What's New in Simulator Version 19

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 19

- Version 19 is a version with many, many, many small changes throughout
- Concentration this past year has been on improving existing features
  - Auxiliary File Format
  - Transient Stability
  - GIC
  - Remedial Action Schemes (RAS)
- These are the highlights
  - Comprehensive list found at http://www.powerworld.com/products/simulator/whats-new

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Auxiliary File Improvements

- First: You will still be able to read AND write Auxiliary Files with the previous syntax
- Repeat: You will still be able to read AND write Auxiliary Files with the previous syntax
- Why are changes are being made?
  - Makes the file format easier for others to parse
  - Makes format easier for you to parse as a user

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Special Auxiliary File Improvements Version 18

- Cleaned up header to replace “DATA” with the object name instead
- No longer include the “CreateIfNotFound” field. YES is always assumed.
- Utilize the ObjectID field so we don’t need separate DATA sections
- Improving the variable names to make more sense
- For version 18, this was only used for “WECC Contingency” file

```
Gen (ObjectID, CTGPreventAGC, CTGPartFact, CTGMaxResp, UseLineDrop, Xcomp)
{
"Gen 'Texan_69.0' '1'" "NO"      same      22.0       "NO"         0.0001
"Gen 'Jet_69.0' '1'"   "YES"     88.0      ""         "PostCTG"    0.0512
"Gen 77 '1'"           "RESPOND" same      0.0        "NO"         0.0001
"Gen 55 '1'"           "NO"      same      ""         "NO"         0.0001
}
```

```
DATA (Gen, [BusName_NomVolt, GenID, GenPostCTGPreventAGC, GenParFac:1, CTGMakupGen, GenUseLDCRCC, GenXLDCRCC],
      AUXDEF, YES)
{
"Gen 'Texan_69.0' '1'" "NO"      same      22.0       "NO"         0.0001
"Gen 'Jet_69.0' '1'"   "YES"     88.0      ""         "PostCTG"    0.0512
}
DATA (Gen, [BusNum, GenID, GenPostCTGPreventAGC, GenParFac:1,
            CTGMakupGen, GenUseLDCRCC, GenXLDCRCC], AUXDEF, YES)
{
"Gen 77 '1'"           "RESPOND" same      0.0        "NO"         0.0001
"Gen 55 '1'"           "NO"      same      ""         "NO"         0.0001
}
```

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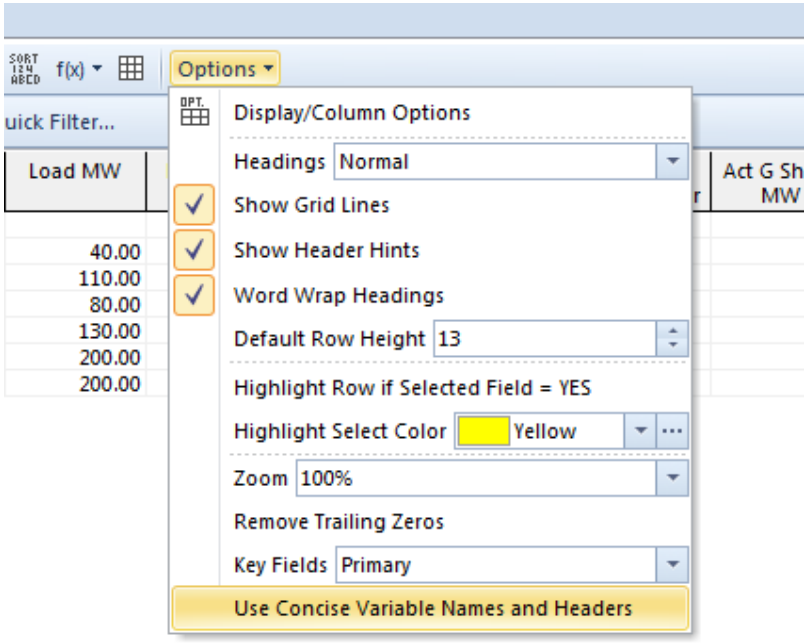
Special Auxiliary File Improvements Continue into Version 19

- 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



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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

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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	NomkVFrom		
1212				BusNomVolt:1	NomkVTo		
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

Switch between showing legacy

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 concise 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	

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Auxiliary Files

- Special string can be used in place of value
  - `"&Objecttype 'key fields' variablenamelegacy:location:digits:decimals"`
  - `"&Objecttype 'key fields' concisename:digits:decimals"`
  - Treated as though the value of the named object and object field is entered in the field
  - If not digits or decimals specified, 7 decimal places will be used
  - Trailing zeros will be removed if no decimals are specified
  - Can be used in Case Information Displays, auxiliary file enterable fields, and script commands
- Specification of star bus is easier when creating a three-winding transformer
  - Enter special strings for BusIDStar (BusIndentifier:3) → Number, STAR, STARMAX, or STAR98765

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New Script Commands

- ATCCreateContingentInterfaces
- CalculateLODFAdvanced
- CalculateLODFScreening
- CTGApply
- CTGClearAllResults
- CTGCompareTwoListsOfContingencyResults
- CTGCreateContingentInterfaces
- CTGCreateExpandedBreakerCTGs
- CTGCreateStuckBreakerCTGs
- CTGReadFilePSLF
- CTGReadFilePTI
- CTGWriteAllOptions
- DoFacilityAnalysis
- EditMultipleOnelineAction
- ExpandAllBusTopology
- ExpandBusTopology
- MergeMSLineSections
- OpenWithBreakers
- PVWriteInadequateVoltages
- ReassignIDs
- Remove3WXFormerContainer
- RenameInjectionGroup
- RestoreState
- SetSelectedFromNetworkCut
- StoreState

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Script Command Modifications

- CalculateTLR
  - Added SetOutOfServiceBuses parameter to specify if out of service buses should have their sensitivity set to the closest in service bus
- CTGSolveAll
  - Added parameter ClearAllResults to specify if all results or only those where Skip = NO should be cleared
- CTGWriteResultsAndOptions
  - Many additional parameters to aid in saving necessary objects and in the format required for the WECC RAS and Contingency Format
- DeleteFile
  - Can now use the special keywords starting with @
- Move
  - Can now move three-winding transformers
- OpenWithBreakers and CloseWithBreakers
  - Optional parameter SwitchingDeviceTypes to specify which switching devices to consider
- SaveDataUsingExportFormat, SaveData, SaveDataWithExtra, SaveObjectFields, and WriteToTextFile
  - Allow special keyword @CASENAME to be used as part of the filename
- SaveData and SaveDataWithExtra
  - Additional parameter to Transpose the output
- Scale
  - Now allows you to not scale MW or Mvar while scaling the other
- SendToExcel
  - Additional parameters SortFieldList, Header_List, and Header_Value_List
- SplitBus
  - Can specify the BranchDeviceType for the bus tie that is created

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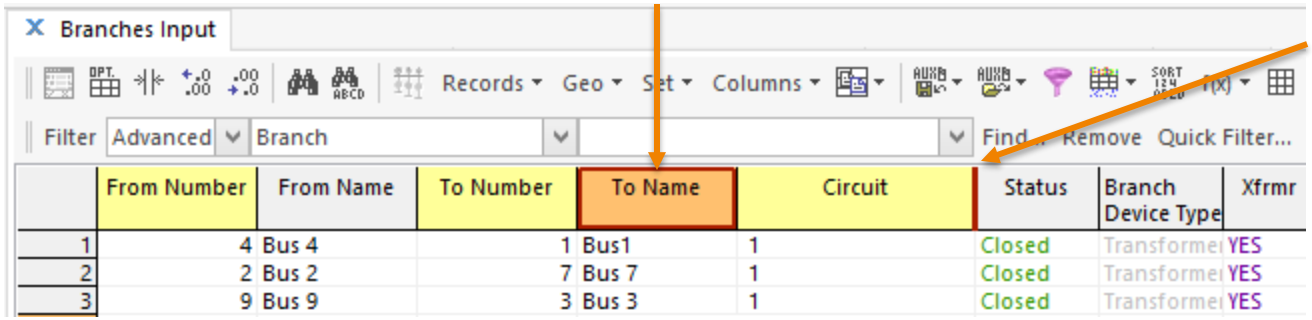
Case Information Displays

- Eliminated the option to highlight column headers. This is now always done.
- To change the column order, a column can be dragged by clicking and holding the left mouse button
  - CTRL key no longer is needed to move a column

Left click and hold on column to move

Drag to new location and release mouse button



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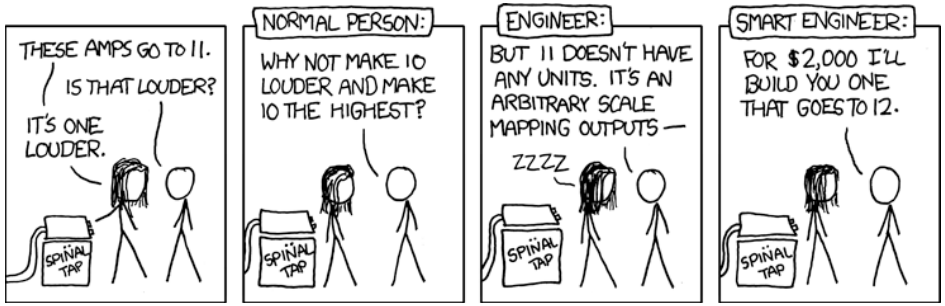
Rating Sets

- There are now 15 limits available with each branch and interface
  - https://xkcd.com/670/



- Rating sets can be given names
  - Useful for identifying different rating sets for different purposes
  - Different names for branches, interfaces, and buses
  - Names will then appear in column headers

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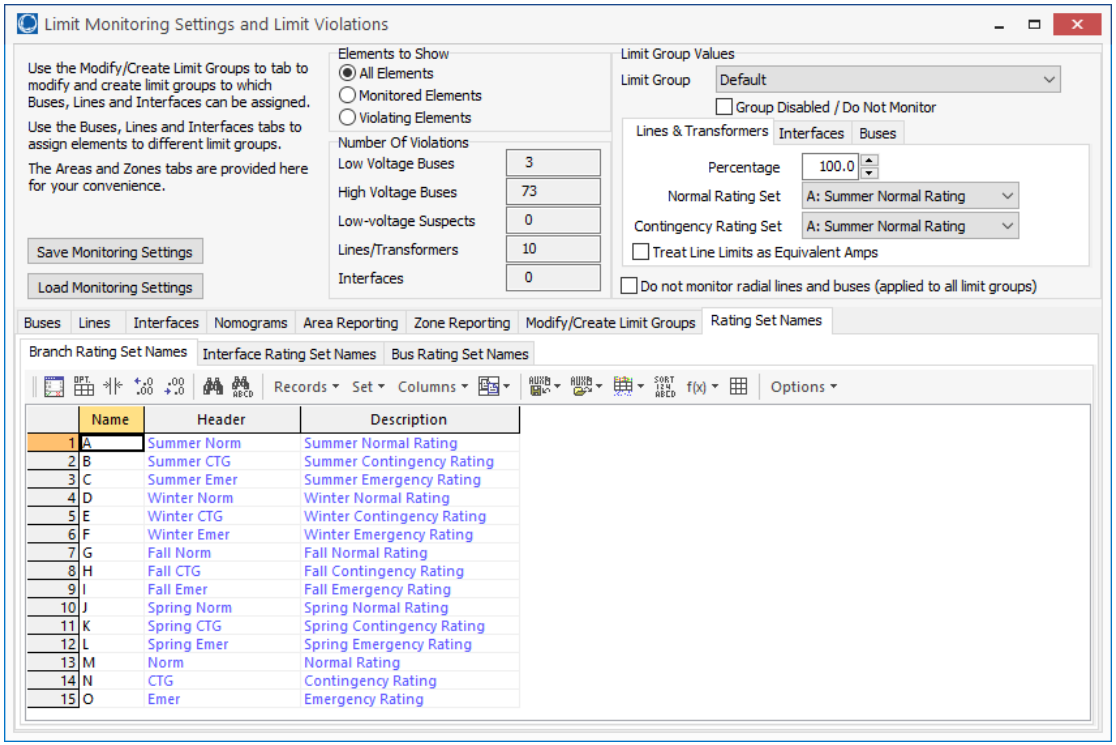
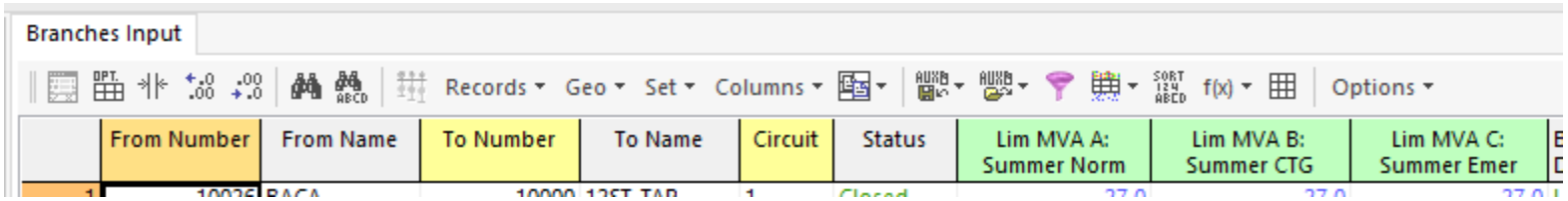
Rating Sets

Define a *Header* for Rating Sets on Limit Monitoring Settings dialog



Column headers will show user-specified names



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Owners

- Generators and Branches
  - Up to 8
- Switched Shunts and Line Shunts
  - Up to 4
- All components of multi-terminal DC lines
  - Up to 8
- Two-terminal DC Lines
  - Up to 8
- VSC DC Lines
  - Up to 8

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Data Maintainer

- Represents the entity responsible for maintaining the input data for an object
- Purpose in software
  - Provide contact information in the form of an email or phone number of someone to contact regarding an object
  - Provides ability in software to use this to filter output
    - Examples
      - Write out some input data for Columbia Grid
      - Write out some input data for Grant County PUD only
    - Makes it easier to piece together portions of a model

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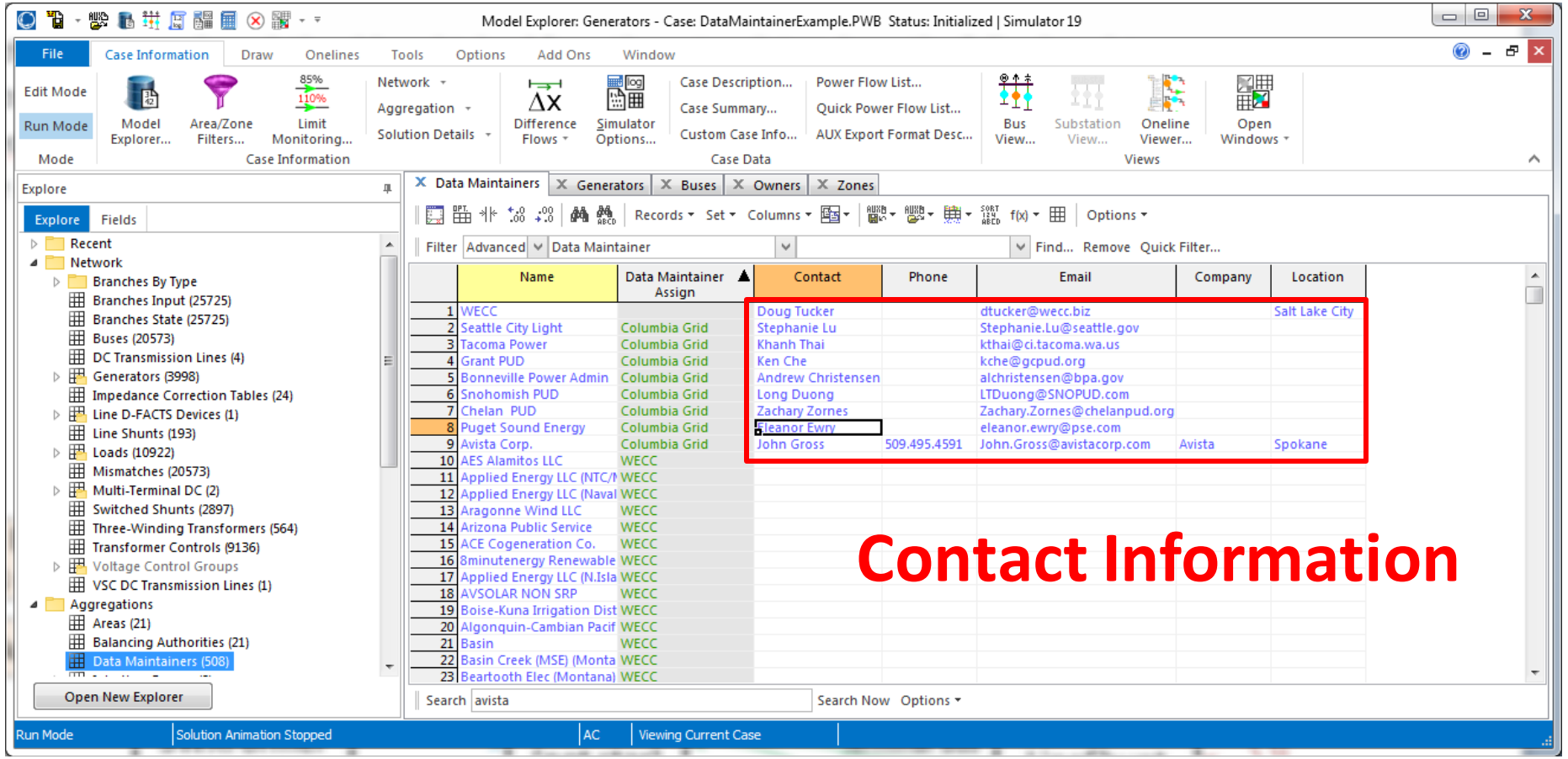
Data Maintainer



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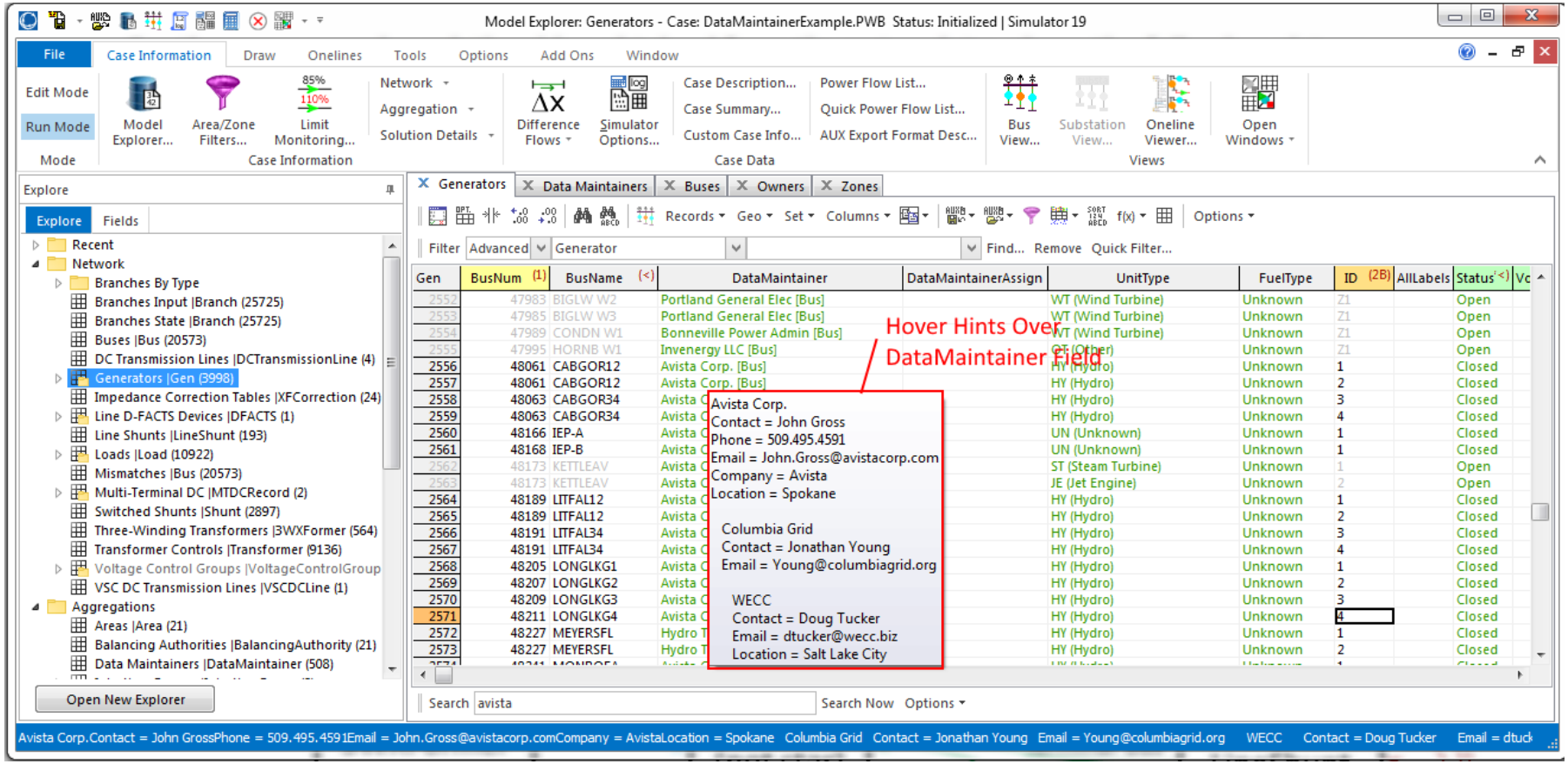
Hover Hints on DataMaintainer field



