A Brief Introduction to the Power System Analysis Toolbox (PSAT) for Power System Analysis Undergraduate Courses

Federico Milano
federico.milano@ucd.ie

Summary

- Introduction to the PSAT
- Internet community
- Installation
- Executing the PSAT – GUI Mode
- Case study and data preparation
- How to set up a test system for power flow analysis
- Settings and power flow solution
- Viewing and analyzing results
- Questions?

Introduction

- **What is the PSAT?**
  - Is an *open source* power system analysis toolbox for Matlab and GNU/Octave developed by Dr. Federico Milano.
- **What is it used for?**
  - It can be used for power system analysis and control learning, education and research.
- **What is this presentation about?**
  - Is about how to use PSAT from scratch to do simple power flow analysis.
- **What will you learn from this presentation?**
  - This presentation does not intend to give you neither a complete nor solid understanding of the PSAT program.
  - It serves as a simple introduction to get you "up and running" with the program.

Internet Community

- The PSAT Forum is an internet community of developers, program users and power system enthusiasts.
- More than 3,500 users around the world!
- Part of the Open Source nature an philosophy of PSAT: a spirit of collaboration.
- You can get help and ask questions related to the PSAT and Power Systems knowledge.
- Also, download the most recent version of PSAT, PSAT Documentation, sample data files, etc.
- Hope to see you there!:

  http://tech.groups.yahoo.com/group/psatforum/

Installation

- You will be provided a compressed *tarball* with the most recent distribution of the PSAT and the documentation.
- You can alternatively download the PSAT from:

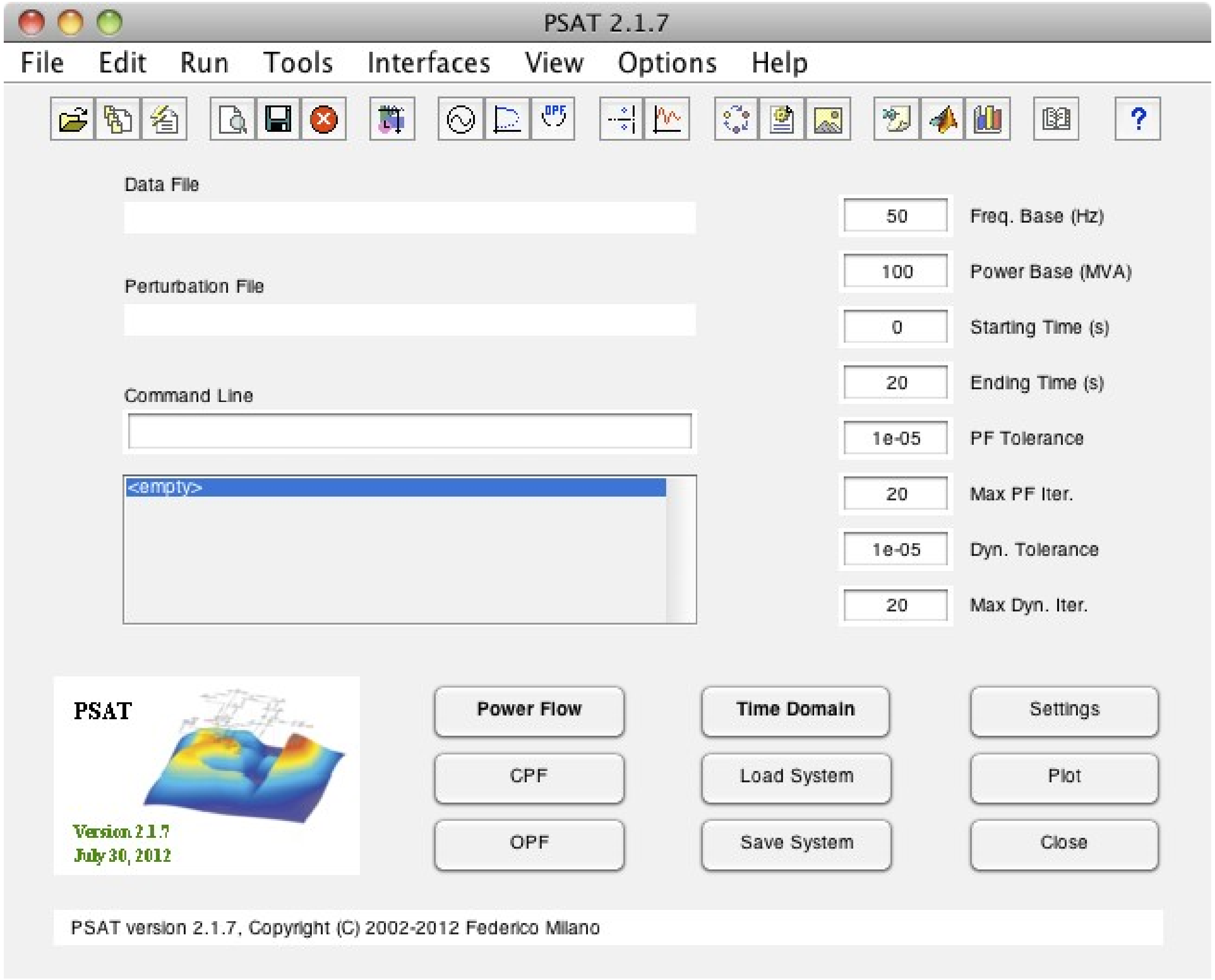
  http://faraday1.ucd.ie/psat.html
- Uncompress the files and copy the "psat" folder preferably to the "work" directory in the Matlab directory.
- It is advisable that you add the "psat" directory and its subdirectories to the Matlab Path.

