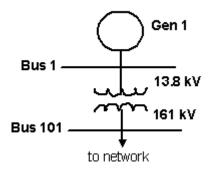
# Power System Simulation for Engineers (PSS/E version 30): Stability Analysis

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:

Generators							
📝 Convert Generators	Generators	are not converted					
Machine impedance							
Use ZSORCE	🔘 Use fault analysis X'						
⊚ Use fault analysis X"	🔘 Use fault analysis Xs						
Loads							
🖉 Convert / Reconstruct L	.oads						
Operation Convert constant MVA loads							
	Active Power	<ul> <li>Reactive Power</li> </ul>					
% Constant current	50 🚖	50 🚖					
% Constant admittance	25 🚖	25 🌲					
% Constant power	25.0	25.0					
Select							
All buses							
-							
Selected bus subsystem	Select						
The following buses							

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:

Channel Setup Wizard	i i			100 1 10	X					
<ul> <li>Categories to Output</li> </ul>	ut									
Machine Basic	· •	🔲 Wind Machine	📃 Load	🕅 Bus	🔲 Branch					
<ul> <li>Select Quantities</li> </ul>	to Output									
📝 Angle	🔲 Vothsg	Wvlcty	🔲 Pload	🔲 BsFreq	Flow (P)					
📝 Pelec	Vref	🔲 Wtrbsp	📃 Qload	Voltage	Flow (P&Q)					
🔲 Qelec	Iterm	🔲 Wpitch		🔲 Voltage & Angle	Flow (MVA)					
📝 Eterm	📃 App Imp	🔲 Waerot			🔲 Relay2 (R&X)					
EFD	🔲 Vuel	C Wrotrv								
🔲 Pmech	🔲 Voel	🔲 Wrotri								
V Speed	C Gref	C Wpomnd								
🕅 Xadifd	Lcref	🔲 Wqcmnd								
Ecomp		🔲 Wauxsg								
Select	All buses									
		Cancel	Finish							

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.

Perform Dynamic Simulation								
Initialization options Channel output file C:\Users\wanning01\Basecase.out •								
Simulation op	ptions							
Run to	1 0.0083 secs							
Print every	0 time steps							
Write every	1 time steps							
Plot every	0 time steps							
Display network convergence monitor Run Close Initialize								

## **3.** Performing a stability run:

For stability analysis the general approach is as follows:

- Apply a fault
- $\circ$  RUN the simulation from time = 0 until t = breakers open
- Clear the fault and remove a line
- $\circ$  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"

PS	®E 33	- C:\Use	rs\wanning01	\Google	e Drive∖	EE 457\ee457	designproje	ct\EX	2_Stabilit	ty_wanning.	sav - C:\U	lsers\wanning	01\Goo	gle Drive\EE 457\ee4	57designpr	oject\4	57p
E File	Edit	View	Power Flow	Fault	OPF	Trans Access	Dynamics	Dis	turbance	Subsyster	n Misc	I/O Control	Tools	Window Help			
10	i 🖓	X D	🔁 🗙 🔊	2	] 🕜	📜 i 🔂 👌	64 ó 🖬	4	Bus fau	lt				· ⊷ ↓ ↓ ↓ ↓ 10	s -H(F 🔠 🛇	to 125	
100	6 -	0 O	. 🖸 🔍 🖭	0.0	_		₩ [?]	- <b>b</b> -	Line fau	ult				1 II III 🕫 🗞 🛙		에 및 LFT	DATE DIFE ASCE IECE R
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			• • • •	Net		ta Dynamics		×		nect bus							
	Plot D	lata Channel F	les		Bus Numt					nect machine	·			Exciter	In Service	Туре	Turbine Govern
	÷	📜 a				1 'OWL'	13.800 1	Ŀ	Change	Vref				None			None
	ė(	🚞 b				2 'SHIFT'	13.800 1	P.	Change	Gref				None			None
			1 - ANGL 1[ 2 - ANGL 2]			3 'PARRO	r 13.8 1	Ŀs	Change	SWSref				None			None
			3 - ANGL 3[					40	Calculat	te and apply	unbaland	ed bus fault					
			4 - POWR 1	•				빌	Calculat	te and apply	branch u	nbalance					
			5-POWR 2 6-POWR 3					J,	Trigger	voltage viola	ation chee	:k					
			7-ETRM 1	Ϋ́										-			
			8-ETRM 2														
			9-ETRM 3 10-SPD 1														
			10-SPD 1 11-SPD 2														
			12-SPD 3														
	📋 🤇	Comtrade	Files														

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

System buses		Filter not applied	
13 ['EGRET' 69.000] 14 ['GULL' 161.00] 15 ['CROW1' 161.00] 16 ['CROW2' 69.000] 17 ['SISKIN2' 69.000] 101 ['OWL_XFMR' 161.00] 102 ['SWIFT_XFMR'161.00] 103 ['PARROT_XMR'161.00]	* 	Bus name mask Bus number range Bus kV range Filter	Bus types Type 1 Type 2 Type 3 Type 4
Bus number		ОК	Cancel

