

# Response to Basic RAS Requirements in PowerWorld Simulator



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**PowerWorld**  
Corporation

May 14, 2013

# Presentation Goal



- Take the example system that James O'Brien created
- Briefly (20 – 30 minutes), walk through defining just one of the RAS schemes from the example
- Demonstrate how they function in PowerWorld
- Peak your interest enough so that you can go read through a detailed white-paper on this example that we put together
- This can be downloaded from PowerWorld Corporation Website at either of the following links
  - [www.powerworld.com/files/RAS\\_Modeling\\_PowerWorld.pdf](http://www.powerworld.com/files/RAS_Modeling_PowerWorld.pdf)
  - [www.powerworld.com/knowledge-base/ras-modelin](http://www.powerworld.com/knowledge-base/ras-modelin)

# http://www.powerworld.com/ knowledge-base/ras-modelin



The screenshot shows a web browser window with the URL [www.powerworld.com/knowledge-base/ras-modelin](http://www.powerworld.com/knowledge-base/ras-modelin). The page features the PowerWorld Corporation logo and a navigation menu with links: Home, Products, Services, Solutions, Download & Purchase, Online Support, Training & Events, and Company. A prominent blue banner reads "Knowledge Base". On the left, a "Filter by" section includes a "PRODUCT" list (Simulator, TransLineCalc, OPS-X Trainer, Retriever, Viewer) and a "TYPE" list (Presentation, Tip, User Guide, How-to, Script, Cases, Technical Papers, FAQ). The main content area is titled "Remedial Action Scheme (RAS) Modeling in Contingency Analysis" and contains a link to a PDF White Paper on RAS Modeling, [RAS\\_Modeling\\_PowerWorld](#). Below this, it states: "PowerWorld is often asked questions about how to model automated and conditional actions that occur when performing steady-state contingency analysis in PowerWorld Simulator. This type of control action goes by many names including the following." A bulleted list follows: Remedial Action Schemes (RAS) or, Special Protection Schemes (SPS), and Operating Procedures. At the bottom, it mentions: "PowerWorld Simulator offers a great amount of flexibility to model these control features of the power system. The [RAS\\_Modeling\\_PowerWorld.pdf](#) document linked above was created in response to a request from the WECC Modeling SPS and Relays Ad-Hoc Task Force (MSRATF) in May 2013 to".

# Best Way to Understand This

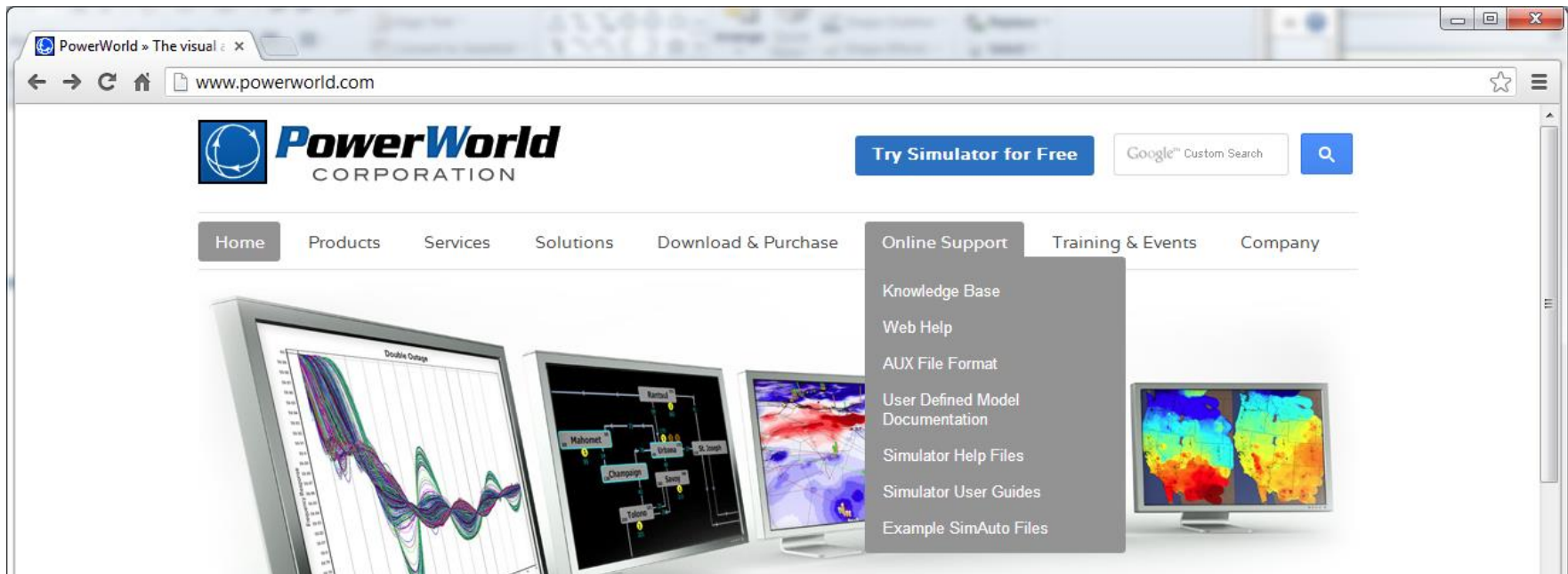


- Sit down and walk through the PDF document from our website
- Where can you get help?
  - As you have questions, call PowerWorld Corporation for support
    - [weber@powerworld.com](mailto:weber@powerworld.com)
    - (217) 384-6330 ext. 13
  - Website
    - Hover over Online Support on the main page
    - Hover over Training & Events on the main page

# PowerWorld Online Support



- Knowledge Base → earlier document
- Web Help → software documentation
- AUX File Format → Auxiliary File Format



