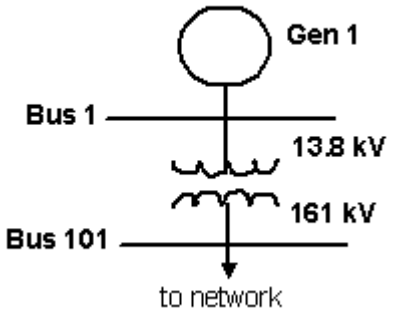
Power System Simulation for Engineers (PSS/E version 30): Stability Analysis

The following provides some step-by-step instructions for using the PSS/E software. Note that these instructions are meant to assist you as a guide, but one should not expect that they are perfect nor will they alleviate you from having to think. Rather, expect to apply good judgment when using the programs. When you come to a point that appears unclear to you, assess the situation as best as you can, make a decision, note your thinking on a pad of paper, and move on. Also, you should have access to the manuals as a resource to clarify any problem you come across. The manuals can be found at Start>All Programs>PSSE 33>Documentation (pdf files), then click on "POM (Programs Operation Manual)," and then "Volume I." You may find some material of particular benefit in these manuals in chapters 5 and 7, particularly chapter 7. Also, "Volume II" of the "Programs Operation Manual" shows the data formats that were used to create the Dynamic Data sheet used for this project.

To perform stability analysis in PSS/E one will need two data files:

- **EX2_Stability.sav**: This is the saved case that was used in the first parts of the project (fault analysis); however it has been slightly modified to directly represent the step-up transformers that follow a generator. In this more realistic case all three generators, still attached to buses 1, 2, and 3, produce power at 13.8 kV. The voltage is stepped-up to 161kV by a transformer. The high sides of the transformers are then attached to new buses 101, 102, and 103 respectively. It is these buses that now go out to the network. There is no line between bus 1 and bus 101, so you can "basically" think of them as the same.



- **457project2.dyr**: This a dynamic data file that has machine data for all machines in the system. Each machine has H = 3 and speed damping = 2.

1. Preparing for a stability run:

Several actions need to be performed before the case is ready for a stability run.

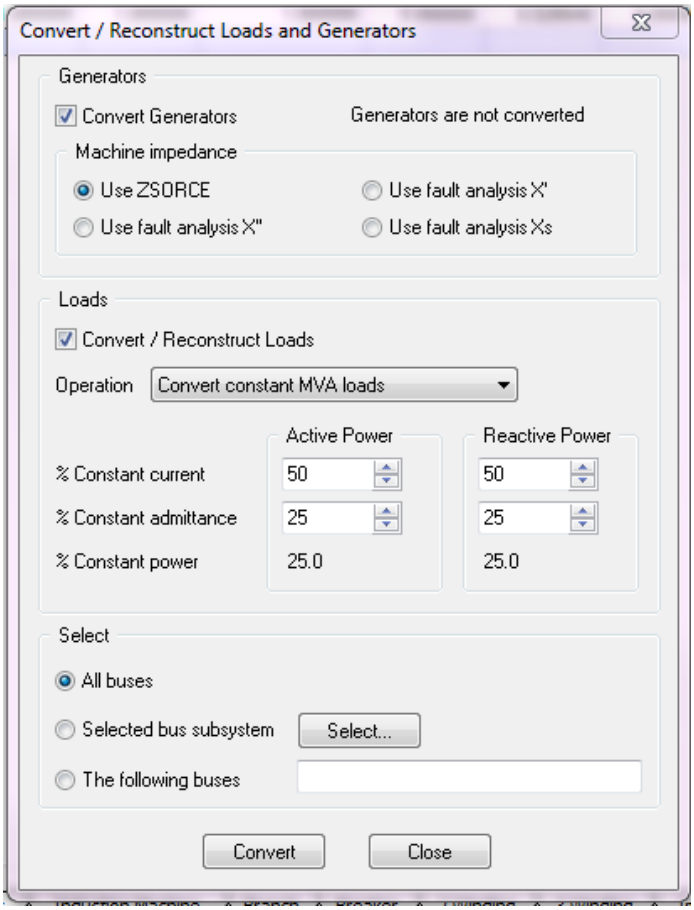
a. Open the new saved case (EX2_Stabiliy.sav). One can access specific instructions for launching PSS/E by viewing the "PSSE_Fault_Intro_Instructions.doc" file.

b. With the file open, click on the **Machines** tab. Under the column labeled **X Source (pu)** input the X_d' value for each of the three generators (use same value for each).

c. Next, input the same negative and zero sequence values that you used in your fault analysis case (specifically Z-Zero on the Branches page).

d. Next, in order to perform stability analysis you need to convert the generators to Norton equivalents (constant current injections) and assign load characteristics to the loads. To

do this, on the top menu go **Powerflow>Convert Loads and Generators**. The following dialog box will be displayed:



Click the same options as done above.

e. Perform **ORDR** (**Powerflow>Solution>Order Network for Matrix Operations**). This re-orders the buses for sparsity (required because we converted the swing bus to a type PV bus).

f. Perform **FACT** (**Powerflow>Solution>Factorize Admittance Matrix**). This factorizes the A-matrix.

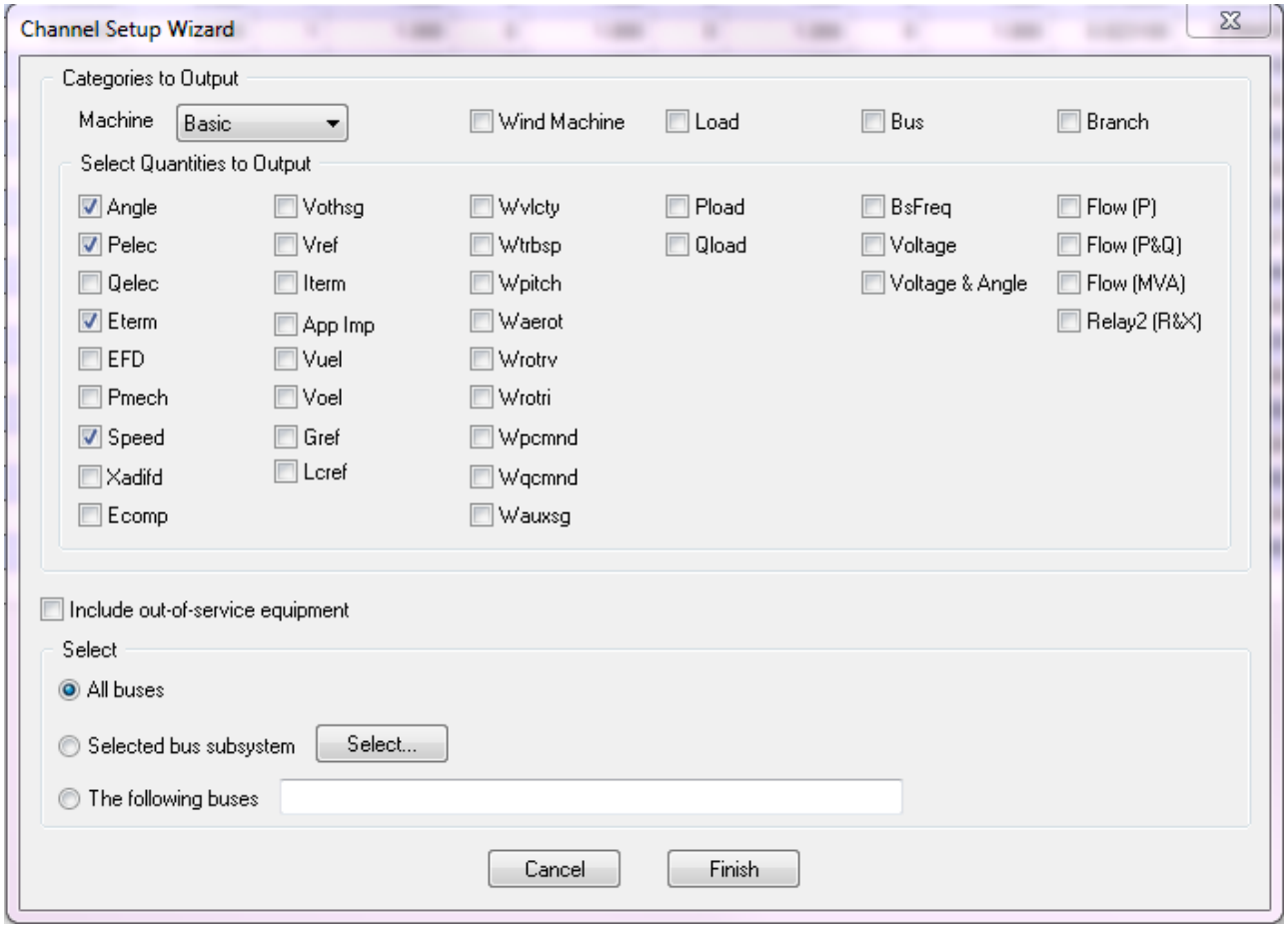
g. Perform **TYSL** (**Powerflow>Solution>Solution for Switching Studies**). This performs what you might think of as an simplified load flow calculation (basically just an I=YV).

