

Transient Stability Analysis with PowerWorld Simulator



T14: Large-Scale Simulation Examples



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Large Scale Simulation Examples



- We'll use a synthetic West model to provide a complete example of running a stability simulation
 - Double Generator Outage
 - Fault at bus
 - Fault a bus with a longer clearing time

Load Case



- Click the Application Menu
- Choose **Open Case...**
- Navigate to choose the file *ACTIVSg10K.pwb*
- Click **Open**
- Click **Solve Power Flow – Newton** Button to solve initial power flow solution
- Open **Transient Stability** Tool from the **Add Ons** Ribbon and navigate to the **Validation → Validation Warnings** Step
- Click the **Run Validation** button and examine Validation Warnings
 - A lot of missing generators models



Check Model Support



- In Model Explorer, go to **Transient Stability\Summary\Models in Use**
- All generators models that are in use in this case are presently fully supported by Simulator (PowerWorld Support = YES)

	Model Class	Object Type	Active and Online Count	Active Count	Inactive Count	PowerWorld Support	GE PSU
1	_All Models	_All Models	5821	7401		YES	ES
2	Exciter	ESAC1A	13	17		YES	ES
3	Exciter	ESAC6A	24	27		YES	ES
4	Exciter	ESDC1A	157	198		YES	ES
5	Exciter	ESDC2A	40	53		YES	ES
6	Exciter	ESST4B	608	753		YES	ES
7	Exciter	EXAC1	13	20		YES	ES
8	Exciter	EXAC2	96	120		YES	ES
9	Exciter	EXPIC1	117	139		YES	ES
10	Exciter	IEEE1	178	231		YES	ES
11	Exciter	SCRX	209	292		YES	ES
12	Governor	GGOV1	791	974		YES	ES
13	Governor	HYGOV	530	715		YES	ES
14	Governor	IEEEG1	134	161		YES	translate (IE
15	Machine Model	GENROU	926	1136		YES	translate (GE
16	Machine Model	GENSAL	530	715		YES	translate (GE
17	Stabilizer	IEEEEST	1455	1850		YES	ES

Load in Transient Contingency and Transient Options



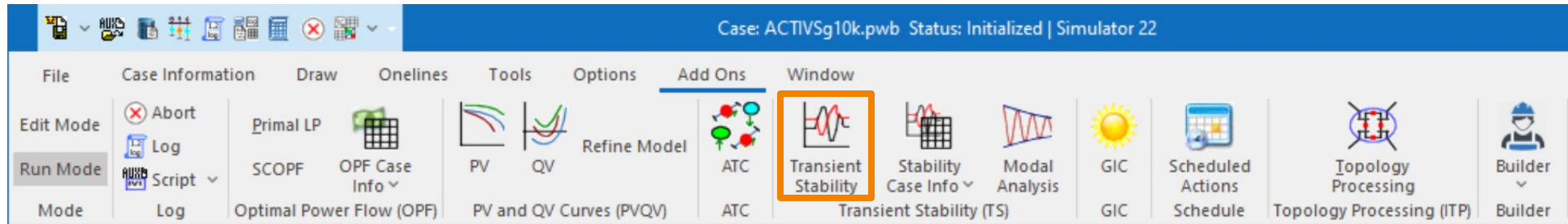
- Click the Application Menu
- Choose **Load Auxiliary**
- Navigate to choose the file *Large10KBusExample.aux*
- Click **Open**
- This created three Transient Contingencies
- Also loaded in some options for the stability simulation

```
-----  
Starting load of auxiliary file: Large10KBusExample.aux  
-----  
TRANSIENT_OPTIONS_VALUE (OPTION,VALUE):  
129 records read from file.  
Script: SelectAll(TSLimitMonitor);  
Script: Delete(TSLimitMonitor, SELECTED);  
TSLIMITMONITOR (NAME,LOGICVARIABLE,ACTIVE,CATEGORYLIST,ABORT,  
4 records read from file.  
TSCONTINGENCY (NAME,CATEGORY,RESULTFILENAME,RESULTDIRECTORY,  
3 records read from file.  
TSCONTINGENCYELEMENT (CONTINGENCY,TIME,OBJECT,ACTION,CRITERIA,  
6 records read from file.  
-----  
Finished load of auxiliary file: Large10KBusExample.aux  
-----
```

Transient Stability Analysis Dialog



- On the Add-Ons Ribbon Tab, click **Transient Stability...**



- Run the AutoCorrection on input data
 - Go to the Validation Step
 - Click **Run AutoCorrection** button
 - No adjustments are needed for this case, but typically there may be notes about changes to time constants and machine reactances on the Informational Messages tab

Result Storage



- Go to **Result Storage\Store to Hard Drive Options**
 - It's configured to store results to the Hard Drive every 6 time steps
 - Saves to directory location to c:\temp
 - Change this if your computer will not allow you to create a directory in c:\temp

Result Storage

Where to Save/Store Results

☒ Store Results to RAM

☒ Save Results to Hard Drive

Save Results Every n Timesteps: 6

☐ Save the Results stored to RAM in the PWB file

☒ Save the Min/Max Results stored to RAM in the PWB file

Do Not Combine RAM Results with Hard Drive Results

Store to RAM Options

Store to Hard Drive Options

Directory in which to store all results TSR files for all contingencies

Location: c:\temp

browse...

