Transient Stability Analysis with PowerWorld Simulator

T9: Multiple Contingencies

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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

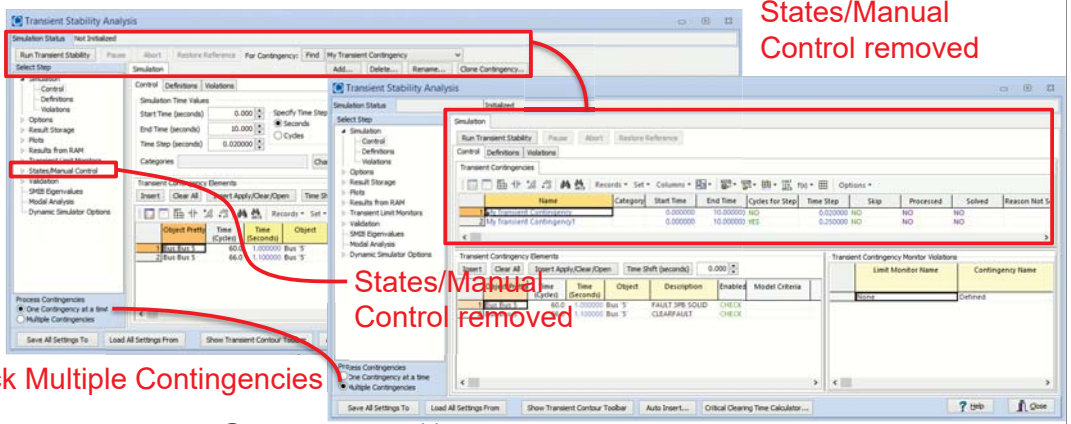
Multiple Contingencies: User Interface Changes

- 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

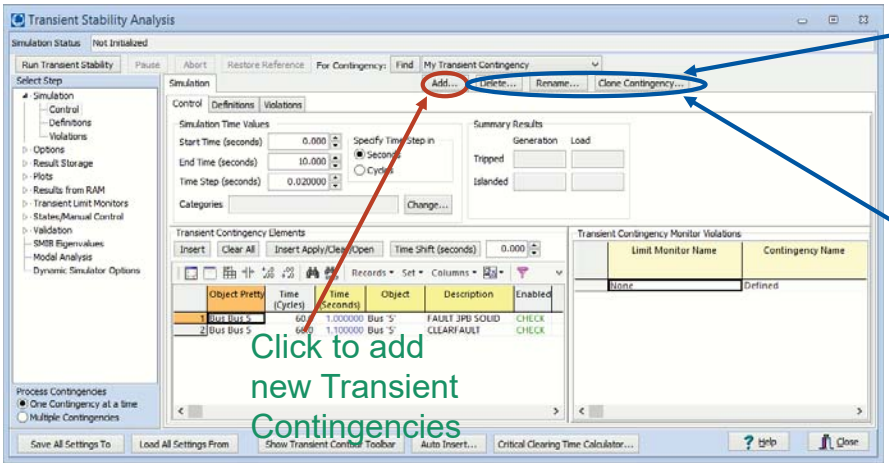
- When processing multiple contingencies, The Transient Stability Analysis dialog looks very similar to PowerWorld's contingency analysis tool
- The top shows a list of the transient contingency definitions, each with its Start Time, End Time, and Time Step
- The bottom shows the Transient Contingency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

Change in appearance of the Transient Stability Analysis Simulation page



Example: Multiple Contigencies

- 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”