h. Perform **Save/Show** on your converted case. **Give this converted case a different name than the saved case used in the first part of the project!** Now that you have this saved you shouldn't need to perform this first set of instructions again.

i. **Close out** of PSS/E (this will make sense in a second).

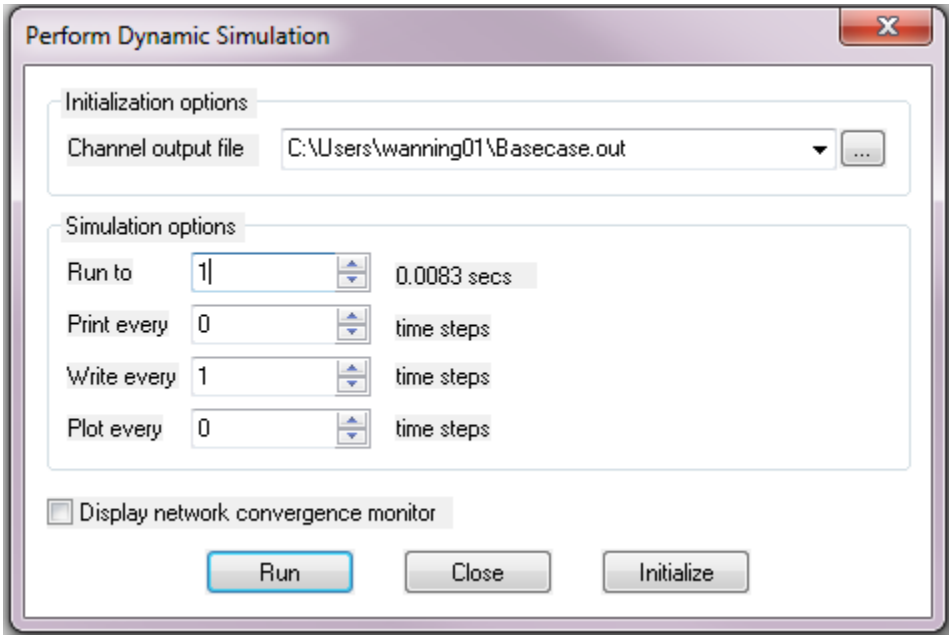
2. **Performing a base case stability run**:
    a. Open the case via **File>Open>(your case.sav)**.
    b. Read in the dynamic data sheet: **File>Open>(your dyr file)**. locate the **457project.dyr** file.
    c. We next need to tell PSS/E which data to record. Under **Dynamics,** Click **Define Simulation Output (CHAN)** menu button. The program responds with a number of options.
        1. Choose **machine quality**
        2. Program responds with "Enter bus number, machine ID (used if there are more than 1 generators at a bus (not our case)), identifier." In the bus number type 1, in the machine ID type 1, and leave the identifier blank. Perform this same task for buses 2 and 3.
        3. Repeat the above steps for output categories **Pelec**, **Eterm**, and **Speed**.

An alternative easy way to add Channel is using Channel setup wizard. Under **Dynamics,** Click **Channel setup wizard** menu button, then you will the following figure:



Click **Angle**, **Pelec**, **Eterm**, and **Speed**. And then select **All buses.**

d. Under **Dynamics**, choose **Simulation** tab, Click the **Perform Simulation (STRT/RUN),** this will perform the initial condition calculation first. Program responds with "Channel output file." Enter a filename with a ".out" suffix.
For Simulation options: Program responds with a menu with user inputs for **Run to, Print Every, Write Every, Plot Every**. Enter **1,0,1,0** respectively. This will run the simulation from 0 to 1 second, writing nothing to screen and writing every time step to the plotting file. Click **Initialize** at the bottom, then Press **Run**. This is now your base case simulation. Press **Close** to exit.



3. Performing a stability run:

For stability analysis the general approach is as follows:

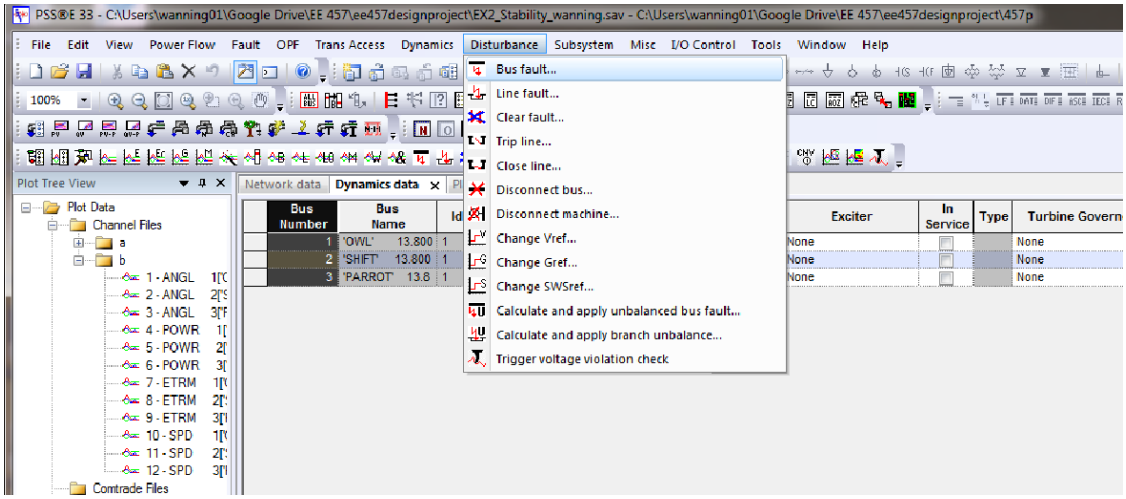
- Apply a fault
- RUN the simulation from time = 0 until t = breakers open
- Clear the fault and remove a line
- RUN the simulation from t = breakers open until t = 10 seconds

a. Initialize

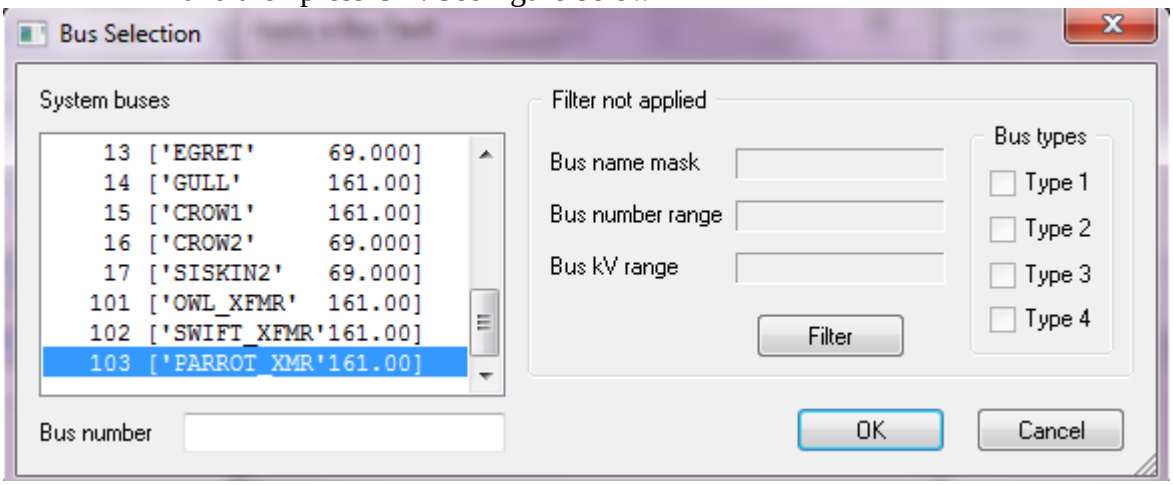
Under **Dynamics**, choose **Simulation** tab, Click the **Perform Simulation (STRT/RUN),** this will perform the initial condition calculation first. Program responds with "Channel output file." Enter a filename with a ".out" suffix. Eg. 'Fault.out' file. Click **Initialize** at the bottom.