# PowerWorld Training Support Online

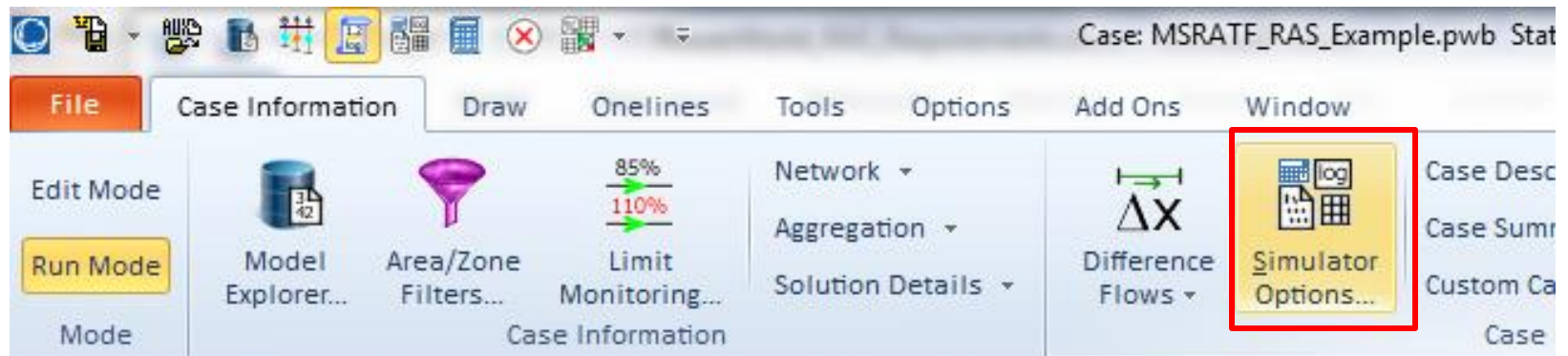


- [www.powerworld.com/training/online-training](http://www.powerworld.com/training/online-training)
- Our entire 2-day introductory course with narrated video has been on our website for several years
- Last year we also put *all* our presentation slides from *all* our training courses under the free download section as well
  - Security Analysis Class covers topics related to RAS modeling
  - [www.powerworld.com/training/online-training/security-analysis](http://www.powerworld.com/training/online-training/security-analysis)

# Make-up Power Demonstration



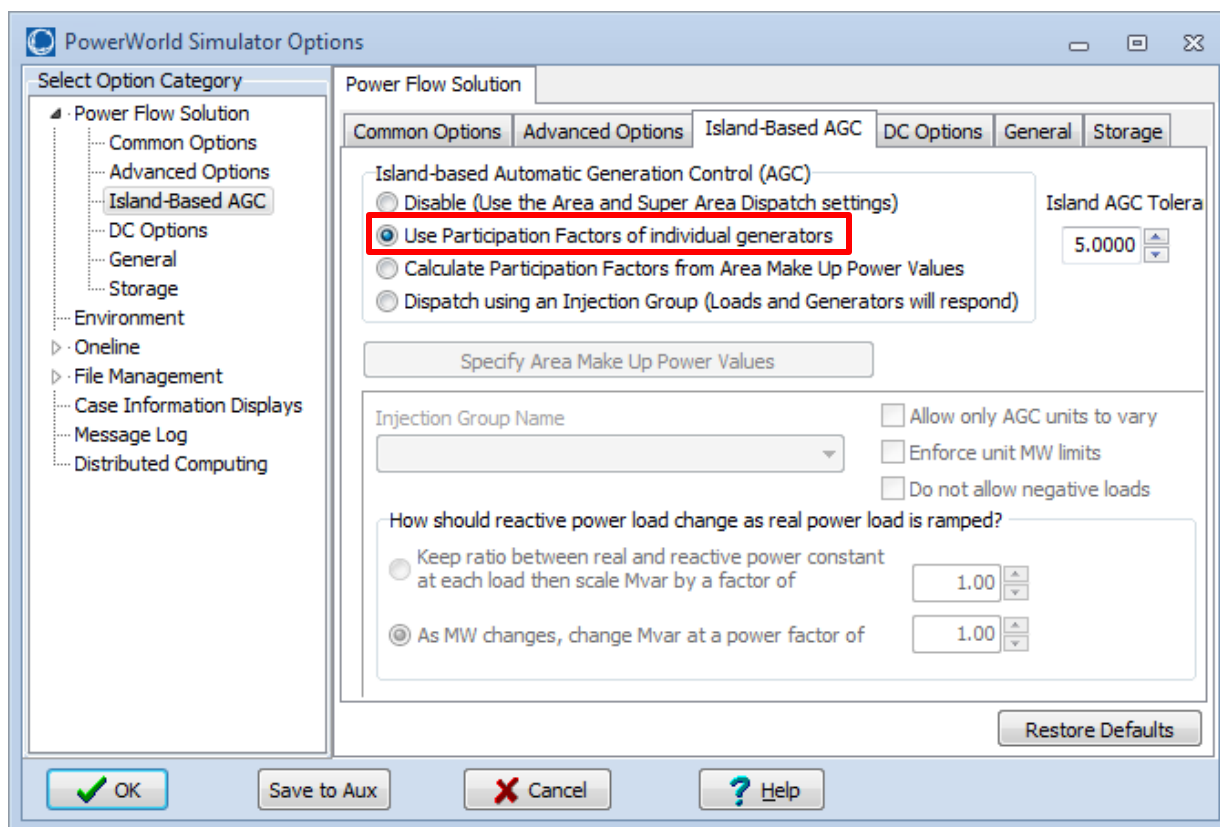
- Open the initial Test Case
- On the Case Information Ribbon Tab, choose **Simulator Options...**



# Configure “Island-Based” AGC Control



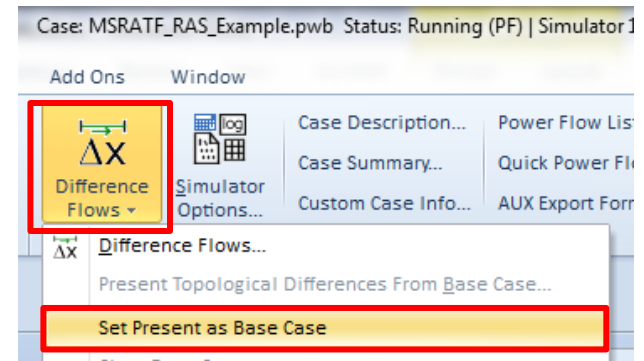
- Go to PowerWorld Solution\Island-Based AGC
- Choose Use Participation Factors of individual generators





# Initial Generation Profile

- Solve the Power Flow
- Click **Difference Flows** > **Set Present as Base Case**
- The initial generation profile is as follows



Model Explorer: Generators

Explore Fields

- Loads (26)
- Mismatches (37)
- Multi-Terminal DC
- Switched Shunts (8)
- Three-Winding Transfo
- Transformer Controls (
- VSC DC Transmission L
- Aggregations
- Areas (1)
- Injection Groups
- Interfaces
- Islands (1)

Open New Explorer

Gen Records Areas Buses

Records Geo Set Columns

Filter Advanced Generator

Find... Remove Quick Filter...