For each transient contingency, one file will be written to this directory. The filename will be the name of the contingency with the *.TSR file extension. Note: If no directory is specified, then the director of the case file will be used. Note: Using a directory on your local computer is recommended.

Storage of States, Other Fields, and Input Fields

☐ Also store states for each object

☒ Also store other fields for each object

☒ Also store input fields for each object

☐ Only store every result for objects which meet the Area/Zone Filters

Edit Area/Zone Filters

TSR File Archiving

☐ Enable Auto-Archive of TSR Files

Maximum Number of Archive Files: 6

Object Types to Include

Object Types to Include	Store
Generators	☒
Buses	☒
Loads	☐
Switched Shunts	☒
Branches	☐
Line Shunts	☐
DC Lines	☒
VSC DC Lines	☒
Multi-Terminal DC	☒
MTDC Converters	☒
Areas	☐
Zones	☐
Substations	☐

Transient Limit Monitoring



- Go to **Transient Limit Monitors**
- Toggle the **Active** column to all say *YES*
- Modify the Limit Monitors to make them more restrictive (so we see some violations)
 - WECC Category B Frequency: Change to 59.9 Hz

Transient Limit Monitors Modal Analysis

Transient Limit Monitors Monitor Violations Limit Logic

Note: Use this button to re-evaluate the results stored to get the transient limit monitor violations. First it will look at the results stored in RAM and then, if not found, look into the Hard Drive *.tsr. If button is press under Multiple Contingencies mode then it will re-evaluate all the contingencies results in the same order as before.

Re-evaluate to Get Limit Monitor Violations

Records Set Columns Options

	Name	Active	Category	Abort	Abort Delay	Max Violations	Object Type	Variable Name	Filter	Limit Value	Duration
1	WECC Category B Voltage Dip Non-Load Bus	YES		Log	0.00	100	Bus	TSBusVPU	Non-Load	-30.000	0.00000
2	WECC Category B Voltage Dip Load Bus	YES		Log	0.00	100	Bus	TSBusVPU	Load Only	-25.000	0.00000
3	WECC Category B Voltage Dip Load Bus Duration	YES		Log	0.00	100	Bus	TSBusVPU	Load Only	-20.000	0.33333
4	WECC Category B Frequency	YES		Log	0.00	100	Bus	Frequency	Load Only	59.900	0.10000