**1.** Then enter "999999999" 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.

Apply a Bus Fault	-		23			
Apply fault at bus (Nu	Base kV					
103		Select	161.00			
Units	Admittar	nce				
MVA	R	×				
⊘ MHO's	0		999999999			
OHM's						
OK Cancel						

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

Bus Number         Bus Name         Bus Name         Area Name         Area Name         Zone Name         Zone Name         Code         In Service         G-Shunt (MW)         B-Shunt (MW)         G-Zero (MW)         B-Zero (MW)           103         'PARROT_XMR'1         1         1         'POWERWORL         1         'URBAN'         1         I         0.00         1e+009         0.00         0.00           k         Image: Service         Image: S

## **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.

Perform Dynamic Simulation										
Initialization of Channel outp		ו								
Simulation op	Simulation options									
Run to	0.1 0.0083 secs									
Print every	0 time steps									
Write every	1 time steps									
Plot every	0 time steps									
Display network convergence monitor     Run     Close     Initialize										

d. Clear fault

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

C	Clear Fault							
	Select existing fault							
	1 103 ['PARROT_XMR'161.00] 1							
l								
	Go Close							

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

Net	work data	x Dynamics	data	PlotBo	ook2										
	Bus Number	Bus Name			Area Ium	Area Name	Zone Num	Zone Name	Code	In Service	G-Shunt (MW)	B-Shunt (Mvar)	G-Zero (MW)	B-Zero (Mvar)	
*										<b>V</b>					
_															<u>,                                     </u>
M		Bus ∧ Plant /	Machi	ne∖l	Load	Fixed Shunt	∬ Swi	tched Shunt	↓ Induct	ion Machine	Branch	Breaker	2 Winding	A 3 Winding	∖ Imp

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 B	Branch and click	the Select option
-----------------	------------------	-------------------

Trip a Line				23
Trip a Branch				
💿 Trip a 3-Winding Tran:	sformer			
From bus (Number)	To bus (Number)	Last bus (Number)	Circuit ID	
				Select
	ОК	Cancel		

4 5 7 8 9	['PARROT' ['LARK' ['JAY' ['RAVEN'	13.800] 161.00] 161.00] 161.00] 161.00] 161.00] 161.00] 69.000]	^	Include multi-section lines Filter not applied Bus name mask Bus number range Bus kV range Fi	lter	Bus types Type 1 Type 2 Type 3 Type 4
11 12 13	['QUAIL' ['HERON' ['EGRET'	161.00] 161.00] 69.000]	Е	To bus		
15 16 17 101 102	['GULL' ['CROW1' ['SISKIN2' ['SISKIN2' ['OWL_XFMR' ['SWIFT_XFMR ['PARROT_XMR	161.00] 161.00]	•	To Bus 7 ['WREN' 161.00] 16 ['CROW2' 69.000] 103 ['PARROT_XMR'161.0	Circuit Id 1 1 0] 1	

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.

Trip a Line				
Irip a Branch ○ Trip a 3-Winding Trans	sformer			
From bus (Number)	To bus (Number)	Last bus (Number)	Circuit ID	
15, 103, '1 '				Select
	ОК	Cancel		

# 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"

Perform Dynamic Simulation								
	Initialization options Channel output file C:\Users\wanning01\Google Drive\EE 457\ee457de: 👻							
- Simulation op	ptions							
Run to	10 🔄 0.0083 secs							
Print every	0 time steps							
Write every	1 time steps							
Plot every	0 time steps							
Display net	Display network convergence monitor Run Close Initialize							

# f. <u>Plotting</u>:

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

N	
Network case	
Network case	and Diagram
Diagram	
Plot Book	
Diagram Templ	late
	late

#### Figure. New PlotBook Dialog

PSS@E - [PlotBook8]		
File Edit View PowerFlow Fault	<u>o</u> PF Trans <u>A</u> ccess Dynamics Disturbance <u>S</u> ubsystem <u>Misc</u> I/O Control <u>T</u> ools <u>Window</u> <u>H</u> elp	_ @ ×
		- 1
	●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●●	6 50 SK
留国道下家医院家	세생생생생생고분치더디운치티뷰트만팀들랑()[[[[[]][[[]]][[]][[]]][[]][[]][[]][[]]	
🗉 🔄 Channel Files	Page 1	
	Channel Plot	
Net OPF Dyn Models Plot	Time (seconds)	