	Number of Bus	Name of Bus	ID	Status	Gen MW	Gen Mvar	Set Volt	AGC	VR	Min MW	Max MW	Min Mvar	Max Mvar	Cost Mode	Part. Factor
1	14	Texan	1	Closed	10.00	5.00	1.01150	YES	ES	10.00	35.00	0.00	5.00	None	35.00
2	28	Viking	1	Closed	150.00	3.04	1.03000	YES	ES	0.00	150.00	-60.00	60.00	None	150.00
3	28	Viking	2	Closed	150.00	3.04	1.03000	YES	ES	0.00	150.00	-60.00	60.00	None	150.00
4	31	Cowboy	1	Closed	187.04	117.14	1.03000	YES	ES	0.00	220.00	-90.00	120.00	None	220.00
5	44	Bill	1	Closed	20.00	-14.03	1.01150	YES	ES	20.00	150.00	-20.00	40.00	None	150.00
6	48	Jet	1	Closed	16.00	-14.00	1.00000	YES	ES	16.00	52.00	-14.00	26.00	None	52.00
7	50	Eskimo	1	Closed	49.01	19.77	1.02000	YES	ES	38.00	80.00	-18.00	33.00	None	80.00
8	53	Stampeder	1	Closed	245.04	45.00	1.02000	YES	ES	0.00	400.00	0.00	45.00	None	400.00
9	54	Roughrider	1	Open	0.00	0.00	1.01000	YES	ES	15.00	110.00	-20.00	60.00	None	110.00

Search Search Now Options

# Demonstration of Participation Factor Control



- Open Generator at Viking 1, and Solve
- New generator MW outputs are now

Bus	Name of Bus	ID	Status	Gen MW	Gen Mvar	Set Volt	AGC	AVR	Min MW	Max MW	Min Mvar	Max Mvar	Cost Model	Part. Factor
14	Texan	1	Closed	15.53	5.00	1.01150	YES	YES	10.00	35.00	0.00	5.00	None	35.00
28	Viking	1	Open	0.00	0.00	1.03000	YES	YES	0.00	150.00	-60.00	60.00	None	150.00
28	Viking	2	Closed	150.00	9.36	1.03000	YES	YES	0.00	150.00	-60.00	60.00	None	150.00
31	Cowboy	1	Closed	221.82	101.85	1.03000	YES	YES	0.00	220.00	-90.00	120.00	None	220.00
44	Bill	1	Closed	43.71	-20.00	1.01150	YES	YES	20.00	150.00	-20.00	40.00	None	150.00
48	Jet	1	Closed	24.22	-14.00	1.00000	YES	YES	16.00	52.00	-14.00	26.00	None	52.00
50	Eskimo	1	Closed	61.66	11.66	1.02000	YES	YES	38.00	80.00	-18.00	33.00	None	80.00
53	Stampeder	1	Closed	308.28	45.00	1.02000	YES	YES	0.00	400.00	0.00	45.00	None	400.00
54	Roughrider	1	Open	0.00	0.00	1.01000	YES	YES	15.00	110.00	-20.00	60.00	None	110.00

- Use difference flows to show the difference

f Bus	Name of Bus	ID	Status	Gen MW	Gen Mvar
14	Texan	1	Closed	5.53	0.00
28	Viking	1	Open	-150.00	-3.04
28	Viking	2	Closed	0.00	6.32
31	Cowboy	1	Closed	34.78	-15.30
44	Bill	1	Closed	23.71	-5.97
48	Jet	1	Closed	8.22	0.00
50	Eskimo	1	Closed	12.65	-8.11
53	Stampeder	1	Closed	63.24	0.00
54	Roughrider	1	Open	0.00	0.00

# Demonstration of Participation Factor Control



- Ignore Viking 2 because it's already at it's maximum MW output.
- Ignore Roughrider because it's OPEN

**MW Change solved for by PowerWorld**

Number	Name	ID	Status	Solved Change	Part. Factor	Percentage of Change		Proportional Change MW
14	Texan	1	Closed	5.53	35	=35/937	3.74%	5.53
31	Cowboy	1	Closed	34.78	220	=220/937	23.48%	34.78
44	Bill	1	Closed	23.71	150	=150/937	16.01%	23.71
48	Jet	1	Closed	8.22	52	=52/937	5.55%	8.22
50	Eskimo	1	Closed	12.65	80	=80/937	8.54%	12.65
53	Stampeder	1	Closed	63.24	400	=400/937	42.69%	63.24
			<b>SUM</b>	<b>148.13</b>	<b>937</b>			