b. Apply a fault

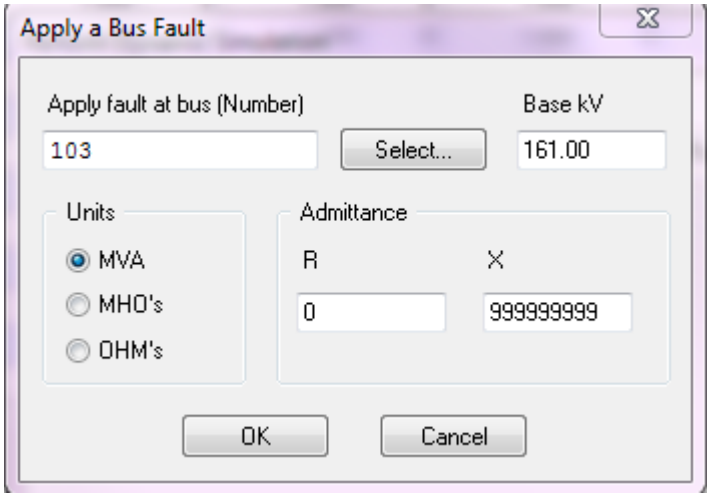
1) Click "**Disturbance**" and choose "**Bus fault"**



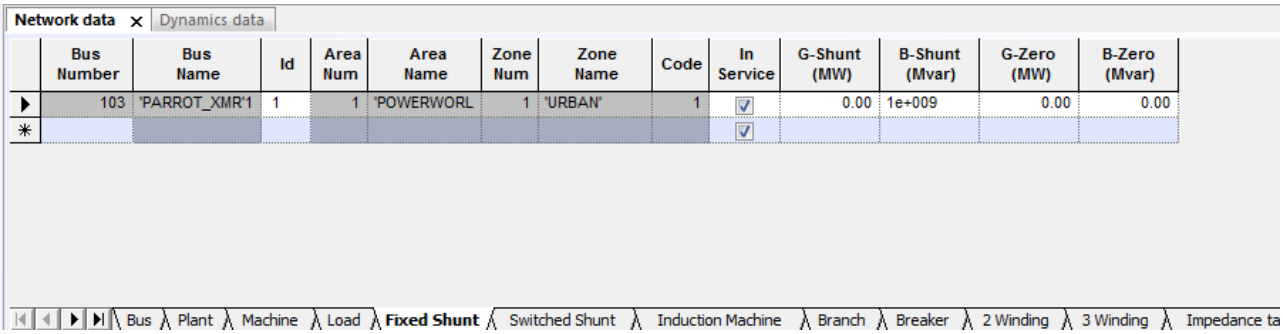
2) Then in the "Apply a But Fault" window, Click **Select** option and choose bus 103 and then press OK. See figure below



1. Then enter "99999999" in admittance X, This puts a fault with a very large susceptance at the bus (effectively, putting a short-circuit at the bus). see below.

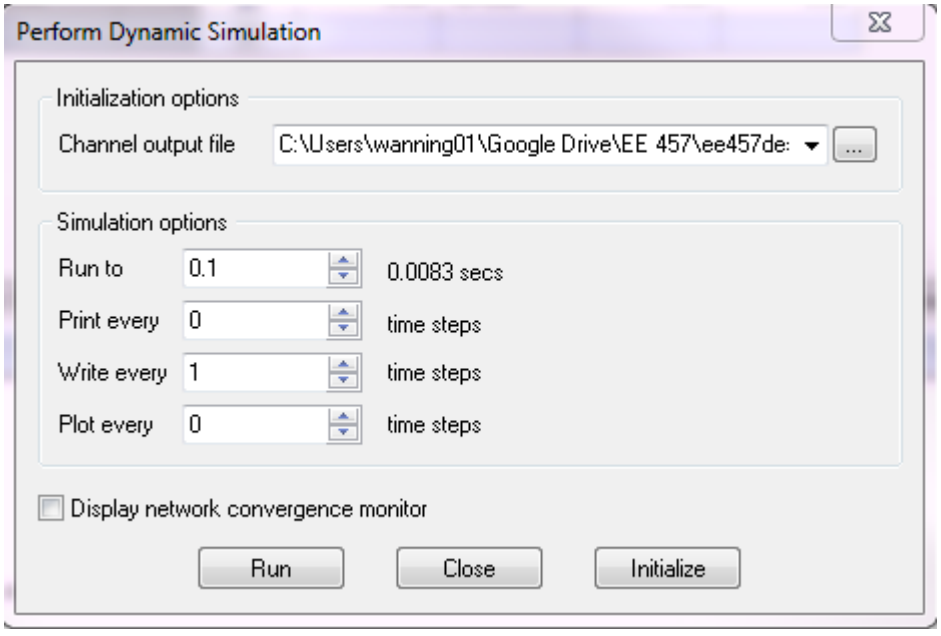


Thus, you can find out in network data at tab “Fixed Shunt”, a fault is applied. As seen below



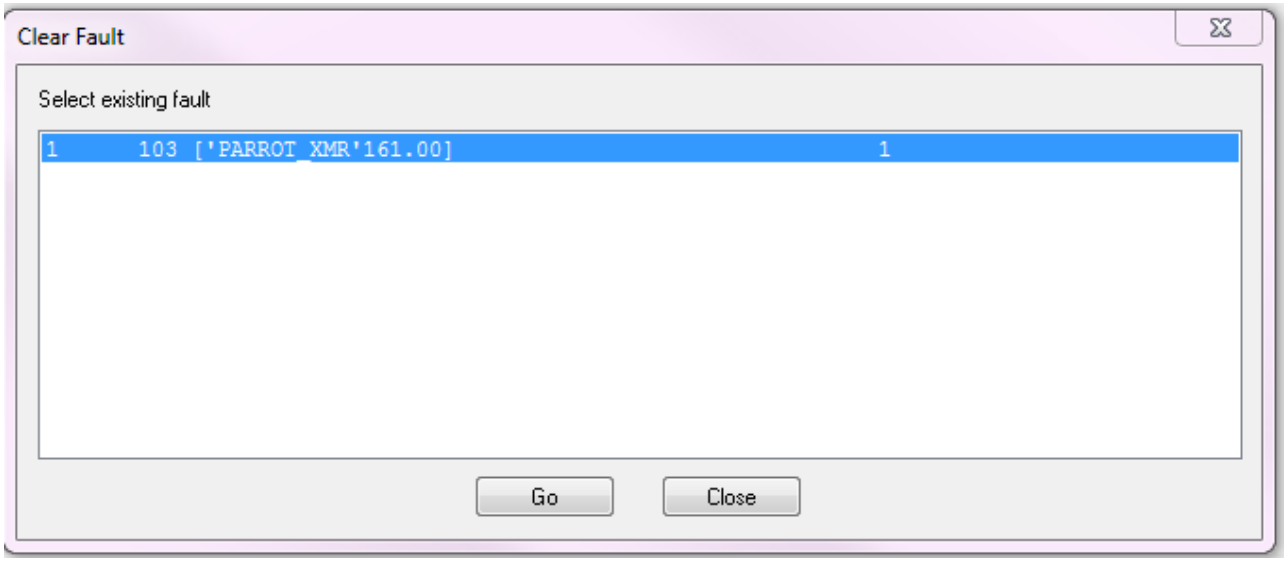
c. RUN the simulation from time = 0 until t = breakers open

Under **Dynamics**, choose **Simulation** tab, Click the **Perform Simulation (STRT/RUN).**Program responds with “Channel output file.” Enter the same “.out” file for which we have initialized above. Eg. ‘Fault.out’ For Simulation options: Program responds with a menu with user inputs for **Run to, Print Every, Write Every, Plot Every**. In this case, we set clear time at 0.1 sec, Enter **0.1,0,1,0** respectively. This will run the simulation from 0 to 0.1 seconds. Since we have already **Initialized, we** Press **Run** now.