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Balancing Authority

- New container object similar to an area or zone
- Buses, generators, and loads can be assigned
- No control functionality presently, but we may add eventually
  - In short-run, just flip the Area designations with the Balancing Authority designations

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Supplemental Data and Classification

- Previously existed for storing database information associated with Shapefiles
  - This information can be used to format onelines created from the Shapefiles
- Expanded for more flexibility
- Use as a testing ground for new object types
- Create user-defined groupings for reporting purposes

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Supplemental Classification

- Allows users to make their own groupings (Classification) and then assign objects to specific entities (Data) within these groupings
  - Example: Create Balancing Authorities as a Classification
- Settings
  - **Contains Objects of Type**
    - Comma-delimited list of object types that are contained by Supplemental Data of this Classification
  - **User Assignable Object Types**
    - Comma-delimited list of object types that can be assigned to Supplemental Data of this Classification
  - **Allow Multiple**
    - If YES, An object can belong to more than one Supplemental Data of this Classification
  - **Inherits from Model Structure**
    - Set to YES to allow objects to inherit which supplemental data they are contained by from the model structure. For example, if a classification only is assigned buses, you may want a generator to inherit from its terminal bus which supplemental data it belongs to.
  - **Object Type**
    - Object Type: this is what will be used in AUX files as the field names to create supplemental data objects of this classification. It is the same as the classification name, but all spaces are removed and all of the following characters are replaced by an underscore \/:*?"<>',|

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Supplemental Data

- Assigned to a Supplemental Classification
- Specific member of the classification
  - Example: Balancing Authority 1
- Objects are assigned to Supplemental Data
- Calculated fields can be used to return information about the objects in the Data groupings

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Supplemental Data Assigning Objects

- New fields become available depending on how the Supplemental Classification is defined
  - *Object Type*
    - Lists all of the Supplemental Data to which an object belongs
    - Field is available for any object types that can be contained in or assigned to Supplemental Data
  - *Object Type* Append
    - Add the name of new Supplemental Data to which an object is assigned
    - Field is available for any object types that can be assigned to Supplemental Data
  - *Object Type* Assign
    - List the name of ALL Supplemental Data to which an object belongs
    - Field is available for any object types that can be assigned to Supplemental Data

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Filtering

- New logical comparisons available with Advanced Filters, Model Conditions, and Model Filters
  - *OneTRUE*
    - Return true if exactly one of the inputs is true
  - *XOR*
    - Return true if an odd number of inputs is true

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Expressions

- Expression parser was given an overhaul in version 19 that should make it more flexible moving forward
- Expressions, Model Expressions, String Expressions, and Model String Expressions are affected
- New string functions
  - *Trim* – remove all leading and trailing spaces
  - *LTrim* – remove leading spaces
  - *RTrim* – remove trailing spaces
- New *XOR* logical function
  - Return true if only one of the inputs is true

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Expressions

- New *IsTrue* string function
  - Returns 1
    - String entered is "T", "True", "Connected", "Closed", "Yes", "Y", or "1"
  - Returns 0
    - Any other string
  - Useful in an expression like this:
    - x1*0.459 + x2*0.49 + x3*0.731 + x4*0.53
      - where x1, x2, x3, and x4 should be either 1 or 0 depending on if a Model Filter is met or not
    - Directly using the variables as the *Meets Filter* field is NOT valid
    - Correct form: IsTrue(x1)*0.459 + IsTrue(x2)*0.49 + IsTrue(x3)*0.731 + IsTrue(x4)*0.53
    - Alternative form prior to Simulator version 19: iif(x1=="YES",1,0)*0.459 + iif(x2=="YES",1,0)*0.49 + iif(x3=="YES",1,0)*0.731 + iif(x4=="YES",1,0)*0.53

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File Formats

- EPC file
  - Support for reading version 19
  - Prompt to save bus records if saving individual records for switched shunts, generators, and branches
- RAW file
  - Records with comments in the format /* [my label, my second label] */ will have labels automatically created for the object
- hdbexport CSV file
  - Custom labels can be defined when loading the file
  - Option to specify if default labels should be created
  - Continuing to add support for additional fields
- Many additional changes for continuing support of RAW, EPC, PTI CON, PTI MON, PSLF OTG, KML, UCTE, hdbexport, PROMOD, and WECC Switch Data formats

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General

- Many new fields added to various object types. Some examples:
  - *Gen MW Setpoint* field for generators to allow access to the output of the generator regardless of it being online or not
  - *RegBus by ObjectID* with branches, generators, and switched shunts to specify the regulated bus by currently selected key field identifier
  - *Number of Gens Online*, *Number of Loads Online*, and *Number of Shunts Online* for injection groups
  - Fields for *Near Bus*, *Far Bus*, and *Element ID* for interface elements
  - Fields with branch for showing the *Open Ended* charging and per unit voltage at each end
  - MW and Mvar flows for branches *Calculated from voltages ignoring status*
  - *MW Surge Impedance Loading* for branches
  - *Limit Group Percentage* with branches and interfaces to show the percentage that is being used in each object's Limit Group settings
  - *Regulated Bus Number (used due to ZBR)* with transformers
  - *Controlling SVC Object ID* with switched shunts used to identify any SVC that is controlling this shunt by the currently selected key field identifier
  - Information only *Interruptible* field with loads
  - *Unit Type Code* field with generators to show only the two character code for *Unit Type*

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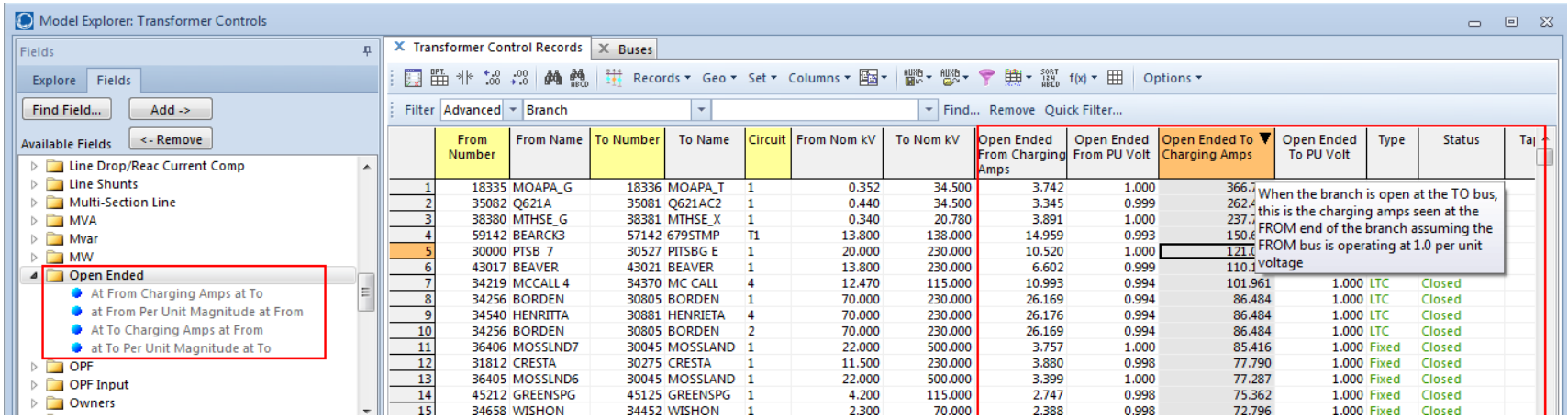
Open Ended Fields for a Branch

- Quickly see the Charging Amps and Open Ended Voltage assuming 1.0 per unit on closed end

Field Listing Value	Column Header	Hint Description	VariableName in Version 19
Open Ended\At From Charging Amps at To	Open Ended From Charging Amps	When the branch is open at the FROM bus, this is the charging amps seen at the TO end of the branch assuming the TO bus is operating at 1.0 per unit voltage	ChargingAmpsToOpenEndedFrom
Open Ended\At To Charging Amps at From	Open Ended To Charging Amps	When the branch is open at the TO bus, this is the charging amps seen at the FROM end of the branch assuming the FROM bus is operating at 1.0 per unit voltage	ChargingAmpsFromOpenEndedTo
Open Ended\at From Per Unit Magnitude at From	Open Ended From PU Volt	When the branch is open at the FROM bus, this is the per unit voltage at the FROM bus assuming the TO bus is operating at 1.0 per unit voltage	VpuFromOpenEndedFrom
Open Ended\at To Per Unit Magnitude at To	Open Ended To PU Volt	When the branch is open at the TO bus, this is the per unit voltage at the TO bus assuming the FROM bus is operating at 1.0 per unit voltage	VpuToOpenEndedTo



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General

- Required fields to create an object have changed for some object types. Some examples:
  - For a Branch either the R/X on the system base OR the R/X on the transformer base can be used when creating a new transformer
  - Line B field is no longer a required field to create a Branch
  - Vhigh and Vlow are no longer required fields to create a Switched Shunt
  - Limit A, Limit B, and Limit C are no longer required fields to create an interface

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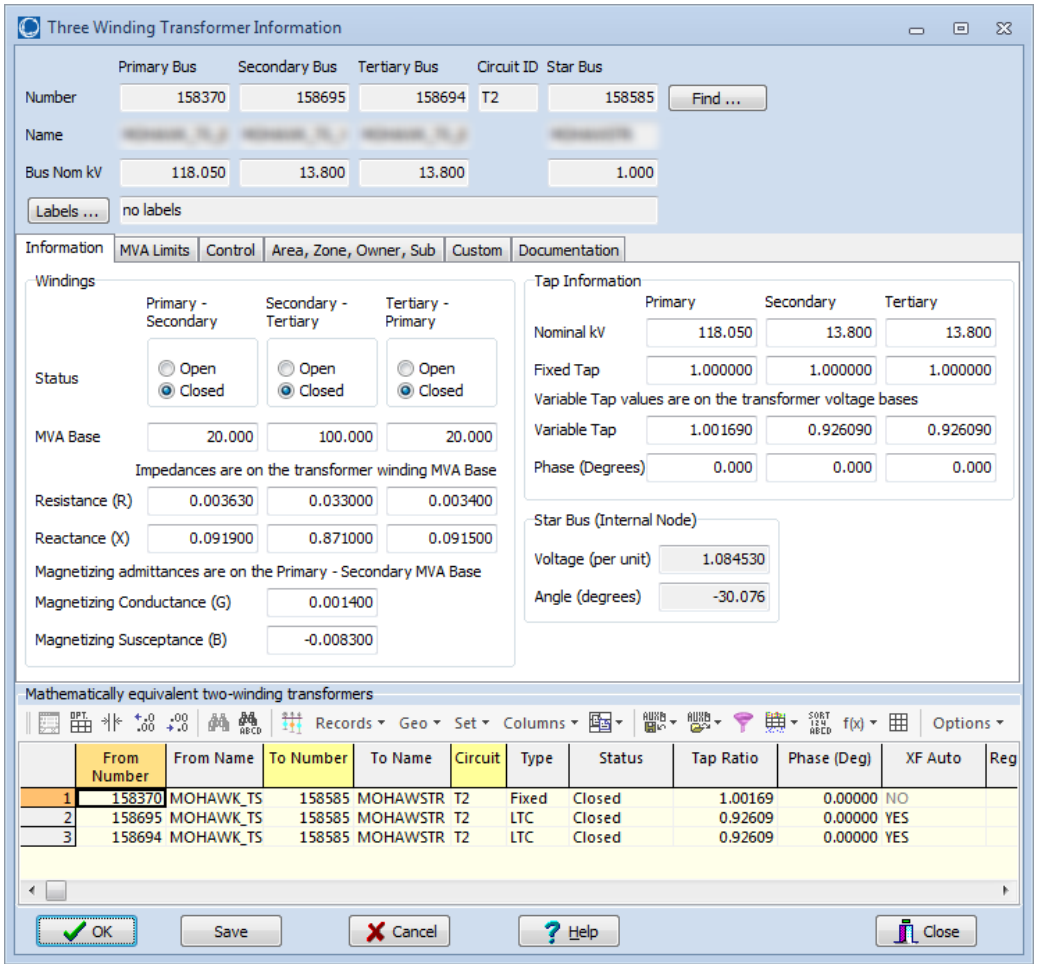
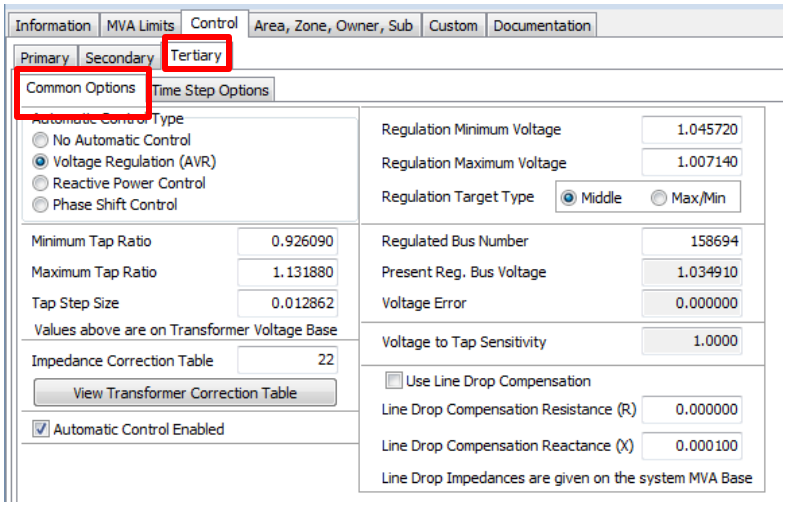
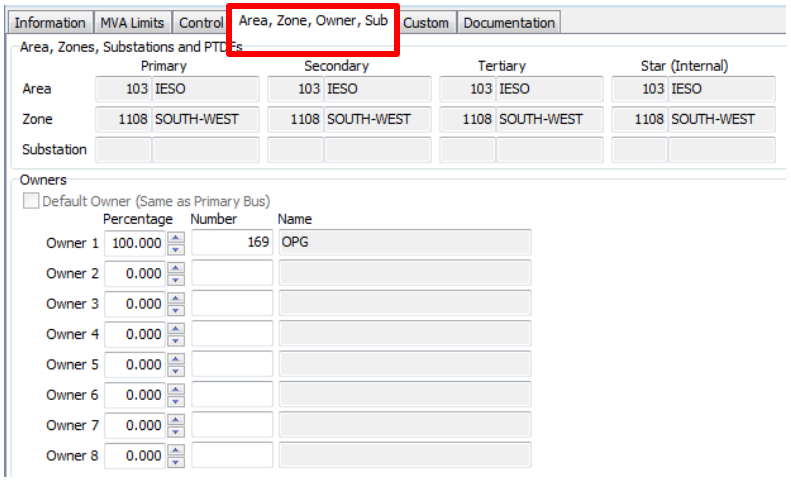
Three-Winding Transformer Dialog







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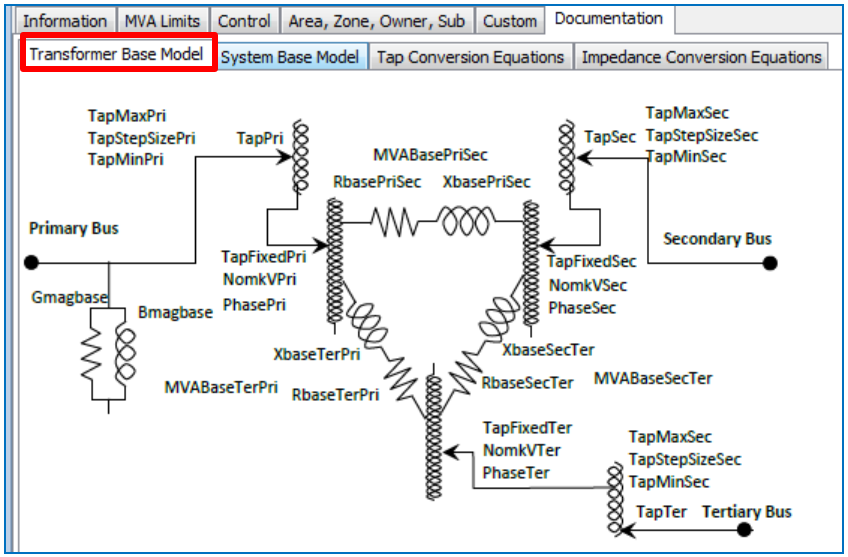
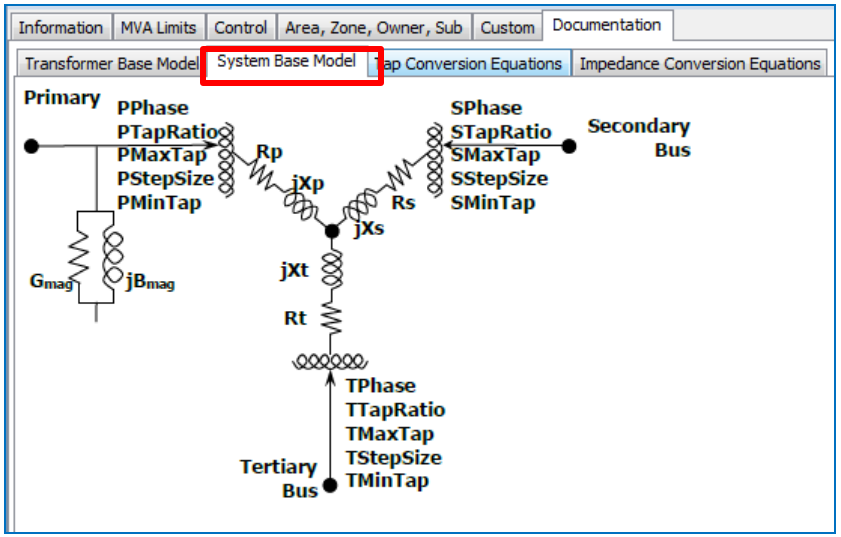
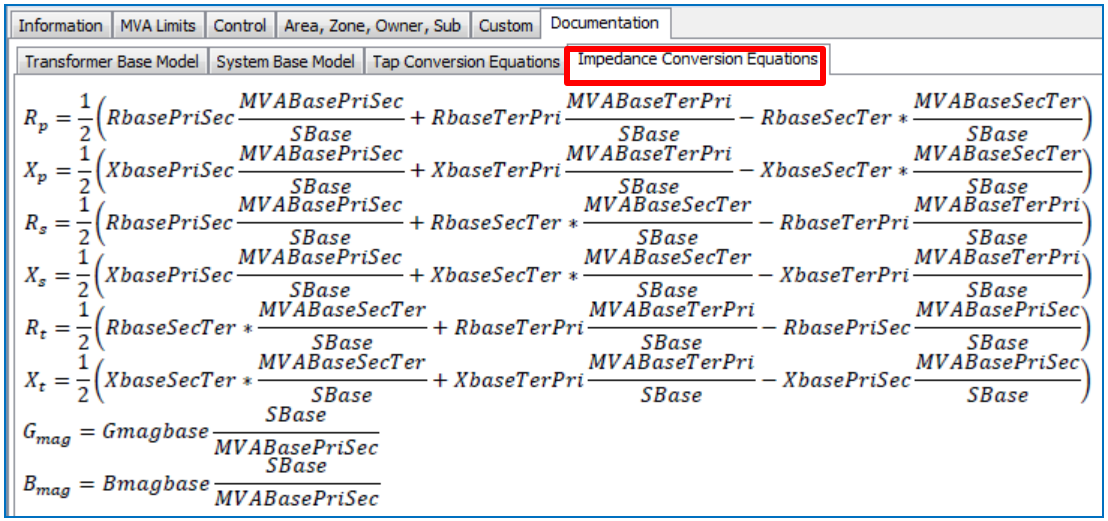
Three-Winding Transformer Dialog Documentation Images