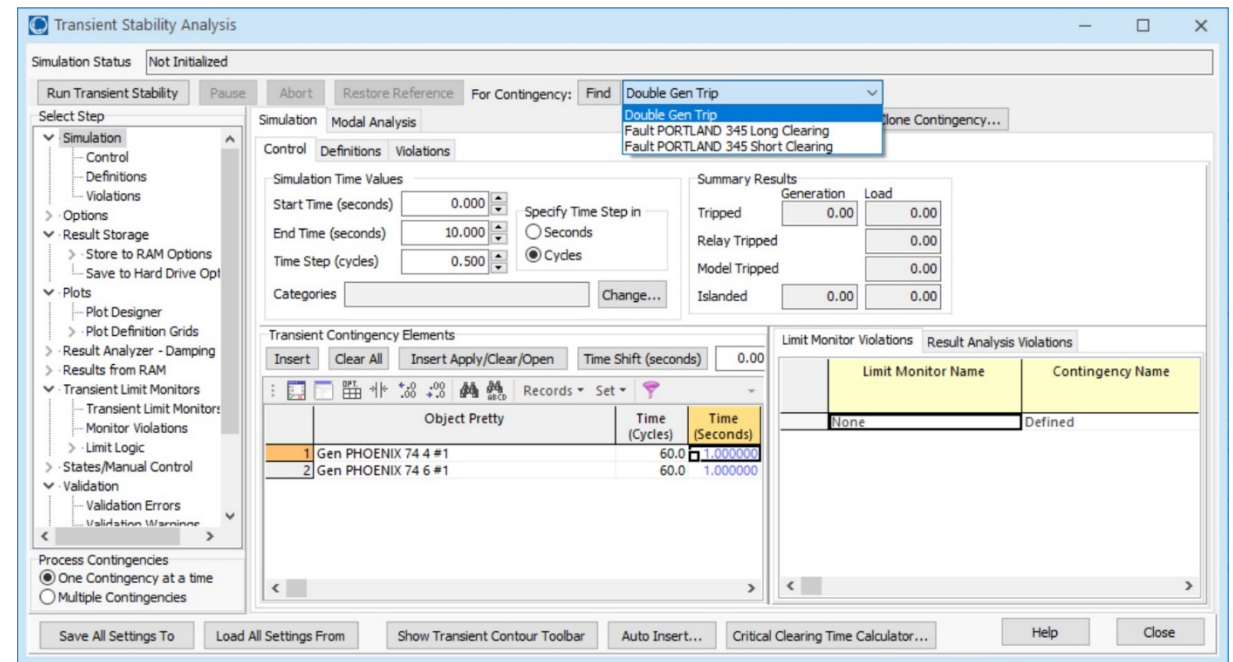
Limit Value

-30.000
-25.000
-20.000
59.900

Run One Transient Contingency



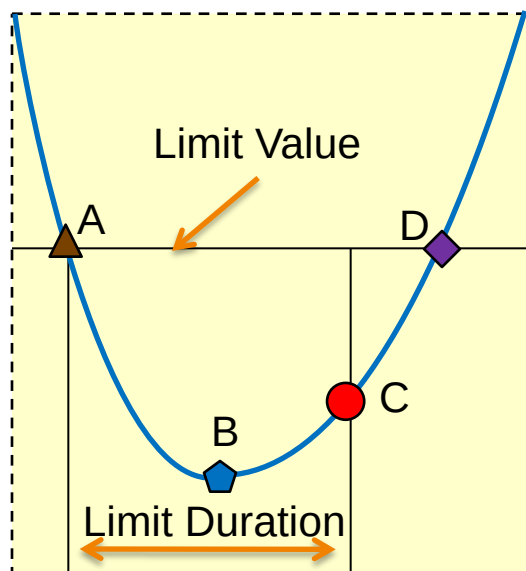
- Go back to the *Simulation* Step
 - Choose the **Double Gen Trip** from the **For Contingency:** listing
 - This trips two Big Nuclear units at time 1.0 seconds.
- Click **Run Transient Stability**





Look at Transient Limit Monitor Violations

- Transient Limit Monitors: Monitor Violations
 - Several show values below 59.9 Hz for more than 0.1 seconds.



Transient Limit Monitors													
Modal Analysis													
Monitor Violations													
Limit Logic													
	Limit Monitor Name	Contingency Name	Violated Device	Limit Monitor Variable	Initial Value	Actual Value	Time of Value	Actual Value Start	Time of Value Start	Actual Value Extreme	Time of Value Extreme	Actual Value No Longer	Time of No Longer
1	WECC Category B Frequency	Double Gen Trip	Bus '40054'	Frequency	60.000000	59.877651	1.3083	59.899715	1.2000	59.8630	4.0750	59.901123	1.6167
2	WECC Category B Frequency	Double Gen Trip	Bus '40777'	Frequency	60.000000	59.877369	1.3083	59.899601	1.2000	59.8630	4.0833	59.901127	1.6167
3	WECC Category B Frequency	Double Gen Trip	Bus '40064'	Frequency	60.000000	59.879841	1.3167	59.899837	1.2083	59.8630	4.0750	59.900047	1.6167
4	WECC Category B Frequency	Double Gen Trip	Bus '40076'	Frequency	60.000000	59.879425	1.3167	59.899960	1.2083	59.8631	4.0833	59.900211	1.6250
5	WECC Category B Frequency	Double Gen Trip	Bus '40103'	Frequency	60.000000	59.879051	1.3167	59.899761	1.2083	59.8630	4.0833	59.900909	1.6250
6	WECC Category B Frequency	Double Gen Trip	Bus '40109'	Frequency	60.000000	59.879158	1.3167	59.899712	1.2083	59.8630	4.0833	59.900940	1.6250
7	WECC Category B Frequency	Double Gen Trip	Bus '40062'	Frequency	60.000000	59.871250	1.3250	59.898178	1.2167	59.8625	4.0833	59.901520	1.6500
8	WECC Category B Frequency	Double Gen Trip	Bus '40070'	Frequency	60.000000	59.880783	1.3250	59.899384	1.2167	59.8630	4.0750	59.901066	1.6250
9	WECC Category B Frequency	Double Gen Trip	Bus '40073'	Frequency	60.000000	59.871731	1.3250	59.898300	1.2167	59.8626	4.0917	59.901569	1.6500
10	WECC Category B Frequency	Double Gen Trip	Bus '40079'	Frequency	60.000000	59.879772	1.3250	59.898502	1.2167	59.8630	4.0833	59.900852	1.6250
11	WECC Category B Frequency	Double Gen Trip	Bus '40082'	Frequency	60.000000	59.880966	1.3250	59.899647	1.2167	59.8630	4.0750	59.901066	1.6250
12	WECC Category B Frequency	Double Gen Trip	Bus '40085'	Frequency	60.000000	59.880051	1.3250	59.898548	1.2167	59.8630	4.0833	59.900970	1.6250
13	WECC Category B Frequency	Double Gen Trip	Bus '40092'	Frequency	60.000000	59.878666	1.3250	59.897816	1.2167	59.8630	4.0833	59.900639	1.6250
14	WECC Category B Frequency	Double Gen Trip	Bus '40093'	Frequency	60.000000	59.878666	1.3250	59.897816	1.2167	59.8630	4.0833	59.900639	1.6250
15	WECC Category B Frequency	Double Gen Trip	Bus '40094'	Frequency	60.000000	59.880486	1.3250	59.899025	1.2167	59.8630	4.0833	59.901077	1.6250
16	WECC Category B Frequency	Double Gen Trip	Bus '40095'	Frequency	60.000000	59.872555	1.3250	59.898357	1.2167	59.8627	4.0917	59.900021	1.6417
17	WECC Category B Frequency	Double Gen Trip	Bus '40096'	Frequency	60.000000	59.872879	1.3250	59.898380	1.2167	59.8627	4.0917	59.900135	1.6417
18	WECC Category B Frequency	Double Gen Trip	Bus '40100'	Frequency	60.000000	59.878601	1.3250	59.898296	1.2167	59.8631	4.0833	59.901260	1.6333
19	WECC Category B Frequency	Double Gen Trip	Bus '40105'	Frequency	60.000000	59.879974	1.3250	59.898354	1.2167	59.8630	4.0750	59.901138	1.6250
20	WECC Category B Frequency	Double Gen Trip	Bus '40108'	Frequency	60.000000	59.880047	1.3250	59.898468	1.2167	59.8630	4.0833	59.901001	1.6250
21	WECC Category B Frequency	Double Gen Trip	Bus '40110'	Frequency	60.000000	59.880226	1.3250	59.898907	1.2167	59.8630	4.0833	59.900890	1.6250
22	WECC Category B Frequency	Double Gen Trip	Bus '40111'	Frequency	60.000000	59.880596	1.3250	59.899117	1.2167	59.8630	4.0750	59.901066	1.6250
23	WECC Category B Frequency	Double Gen Trip	Bus '40112'	Frequency	60.000000	59.880268	1.3250	59.898743	1.2167	59.8630	4.0833	59.901024	1.6250
24	WECC Category B Frequency	Double Gen Trip	Bus '40115'	Frequency	60.000000	59.881130	1.3250	59.899689	1.2167	59.8630	4.0750	59.901165	1.6250

