

# Specifics of Implementation



- Defining Criteria
  - Filtering
  - ModelCondition
  - ModelFilter
- Conditional Contingency Actions
- CriteriaStatus = *POSTCHECK*
- ModelExpression (lookup tables)
- RemedialAction
- Complexity of Injection Group Gen/Load dropping
- Injection Group Actions
- Overlapping Gen Drop
- Evaluate Model in Reference State
- CriteriaStatus = *TOPOLOGYCHECK*
- Disable if TRUE in Reference State
- Transient Stability Models in Power Flow Contingencies
- Time Delay
- Overall Contingency Process

# Advanced Filtering

## First Step for Conditional RAS

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- Filtering is completely generic and available for all objects
  - Compare field to a constant (Flow > 500)
  - Compare field to another field (Flow > Limit)
  - Build any logical combinations of conditions and other filters
    - Be careful for circular references when using filters inside filters
  - No maximum on conditions
  - Compare across objects (Branches could be filtered based on whether the voltage was low at either end)

# Advanced Filter Dialog



Filter By will be discussed shortly (Advanced or Device)

Type of object being filtered

Logical Comparator

Conditions

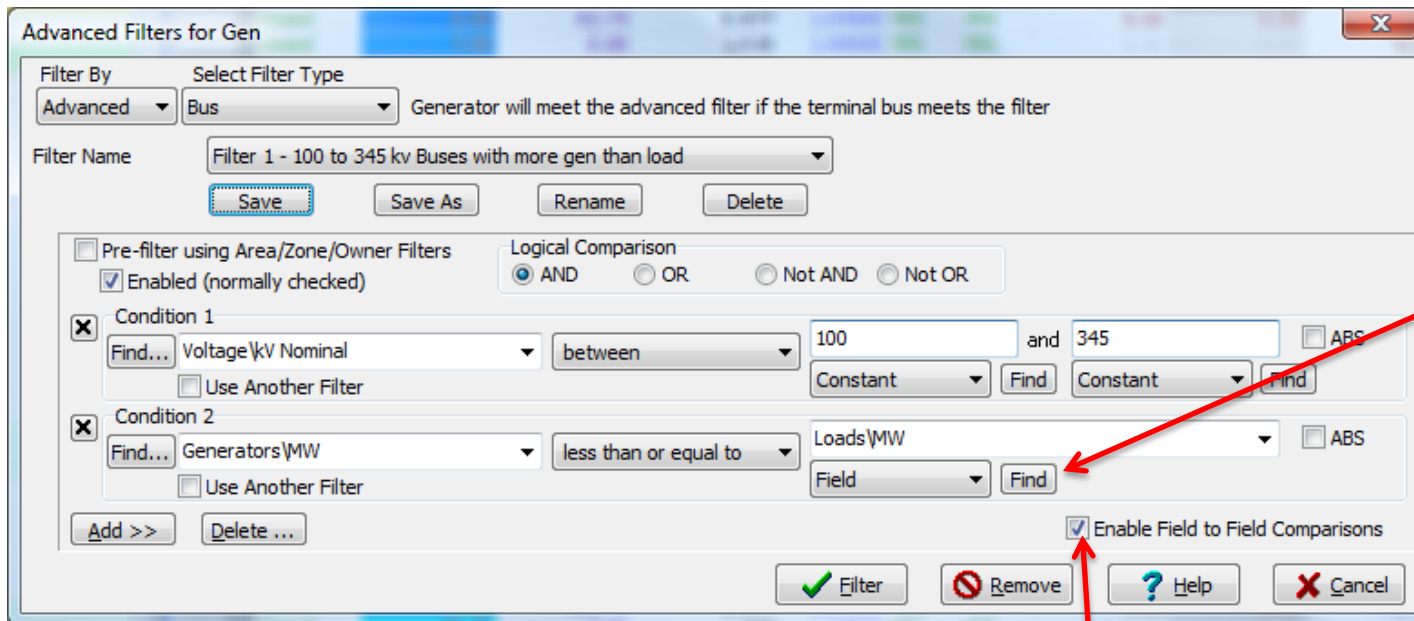
Use the Find... buttons

Click to delete a condition

# Field-To-Field Comparisons



- Users have the option to include Field-To-Field comparisons



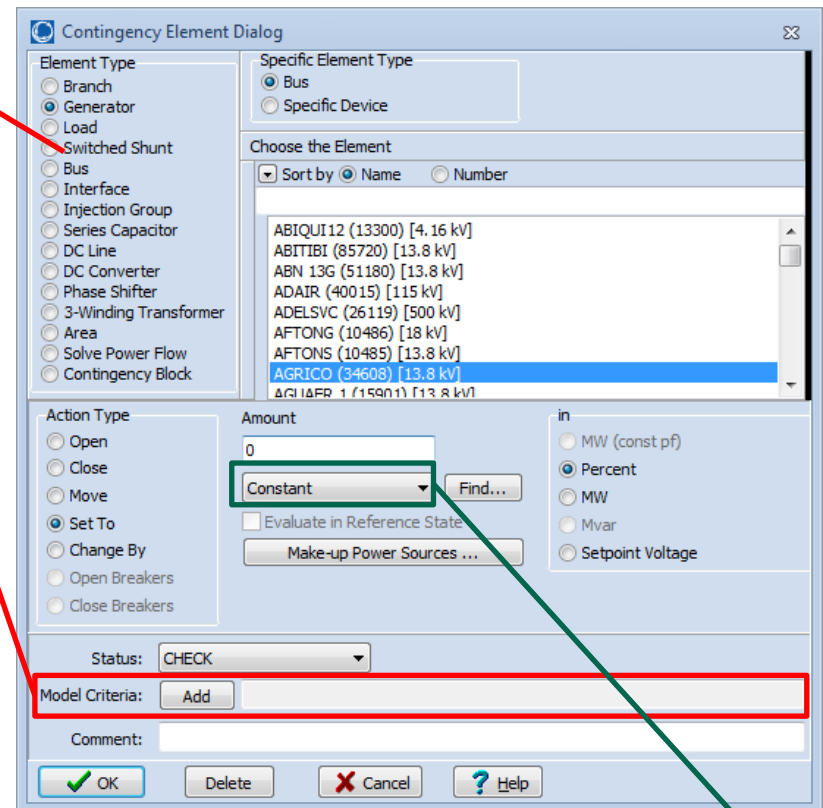
**Click the Find Button to choose another field to compare to instead of a constant value.**

**Check the box for Enable Field to Field Comparisons**

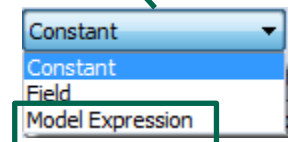
# Conditional Contingency Actions



- Many choices of various contingency actions are available
- Model Criteria specifies a Boolean condition under which the action should be applied
  - Model Conditions
  - Model Filters
  - When a contingency is applied, these actions only occur if the Model Criteria is true



We'll discuss shortly



# Model Conditions and Model Filters



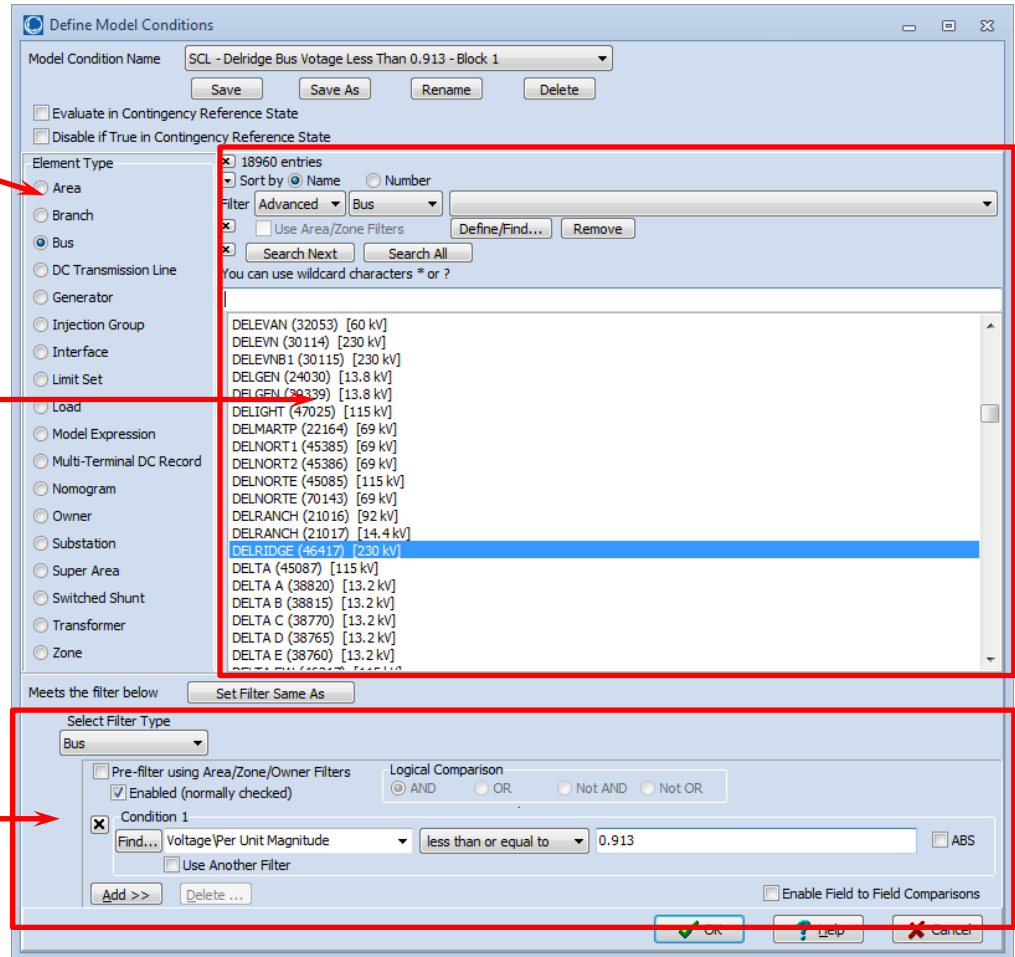
- Model Condition (couples two things)
  - Particular object
  - An Advanced Filter definition
  - Model Condition is met if the advanced filter to the particular object is TRUE
  - TRUE Model Condition means action is applied
- Model Filter
  - A Boolean expression of other Model Conditions and Model Filters
  - TRUE Model Filter means action is applied