Executing the PSAT in GUI Mode

- Once PSAT has been installed type in the Matlab Command Window:

>> psat

- After a splash window, the "Main GUI" will appear in your screen:

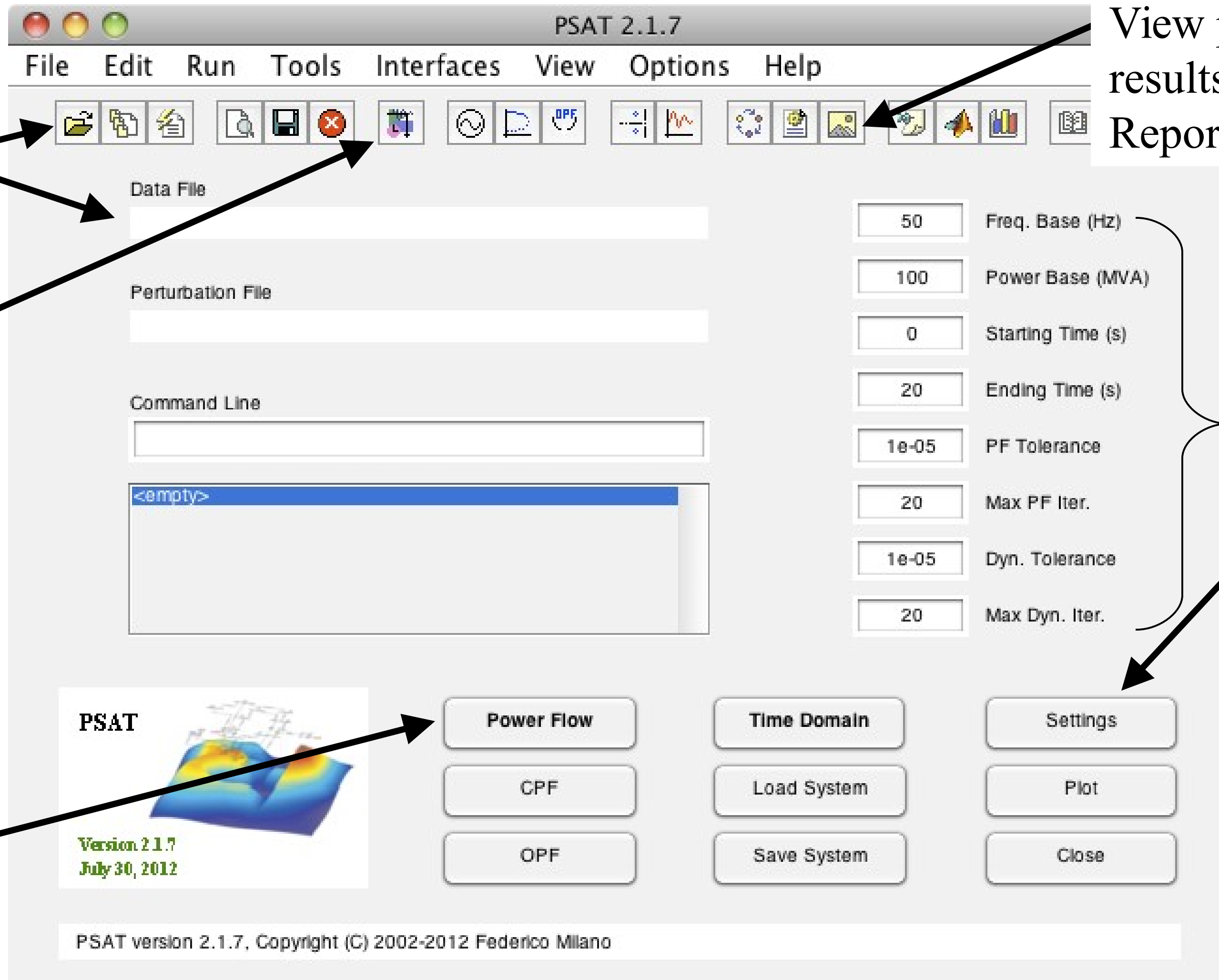


Options and settings you will be using

Open a data file

Launch the PSAT-Simulink model library (to set up your one-line diagram)