The drop-down displays which contingency is active

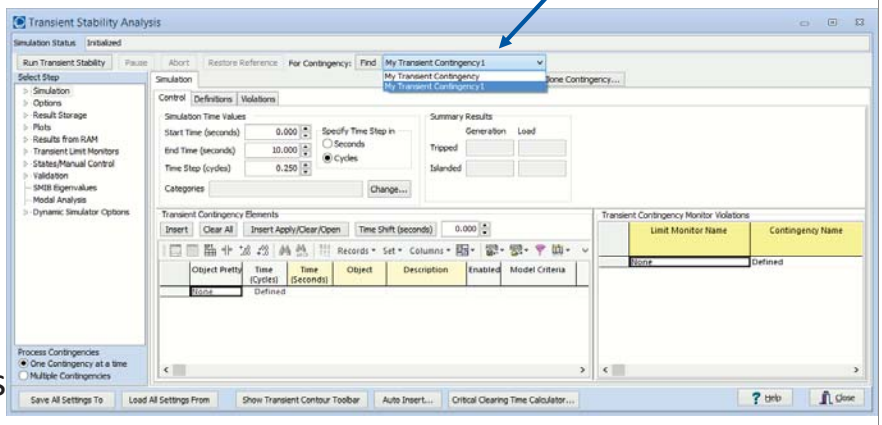
Can also delete, rename or clone a contingency

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)

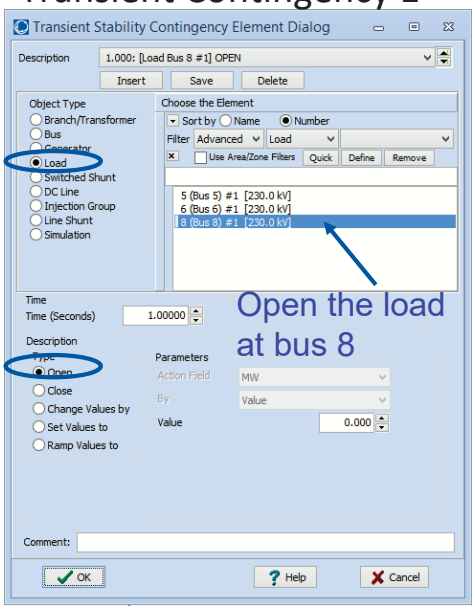
Adding a new Transient Contingency

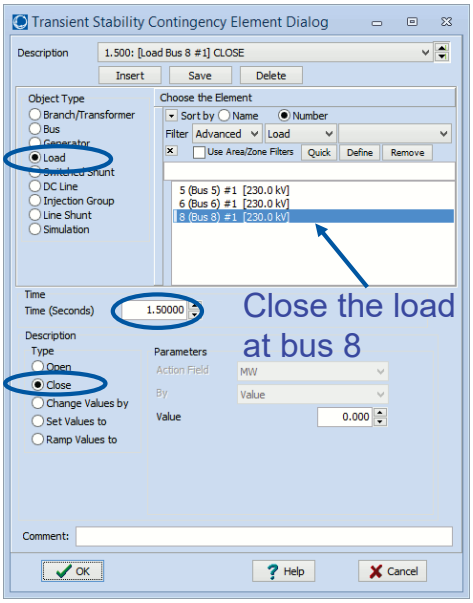
Use the drop-down to switch contingencies



Example: Multiple Contingencies

- Add new Transient Contingency Elements to "My Transient Contingency 1"

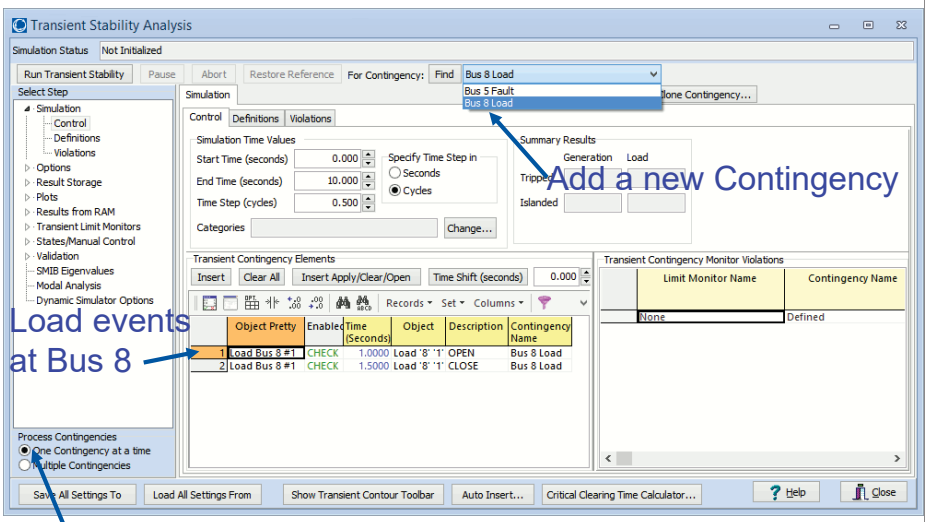




- Make events to open the load at bus 8 at 1.0 seconds and close it again at 1.5 seconds

