What's New in Simulator Version 20

Prepared by Caroline Marzinzik
caroline@powerworld.com
217 384 6330 Ext. 12

PowerWorld Corporation

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

What's New in Version 20

- Version 20 is a version with many, many, many small changes throughout
- Concentration this past year has been on improving existing features
  - Difference Flows
  - Scheduled Actions
  - Transient Stability
  - Remedial Action Schemes (RAS)
- These are the highlights
  - Comprehensive list found at http://www.powerworld.com/products/simulator/whats-new

© 2017 PowerWorld Corporation

Simulator Installation

- MSI file will be used for installations and patches
- User installation will be possible without admin privileges
  - Will still be able to install for all users as an administrator
- There will be no separate zip file for patching
- Locally installed Help will be separate and optional
  - Default Help link is the PowerWorld website
- 32-bit and 64-bit will be installed simultaneously

© 2017 PowerWorld Corporation

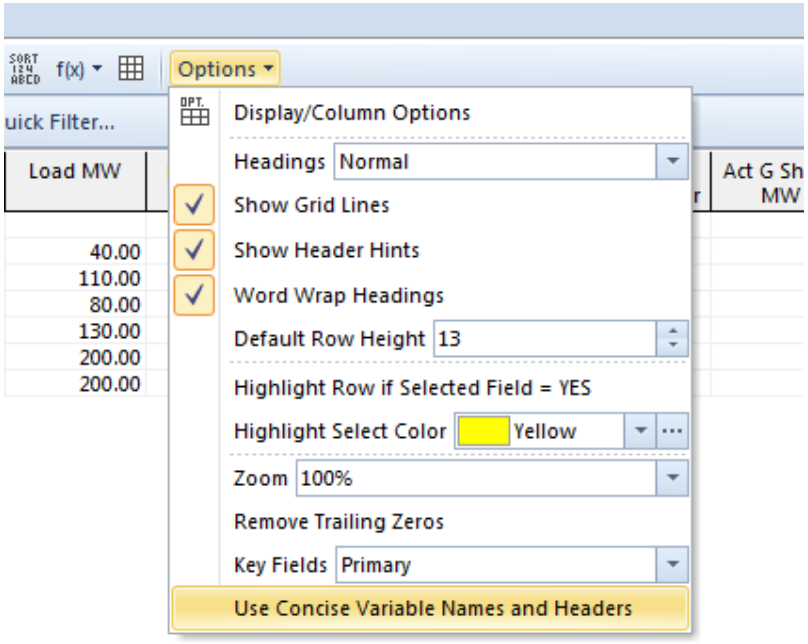
64-bit Simulator

- We are almost there
- Simulator is compiling and running
- PWB file format issues have been worked through
- SimAuto and Distributed Computing are working

© 2017 PowerWorld Corporation

Special Auxiliary File Improvements Continue into Version 19

- All variable names throughout Simulator have been overhauled
- Easier access to concise format
  - New option on Case Information Toolbar to show in concise format
  - If option selected, any saved auxiliary file will be in concise format
  - Default option in Version 19 is to not use this, but in Version 20 we will change default



© 2017 PowerWorld Corporation

Concise vs. Legacy Variable Names

- Concise names no longer use the location integer (:0, :1, etc.) wherever possible
- Concise names better reflect their purpose and have been made more understandable
  - For BRANCH object LineMW:1 (legacy) is now MWTo (concise)
- For fields in which a dynamic number is available the concise names will still use the location integer
  - CustomInteger, CustomFloat, CustomString, and other Custom fields
  - Multiple direction PTDF
  - Multiple Element TLR
  - LODF Matrix
  - Bus OPF Results
  - OPF Load and Generator Linear Bids

© 2017 PowerWorld Corporation

Concise vs. Legacy Variable Names

- *Export Case Object Fields…* will provide a comparison of the legacy and concise names

	A	B	C	D			
1	Object Type	SUBDATA Allowed	Key/Required Fields	Variable Name			
1205	Branch			BusName			
1206				BusName:1			
1207			*A*	BusName_NomVolt			
1208			*B*	BusName_NomVolt:1			
1209				BusName_NomVolt:2			
1210				BusName_NomVolt:3			
1211				BusNomVolt			
1212				BusNomVolt:1			
1213			*1*	BusNum	BusNumFrom	Integer	Number at From bus
1214			*2*	BusNum:1	BusNumTo	Integer	Number at To bus
1215				BusNum:2	MSBusNumFrom	Integer	Multi-Section Line Record's Number at From bus

BusNomVolt	NomkVFrom
BusNomVolt:1	NomkVTo
BusNum	BusNumFrom
BusNum:1	BusNumTo
BusNum:2	MSBusNumFrom

Switch between showing <u>legacy</u>

Branch	BusNum(1)	BusName	BusNum:1(2)	BusName:1	LineCircuit(3C)	LineStatus	BranchDeviceType	LineXfmr	LineMW	LineMVR	LineMVA	LineLimMVA	Li
1	1	One	2	Two	1	Closed	Line	NO	59.1	-4.5	59.2	150.0	

and <u>concise</u> variable names on a case information display

Branch	BusNumFrom(1)	BusNameFrom	BusNumTo(2)	BusNameTo	Circuit(3C)	Status	BranchDeviceType	IsXF	MWFrom	MvarFrom	MVAFrom	Li
1	1	One	2	Two	1	Closed	Line	NO	59.1	-4.5	59.2	

© 2017 PowerWorld Corporation

New Script Commands

- CTGSaveViolationMatrices
- DeleteDevice
- DiffFlowWriteRemovedEPC
- IdentifyBreakersForScheduledActions
- ImportDDLAsTranslation
- InjectionGroupCreate
- LoadAuxDirectory
- LoadEMS
- MessageBox
- ObjectFieldsInputDialog
- RelinkAllOpenOnelines
- SaveDataEPC
- SetScheduleView
- SetScheduleWindow
- TSAutoInsertDistRelay
- TSAutoInsertZPOTT
- TSCalculateCriticalClearTime
- TSLoadRDB
- TSLoadRelayCSV
- UpdateIslandsAndBusStatus

© 2017 PowerWorld Corporation

Script Command Modifications

- CalculateLODF, CalculateLODFMatrix
  - Added parameter PostClosureLCDF. If YES calculate the closure sensitivities relative to post-closure flow (LCDF). If NO calculate the closure sensitivities relative to pre-closure voltages and angles (MLCDF).
- CalculateTLR
  - Added AbortOnError parameter that indicates if the TLR calculation fails whether the auxiliary file containing the command should cease processing or continue
- CTGWriteResultsAndOptions, CTGWriteAllOptions
  - Added SaveDependencies parameter to specify if all objects needed to define selected objects are also saved
- CloseWithBreakers
  - Added parameter CloseNormallyClosedDisconnects that will close any disconnect that is normally closed but currently open when searching for breakers
- DiffFlowMode
  - diffmode can also be specified as CHANGE
- OpenOneline
  - Wildcards are allowed in the filename when opening a DDL file. This is useful for loading DDLs via browsing path searches.
- OpenWithBreakers
  - Added parameter OpenNormallyOpenDisconnects that will open any disconnect that is normally open but currently closed when searching for breakers
- Renumber3WXformerStarBuses
  - Added Delimiter parameter for specifying the file delimiter
- RenumberMSLineDummyBuses
  - Added Delimiter parameter for specifying the file delimiter
- ReassignIDs
  - Added parameter UseRight that will use the last two characters of the specified field that contains the new IDs
- SetCurrentDirectory
  - Filedirectory can now be specified using the special keywords staring with @, i.e. @BUILDDATE, @DATETIME, @DATE, @TIME, @VERSION, @CASENAME, and @MODELFIELD. The & format that allows specification of a Model Expression or model field can also be used.

© 2017 PowerWorld Corporation

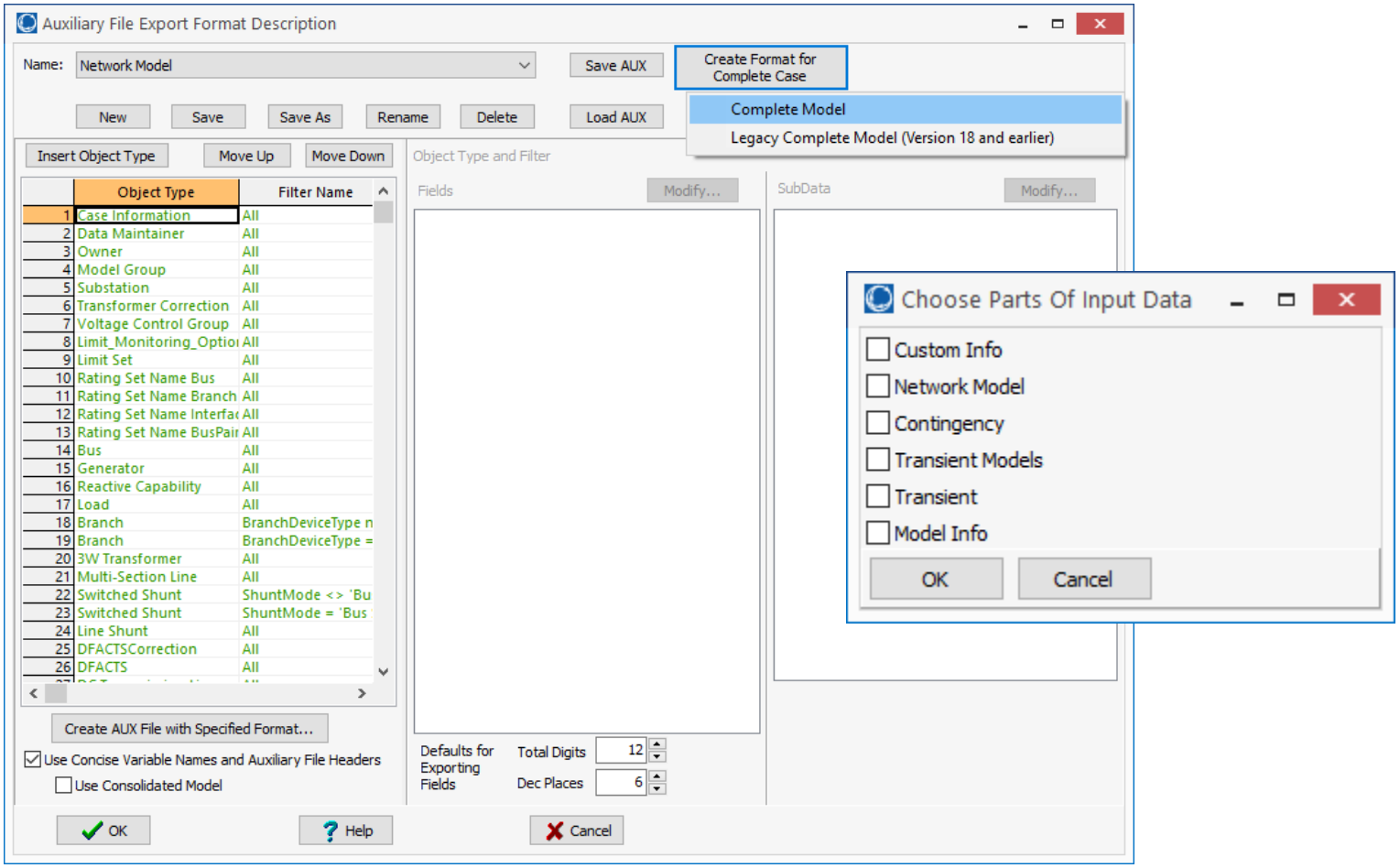
Script Command Modifications

- @MODELFIELD keyword
  - Can be used to insert the value of a model field as part of filenames and other text specified in script commands
  - `@MODELFIELD<objecttype 'key1' 'key2' 'key3' variablename:digits:rod>`

© 2017 PowerWorld Corporation

AUX Export Format Description

- Added more built-in definitions for creating auxiliary files for various tools



SimAuto

- Can optionally make Simulator visible while running SimAuto
- SimAuto property
  - UIVisible set to TRUE or FALSE
- Need to link to pwrworld 19.0 type library

© 2017 PowerWorld Corporation

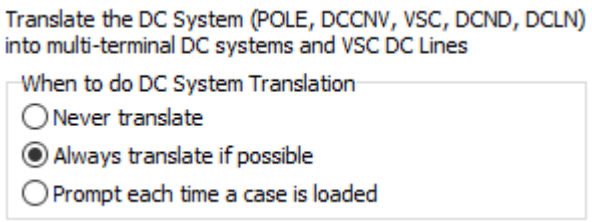
Case Information Displays

- Added support for filtering on DateTime fields

© 2017 PowerWorld Corporation

File Formats

- EPC file
  - Version 21
- RAW file
  - Working on version 34
- hdbexport CSV file
  - Use the option *Close Breakers to Energize Switched Shunts* by default when loading a file
  - DC system translation
  - RASMOM loading is now supported



- ABB Spider
  - Use the option *Close Breakers to Energize Switched Shunts* by default when loading a file

© 2017 PowerWorld Corporation

General

- 15 Negative interface limits
  - Integrated into Contingency Analysis, ATC, and OPF tools

© 2017 PowerWorld Corporation

Difference Flows Tool

- See separate presentation

© 2017 PowerWorld Corporation

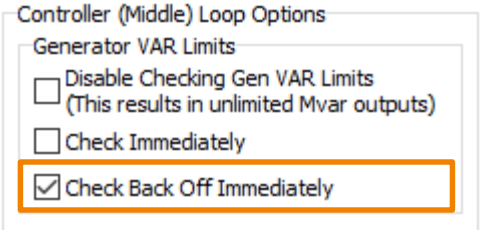
Difference Flows Tool
Change Case

- *Change Case* is new mode that shows only the fields that have changed

© 2017 PowerWorld Corporation

Power Flow Solution

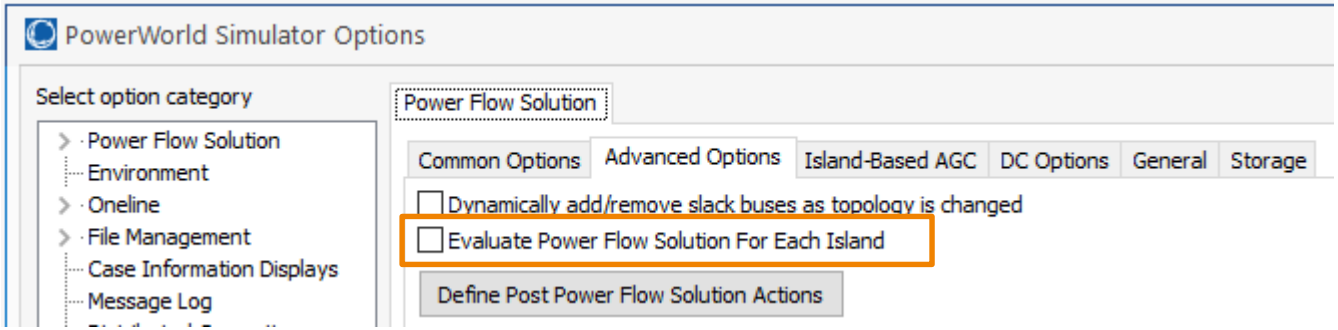
- *Check Back Off Immediately* option
  - Check done in inner power flow loop to determine if generators at Mvar limits can back off the limit
    - PQ type bus goes to PV type bus
  - No check is done for generators hitting limits
    - PV type bus goes to PQ type bus
  - Default in Version 20 is to check this option



© 2017 PowerWorld Corporation

Power Flow Solution

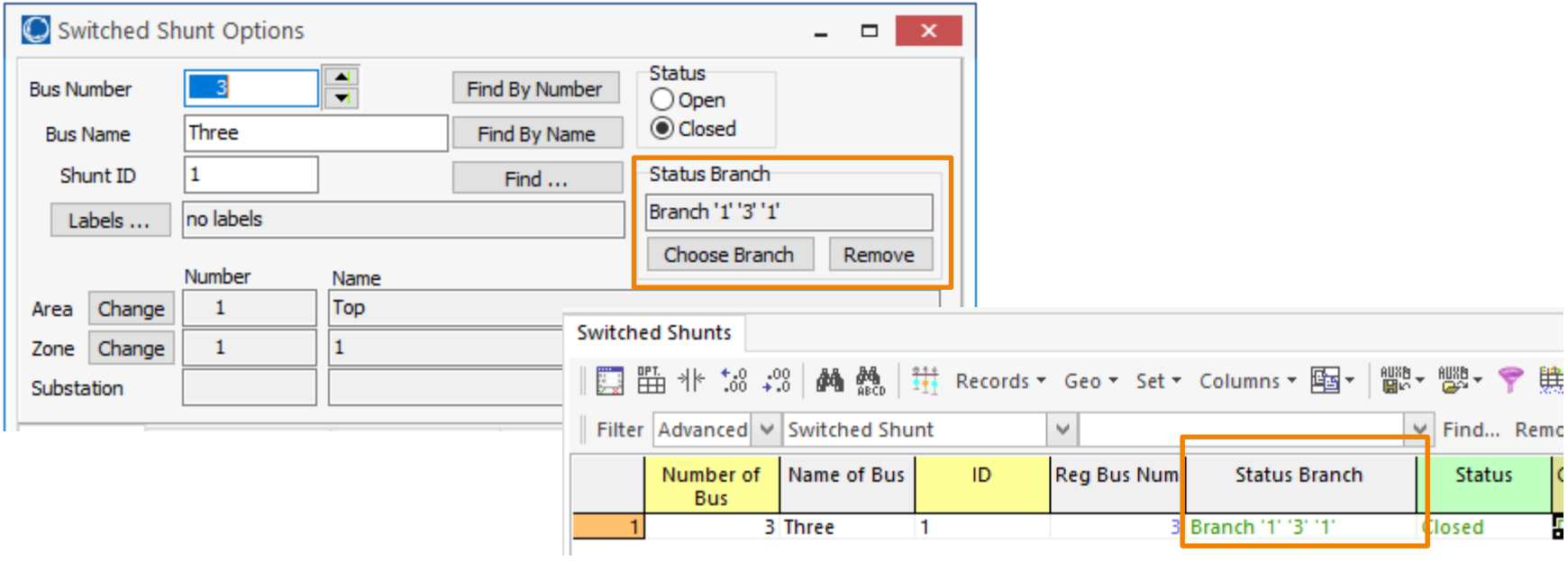
- *Evaluate Power Flow Solution for Each Island*
  - Solution for a particular island will be abandoned, but the solution for other islands will continue as long as at least one island converges
    - *Solved* field with Island objects will indicate which ones solved
  - Mismatch messages in the log will indicate the maximum mismatch for each island, as well as, the maximum mismatch across the entire case
  - When not using this option, the power flow will be reported as unsolved if any island does not converge