Transient Events



- Look at Results from RAM\Events in the Steps
- You see the two generators opening

Results from RAM Modal Analysis

Time Values Minimum/Maximum Values Summary Events Solution Details Power Flow States

Records Set Columns Options

Choose which Events to display by level AND Object Type. (Note: Events are still recorded and stored according to the Result Options settings.)

	Contingency Name	Time (Cycles)	Time (Seconds)	Time Requested (Seconds)	Object	Model Type	Description	Level
1	Double Gen Trip	60.0	1.000000	1.000000	Gen '40843' '1'	TXGenericGen	Open	User
2	Double Gen Trip	60.0	1.000000	1.000000	Gen '40845' '1'	TXGenericGen	Open	User

Event Levels:

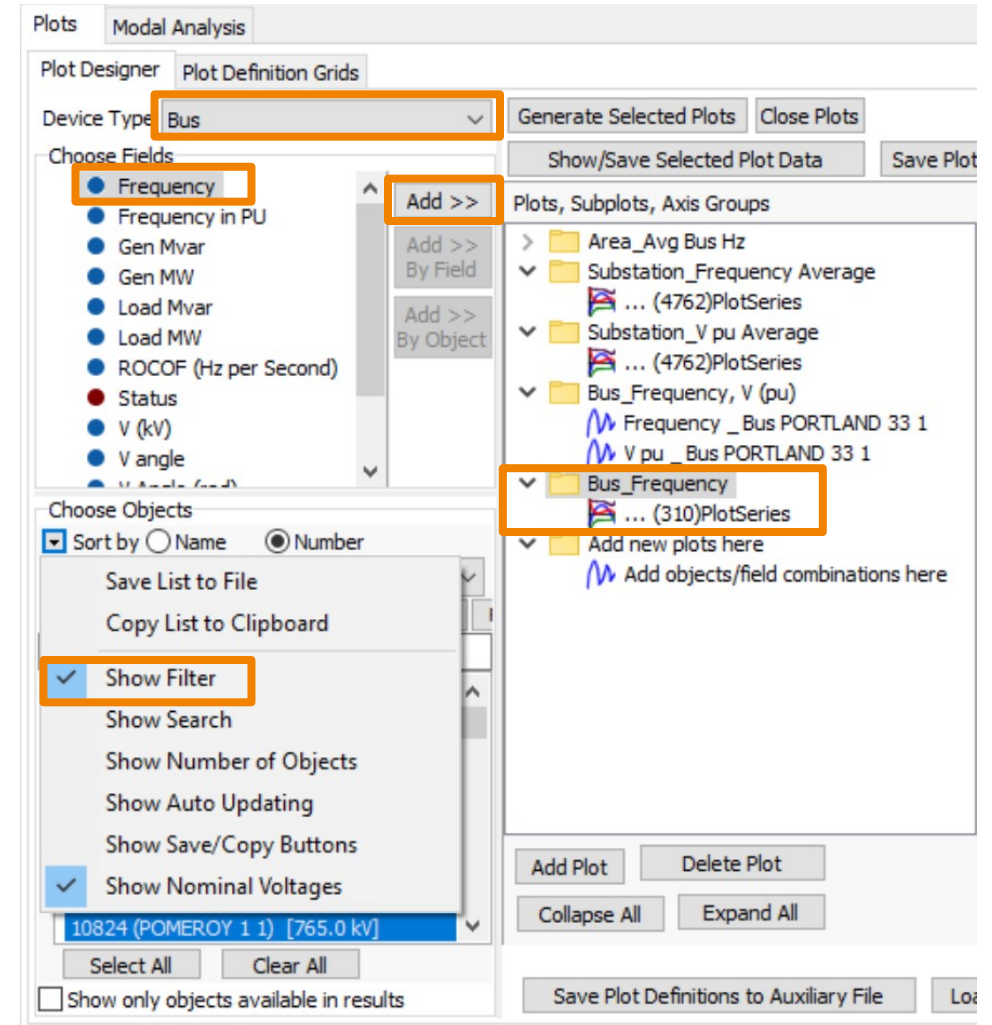
- ☒ Error
- ☒ Info
- ☒ Skipped
- ☒ User
- ☐ Transition
- ☐ Model Trip
- ☒ Relay Trip
- ☒ DS User
- ☒ Remedial Action