Run power flow



View power flow results, "Static Report" icon

Program settings

Case Study and Data Preparation

- **Power flow example from Grainger and Stevenson's book.**

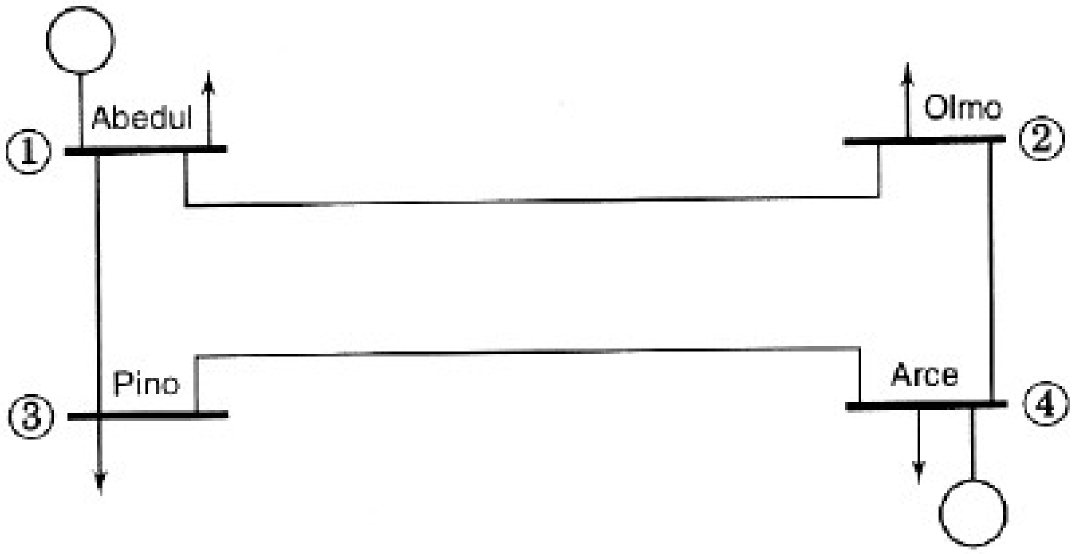


FIGURA 9.2
Diagrama unifilar para el ejemplo 9.2 en que se muestran los nombres y números de las barras.

Case Study and Data Preparation

- **You should prepare your system data in tables for easy input into PSAT:**

Voltage base	20 kV
System base	100 kVA

System data

Bus	V	Pg (kW)	Qg (kVAr)	Pd (kW)	Qd (kVAr)	type
1	1.00	?	?	50	30.99	slack
2	?	0	0	170	105.35	PQ
3	?	0	0	200	123.94	PQ
4	1.02	318	?	80	49.58	PV

