version
1.0.2.1   License is valid   PSS®E to EMTP Documentation

When you start the software up for the first time, a message will pop up telling that license is not valid. The licensing tool to activate the license will then show up.

| Installation Info | License Summary | License Operations | Advanced |

Licenses

Product	Key	Status
EMTP	G████████████M	2 of 5 activations used

License Info

Check Online   Enter License Key   Deactivate   Copy to Clipboard
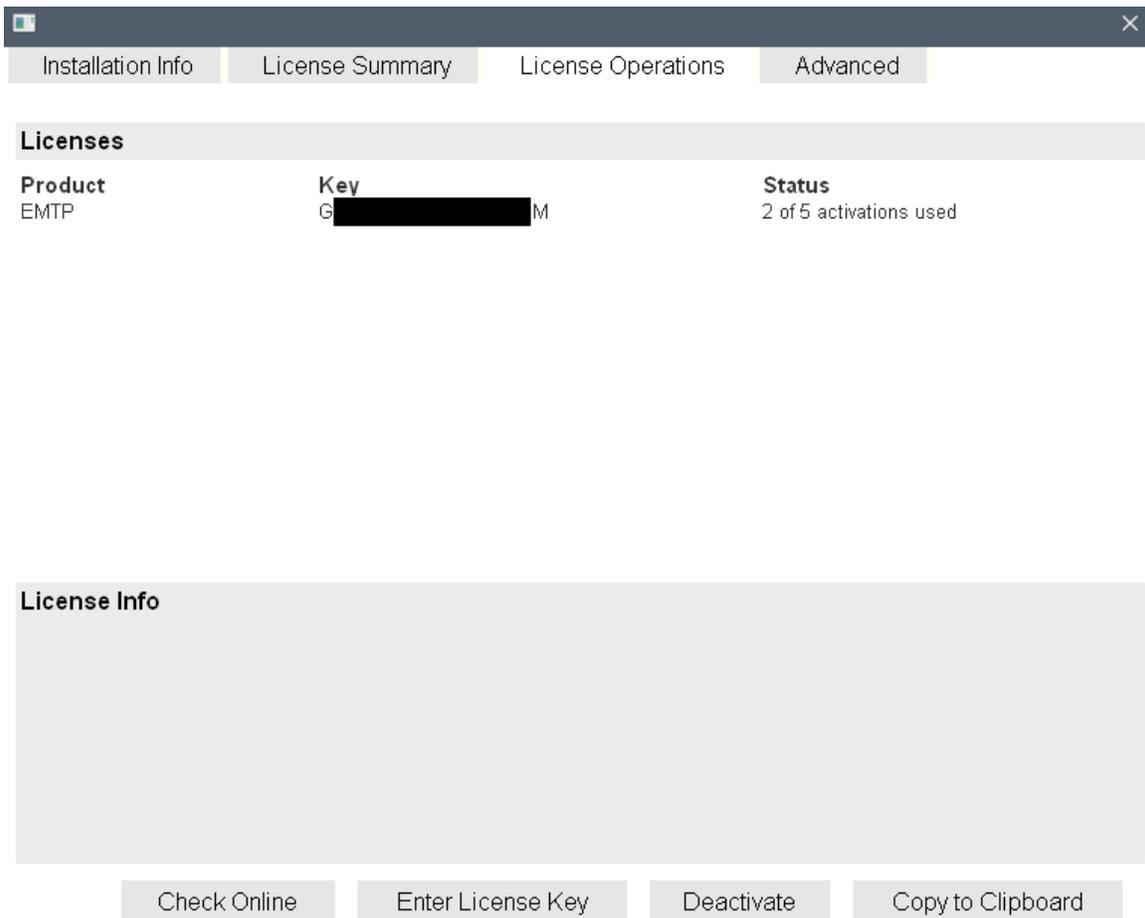
To register your license, hit the "Enter License Key" button. Once you get the message that your license was successfully activated you may now reopen the PSSE Import Tool and start using it.

4.2 Advanced Tab View

The advanced tab allows you to set the display and layout of the network on the design.