# Conditional Contingency Actions

## Model Conditions



- Choose Object Type
- Choose Object
- Build Advanced Filter Definition

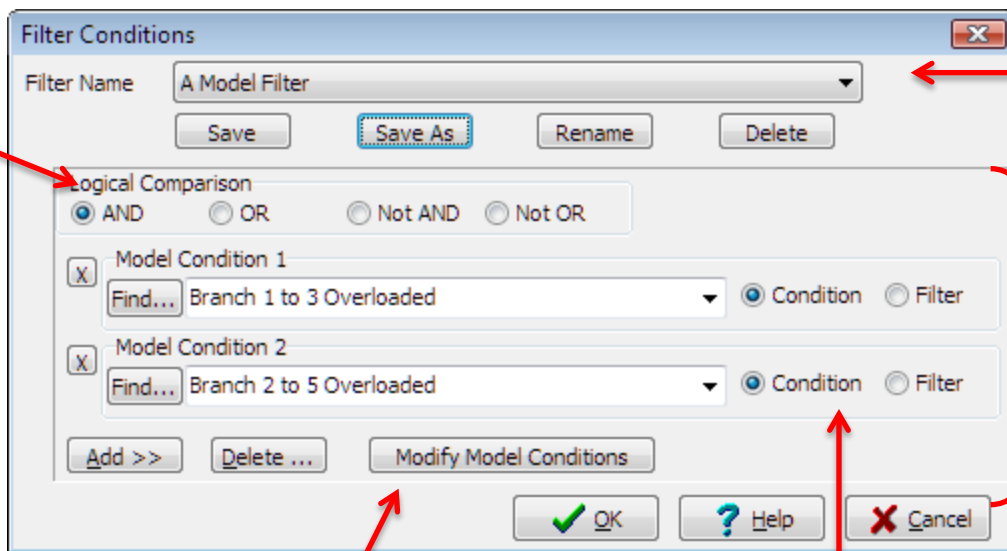


# Conditional Contingency Actions

## Model Filters



- Just piece together a list of Model Conditions or Filters and a logical comparison



Logical comparison for the Model Conditions

Give the Model Filter a name and save

Similar to the Advanced Filter Dialog

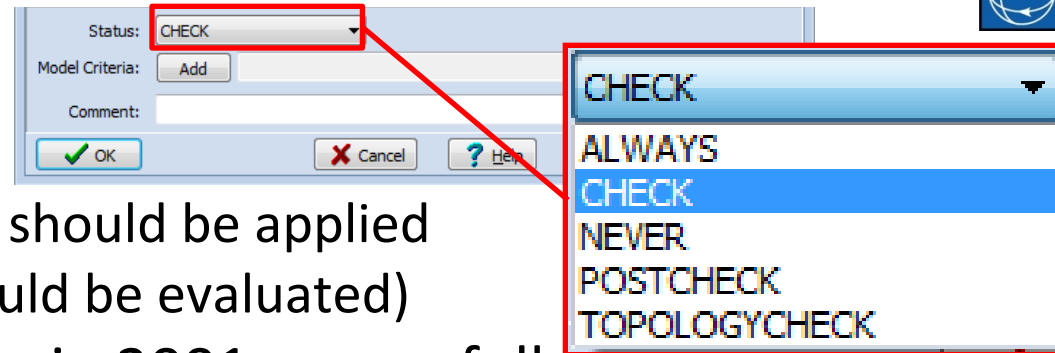
Click to Modify Model Conditions

Model Filters may contain Model Conditions or other Model Filters



# Conditional Contingency Actions: Action Status

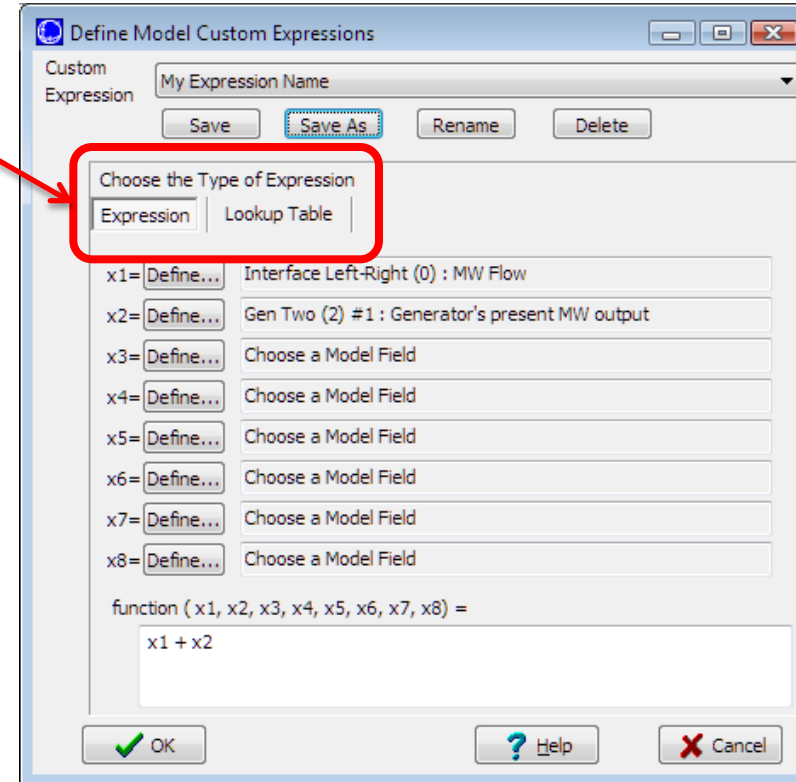
- Action Status
  - Specifies when action should be applied
  - (i.e. when criteria should be evaluated)
- Contingency Processing in 2001 was as follows
  1. Apply *ALWAYS* actions and true *CHECK* actions
    - (Note: *CHECK* actions are evaluated in reference state)
  2. Update topology (branch, bus status)
  3. Solve power flow
  4. Apply true *POSTCHECK* actions
  5. Repeat steps 2-4 until no more *POSTCHECK* actions become true
- We will discuss *TOPOLOGYCHECK* shortly