Object Types:

- ☒ Simulation
- ☒ Bus
- ☒ Gen
- ☒ Load

Let's create some Plots

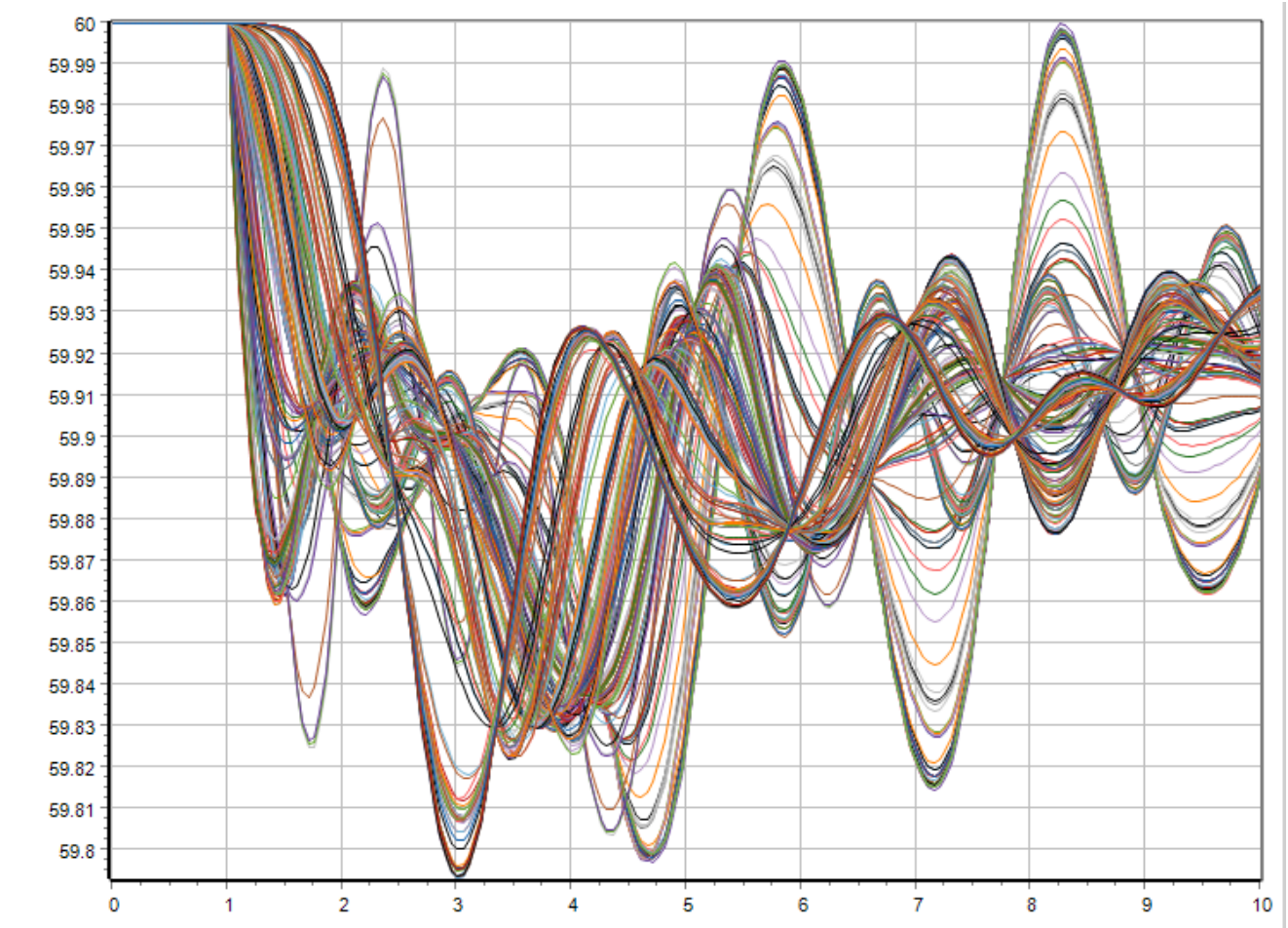
- Go to Plots and then the Plot Designer
- Change **Device Type** to *Bus*
- **Choose Fields** = *Frequency*
- Under **Choose Objects**, right-click and choose **Show Filter**
- Click the **Define** button
- Define a filter for all buses with *Voltage\kV Nominal* greater than 400 kV and *Voltage\Per Unit Magnitude* greater than 0.1pu
- After defining the filter, click the **Select All** button
- Finally Click the **Add >>** button to define the plot (310 series)



Generate Selected Plot



- Click the **Generate Selected Plots** button
- If you run this farther out than 10 seconds you'll see it's stable



