

# Transient Stability Analysis with PowerWorld Simulator

---



## T9: Multiple Contingencies



**PowerWorld**  
Corporation

2001 South First Street  
Champaign, Illinois 61820  
+1 (217) 384.6330

[support@powerworld.com](mailto:support@powerworld.com)  
<http://www.powerworld.com>

# Multiple Contingencies

---



- In most of the training, we just talk about simulating a single transient contingency which can contain multiple transient elements used to simulate events
- The PowerWorld design goal is to make running transient stability a similar environment to running a contingency analysis study with repeated power flow solutions
- Changing the Process Contingencies option on the Simulation page of the dialog from “One Contingency at a time” to “Multiple Contingencies” changes the dialog in small ways throughout
- Three subtopics for processing multiple contingencies
  - User interface
  - Data storage
  - Transient limit monitors

# Multiple Contingencies: User Interface Changes



- The Simulation page is changed
- The Plots and Results pages are changed
- The States/Manual Control page is no longer present
- The rest of the dialog has very few changes
  - The Options page does not change and will apply to all transient contingencies
  - The Results Storage page will also apply to all transient contingencies
  - Validation and SMIB do not change since they apply to the initial steady-state condition of the system
  - Transient Limit Monitors apply to all contingencies, and Transient Limit Violations reference a particular contingency

# Multiple Contingencies: User Interface Changes



- When processing multiple contingencies, The Transient Stability Analysis dialog looks very similar to PowerWorld's contingency analysis tool
- The top shows a list of the transient contingency definitions, each with its Start Time, End Time, and Time Step
- The bottom shows the Transient Contingency Elements which are part of the selected contingency

Change in appearance of the Transient Stability Analysis Simulation page

Top Portion turning into a list of Transient Contingencies

States/Manual Control removed

Check Multiple Contingencies

Name	Start Time	End Time	Cycles for Step	Time Step	Skip	Processed	Solved	Violations
1 My Transient Contingency	0.000000	10.000000	NO	0.020000	NO	NO	NO	0
2 Another Contingency	0.000000	10.000000	NO	0.020000	NO	NO	NO	0
3 Contingency X	0.000000	10.000000	NO	0.020000	NO	NO	NO	0
4 Contingency Y	0.000000	10.000000	NO	0.020000	NO	NO	NO	0

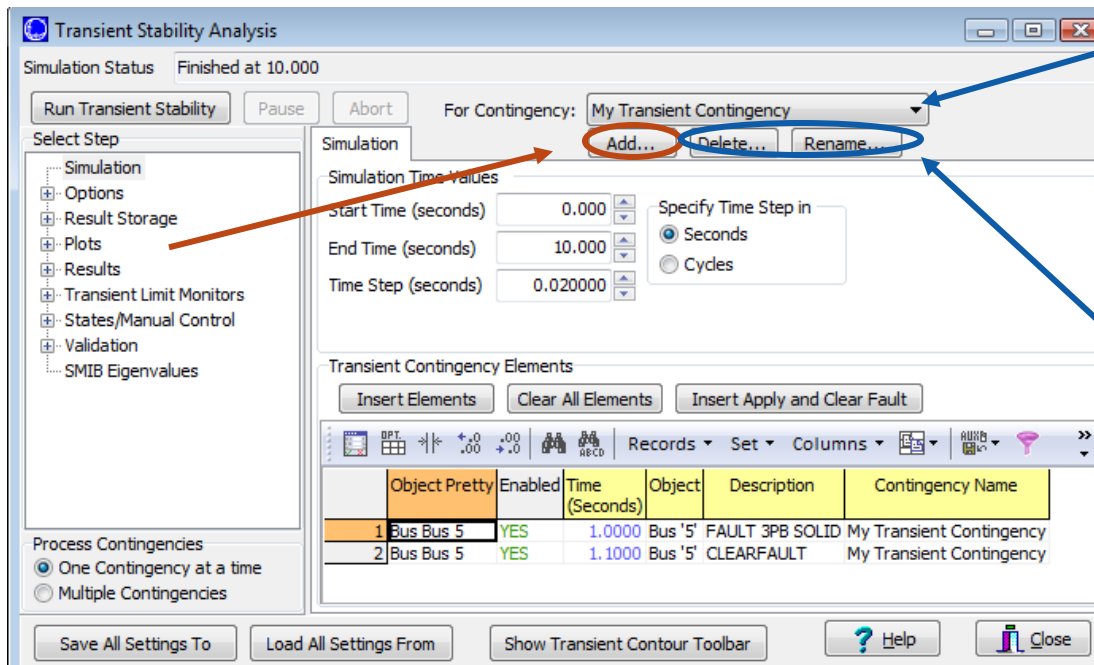
Time (Seconds)	Enabled	Object	Object Pretty	Description
1 1.0000	YES	Bus '5'	Bus Bus 5	FAULT 3PB SOLID
2 1.1000	YES	Bus 'S'	Bus Bus 5	CLEARFAULT