# Contingency Model Expressions



- Types
  - Expressions: mathematical expressions involving one or more model fields
    - Model Field can be any field of any object in the model
  - Lookup Tables: return a value based on the values of one or two model fields
- May be used inside
  - Some kinds of contingency elements
    - Set Gen MW to Model Expression
    - See earlier slide
  - Advanced Filters
  - Model Conditions
- Examples
  - Gen Drop Equal to a Lookup Table
  - Gen Drop Equal to 40% of Interface Flow



# RemedialAction Objects

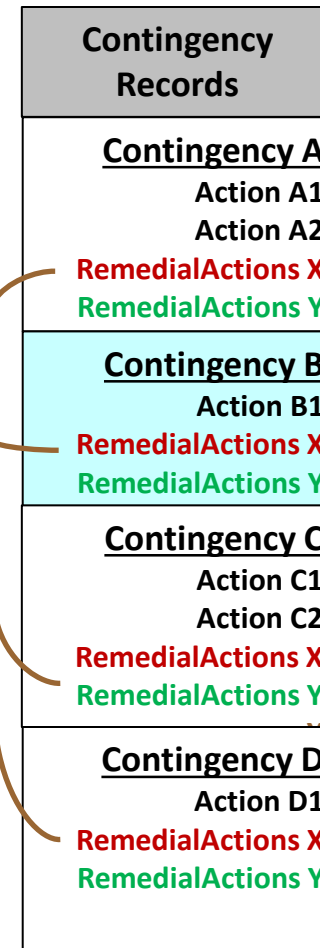
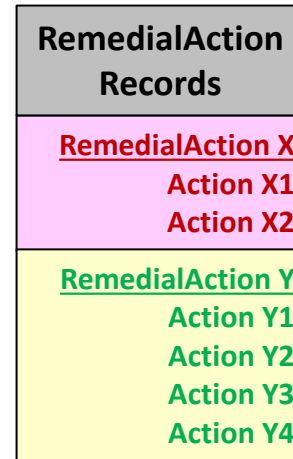
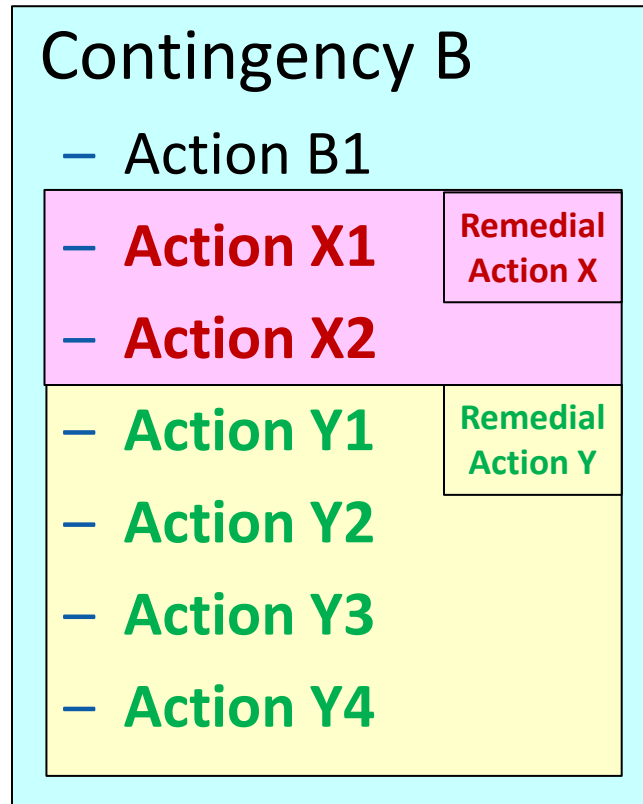


- The general logic shown still requires you to put all the actions inside of each contingency record
- **RemedialAction** records (and **RemedialActionElement** records)
  - This are a separate list of data record
  - They function the SAME AS a **Contingency** and **ContingencyElement** records
  - But every **RemedialActionElement** is automatically used as part of every **Contingency**