- **None / Virtual Connections**: In this configuration, devices are positioned one after the other without any organization. They are then connected using power page connectors (Figure 2)
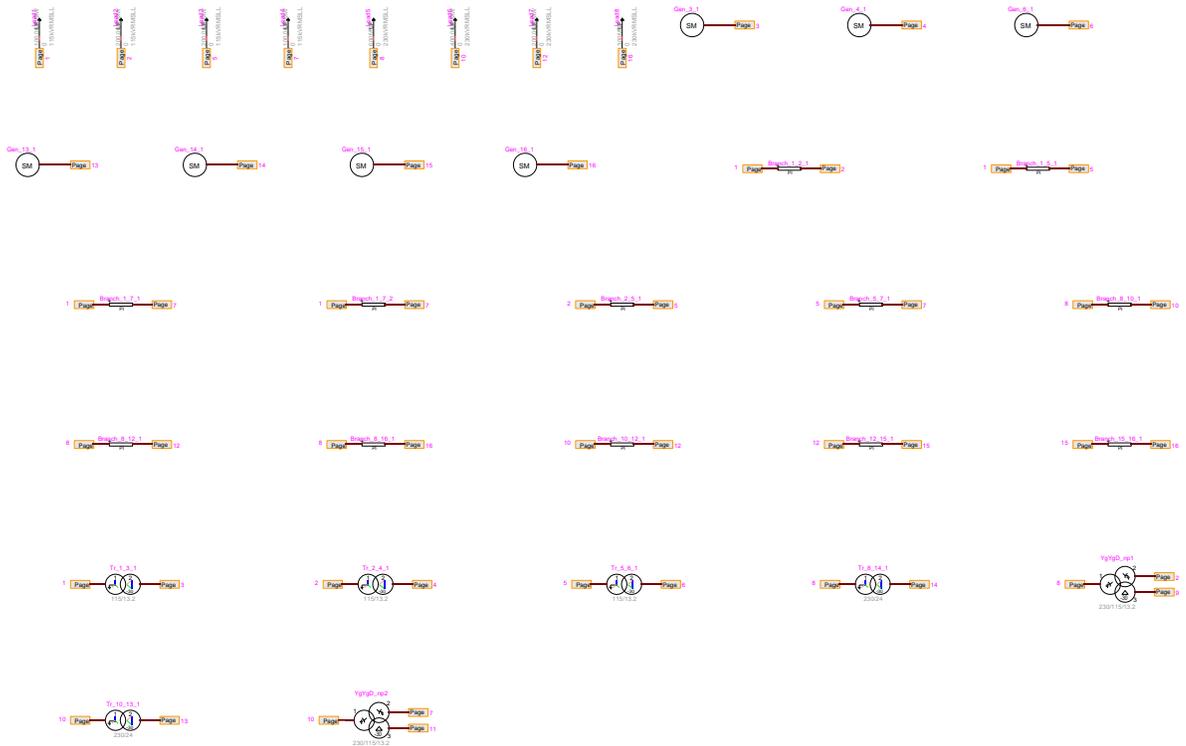
Figure 2: Device organization when 'None / Virtual connections is used

- **Organization by Voltage Levels**: The network is organized by areas first. All areas are positioned in apparition order vertically. Then, inside each area, the zones are separated horizontally. Inside each zone, the buses are vertically positioned based on their voltage level. For a given voltage level, buses are organized horizontally aligned one next to another (Figure 3).
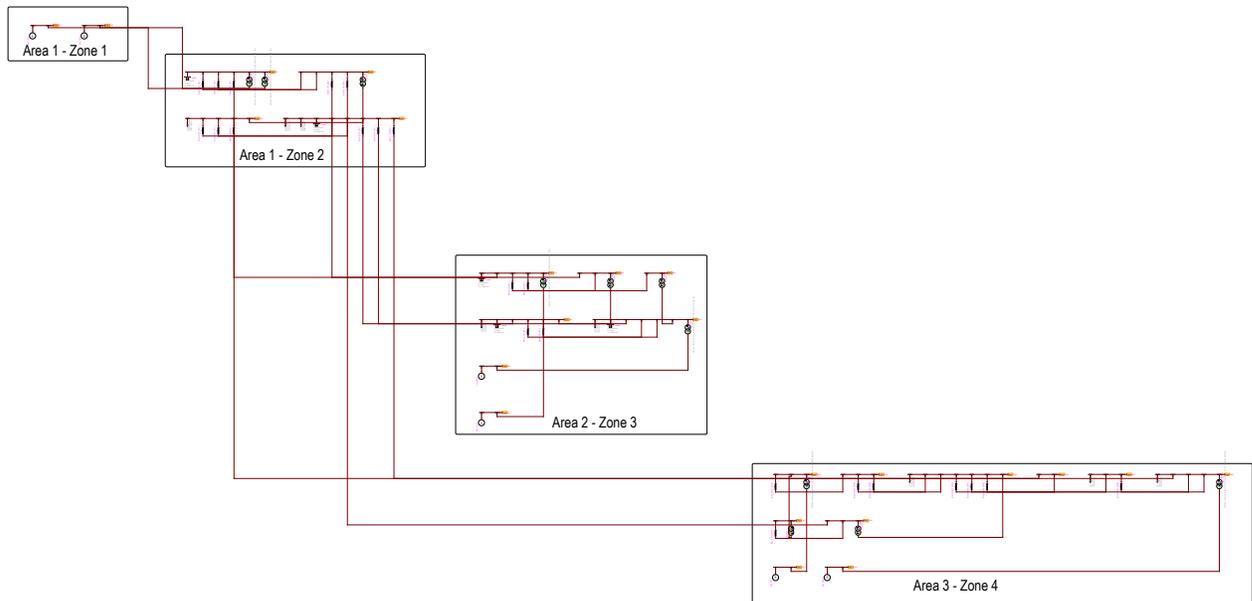
Figure 3: Devices organization when 'By voltage levels' is checked