© 2017 PowerWorld Corporation

Switched Shunts
Status Branch

- *Status Branch* field for switched shunt
  - Defines a branch that will affect the status of a switched shunt
  - If the branch is open, the switched shunt will also be open
  - Allows line shunts to be modeled as switched shunts with automatic controls



SVCs

- SVCs can now control any switched shunt except other SVCs
  - When SVC is in service it will control the controlled shunt and controlled shunt will act as if it is fixed
  - When SVC is out of service, switched shunt being controlled will obey its own Control Mode

© 2017 PowerWorld Corporation

Bus Pairs

- New object to monitor differences between angles at two different buses
- Uniquely identified by Name
- Specify up to 4 angle limits
- Limit Monitoring Settings options used for identifying violations on the angle difference
  - Percentage, Normal Rating Set, and Contingency Rating Set are specified
  - Each Bus Pair must be assigned to a Limit Group
  - Area and Zone Reporting options are ignored for bus pairs
- Contingency violation: *Bus Pair Angle*

© 2017 PowerWorld Corporation

Limit Monitoring

- *Only show the primary bus for each superbus*
  - Also applies to the contingency analysis option *When using Integrated Topology Processing, monitor only the primary bus for each superbus*
  - Will now monitor the primary bus for each superbus, bus with the highest low voltage limit, and bus with the lowest high voltage limit so as not to miss any possible violations
- Option *Do not monitor radial lines and buses* is ignored if using Topology Processing

© 2017 PowerWorld Corporation

Contingency Analysis General

- Contingency records have highlighting based on results
  - If *Processed* = YES then colors indicate the following values of the *Solved* field
    - YES – normal fill color
    - NO – light red
    - ABORTED – light orange
    - RESERVE LIMITS – light yellow
    - PARTIAL – light yellow

© 2017 PowerWorld Corporation

Contingency Analysis General

- When choosing to either Save Case or Save Case As, a check is now done to help ensure that a user does not save a post-contingency system state accidentally
  - If all conditions are met, a dialog will appear asking the user to confirm that they want to save the case
  - The check evaluates the following three conditions
    - Contingency Analysis dialog is open
    - Contingency Reference State exists
    - At least one system device status in the present system is different than the status in the Contingency Reference State

© 2017 PowerWorld Corporation

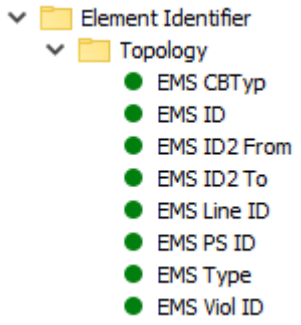
Contingency Analysis Violations

- New violation Category of *Unsolved* indicates if the contingency solution did not converge
  - Element will be *System*
- Added 7 new fields with LimitViol object type that give information about the violated end of the violated element
  - BusNumViolEnd, BusNameViolEnd, NomkVViolEnd, AreaNameViolEnd, BANameViolEnd, ZoneNameViolEnd, and SubNameViolEnd
  - These fields are then available in the ViolationCTG object as well
    - LV_BusNumViolEnd, LV_BusNameViolEnd, LV_NomkVViolEnd, LV_AreaNameViolEnd, LV_BANameViolEnd, LV_ZoneNameViolEnd, and LV_SubNameViolEnd

© 2017 PowerWorld Corporation

Contingency Analysis Violations

- Contingency records can be filtered by filters created for object type LimitViol. This is useful for finding contingencies that have violations of specific elements.
- Added ability for the LimitViol and ViolationCTG object types to return EMS identifying information



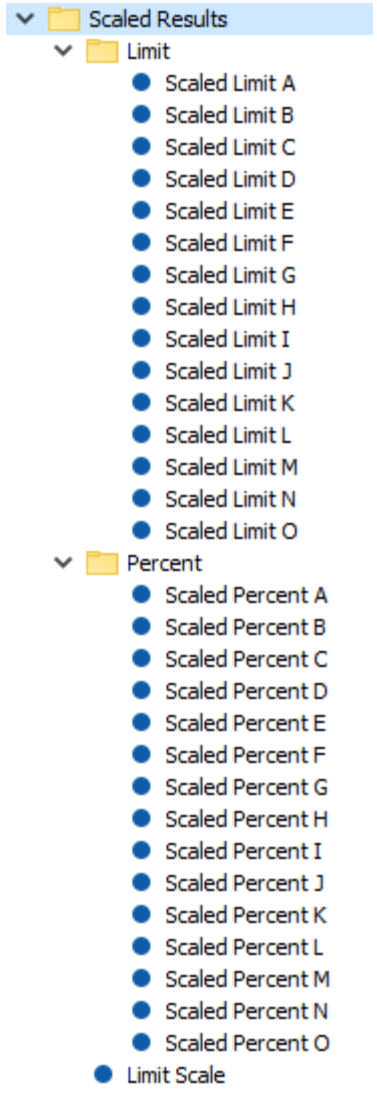
© 2017 PowerWorld Corporation

Contingency Analysis Violations

- Percent field for a voltage violation will now show a value that is based on the voltage limit
  - Value = 0.90 with Limit = 0.95 will show Percent = (0.90/0.95)*100 = 94.74.
- New *Source List* field with LimitViol object type that is used to indicate the origin of the violation when comparing two lists of results
  - Options are *Both*, *Comparison*, or *Controlling*
- Added fields to LimitViol and ViolationCTG object types for showing Reference State fields in the Comparison Case

© 2017 PowerWorld Corporation

Contingency Analysis Violations



- Scaled Results
  - *Limit Scale*
    - Value is stored when violation is recorded to maintain what respective device limit was used to calculate the stored limit
    - Used with the Scaled Limit A…Scaled Limit O and Scaled Percent A…Scaled Percent O terms to show what the limit would have been using the present device limits
    - Allows storing the limit violations against the most restrictive rating set and still show what the percentage would be against all limit sets
  - *Scaled Limit x*
    - (*Limit*/*LimitScale*)**PresentDeviceLimitx*
  - *Scaled Percent x*
    - *Percent*LimitScale/PresentDeviceLimitx*

© 2017 PowerWorld Corporation

Contingency Analysis Fields New and Changed

- *Solved*
  - PARTIAL is now an option if only some of the islands have solved
- *Include Remedial Actions*
  - Specifies whether or not a given contingency should also include Remedial Actions
- *Screen Allow*
  - Specifies if the contingency should be screened or just always run the full solution
- *Calculation Method*
  - Unknown, AC, FullDC, DC, DCPS, ScreenDC, ScreenDCPS, IteratedDC, IteratedDCPS, IteratedScreenDC, IteratedScreenDCPS
    - *Unknown* means that no solution has been attempted
    - *AC* means that the full solution method was used while in ac power flow mode
    - *FullDC* means that the full solution method was used while in dc power flow mode
    - *DC* means the linear method without enforcing phase shifters was used
    - *DCPS* means that the linear method enforcing phase shifters was used
    - *Screen* indicates the solution was achieved by screening process only
    - *Iterated* indicates that the Iterate on Action Status option was used with one of the linear methods
- *Screening Rank for Branches, Buses, BusPairs,* and *Interfaces*
  - Shows the ranking for each contingency for each of the screening categories

© 2017 PowerWorld Corporation

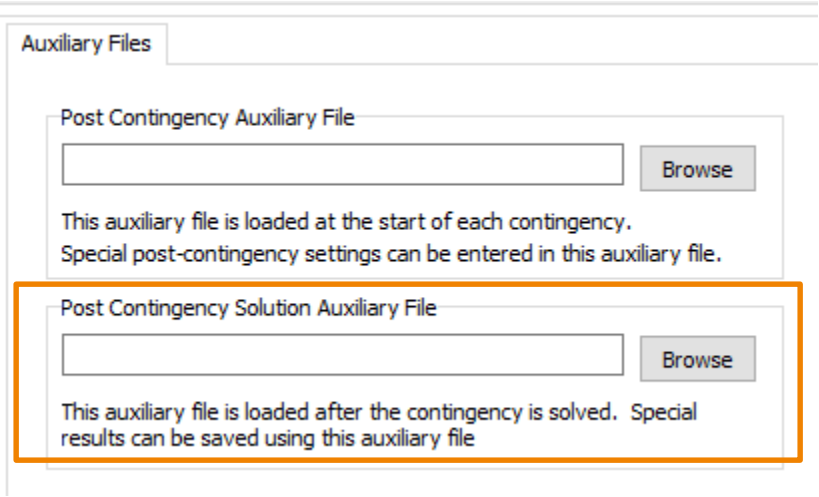
Contingency Analysis Fields New and Changed

- *Substation Names* and *Substation Numbers*
  - Lists all of the substations represented by all contingency elements
- *Voltage Reduced Load MW*
  - Amount that the total MW load has been reduced due to the options for Minimum Voltage for Constant Power and Constant Current Load
- *Bus Pair Angle Violations*
  - Number of bus pair angle violations
- *Max Bus Pair Angle*
  - Value of the maximum bus pair angle violation
- Comparison fields for bus pair angle violations

© 2017 PowerWorld Corporation

Contingency Analysis
New Options

- Post Contingency Solution Auxiliary File
  - Loaded after the contingency is solved
  - Previously existing *Post Contingency Auxiliary File* is loaded before the contingency is implemented and solved



© 2017 PowerWorld Corporation

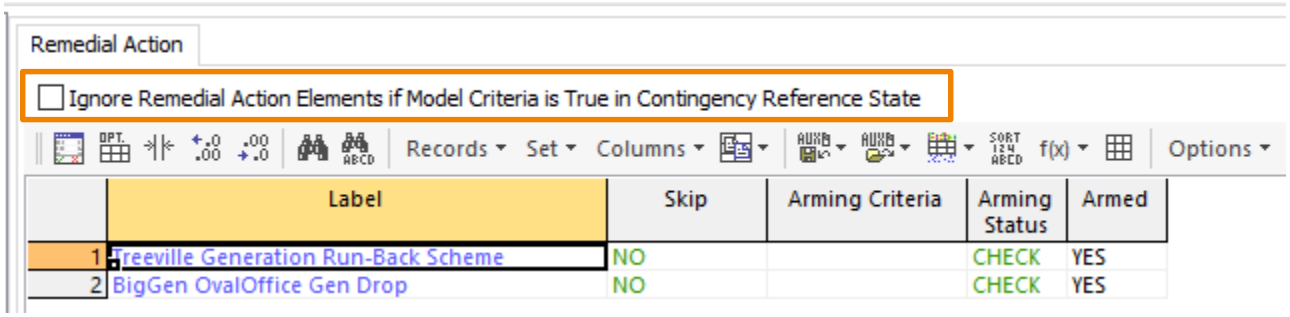
Active Contingency Object

- New object type ContingencyActive to access all fields associated with a Contingency record for the currently active contingency
  - Useful with the new Post Contingency Solution Auxiliary File for saving results and identifying the correct contingency
- CTG_Options object type *Active Contingency* field provides the name of the active contingency
  - This can be added to a oneline using the Case Information Memo Field object with the *Contingency Analysis Active Contingency Name* field

© 2017 PowerWorld Corporation

Contingency Analysis
New Options

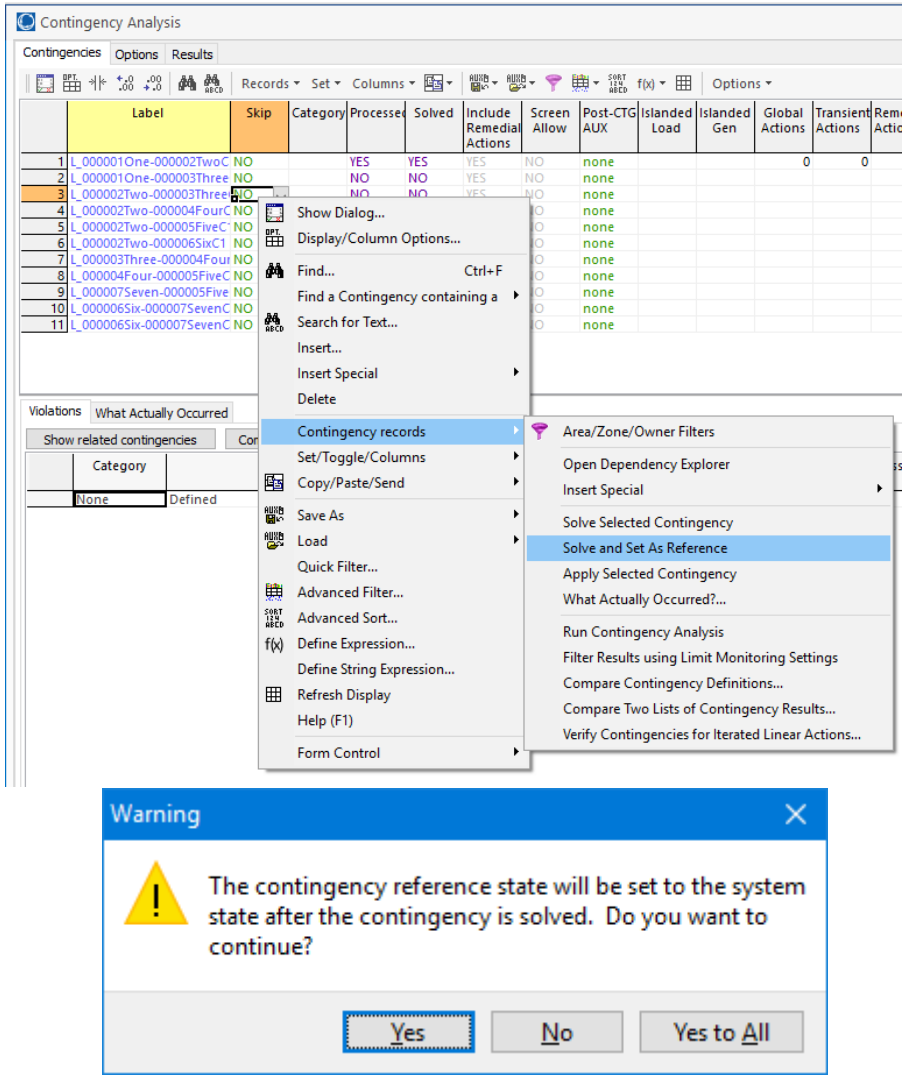
- *Ignore Remedial Action Elements if Model Criteria is True in Contingency Reference State*
  - Individual elements of a Remedial Action are ignored of their Model Criteria evaluates to true in the reference state
  - Other elements of a Remedial Action will still be implemented
  - When loading an Areva contingency file this is set based on the SCNBCRAS field in the ITEMS record



© 2017 PowerWorld Corporation

Solve and Set As Reference Warning Message

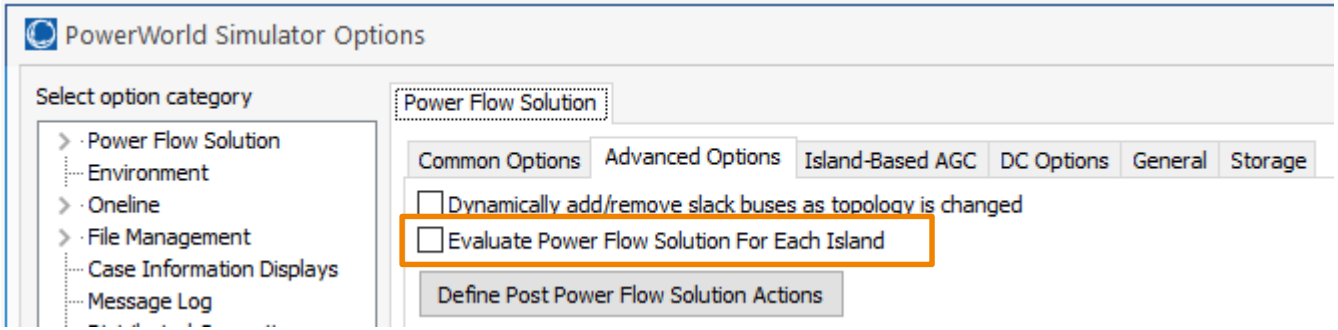
- Warning message will now appear when selecting *Solve and Set As Reference*
- *YES* – contingency will be solved and that state will be set as the reference state
- *NO* – contingency will not be solved and the references state will not change
- *Yes to All* – contingency will be solved and that state will be set as reference state. This will be done for all subsequent calls of this option and no more prompting will occur. Prompting will appear again once contingency analysis dialog is closed and reopened.