# Contingency Records, RemedialAction Records

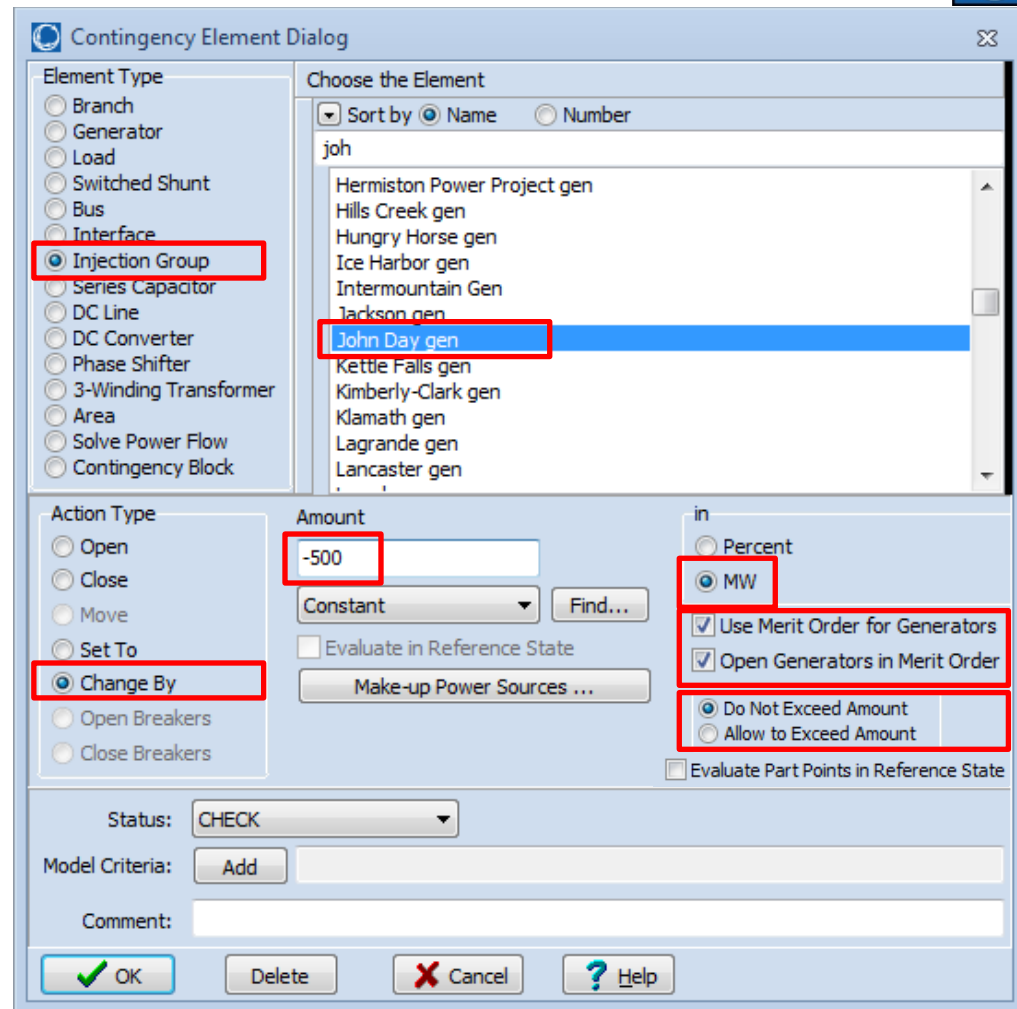


- End up with 7 actions actually used for a simulation of



# Example of Injection Group Contingency Action

- Assume Injection Group named John Day gen is defined
- Change the total John Day generation by -500 MW by opening generator in merit order



# Contingency Analysis: Overlapping Gen Drop



- Accounting for Overlapping Generation when using merit-order generation dropping
  - Drop 500 MW from Injection Group #1
  - Drop 400 MW from Injection Group #2
  - Order matters: Group #1 will drop 500 MW, but when going to drop Group #2, if there is overlap and 200 MW of generation in Group #2 was already dropped due to Group #1 dropping, then only an additional 200 MW will be dropped.
  - You won't always get 900 MW of dropping (example above would only drop 700 MW)
- Note: default behavior is to take into account this overlap. This may be turned off in the Basic Contingency Modeling options

# Evaluate Model in Reference State



- Needed to arm the amount of generation drop based on *Reference State* only
  - Important if there are *POSTCHECK* actions
  - Possible that other *POSTCHECK* actions have occurred and you're iterating back on subsequent *POSTCHECK* actions with a new system state.
- Example:
  - Amount of generation drop is based on a two-dimensional nomogram which is a function of two interface flows
  - The “arming level” is handle based on the reference state, not what the MW flow happens to be at a particular point in contingency analysis process
    - Use Model Expression Lookup Table (Simulator supports 1D and 2D lookups tables)
    - For amount to drop, point to Model Expression
    - Check box for **Evaluate Model in Reference State**