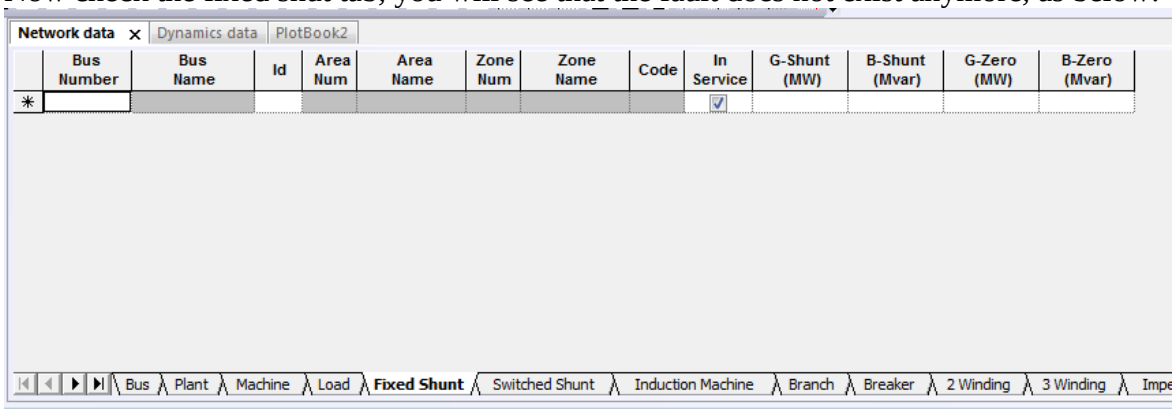


d. Clear fault

1. Click “**Disturbance**” and choose “**clear fault”**
2. Choose existing fault and press go, as below figure.



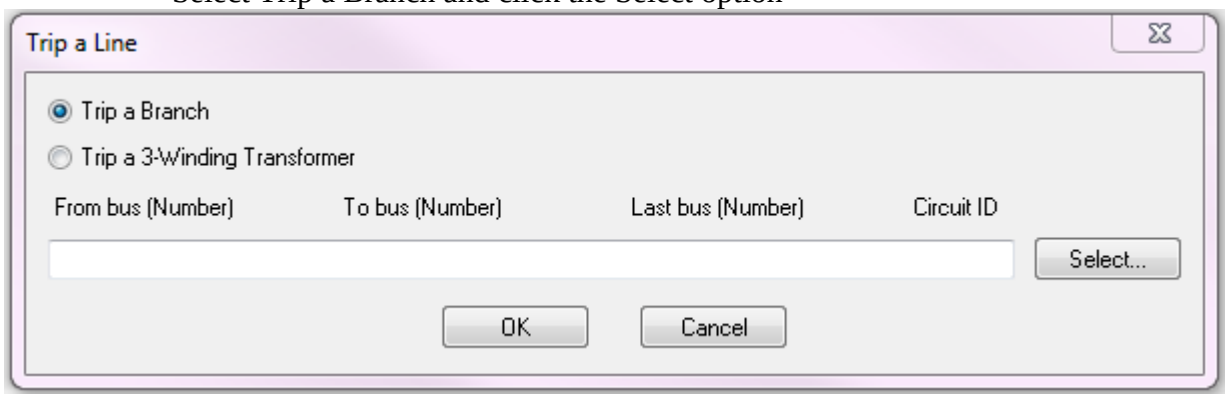
Now check the fixed shut tab, you will see that the fault does not exist anymore, as below.



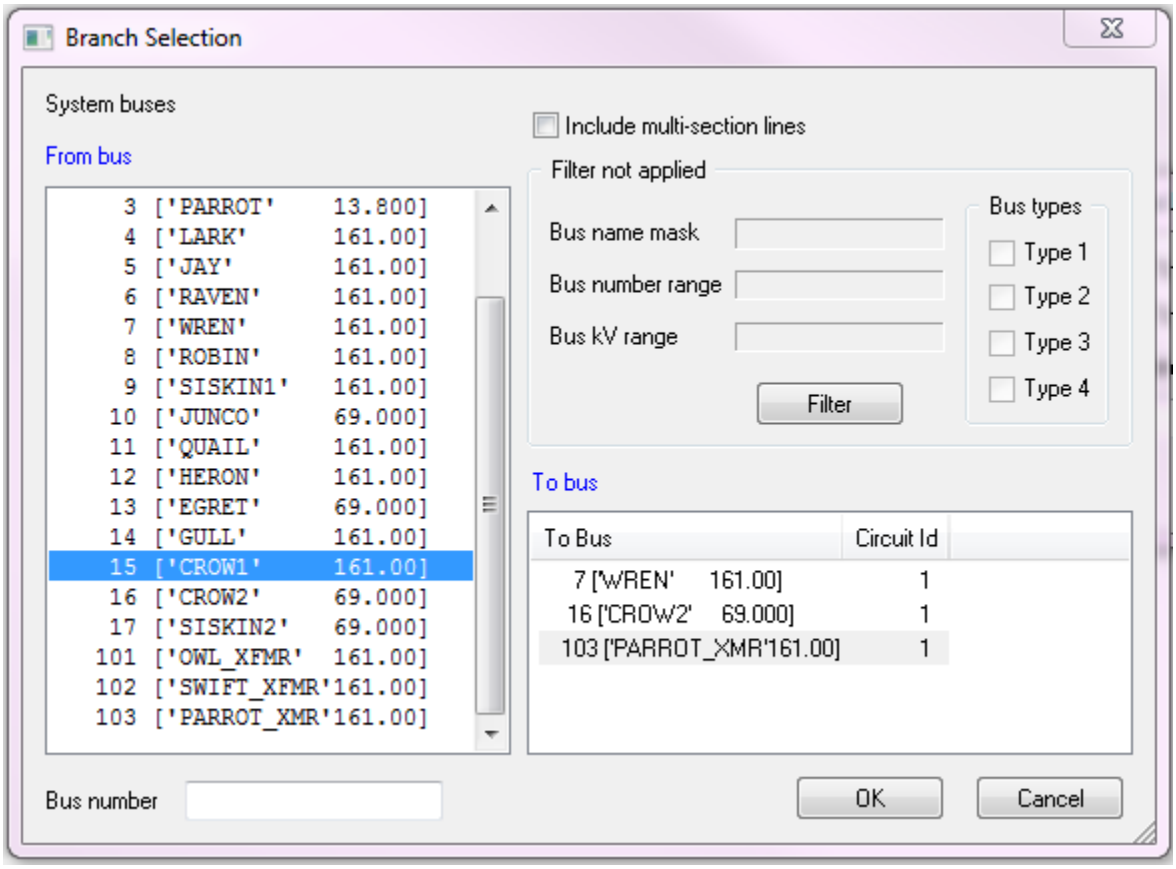
NOTE: To clear the fault, we also need to remove the circuit from Parrot to Crow, say trip line from bus 15 to 103.