© 2017 PowerWorld Corporation

Contingency Analysis Handling Islands

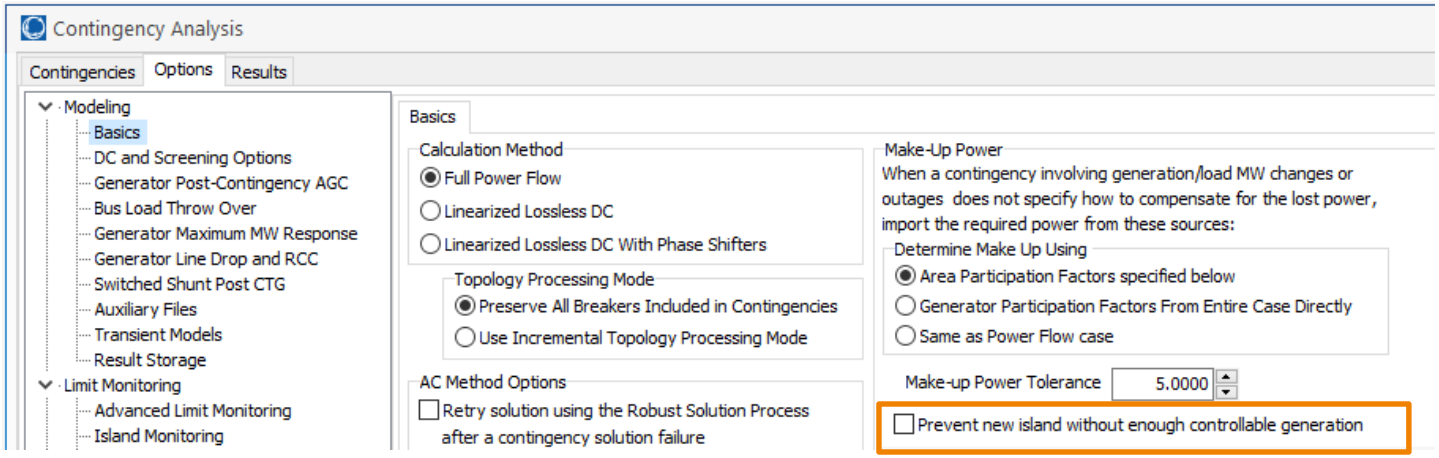
- Power flow solution option *Evaluate Power Flow Solution for Each Island* will prevent a failed contingency solution if at least one island solves
  - Solved field for Contingency can be PARTIAL to indicate multiple islands in the solution with only some solving



© 2017 PowerWorld Corporation

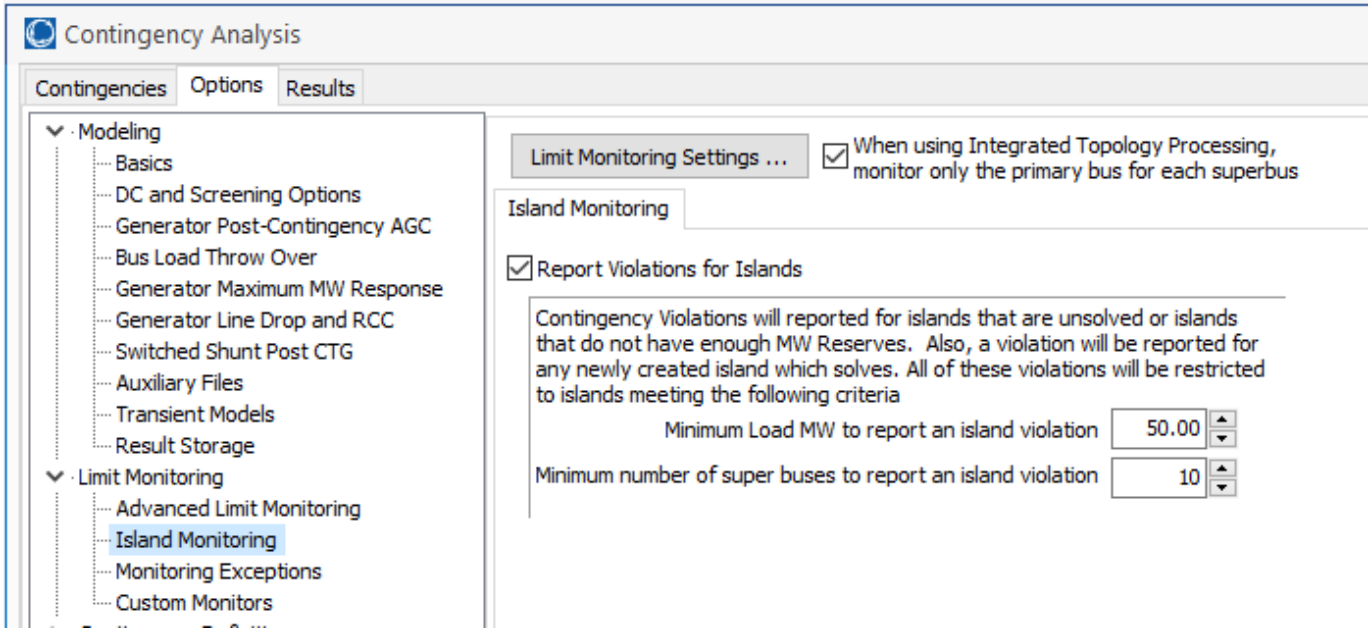
Contingency Analysis Handling Islands

- *Prevent new island without enough controllable generation*
  - During contingency solution that creates new islands, new islands will not be considered viable, i.e. even attempted as part of the solution, if they do not have enough controllable (Online = YES and AGC = YES) generation to meet the load and losses in the island
  - This check is only done on islands in which the load estimate is less than 50% of the total load in an attempt to only do this for small islands and not the largest island in the case



© 2017 PowerWorld Corporation

Contingency Analysis
Island Monitoring



- *Report Violations for Islands*
  - Check this to include island violations with the results
  - This only affects the reporting of island violations and does not impact if an island is created or not

© 2017 PowerWorld Corporation

Contingency Analysis
Report Violations for Islands

- Island violations can be restricted to only report if the island is “large enough”
  - *Minimum Load MW to report an island violation*
    - Specify the MW amount of load that must exist in the island
    - Determined after the solution for islands for which a solution was determined or during the island check for islands that are not viable because of the *Prevent new island without enough controllable generation* option
  - *Minimum number of super buses to report an island violation*
    - For systems that are not using Integrated Topology Processing, the number of buses is used instead

© 2017 PowerWorld Corporation

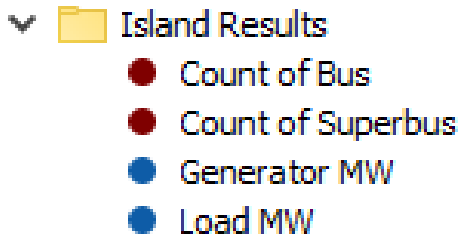
Contingency
Island Violation Categories

- Island violations are reported only if there is at least one island that solves in the case
  - Violation with Category = *Unsolved* for Element = *System* will result instead
- The Category field for violations now has the following options for reporting island violations
  - Island Unsolved
    - An unsolved island was found during the solution
    - This could result from an existing island or a new island created during the contingency
  - Island Reserve Limits
    - An island was found that did not have enough make-up generation
    - This could result from an existing island or a new island created during the contingency
  - Island Solved
    - This will result only for an island that was created during the contingency

© 2017 PowerWorld Corporation

Contingency
Island Violations Fields

- Islands are identified by the island slack bus as the violation Element
- Special fields are available for island violations



  - These will be blank for other types of violations
- View Results by Element
  - Island violations will appear with Bus violations

© 2017 PowerWorld Corporation

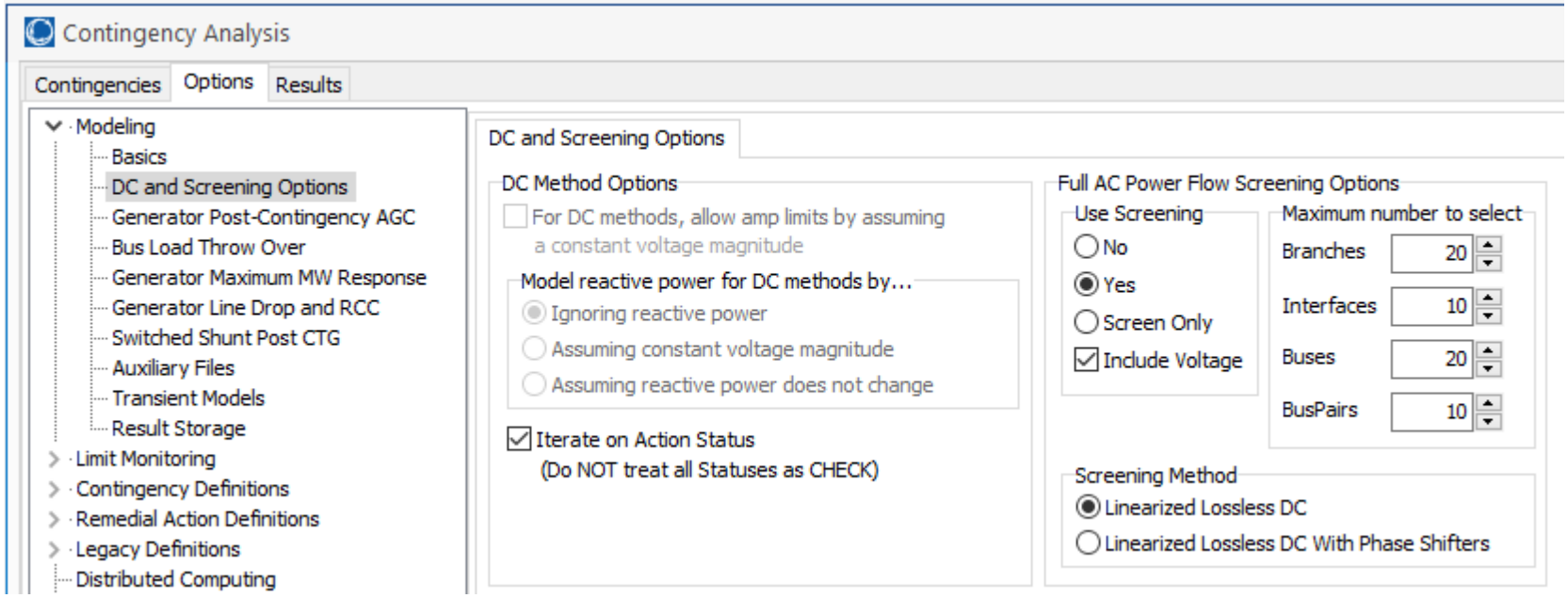
Contingency Screening

- Process uses linear contingency analysis to screen contingencies prior to running full ac analysis on contingencies that pass the screening
- Attempts to speed up the process by only running full ac analysis on a subset of contingencies

© 2017 PowerWorld Corporation

Contingency Screening

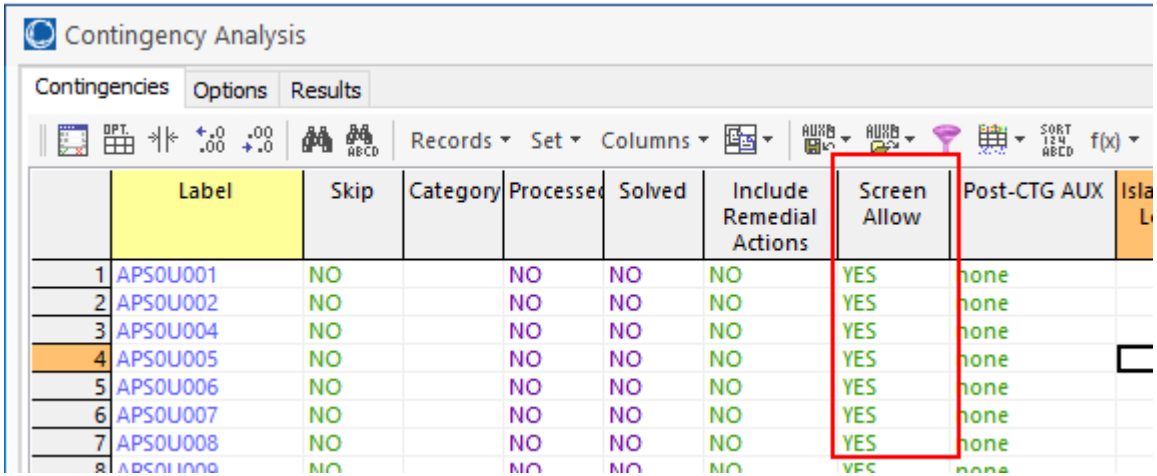
- *DC and Screening Options* page on Contingency Analysis dialog provides options for using screening



© 2017 PowerWorld Corporation

Contingency Screening

- *Screen Allow* field must be set to YES for any contingency that should be screened
  - If set to NO, full ac analysis will be done on that contingency



	Label	Skip	Category	Processed	Solved	Include Remedial Actions	Screen Allow	Post-CTG AUX	Isla L
1	APS0U001	NO		NO	NO	NO	YES	none	
2	APS0U002	NO		NO	NO	NO	YES	none	
3	APS0U004	NO		NO	NO	NO	YES	none	
4	APS0U005	NO		NO	NO	NO	YES	none	
5	APS0U006	NO		NO	NO	NO	YES	none	
6	APS0U007	NO		NO	NO	NO	YES	none	
7	APS0U008	NO		NO	NO	NO	YES	none	
8	APS0U009	NO		NO	NO	NO	YES	none	

© 2017 PowerWorld Corporation

Iterated Linear Contingency Analysis

- Attempts to model remedial actions using linear sensitivity calculations
  - No actual system changes are made
  - Linear sensitivities are used to determine the impact of conditional actions
  - At each iteration all actions that were implemented at prior steps in addition to any new actions that meet conditions at current step will be "implemented"

© 2017 PowerWorld Corporation

Iterated Linear Contingency Analysi

- Linear impact of line flows and MW injection changes can be modeled
  - No voltage changes are modeled
- *Verify Contingencies for Iterated Linear Actions*
  - Checks conditional actions to determine if monitored fields are handled or not
  - Because no actual system changes are made, Simulator needs to know which values need to be calculated linearly