# Example: Multiple Contingencies



- Open the **TS9BusCtgEx** case
- This case initially contains a fault at bus 5 as well as some plot settings
- We will add another Transient Contingency and show how to handle the processing of multiple contingencies
- Open the Transient Stability Analysis dialog and Click “Add”

Click to add new Transient Contingencies



The drop-down displays which contingency is active

Can also delete or rename a contingency

# Example: Multiple Contingencies



- After clicking “Add,” the dialog will appear as below
- Similar to the blank Transient Stability Analysis dialog before any events are inserted, but the name says “My Transient Contingency 1”
- Click the drop-down and verify that you can still switch back to the first contingency (the bus 5 fault)

Use the drop-down to switch contingencies

Adding a new Transient Contingency

Transient Stability Analysis

Simulation Status: Not Initialized

Run Transient Stability | Pause | Abort | For Contingency: My Transient Contingency 1

Select Step

- Simulation
- Options
- Result Storage
- Plots
- Results
- Transient Limit Monitors
- States/Manual Control
- Validation
- SMIB Eigenvalues

Simulation Time Values

Start Time (seconds): 0.000

End Time (seconds): 10.000

Time Step (cycles): 0.500

Specify Time Step in:  Seconds  Cycles

Transient Contingency Elements

Insert Elements | Clear All Elements | Insert Apply and Clear Fault

Object	Pretty	Enabled	Time (Seconds)	Object	Description	Contingency Name
None		Defined				