Line data

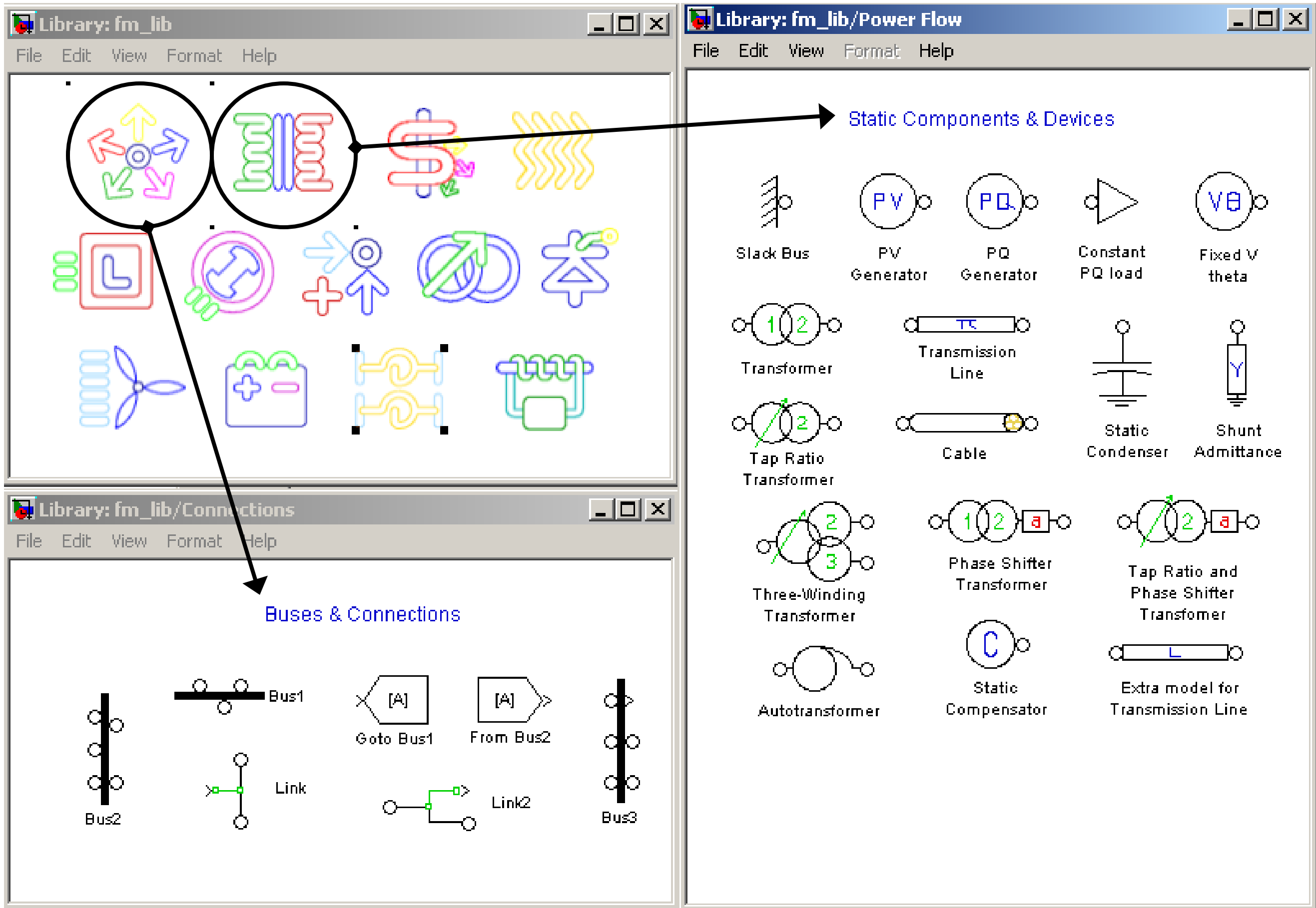
From bus	To bus	r (pu)	x (pu)	b (pu)
1	2	0.01008	0.0504	0.1025
1	3	0.00744	0.0342	0.0775
2	4	0.00744	0.0342	0.0775
3	4	0.01272	0.0636	0.1275

Setting up the system in PSAT

- **Two options: data files or one-line diagrams via the Graphical Network Editor using the PSAT-Simulink library**
- **Simulink is used as a Graphical Editor, *<u>not a simulation environment</u>*.**
- **After you finish drawing your one-line diagram, you must save the file and load it to PSAT it via the "Data File" field in the PSAT Main GUI.**
- **This will translate your Simulink diagram to a PSAT readable data file.**
- **We will cover how to use the GNE, if you want to learn how set up a data file by directly inputting the data, refer to the PSAT documentation.**

Using the GNE Power Flow Components

- Click on the Simulink icon of the PSAT Main GUI.
- The Simulink model library will appear.
- You only need to use two of the sub libraries.