© 2017 PowerWorld Corporation

Validate Contingencies for Iterated Linear Actions

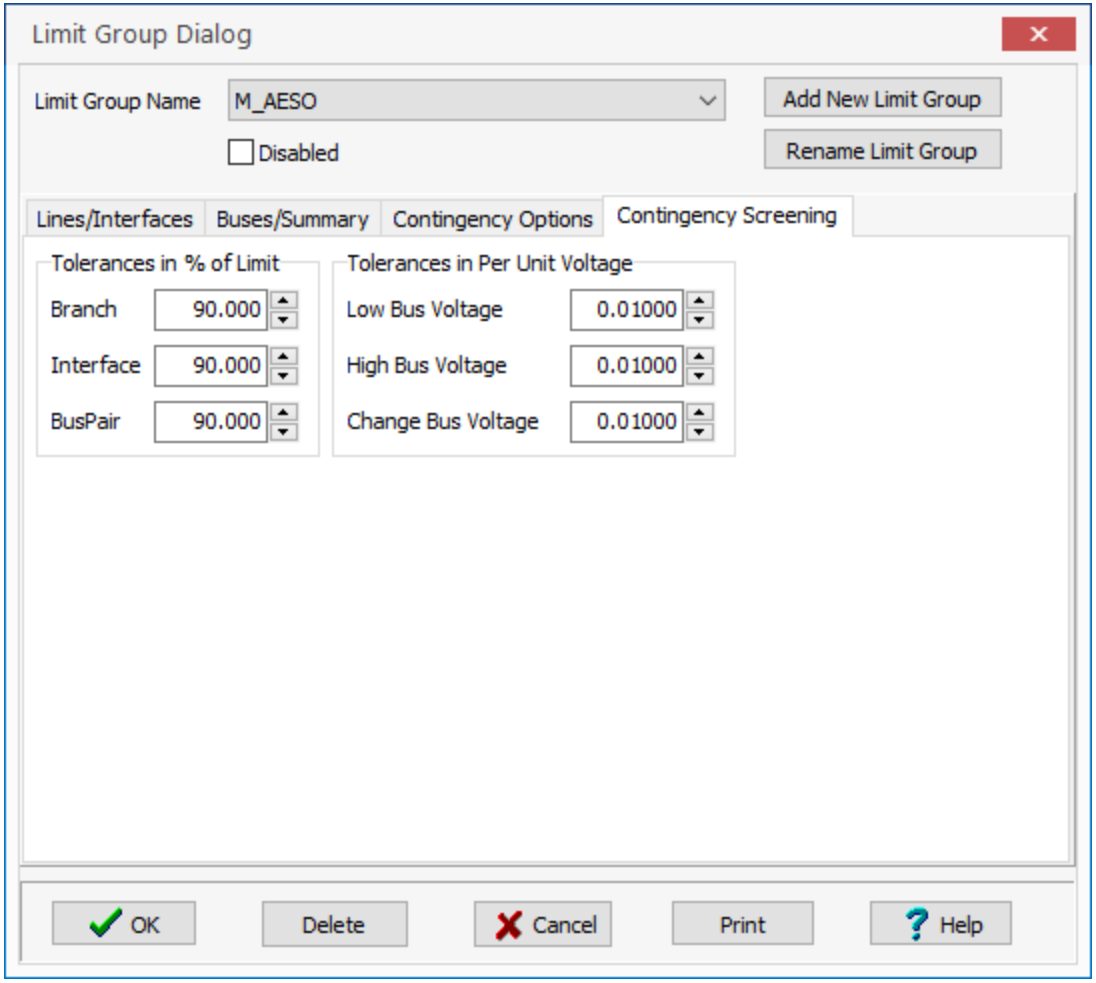
```
------------------
Valid Fields Found
------------------
Branch,MWFrom,"MW\MW at From Bus"
ModelExpression,Result,Result
Branch,DerivedOnline,"Derived Online"
Branch,PercentMVACFrom,"Limit Monitoring\MVA Limits\% of MVA Limit C at From Bus"
Branch,PercentMVABTo,"Limit Monitoring\MVA Limits\% of MVA Limit B at To Bus"
Branch,MVAFrom,"MVA\MVA at From Bus"
Branch,PercentMVACTo,"Limit Monitoring\MVA Limits\% of MVA Limit C at To Bus"
Interface,MW,"MW\MW Flow"
MTDCConverter,Online,Online
Branch,PercentMVAAFrom,"Limit Monitoring\MVA Limits\% of MVA Limit A at From Bus"
Branch,MWFromIntoBus,"MW\MW at From Bus (Into Bus)"
Branch,PercentMVABFrom,"Limit Monitoring\MVA Limits\% of MVA Limit B at From Bus"
Branch,Status,Status
Branch,PercentMVAATo,"Limit Monitoring\MVA Limits\% of MVA Limit A at To Bus"
Branch,MWToIntoBus,"MW\MW at To Bus (Into Bus)"
Branch,MWTo,"MW\MW at To Bus"
Branch,MVATo,"MVA\MVA at To Bus"

--------------------
InValid Fields Found
--------------------
Gen,Mvar,"Mvar Output\Mvar"
Bus,kV,"Voltage\kV Actual"
```

© 2017 PowerWorld Corporation

Screening
Limit Monitoring Settings

- Specify tolerances with Limit Groups to determine how limits for screening should be treated



© 2017 PowerWorld Corporation

Screen Ranking

- Branch Screening
  - A branch will be included in the ranking for branches if (MW > Limit*ScreenBranchPercent) and it is a monitored branch
  - Branch ranking is the sum of (Limit*ScreenBranchPercent – MW) for all branches meeting the ranking criteria
- Interface Screening
  - An interface will be included in the ranking for interfaces if (MW > Limit*ScreenInterfacePercent) and it is a monitored interface
  - Interface ranking is the sum of Abs(MW – Limit*ScreenInterfacePercent) for all interfaces meeting the ranking criteria

© 2017 PowerWorld Corporation

Screen Ranking

- Bus Pair Screening
  - A bus pair will be included in the ranking for bus pairs if (Abs(AngleDiff) > Limit*ScreenBusPairPercent) and it is a monitored bus pair
  - Bus pair ranking is the sum of (Abs(AngleDiff) – Limit*ScreenBusPairPercent) for all bus pairs meeting the ranking criteria
- Bus Voltage
  - ScreenLowLim = LowLimit + ScreenTolLowVolt
  - ScreenHighLim = HighLimit – ScreenTolHighVolt
  - If (Volt > ScreenHighLim) then Rank = Volt – ScreenHighLim

    Else if (Volt < ScreenLowLim) then Rank = ScreenLowLim – Volt

    Rank is calculated for all buses that are monitored
  - Bus ranking is the sum of Rank for all buses meeting the ranking criteria
  - Voltage change can also contribute to the ranking if the options *Always report as a violation if the …* are in use

© 2017 PowerWorld Corporation

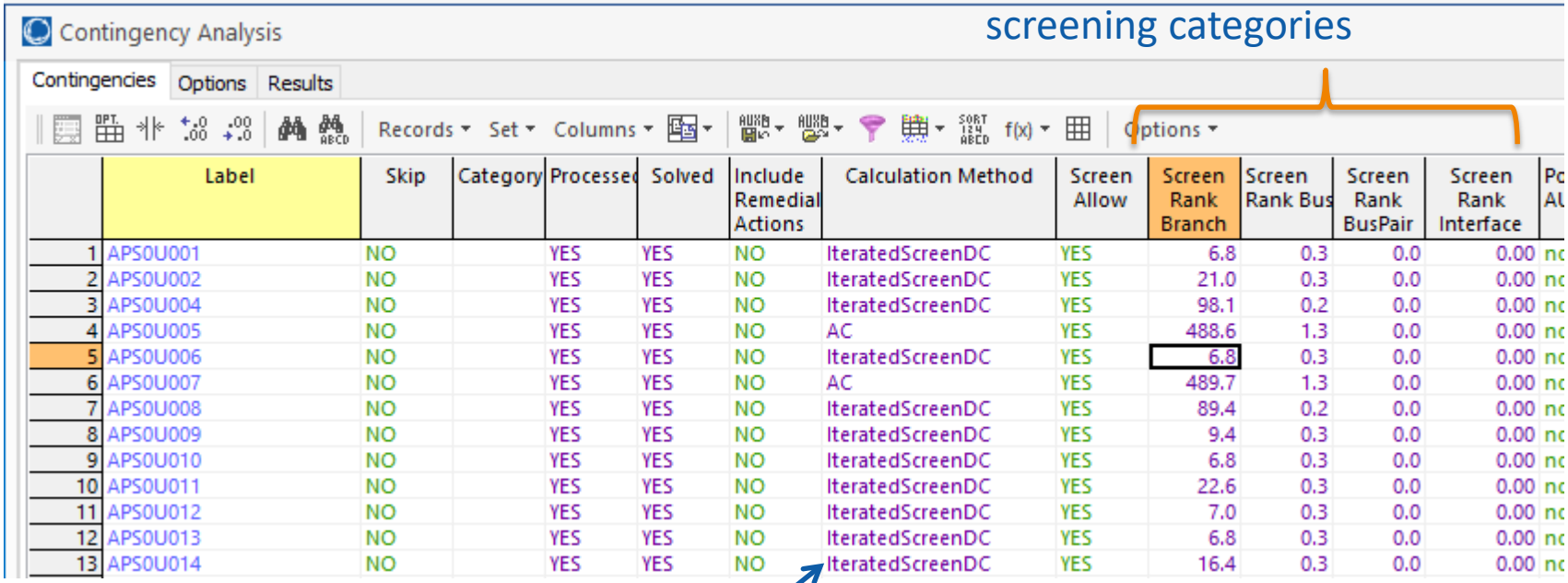
Voltage Screening

- *Include Voltage* option must be checked for voltage screening to occur
  - This is a time consuming process that is not done linearly
  - Linear contingency process determines which actions should be implemented
  - Actions are actually implemented and 2 power flow iterations are done

© 2017 PowerWorld Corporation

Screening Results

Ranking by each of the different screening categories



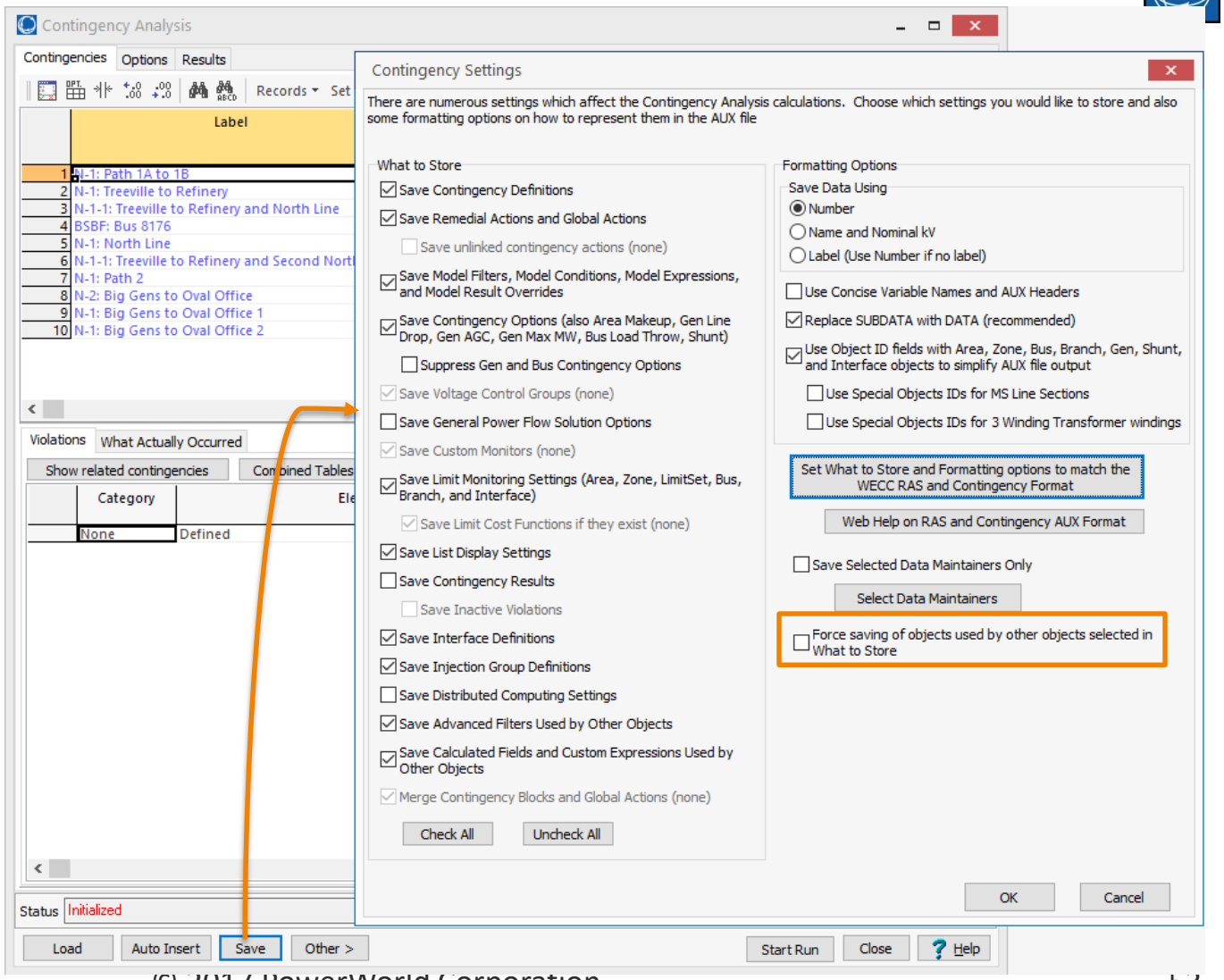
	Label	Skip	Category	Processed	Solved	Include Remedial Actions	Calculation Method	Screen Allow	Screen Rank Branch	Screen Rank Bus	Screen Rank BusPair	Screen Rank Interface	Po Al
1	APS0U001	NO		YES	YES	NO	IteratedScreenDC	YES	6.8	0.3	0.0	0.00	no
2	APS0U002	NO		YES	YES	NO	IteratedScreenDC	YES	21.0	0.3	0.0	0.00	no
3	APS0U004	NO		YES	YES	NO	IteratedScreenDC	YES	98.1	0.2	0.0	0.00	no
4	APS0U005	NO		YES	YES	NO	AC	YES	488.6	1.3	0.0	0.00	no
5	APS0U006	NO		YES	YES	NO	IteratedScreenDC	YES	6.8	0.3	0.0	0.00	no
6	APS0U007	NO		YES	YES	NO	AC	YES	489.7	1.3	0.0	0.00	no
7	APS0U008	NO		YES	YES	NO	IteratedScreenDC	YES	89.4	0.2	0.0	0.00	no
8	APS0U009	NO		YES	YES	NO	IteratedScreenDC	YES	9.4	0.3	0.0	0.00	no
9	APS0U010	NO		YES	YES	NO	IteratedScreenDC	YES	6.8	0.3	0.0	0.00	no
10	APS0U011	NO		YES	YES	NO	IteratedScreenDC	YES	22.6	0.3	0.0	0.00	no
11	APS0U012	NO		YES	YES	NO	IteratedScreenDC	YES	7.0	0.3	0.0	0.00	no
12	APS0U013	NO		YES	YES	NO	IteratedScreenDC	YES	6.8	0.3	0.0	0.00	no
13	APS0U014	NO		YES	YES	NO	IteratedScreenDC	YES	16.4	0.3	0.0	0.00	no

Only contingencies with the top x specified ranking in each screening category will have the full AC method run. *Calculation Method* specifies how the violation results are calculated.

© 2017 PowerWorld Corporation

Saving Contingencies and Options Dependencies

- New option on contingency dialog for saving options that makes it much easier to save all of the objects required to define remedial action schemes and other conditional actions



© 2017 PowerWorld Corporation

Saving Contingencies and Options Dependencies

- *Force saving of objects used by other objects selected in What to Store*
- The top of the hierarchy is specified by *What to Store* objects
- Other objects that are required, i.e. dependencies, to define objects higher up the hierarchy will also be saved
- When also saving by selected data maintainers, the data maintainer condition will only be enforced for the objects specified in *What to Store* and dependencies will not have this enforced

© 2017 PowerWorld Corporation

Saving Contingencies and Options Dependencies

- Remedial Action case information display local menu options
  - *Save As Auxiliary File (all related info)…*
  - *Save As Auxiliary File (all related/only selected records)…*
  - Allows filtering on remedial actions other than data maintainer to select which ones should be saved
  - Format options are the same as those required by the WECC RAS format

© 2017 PowerWorld Corporation

Contingency Analysis
Auto Insert Options

- Combinations of buses can be used in creating automatically inserted contingencies
- Contingencies can be created based on
  - Bus Groupings
  - Line Shunts

© 2017 PowerWorld Corporation

Bus Groupings and Implicit Breakers

- *Implicit Breaker* field added to buses
  - User specified field to indicate where breakers exist when using a case without all actual breakers defined
  - If set to YES implies that there is a breaker between the bus and every object connected to the bus
- Auto inserting contingencies by Bus Groupings
  - Software will automatically detect groups of buses contained inside implicit and explicit breakers
  - Contingencies will be made from the boundary branches (either explicit breakers or lines) that connect one bus group to another bus group
- Working on a dialog *Breaker Isolated Groups* to show the bus groupings that exist throughout the case

© 2017 PowerWorld Corporation

Contingency Analysis
New Actions and Action Changes

- New actions
  - Injection Group BEST FIT OPEN
  - Interface MERIT ORDER OPEN
  - Interface BEST FIT OPEN
  - Interface MW EFFECT OPEN
  - Phase Shifter ANGLE SET TO and CHANGE BY
  - Substation MW/PERCENT SET TO and CHANGY BY

© 2017 PowerWorld Corporation

Remedial Actions
Arming Criteria

- Arming criteria can optionally be specified to determine if an entire Remedial Action should be ignored during the contingency
- Arming criteria is either a Model Filter or Model Condition that is evaluated during the contingency reference state
- New fields added to specify and indicate the arming
  - *Arming Criteria*
    - Specifies the Model Filter or Model Condition for the arming
  - *Arming Status*
    - CHECK means to evaluate the Arming Criteria or armed if no Arming Criteria specified
    - ALWAYS means always armed regardless of the Arming Criteria
    - NEVER means never armed regardless of the Arming Criteria
  - *Armed*
    - Read only field indicating if the remedial action is armed based on the Arming Criteria and Arming Status