Run the two Fault PORTLAND Contingencies

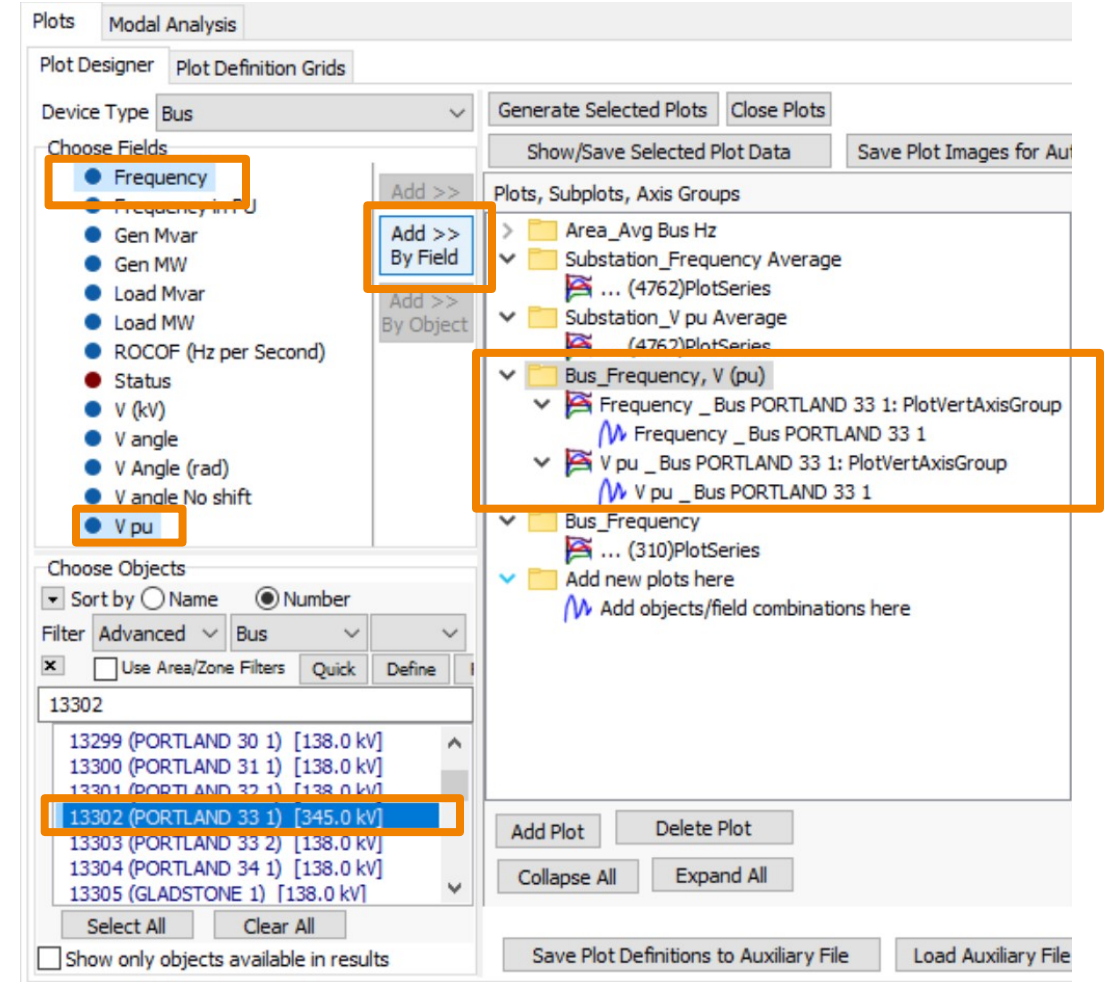


- Go back to the *Simulation* Step
 - Choose the **Fault PORTLAND 345 Short Clearing** from the **For Contingency:** listing
 - This faults the PORTLAND 15 2 bus (13264) at 1.0 seconds and leaves the fault on until 1.1 seconds
 - Click **Run Transient Stability**
 - Choose the **Fault PORTLAND 345 Long Clearing** from the **For Contingency:** listing
 - This faults the PORTLAND 15 2 bus (13264) at 1.0 seconds and leaves the fault on until 2 seconds
 - Click **Run Transient Stability**

Build a Plot of the PORTLAND 345 Voltage and Frequency



- Go to Plots and then the Plot Designer
- Change **Device Type** to *Bus*
- Hold Ctrl key and **Choose Fields** *Frequency* and *Voltage pu*
- Under **Choose Objects**, right-click and choose **Show Filter**
- Click the **Define/Find...** button
- Click **Remove**
- Navigate to find the PORTLAND 33 1 345 kV bus (13302)
- On the tree-view list of plots, choose **Add new plots here**
- Click **Add >> By Field**