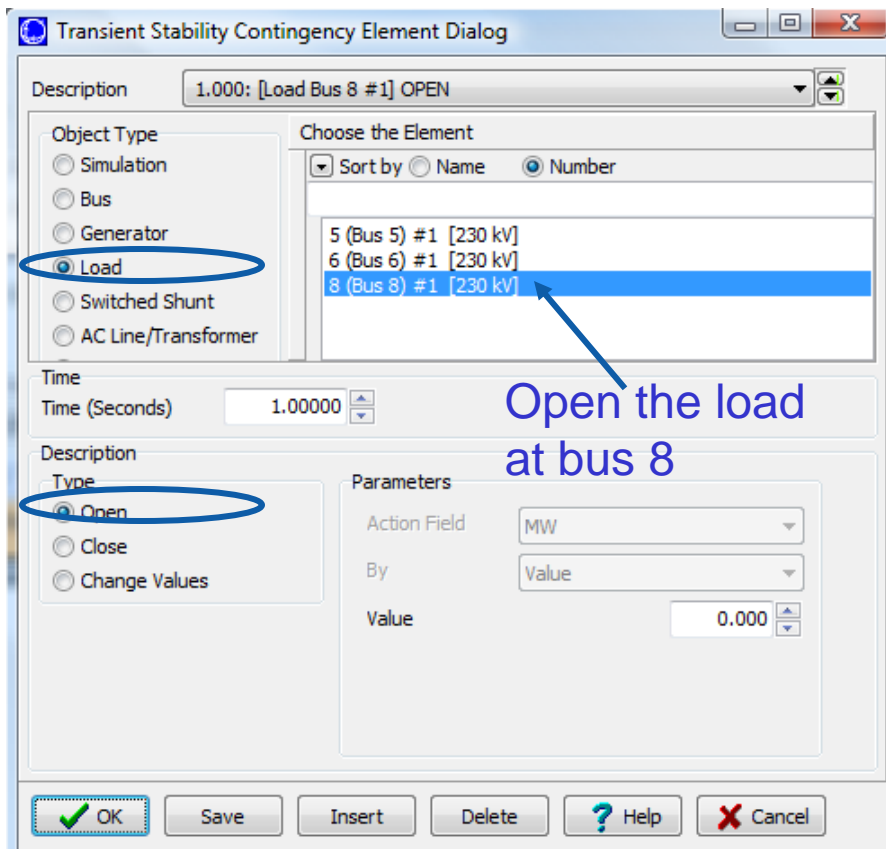
Process Contingencies

One Contingency at a time  Multiple Contingencies

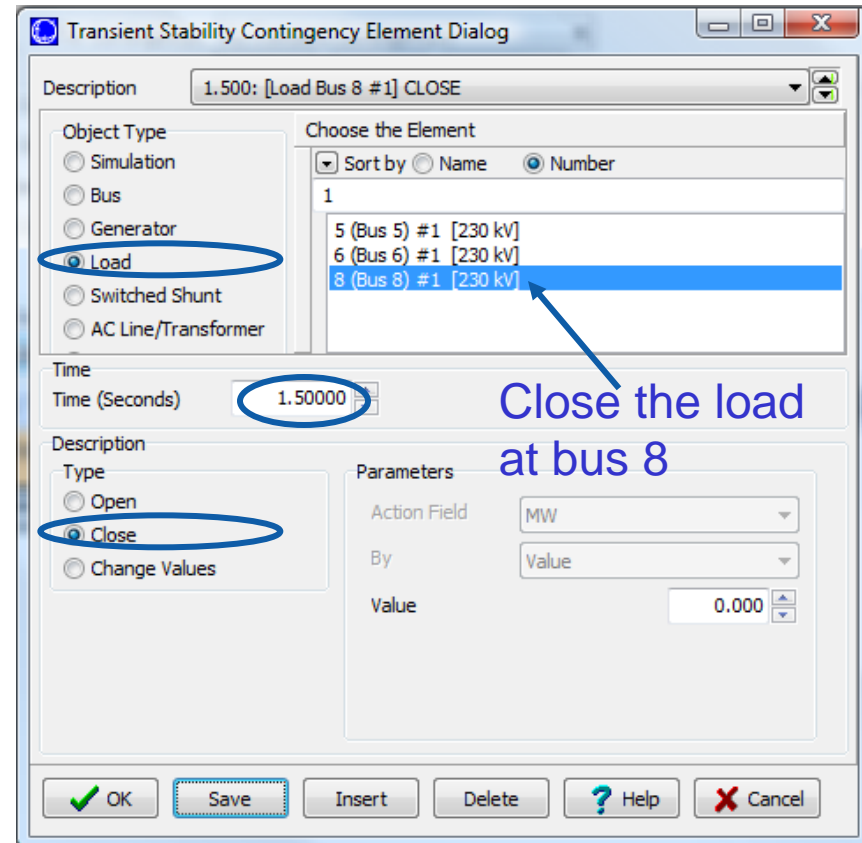
Save All Settings To | Load All Settings From | Show Transient Contour Toolbar | ? Help | Close

# Example: Multiple Contingencies

- Add new Transient Contingency Elements to “My Transient Contingency 1”



Open the load at bus 8



Close the load at bus 8

- Make events to **open** the load at bus 8 at 1.0 seconds and **close** it again at 1.5 seconds

# Example: Multiple Contingencies



- You can give each Transient Contingency a more meaningful name
- Click “Rename”
- Name the two contingencies “Bus 5 Fault” and “Bus 8 Load”
- Save the case as **TS9BusMultipleContingency**

Simulation Status: Not Initialized

For Contingency: Bus 8 Load

Simulation Time Values

Start Time (seconds): 0.000

End Time (seconds): 10.000

Time Step (cycles): 0.500

Specify Time Step in: Seconds, Cycles

Transient Contingency Elements

Object Pretty	Enabled	Time (Seconds)	Object	Description	Contingency Name
1 Load Bus 8 #1	YES	1.0000	Load '8' OPEN		Bus 8 Load
2 Load Bus 8 #1	YES	1.5000	Load '8' CLOSE		Bus 8 Load

Process Contingencies: One Contingency at a time, Multiple Contingencies

Load events at Bus 8

Add a new Contingency

Currently, only the selected contingency will be processed



# Example: Multiple Contingencies



- Under “Process Contingencies,” change the option to “Multiple Contingencies”
- The dialog has visibly changed to the one shown below
- This view allows you to study multiple Transient Contingencies at once

Click on each Transient Contingency to view its constituent elements below

Simulator is now set to process multiple contingencies at once

Transient Stability Analysis

Simulation Status: Not Initialized

Select Step: Simulation, Options, Result Storage, Plots, Results, Transient Limit Monitors, Validation, SMIB Eigenvalues

Simulation: Run Transient Stability, Pause, Abort

	Name	Start Time	End Time	Cycles for Step	Time Step	Skip	Processed	Solved	Violations
1	Bus 5 Fault	0.000000	10.000000	NO	0.020000	NO	NO	NO	0
2	Bus 8 Load	0.000000	10.000000	YES	0.500000	NO	NO	NO	0