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

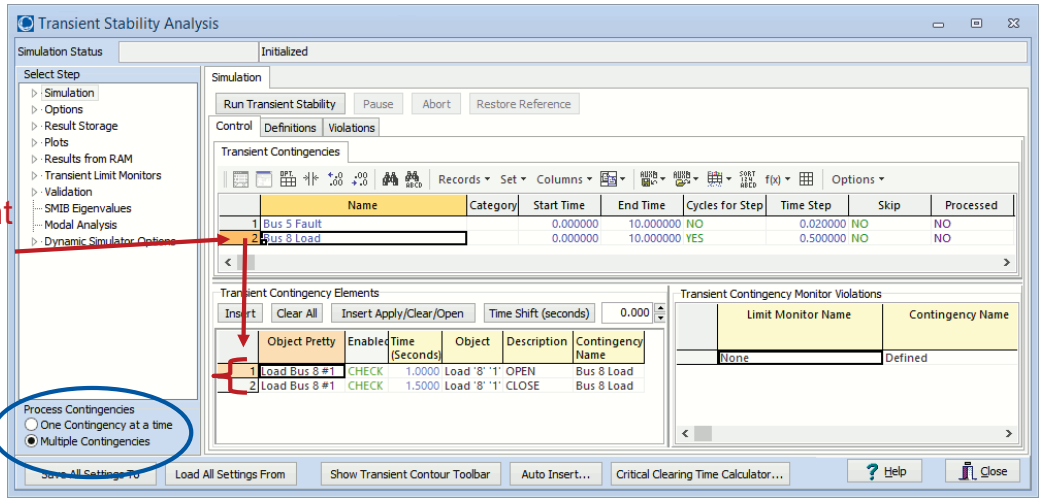


Example: Multiple Contingencies

- 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

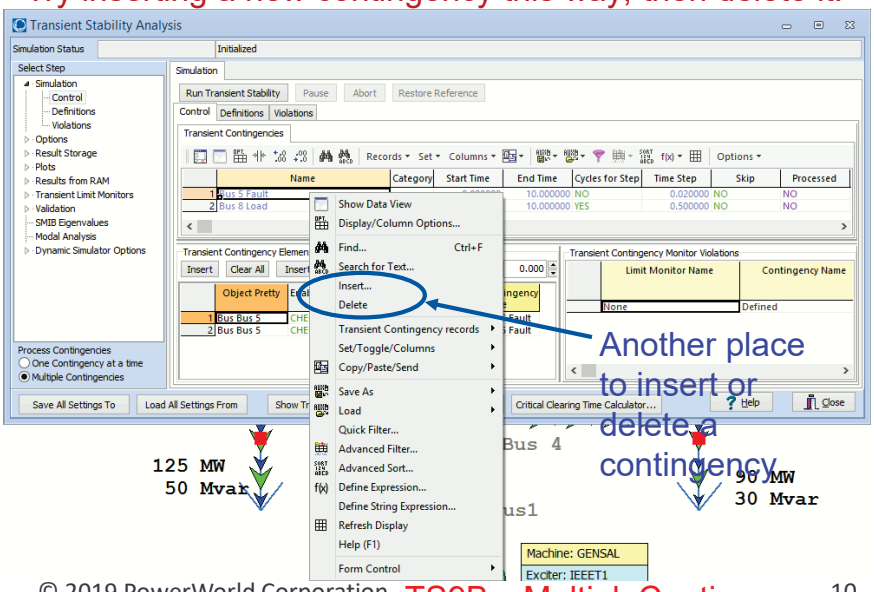


TS9BusMultipleContingency

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
- 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