© 2017 PowerWorld Corporation

Remedial Action Elements
Arming Criteria

- Arming criteria can optionally be specified to determine if a single Remedial Action Element should be ignored during the contingency
  - For a Remedial Action Element to be armed, it must be armed based on its own criteria as well as that of its Remedial Action
- Arming criteria is either a Model Filter or Model Condition that is evaluated during the contingency reference state
- New fields added to specify and indicate the arming
  - *Arming Criteria*
    - Specifies the Model Filter or Model Condition for the arming
  - *Arming Status*
    - CHECK means to evaluate the Arming Criteria or armed if no Arming Criteria specified (element might still not be armed if the Remedial Action is not armed)
    - ALWAYS means always armed regardless of the Arming Criteria (element might still not be armed if the Remedial Action is not armed)
    - NEVER means never armed regardless of the Arming Criteria
  - *Armed*
    - Read only field indicating if the remedial action element is armed based on its own Arming Criteria and Arming Status AND the Arming Criteria and Arming Status of its Remedial Action

© 2017 PowerWorld Corporation

Disable if True in Contingency Reference State

- Model Conditions already had this option
- Model Filters now have this option
  - Will be disabled if it evaluates to true and its *Disable if True in CTG Ref State* option is set to YES
  - Will also be disabled if all of the Model Conditions or Model Filters that are part of the Model Filter are disabled because they are all true in the reference state and are also using the *Disable if True in CTG Ref State* option

© 2017 PowerWorld Corporation

Model Result Override

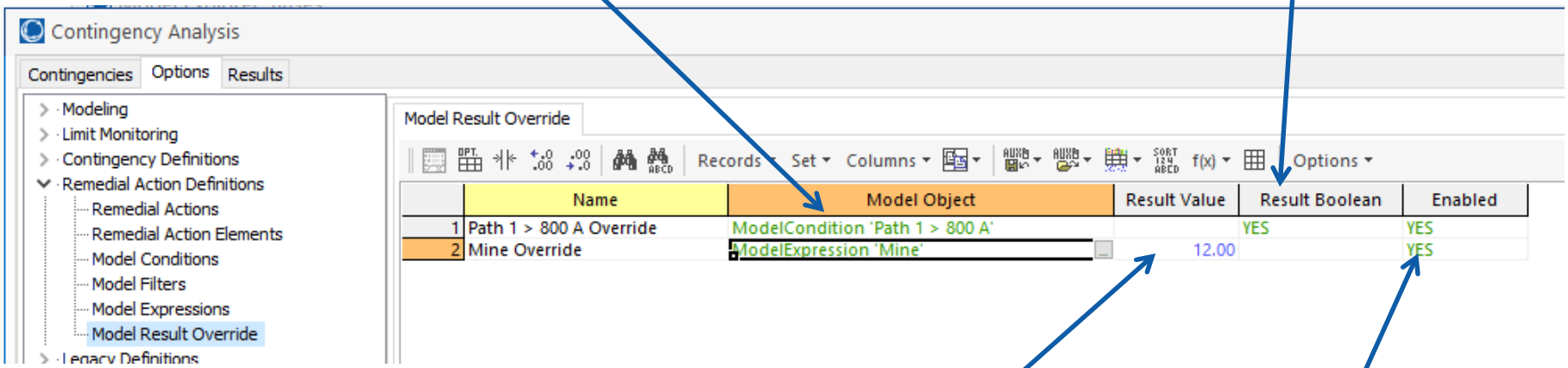
- New object that will override the result of a Model Condition, Model Filter, or Model Expression
  - All logic will be ignored and the value specified with the override will be the result of the filter, condition, or expression
  - Each Model Result Override can specify a numeric result and a boolean result, with the appropriate one being used based on the object type to which the override is assigned
  - Useful with EMS cases and measurements for RAS arming
- Model Conditions, Model Filters, and Model Expressions have an *Overridden* field that indicates if there is an enabled Model Result Override acting on it

© 2017 PowerWorld Corporation

Model Result Override

Model Condition, Model Filter, or Model Expression

Result Boolean used with Model Conditions and Model Filters

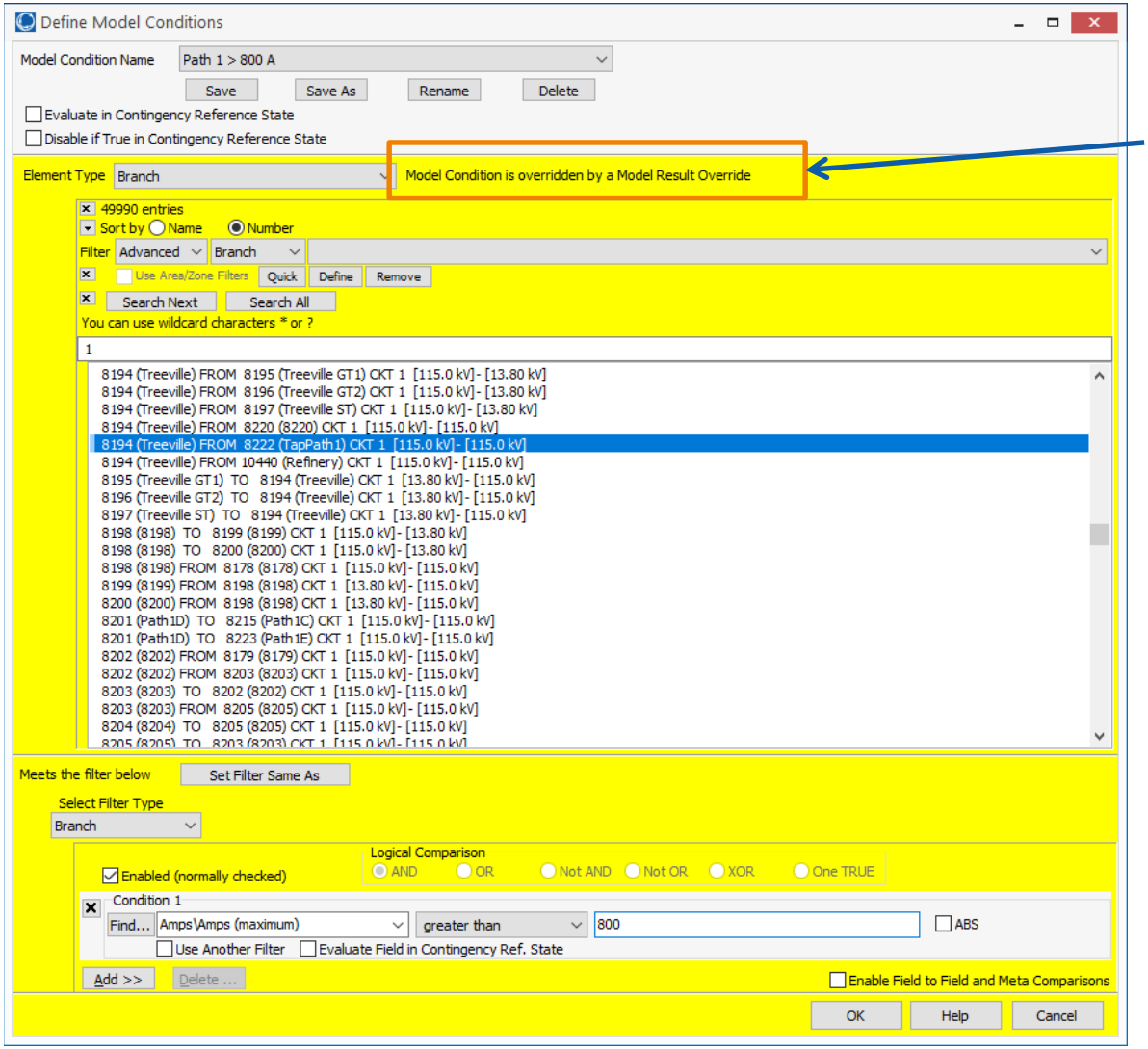


Result Value used with Model Expressions

Set *Enabled* = YES to override the *Model Object*. If not enabled, the logic specified with the *Model Object* will be used to determine its result.

© 2017 PowerWorld Corporation

Overridden Model Condition

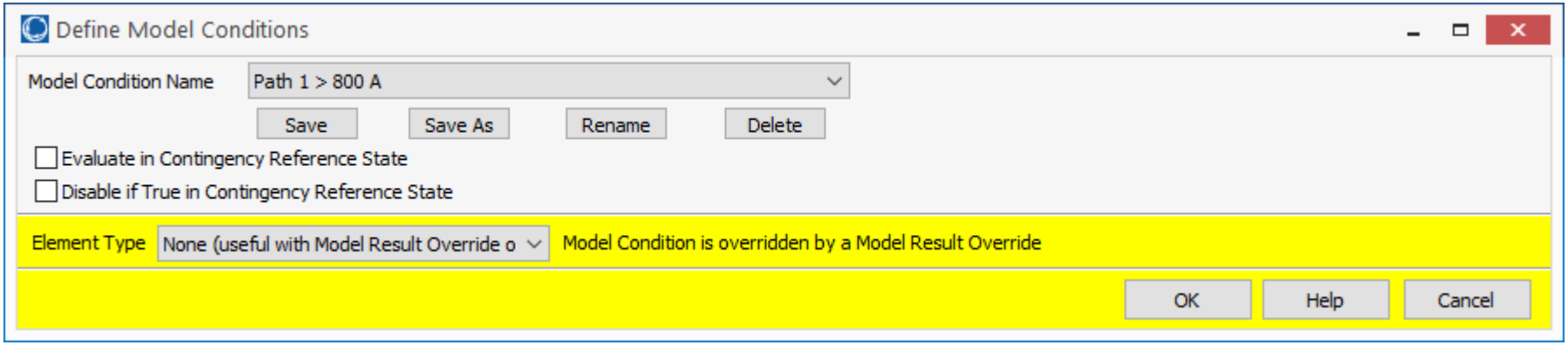


Bright yellow on dialogs and comment indicate that a Model Condition, Model Filter, or Model Expression is being overridden by an enabled Model Result Override

© 2017 PowerWorld Corporation

Overridden Model Condition

- Empty Model Conditions can be created to give access to a Model Result Override boolean result
- Empty Model Expressions can be created to give access to a Model Result Override numeric result



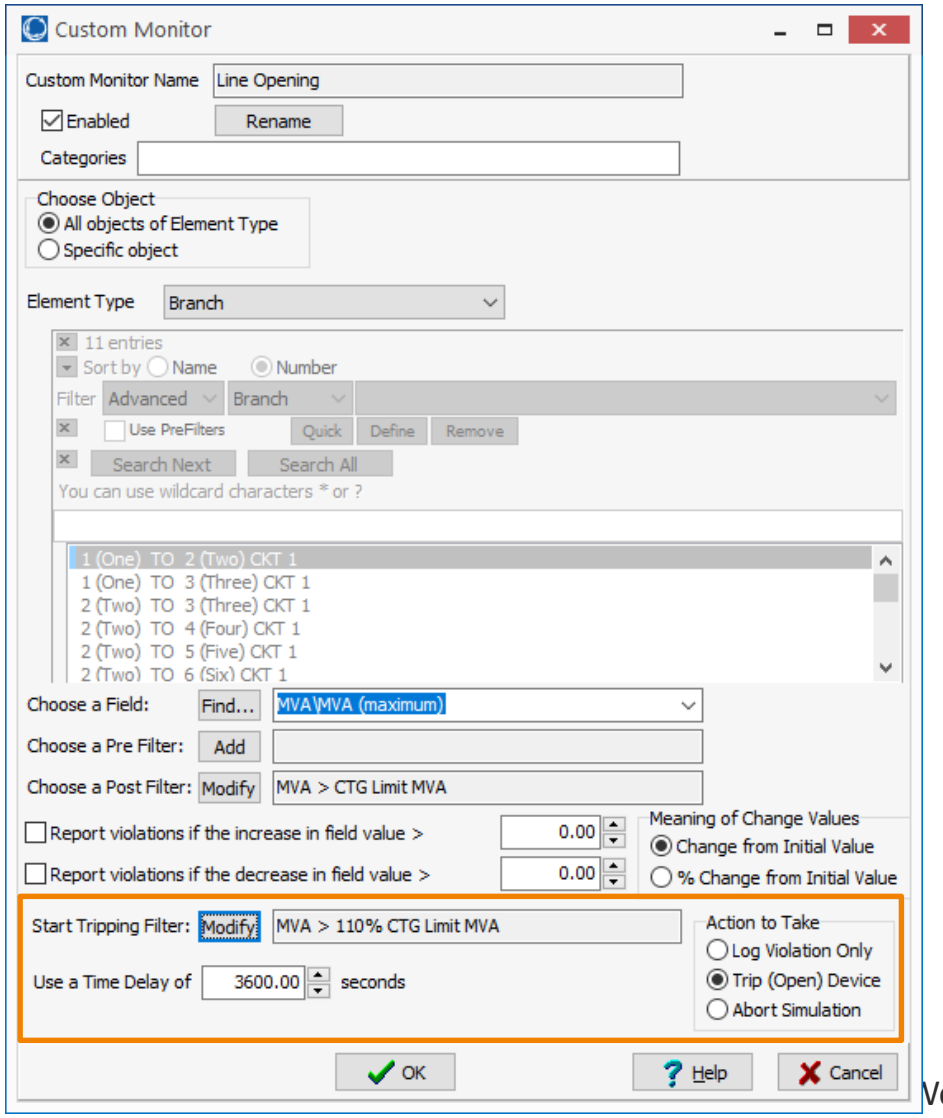
© 2017 PowerWorld Corporation

What Actually Occurred

- Actions using Open with Breakers will now report how much MW or MVA was opened on the element being isolated by breakers instead of just showing the flow on the breakers

© 2017 PowerWorld Corporation

Custom Monitors



- New options for tripping a device or aborting the entire simulation
- Existing functionality for Custom Monitors is the same if using *Log Violation Only*
- *Pre Filter* must be met for *Trip* or *Abort* action to be implemented
- *Start Tripping Filter*
  - Filter that is checked until at least one device has tripped for this Custom Monitor
  - Once a tripping action occurs, *Post Filter* is used for all subsequent checks
- *Time Delay* is used in comparison to the time delays for other contingency actions and Custom Monitors to determine if a device should trip

Processing Order of Contingency

1. Apply ALWAYS actions, true CHECK actions, and unconditional actions (actions with no Model Criteria except for SOLUTIONFAIL actions
2. Update topology (branch, bus status)
3. Apply true TOPOLOGYCHECK actions
4. Store reference state for use if solution failure occurs and SOLUTIONFAIL actions exist
5. Solve power flow
   a) If the power flow solution fails and SOLUTIONFAIL actions are available, the reference state in step 4 is restored and any true SOLUTIONFAIL actions with the smallest Time Delay are then applied
   b) If any SOLUTIONFAIL actions are applied, the process will go back to step 4 and repeat (This loop will abort after 100 solution failures)
6. Apply true POSTCHECK actions and true TOPOLOGYCHECK actions
   a) TRANSIENT actions will also be evaluated
   b) CUSTOMMONITORs with Trip action will be evaluated
   c) TRANSIENT, CUSTOMMONITOR, POSTCHECK, or TOPOLOGYCHECK actions with smallest Time Delay will be applied
7. If any POSTCHECK, TOPOLOGYCHECK, or TRANSIENT actions are implemented then repeat steps 2-6 (This loop will abort after 100 iterations)

© 2017 PowerWorld Corporation

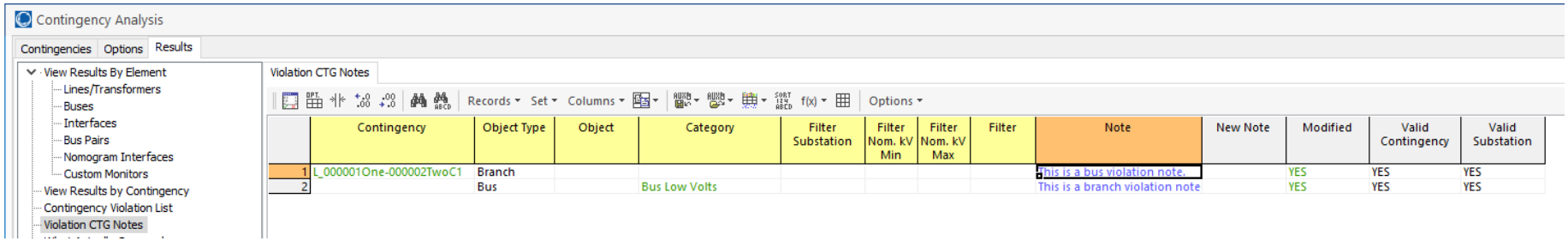
Violation CTG Note

- Contingency violations are not persistent objects
  - Once you rerun contingency analysis they are destroyed even if you end up with the same violations
- Any comments that would be associated directly with a violation would be lost
- Object that can persist is needed to store notes for violations