- **Organization by Areas**: The network is organized based on the voltage levels, but areas are imported on different pages and the devices from different areas are connected using page power connectors. Use virtual connections to connect zones in the same area: The devices from different zones are connected using page power connectors instead of wires (virtual connection).

    o **Use virtual connections to connect Zones inside Areas**: Devices which are in the same zones but not the same Areas are connected using page connectors instead of wires.

    o **Place Zones on different pages**: Zones inside each Areas are imported on different pages and connected using page connectors.

    o **Import Areas/Zones in Sub-Circuits**: This option allows you to import every area (or every zone inside every area when 'Place Zones on different pages' is checked) into a sub-circuit and save all the sub-circuits in a library. All subcircuit are saved into a library named *designName*_subcircuits.clf and saved in the same folder as the EMTP file.

Figure 4: Device organization when Import Areas/Zones in subcircuits is checked

- **Use an Additional Coordinate File for Zones/Areas Location:** allow user to provide coordinates of Zones/Areas. These coordinates are used to place the Zones/Areas subcircuits in the GUI.
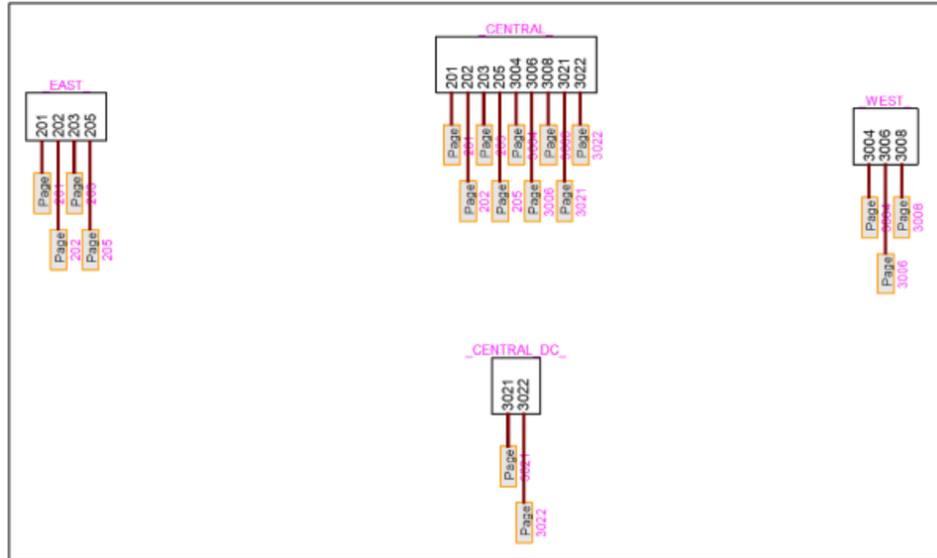
- **Scale factor:** The scale factor between the coordinates specified I the coordinate file and the Coordinate used in the EMTPWorks GUI grid (see Figure 5). For example, if 200 is entered and the length unit of the values in the Coordinate file is miles, each grid division in EMTPWorks is equivalent to 200miles.