Transient Contingency Elements

Insert Elements, Clear All Elements, Insert Apply and Clear Fault

	Object Pretty	Enabled	Time (Seconds)	Object	Description	Contingency Name
1	Bus Bus 5	YES	1.0000	Bus '5'	FAULT 3PB SOLID	Bus 5 Fault
2	Bus Bus 5	YES	1.1000	Bus '5'	CLEARFAULT	Bus 5 Fault

Process Contingencies:  One Contingency at a time,  Multiple Contingencies

Save All Settings To, Load All Settings From, Show Transient Contour Toolbar, Help, Close

# Multiple Contingencies



- A convenient way to add Transient Contingencies is from the display which appears at the top of the dialog when “Multiple Contingencies” is selected

Try inserting a new contingency this way; then delete it.

- New Transient Contingencies can be created by choosing “Insert” from the right-click menu

- Transient Contingencies can also be deleted from the right-click menu

The screenshot shows the 'Transient Stability Analysis' window. The 'Simulation Status' is 'Not Initialized'. The 'Simulation' section has 'Run Transient Stability', 'Pause', and 'Abort' buttons. The 'Transient Contingencies' table is as follows:

Name	Start Time	End Time	Cycles for Step	Time Step	Skip	Processed	Solved	Violations
1 Bus 5 Fault	0.000000	10.000000	NO	0.020000	NO	NO	NO	0
2 Bus 8 Load	0.500000		NO	0.500000	NO	NO	NO	0

The 'Transient Contingency Element' section shows 'Object Pretty' as 'Enabled'. Below it, a table lists elements:

Object	Enabled
1 Bus Bus 5	YES
2 Bus Bus 5	YES

The 'Process Contingencies' section has radio buttons for 'One Contingency at a time' and 'Multiple Contingencies' (selected). A context menu is open over the table, with 'Insert...' and 'Delete' options circled in blue. A blue arrow points from the text 'Another place to insert or delete a contingency' to the 'Insert...' option.

Another place to insert or delete a contingency

# Multiple Contingency: Plot Definition



- You can choose to define plots for only one contingency at a time
- Alternatively, you can click “Plot Multiple Contingencies” to specify plots for multiple transient contingencies at once

The screenshot shows the 'Plot Designer' window in the software. At the top, there are two options: 'Plot for only one contingency' (selected) and 'OR, Choose Contingencies to Plot'. The 'Plot for only one contingency' option is highlighted with a red box and a red arrow pointing to the 'Plot Multiple Contingencies' checkbox, which is unchecked. The 'OR, Choose Contingencies to Plot' option is also highlighted with a red box and a red arrow pointing to the 'Choose Contingencies to Plot' button, which is checked. Below these options, the 'Plot Definition Grids' section is visible, showing a list of fields and objects to be plotted. The 'When to show the plot' section is also visible, with 'Completion of a stability run' selected. At the bottom, a 'Transient Contingency' table is shown, with a red box highlighting the 'Show' column. The table has the following data:

Name	Show	Plot Color	Plot Dashed	Plot Thickness	Plot Symbol
1 My Transient Contingency	YES	Default	Default	Default	Default
2 Another Contingency	YES	Default	Default	Default	Default
3 Contingency X	YES	Default	Default	Default	Default
4 Contingency Y	YES	Default	Default	Default	Default

The 'Specify whether to Show' text is written in red below the table, pointing to the 'Show' column. The 'Close' button is visible at the bottom right of the table window.

# Multiple Contingencies: Plot Definition



- On the Plots page, check the “Plot Multiple Contingencies” checkbox and click “Choose Contingencies to Plot”

Generate a plot showing multiple traces from multiple Transient Contingency simulations

The screenshot shows the 'Transient Stability Analysis' software interface. The 'Plots' section is active, and the 'Plot Multiple Contingencies' checkbox is checked and circled in blue. A blue arrow points from this checkbox to the 'Choose Contingencies to Plot' button. The 'Choose Fields' list includes Accel MW, Field Current, Field Voltage (pu), Mech Input, Mvar Terminal, MW Terminal, Rotor Angle, Rotor Angle, No Shift, Speed, and Stabilizer Vs. The 'Plots, Subplots, Axis Groups' section shows a tree view with 'MW output' and two subplots. The 'Plot Name' is 'MW output'. The 'When to show the plot' section is set to 'Completion of a stability run'. The 'Transient Contingency' dialog box is overlaid on the main window, showing a table of contingencies.