## 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"

)pen				?
Look in:	EXAMPLE	X	9300	
Recent Desktop My Documents	SavnwChanO SavnwNewCh test31.out			
My Computer	File name:		×	Open
My Network	Files of type:	Channel Output file (*.out)		Cancel
		Save Case file (*.sav) Slider Binary file (*.sld) Power Flow Raw Data file (*.raw) Power Flow Data file, Options (*.raw) Dynamics Snapshot Data file (*.snp) Dynamics Model Raw Data file (*.dy) Add Dynamics Model Data (*.dyr) Dynamics Snapshot Raw Data file (*.dyr) Bus Location Data file (*.loc) Sequence Data file (*.loc) Sequence Data file (*.loc) Sequence Data file (*.loc) Transactions Raw Data file (*.row) Machine Inpedance Data file (*.rown Slider XML file (*.sldxml) Ucte Data file (*.uct) Event Study file (*.evs) Channel Output file (*.pout)	(1) * srs]	

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.

Plot Tree View 🔻 🕈 🗙	Network data Dynamics data PlotBook2 x
Plot Data Channel Files Taut Channel Files Channel Files Chan	Page 1 Channel Plot
Network OPF Tree Dynamic Model Tr Plot Tree	

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.

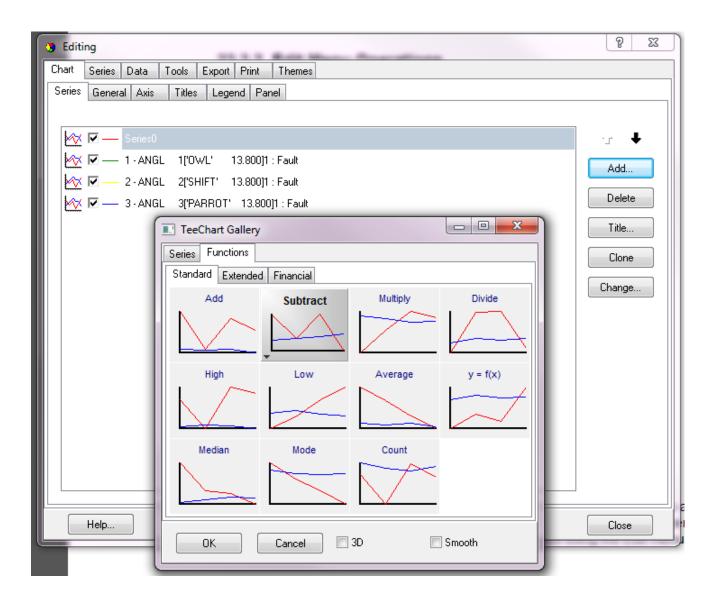
Properties Сору Paste Zoom Show Edtor Plot Title Plot Panel Plot Legend Plot Axis Plot Series Plot Annotation Plot Selector Move Up 41 Move Down Move Left

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 Editing	? ×
Chart Series Data Tools Export Print Themes	
Series General Axis Titles Legend Panel	
₩ 🗖 — 4 · POWR 1['OWL' 13.800]1 : fault3	-r <b>↓</b>
🔯 🗖 — 5 - POWR 2['SHIFT' 13.800]1 : fault3	Add
🔣 🗠 🖂 — 6 - POWR 3('PARROT' 13.800)1 : fault3	
₩ □ 1 - ANGL 1['0WL' 13.800]1 : fault3	Delete
📉 🗁 — 2 - ANGL 2['SHIFT' 13.800]1 : fault3	Title
Martin III	Clone
🛛 🗠 🗹 — Series6	
	Change

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.

DVDattile Sittulailon Pioleackane						
3 Editing	? ×					
Chart Series Data Tools Export Print Themes						
Series7 🗸 😽 Line: Series7	—					
Format Point General Marks Data Source						
Function						
Eunctions: Subtract						
Source Series Options						
Available: Selected:						
4 · POWR 1['0WL' 1 → 3 · ANGL 3['PARROT' 13.800]1 : fault3 5 · POWR 2['SHIFT' 1 → 1 → 1 · ANGL 1['0WL' 13.800]1 : fault3 6 · POWR 3['PARROT' → 1 → 1 · ANGL 1['0WL' 13.800]1 : fault3	·⊥ •					
Series6						
Help	Close					

- 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.

		Plo	t Axes			X
			Title			
			Text			
			Visible			Font
			Axis		Scales	
			Bottom Axis Left Axis	<u>^</u>	Inverted	Visible
			Right Axis		Desired Increment	0.5
					Minimum	0
	Properties				Maximum	200
	Сору					
	Paste				Labels	
	Zoom				Visible	Font
	Show Edtor					
	Plot Title Plot Panel				Value Format	▼
	Plot Legend				Axis	Grid
	Plot Axis Plot Garia				Visible	Visible
	Plot Series Plot Annotation				Width	Style
	Plot Selector			-	2	
	Move Up					
_	Move Down			ОК	Cancel	
	Move Left	•			Cancel	