  To use this option, the .CSV file must be filled by the user with the coordinates of every area, using the right format. A template of .CSV file can be automatically generated using the **Generate Coordinate file template button**. In this case, all Areas of the .RAW file are added to the template with empty cells allowing user to enter their coordinate. Once the .CSV file is generated and opened, fill in the coordinates, close the file and select it using the Select button and set a scale factor.

  The areas will then be imported into sub-circuits, saved in the specified library, and placed on the design with respect to the specified coordinates in the .CSV file. All sub-circuits are connected using power page connectors (Figure 6).

  If the placing of the sub-circuits does not happen properly (because the coordinates are not specified, the .CSV file is still opened) or if one wants to place the sub-circuits again manually (if the scale factor is not well chosen, the display might be messy) it is possible. Open the saved library in a new design, place the devices from that library (which represent the areas) on the design and connect them.
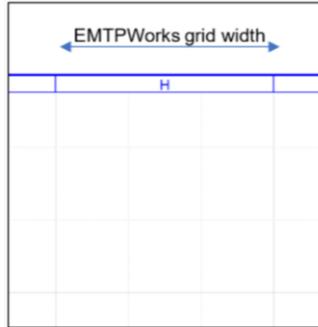
Figure 5: EMTPWorks GUI grid

4.3 Line Model Tab View

In this tab, you can choose what line model to use for branches. The parameter Line length limit represents the length above which branches are modeled using a CP line. If the length of the branch is below this parameter, it is modeled as a PI-line.

In PSS/E, the lengths of branches is not mandatory so might not be available. In this case, to estimate the length of branches, we use the following approximate formula:

$$length = 0.97c\sqrt{LC}$$

where $length$ (in km) is the length of the branch, c is the speed of light, L is the branch total inductance in Henries and C is the branch capacitance in Farads.

4.4 Debugging Tab View

This tab allows to import the network using different options that can help find the source of your issues. For example, if the network is very big and the load-flow does not converge, you can import Areas and/or Zones in different circuits. This way you can test each Area and/or Zone by directly validating the load-flow with the tool and quickly find the source of the error.

- **Import Areas in Separate Designs**: import each Area in a separate circuit. Slack buses are used at the boundaries of each Area with the voltage specified in the .RAW file.

- **Import Zones in Separate Designs**: does the same thing as '**Import areas in separate designs'** but with the Zones. If both Import areas and import zones are checked, every zone inside every area is imported in a separate circuit.

- **Show PSS/E and EMTP bus voltages on the design after load-flow validation**: when the load-flow validation is performed, this option allows you to get the per unit voltage module and phase of each bus written on the design (as a note for each power page connector).

- **Import the network in P.U.**: in some cases, the user might provide a wrong voltage base for a bus which can lead to load-flow convergence issues. With this option, it is possible to ignore the base voltages and import the network entirely in P.U. just like in PSS/E.

4.5 Logging tab

The output view provides a location for the Import Tool to generate and display diagnostic, warning and error messages while the import activity is underway.
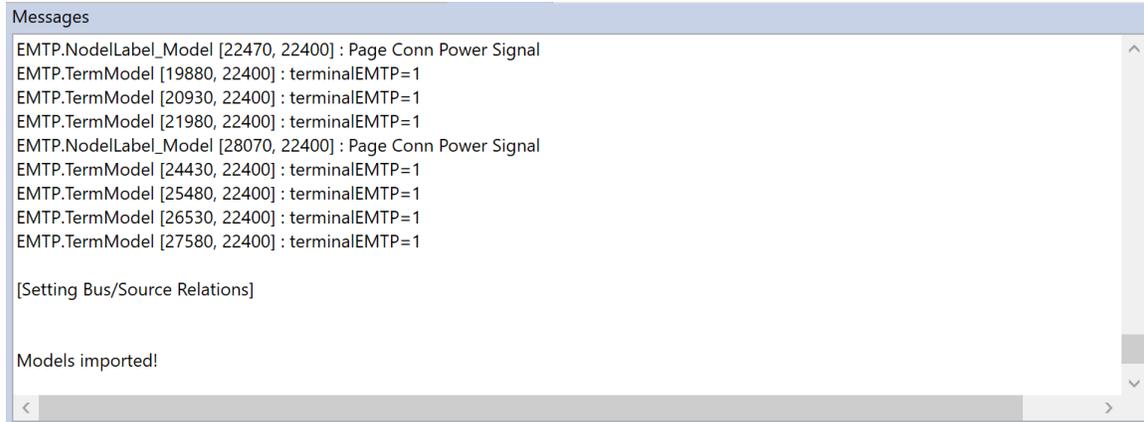


```
Messages
EMTP.NodelLabel_Model [22470, 22400] : Page Conn Power Signal
EMTP.TermModel [19880, 22400] : terminalEMTP=1
EMTP.TermModel [20930, 22400] : terminalEMTP=1
EMTP.TermModel [21980, 22400] : terminalEMTP=1
EMTP.NodelLabel_Model [28070, 22400] : Page Conn Power Signal
EMTP.TermModel [24430, 22400] : terminalEMTP=1
EMTP.TermModel [25480, 22400] : terminalEMTP=1
EMTP.TermModel [26530, 22400] : terminalEMTP=1
EMTP.TermModel [27580, 22400] : terminalEMTP=1

[Setting Bus/Source Relations]


Models imported!
```