Name	Show	Plot Color	Plot Dashed	Plot Thickness	Plot Symbol
1 Bus 5 Fault	YES	Default	Default	Default	Default
2 Bus 8 Fault	YES	Default	Default	Default	Default

# Multiple Contingencies: User Interface Changes



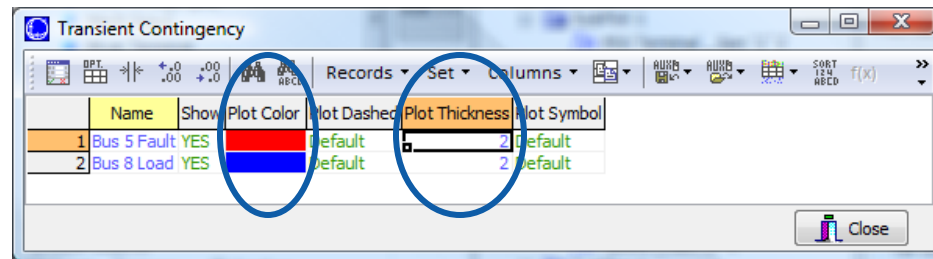
- Clicking “Choose Contingencies to Plot” brings up the list of the Transient Contingencies defined in the case
- There are five columns next to each contingency
  - Show
  - Plot Color
  - Plot Dashed
  - Plot Thickness
  - Plot Symbol
- Setting “Show” to YES causes the plot series for that contingency to be generated (it is set to YES by default)
- Plot Color, Dashed, Thickness, and Symbol will override what is specified with the plot definition and will be applied to all plot series for the particular contingency

# Multiple Contingencies: Plot Definition



- After clicking “Choose Contingencies to Plot,” use the dialog to customize how the plots will appear
- Both Transient Contingencies are set to be shown
- Plot Colors and Plot Thickness have been changed

Show Bus 5 and Bus 8 events as different colors in the defined plots



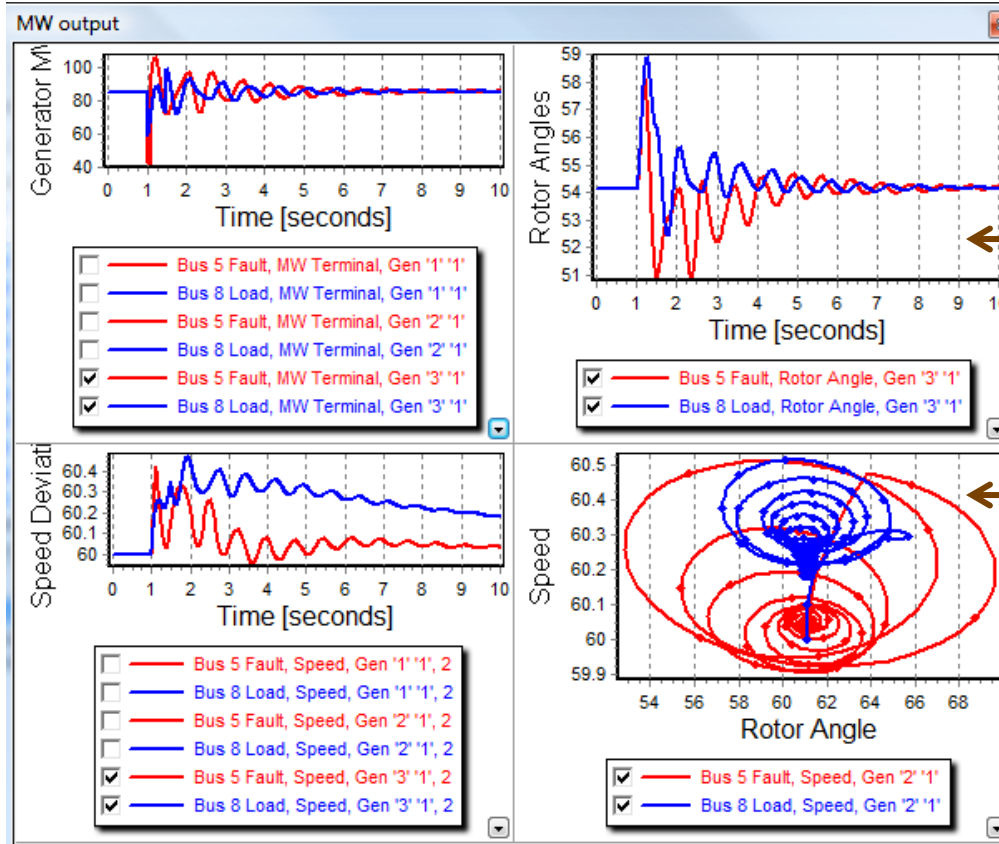
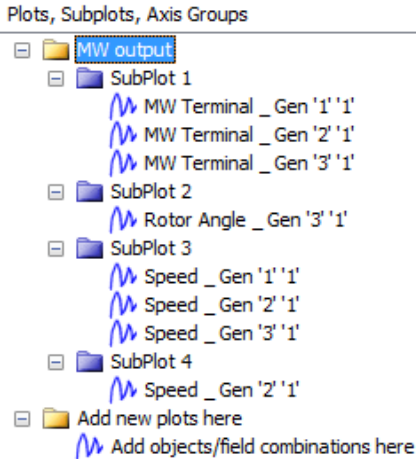
- Go back to the Simulation page
- Click Run Transient Stability
- Go back to the Plot page