$$TapMultPri = \frac{NomkVPri}{NomkVSystemPriBus}$$
$$PMinTap = (TapMinPri + TapNomPri - 1) * TapMultPri$$
$$PMaxTap = (TapMaxPri + TapNomPri - 1) * TapMultPri$$
$$PTapRatio = (TapPri + TapNomPri - 1) * TapMultPri$$
$$PStepSize = (TapStepSizePri) * TapMultPri$$
$$PPhase = PhasePri$$
$$TapMultSec = \frac{NomkVPri}{NomkVSystemPriBus}$$
$$SMinTap = (TapMinSec + TapNomSec - 1) * TapMultSec$$
$$SMaxTap = (TapMaxSec + TapNomSec - 1) * TapMultSec$$
$$STapRatio = (TapSec + TapNomSec - 1) * TapMultSec$$
$$SStepSize = (TapStepSizeSec) * TapMultSec$$
$$SPhase = PhaseSec$$
$$TapMultTer = \frac{NomkVTer}{NomkVSystemTerBus}$$
$$TMinTap = (TapMinTer + TapNomTer - 1) * TapMultTer$$
$$TMaxTap = (TapMaxTer + TapNomTer - 1) * TapMultTer$$
$$TTapRatio = (TapTer + TapNomTer - 1) * TapMultTer$$
$$TStepSize = (TapStepSizeTer) * TapMultTer$$
$$TPhase = PhaseTer$$



$$R_p = \frac{1}{2}\left(RbasePriSec\frac{MVABasePriSec}{SBase} + RbaseTerPri\frac{MVABaseTerPri}{SBase} - RbaseSecTer * \frac{MVABaseSecTer}{SBase}\right)$$
$$X_p = \frac{1}{2}\left(XbasePriSec\frac{MVABasePriSec}{SBase} + XbaseTerPri\frac{MVABaseTerPri}{SBase} - XbaseSecTer * \frac{MVABaseSecTer}{SBase}\right)$$
$$R_s = \frac{1}{2}\left(RbasePriSec\frac{MVABasePriSec}{SBase} + RbaseSecTer * \frac{MVABaseSecTer}{SBase} - RbaseTerPri\frac{MVABaseTerPri}{SBase}\right)$$
$$X_s = \frac{1}{2}\left(XbasePriSec\frac{MVABasePriSec}{SBase} + XbaseSecTer * \frac{MVABaseSecTer}{SBase} - XbaseTerPri\frac{MVABaseTerPri}{SBase}\right)$$
$$R_t = \frac{1}{2}\left(RbaseSecTer * \frac{MVABaseSecTer}{SBase} + RbaseTerPri\frac{MVABaseTerPri}{SBase} - RbasePriSec\frac{MVABasePriSec}{SBase}\right)$$
$$X_t = \frac{1}{2}\left(XbaseSecTer * \frac{MVABaseSecTer}{SBase} + XbaseTerPri\frac{MVABaseTerPri}{SBase} - XbasePriSec\frac{MVABasePriSec}{SBase}\right)$$
$$G_{mag} = Gmagbase\frac{SBase}{MVABasePriSec}$$
$$B_{mag} = Bmagbase\frac{SBase}{MVABasePriSec}$$

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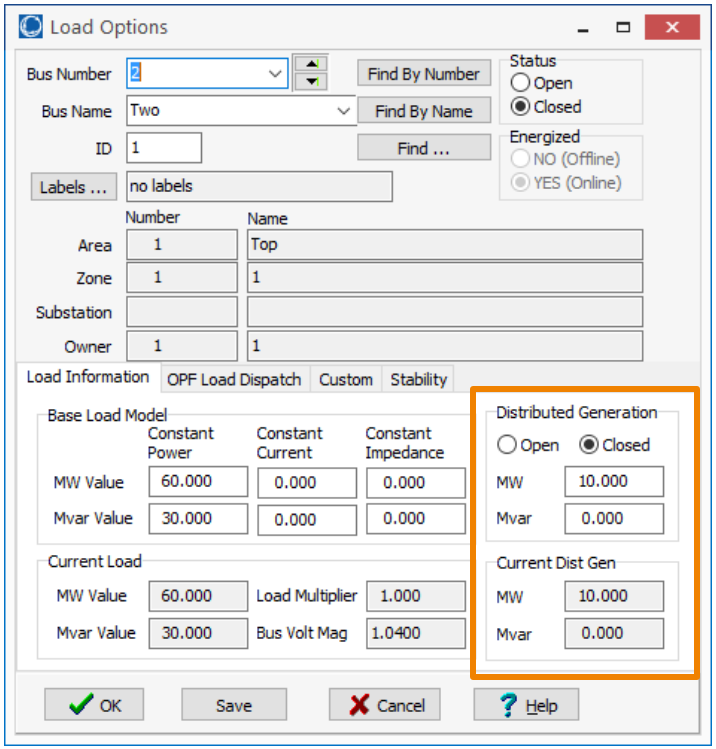
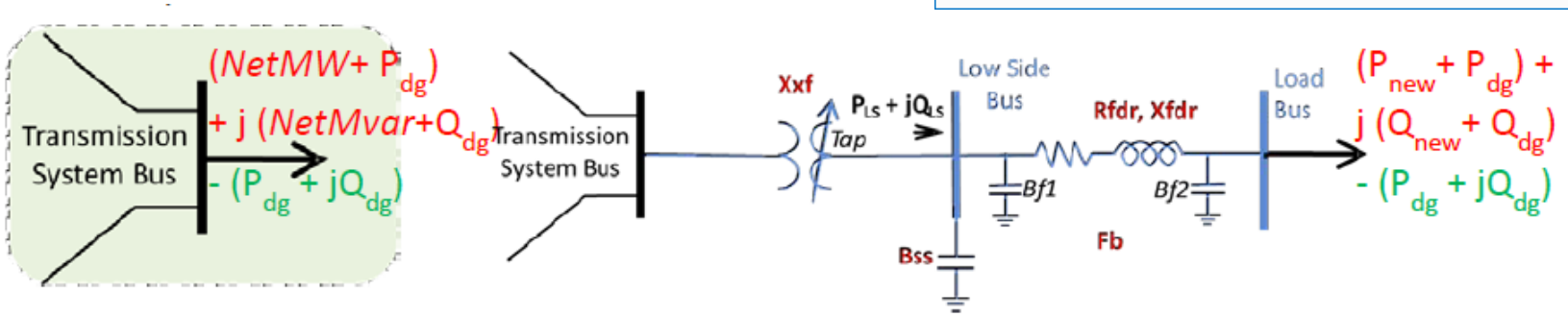
Distributed Generation

- Define as part of load
- Steady-state modeling
  - Contributes to Net MW
  - Does not scale with scaling tools
- Transient stability modeling
  - DGPV model
  - Modeled at the end of the distribution equivalent





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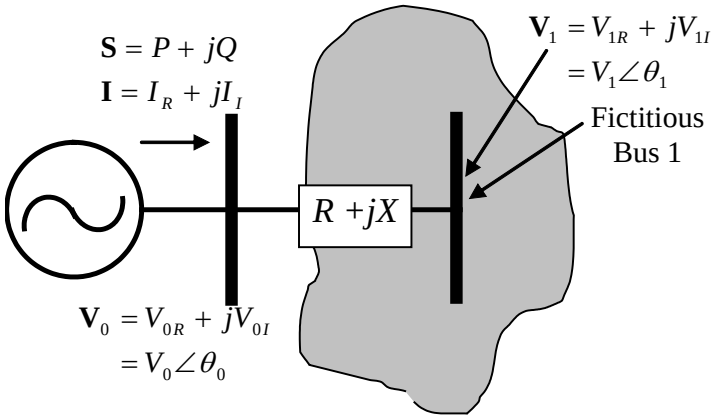
Generator Line Drop Compensation

- R can now be defined in addition to X as part of the line drop impedance
- Generator using LDC or RCC control
  - Generator controls the voltage at a "fictitious bus" some impedance away from the generator
  - This models the real-time control done at some real generators
  - If RLDC_RCC and XLDC_RCC are both less than the ZBR Threshold (default 0.0002) the generator will regulate its own terminal



X > 0 : Called LDC

X < 0 : Called RCC

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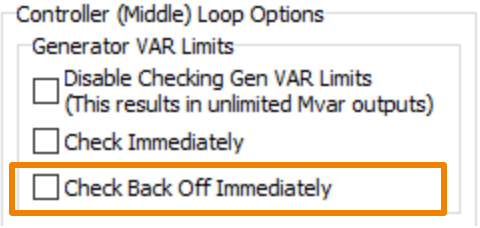
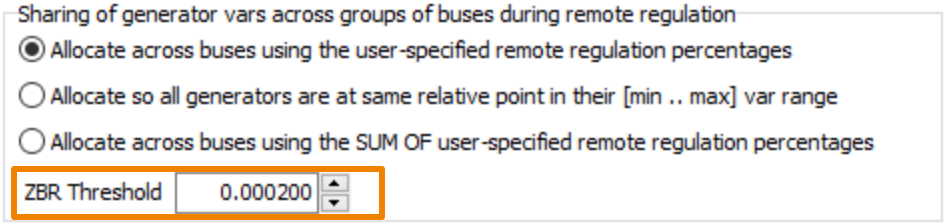
Power Flow Solution

- *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



- Generators at the same bus are no longer required to have the same Mvar remote regulation percentage
- *ZBR Threshold* can now be specified by the user
  - Used internally to build groups of buses connected by very low impedance branches
    - Coordinate generator and switched shunt Mvar control
    - Balance parallel transformer taps
  - Default is 0.0002 per unit



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Voltage Control Group

- Models the Centralized Grid Capacitor Control (CGCC) algorithm for Southern California Edison
- New object Voltage Control Group
  - Status determines how they are used
    - ON – Normal behavior where the Control Group acts as expected as long as the global option for moving switched shunts is enabled
    - OFF – Control group is ignored and the individual switched shunts in the group revert back to their own individual control behavior
    - FORCEON – Ignore the global option (or Area record option) that disable switched shunt control and always force control enabled for this group. This option makes it easy to have control on ONLY for switched shunts in Voltage Control Groups.
  - Assign Switched Shunts to control group
- Voltage control range is still set with each Switched Shunt – Volt High and Volt Low

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Voltage Control Group Algorithm

- Voltage Control Group processing occurs in the Voltage Control Loop of the Simulator Single Solution process
- Each Voltage Control Group processes its own list of switched shunts independently
  - Largest deviations are measured in kV and not per unit so that regulated buses with a higher nominal voltage have a higher precedence
  - Only switched shunts that are marked as Control Mode = *Discrete* participate in Voltage Control Groups. Any marked as *Continuous, SVC, Fixed,* or *BusShunt* will be ignored and will not switch at all.
  - Voltage Control Group processing
    - Determine the switched shunt that has the largest deviation below Vlow (call this LowShunt)
    - Determine the switched shunt that has the largest deviation above Vhigh (call this HighShunt)
    - If LowShunt found, move that switched shunt UP by one step, Else if HighShunt found, move this switched shunt DOWN by one step
- Switched shunts that are not in Voltage Control Groups are processed after the control groups and operate as they always have

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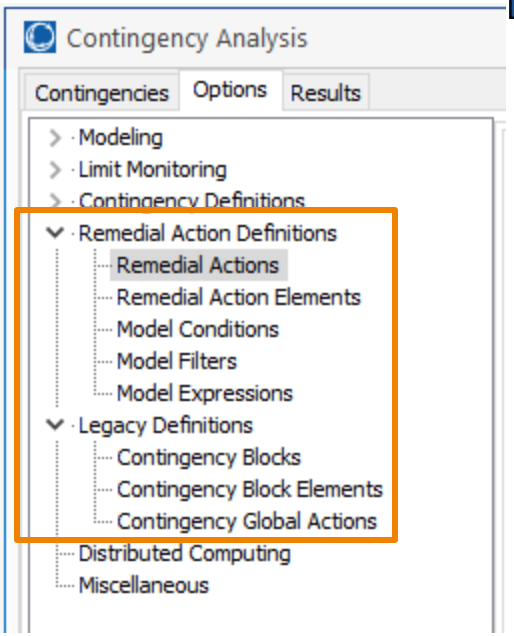
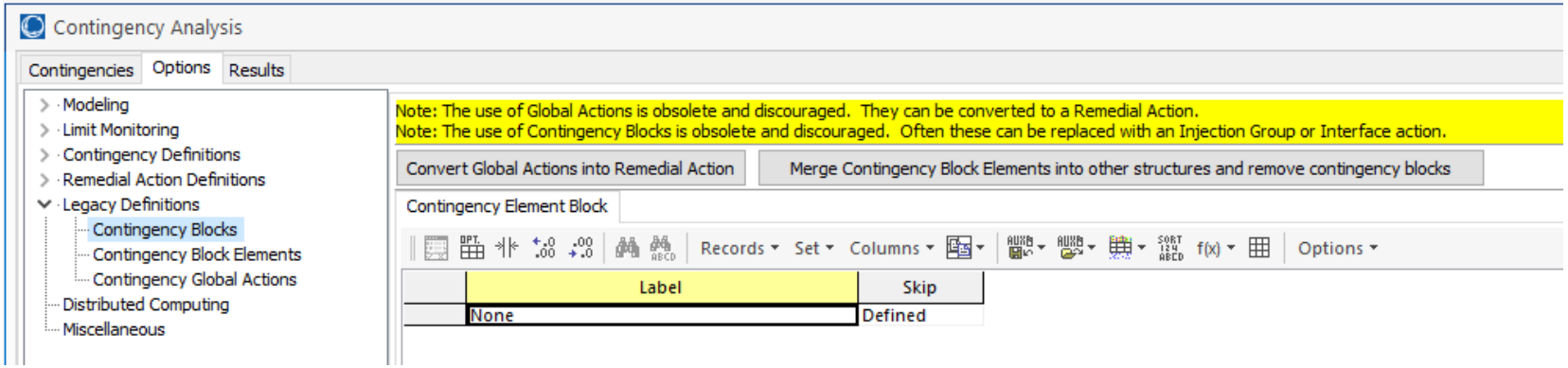
Contingency Analysis Dialog

- Reorganization of the dialog
  - Remedial Action Definitions (AKA Use these)
    - All of the objects necessary for designing RAS
  - Legacy Definitions (AKA Don't use these)
    - Contingency Blocks and Global Actions
    - Going forward Remedial Actions should be used instead of Global Actions
    - Contingency Blocks can be converted into individual contingency elements or replaced with Injection Groups or Interfaces
    - Buttons have been added to make converting legacy objects easier





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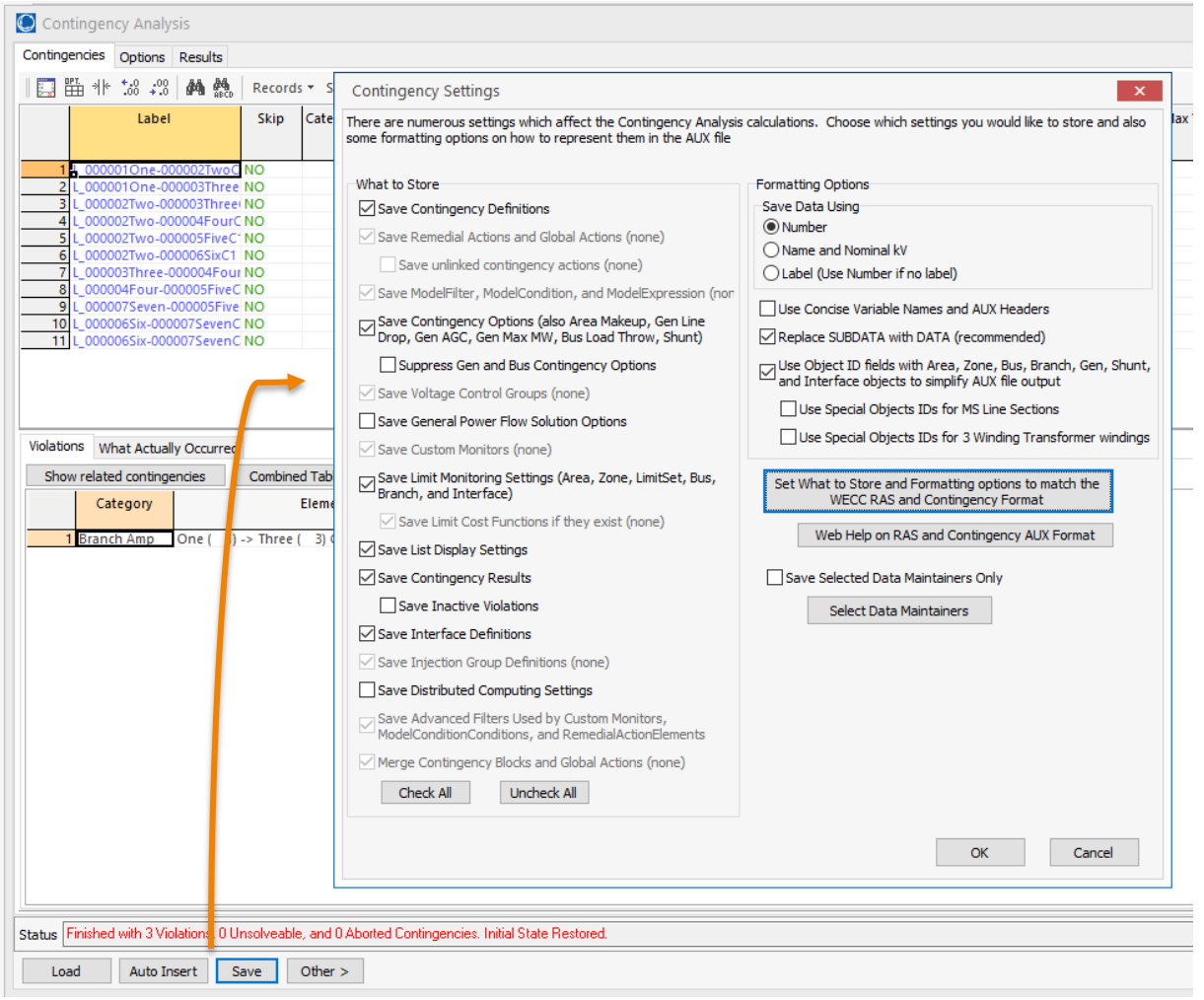
Saving Contingencies and Options