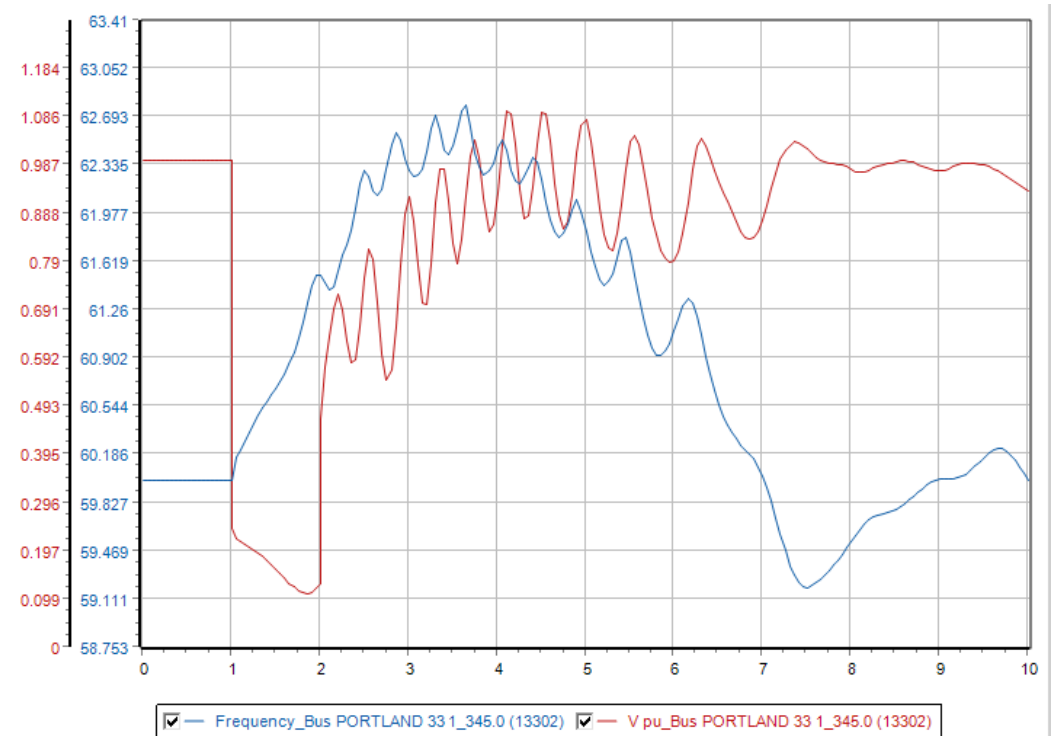
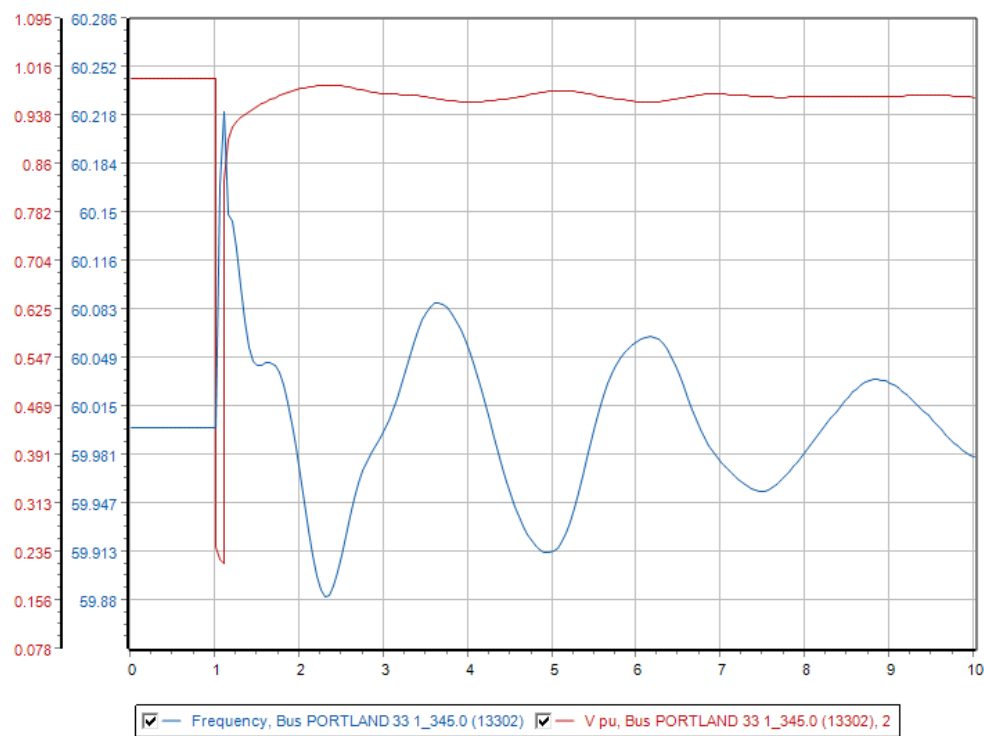


Plots can be viewed as normal for each contingency separately



Fault PORTLAND 345 Short Clearing

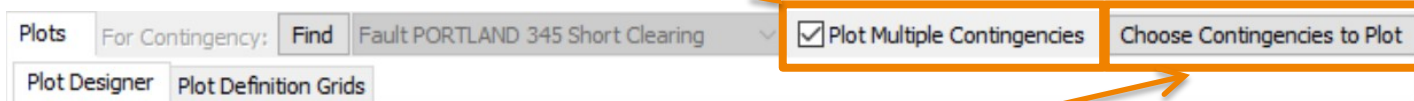
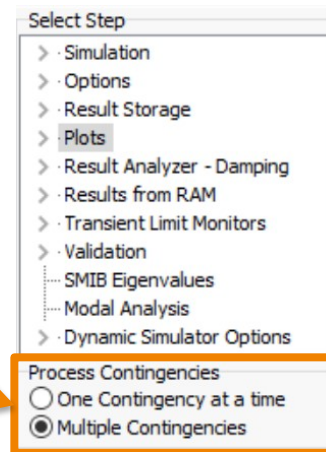
Fault PORTLAND 345 Long Clearing