© 2017 PowerWorld Corporation

Violation CTG Notes

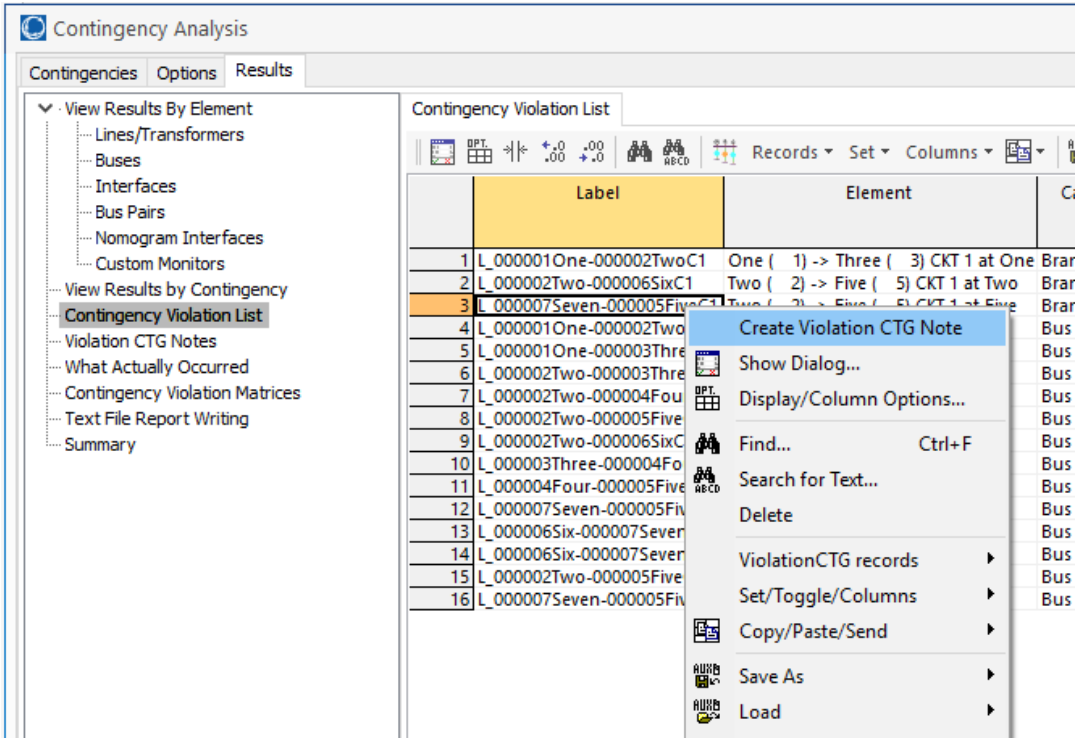
- Create from the Results tab of the Contingency Analysis dialog



© 2017 PowerWorld Corporation

Violation CTG Note

- Can also be created from Contingency Violation List table with local menu option *Create Violation CTG Note*
  - This is more convenient because it fills in parameters based on the current violation



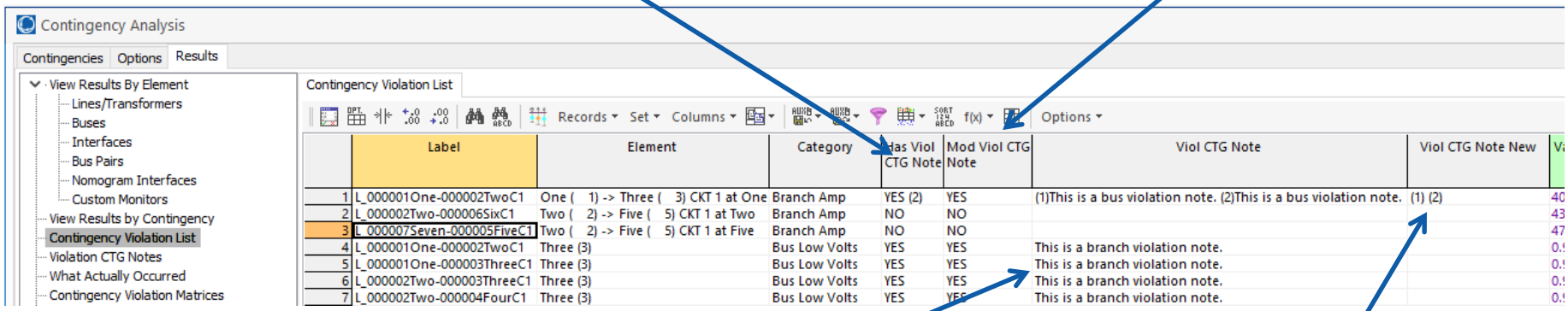
© 2017 PowerWorld Corporation

Violation CTG Note

Fields can be added to violation tables to show the notes

Indicates if the violation has any notes, and if it does how many

Indicates if a note associated with the violation has been modified



Actual *Note* associated with this violation. If more than one is applicable all will be displayed.

Actual *New Note* associated with this violation. If more than one is applicable all will be displayed.

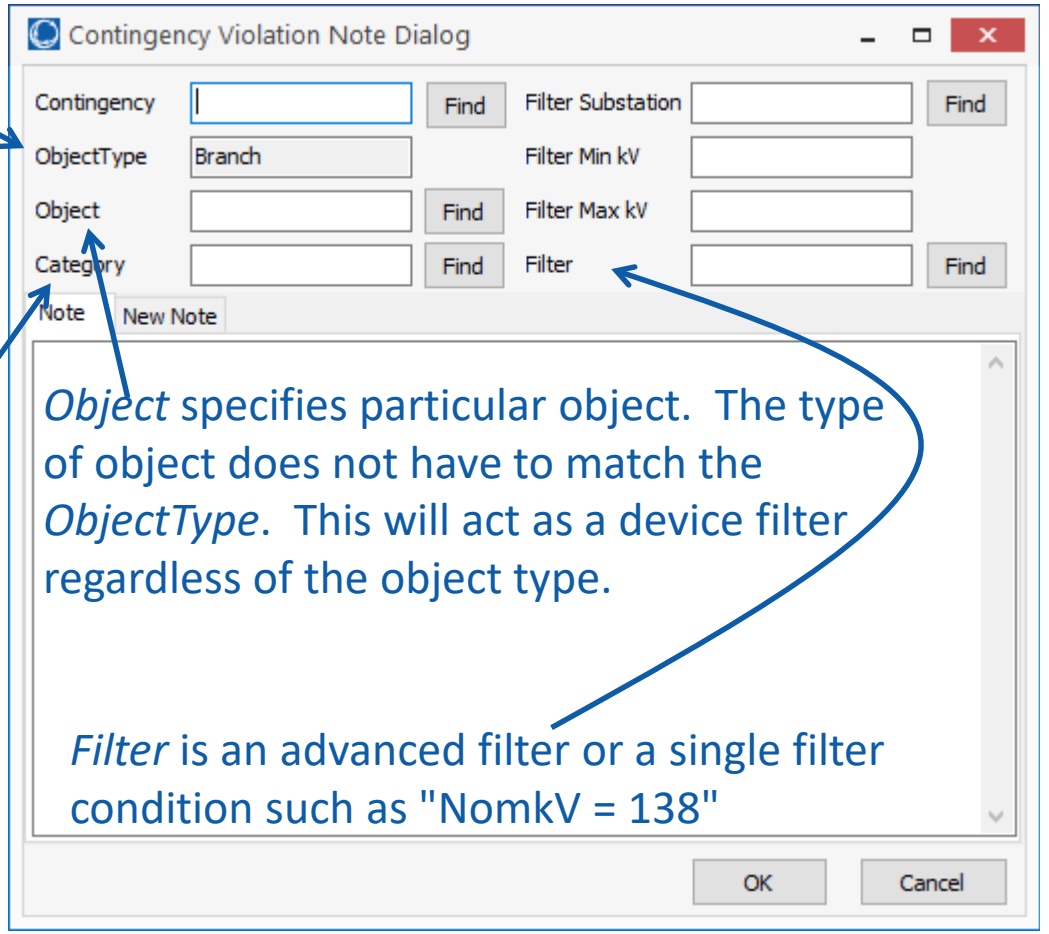
© 2017 PowerWorld Corporation

Violation CTG Note

At a minimum, *ObjectType* must be specified. The *Element* of the violation must be this object type for the note to be applicable.

For a note to be applicable to a particular violation, the violation must match all of the identifying information within the Violation CTG Note. If the identifying information is left blank, a note is applicable to all violations of the specified *ObjectType*.

Category is the type of violation



© 2017 PowerWorld Corporation

Violation CTG Note

- New Note
  - This can act as an extra note or it can be used to update the Note field by using the Append, Prepend, and Replace buttons on the Contingency Violation Note Dialog
- *Modified* field
  - This is a user enterable field
  - Simulator will change this to YES any time that the Note has been modified

© 2017 PowerWorld Corporation

Contingency Result Storage

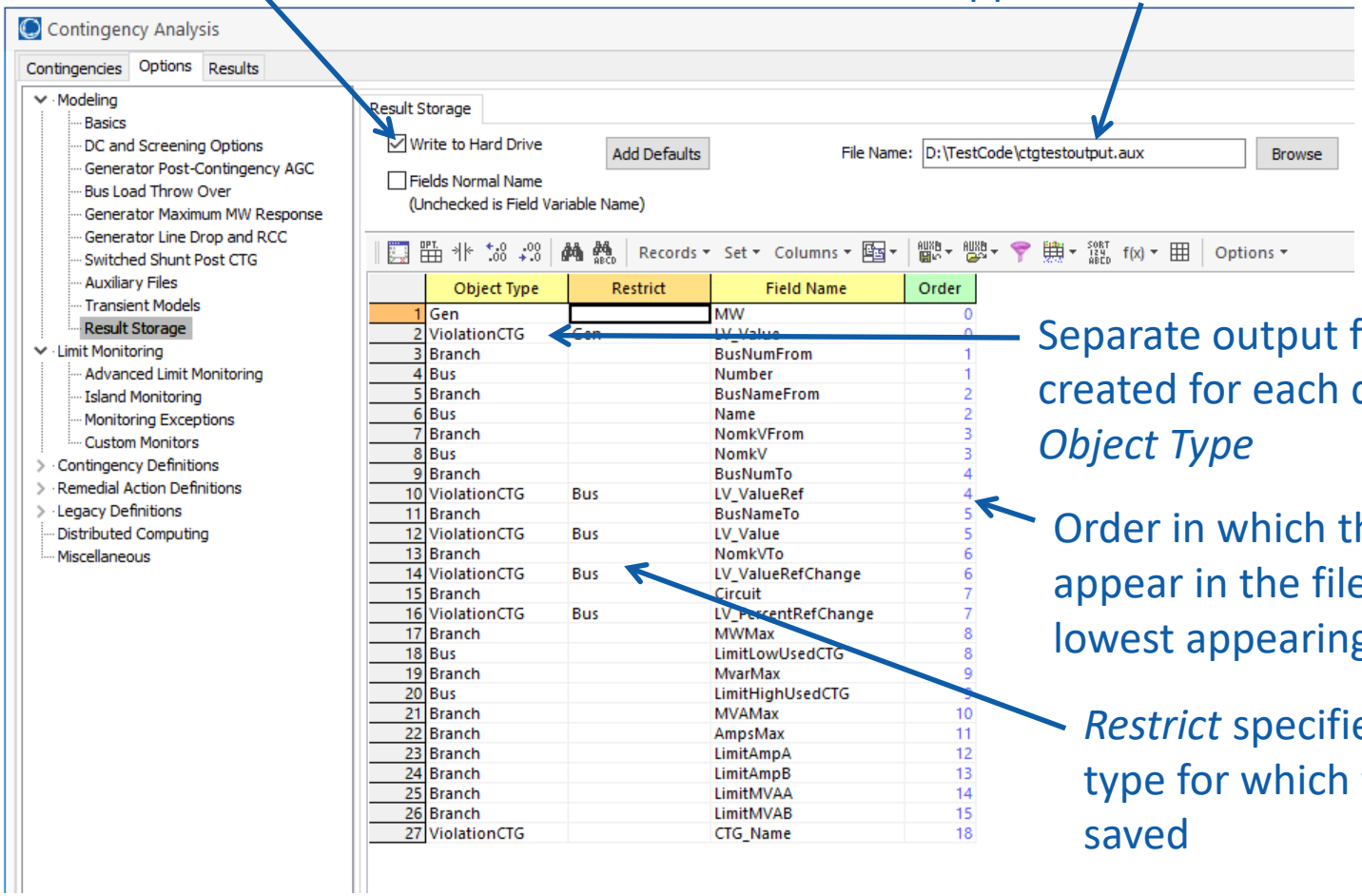
- Allows storing results to file instead of computer memory
- Only allows storing while contingency analysis is running
  - Cannot save to file in this format once the run has completed
  - Can access most any object that you would want to monitor during contingency analysis to get the value of fields following the contingency
  - All of this information is not stored in memory to be accessed later. That's why you are using this option in the first place!

© 2017 PowerWorld Corporation

Contingency Result Storage

When saving to hard drive there will be NO results in memory

File location and prefix of the file name. *Object Type* will be appended to this.



Separate output file will be created for each different *Object Type*

Order in which the field will appear in the file with the lowest appearing first

Restrict specifies the only object type for which this field will be saved

Contingency Result Storage

- Results will only be stored for objects that are considered violations
  - Typical violations include line overloads and bus voltage violations
  - To store a result for something that is not a “typical” violation it must be monitored it using Custom Monitors
- ViolationCTG
  - Violations when stored in computer memory are kept in this object
  - All results will be written in an aux file format so that they can be loaded back into Simulator if necessary
  - Fields not relevant for this ViolationCTG will be prepended with the object type
  - Fields specified for this *Object Type* will be saved to all files unless *Restrict* limits where they are saved

© 2017 PowerWorld Corporation

Contingency Result Storage

Example for the Branch and Bus file

```
ViolationCTG(|Branch|BusNumFrom,|Branch|BusNameFrom,|Branch|NomkVFrom,|Branch|BusNumTo,|Branch|BusNameTo,|Branch|NomkVTo,|Branch|Circuit,
             |Branch|MWMax,|Branch|MvarMax,|Branch|MVAMax,|Branch|AmpsMax,|Branch|LimitAmpA,|Branch|LimitAmpB,|Branch|LimitMVAA,
             |Branch|LimitMVAB,CTG_Name)
{
 "     1"  "One"  "138.000000"  "     3"  "Three"  "138.000000"  " 1"  "101.867912"  "16.200129"  "101.875053"  "405.852468"  "271.940304"
"334.695776"  "64.999998"  "80.000001"  "L_000001One-000002TwoC1"
 "     2"  "Two"  "138.000000"  "     5"  "Five"  "138.000000"  " 1"  "108.006256"  "10.669624"  "108.009720"  "434.499261"  "418.369714"
"418.369714"  "100.000000"  "100.000000"  "L_000002Two-000006SixC1"
 "     2"  "Two"  "138.000000"  "     5"  "Five"  "138.000000"  " 1"  "109.542859"  "41.207544"  "117.037172"  "474.708496"  "418.369714"
"418.369714"  "100.000000"  "100.000000"  "L_000007Seven-000005FiveC1"
}
```

Branch fields are prepended with |Branch|

ViolationCTG fields are simply the variablename with no modification

Bus fields are prepended with |Bus|

ViolationCTG fields that have *Restrict* = Bus only appear in the bus file

```
ViolationCTG(|Bus|Number,|Bus|Name,|Bus|NomkV,LV_ValueRef,LV_Value,LV_ValueRefChange,LV_PercentRefChange,|Bus|LimitLowUsedCTG,
             |Bus|LimitHighUsedCTG,CTG_Name)
{
 "     3"  "Three"  "138.000000"  "0.992688"  "0.990533"  "-0.002154"  "0.215435"  "1.000000"  "1.100000"  "L_000001One-000002TwoC1"
 "     3"  "Three"  "138.000000"  "0.992688"  "0.985778"  "-0.006910"  "0.691009"  "1.000000"  "1.100000"  "L_000001One-000003ThreeC1"
 "     3"  "Three"  "138.000000"  "0.992688"  "0.984803"  "-0.007885"  "0.788510"  "1.000000"  "1.100000"  "L_000002Two-000003ThreeC1"
 "     3"  "Three"  "138.000000"  "0.992688"  "0.992241"  "-0.0004469"  "0.044692"  "1.000000"  "1.100000"  "L_000002Two-000004FourC1"
 "     3"  "Three"  "138.000000"  "0.992688"  "0.992339"  "-0.0003490"  "0.034904"  "1.000000"  "1.100000"  "L_000002Two-000005FiveC1"
 "     5"  "Five"  "138.000000"  "1.006646"  "0.991720"  "-0.014926"  "1.492649"  "1.000000"  "1.100000"  "L_000002Two-000005FiveC1"
 "     3"  "Three"  "138.000000"  "0.992688"  "0.992588"  "-0.0001001"  "0.010014"  "1.000000"  "1.100000"  "L_000002Two-000006SixC1"
}
```

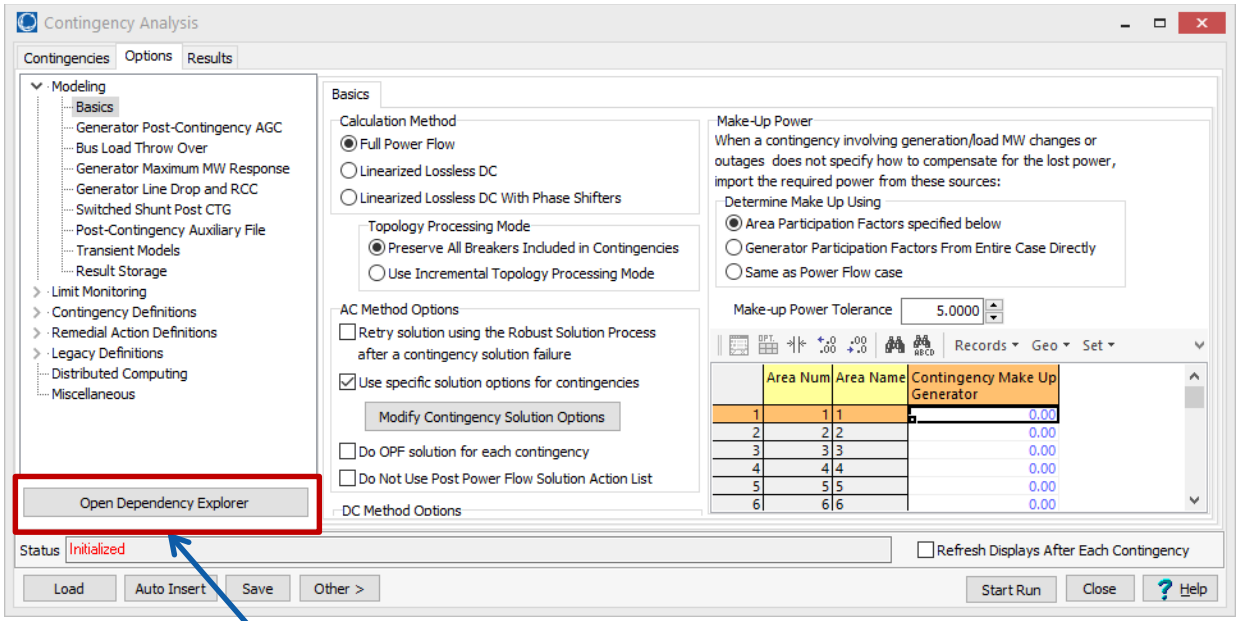
© 2017 PowerWorld Corporation

Dependency Explorer

- Enhances the understanding of Remedial Action Schemes (RAS) used with contingency analysis
- Allows for the viewing and modification of all RAS associated objects
  - Remedial Actions, Remedial Action Elements, Model Filters, Model Conditions, etc.