**Sum of Change**

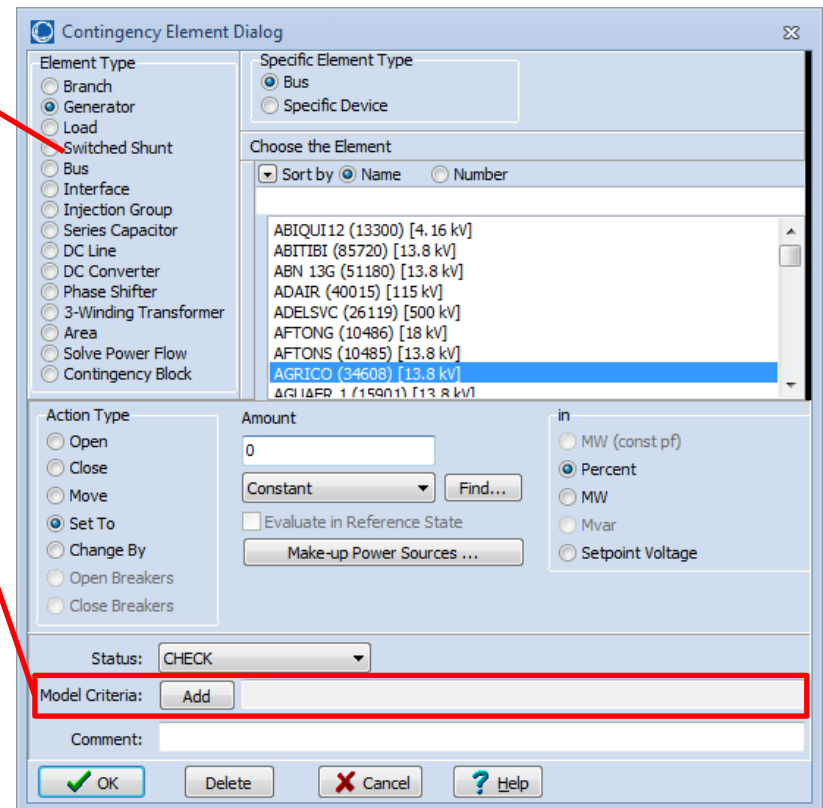
**Normalized Percentage**

**Percentage \* Sum change**

# Defining a Conditional Contingency Action



- 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



# Relationships



- Model Condition, Model Filter, Contingency Element Relationship

*Contingency Element groups together the Model Criteria with the Action*

*One Model Filter (Boolean Expression of other Criteria)*

*Three Model Conditions*

Cowboy-Cardinal 1 345kV Line

Cowboy-Seahawk 1 345kV Line

Cowboy-Lion 345/138kV Transformer

AND

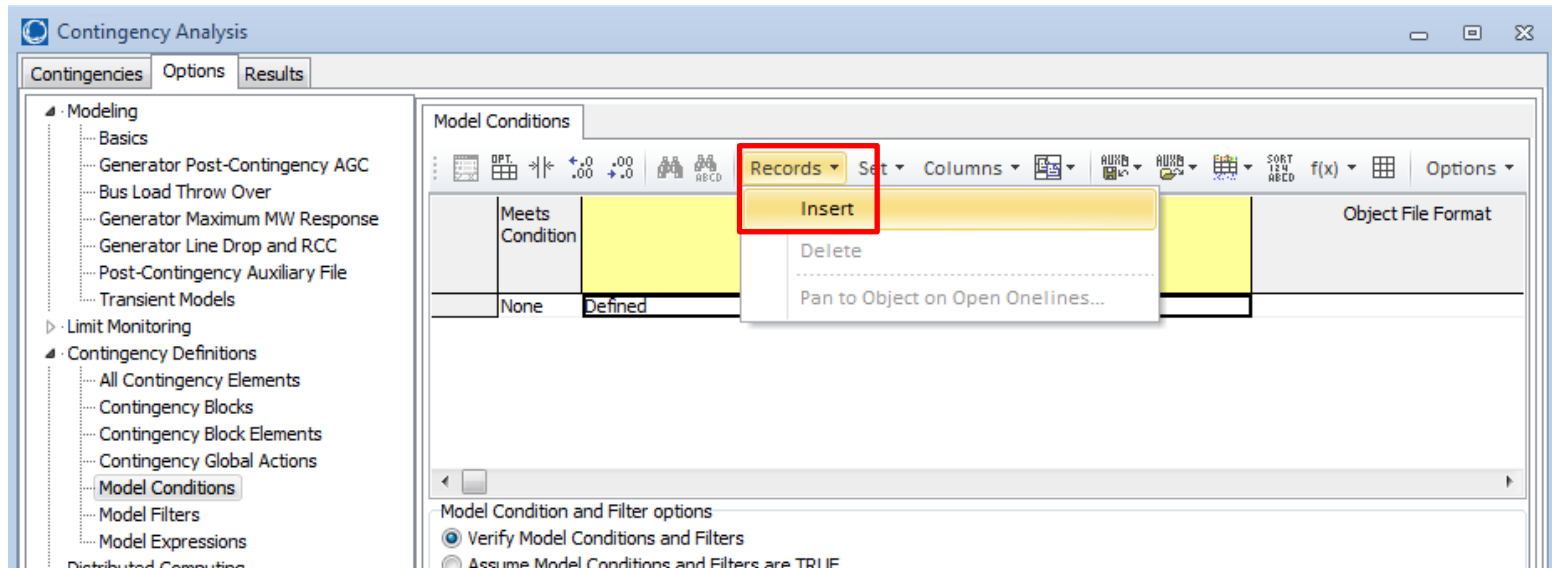
*Contingency "Action"*

OPEN Cowboy G1

# Model Condition Creation



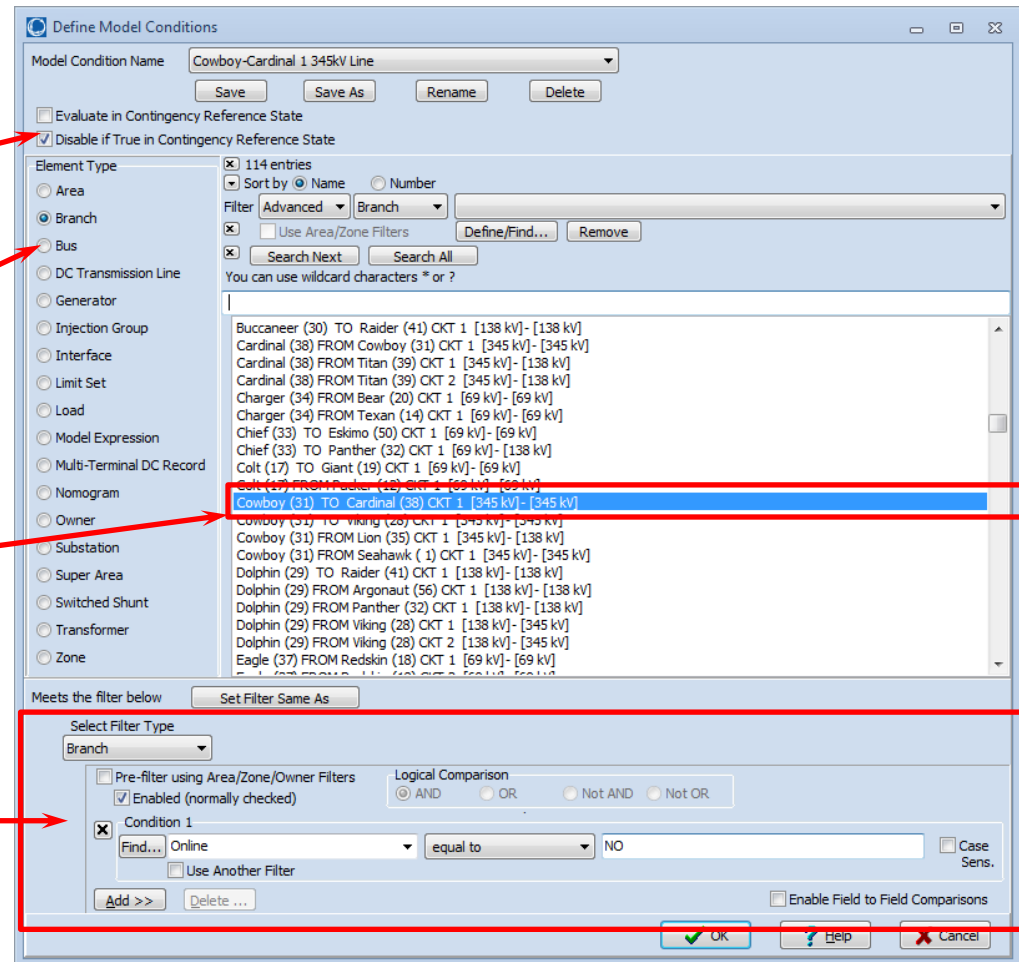
- Open the Contingency Analysis Dialog
- On the Options Tab, go to Contingency Definitions\Model Conditions
- Choose Records>Insert