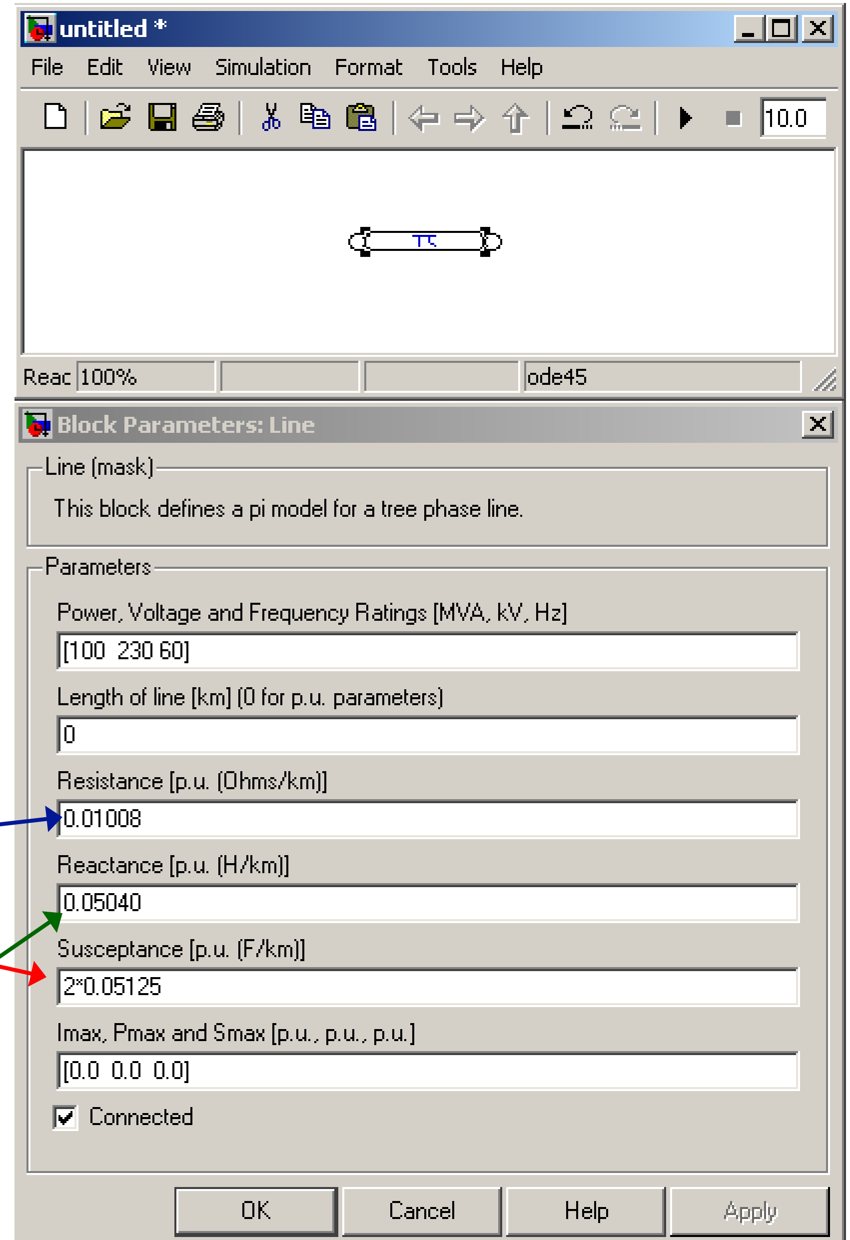
- Drag and drop the components you need to use in a blank Simulink file.

TL from Abedul to Olmo

- **Drag and drop the PI transmission model to a blank Simulink File.**
- **Double click on the component and introduce all the data.**
- **Line data:**

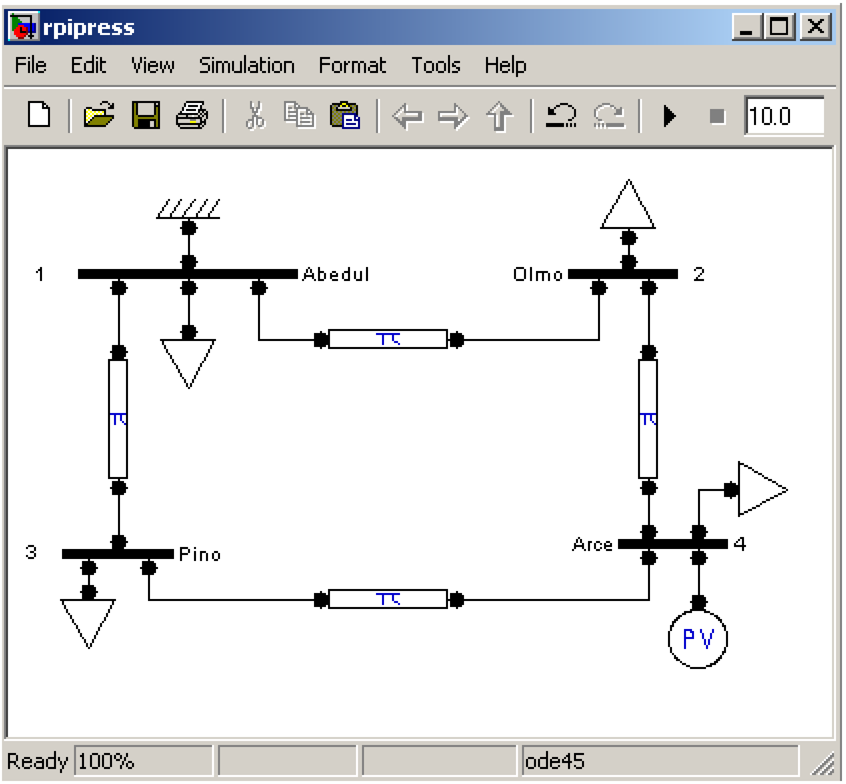
From Bus	To Bus	R	X	Y/2
1	2	0.01008	0.05040	0.05125

(Use per unit values)



Final One-Diagram

- Keep adding each of the remaining elements of the one-line diagram.
- If you have doubts on what to enter for each field of any element, you should first refer to the manual.
- If you don't have data for any specific field, use standard values.
- The final result looks similar to the one on the right.