- Greatly enhanced the dialog to save options, results, and objects from the Save button on the Contingency Anaylsis dialog
- Dialog makes it easier to save the object types and format required for the WECC RAS and Contingency Format



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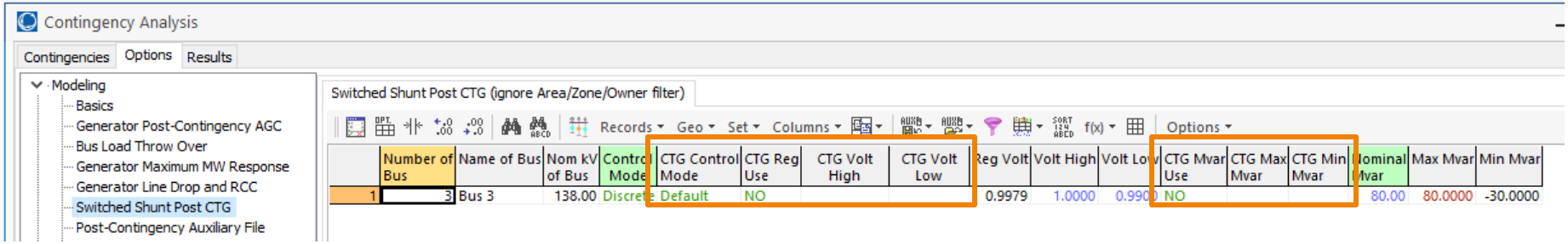
Contingency Analysis Options

- Switched Shunt Post CTG
  - Global and area options for allowing switched shunt control must be enabled for a shunt to operate during contingency
  - Change parameters for shunt operation during contingency
    - Control Mode
    - Volt High
    - Volt Low
    - Min and Max Mvar for shunts that are on Continuous control during contingency



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Contingency Analysis
New Fields

- *Monitor (element)* field added to contingency violations to make it easy to not monitor objects
- With contingency violations, Custom Float, Integer, and String fields associated with the overloaded element can be accessed
- Added fields to display owner names and numbers with contingency elements
- *Contingency Results\Max % Ld Loading Direction* with branches to show the direction of loading on this line during the contingency that causes the maximum overload
- *Total Dropped Load MW* with contingency to summarize amount of load islanded or dropped due to contingency actions

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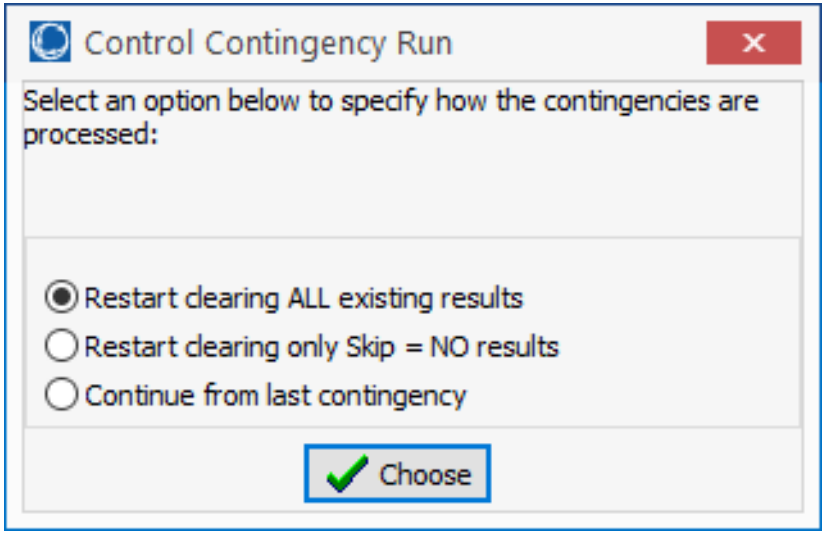
Contingency Analysis Options

- When running contingency analysis and results already exist, user will be prompted which results should be cleared
- Partial runs can be done without losing results
- CTGSolveAll script command also has similar functionality



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Contingency Analysis
New Actions and Action Changes

- New actions
  - OPEN a Substation
    - Can also auto insert substation outages
  - OPEN a Substation WITH BREAKERS
  - SET resistance of DC Line TO an Amount
  - SET MVA Limit of Branch TO an Amount
  - OPEN Number Elements in an Injection Group
  - CHANGE Injection Group BY MW Effect Amount
- Action Changes
  - When opening Injection Group in Merit Order, added options to *Do Not Exceed Amount* and *Allow to Exceed Amount*
  - Added option to *Evaluate Part Points in Reference State* for Injection Groups
    - Injection Group participation factors can be specified by a Model Expression or Field of the participation point object
  - Injection Group Merit Order actions now include loads

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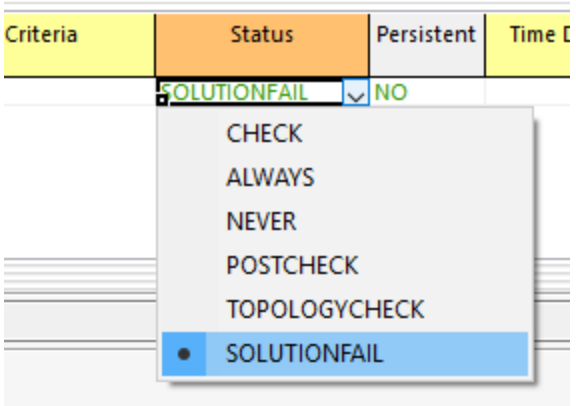
Contingency Analysis SOLUTIONFAIL Status

- Action is conditional on the power flow not solving
- Model Criteria may also be specified but is not required
- If failed power flow is encountered, system state is restored to what existed before the failed solution
  - Any SOLUTIONFAIL action where Model Criteria is met, or none is defined, will be applied
  - Another power flow solution will be attempted
  - This is repeated until the power flow solves or there are no more SOLUTIONFAIL actions



- If Solve Power Flow actions exist, all of these will be processed before any SOLUTIONFAIL actions are attempted

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Contingency Analysis Persistent Actions

- Normally after any contingency action is applied it will not be applied again
- Marking an action as *Persistent* will allow the action to be applied as long as its Model Criteria is met
  - Only allowed for TOPOLOGYCHECK, POSTCHECK, and SOLUTIONFAIL actions
  - SOLUTIONFAIL actions will only remain persistent up until a solution is achieved
- Useful for dropping generation or load in steps until a line is no longer overloaded

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Contingency Analysis
Time Delay

- Time to wait in seconds before an action is applied
- Serves as a relative ordering for implementation of actions during steady state analysis
- Actions with smallest delay (down to a microsecond) will be applied first during TOPOLOGYCHECK, POSTCHECK, and SOLUTIONFAIL solution steps
- Ignored during CHECK solution step
- Default all time delays to 0 to ignore

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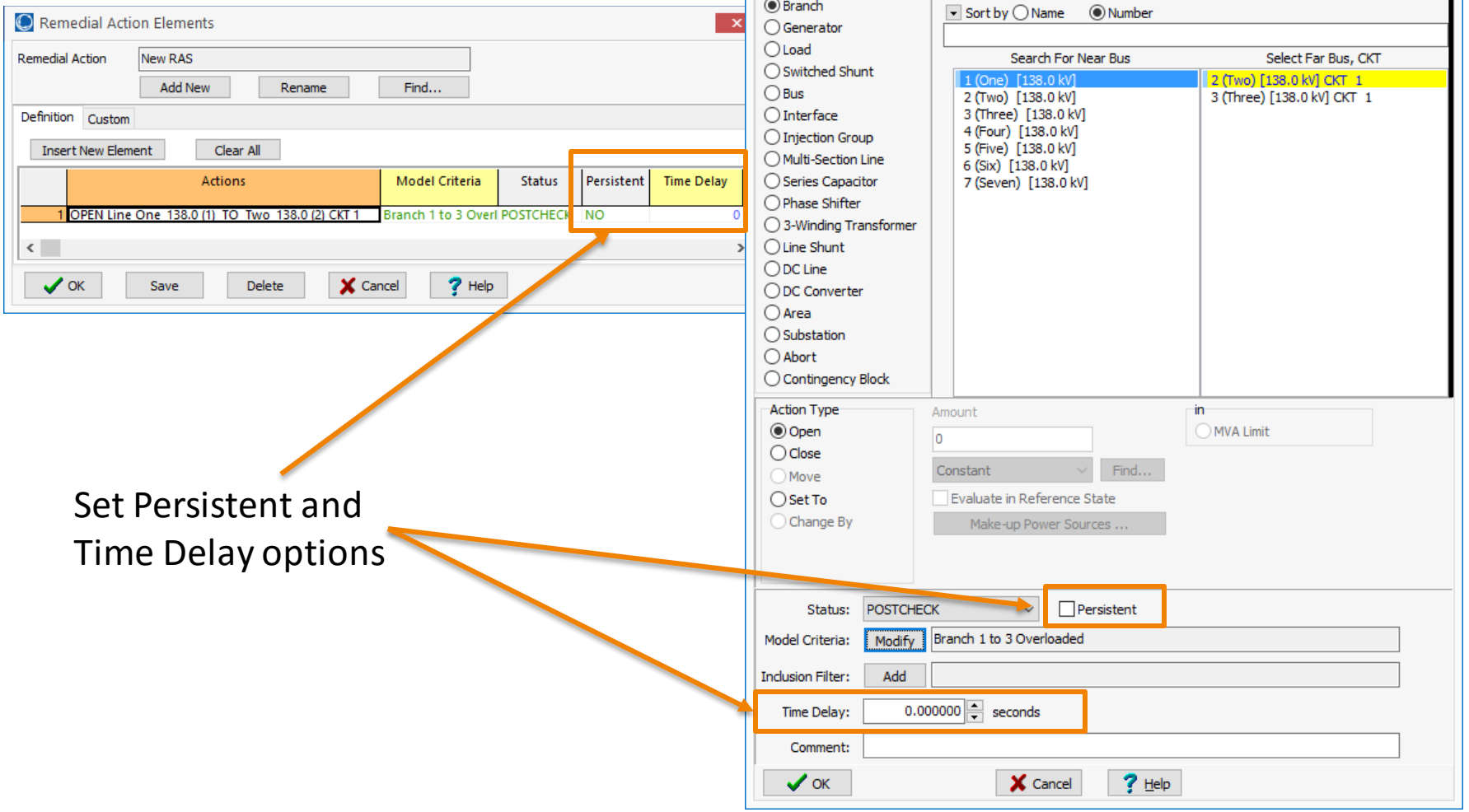
Contingency Analysis Options



Set Persistent and Time Delay options

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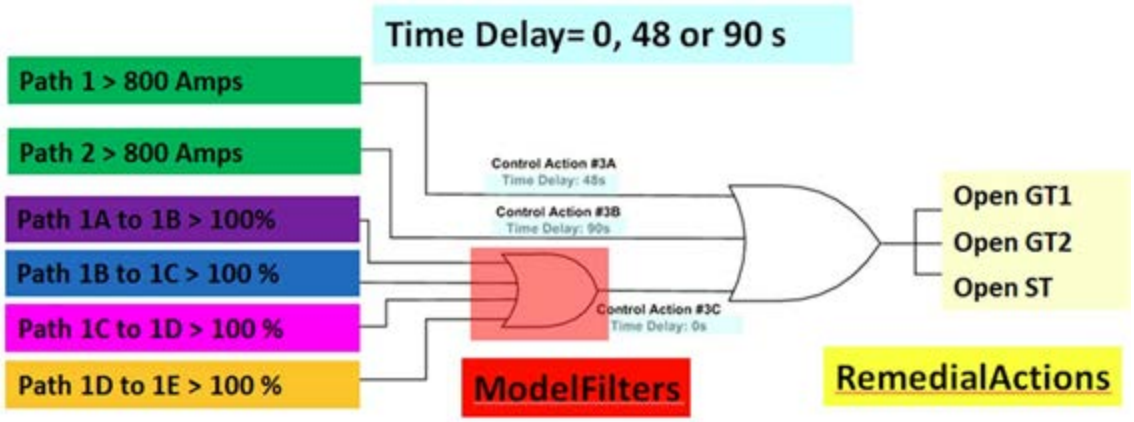
Model Filter Condition Time Delay

- Time Delay can be used with Model Filter Conditions
  - Allows time delay on the input of a logic gate
  - Helpful when same exact actions need to occur based on Model Filters or Conditions being true at different time delays



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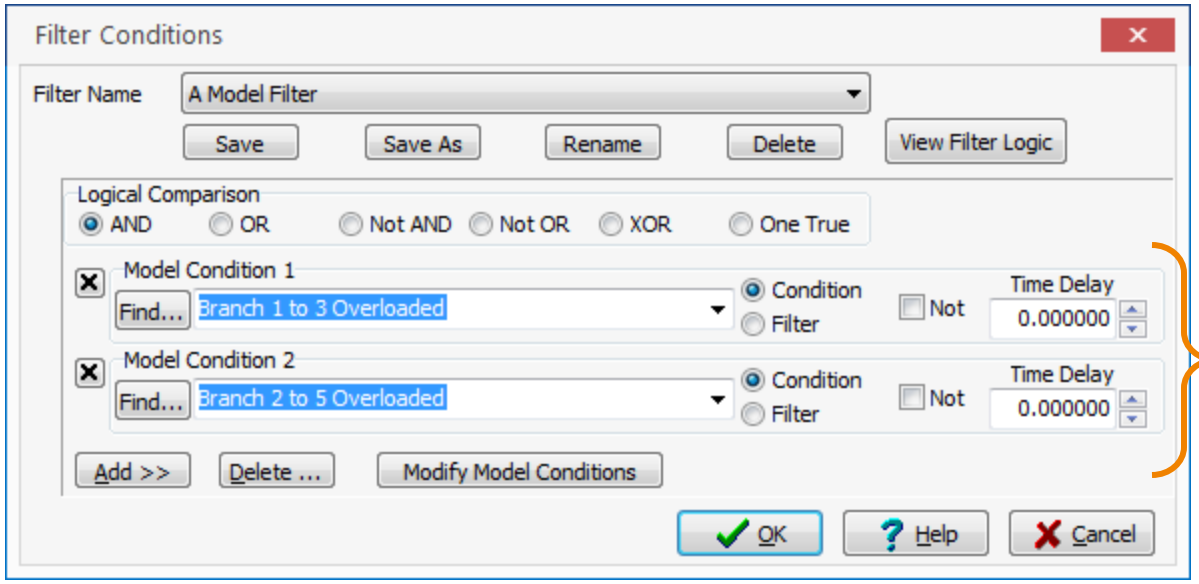
Model Filter
Calculated Time Delay

- Calculated Time Delay must be determined for any Model Filter that has ModelFilterConditions using Time Delays
- Calculated Time Delay depends on the logic being used



Time Delay with ModelFilterCondition

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Model Filter
Calculated Time Delay

- ModelFilterCondition can be either a ModelFilter or ModelCondition
- *InputTimeDelay* is the Time Delay with the ModelFilterCondition

Criteria Object	***InputTimeDelay* for the ModelFilterCondition**
ModelFilter	Use the summation of the Calculated Time Delay of the ModelFilter and the TimeDelay associated with this ModelFilterCondition
ModelCondition	Directly use TimeDelay associated with this ModelFilterCondition

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Model Filter
Calculated Time Delay

- Logic of the Model Filter will determine the Calculated Time Delay

Gate Logic	Calculated Time Delay
AND	The maximum *InputTimeDelay* associated with any of the TRUE ModelFilterCondition inputs
OR	The minimum *InputTimeDelay* associated with any of the TRUE ModelFilterCondition inputs
NAND	The minimum *InputTimeDelay* associated with any of the FALSE ModelFilterCondition inputs
NOR	The maximum *InputTimeDelay* associated with any of the FALSE ModelFilterCondition inputs
XOR	The minimum *InputTimeDelay* associated with any of the TRUE ModelFilterCondition inputs.
OneTRUE	The *InputTimeDelay* associated with the TRUE ModelFilterCondition

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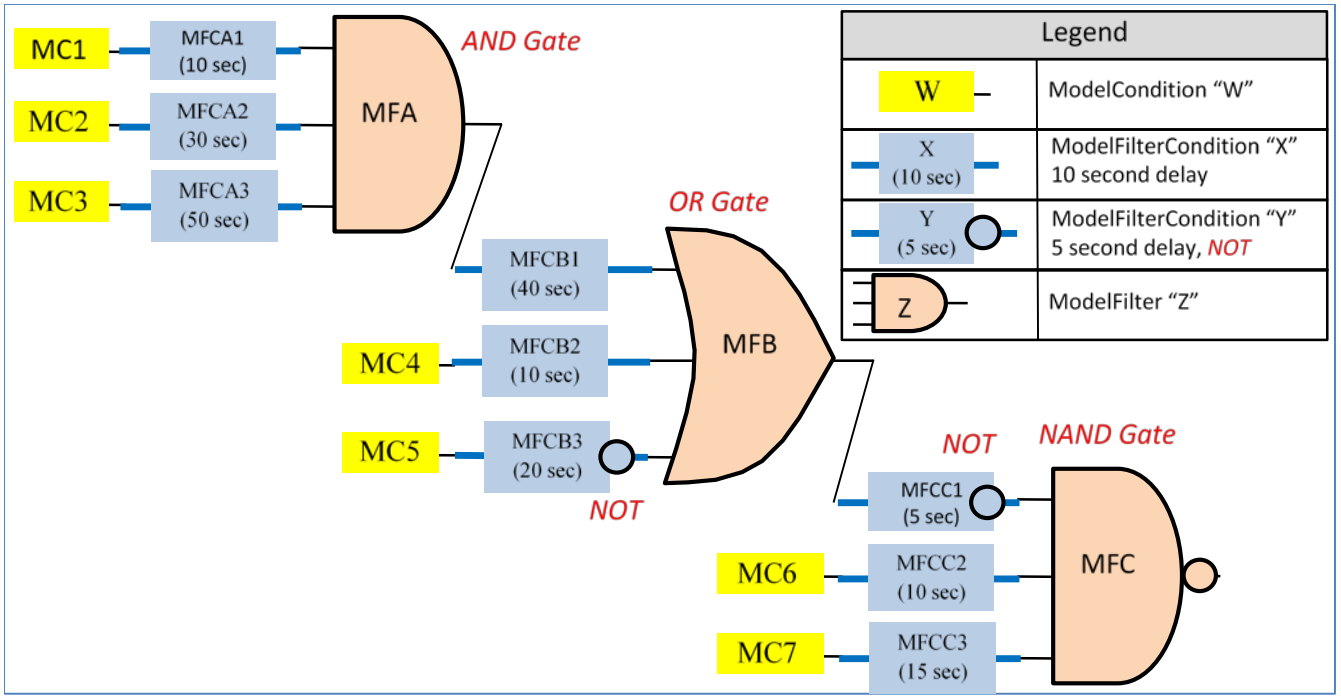
Calculated Time Delay Example



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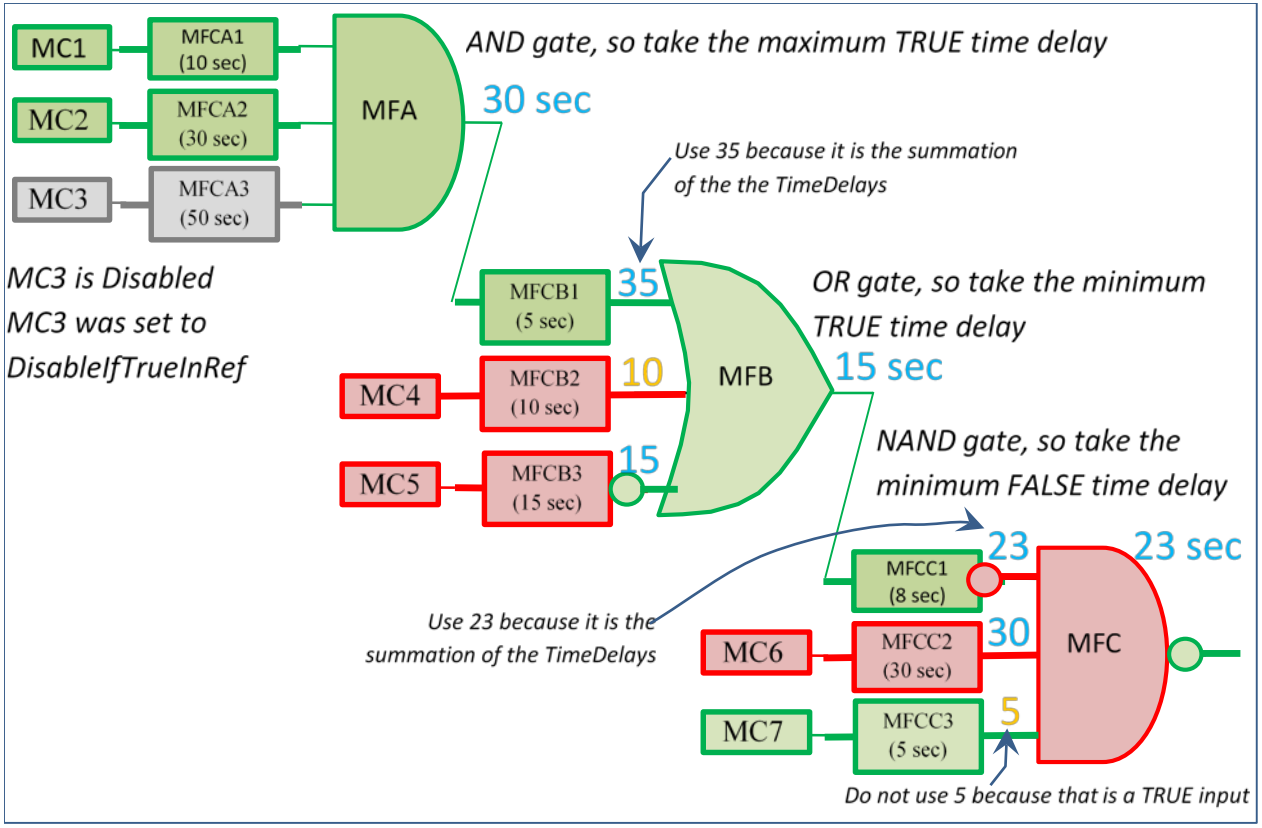
Calculated Time Delay Example



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What Time Delay is Used?