# Cowboy-Cardinal 1 345 kV Line



- Disable if True in Ctg Ref State
  - YES (checked)
- Object Type
  - Branch
- Choose Object
  - Cowboy-Cardinal
- Build Advanced Filter Definition
  - Online = NO



# Cowboy-Seahawk 1 345 kV Line



- Disable if True in Ctg Ref State
  - YES (checked)
- Object Type
  - Branch
- Choose Object
  - Cowboy-Seahawk
- Build Advanced Filter Definition
  - Online = NO

Define Model Conditions

Model Condition Name: Cowboy-Seahawk 1 345kV Line

☐ Evaluate in Contingency Reference State

☒ Disable if True in Contingency Reference State

Element Type: ☒ Branch

Filter: Advanced

Condition 1: ☒ Find... Online equal to NO

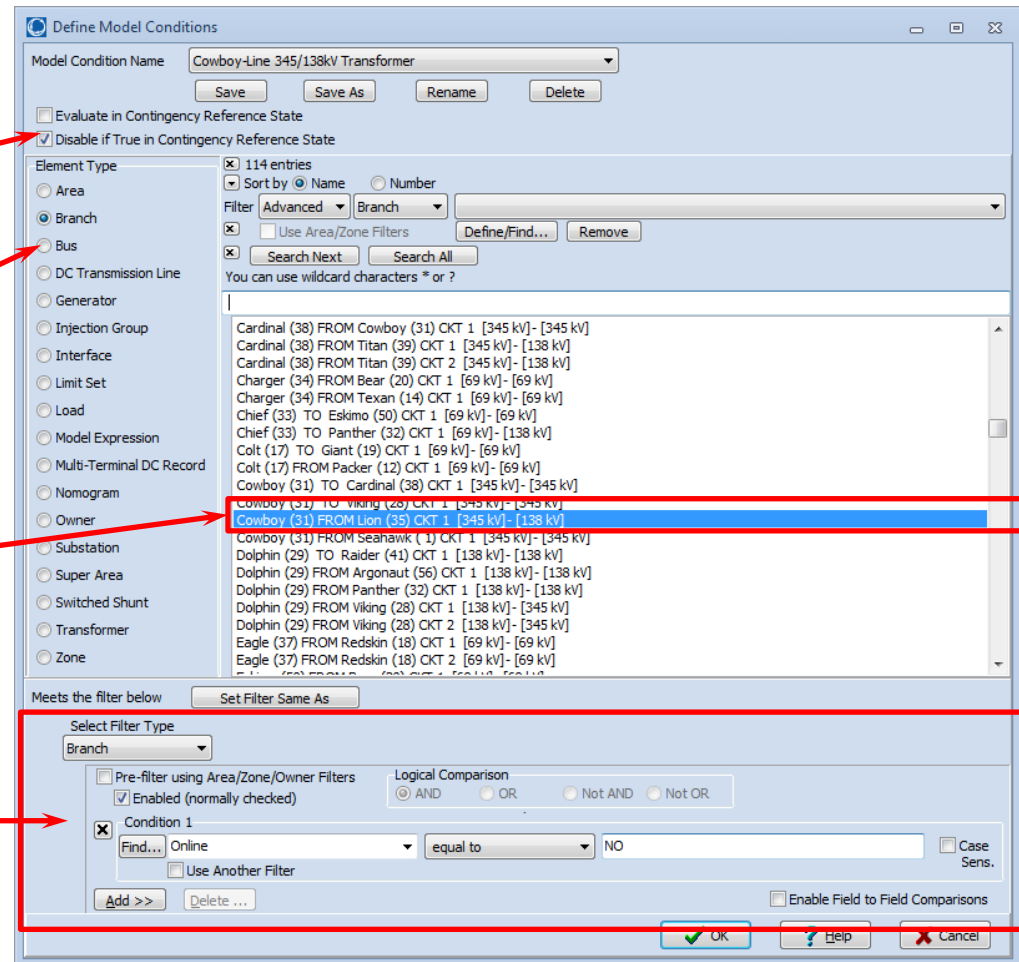
Cowboy (31) FROM Seahawk (1) CKT 1 [345 kV] - [345 kV]