Figure 6: Messages Panel

Normal activity and diagnostic messages appear in black. Information such as the location of EMTP and the input files are echoed back to the display to confirm the value that were provided to the import tool. Messages that are warning, but do not necessarily mean there is a fault in the import activity will be displayed using a brown color and are displayed in the Warnings/Errors panel.


```
Warnings/Errors
Warning: the line 83 in the RAW file is not processed.
Warning: the line 84 in the RAW file is not processed.
Warning: the line 85 in the RAW file is not processed.
Warning: the line 87 in the RAW file is not processed.
Warning: the line 88 in the RAW file is not processed.
Warning: the line 96 in the RAW file is not processed.
Warning: the line 97 in the RAW file is not processed.
To find the devices with an error during the import (ModelDataError = 1):
Click on "Advanced Find" on EMTP then search for EMTP Error Check.
```
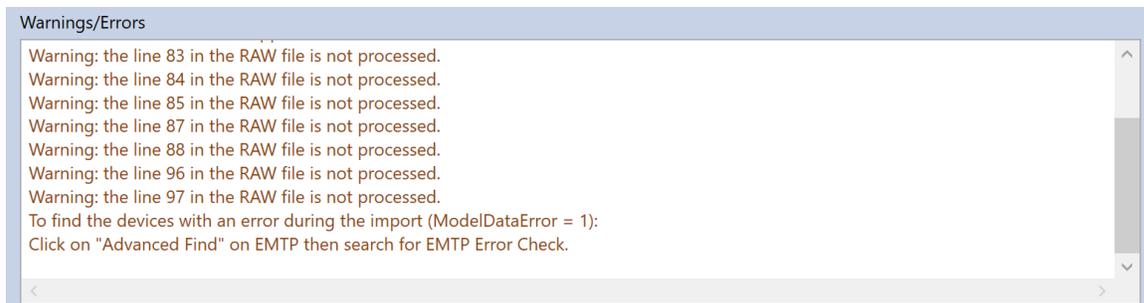
Figure 7: Warnings/Errors Panel

If something occurs that is fatal to the process, this will be displayed in a red color. This could be any number of things including system exceptions as shown below:
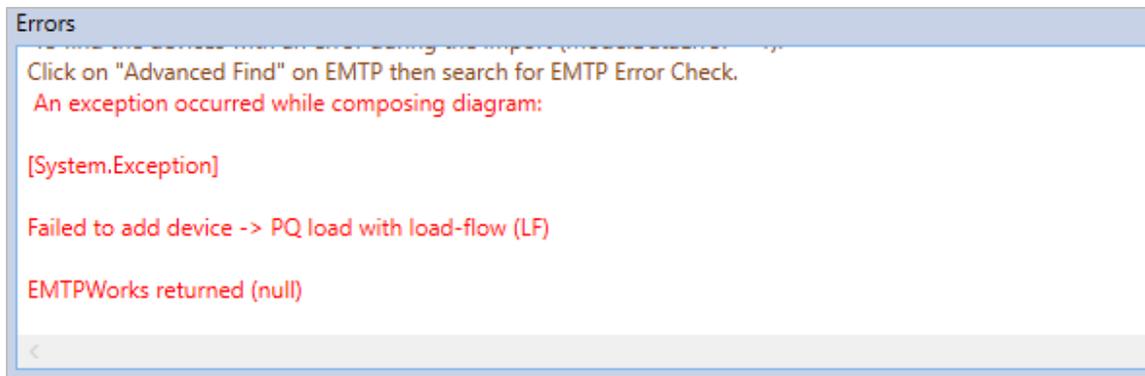
```
Errors
To find the advices with an error during the import (module status = 4),
Click on "Advanced Find" on EMTP then search for EMTP Error Check.
 An exception occurred while composing diagram:

[System.Exception]

Failed to add device -> PQ load with load-flow (LF)

EMTPWorks returned (null)

<
```

Figure 8: example of error

If an error occurs, please contact the technical support for assistance.