- Determined by type of Model Criteria of Contingency Element or Remedial Action Element
  - Model Condition
    - Time Delay specified with the Contingency or Remedial Action Element is used directly
  - Model Filter
    - Time Delay specified with the Contingency or Remedial Action Element is added to the Calculated Time Delay of the Model Filter

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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
   a) TRANSIENT actions will also be evaluated
   b) TRANSIENT or TOPOLOGYCHECK actions with smallest Time Delay will be applied
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) TRANSIENT, 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)

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Contingency Analysis
What Actually Occurred Order

- New fields have been added to indicate the order and the step in the contingency process in which an action was applied
  - Group Order
    - Groups are defined by the different Status checks, i.e. CHECK, TOPOLOGYCHECK, POSTCHECK, etc. that occur during the contingency process
  - Subgroup Order
    - Specific order in which an action was applied within a Group
  - Group Status
    - Status that defines the step in the process in which the action was applied, i.e. CHECK, TOPOLOGYCHECK, POSTCHECK, etc.
    - This may differ from the Status of the contingency/remedial action element

Violations | What Actually Occurred

	Contingency	Applied or Skipped	Actions	Group Order	Subgroup Order	Group Status	Origin of Action	
1	Open 2 to 5	Applied	OPEN Line Two_138.0 (2) TO Five_138.0 (5) CKT 1	1	1	CHECK	ELEMENT	Op
2	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	3	1	POSTCHECK	REMEDIAL	Ge
3	Open 2 to 5	Applied	CHANGE GENERATION AT BUS Two_138.0 (2) BY -2 % of present MW	3	2	POSTCHECK	REMEDIAL	Bu
4	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	5	1	POSTCHECK	REMEDIAL	Ge
5	Open 2 to 5	Applied	CHANGE GENERATION AT BUS Two_138.0 (2) BY -2 % of present MW	5	2	POSTCHECK	REMEDIAL	Bu
6	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	7	1	POSTCHECK	REMEDIAL	Ge
7	Open 2 to 5	Applied	CHANGE GENERATION AT BUS Two_138.0 (2) BY -2 % of present MW	7	2	POSTCHECK	REMEDIAL	Bu
8	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	9	1	POSTCHECK	REMEDIAL	Ge
9	Open 2 to 5	Applied	CHANGE GENERATION AT BUS Two_138.0 (2) BY -2 % of present MW	9	2	POSTCHECK	REMEDIAL	Bu
10	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	11	1	POSTCHECK	REMEDIAL	Ge
11	Open 2 to 5	Applied	CHANGE GENERATION AT BUS Two_138.0 (2) BY -2 % of present MW	11	2	POSTCHECK	REMEDIAL	Bu
12	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	13	1	POSTCHECK	REMEDIAL	Ge
13	Open 2 to 5	Applied	CHANGE GENERATION AT BUS Two_138.0 (2) BY -2 % of present MW	13	2	POSTCHECK	REMEDIAL	Bu
14	Open 2 to 5	Applied	CHANGE GENERATOR One_138.0 (1) #1 BY -5 % of present MW	15	1	POSTCHECK	REMEDIAL	Ge

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Options to Evaluate in Contingency Reference State

- More options added to evaluate fields in contingency reference state
  - Expression variables
  - Model Expression variables
  - ModelConditionCondition variables
- Will increase the flexibility of RAS modeling
  - Instead of two different model conditions to check the status of a branch in the reference state and the contingency state only one is necessary

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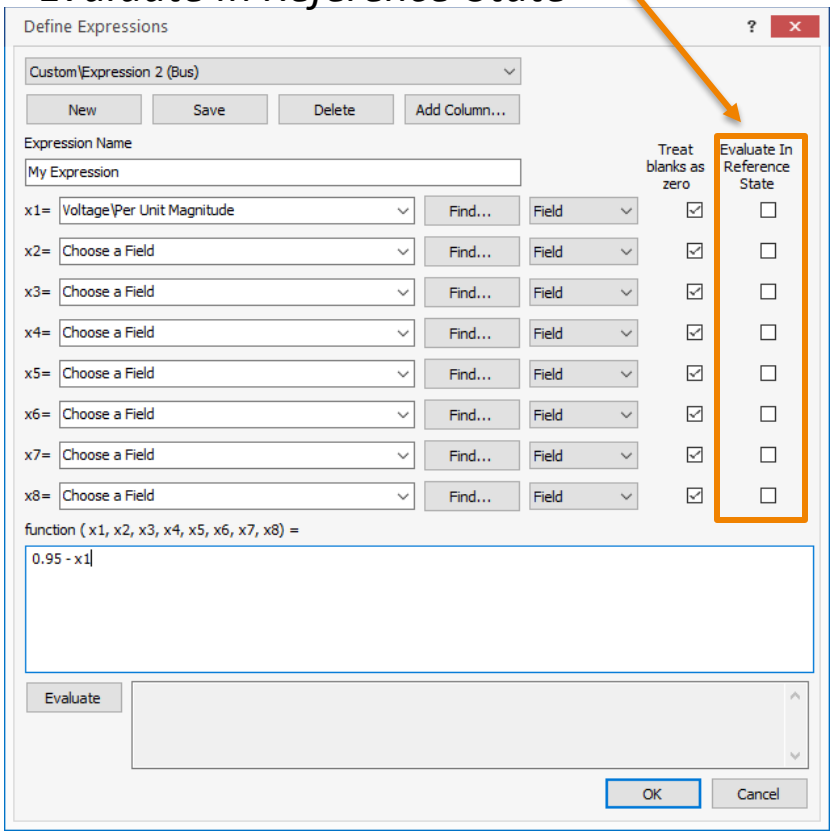
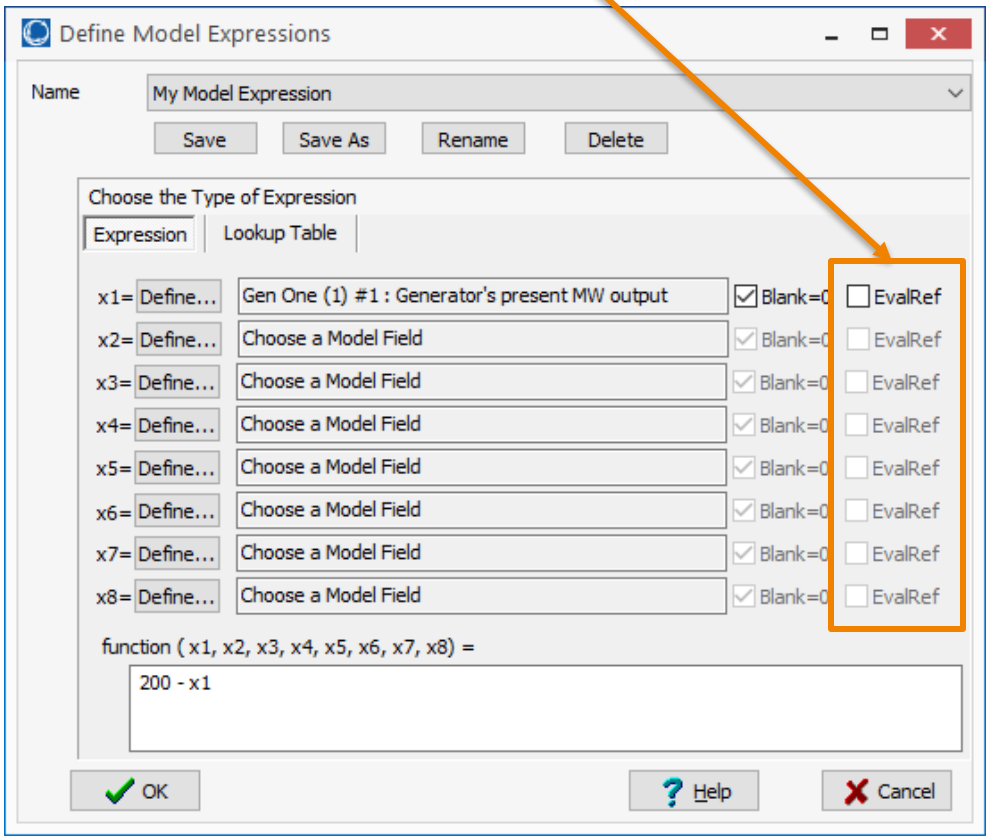
Evaluate in Contingency Reference State

Each variable of an Expression has an option to *Evaluate in Reference State*

Each variable of a Model Expression has an option to *EvalRef*





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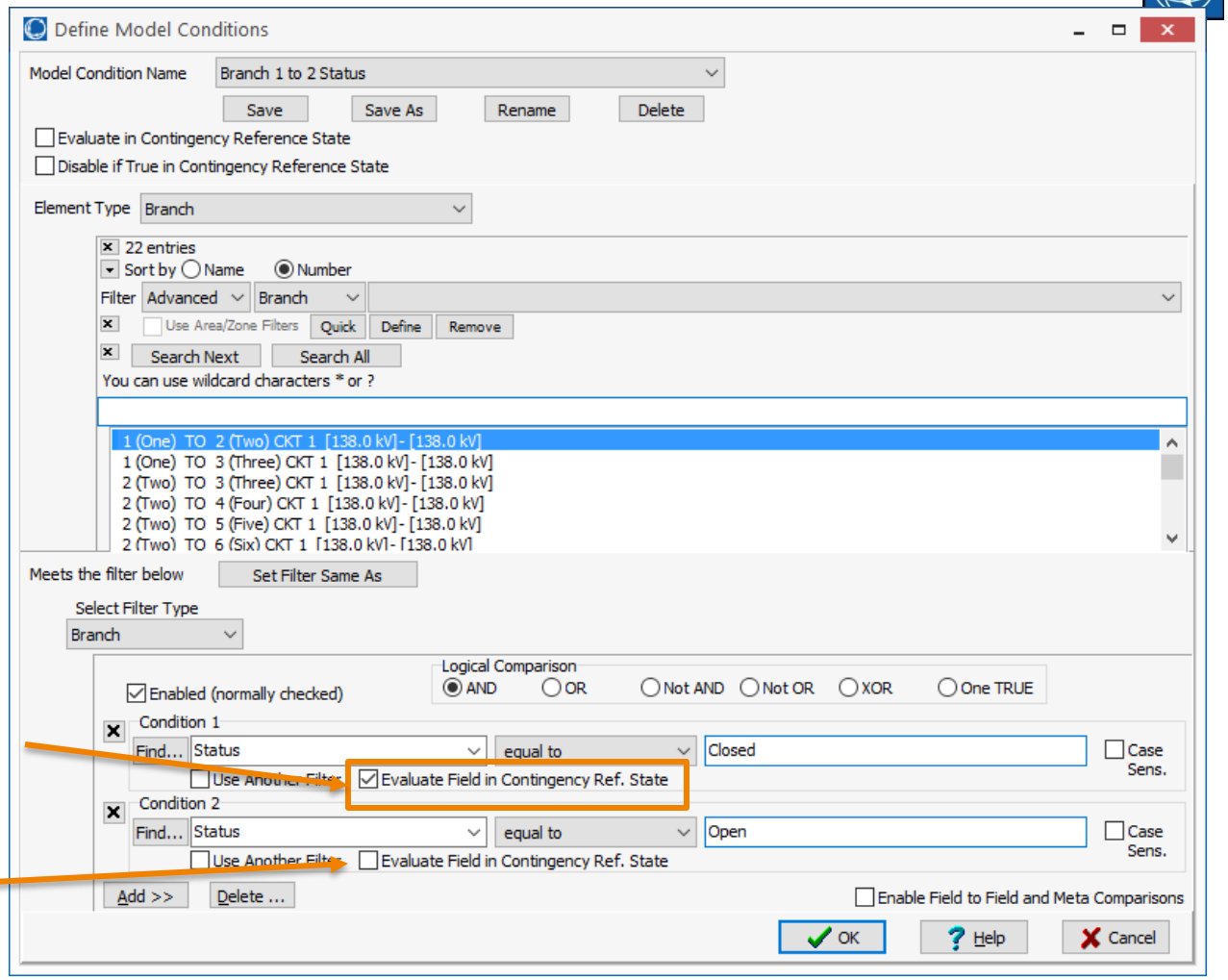
Evaluate in Contingency Reference State

Single Model Condition comprised of two ModelConditionConditions



Branch must be Closed in the contingency reference state

AND Open in the contingency state to meet the condition

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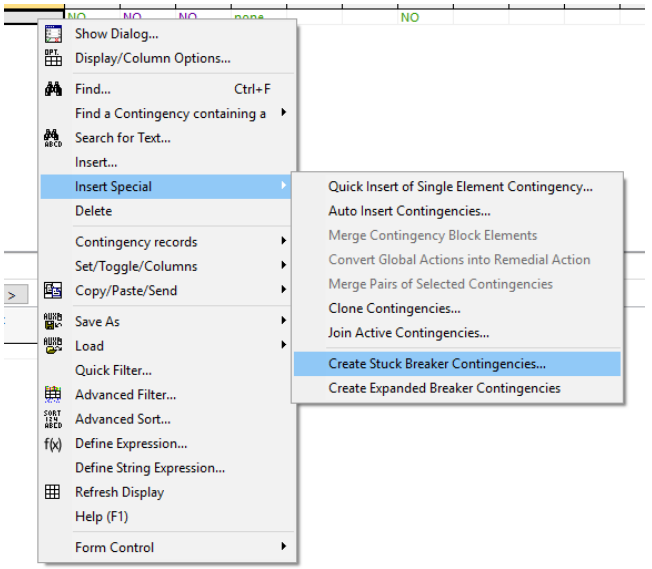
Contingency Analysis
Breaker Contingencies

- *Create Stuck Breaker Contingencies*
  - Processes each contingency that has explicit breakers defined and creates new contingencies by treating each breaker as stuck in turn
  - New contingencies comprised of all existing elements, minus the stuck breaker outage, plus open actions for breakers that are identified to isolate the stuck breakers



- *Create Expanded Breaker Contingencies*
  - Converts any *Open with Breakers* or *Close with Breakers* contingency actions into *Open* actions on explicit breakers

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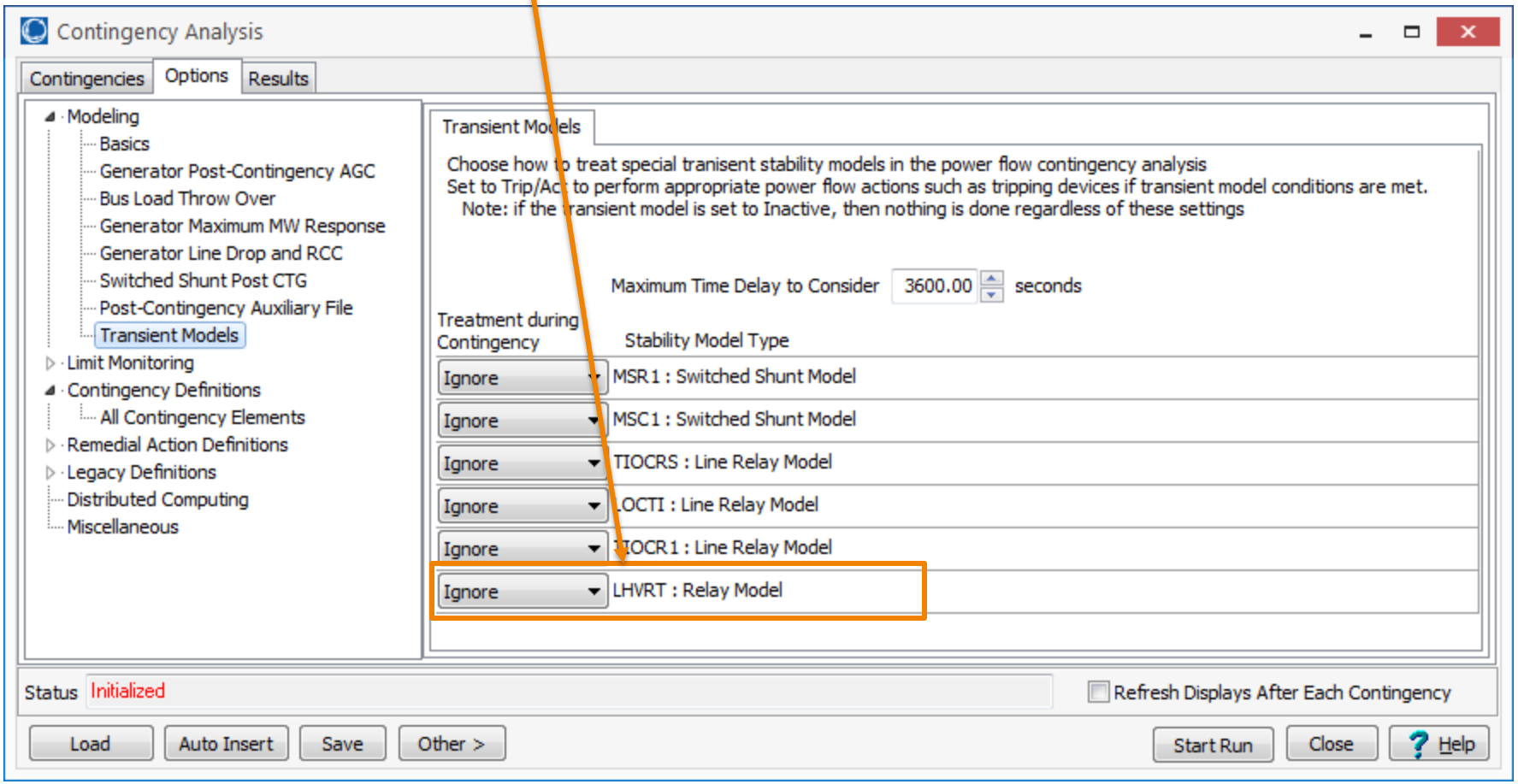
Transient Stability Models in Steady State Contingency Analysis