# Conditional Actions based on Status Only



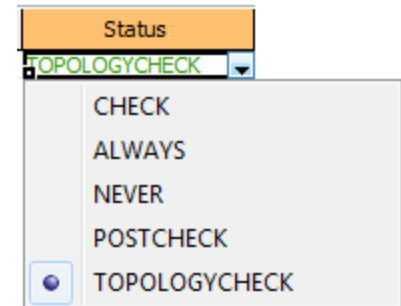
- Users of Simulator had a persistent problem in some contingency runs when using RAS
  - RAS is configured to open 2,000 MW of generation when Line X trips
  - Before 2012, this was achieved by configuring a *POSTCHECK* action that looks at the branch status and trips generation if the branch is out of service
  - Works most of the time, but...
  - What if the outage of Line X results in an unsolvable steady state power flow solution?
    - Basically means that the RAS scheme is actually preventing a voltage collapse from occurring
    - This means that the *POSTCHECK* action is never evaluated because the power flow solution failed.
- Solution: *TOPOLOGYCHECK* actions



# Contingency Analysis: TOPOLOGYCHECK



- **TOPOLOGYCHECK** Contingency Element Status.
- Contingency Processing now goes as follows
  1. Apply **ALWAYS** actions and true **CHECK** actions
  2. Update topology (branch, bus status)
  - ADD** 3. Apply true **TOPOLOGYCHECK** actions
  4. Solve power flow
  5. Apply true **POSTCHECK** actions
  6. Repeat steps 2-5 until no more **POSTCHECK** and no **TOPOLOGYCHECK** actions are done
- Note: TOPOLOGYCHECK should only be used with Model Conditions related to bus/branch statuses



# TOPOLOGYCHECK Status Message Log



```

****
**** Solving contingency N-2: Slatt-John Day 1 500kV & John Day-Grizzly 2 500kV Lines ****
****
28 generators changed to use Line-Drop Compensation due to Use LDC_RCC Option.
438 generators changed to regulate their terminal bus due to Use LDC_RCC Option with a very small XLDC_RCC.
1488 generators changed maximum MW limit due to Maximum MW Response in Post-Contingency Options.
1936 generators changed minimum MW limit due to Maximum MW Response in Post-Contingency Options.
1928 generators changed AGC status to YES due to Post-Contingency AGC Options.
APPLYING: OPEN Line JOHN DAY_500.0 (40585) TO SLATT_500.0 (40989) CKT 1
APPLYING: OPEN MultiSectionLine GRIZZLY_500.0 (40489) TO JOHN DAY_500.0 (40585) CKT 2
SKIPPING: CHANGE INJECTION GROUP East of Marion Gen Drop BY -1500 MW in generator merit order by opening
SKIPPING: CHANGE INJECTION GROUP East of Marion Gen Drop BY -750 MW in generator merit order by opening
SKIPPING: CHANGE INJECTION GROUP North of Grizzly Gen Drop BY -2000 MW in generator merit order by opening
SKIPPING: CHANGE INJECTION GROUP North of Grizzly Gen Drop BY -1000 MW in generator merit order by opening
****
****
**** Applying TOPOLOGYCHECK for Contingency N-2: Slatt-John Day 1 500kV & John Day-Grizzly 2 500kV Lines ****
****
APPLYING: CHANGE INJECTION GROUP East of Marion Gen Drop BY -750 MW in generator merit order by opening
APPLYING: CHANGE INJECTION GROUP North of Grizzly Gen Drop BY -1000 MW in generator merit order by opening
Warning - MCNRY S3_230.0 (41353) TO MCNARY_115.0 (40717) CKT 1 regulated bus MCNARY_115.0 (40717) is all
AGC in island changed gen 1 at bus SJUAN_G2_24.0 (10319) by 7.93 MW to 357.9
AGC in island changed gen 1 at bus SJUAN_G4_22.0 (10321) by 11.56 MW to 521.2
AGC in island changed gen 1 at bus LEF_G1_18.0 (10394) by 3.19 MW to 145.7
AGC in island changed gen 1 at bus LEF_G2_18.0 (10395) by 3.19 MW to 145.7
AGC in island changed gen 1 at bus LEF_S1_18.0 (10396) by 6.38 MW to 286.4
AGC in island changed gen 1 at bus R5M5C4_0.7 (10000) by 2.17 MW to 7.0