# Multiple Contingencies: Plot Definition



- Create and customize plots for the simulation as desired
- Click “Generate Selected Plots”

Generate Selected Plots



Generator 3 Rotor Angle plots for both contingencies

Generator 3 Speed vs. Rotor Angle for both contingencies

Plot legends include the name of the Transient Contingency

# Multiple Contingencies: Result Storage



- Result storage options apply to all of the contingencies being processed, but the settings are the same as when processing one contingency
- It is important to be aware of what you are saving, especially when processing multiple contingencies
- When saving to RAM, results are stored to RAM for each contingency – be careful what you store
- When saving to Hard Drive, two files are created for each contingency
  - *Contingency Name.TSR*
    - Plot generation can get data directly from the Hard Drive
    - Data shown in case information displays can not come from Hard Drive; however, you can load from hard drive a subset of the data so that it can be viewed in a case information display
  - *Contingency Name.AUX*
    - Stores the Min/Max Values, Summary Information, Events, and Solution Details information for the contingency



# Multiple Contingencies: Result Storage



- Open the Results Storage page
- All of the fields for Generators and Buses are currently being saved
- This case is small and we are only simulating two contingencies, so this is okay for the purposes of our demonstration
- In general, you probably do not want to do this

Result Storage

Where to Save/Store Results  Store Results to RAM  Save Results to Hard Drive Save Results Every n Timesteps: 1

Load from Hard Drive File into RAM resu specified by Store to RAM Options

Save the Results stored to RAM in the PWB file

Store to RAM Options Save to Hard Drive Options

Note: All fields that are specified in a plot series of defined plot will also be stored to RAM.

Store Results for Open Devices Set All to NO for All Types Set Save All by Type ...

Generator	Bus	Load	Branch	DC Transmission Line	Multi-Terminal DC Converter	Area	Zone
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9

Result Storage

Where to Save/Store Results  Store Results to RAM  Save Results to Hard Drive Save Results Every n Timesteps: 1

Load from Hard Drive File into RAM resu specified by Store to RAM Options

Save the Results stored to RAM in the PWB file

Store to RAM Options Save to Hard Drive Options

Note: All fields that are specified in a plot series of defined plot will also be stored to RAM.

Store Results for Open Devices Set All to NO for All Types Set Save All by Type ...

Generator	Bus	Load	Branch	DC Transmission Line	Multi-Terminal DC Converter	Area	Zone
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3

# Multiple Contingencies: Time Value Results



- Showing the time value results for multiple contingencies at once would be overwhelming
- On the Results page of the Transient Stability Analysis dialog, a dropdown is provided to allow you to choose which transient contingency's results you would like to view

Bus 8 Contingency is selected to view results

Simulation Status

Select Step

- Simulation
- Options
- Result Storage
- Plots
  - Plot Designer
  - Plot Definition Grids
- Results
- Transient Limit Monitors
- Validation
- SMIB Eigenvalues

Process Contingencies

One Contingency at a time

Multiple Contingencies

Results For Contingency: Bus 8 Load

Results can be viewed in the case information displays for only one transient contingency at a time