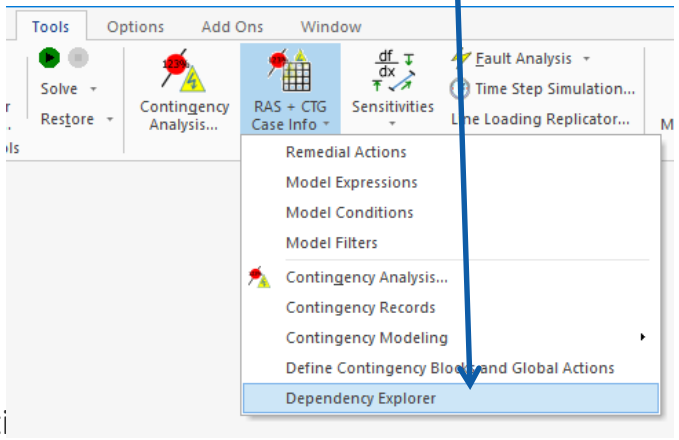
© 2017 PowerWorld Corporation

Opening the Dependency Explorer



Select the Dependency Explorer option on the RAS + CTG Case Info dropdown on the Tools tab of Simulator ribbon interface

Click the Open Dependency Explorer button on the Options page of the Contingency Analysis dialog

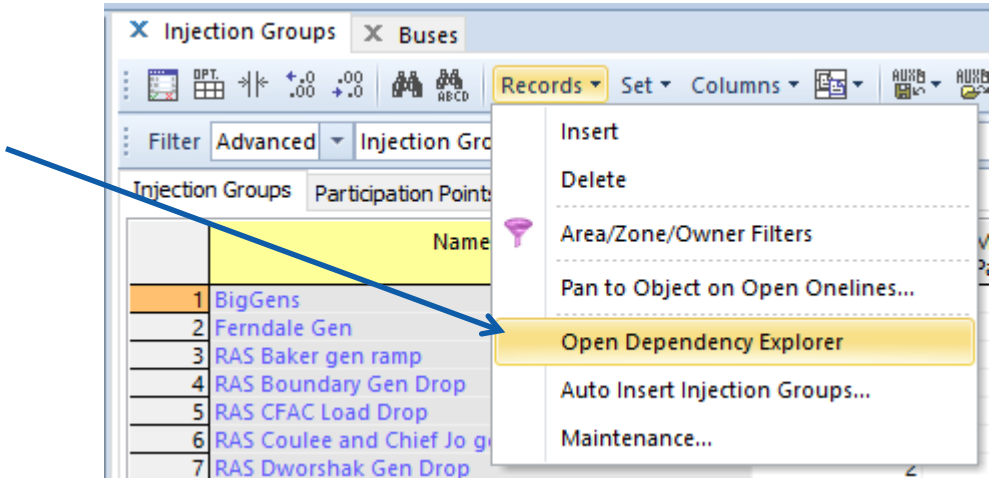


© 2017 PowerWorld Corporati

Opening the Dependency Explorer

- Option on local menu of objects that can have dependencies

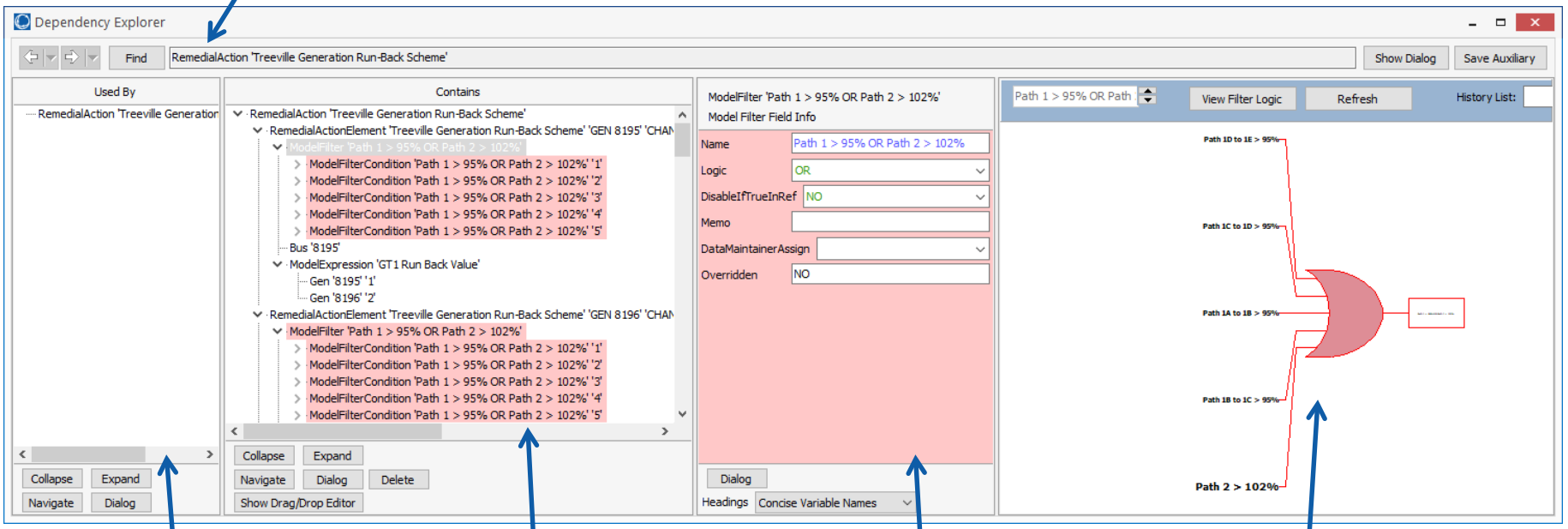
Select the Open Dependency Explorer option on Records dropdown of case information toolbar (or use right-click local menu)



© 2017 PowerWorld Corporation

Dependency Explorer

Currently selected object known as the *Top Object*



Used By pane

Contains pane

Field Info pane

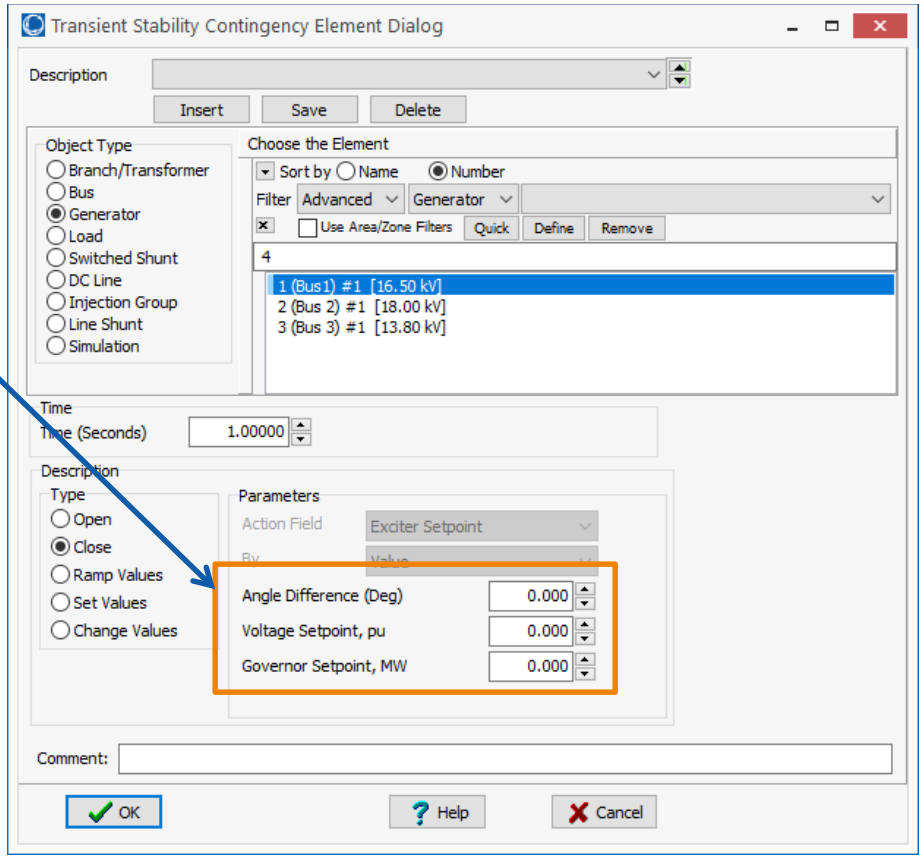
Filter Visualization pane

© 2017 PowerWorld Corporation

Transient Stability Contingencies

- Closing a generator through transient contingency action

Specify three parameters with all defaulted to 0



© 2017 PowerWorld Corporation

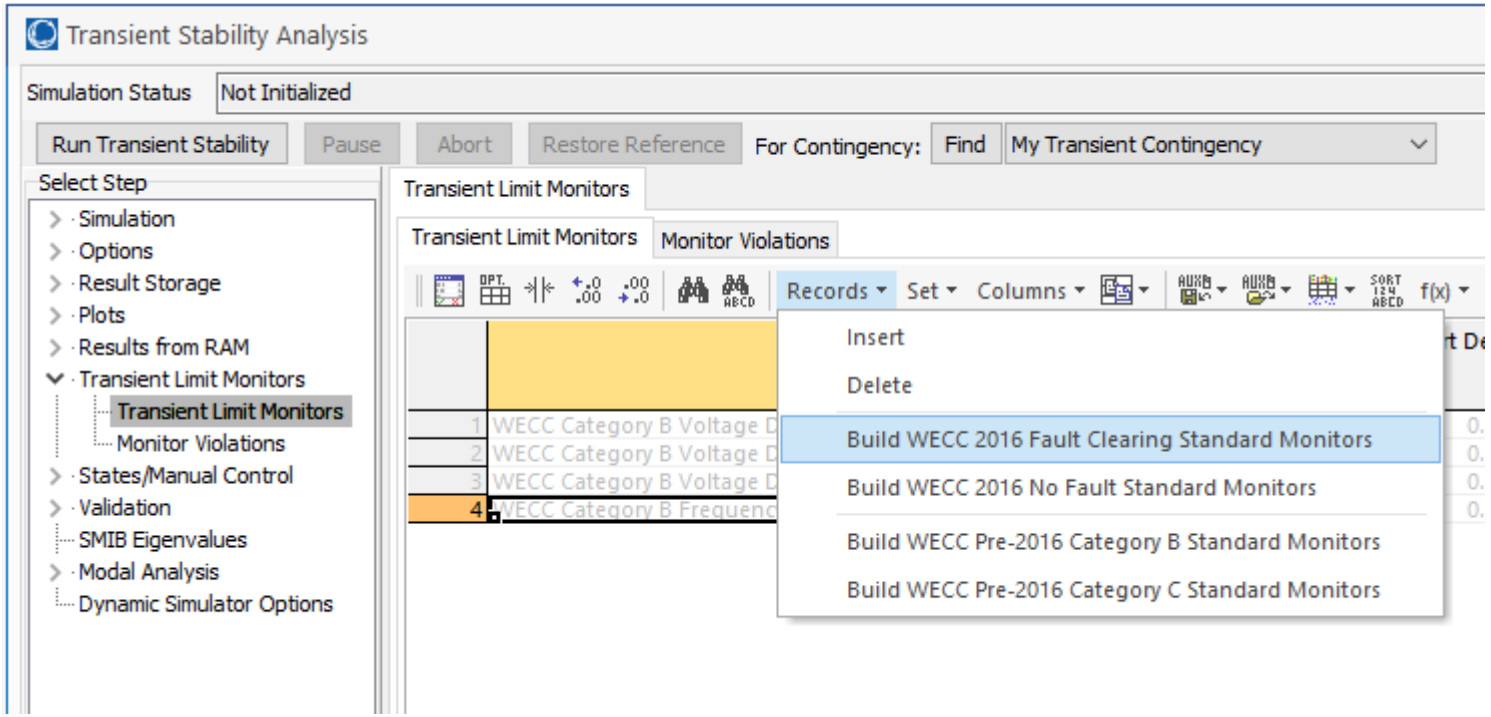
Transient Contingency Generator Close Action

- Initialization of generator model states
  - MW = 0.0, Mvar = 0.0
  - Frequency is nominal (60 Hz normally)
  - Terminal voltage magnitude = generator bus voltage magnitude
  - Terminal voltage angle = (generator bus angle) – (*Angle Difference)*
- Exciter Vref initialization
  - If abs(*Voltage Setpoint*) = 0, Vref is unchanged
  - Else if abs(*Voltage Setpoint*) < 0.5 then Vref = Vref + *Voltage Setpoint*
  - Else Vref = *Voltage Setpoint*
- Governor Pref initialization
  - If abs(*Governor Setpoint*) = 0, Pref is unchanged
  - Else Pref is calculated such that the MW (Pmech) will be equal to *Governor Setpoint* when the system is operating at nominal frequency

© 2017 PowerWorld Corporation

Transient Stability
Transient Limit Monitor

- WECC voltage criteria monitoring is now available built-in to Simulator
- Selecting option from local menu for Transient Limit Monitors will create appropriate monitors
- WECC criteria states: “BES bus that is serving load is the bus with direct transformation from BES-level voltage to distribution-level voltage that serves load”
  - Transient Limit monitor filter for *Load Buses Only* monitors the bus that contains the load



© 2017 PowerWorld Corporation

Transient Stability Models New and Changed

- Over Excitation Limiter
  - OEL4C
- Under Excitation Limiter
  - UEL2_PTI
- Load Characteristics
  - CompLoad
  - Modified or added models to build up the pieces inside the CMPLDW model
    - MOTOR_CMP to represent the 3-phase induction motor used in CMPLDW
    - LD1PAC_CMP (same as LD1PAC but with many parameters hard-coded as done in CMPLDW)
    - LDELEC added pfel parameter to indicate the power factor
    - IEEL added pfs parameter to indicate the power factor
    - MOTORX (same as MOTORW but using circuit parameters as input)
  - CMLD – PSS/E version of CMPLDW

© 2017 PowerWorld Corporation

Transient Stability Models New and Changed

- Line Relay
  - TICORSRF
  - DISTRelayRF
  - SCGAP
- DC Line Model
  - CHVDC2
- Switched shunts being controlled by SVSMOx models can have their own switched shunt transient models, i.e. MSC1, MSR1, etc.
  - When the SVSMOx model is inservice the model at the controlled shunt is ignored
  - When the SVSMOx model is out of service the transient model at the controlled shunt is allowed to operate

© 2017 PowerWorld Corporation

Modular Load Model

- See separate presentation on CompLoad

© 2017 PowerWorld Corporation

Transient Stability
DYR Models

- USRMDL from DYR read into Simulator models
  - WTDTAU1/WTDTA1 (WTDAT1)
  - WTARAU1/WTARA1 (WTARA1)
  - WTTQAU1/WTTQA1 (WTTQA1)
  - WTPTAU1/WTPTA1 (WTPTA1)
  - REECAU1/REECA1 (REEC_A/REECA1)
  - REECBU1 (REEC_B/REECB1)
  - REGCAU1/REGCA1 (REGC_A)
  - REPCAU1/REPCA1 (REPCA1)
  - REPCTA1 (REPCTA1)