Plotting Multiple Contingencies Simultaneously



- First change the **Process Contingencies** to *Multiple Contingencies*
- Go to the Plots Step
- Check the box for **Plot Multiple Contingencies**



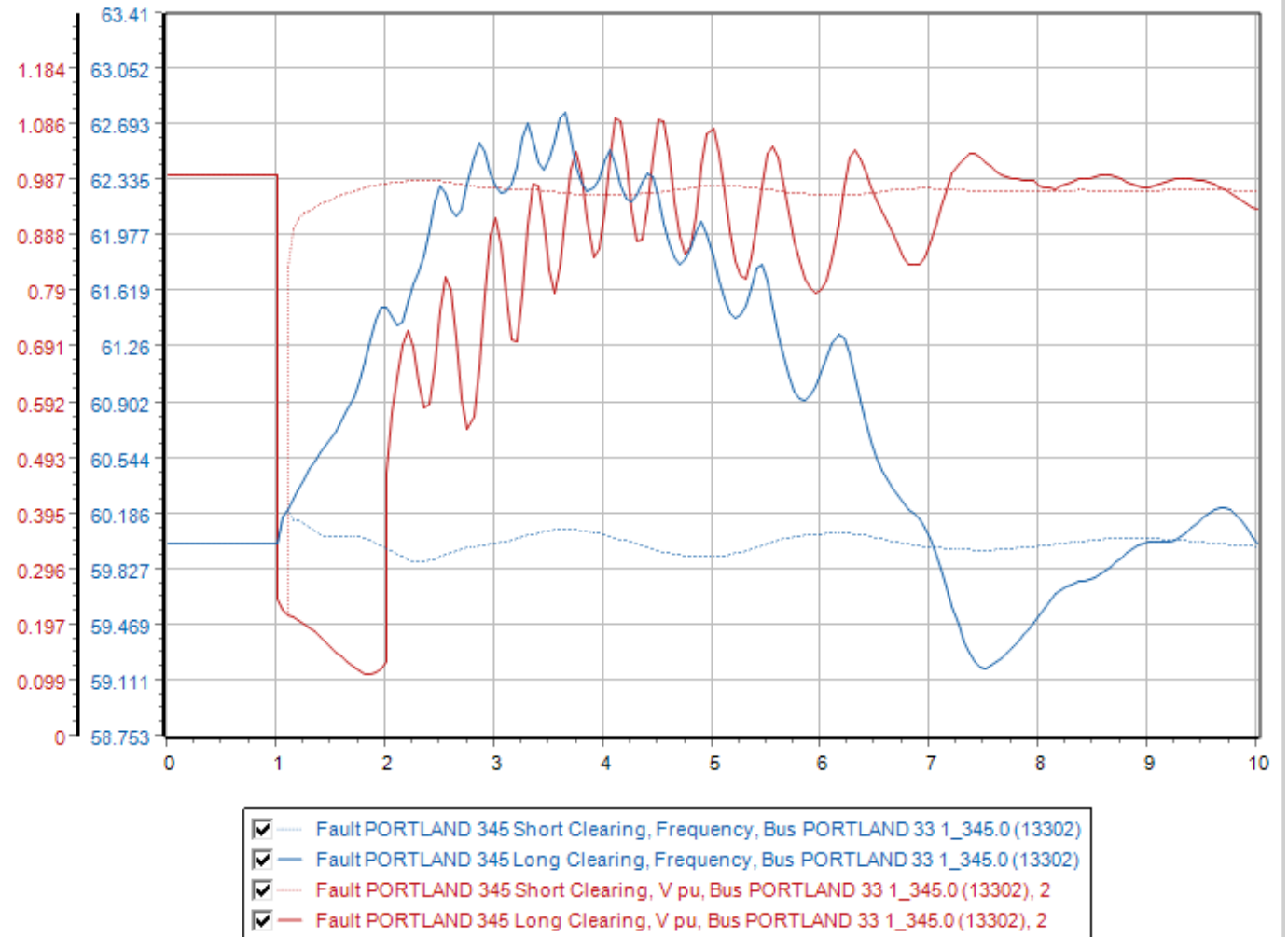
- Click **Choose Contingency to Plot**
 - Modify to only **Show** column to *YES* for only the PORTLAND faults
 - Change Short Clearing **Plot Dashed** to *Dot*
 - Change Long Clearing **Plot Dashed** to *Solid*

	Name	Show	Plot Color	Plot Dashed	Plot Th
1	Double Gen Trip	NO	Default	Default	
	Fault PORTLAND 345 Short Clearing	YES	Default	Dot	
	Fault PORTLAND 345 Long Clearing	YES	Default	Solid	

Plotting Multiple Contingencies Simultaneously



- Click the **Generate Selected Plots** button



Final Simulation



- Change the **Process Contingencies** back to *One Contingency at a time*
- Go back to the Simulation step
 - Choose the **Double Gen Trip** from the **For Contingency:** listing
 - Change the **End Time** to *20.00* seconds
 - Click **Run Transient Stability**

Simulation Add...

Control Definitions Violations

Simulation Time Values

Start Time (seconds) 0.000

End Time (seconds) 20.000

Time Step (cycles) 0.500

Specify Time Step in

☐ Seconds

☒ Cycles

Categories Change...

Double PHOENIX Trip - Run for 20 Seconds