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

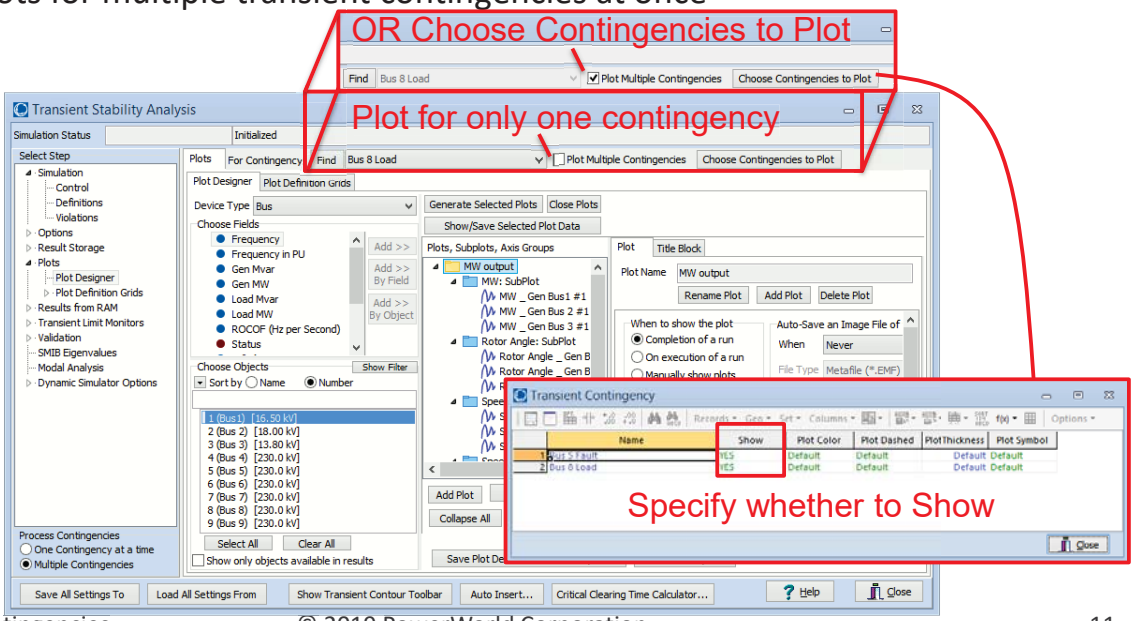


Another place to insert or delete a contingency

TS9BusMultipleContingency

Multiple Contingency: Plot Defintion

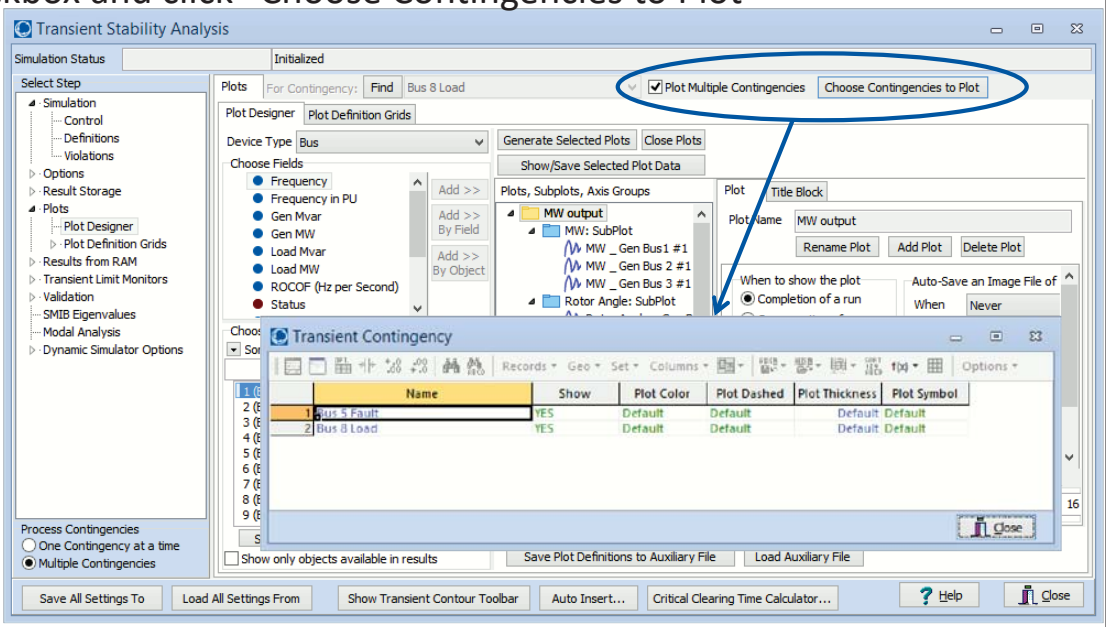
- You can choose to define plots for only one contingency at a time
- Alternatively, you can click “Plot Multiple Contingencies” to specify plots for multiple transient contingencies at once