Remarks on Per Unit Values in PSAT

- **The default power base is 100 MVA. This value can be changed in the main PSAT window.**
- **Buses define the voltage base in kV.**
- **Per unit values of each device are defined based on the power and voltage nominal rates of the device.**
- **Before running the power flow analysis the per unit value of each devices are converted to the system power base and to the voltage base of the bus at which the device is connected.**

Very Important Remarks

- Power bases **always** refer to three-phase apparent powers and are expressed in **MVA**.
- Voltage bases **always** refer to line-to-line values and are expressed in **kV**.
- Impedance and admittance values are always **per phase**.

Example on Per Unit Values in PSAT (I)

- **Let assume the the system power base is Sb = 0.1 MVA.**
- **Let define two Buses with a nominal voltage rate Vb = 20 kV.**
- **Let connect the two buses through a transmission line.**
- **The transmission line has the following data: power rate Sn = 0.05 MVA, voltage rate Vn = 22 kV and resistance r = 0.1 pu.**
- **What is the line resistance used by PSAT?**

Example on Per Unit Values in PSAT (II)

- **The nominal impedance on line nominal rates is:**

$$Z_n = \frac{V_n^2}{S_n} = \frac{22^2}{50} = 9.68 \text{ kA}$$

- **The system base is:**

$$Z_b = \frac{V_b^2}{S_b} = \frac{20^2}{100} = 4.0 \text{ kA}$$

- **Hence the final resistance value used in power flow analysis is:**

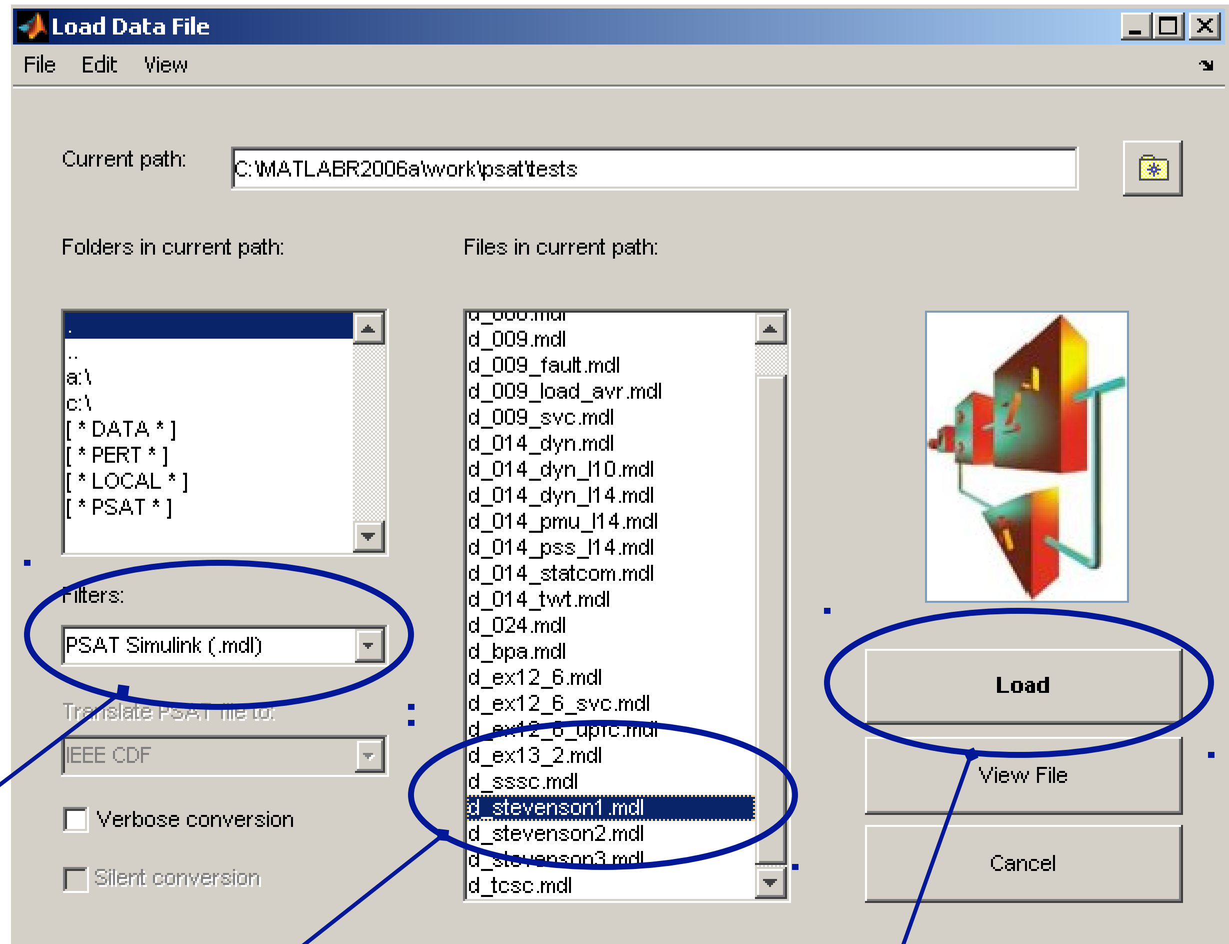
$$r_{system} == r_{line} \frac{Z_b}{Z_n} = 0.1 \frac{9.68}{4.0} = 0.242 \text{ pu}$$