```

Contingency pre-processing

CHECK and unconditional actions

Skipped actions because Model Criteria not met

Actions applied with TOPOLOGYCHECK status met

Start the power flow

Light blue indicates contingency element

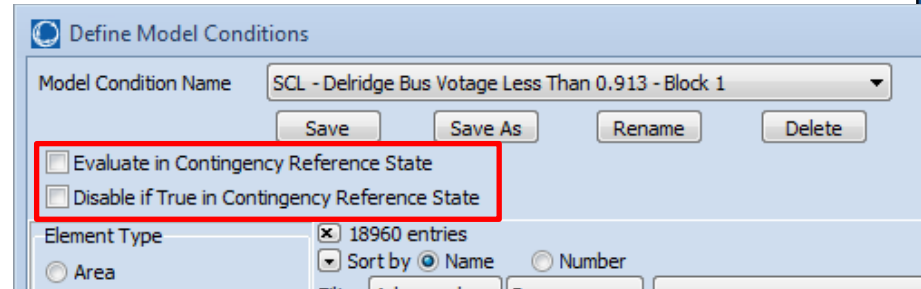
Pink indicates Global Action

# Global RAS Modeling: Reference State Evaluations

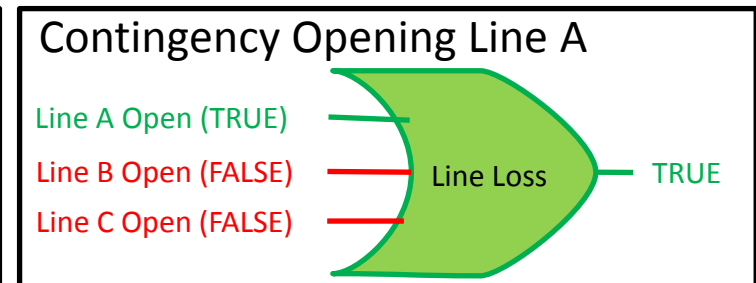
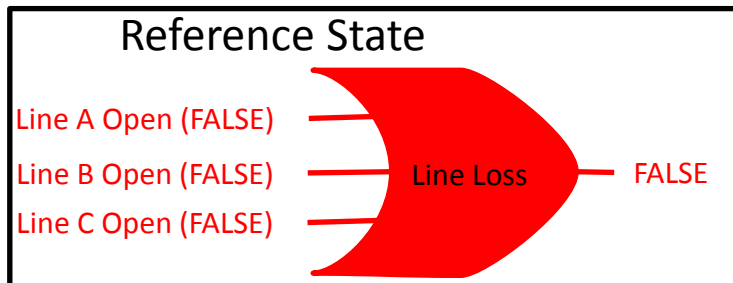


- Model Condition Option

- Evaluate in Contingency Reference State
- Disable if True in Contingency Reference State



- Example: Model Filter that takes the OR of three Model Conditions that test whether particular lines are Open
  - As soon as one of the lines is opened by a contingency, the model filter will evaluate to TRUE and you'll trigger appropriate actions.

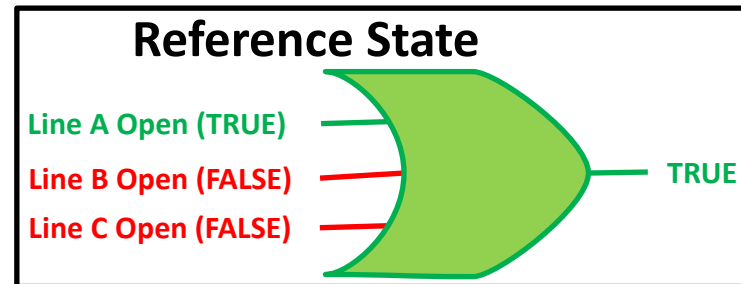


- Works great as long as all three lines are CLOSED in the Reference State

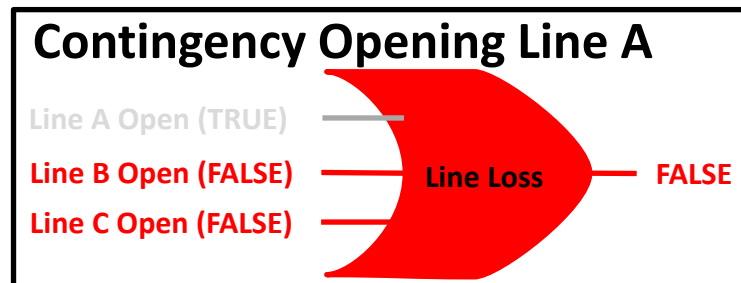
# Contingency Analysis: Disable if TRUE in Reference State



- What if Line A is OPEN in the Reference State?
  - This logic will end up returning TRUE for *EVERY* contingency



- Disable if TRUE in Reference State Option means
  - The Model Condition is completely ignored!
  - It's like the Model Condition doesn't even exist.
  - The result of this will depend on the type of logic the model condition is fed into



# Contingency Analysis: Disable if TRUE in Reference State



- Reminder
  - Global Contingency Actions are a list of contingency elements that are included as part of every contingency solution
- Implication:
  - Specify an action as part of the Global Contingency Actions using the *Disable if TRUE in Reference State* choice
  - This allows you to model a global RAS in the power flow contingency action
    - Define one record in Global Contingency Action and you don't need to manage which contingencies use it
    - Also allows potential for cascading RAS under any contingency

# Transient Relay Models in the Power Flow Contingency



- Conceptually a Transient Stability Relay Model in power flow contingency analysis act similarly to
  - Contingency action that opens a device (or devices)
  - **Status** = *POSTCHECK*
  - **Model Criteria** = Model Condition based on
    - Violating Bus Voltage Limit
    - Over Line Current
    - Apparent Impedance looking down line is inside Impedance Region (distance relay)
    - Voltage Limit for Load Relays as well
- Use in power flow contingency analysis
  - Force software to directly use *transient stability* relay models in *power flow* contingency analysis
  - Note: do NOT force extra definition of actions

# Transient Relay Models in the Power Flow Contingency



- Internally automatically evaluate steady-state implications of the stability relay models at the same time that existing *POSTCHECK* actions are evaluated
  - Assume in power flow contingency that post-contingency states exists forever
    - Timing data in relay models would be ignored as state exists forever
    - Over-current relays would just look at the minimum current threshold from transient model
    - Voltage based relays would look at largest minimum voltage and smallest maximum voltage
    - Distance/Impedance relays would evaluate highest zone for model
  - What Actually Occurred results would indicate if any of these actions are initiated
  - User Requirements for this feature
    - Define your stability relay models (Line and Load Relays)
    - Check a box to enable this new feature
- Auto-reporting options
  - Automatically report as a contingency violation if any relay models actual operate

# 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* and *POSTCHECK* solution steps
- Ignored during *CHECK* solution step
- Default all time delays to 0 to ignore



# Time Delay



The image shows two overlapping dialog boxes from a software application. The 'Contingency Definition Dialog' is on the left, and the 'Contingency Element Dialog' is on the right. A green arrow points from the 'Time Delay' column in the table of the first dialog to the 'Time Delay' input field in the second dialog.