Multiple Contingencies: Plot Definition

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

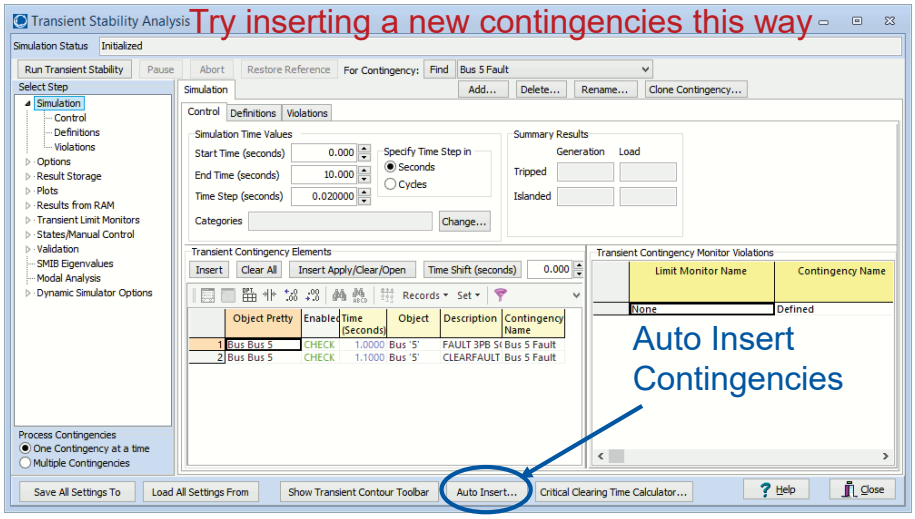
Generate a plot showing multiple traces from multiple Transient Contingency simulations



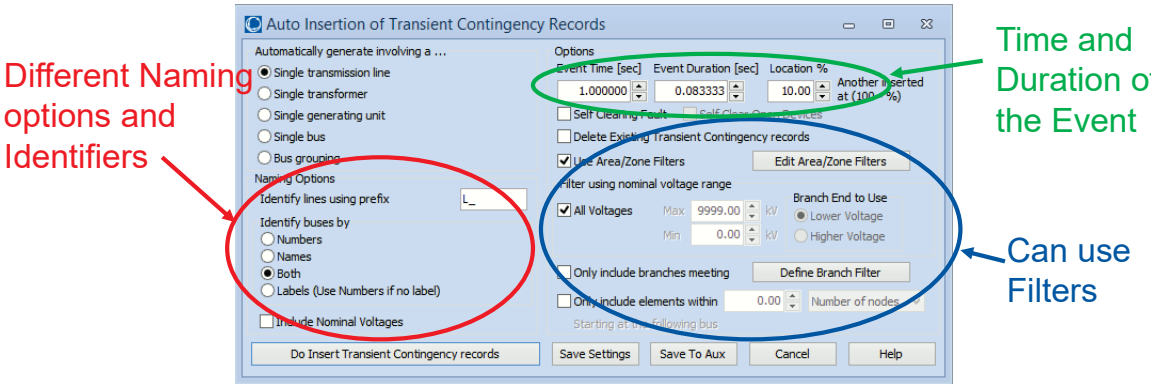
TS9BusMultipleContingency

Auto Insert Multiple Contingencies

- A convenient way to add Transient Contingencies is from the *Auto Insert…* button
- New Transient Contingencies using *Auto Insert…* can be created in the One Contingency at a time or Multiple Contingencies User Interface