Hints to avoid Errors

- **Use the same value for the system power base and device nominal power rates.**
- **Use the same value for bus voltage bases and device nominal voltage rates.**
- **If the rules above are satisfied, then base conversion does not change user input values.**
- **Note: if Sn = Sb = 1 MVA and Vn = Vb = 1 kV for all devices, then one can think as powers in MVA, voltages in kV, currents in kA, and impedances in Ohms.**

Load the model to PSAT

- ***Save the Simulink model, AFTER saving the model LOAD IT to PSAT via the “Data File” field of the M***



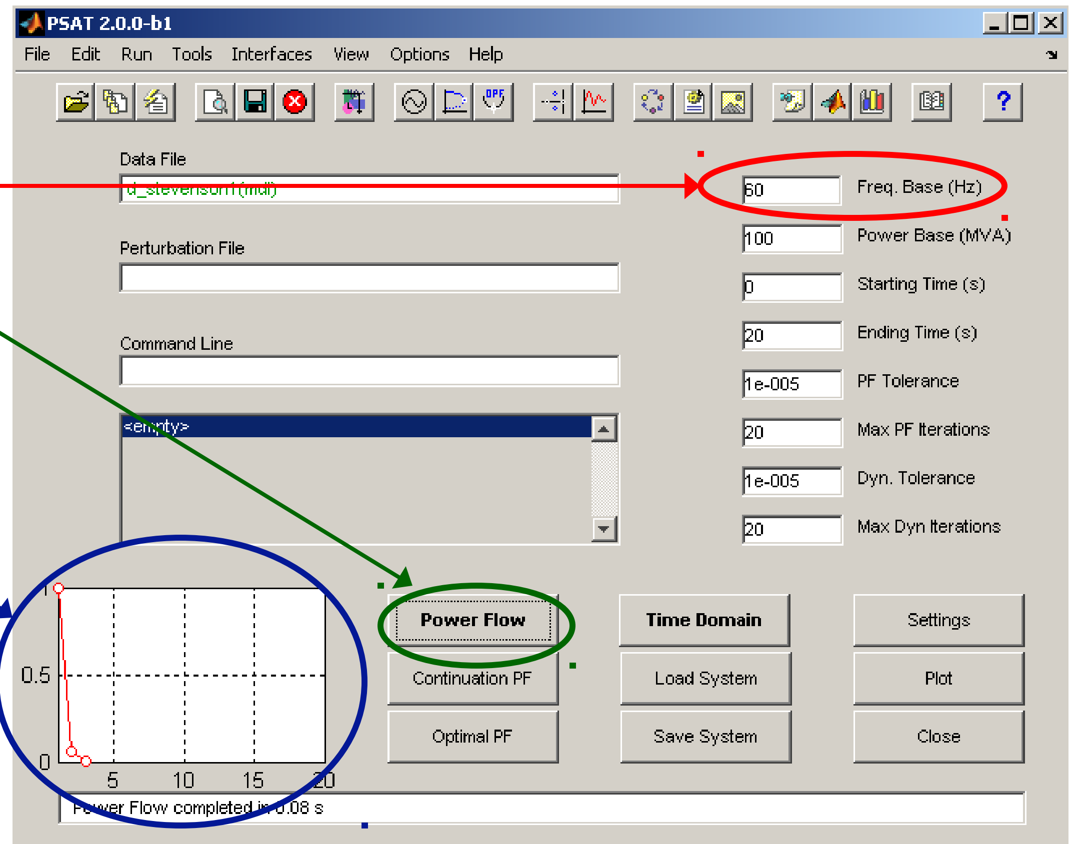
Set the type of your file

Choose the file you created

Click on “Load”