# Cowboy-Lion 345/138 kV Transformer



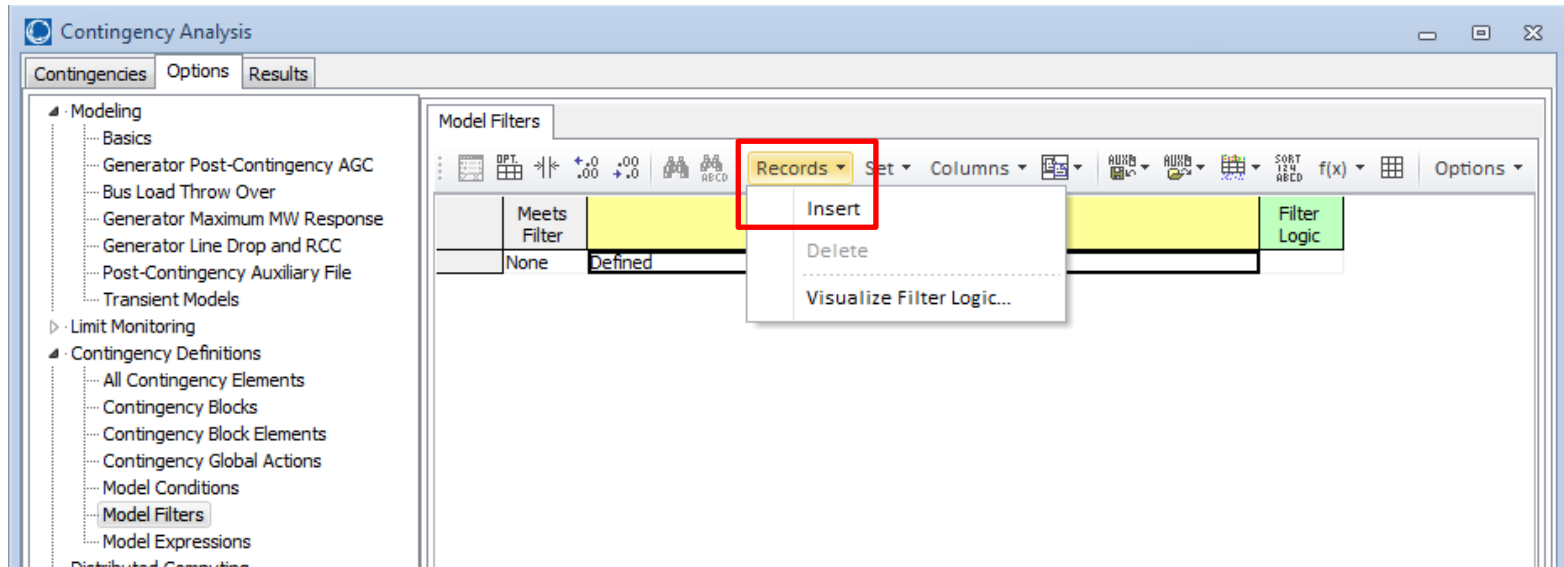
- Disable if True in Ctg Ref State
  - YES (checked)
- Object Type
  - Branch
- Choose Object
  - Cowboy-Lion
- Build Advanced Filter Definition
  - Online = NO



# Model Filter Creation



- Open the Contingency Analysis Dialog
- On the Options Tab, go to Contingency Definitions\Model Conditions
- Choose Records>Insert



# Model Filter Creation



- Choose AND Logic
- Choose Conditions

A screenshot of the 'Filter Conditions' dialog box. The 'Filter Name' is 'OPEN Cowboy G1'. The 'Logical Comparison' section has 'AND' selected. There are three model conditions listed: 'Model Condition 3' with 'Cowboy-Line 345/138kV Transformer', 'Model Condition 2' with 'Cowboy-Seahawk 1 345kV Line', and 'Model Condition 1' with 'Cowboy-Cardinal 1 345kV Line'. Each condition has radio buttons for 'Condition', 'Filter', and 'Not'. At the bottom are 'Add >>', 'Delete ...', 'Modify Model Conditions', 'OK', 'Help', and 'Cancel' buttons.

Filter Conditions

Filter Name: OPEN Cowboy G1

Save Save As Rename Delete View Filter Logic

Logical Comparison

☒ AND ☐ OR ☐ Not AND ☐ Not OR

Model Condition 3  
Find... Cowboy-Line 345/138kV Transformer ☒ Condition ☐ Filter ☐ Not

Model Condition 2  
Find... Cowboy-Seahawk 1 345kV Line ☒ Condition ☐ Filter ☐ Not

Model Condition 1  
Find... Cowboy-Cardinal 1 345kV Line ☒ Condition ☐ Filter ☐ Not

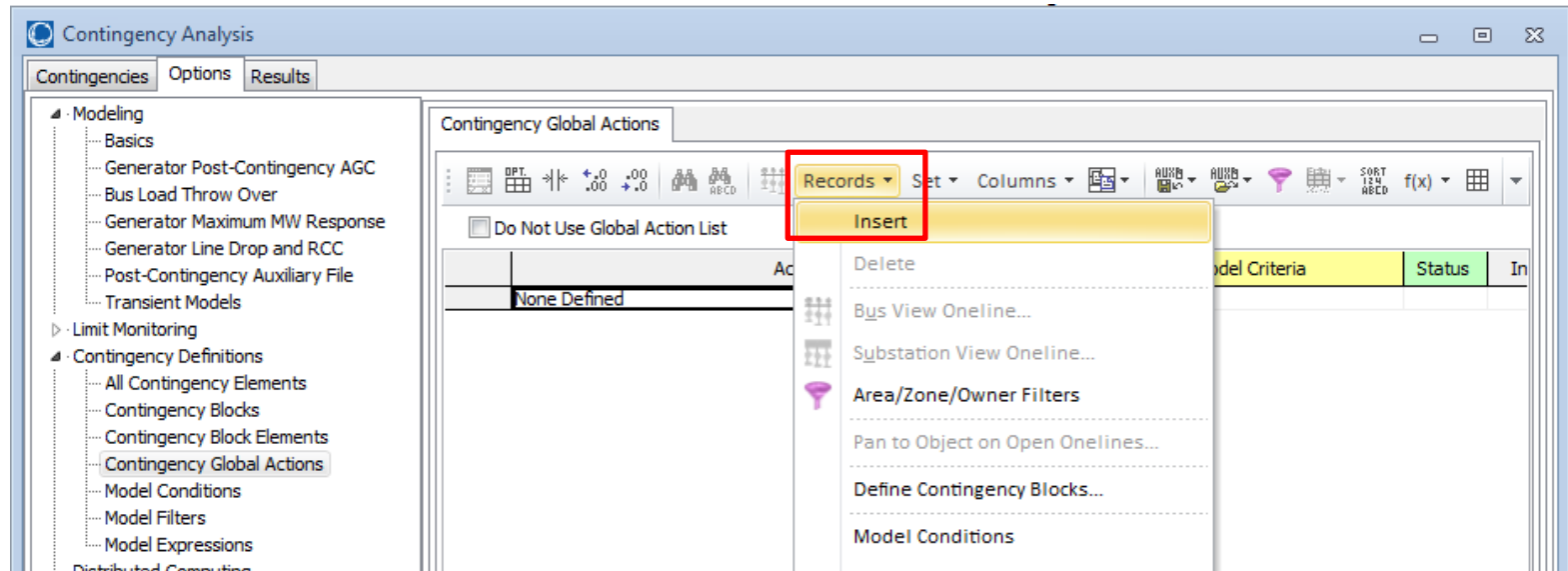
Add >> Delete ... Modify Model Conditions