Auto Insert Multiple Contingencies



- Objects and Contingency Type Allowed:
  - Single *Transmission Line* Solid Three phase Fault and clearing
  - Single *Transformer* Solid Three phase Fault and clearing
  - Single *Generator* Unit Opening
  - Single *Bus* Solid Three phase Fault and clearing

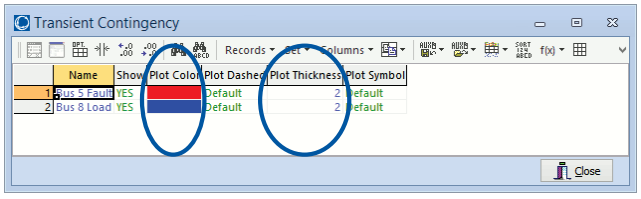
Multiple Contingencies: User Interface Changes

- 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 →

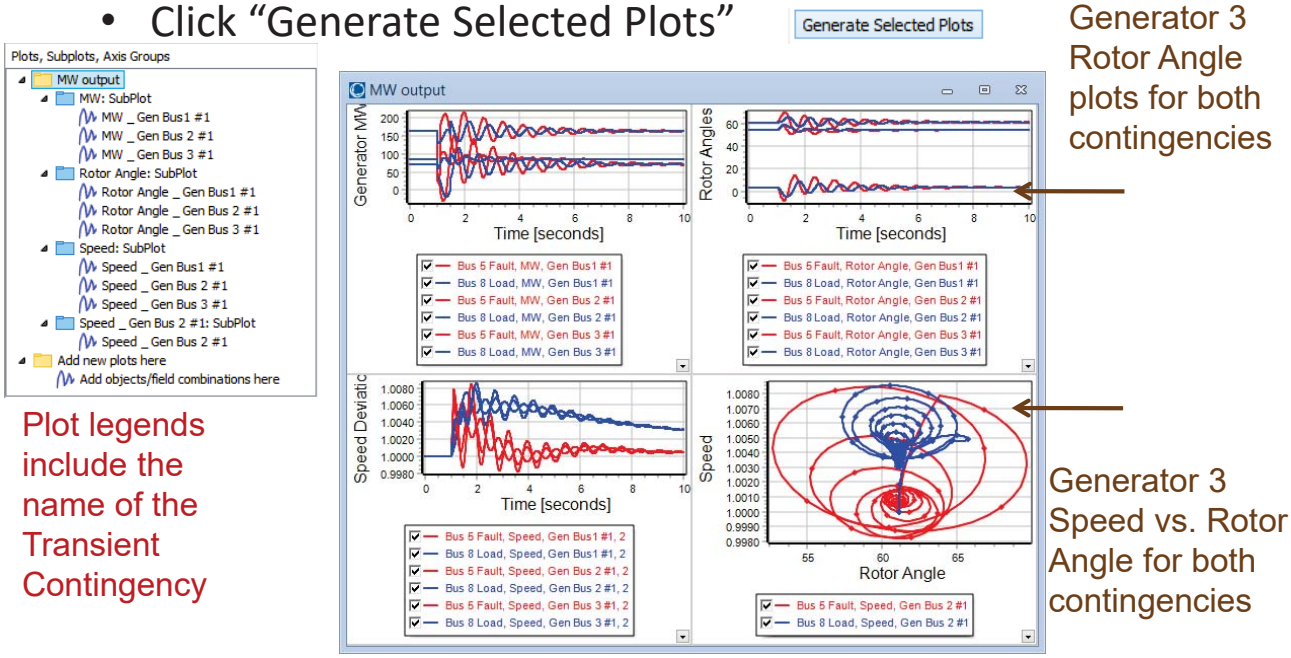


- Go back to the Simulation page
- Click Run Transient Stability
- Go back to the Plot page