3. Click **Disturbance** and select **Trip a line**. See below.

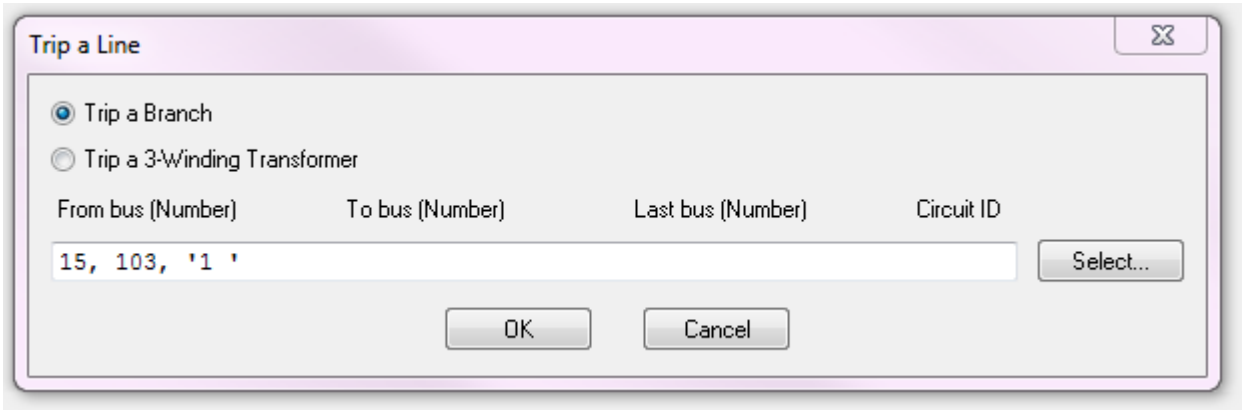
Select Trip a Branch and click the Select option



Then select From bus 15. Select To bus 103 in the right. Then click Ok.



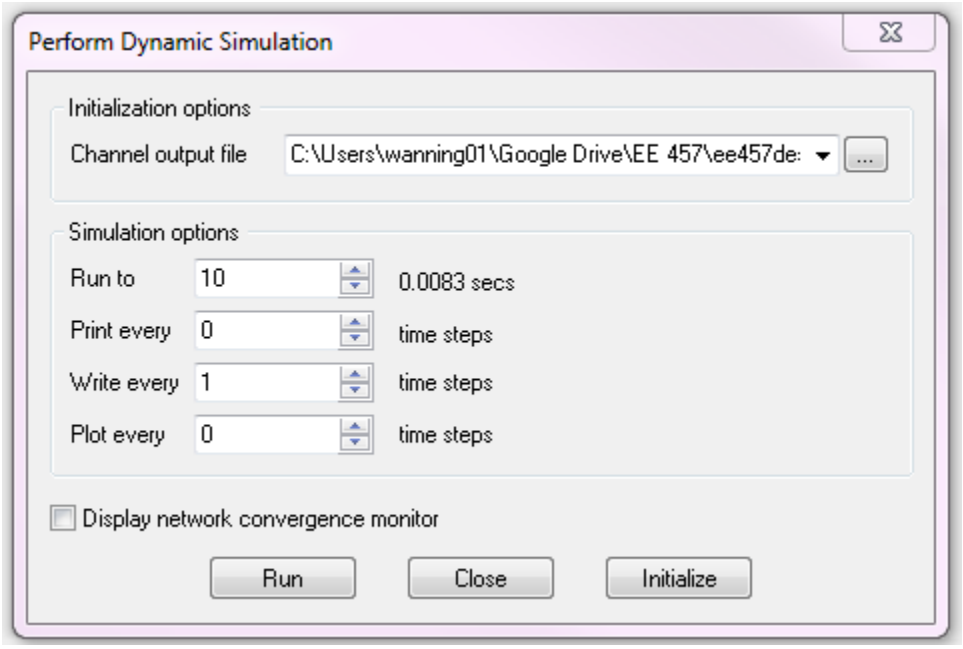
Then you will see the following figure. Press OK. Then Line CROW to PARROT has been tripped.



e. RUN the simulation from t = breakers open until t = 10 seconds

Under **Dynamics**, choose **Simulation** tab, Click the **Perform Simulation (STRT/RUN),** Program responds with "Channel output file." Enter the same filename with a ".out" suffix with step b, say, "fault.out". For Simulation options: Program

responds with a menu with user inputs for **Run to, Print Every, Write Every, Plot Every**. Enter **10,0,1,0** respectively. This will continue to run the simulation from 0.1 to 10 seconds. Remember do **not** click **Initialize** at the bottom, Click **Run** directly. And then click "**Close**"



f. **Plotting**:

Here, we introduce a new PlotPackage called Plotbook for PSS@E 33.

The manuals can also be found at Start>All Programs>PSSE 33>Documentation folder, then click on "GUI_guide" and then "Volume I." you will find the Plot instruction in Chapter 23, Dynamic Simulation PlotPackage.

1. Creat a PlotBook

   A PlotBook is opened by clicking on File > New and selecting the Plot Book radio button as shown in Figure below