© 2017 PowerWorld Corporation

Transient Stability Options

- Changed the default time step from 0.5 cycle to 0.25 cycle
- Changed the default MVA convergence tolerance from 0.1 MVA to 0.01 MVA
- When Using PlayIn Models Set Initial Hz to First Value
  - Initialize models assuming that system is at the first frequency value in the PlayIn information rather than initializing at nominal frequency
- Network Equations Solution Options – Abort after number of failed solutions
  - Current injection models sometimes make it difficult to solve the network boundary equations during a fault. When this happens the current network solution is aborted (not the entire simulation) and we assume that we will solve on the next time step.
  - This option specifies the number of times that the network boundary equations are allowed to fail consecutively before the entire simulation is aborted

© 2017 PowerWorld Corporation

Transient Stability Options

- When to use Complex Load Models
  - Complex loads represent a composite of various load types. Examples include CLOD, CMLD, CMPLDW, MOTORW, and CompLoad
  - If load doesn't meet these criteria, load falls back to the hierarchy of load models
    - Minimum Load P (MW) - default is 0.5
    - Minimum Load P/Q Ratio – default is 0.25
    - Minimum Initial per unit voltage – default is 0.0
  - If these criteria are not met, the distribution equivalent will also not be used for load
- Distribution Equivalent Models Options – Min Nom kV for Transformer
  - Default is 0.0
  - Xxf parameter of a distribution equivalent represents the transformer impedance. If nominal kV of bus is below this threshold then Xxf will be treated as zero.
  - When loading a DYD file this value is determined based on the CMPLDW data
- Frequency Measurement Options- Calculate Bus ROCOF (Rate of Change of Freq)
  - ROCOF can be monitored for buses only if this option it checked
  - Takes extra time to calculate the derivative of the frequency (derivative of the derivative of the angle) and only do this if you really want the value

© 2017 PowerWorld Corporation

Transient Stability Options

- Island Synchronization
  - Specify what happens when you close in a line that connects two energized islands
  - Angle Options
    - *Set to Degree Value*
      - Shift all angles in one island so that across the line you are going to close the angle difference is zero
    - *Set if > Degree Value specified*
      - Only do the shift if the difference across the line is greater than the specified value
    - *No Change*
      - Don't do anything
  - Frequency Options
    - *Set to Hz Value*
      - Makes changes so that the frequency is the same in both islands
      - Instantaneously changes the speed of all of the synchronous generators and reinitializes the bus frequency calculation
    - *Set if > Hz Value*
      - Only does change if the frequency difference across the line being closed is greater than the specified value
    - *No Change*
      - This option seems to make the most sense with reality

© 2017 PowerWorld Corporation

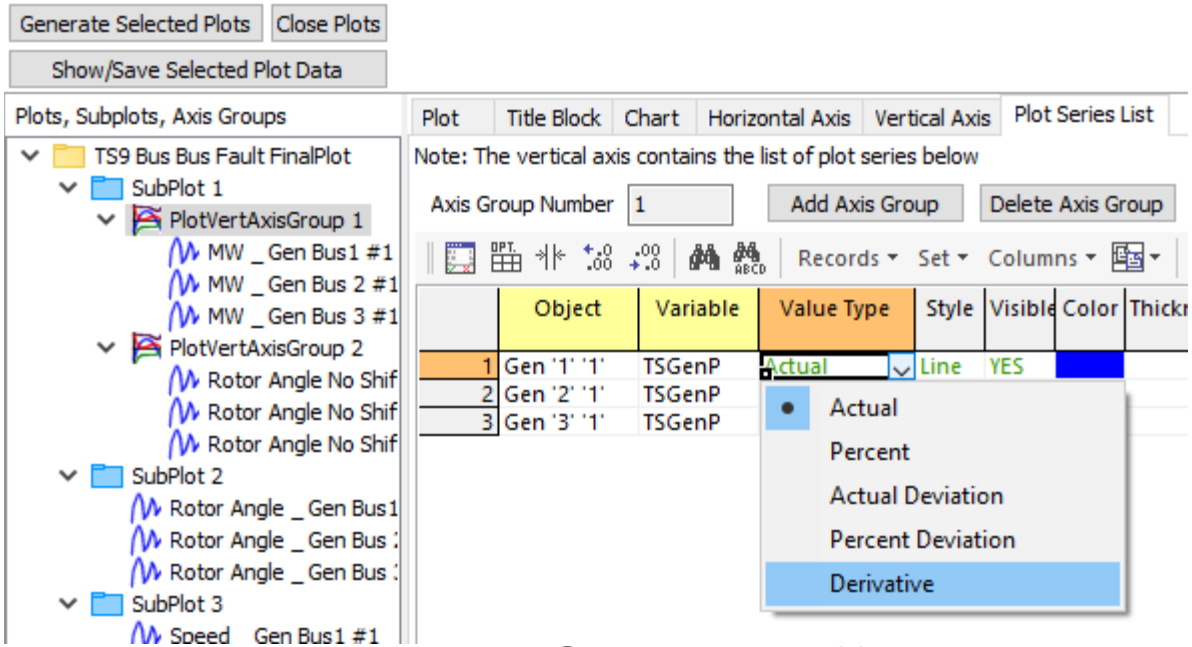
Transient Stability
Store to RAM Options

- Bus
  - ROCOF (Hz)
    - Rate of change of frequency
    - Derivative of frequency needed for output signal for standard format C37.118 for measured streaming data
    - This will only be calculated if the option to calculate it is also set
- Area
  - Weight Avg Speed
  - Average generator speed for all synchronous generators weighted by MVA base
  - GIC Mvar Losses
- Zone
  - Weight Avg Speed
- Substation
  - GIC EField Magnitude
  - GIC EField Direction
- Case Information
  - GIC Total Mvar Losses
  - GIC Maximum Transformer Ieffective (Amps)

© 2017 PowerWorld Corporation

Transient Stability Plotting

- Value Type when plotting can now be *Derivative*
  - Difference between the present point and the previous point is divided by the time difference



© 2017 PowerWorld Corporation

Bus Driving Point Impedances

- Found under Tools → Connections → Driving Point Impedances
- Driving point impedance is the impedance looking from a bus out into the system
- Would typically use this dialog after loading in transient stability data
  - Use Ybus from transient stability, which includes the internal impedances of generators and loads (induction motors for example)
  - Without Bus Local Shunts
    - Subtract out local impedances at the bus, i.e. bus shunts, switched shunts, internal impedances of generators, internal impedances of induction motors, etc.
    - This is similar to what is done in the SMIB two bus equivalent calculations and is the most appropriate option to choose
  - Including Bus Local Shunts
    - No subtraction of local impedances
- Power Flow Use
  - Use power flow Ybus to calculate
  - Depends on the slack bus and does not include the internal impedance of generators

© 2017 PowerWorld Corporation

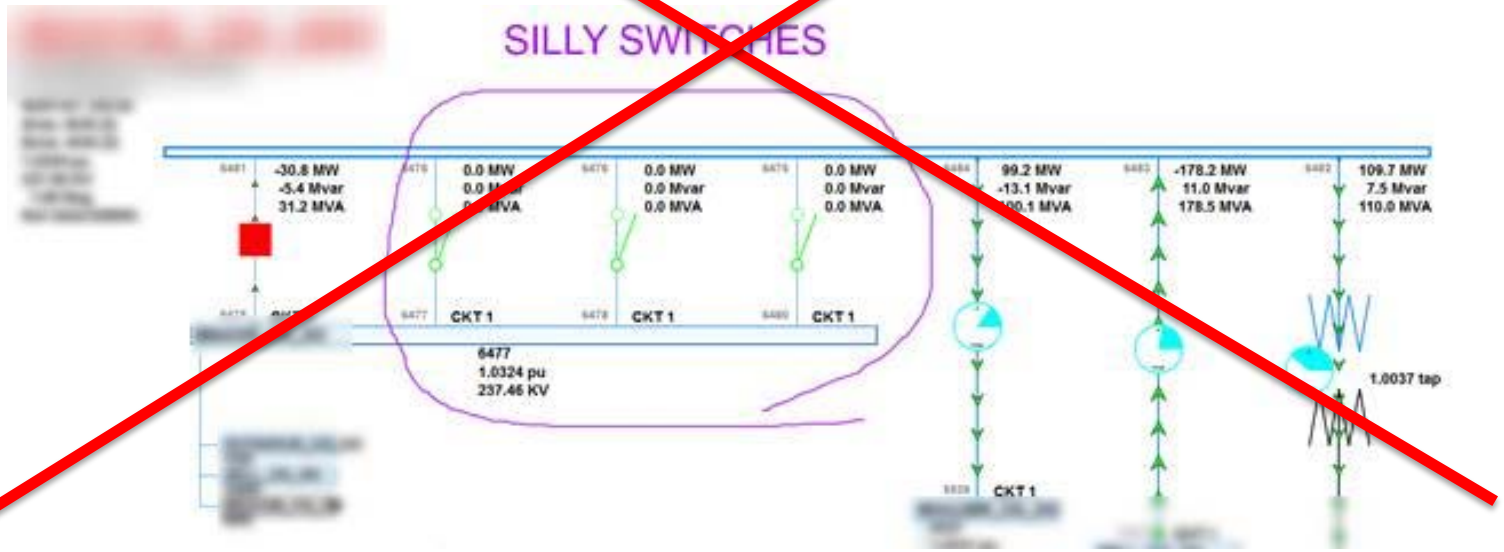
Merit Order Close Ramping

- Available with PV, ATC, Scale, and Time Step Simulation tools
- Generators within an injection group will be dispatched in merit order determined by their specific participation factors from highest to lowest
- Economic generator limits will be enforced during this process regardless of how options to enforce generator MW limits are set
  - *MW Economic Minimum* and *MW Economic Maximum*
  - *MW Economic Maximum* must be greater than zero in order for a generator to participate in the dispatch
- If increasing the injection and the next generator in merit order is not already online, the *Status* of the generator will be set to CLOSED with an initial Mvar output of 0
  - Breakers will be closed as necessary to connect a generator
- If decreasing the injection and generators are being backed down to their minimum limit, generators will remain online when they hit their minimum limit
- Generators will only be adjusted to pick up a change in generation
  - No change to base dispatch is done

© 2017 PowerWorld Corporation

Integrated Topology Processing

- Consolidation changes
  - If there is a CLOSED switching device in parallel (between exact same buses) to an OPEN switching device, the OPEN switching device is consolidated if the CLOSED one cannot be consolidated
    - This is a special situation because normally both switching devices would be consolidated
    - In this situation the CLOSED switching device is marked as Allow Consolidation = NO or is part of an interface or tie-line

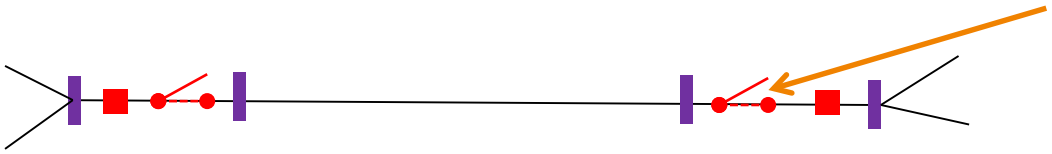


These open breakers are NOT consolidated in version 20

© 2017 PowerWorld Corporation

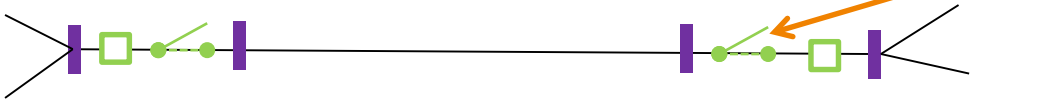
Full Topology Features

- *Open* or *Close with Breakers* local menu options on case information displays and oneline have additional options for what should be switched
  - *With Options*
    - *Open Normally Open Disconnects*



If normally open this will be opened and the search for breakers will terminate

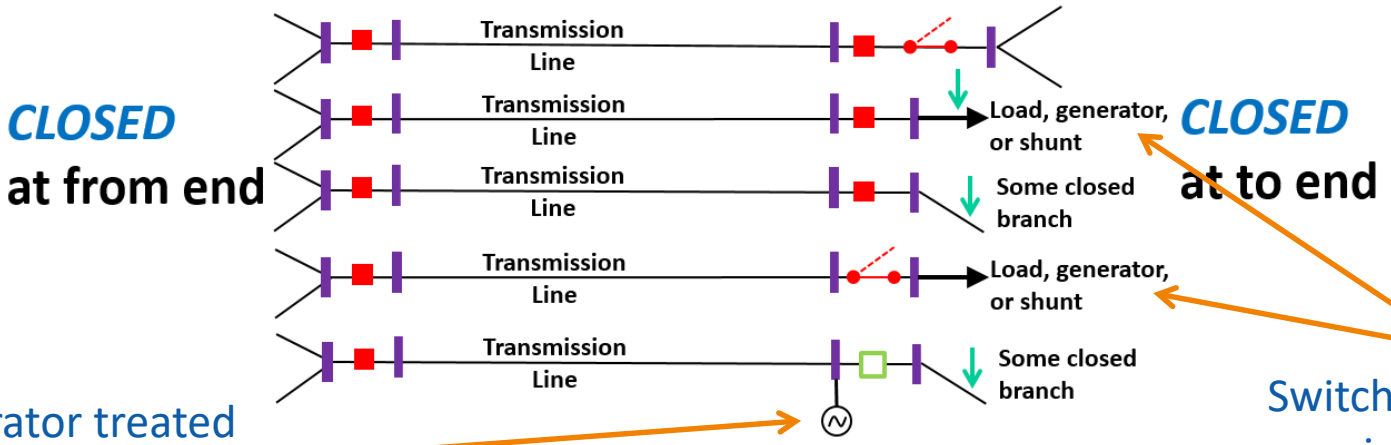
    - *Close Normally Closed Disconnects*



If normally closed this will be closed and the search for open breakers will continue

© 2017 PowerWorld Corporation

Derived Status



Generator treated the same as finding a closed breaker

Switched shunts are now included here

Open switching device beyond the closed breaker is treated as open

© 2017 PowerWorld Corporation

Oneline Features

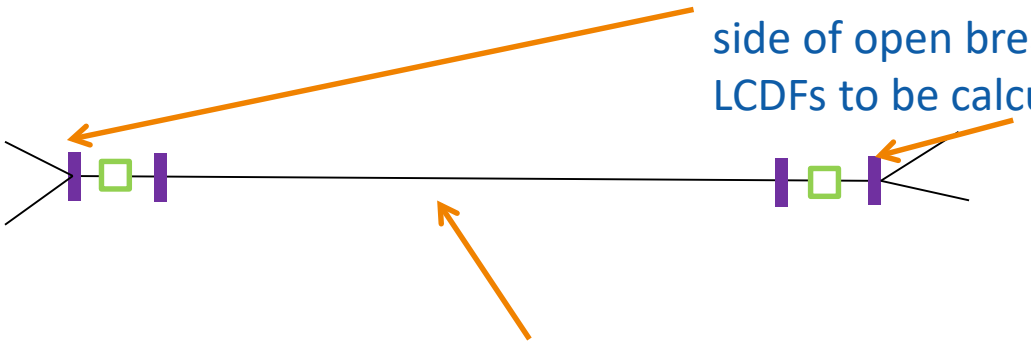
- Areva Diagram Import
  - New translations have been added to properly render overview diagram objects
  - See separate presentation for more details
- Oneline Viewer
  - Performance has been greatly improved
  - Backward, forward, and history buttons have been added
  - Custom menus
    - Menu definitions from EMS system can be imported
    - CustomMenuNode object allows menus to be saved to and loaded from auxiliary files
- Oneline Browsing Path
  - Order in which paths are defined is the order in which they will be searched
  - Useful with loading Areva DDL files

© 2017 PowerWorld Corporation

Sensitivities

- Line Closure Sensitivities
  - *Breaker Status* and *Breaker and Load Break Disconnect Status*

Using *Breaker…* options, the calculation is transferred to the connected buses on the other side of open breakers. This will allow non-zero LCDFs to be calculated.



Line being closed. If using *Line Status* option, the LCDF for this line is calculated based on the line only. This will always return 0 because both terminals of the line are disconnected due to the open breakers.

© 2017 PowerWorld Corporation

Sensitivities

- Line Closure Sensitivities
  - *Calculate based on post-closure flow (LCDF)*
    - $LCDF_{l,k} = \frac{\Delta P_{l,k}}{\tilde{P}_k}$ where $\tilde{P}_k$ is the post-closure flow
    - We haven't closed the line so $\tilde{P}_k$ must be calculated from $\tilde{P}_k = \frac{P_k}{1 + PTDF_k}$
  - *Calculate based on pre-closure flow (MLCDF)*
    - $MLCDF_{l,k} = \frac{\Delta P_{l,k}}{P_k}$ where P_k is the pre-closure flow calculated from the present voltages and angles
    - Simpler to calculate because we do not need to store the $PTDF_k$ factor
    - Useful if trying to do your own calculations with multiple line outages

© 2017 PowerWorld Corporation

GIC

- See separate presentation

© 2017 PowerWorld Corporation