TS9BusMultipleContingency

Multiple Contingencies: Plot Definition

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



Generator 3 Rotor Angle plots for both contingencies

Plot legends include the name of the Transient Contingency

Generator 3 Speed vs. Rotor Angle for both contingencies

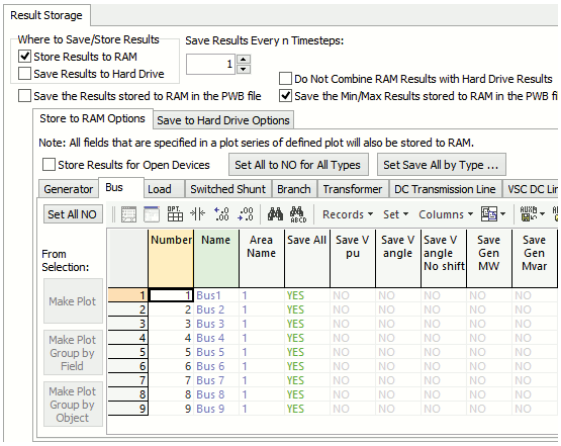
TS9BusMultipleContingency

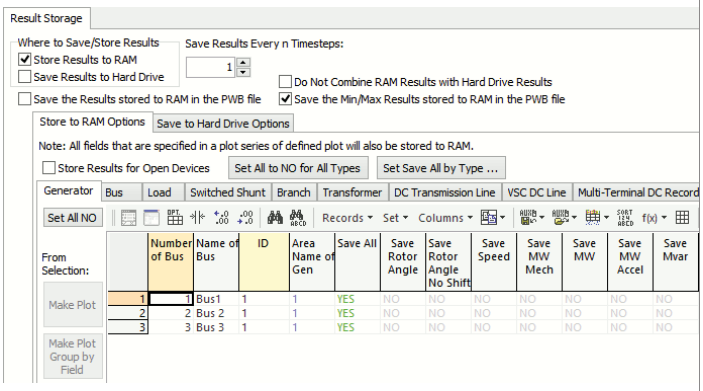
Multiple Contingencies: Result Storage

- 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

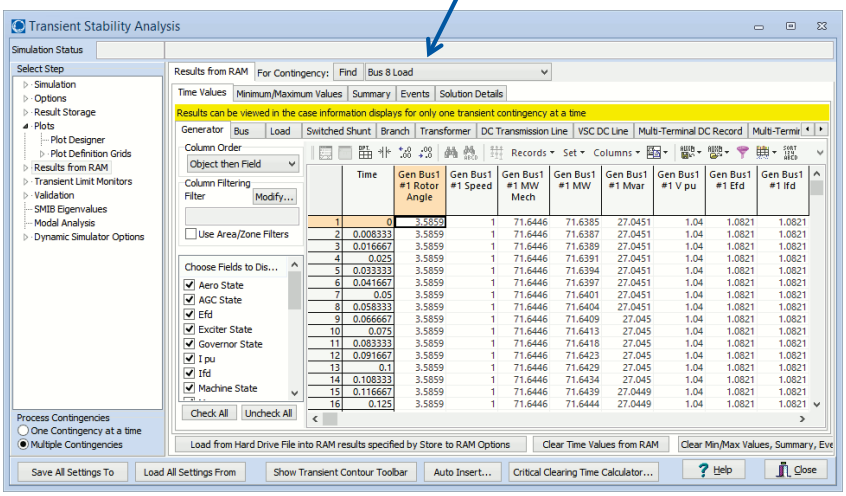




Multiple Contingencies: Time Value Results

- 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

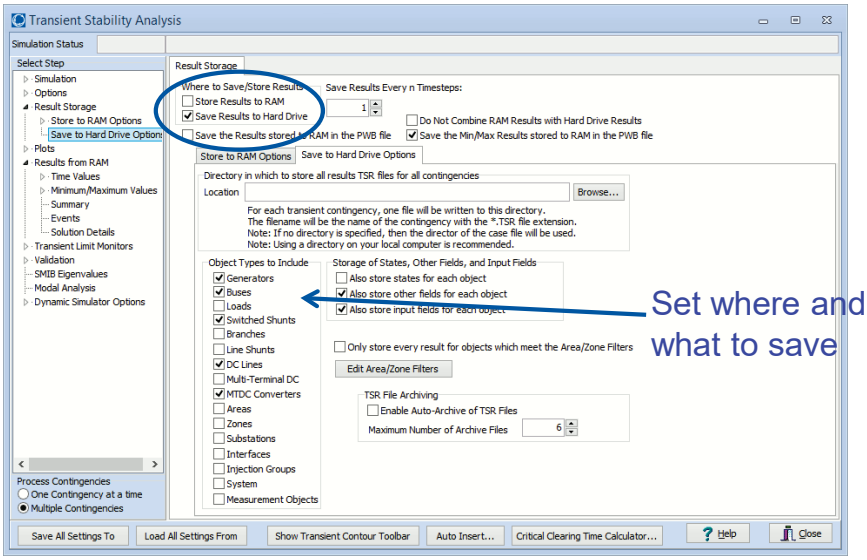
Bus 8 Contingency is selected to view results