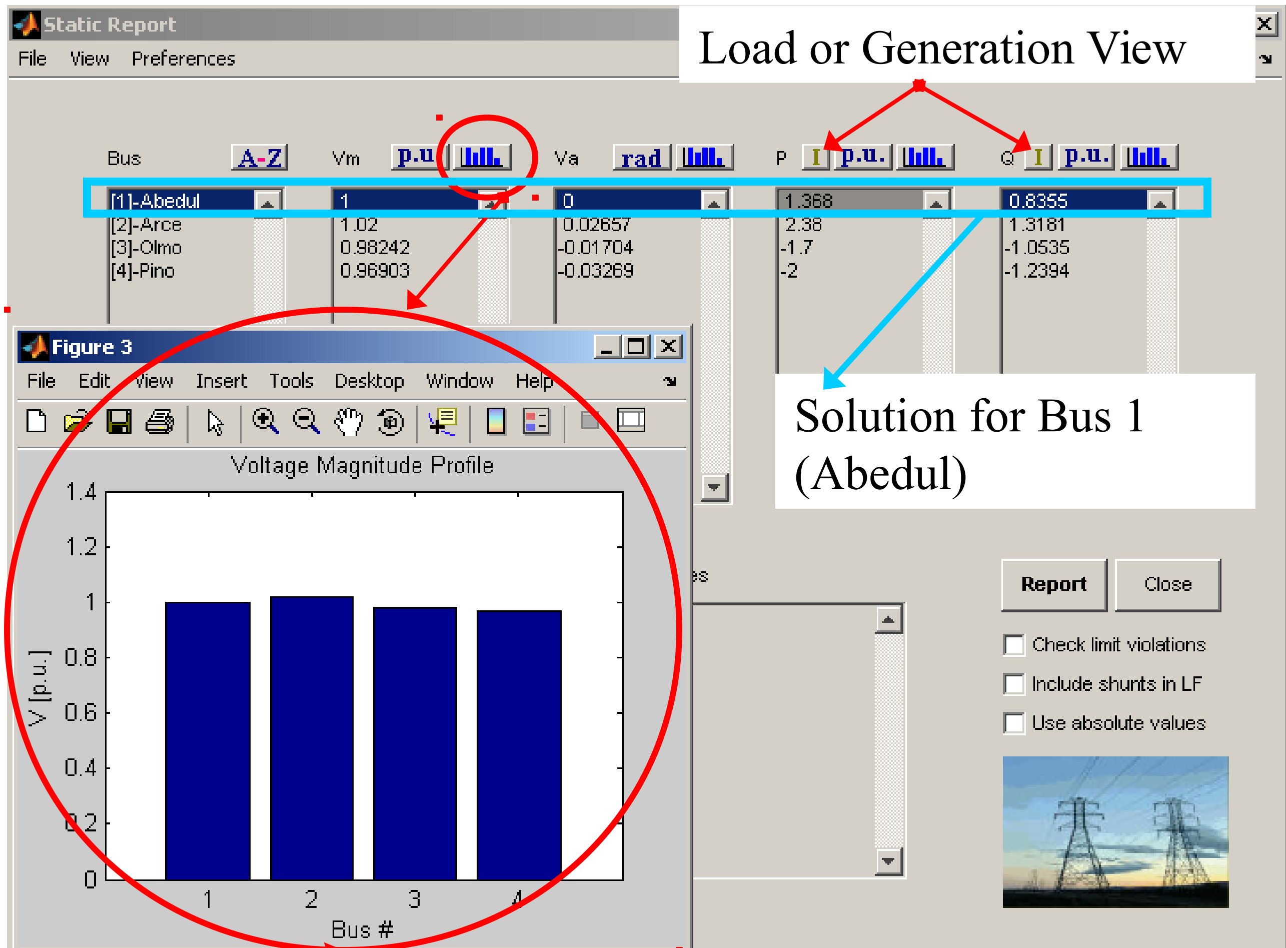
Running Power Flow

- Remember to adjust the settings to what you desire (Frequency is 60 Hz in the US)
- Click on the "Power Flow" icon.
- A small window in the Main GUI will show you the iteration process, you will know when the program has converged to a solution.



Viewing the Power Flow Results

- Click on the "Static Report" icon.
- The "Static Report GUI" will appear in your screen.



Voltage (Magnitude) Profile Plot

Generating a power flow report

- To generate a power flow report, click on the “Report” icon on the “Static Report” GUI.
- A text file will appear in your screen with the solution details.
- You can also set your preferences, such as Text Viewer in the “Preferences Menu”.
- You can also check limit violations and include shunts through the options below the “Report” button.