Time Values From RAM Minimum/Maximum Values Summary Events Solution Details

Generator	Bus	Load	Branch	DC Transmission Line	Multi-Terminal DC Converter	Area	Zone				
Column Order	Object then Field	Column Filtering Filter	Modify...	Choose Fields to Dis...	Use Area/Zone Filters	Records	Set	Columns	Records	Set	Columns
Time	Gen Bus1 #1 Rotor Angle	Gen Bus1 #1 Speed	Gen Bus1 #1 Mech Input	Gen Bus1 #1 MW Terminal	Gen Bus1 #1 Mvar Terminal	Gen Bus1 #1 Term. PU	Gen Bus1 #1 Field Voltage (pu)	Gen Bus1 #1 Field Current	Gen #1 St		
1	0	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
2	0.008	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
3	0.017	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
4	0.025	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
5	0.033	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
6	0.042	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
7	0.05	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
8	0.058	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
9	0.067	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
10	0.075	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
11	0.083	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
12	0.092	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
13	0.1	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
14	0.108	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
15	0.117	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
16	0.125	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
17	0.133	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
18	0.142	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
19	0.15	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
20	0.158	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		
21	0.167	3.586	60	71.645	71.645	27.039	1.04	1.082	1.082		

Save All Settings To Load All Settings From Show Transient Contour Toolbar

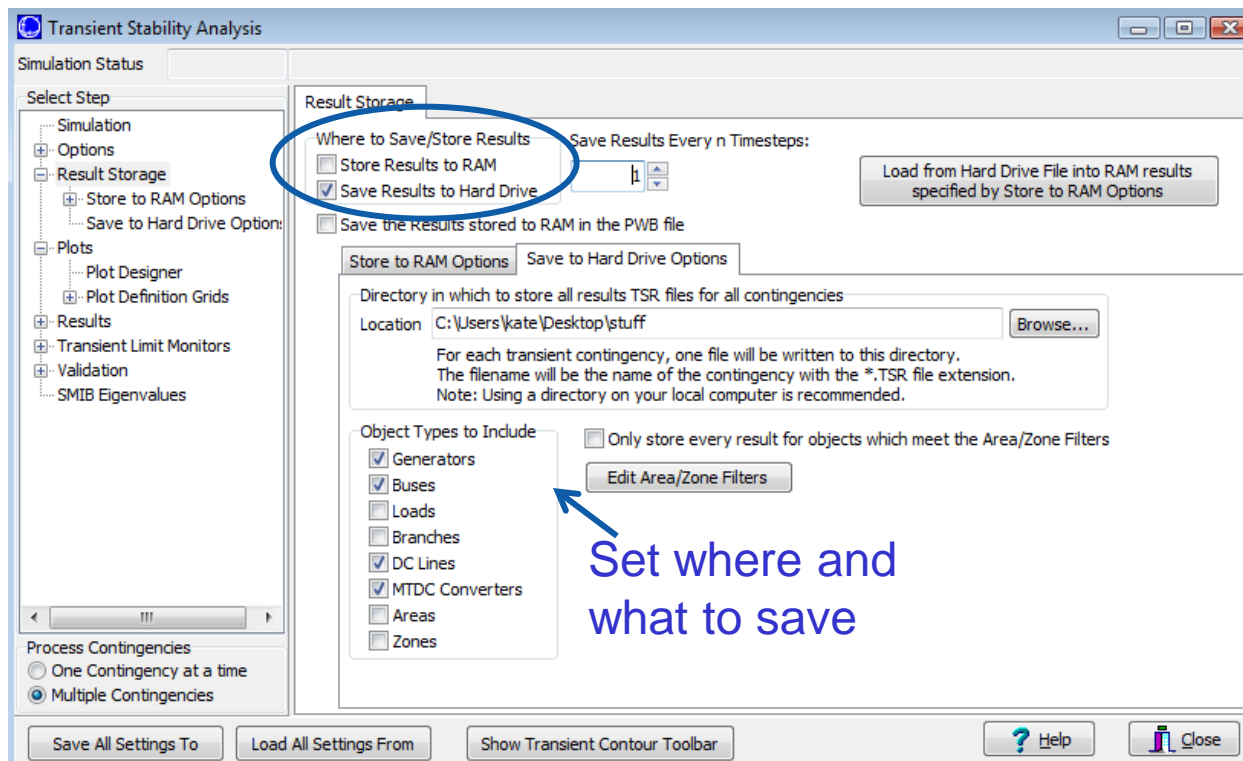
Help Close

# Multiple Contingencies: Hard Drive Storage



- Open the Result Storage page
- Change Where to Save/Store Results to “Save Results to Hard Drive”
- Choose a location where the files should be saved