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

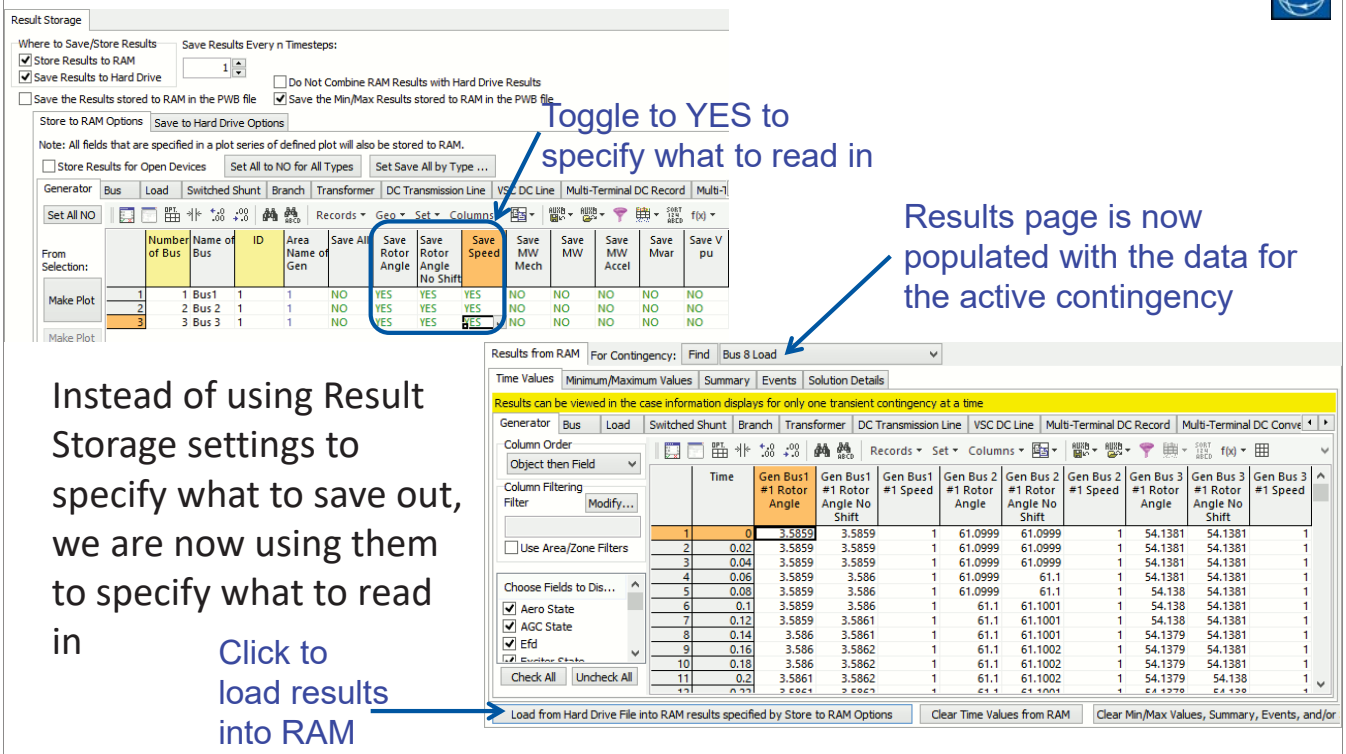


Set where and what to save

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



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

Click to load results into RAM

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