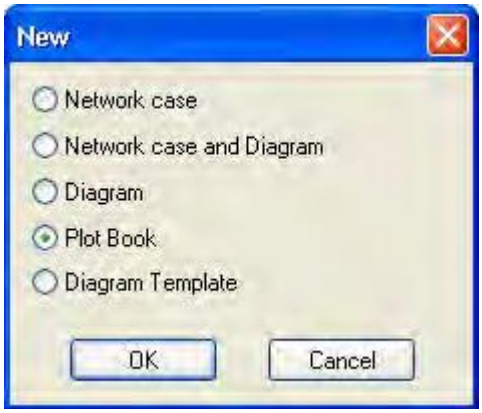
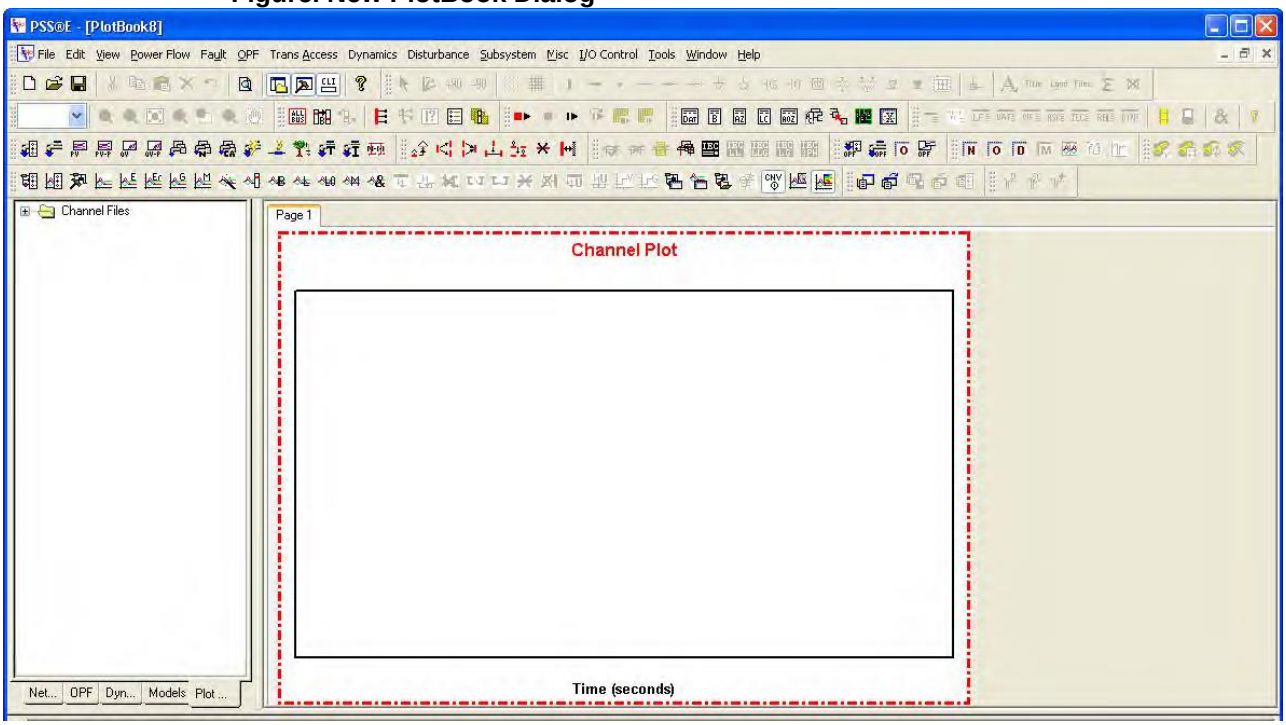
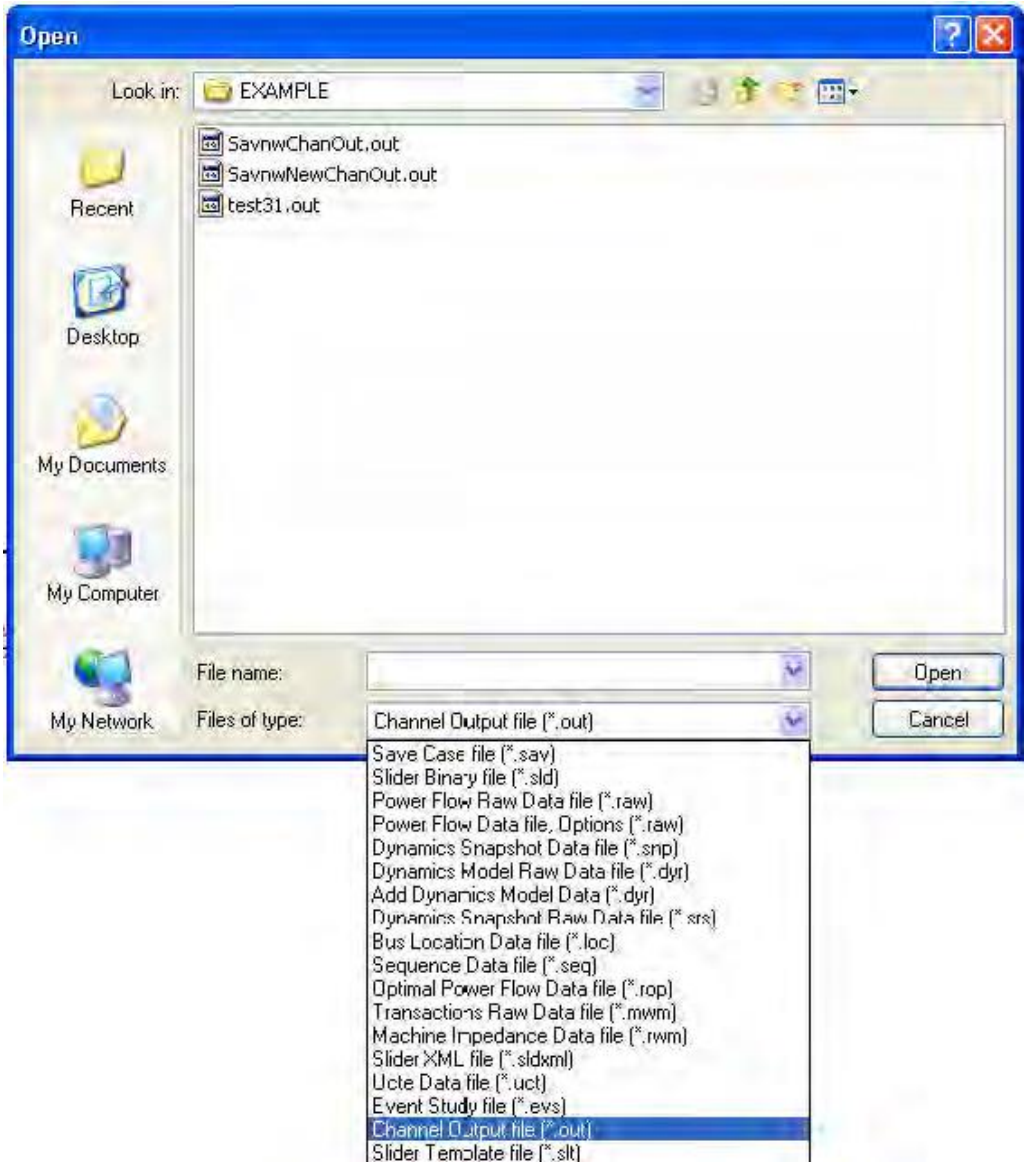


Figure. New PlotBook Dialog



2. Chanel Output File

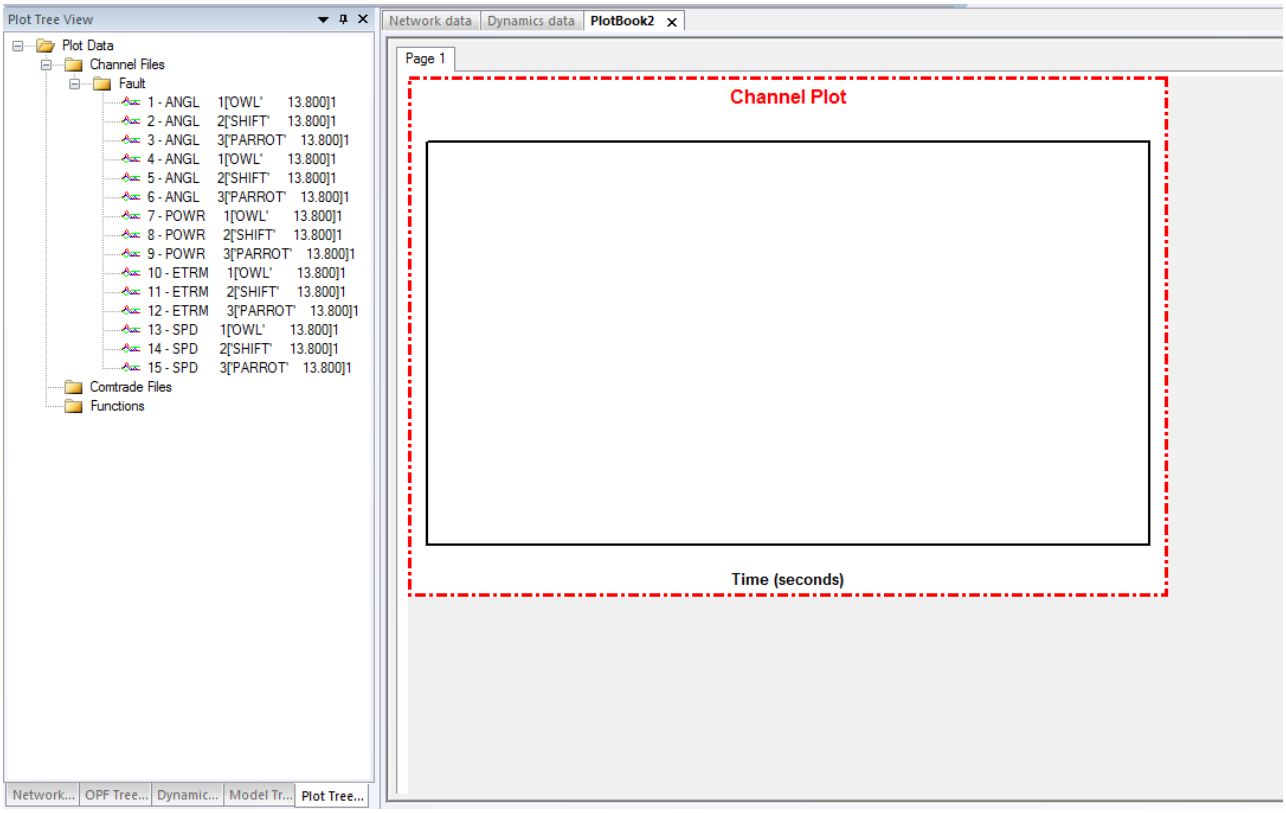
The channel output file contains the dynamic simulation results and can be opened by selecting ***File > Open***. The ***File > Open*** method displays a file selector dialog. In the file selector dialog, under *File type*, select *Channel Output file (*.out)*, and then select the channel output file, as shown in Figure below. In our case, we select “Fault.out”



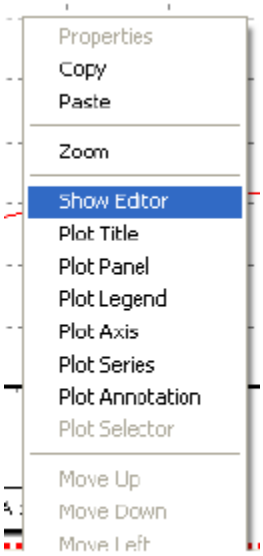
3. Drag and Drop Channels

After a PlotBook is created, any channel (from any of the channel output files in can be viewed by dragging and dropping into the desired plot in the selected page. Multiple channels can be dropped into the same plot.
Many of the interactions involved in creating and customizing the PlotBook.