5   Validate Load-flow button

Clicking this button starts a load-flow calculation in EMTP and the output results to be written to an output folder that contains the detailed result of the solution. Once the simulation completed, the EMTP load-flow results are compared with the PSS/E load-flow results given in the .RAW file. A summary printout is generated in the message window to display the basic difference between the two solutions.

In case of errors during the EMTP load-flow resolution, look at the EMTPWorks console.

6   Supported PSS/E versions

This tool has been tested for the following versions:

- PSS/E 32

- PSS/E 33

7   List of supported PSS/E components and EMTP devices

The following table summarizes the list of PSS/E components supported by the Import Tool and the equivalent devices used in EMTP.

Table 1: list of supported components

PSS/E components	EMTP devices
Bus	Page connector Power Signal
Non-Transformer Branch	PI or CP lines
Load	PQ Load with Load-flow (see 7.1)
Fixed Bus Shunt	RLC load or ideal voltage source (see 7.2)

Generator	Synchronous machine + Exciter + Governor + Power system stabilizer (if applicable) or ideal voltage source and impedance (see 7.5)
Transformer	- 2-winding transformer: Three-phase nameplate input - 3-winding transformer: YDD, YYD, YYY
Breaker	Ideal switch
Impedance correction table	factor
2-terminal DC lines	Not supported
Multi-terminal DC	Not supported
Multi-section line	Not supported

If a PSS/E design contains components which are not supported by the Import Tool, the following device will be placed in EMTP instead (see Figure 9). Their location can be found after the importation by doing and EMTP search (Ctrl+F) under the 'EMTP Error Check' list.
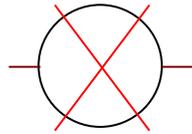

Figure 9: Error device when a PSS/E component cannot be imported

During the importation, connector devices are used to connect devices together. This device has no internal impedance and its sole purpose is to organize the GUI and make clean connection.

Figure 10: connector device

7.1 Loads

Otherwise the power is negative, then there is a power injection to the system. When this happens, the load is replaced by an **AC Source** associated with a **Load Flow Bus**.

7.1.1 Constant Power

If the power is positive, the load is modeled using the **PQ load with load-flow (LF)** where parameters Np and Nq are set to zero.

7.1.2 Constant Current

With a constant current load, the load is modeled using the **PQ load with load-flow (LF)** where parameters Np and Nq are set to one

7.1.3 Constant Impedance

With a constant current load, the load is modeled using the **PQ load with load-flow (LF)** where parameters Np and Nq are set to two

7.2 Fixed Shunt

Fixed shunts can have positive or negative values of active power.

7.3 Positive Power

With positive power, the fixed shunt is modeled using a **PQ load (RLC)** device.

7.4 Negative Power

If the power is negative, then we use both the **PQ load (RLC)** model with an active power parameter of zero and an **AC Source** associated with a **Load Flow Bus**.

7.5 Generators

Processing the generators will execute differently if a DYR file is specified. The is specified in the list below that states the compatible models.

7.5.1 Without Dynamics DYR File

Generators are modeled using an **AC voltage source and impedance**. A transformer is added if an implicit transformer is defined in PSS/E.

7.5.2 With Dynamics DYR File

Generators are created inside a subcircuit containing a synchronous machine connected to it controls (exciter, governor, power system stabilizer) (see Figure 11). If no matching model is found it defaults back to the **AC Source**.

If the exciter information is not available in the DYR file or if the model does not exist in EMTP, the generator field voltage control is not modeled and its value remains constant through out time-domain simulations. The value used is the one calculated during load-flow conditions.