LHVRT Generator Relay now supported



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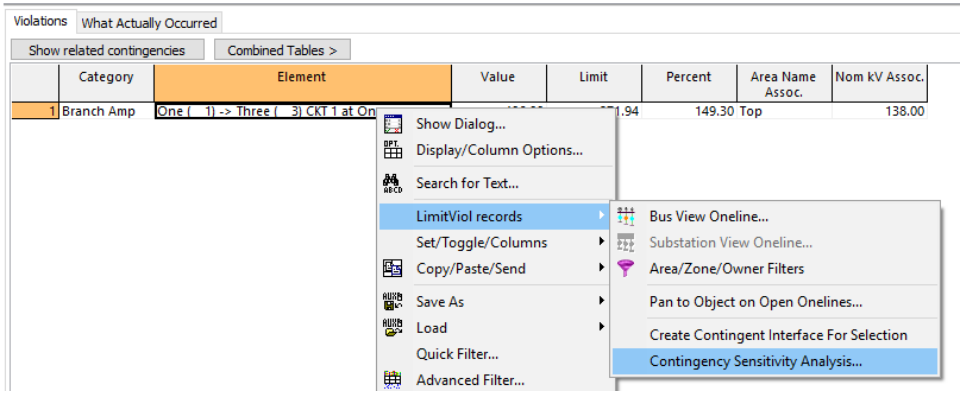
Contingency Sensitivity Analysis

- New tool to perform sensitivity analysis on a particular contingency and violation
- Contingency for selected violation is actually implemented
- GSF/TLR calculations on violated element



- Interfaces can be selected for additional GSF/TLR calculations
- Branches can be selected for LODF/LCDF calculations and their impact on the violated element
- Some options included for facilitating Dynamic Formatting of results

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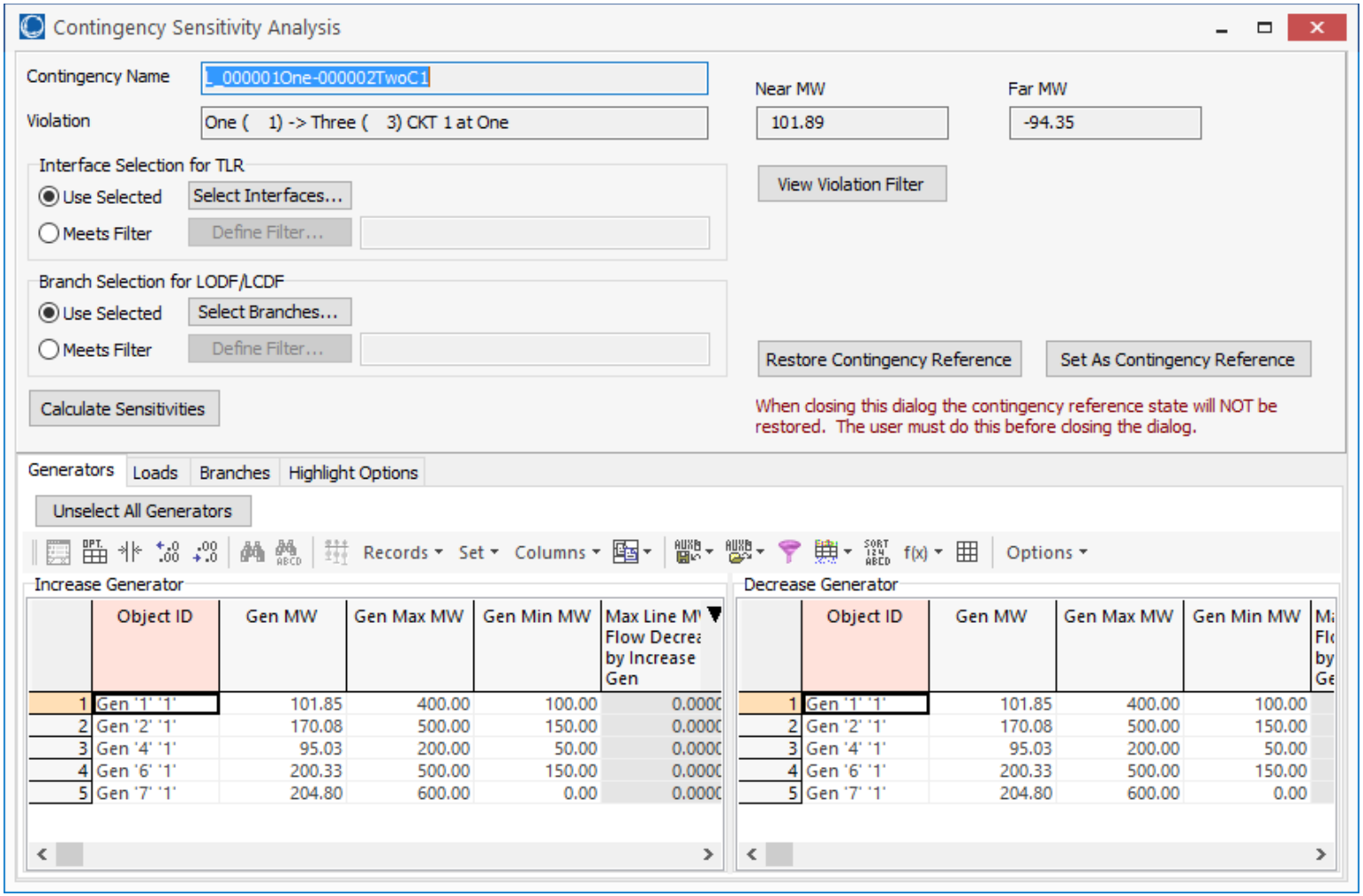
Contingency Sensitivity Analysis



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Transient Stability Help

- Block Diagrams are integrated into the PowerWorld website help documentation
  - http://www.powerworld.com/webhelp
  - Transient Stability Add-On (TS) folder
  - *Show Block Diagram* buttons within GUI will take you to the website
  - Continuing to add more complete documentation
    - Data checking and auto-correction descriptions

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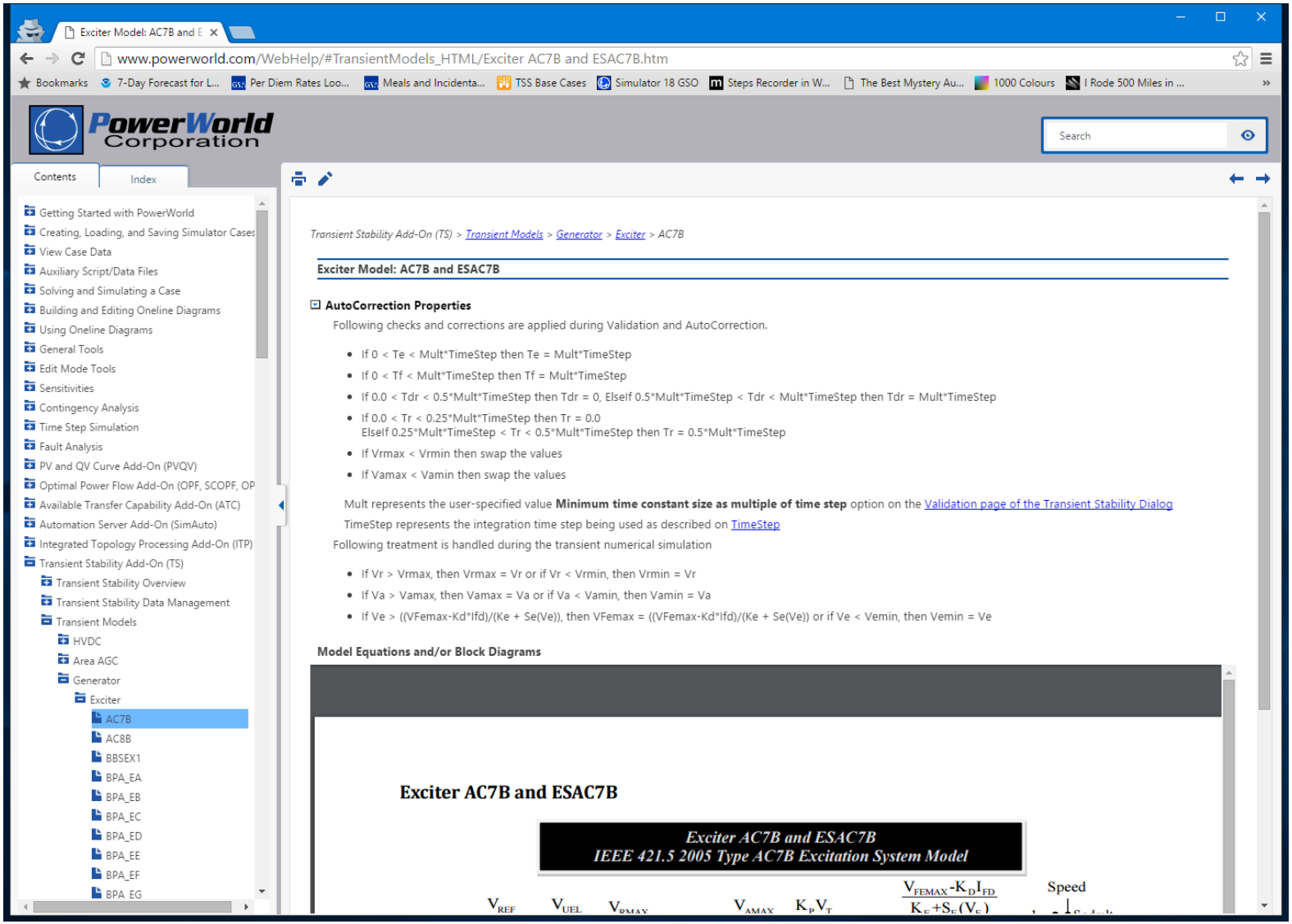
Transient Stability Help



Transient Stability
General

- Modified to store and show generator Speed values in per unit instead of Hz
  - When reading old cases or AUX files with transient limit monitors this conversion occurs automatically
- A lot of additional data error checking
  - SVCs
  - Load models
  - Distribution Equivalent
- Negative simulation start times and end times are allowed
- Added ability to compare transient stability input data using Difference Flows tool
  - Still need to complete the machine models

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Transient Stability
General

- *TS Contour Export Options*
  - New feature for easy creation of a time series of images using the Transient Contour Toolbar
- New objects included in results monitoring:
  - Substations
  - Case Information
    - Case-wide quantities such as total generator or load
  - Line Shunts
- Continuing support for reading (*.SWT) switch files
- Support for reading DYD file with label identifiers

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Transient Stability Contingencies

- New fields available when viewing Multiple Contingencies table:
  - *Processed* field expanded into *Processed*, *Solved*, and *Reason Not Solved* fields to provide more details on what happened
  - *Islanded Load*
  - *Islanded Gen*
- Label identifiers can be used when auto inserting contingencies
- *Clone Transient Contingency* option
  - Creates new contingencies that are copies of the selected contingencies
  - Available from local menu of Multiple Contingencies table or button when viewing single contingencies

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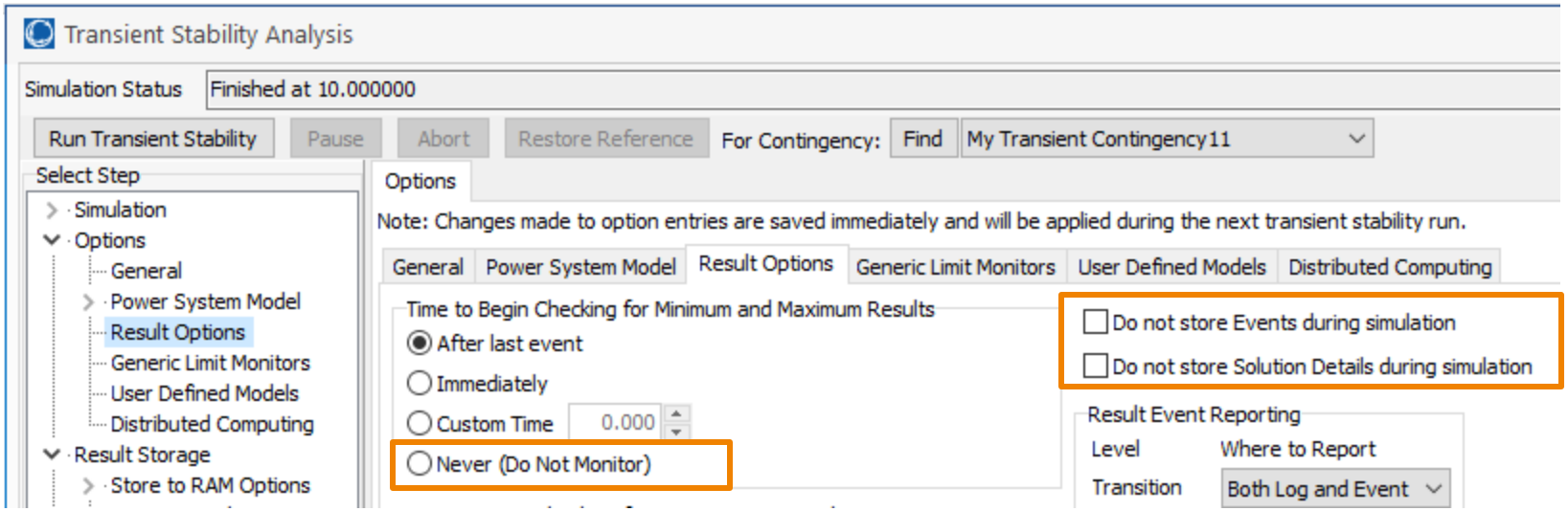
Transient Stability
Result Options

- Option to not monitor Min/Max limits
- Option to not store Events during simulation
- Option to not store Solution Details during simulation



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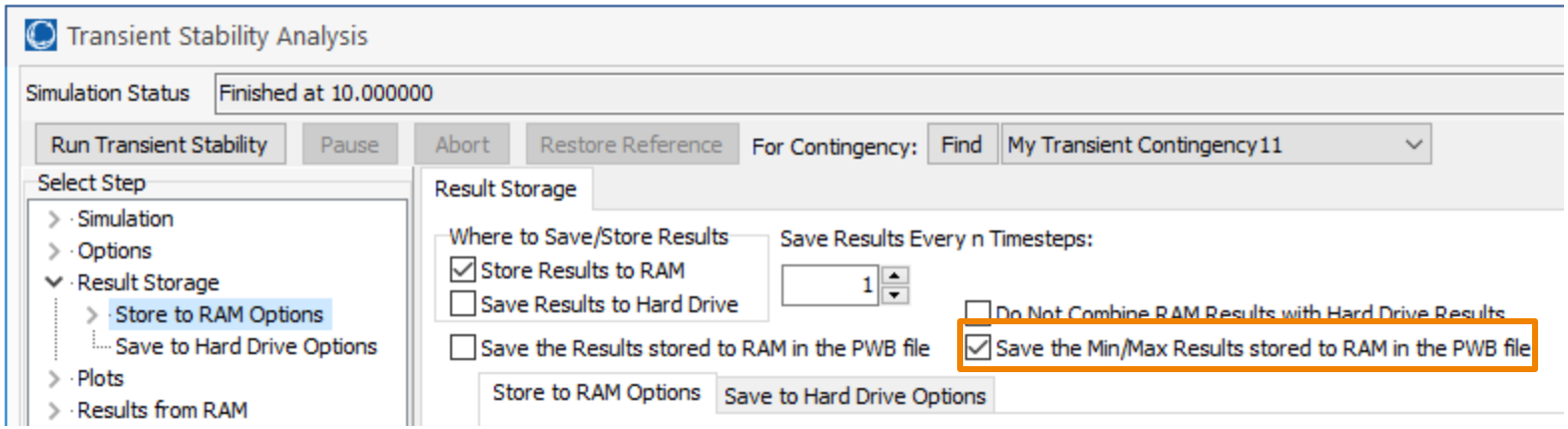
Transient Stability
Result Storage

- Option to save Min/Max results stored in RAM in PWB file instead of just always saving them



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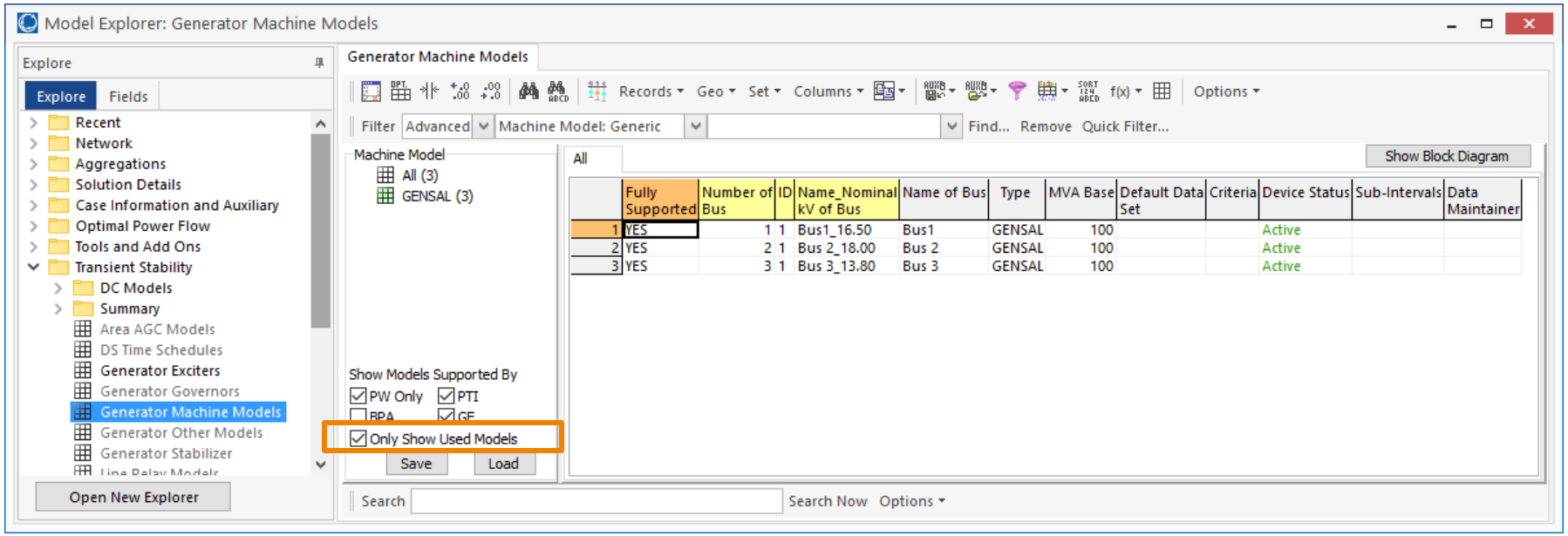
Transient Stability Data Management

- In case information tables listing particular classes of transient models (i.e. Machine Models, Governors, etc.) an option has been added to *Only Show Used Models*