Save the results of multiple contingency runs to hard drive



Set where and what to save

# Multiple Contingencies: Results



- Go back to the Simulation page and click “Run Transient Stability”
- Open the Results page; it does not show the time values because they have not been loaded from RAM
- A separate file with extension \*.tsr is generated for each Transient Contingency
- Verify that the two files “Bus 5 Fault.tsr” and “Bus 8 Load.tsr” are both in the folder where you saved them
- You can go to the Result Storage page, change the Store Results to RAM settings, and use the “Load from Hard Drive File into RAM results specified by Store to RAM Options” button to load in specified fields from RAM
- Also, you can still generate the selected plots on the Plots page

# Multiple Contingencies: Results



Result Storage

Where to Save/Store Results: Save Results Every n Timesteps: 1

Store Results to RAM

Save Results to Hard Drive

Save the Results stored to RAM in the PWB file

Store to RAM Options: Save to Hard Drive Options

Note: All fields that are specified in a plot series of defined plot will also be stored to RAM.

Store Results for Open Devices Set All to NO for All Types Set Save All by Type...

Generator	Bus	Load	Branch	DC Transmission Line	Multi-Terminal DC Converter	Area	Zone										
Set All NO		Number of Bus	Name of Bus	ID	Area Name of Gen	Save All	Rotor Angle, No Shift	Rotor Angle, No Shift	Speed	Mech Input	MW Terminal	Accel MW	Mvar Terminal	Term. PU	Field Voltage (pu)	Field Current	Stabilizer Vs
From Selection:	1	1	Bus 1	1	1	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
	2	2	Bus 2	1	1	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
	3	3	Bus 3	1	1	NO	YES	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO

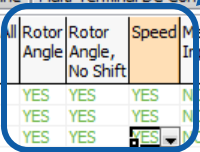
Make Plot

Load from Hard Drive File into RAM results specified by Store to RAM Options



Click to load results into RAM

Toggle to YES to specify what to read in



Results page is now populated with the data for the active contingency

Results For Contingency: Bus 8 Load

Results can be viewed in the case information displays for only one transient contingency at a time

Time Values From RAM Minimum/Maximum Values Summary Events Solution Details

Generator	Bus	Load	Branch	DC Transmission Line	Multi-Terminal DC Converter	Area	Zone
Column Order	Object then Field						
Column Filtering	Filter	Modify...					
Choose Fields to Dis...	<input checked="" type="checkbox"/> Accel MW	<input checked="" type="checkbox"/> Field Current	<input checked="" type="checkbox"/> Field Voltage (pu)	<input checked="" type="checkbox"/> Mech Input	<input checked="" type="checkbox"/> Mvar Terminal	<input checked="" type="checkbox"/> MW Terminal	<input checked="" type="checkbox"/> Rotor Angle
	<input checked="" type="checkbox"/> Rotor Angle, No S...						
	Time	Gen Bus 1 #1 Rotor Angle	Gen Bus 1 #1 Rotor Angle, No Shift	Gen Bus 1 #1 Speed	Gen Bus 2 #1 Rotor Angle	Gen Bus 2 #1 Rotor Angle, No Shift	Gen Bus 2 #1 Speed
	1	0	3.586	3.586	60	61.1	61.1
	2	0.008	3.586	3.586	60	61.1	61.1
	3	0.017	3.586	3.586	60	61.1	61.1
	4	0.025	3.586	3.586	60	61.1	61.1
	5	0.033	3.586	3.586	60	61.1	61.1
	6	0.042	3.586	3.586	60	61.1	61.1
	7	0.05	3.586	3.586	60	61.1	61.1
	8	0.058	3.586	3.586	60	61.1	61.1
	9	0.067	3.586	3.586	60	61.1	61.1
	10	0.075	3.586	3.586	60	61.1	61.1
	11	0.083	3.586	3.586	60	61.1	61.1
	12	0.092	3.586	3.586	60	61.1	61.1
	13	0.1	3.586	3.586	60	61.1	61.1
	14	0.108	3.586	3.586	60	61.1	61.1

Instead of using Result Storage settings to specify what to save out, we are now using them to specify what to read in

# Transient Limit Monitors



- Transient Limit Monitoring is applied to each contingency
- Each Transient Limit Violation refers to the contingency which caused it
  - Similar to contingency analysis
  - You get a list of contingency violations
- Transient Limit Monitors greatly facilitate the processing of multiple contingencies by reducing the need to save a lot of data when you only want to verify that certain criteria are met during the run
- Discussed in the Transient Limit Monitors section

Blank Page

Blank Page