Click **Plot Tree View** on the left, you will see all your selected Channels, drag the desired Channel to right Channel Plotbook.

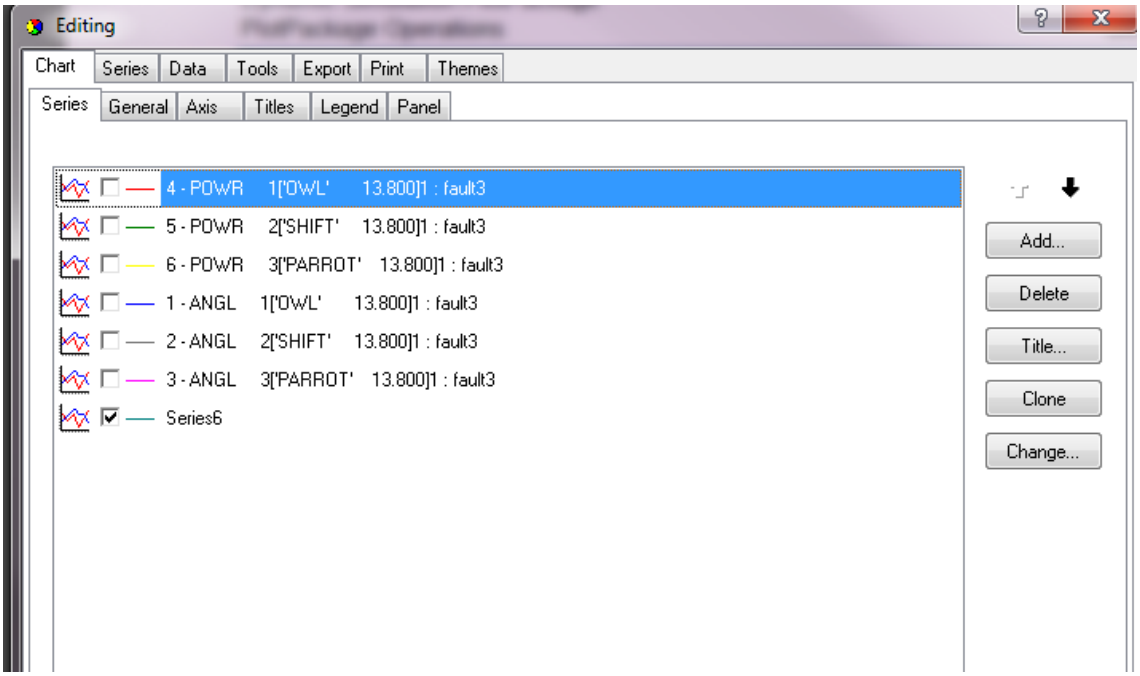


After you have your channel shown on plotbook, you can edit. Right Click on the Plotbook, you will see the following options, select Show Editor. You can do the settings of the plot.

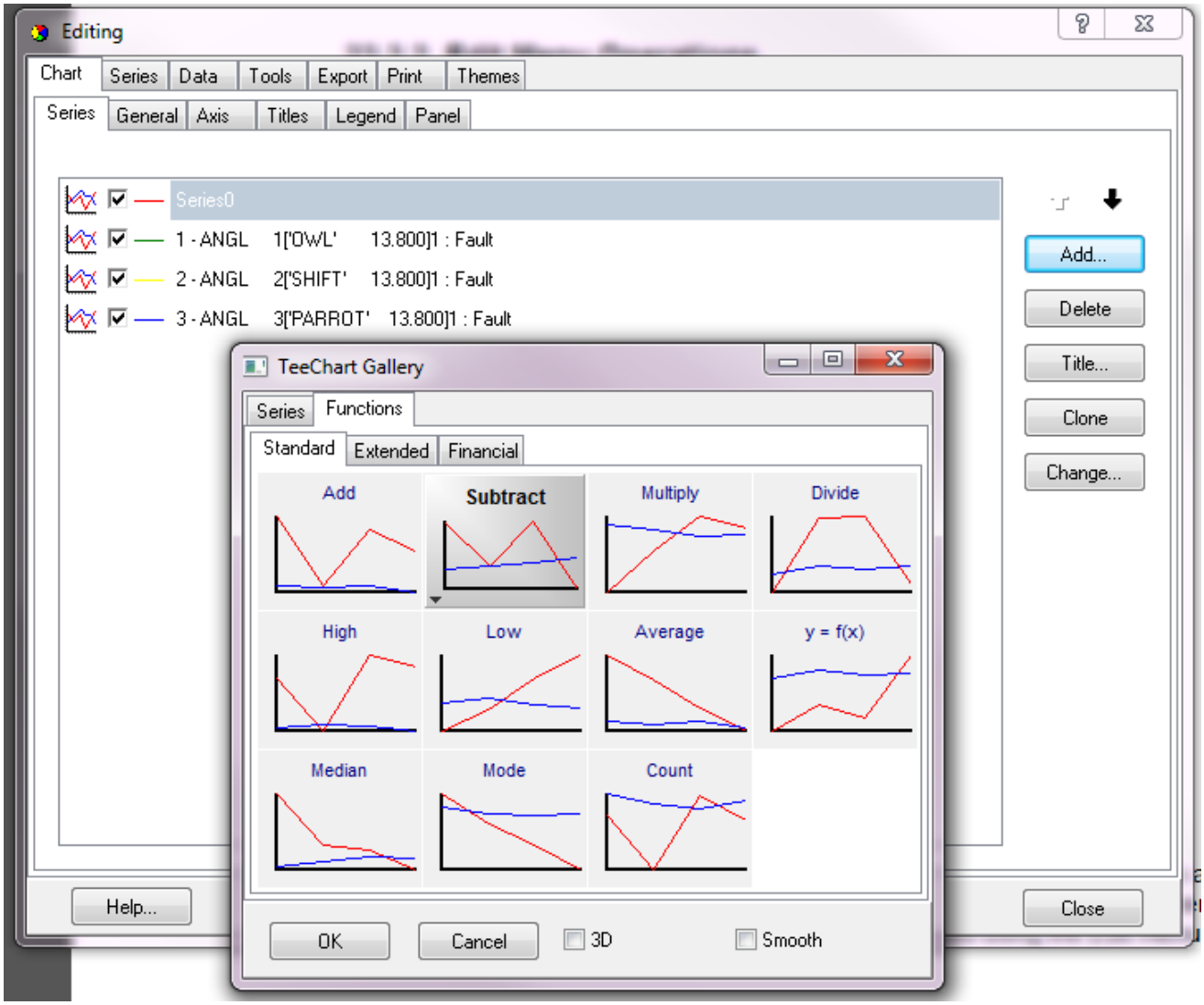


In this Project, we want to plot relative angles. The way to plot relative angles is shown in below figure.