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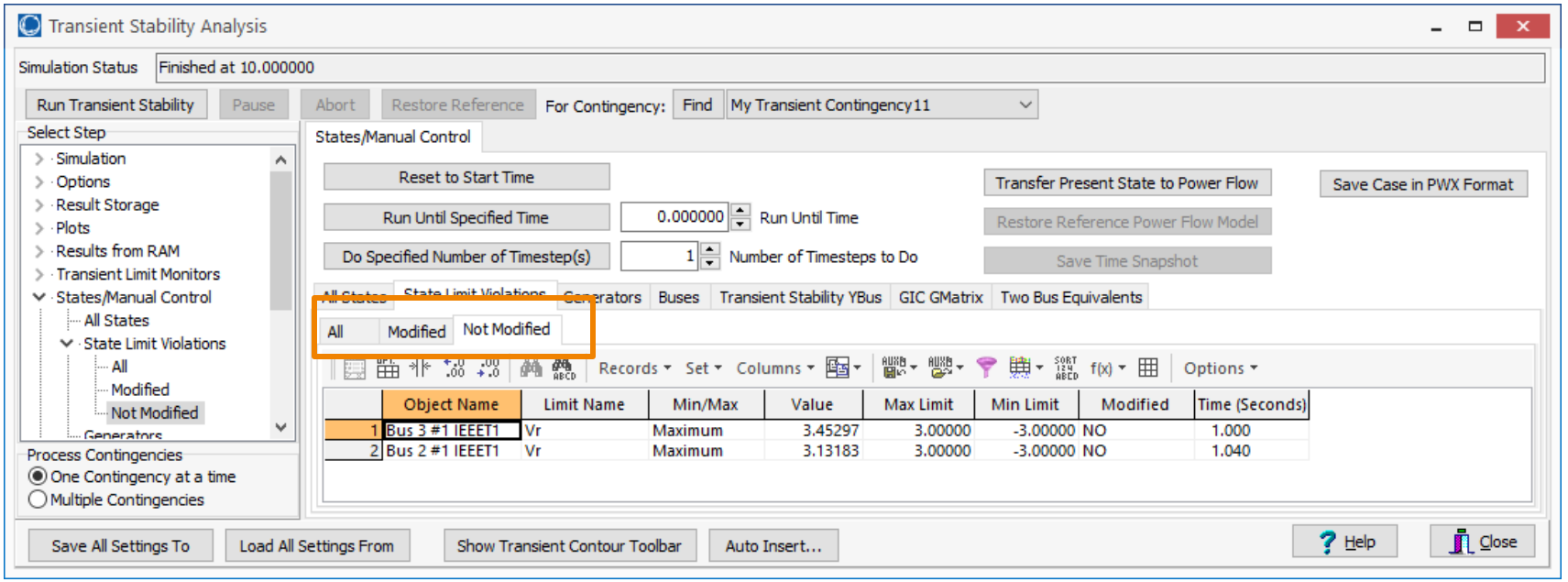
Transient Stability Data Management

- State Limit Violations can now be shown in *Modified* or *Not Modified* tables
  - There is an option for handling initial limit violations which can be set to *Modify Limits and Run*. When choosing this the violation is removed by modifying the limit



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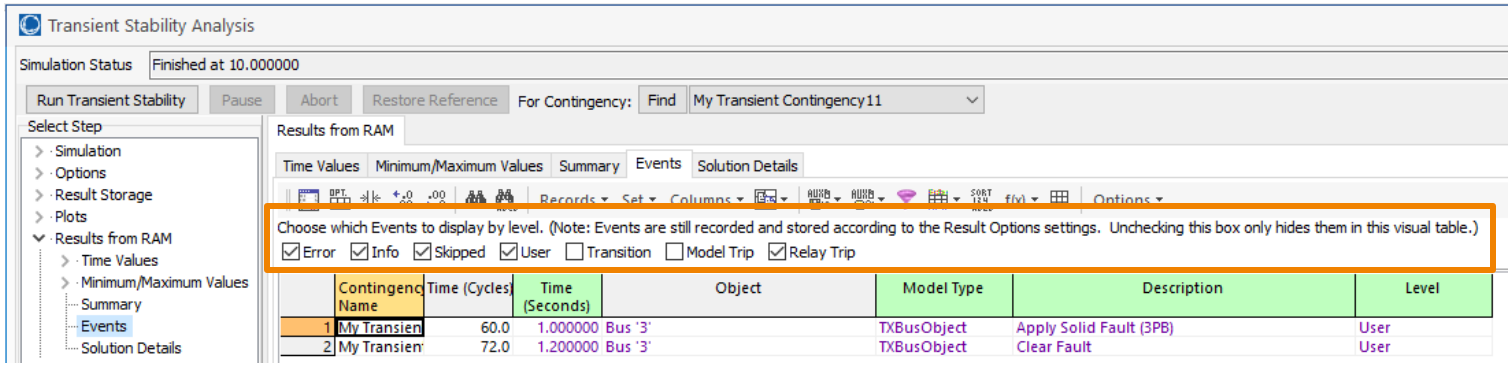
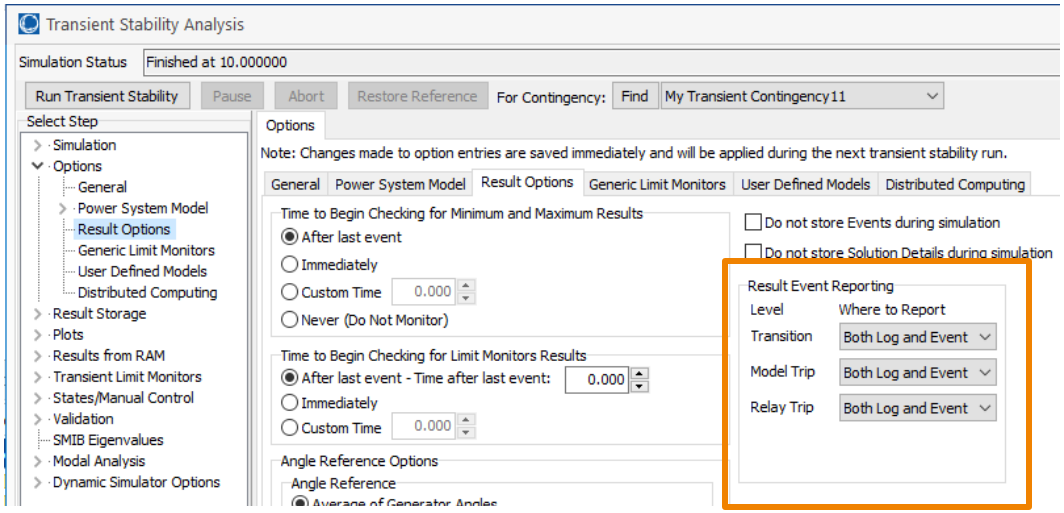
Transient Stability Reporting Events

- Filtering what is shown in the Events table by level

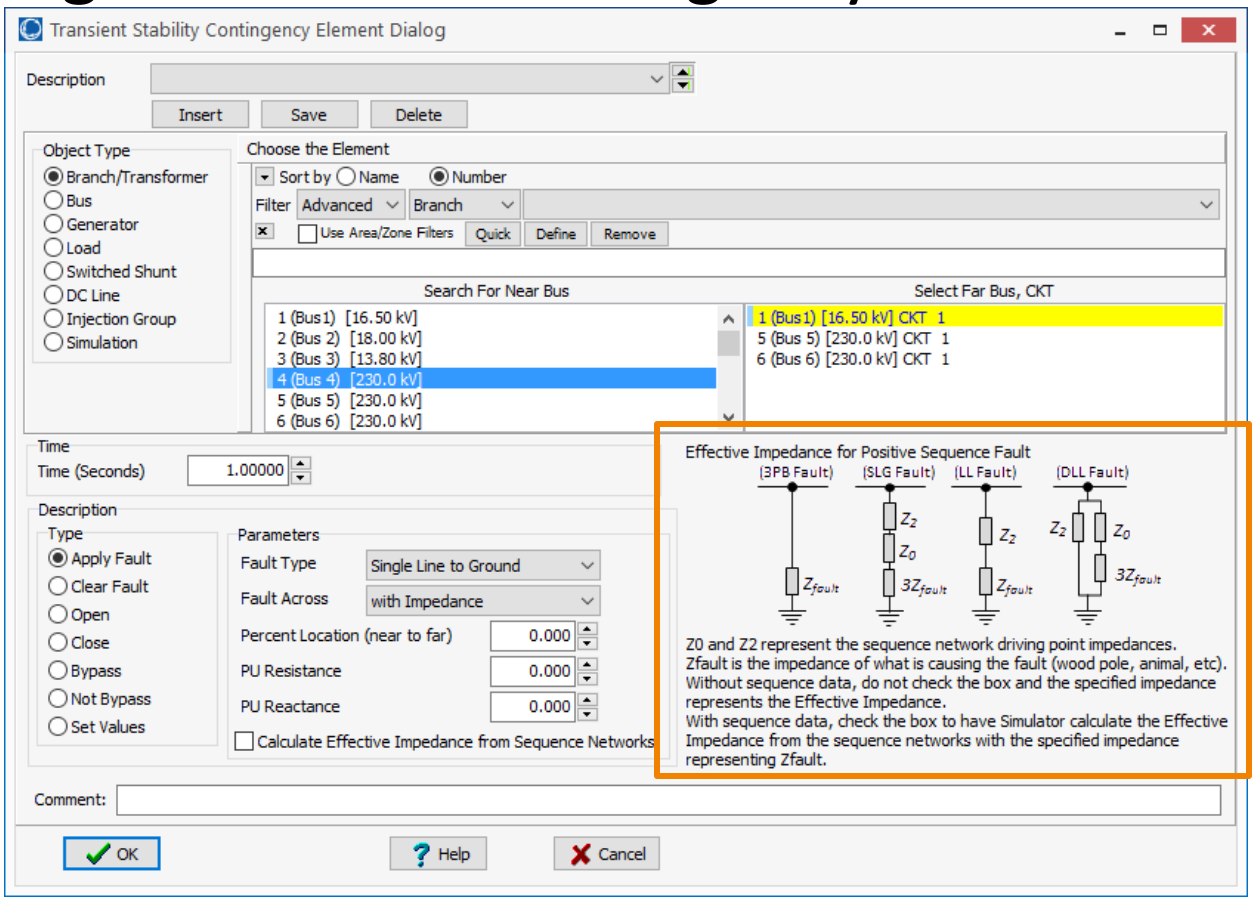


- *Result Event Reporting*
  - Remove clutter in the Message Log by not reporting all messages
  - Will always be reported in the Events table



Transient Stability
Faults

- Greatly improved description of Fault Type when defining a transient contingency



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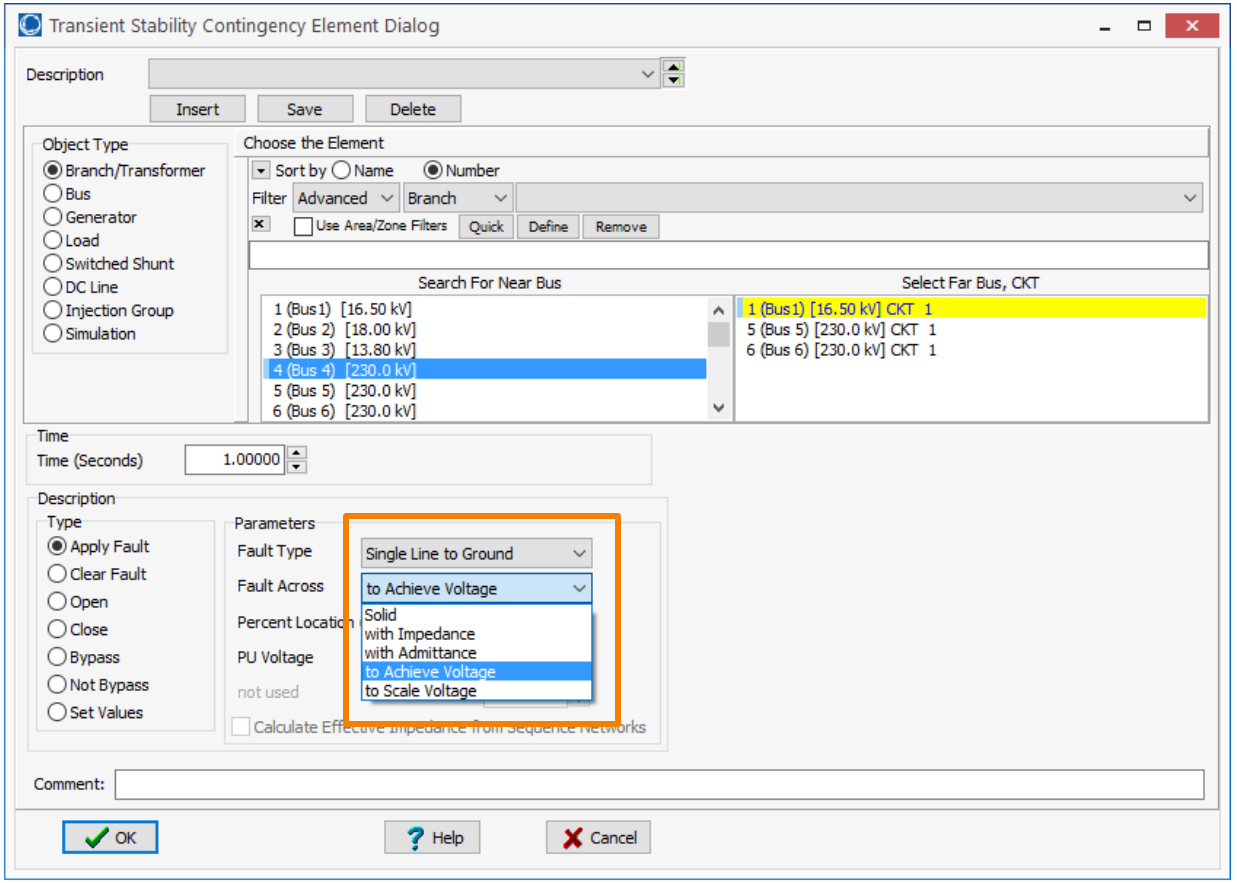
Transient Stability Faults

- Added new feature with a transient stability fault to…
  - *Apply Fault to achieve voltage* (immediately following the fault)
  - *Apply Fault to scale voltage* (by a factor immediately following the fault)



Transient Stability
Power System Model

- Added new option *Minimum PU Voltage for Relay Frequency Measurement* threshold
  - When per unit voltage at a bus is below this threshold then all frequency relays at that bus will treat their measured frequency as nominal frequency
  - In discussions with relay manufacturer it was clear that frequency measurement is not even attempted when voltages fall too low

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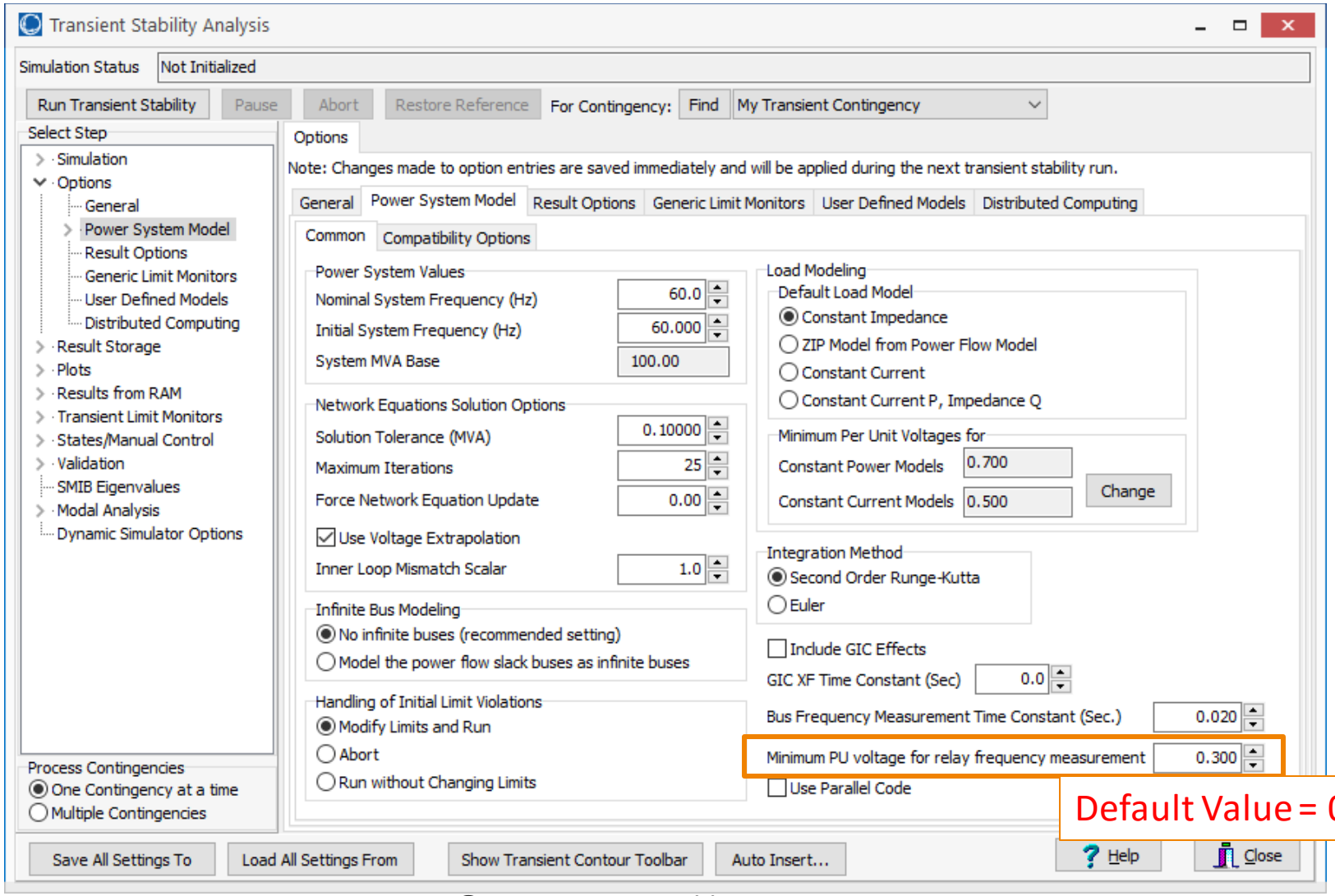
Transient Stability
Minimum Voltage for Relay Frequency



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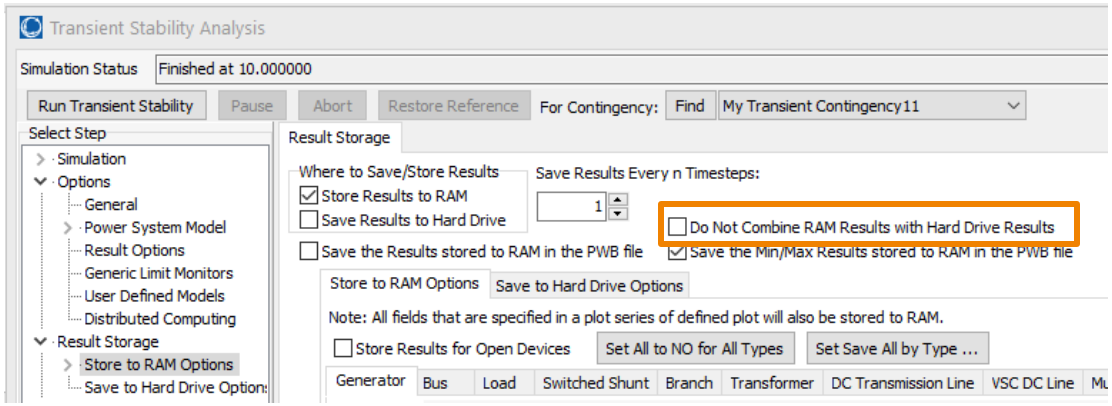
Transient Stability Plotting

- Added ability to use the special string @CTGMemo in transient stability plot definition strings
  - This string will be replaced with the memo of the transient contingency in the plot
- Options to *Show Gridlines* on both the Horizontal Axis and Vertical Axis of a plot
- Option regarding whether to show the Legend on a subplot
- *Do Not Combine RAM Results with Hard Drive Results*
  - Used when plotting to ONLY plot results that are in RAM and ignore results stored in hard drive



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New Transient Stability Models

- Area
  - AreaAGC
- Generator Exciter
  - PV1E
  - REEC_C
- Generator Machine Models
  - PV1G
  - PVD1
- Generator AGC Controller
  - AGCPulseRate
  - AGCSetpoint
- Generator Plant Controller
  - REPC_B

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New Transient Stability Models

- Generator Relay
  - ATRRelay
  - GENOF
  - GP2
  - GVPHZFT
  - GVPHZIT
  - LHSRT
- Generator Under Excitation Limiter
  - UEL1
- Generator Voltage Compensator
  - CCOMP4
- Line Relay
  - OOSMHO
  - DIRECLEN
  - RELODEN
  - SCGAP

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New Transient Stability Models

- Line Shunt
  - MSLR1
- Load Characteristic
  - BRAKE
- Load Distributed Generation
  - DGPV
- Load Relay
  - LSDT3
  - LSDT7
- Switched Shunt
  - MSR1
  - SVCALS

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Converting Power Flow Contingencies to Transient Contingencies

- New option on *Other>* button of Contingency Analysis dialog
- Objects converted
  - Bus, Branch, Load, Switched Shunt, Generator, DC Line
- Default Assumptions
  - Fault on time: 1 second
  - Fault location:
    - If first element in contingency is a bus, apply fault at that bus
    - If first element in contingency list is a branch, apply fault at "from" bus of that branch
    - If first element is anything besides a bus or a branch (i.e. generator, etc.) do not apply any fault. Rather, open all elements ONLY if the bus voltage is 500 kV, 230 kV, or 115 kV at 1 second. The same is true if the object is part of the contingency when the first object is a bus or a branch.
  - Fault type: 3 phase bolted fault
  - Fault clearing time:
    - If bus fault
      - 500 kV bus, assume 1 second plus 3 cycles
      - 230 kV bus, assume 1 second plus 4 cycles
      - 115 kV bus , assume 1 second plus 6 cycles
    - If branch fault
      - 500 kV branch, assume 1 second plus 3 cycles at "from" end, 1 second plus 4 cycles at "to" end
      - 230 kV branch, assume 1 second plus 4 cycles at "from" end, 1 second plus 5 cycles at "to" end
      - 115 kV branch, assume 1 second plus 6 cycles at "from" end, 1 second plus 7 cycles at "to" end
  - Time to change remaining element topology
    - If bus fault, open all remaining elements when fault is cleared
    - If branch fault, open all remaining elements when "to" end of line is opened.