OK Help Cancel

# Contingency Global Actions



- Open the Contingency Analysis Dialog
- On the Options Tab, go to Contingency Definitions\Contingency Global Actions
- Choose Records>Insert



# Contingency Global Actions



- Element Type  
= Generator
- Element  
= Cowboy Generator
- Action  
= Open
- Status  
= TOPOLOGYCHECK
- Model Criteria  
= OPEN Cowboy G1d

The screenshot shows the 'Contingency Element Dialog' window. Red boxes and arrows highlight the following settings:

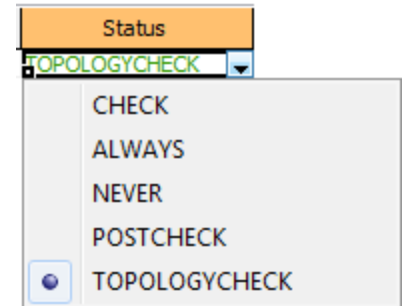
- Element Type:** 'Generator' is selected in the list.
- Choose the Element:** 'Cowboy (31) #1 [345 kV]' is selected in the list.
- Action Type:** 'Open' is selected.
- Status:** 'TOPOLOGYCHECK' is selected in the dropdown.
- Model Criteria:** 'OPEN Cowboy G1d' is entered in the text field.

Other visible details include a 'Sort by' dropdown set to 'Name', a list of other elements like 'Bill (44) #1 [69 kV]', and buttons for 'OK', 'Delete', 'Cancel', and 'Help' at the bottom.

# Contingency Analysis Processing



- Contingency Processing flowchart
  1. Apply **ALWAYS** actions and true **CHECK** actions
  2. Update topology (branch, bus status)
  3. Apply true **TOPOLOGYCHECK** actions
  4. Solve power flow
  5. Apply true **POSTCHECK** and **TOPOLOGYCHECK** 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



# Demonstrate the Function



- Open the Case
- Open the Auxiliary File “DefineAll.aux”
  - Show Model Conditions
  - Show Model Filters
  - Show Contingency Global Actions
- Under no outage condition, run the contingency analysis tool
  - Show the Violation list
  - Show What Actually Occurred

# Contingency Violation List



Contingency Analysis

Contingencies Options Results

View Results By Element

- Lines/Transformers
- Buses
- Interfaces
- Nomogram Interfaces
- Custom Monitors

View Results by Contingency

- Contingency Violation List
- What Actually Occurred
- Contingency Violation Matrices
- Text File Report Writing
- Summary

Contingency Violation List

Records Set Columns

	Label	Element	Category	Value	Limit	Percent
1	L_Packer-RedskinC1	Bronco ( 5) -> Redskin ( 1	Branch MV	88.64	82.00	108.10
2	L_Packer-RedskinC1	Bill ( 44) -> Bronco ( 5)	Branch MV	110.36	82.00	134.59
3	L_Cowboy-CardinalC1	Viking ( 28) -> Dolphin ( 2	Branch MV	110.02	100.00	110.02
4	T_Seahawk-BrownC1	Viking ( 28) -> Dolphin ( 2	Branch MV	111.08	100.00	111.08
5	L_Seahawk-CowboyC1	Viking ( 28) -> Dolphin ( 2	Branch MV	111.08	100.00	111.08
6	L_Cowboy-CardinalC1	Viking ( 28) -> Dolphin ( 2	Branch MV	110.02	100.00	110.02
7	T_Seahawk-BrownC1	Viking ( 28) -> Dolphin ( 2	Branch MV	111.08	100.00	111.08
8	L_Seahawk-CowboyC1	Viking ( 28) -> Dolphin ( 2	Branch MV	111.08	100.00	111.08
9	T_Roughrider-StampederC1	Jaguar ( 47) -> Jet ( 48)	Branch MV	214.55	187.00	114.73
10	T_Roughrider-StampederC1	Stampeder ( 53) -> Jaguar	Branch MV	187.22	185.00	101.20
11	T_Roughrider-StampederC1	Jet ( 48) -> Roughrider ( 5	Branch MV	107.51	83.00	129.53
12	T_Jet-JaguarC1	Stampeder ( 53) -> Roughr	Branch MV	200.04	187.00	106.97
13	L_Falcon-PatriotC1	Roughrider ( 54) -> Bomber	Branch MV	72.73	50.00	145.45
14	T_Falcon-TitanC1	Roughrider ( 54) -> Bomber	Branch MV	64.34	50.00	128.67
15	L_Seahawk-CowboyC1	Seahawk ( 1)	Bus Low V	0.88	0.90	

Status Finished with 15 Violations and 1 Unsolveable Contingencies. Initial State Restored.

Refresh Displays After Each Contingency

Load Auto Insert Save Other > Start Run Close ? Help



# Contingency What Actually Occurred



Contingency Analysis

Contingencies Options Results

View Results By Element

- Lines/Transformers
- Buses
- Interfaces
- Nomogram Interfaces
- Custom Monitors

View Results by Contingency

- Contingency Violation List
- What Actually Occurred
- Contingency Violation Matrices
- Text File Report Writing
- Summary