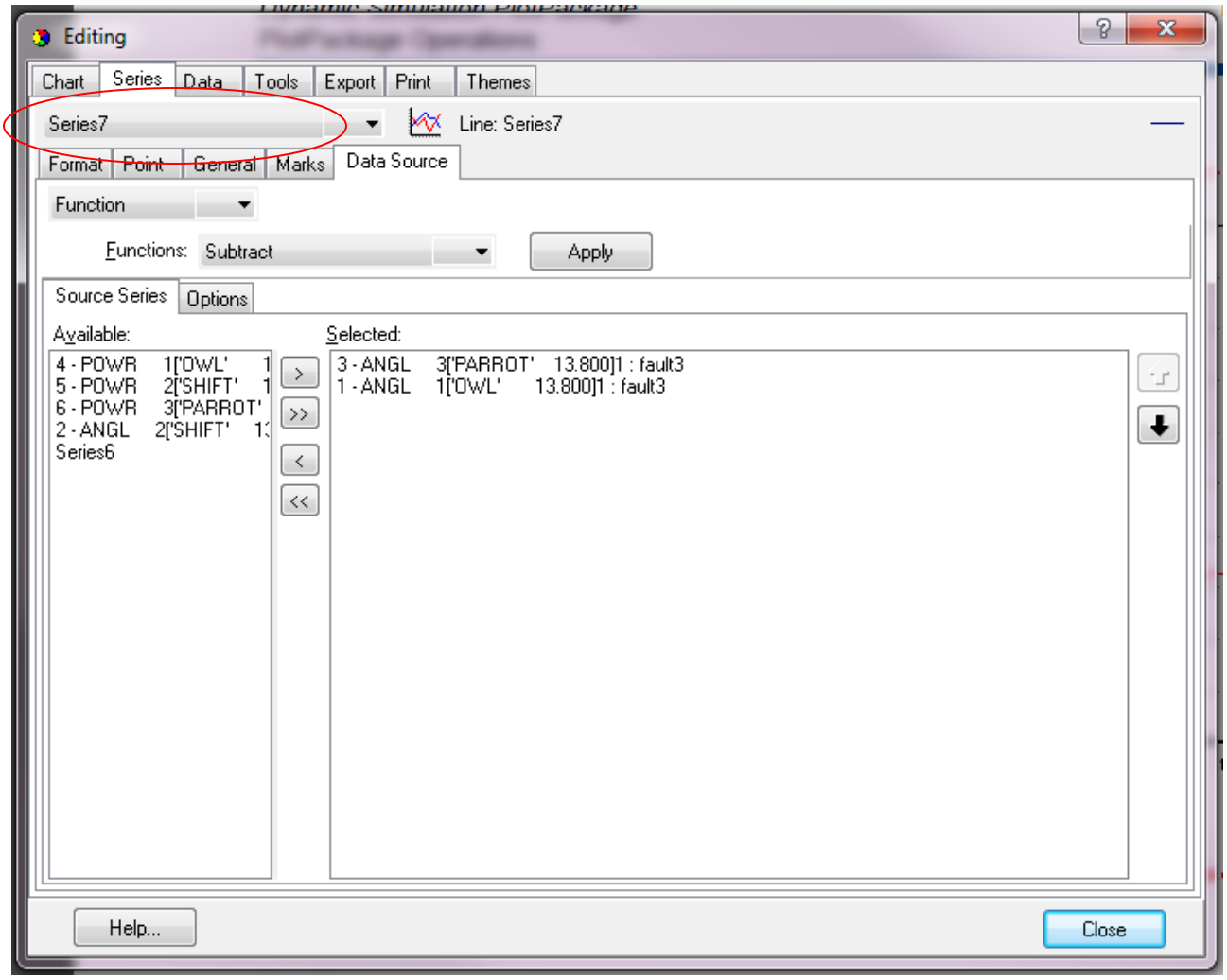
1) Drag Angle for Bus 1, 2, 3 to PlotBook.
2) Right Click and then Choose Show editor. Then you will see the following figure



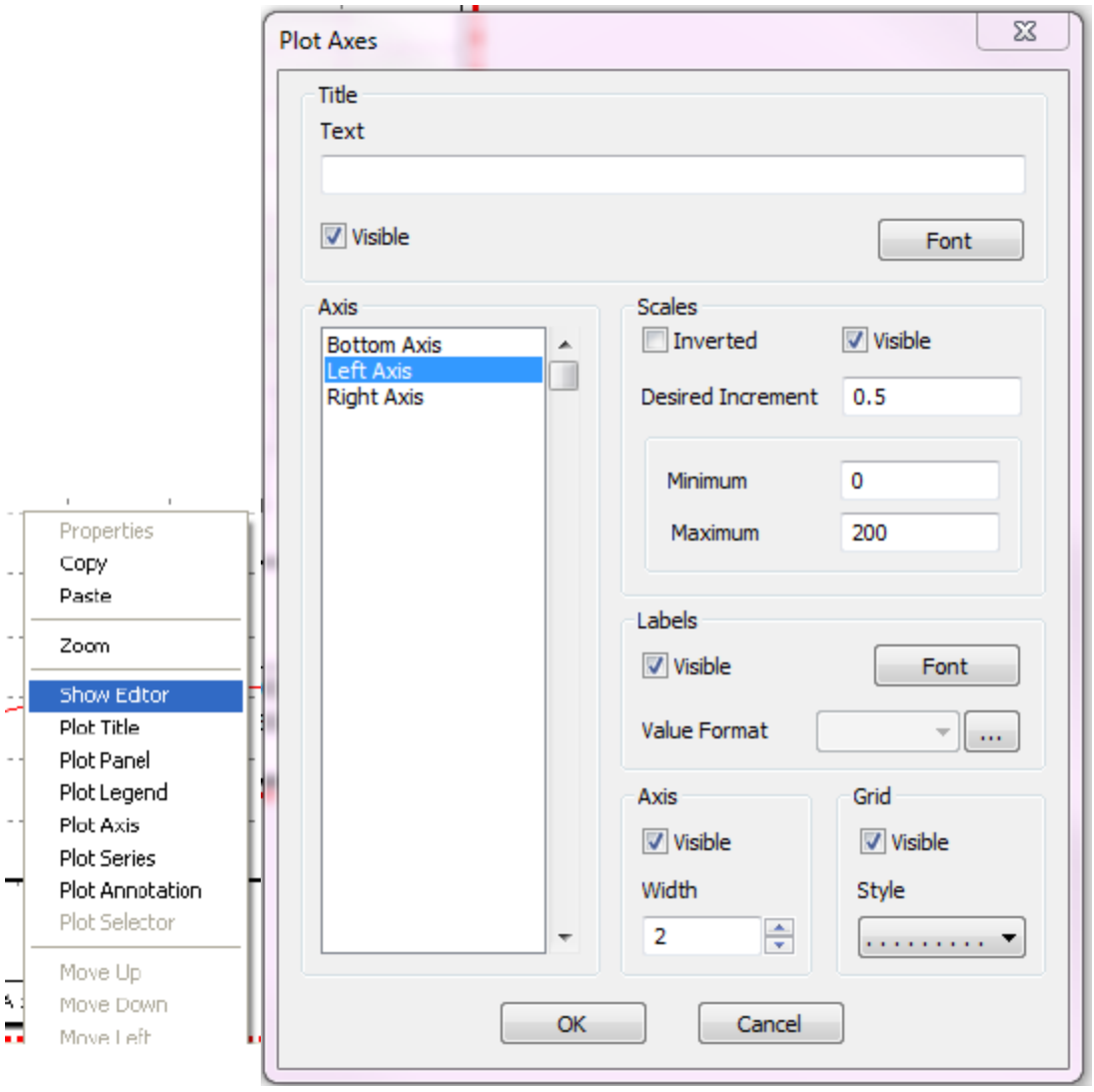
3) Click Add on the right and on the top Select **Functions, Then** select **« Subtract », see below figure**



4) Then you will see the follwing figure. If you want to plot relative angle between bus 1 and bus 3, please choose 1- ANGL and 3-ANGL, then press « **Apply** » see below.



5) Then this plot will be relative angle between bus 1 and bus 3, the legend is Series 7 in this case.
6) Click Close and you will see relative angle on your Plotbook. Adjust your plot Axis to see the angle. Right click the Plotbook and choose Plot Axis.


Properties
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Paste
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Plot Title
Plot Panel
Plot Legend
Plot Axis
Plot Series
Plot Annotation
Plot Selector
Move Up
Move Down
Move Left
Plot Axes
Title
Text
Visible
Font
Axis
Bottom Axis
Left Axis
Right Axis
Scales
Inverted
Visible
Desired Increment
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Maximum
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Labels
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Font
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Axis
Visible
Width
2
Grid
Visible
Style
OK
Cancel