**Contingency Definition Dialog**

Contingency Label: Open 1 to 3

Buttons: Add New, Rename, Find...

Definition: Custom | Monitoring Exceptions

Buttons: Insert New Element, Clear All

Actions	Model Criteria	Status	Time Delay	Comment
1 OPEN Line One 138.0 (1) TO Three 138.0 (3) CKT 1		CHECK	0	

Categories:

- Use specific solution options
- Ignore ALL contingency specific solution options

Post-Contingency Auxiliary File: [Browse]

Buttons: OK, Save, Delete, Cancel, Help

**Contingency Element Dialog**

Element Type: Branch (selected)

Choose the Element: Sort by Name (selected) / Number

Search For Near Bus	Select Far Bus, CKT
1 (One) [138 kV]	2 (Two) [138 kV] CKT 1
2 (Two) [138 kV]	3 (Three) [138 kV] CKT 1
3 (Three) [138 kV]	
4 (Four) [138 kV]	
5 (Five) [138 kV]	
6 (Six) [138 kV]	
7 (Seven) [138 kV]	

Action Type: Open (selected)

Amount: 0

Constant: [Find...]

Evaluate in Reference State

Make-up Power Sources ...

Status: CHECK

Model Criteria: Add

Time Delay: 0.000000 seconds

Comment:

Buttons: OK, Delete, Cancel, Help

**Set optional  
Time Delay**

# Transient Models



Contingency Analysis

Contingencies Options Results

Modeling

- Basics
- Generator Post-Contingency AGC
- Bus Load Throw Over
- Generator Maximum MW Response
- Generator Line Drop and RCC
- Post-Contingency Auxiliary File
- Transient Models**

Limit Monitoring

Contingency Definitions

Distributed Computing

Miscellaneous

Transient Models

Choose how to treat special transient stability models in the power flow contingency analysis  
Set to Trip/Act to perform appropriate power flow actions such as tripping devices if transient model conditions are met.  
Note: if the transient model is set to Inactive, then nothing is done regardless of these settings

Maximum Time Delay to Consider 3600.00 seconds

Treatment during Contingency	Stability Model Type
Ignore	MSC1 : Switched Shunt Model
Ignore	TIOCRS : Line Relay Model
Ignore	LOCTI : Line Relay Model
Ignore	TIOCR1 : Line Relay Model
Ignore	LHVRT : Relay Model

Status **Initialized**  Refresh Displays After Each Contingency

Load Auto Insert Save Other > Start Run Close ? Help

# Transient Models



- Several transient stability models can be included in steady state contingency analysis
- Options to specify how models are treated during steady state contingency analysis
  - Ignore
    - Nothing happens with this model during steady state contingency analysis
  - Trip/Act
    - If conditions are met, actual actions will be taken (such as tripping a line for overcurrent)
    - Some models have a Monitor flag. If this flag is set to monitor only, an individual model will not act regardless of contingency setting.
  - Monitor Only
    - If conditions are met, special contingency violations are reported
- Transient models are handled as part of the *TOPOLOGYCHECK* and *POSTCHECK* solution steps

# Summary of Criteria Status and Transient Models



- Each **ContingencyElement** and **RemedialActionElement** have the following
  - Object (**who** to act upon)
  - Action (**what** to do)
  - Criteria (**whether** to apply)
  - TimeDelay (**when** to apply)
  - CriteriaStatus (**where** to apply in solution process)
    - *ALWAYS, NEVER, CHECK*
    - *TOPOLOGYCHECK*
    - *POSTCHECK*
- Transient Stability models can also be used in the power flow contingency processor
  - Call these *TRANSIENT* actions
  - Presentation today won't cover, but concept is the same to user

# Processing Order of Contingency



1. Apply *ALWAYS* actions and true *CHECK* actions
  2. Update topology (branch, bus status)
  3. Apply true *TOPOLOGYCHECK* actions, and also any *TRANSIENT* actions
    - Only *TOPOLOGYCHECK* and *TRANSIENT* actions with smallest Time Delay
  4. Solve power flow
  5. Apply true *POSTCHECK* and true *TOPOLOGYCHECK* actions, and also any *TRANSIENT* actions
    - Only *POSTCHECK*, *TOPOLOGYCHECK*, and *TRANSIENT* actions with smallest Time Delay will be applied
  6. If any *POSTCHECK*, *TOPOLOGYCHECK*, or *TRANSIENT* actions are implemented then repeat steps 2-6
- Keep repeating this over and over until no more actions occur