If the governor information is not available in the DYR file or if the model does not exist in EMTP, the generator mechanical power control is not modeled and its value remains constant through out time-domain simulations. The value used is the one calculated during load-flow conditions.
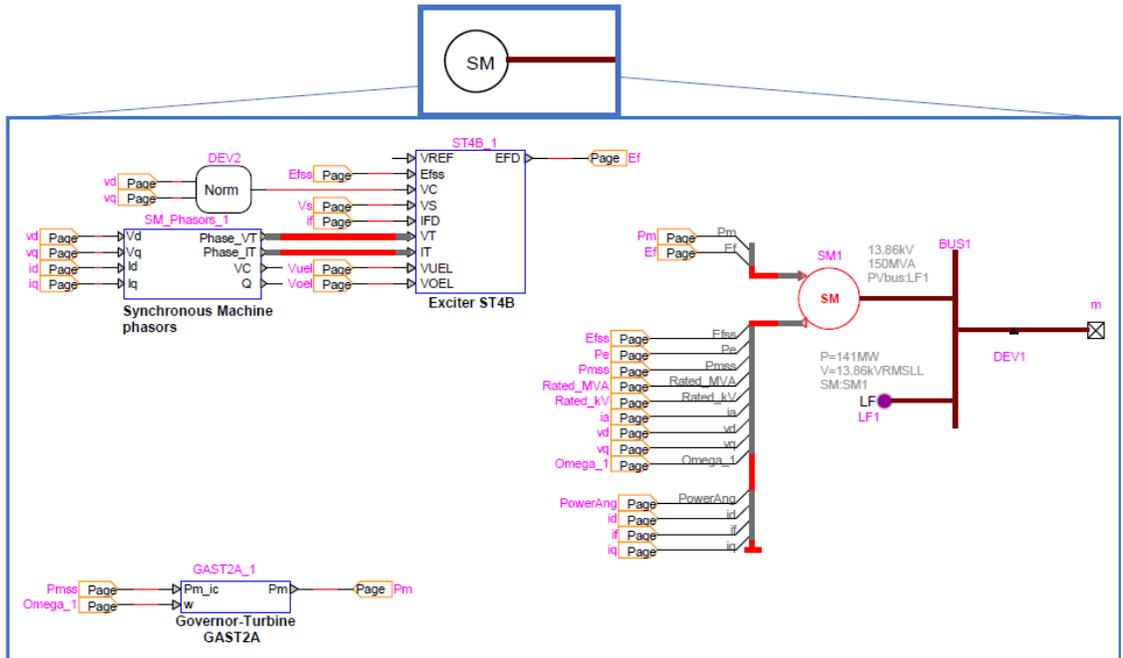
• **Figure 11: PSS/E Generator model imported in EMTP**

7.5.2.1 Supported Exciters.

- Exciter DC1A
- Exciter DC2A
- Exciter AC1A
- Exciter AC3A
- Exciter ST4B
- Exciter AC8B
- Exciter AC7B
- Exciter DC3A
- Exciter AC4A
- Exciter AC2A
- Exciter AC5A
- Exciter AC6A
- Exciter ST1A
- Exciter ST2A
- Exciter ST3A
- Exciter ST1
- Exciter IEEET5
- Exciter SEXS
- Exciter DC4B
- Exciter IEEET1
- Exciter ST5B
- Exciter ST6B
- Exciter ST7B
- Exciter ST8C
- Exciter ST9C
- Exciter ST10C
- Exciter AC10C

- Exciter AC9C
- Exciter AC11C
- Exciter DC1A
- Exciter DC2A
- Exciter AC1A
- Exciter AC3A
- Exciter ST4B
- Exciter AC8B
- Exciter AC7B
- Exciter DC3A
- Exciter AC4A
- Exciter AC2A
- Exciter AC5A
- Exciter AC6A
- Exciter ST1A
- Exciter ST2A
- Exciter ST3A
- Exciter ST1
- Exciter IEEET5
- Exciter SEXS
- Exciter AC2
- Exciter AC3
- Exciter EXPI
- Exciter IEEET2
- Exciter IEEET3
- Exciter REXSYS
- Exciter ST3
- Exciter AC2
- Exciter AC3
- Exciter EXPI
- Exciter IEEET2
- Exciter IEEET3
- Exciter REXSYS
- Exciter ST3