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Geomagnetic Induced Currents

- Continues to be updated
- "Hot Spot Analysis"
  - Define location of hotspot
  - Define a specific value or multiplier for existing field
- More details will be covered in a separate presentation

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PV Tool

- *High Voltage Violations* can now be monitored
  - Can stop when voltages become inadequate because they are too high
- *Restore Initial State on Completion of Run* option
  - Default is to leave the system state at the transfer level of the last studied scenario, which requires the user to remember to Restore Initial State before running again
  - New option will automatically restore to the initial state on completion of all scenarios

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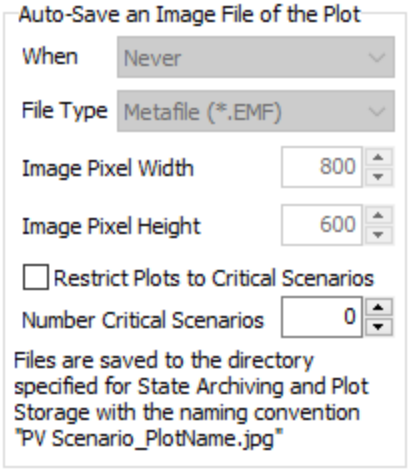
PV Plotting

- Options to *Show Gridlines* on both the Horizontal Axis and Vertical Axis of a plot
- @CASENAME, @CTGNAME, and @CTGMEMO will now work as special keywords any place the user can enter text for PV plots
- Added options to save PV plot images to file
  - Plots can be restricted to only showing the specified number of critical scenarios



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QV Tool

- Make-Up Power option
  - MW losses can have a significant impact on the results
  - Too much reactive margin could result if all changes go to the system slack
  - Two options for Make-Up Power

    - *System Slack*
      - Prior to version 19 this was how make-up power was always handled
    - *Same as Contingency Analysis*
      - Allows changes to be spread out across all generators in the system
      - **This is the default setting**
- *User Defined Integer* field available with results table
  - Useful for ordering and selecting scenarios to plot together

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Available Transfer Capability Tool (ATC)

- Added option with Transfer Limiters to *Create Contingent Interface for Selection*
  - Interface will be created with the Limiting Element being monitored and the Limiting CTG as a contingency element in the interface
- *Allow Generator MW Limit Enforcement in Single Linear Step*
  - This option is now used with the iterated solution methods to allow users to replicate results from previous versions of Simulator
  - Previously, this option only applied when using the Single Linear Step method
  - All other appropriate options that determine if generator MW limits should be enforced must also be set

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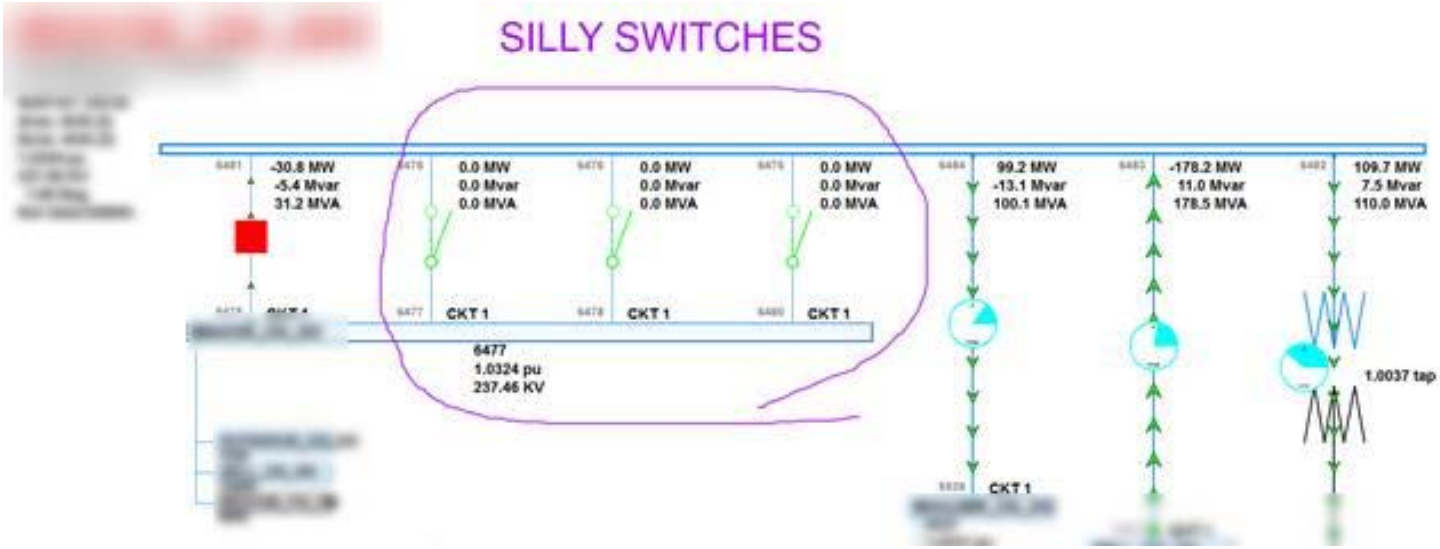
Integrated Topology Processing

- 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



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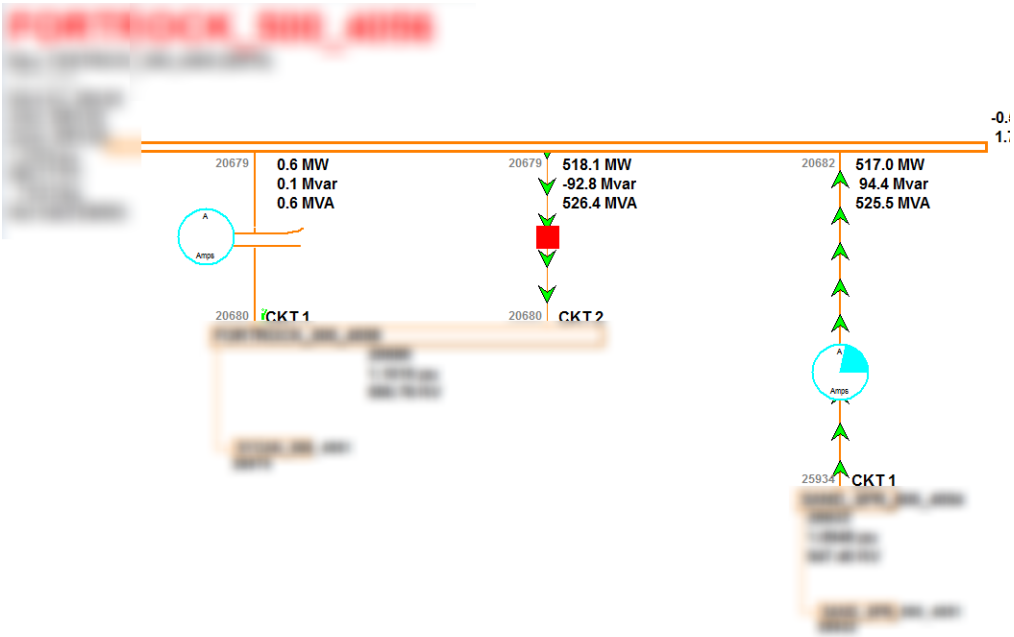
Integrated Topology Processing

- Consolidation changes
  - If there is a switching device in parallel (between exact same buses) to a non-switching device, the switching device will not be consolidated
    - This prevents series capacitors from being removed from the model when they are bypassed
    - The series capacitor can still be completely consolidated if modeled with disconnects at its terminals



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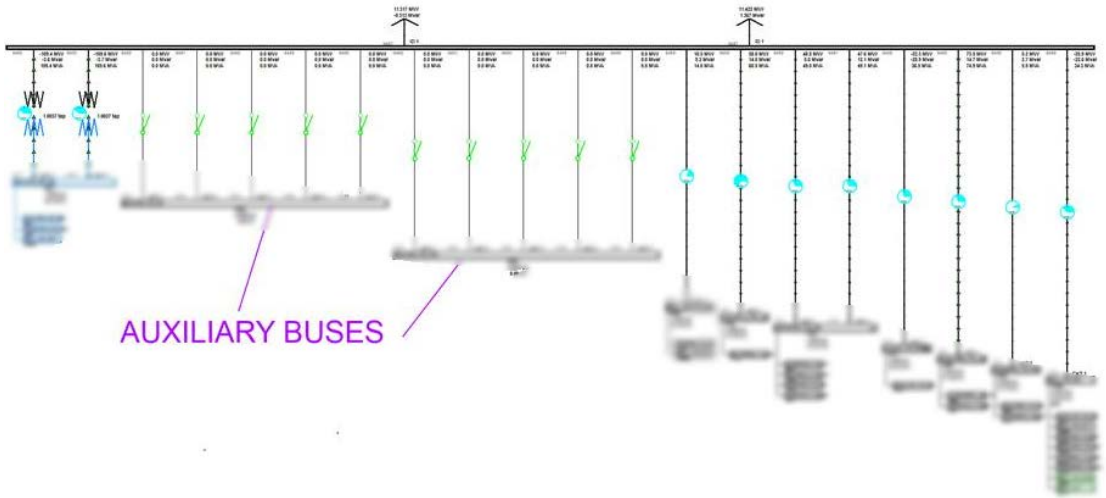
Integrated Topology Processing

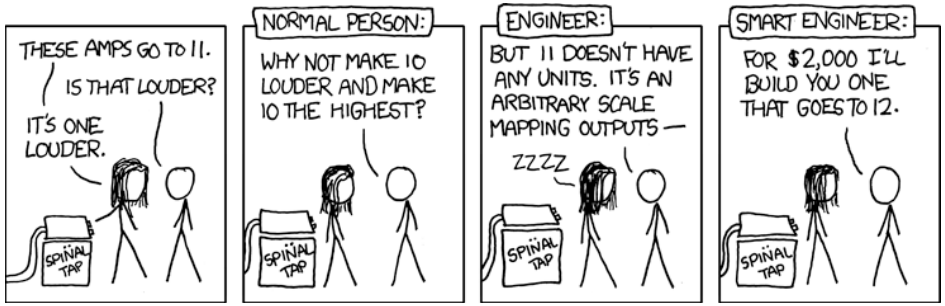
- Consolidation changes
  - Superbuses that contain ONLY switching devices that are connected to other superbuses ONLY by open switching devices will be merged into other superbuses
  - A dead bus will be consolidated to a neighboring superbus if all of the following are met:
    - It has no generators, loads, or shunts
    - It is connected to the rest of the system only by open ac branches
    - It is only connected to one other superbus through these ac branches



Full Topology Features

- ExpandBusTopology(BusIdentifier, TopologyType) script command
  - TopologyTypes
    - DoubleBusDoubleBreaker
    - MainTransfer
    - RingBus
    - BreakerAndAHalf
    - SingleBus
    - SectionalizeBus

But why don't you just use your EMS case?



- Will build out specified bus by adding breakers in the specified topology
- ExpandAllBusTopology script command will build out all buses with the Topology Type specified in a Custom String field for the bus

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Full Topology Features

- When saving a full topology model to a consolidated case, switched shunts that are connected to the same Superbus by open breakers will be merged into a single shunt with blocks
- *Topology* folder in list of available fields for Branch, Bus, Generator, Load, and Switched Shunt objects contain identifiers from EMS case
  - Useful internally for loading DDL and DYD files without the need for extra labels
- *Open* or *Close with Breakers* local menu options on case information displays and oneline have additional options for what should be switched
  - *Only Breakers*
  - *Breakers and Load Break Disconnects*
  - *Breakers and All Disconnects*

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Oneline Features

- *Create a Case Information from Selection*
  - Open a case information display of the objects selected on a oneline
  - Initially intended as a way to create substations by selecting objects on a oneline
- *Convert multi-section line to background line*
- Albers Conic map projection (Alaska)
- Line drawn through switched shunts with Control Mode of *Continuous* or *SVC* to indicate shunt on automatic control
- While in Run Mode, left-clicking on bus name or number field will open the Bus View
- Bus View or Substation View can be opened from the contingency violations

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Oneline Features

- Contouring color key can be moved outside of a oneline window
  - Will retain its relative position to the oneline as the oneline is moved
- Option to view *Objects Not on Oneline*
  - Additional option to views object that are not on the oneline but are connected to buses that are on the oneline
- Added ability to reload active display in the Oneline Viewer by double-clicking on its tree node
- Added ability for showing dialogs for generators, loads, and branches when right-clicking on various background lines used when rendering an Areva DDL oneline diagram

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Geographic Data Views

- Contouring can now be done on geographic data view objects based on the object type that they represent
- Additional options for managing the geographic data view objects on a oneline
- Added options to make it easier to create a new oneline for adding geographic data view objects
  - Option to add geographic borders

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Sparklines

- Small character-sized graphic
- Currently can be used with transient stability results
- Can be displayed instead of a field value when specifying a field on a oneline
- Can be displayed as part of a Geographic Data View object

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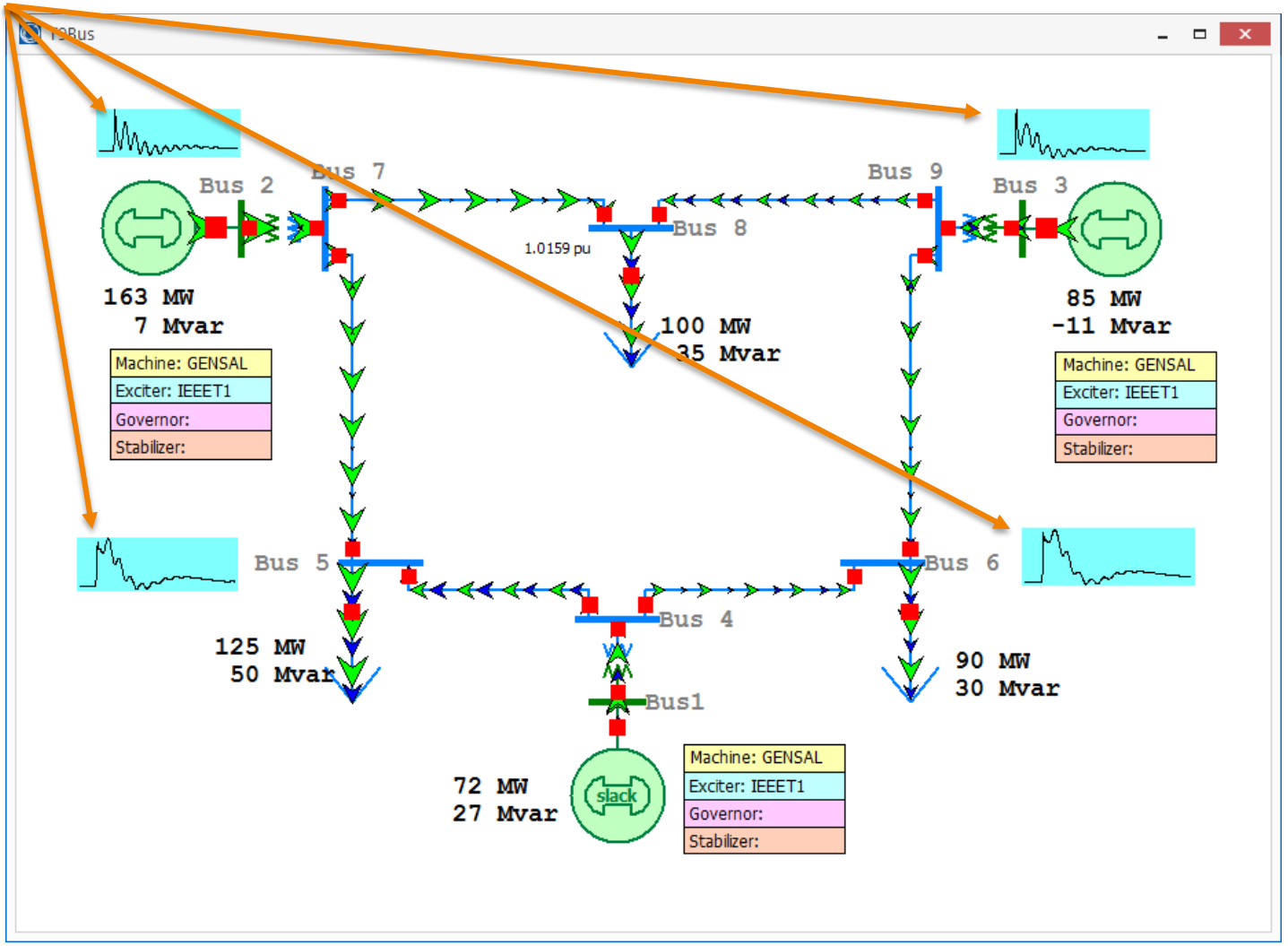
Sparklines

Sparklines showing bus frequency during transient run



Sensitivities

- dAmp/dControl and dMVA/dControl calculations available for Branches on *Multiple Meters, Single Control Change* dialog
- Generator MW can be selected as Control Type on *Multiple Meters, Single Control Change* dialog and *Multiple Meters, Multiple Control Change* dialog
- LODF Screening tool
- Interfaces can be monitored with *LODF Matrix* calculations

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Fault Analysis

- When defining multiple faults, position of the fault along the line can be specified
  - By default a location >= 50 assumes a fault at the To Bus and < 50 assumes a fault at the From Bus
  - An option has been added to instead add a dummy bus at the actual fault location
    - This will make the solution slower
- Added option to name faults by label when auto inserting
- Added options to make it easier to switch between amps and pu for displaying fault current

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