7.5.2.2 Supported Governors

- Governor-Turbine TGOV1
- Governor-Turbine IEEEG1
- Governor-Turbine IEEEG3
- Governor-Turbine IEESGO
- Governor-Turbine GAST2A
- Governor-Turbine GAST
- Governor-Turbine DEGOV1
- Governor-Turbine GGOV1
- Governor-Turbine IEEEG2
- Governor-Turbine HYGOV
- Governor-Turbine HYGOV4
- Governor-Turbine PIDGOV
- Governor-Turbine WSHYGP
- Governor-Turbine HYGOVR
- Governor-Turbine WSHYDD
- Governor-Turbine TGOV5

- Governor-Turbine WSIEG1
- Governor-Turbine TGOV1
- Governor-Turbine IEEEG1
- Governor-Turbine IEEEG3
- Governor-Turbine IEESGO
- Governor-Turbine GAST2A
- Governor-Turbine BBGOV1
- Governor-Turbine WEHGOV
- Governor-Turbine WESGOV
- Governor-Turbine BBGOV1
- Governor-Turbine WEHGOV
- Governor-Turbine WESGOV
- Governor-Turbine BBGOV1
- Governor-Turbine WEHGOV
- Governor-Turbine WESGOV

7.5.2.3 Supported power system stabilizers and other control systems

- Power System Stabilizer IEEEST
- Power System Stabilizer PSS3B
- Power System Stabilizer PSS4B
- Power System Stabilizer PSS5C
- Power System Stabilizer PSS6C
- Power System Stabilizer PSS7C
- Power System Stabilizer PSS1A
- Power System Stabilizer PSS2B
- Power System Stabilizer PSS3B
- Power System Stabilizer PSS1A
- Power System Stabilizer PSS2B
- Under Excitation Limiter UEL1
- Under Excitation Limiter UEL2C
- Under Excitation Limiter UEL1
- Over Excitation Limiter OEL1B
- Over Excitation Limiter OEL4C
- Over Excitation Limiter OEL3C
- Over Excitation Limiter OEL5C
- Over Excitation Limiter OEL2C
- Over Excitation Limiter MAXEX2
- Stator Current Limiter SCL1C
- Turbine Load Controller LCBF1
- Voltage Regulator COMP
- Voltage Regulator COMPCC
- Voltage Regulator IEEEVC
- Voltage Regulator COMP

7.6 Branches

Passive branches are mapped to multiple models depending on the parameters specified.

7.6.1 Negative Reactance (X)

Modeled with a **PQ load (RLC)**

7.6.2 Shunt (Gi != 0 || Gj != 0 || Bi != 0 || Bj != 0)

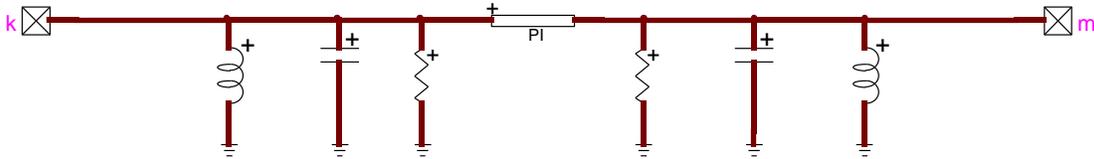Modeled with a **branch** device, which has the following subcircuit:

Figure 12: EMTP branch device subcircuit

7.6.3 Transmission Line

Modeled as a **PI Section** Line if the minimum line length is not met.

Modeled as a **CP Line** if the line is long enough to decouple the network.

7.6.4 Switch (Version 33)

Modeled as an **Ideal Switch** if the ID starts with an '@' character.

7.7 Transformers

2 Winding types are modeled using **Three-phase nameplate input transformer**.

3 Winding types are modeled using **YDD, YYY or YYD nameplate input transformer**

7.8 Impedance Correction Table

If an impedance correction table is defined in PSS/E, the transformer impedance in EMTP is multiplied by a factor calculated based on the interpolation of the RAW file tap voltage and the values of the impedance correction table.

7.9 2 Terminal DC Lines

Not supported in this version. Multi-Terminal DC

Not supported in this version.

7.10 Multi-Section Line

Not supported in this version.

7.11 Zone

See 4.2.

7.12 Inter-Area Transfer

- Not use by the Tool

7.13 Owner

- Not use by the Tool

7.14 FACTS Device

Not supported in this version.

7.15 Switched Shunt

All switched Shunts are modeled as Fixed Shunts

7.16 GNE Device

Not supported in this version.

7.17 Induction Machine

Not supported in this version.