What Actually Occurred

	Contingency	Applied or Skipped	Actions	Model Criteria	Status
1	L-2_Roughrider-Rav	Applied	OPEN Line Raven_69.0 (15) TO Roughr		CHECK
2	L-2_Roughrider-Rav	Applied	OPEN Line Raven_69.0 (15) TO Roughr		CHECK
3	L-2_Roughrider-Rav	Applied	OPEN Gen Stampeder_138.0 (53) #1	OPEN Stampede TOPOLO	
4	L-2_Roughrider-Rav	Skipped	OPEN Gen Cowboy_345.0 (31) #1	OPEN Cowboy G TOPOLO	
5	L-2_Roughrider-Rav	Skipped	OPEN InjectionGroup Viking G1 and G2	OPEN Viking G1: TOPOLO	
6	L-2_Roughrider-Rav	Skipped	OPEN Gen Viking_345.0 (28) #1	Dolphin-Raider 1 TOPOLO	
7	L-2_Roughrider-Rav	Skipped	OPEN Transformer Viking_345.0 (28) TO Viking-Dolphin 1	POSTCHE	
8	L-2_Roughrider-Rav	Skipped	OPEN Transformer Viking_345.0 (28) TO Viking-Dolphin 2	POSTCHE	
9	L-2_Roughrider-Rav	Applied	OPEN Line Raven_69.0 (15) TO Roughr		CHECK
10	L-2_Roughrider-Rav	Applied	OPEN Line Raven_69.0 (15) TO Roughr		CHECK
11	L-2_Roughrider-Rav	Applied	OPEN Gen Stampeder_138.0 (53) #1	OPEN Stampede TOPOLO	
12	L-2_Roughrider-Rav	Skipped	OPEN Gen Cowboy_345.0 (31) #1	OPEN Cowboy G TOPOLO	
13	L-2_Roughrider-Rav	Skipped	OPEN InjectionGroup Viking G1 and G2	OPEN Viking G1: TOPOLO	
14	L-2_Roughrider-Rav	Skipped	OPEN Gen Viking_345.0 (28) #1	Dolphin-Raider 1 TOPOLO	

Status Finished with 15 Violations and 1 Unsolveable Contingencies. Initial State Restored.

Refresh Displays After Each Contingency

Load Auto Insert Save Other > Start Run Close ? Help

# Contingency What Actually Occurred



- Using Advanced Filtering to show only Applied actions

	Contingency	Applied Skipped	Actions	Model Criteria	Status	Comment	Brief What Occurred	Origin of Action
1	L-2_Roughrider-Raven 2&3	Applied	OPEN Line Raven_69.0 (15) TO Rou		CHECK		Opened flow of 39.37 MVA	ELEMENT
2	L-2_Roughrider-Raven 2&3	Applied	OPEN Line Raven_69.0 (15) TO Rou		CHECK		Opened flow of 39.19 MVA	ELEMENT
3	L-2_Roughrider-Raven 2&3	Applied	OPEN Gen Stampeder_138.0 (53) #1	OPEN Stampeder G1	TOPOLOGYCHECK		Opened 245.04 MW	GLOBAL
4	L-2_Roughrider-Raven 1&2	Applied	OPEN Line Raven_69.0 (15) TO Rou		CHECK		Opened flow of 39.79 MVA	ELEMENT
5	L-2_Roughrider-Raven 1&2	Applied	OPEN Line Raven_69.0 (15) TO Rou		CHECK		Opened flow of 39.37 MVA	ELEMENT
6	L-2_Roughrider-Raven 1&2	Applied	OPEN Gen Stampeder_138.0 (53) #1	OPEN Stampeder G1	TOPOLOGYCHECK		Opened 245.04 MW	GLOBAL

	Contingency	Applied Skipped	Actions	Model Criteria	Status	Comment	Brief What Occurred	Origin of Action
41	L_Cowboy-VikingC1	Applied	OPEN Line Cowboy_345.0 (31) TO Viking_345.0 (		CHECK		Opened flow of 122.97 MVA	ELEMENT
42	L_Cowboy-VikingC1	Applied	OPEN Transformer Viking_345.0 (28) TO Dolphin_Viking-Dolphin 1 345/		POSTCHECK		Opened flow of 151.23 MVA	GLOBAL
43	L_Cowboy-VikingC1	Applied	OPEN Transformer Viking_345.0 (28) TO Dolphin_Viking-Dolphin 2 345/		POSTCHECK		Opened flow of 151.23 MVA	GLOBAL

# POSTCHECK Demo: L\_Cowboy-VikingC1



```
Message Log: MSRTAF_RAS_Example.pwb

5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM ***** Solving contingency L_Cowboy-VikingC1 *****
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM APPLYING: OPEN Line Cowboy_345.0 (31) TO Viking_345.0 (28) CKT 1
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Stampeder_138.0 (53) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Cowboy_345.0 (31) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN InjectionGroup Viking G1 and G2
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Viking_345.0 (28) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 1
5/10/2013 2:56:59 PM SKIPPING: OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 2
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM ***** Applying TOPOLOGYCHECK for Contingency L_Cowboy-VikingC1 *****
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Stampeder_138.0 (53) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Cowboy_345.0 (31) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN InjectionGroup Viking G1 and G2
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Viking_345.0 (28) #1
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM Number: 0 Max P: 120.485 at bus 28 Max Q: 0.000 at bus 47
5/10/2013 2:56:59 PM Number: 1 Max P: 10.744 at bus 28 Max Q: 1.202 at bus 28
5/10/2013 2:56:59 PM Number: 2 Max P: 0.189 at bus 28 Max Q: 0.005 at bus 28
5/10/2013 2:56:59 PM Number: 3 Max P: 0.000 at bus 28 Max Q: 0.000 at bus 28
5/10/2013 2:56:59 PM Finished voltage control loop iteration: 1
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM ***** Applying POSTCHECK Iteration #1 for Contingency L_Cowboy-VikingC1 *****
```

Contingency Record  
elements are applied

TOPOLOGYCHECK is done,  
but nothing meets the  
criteria so nothing is done

Power Flow Solution Solves

Action occurs AFTER Power Flow

POSTCHECK is done and  
Viking-Dolphin transformers  
are overloaded so they  
opened

```
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM ***** Applying POSTCHECK Iteration #1 for Contingency L_Cowboy-VikingC1 *****
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Stampeder_138.0 (53) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Cowboy_345.0 (31) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN InjectionGroup Viking G1 and G2
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Viking_345.0 (28) #1
5/10/2013 2:56:59 PM APPLYING: OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 1
5/10/2013 2:56:59 PM APPLYING: OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 2
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM ***** Applying TOPOLOGYCHECK for Contingency L_Cowboy-VikingC1 *****
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Stampeder_138.0 (53) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Cowboy_345.0 (31) #1
5/10/2013 2:56:59 PM SKIPPING: OPEN InjectionGroup Viking G1 and G2
5/10/2013 2:56:59 PM SKIPPING: OPEN Gen Viking_345.0 (28) #1
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 14 by 11.08 MW to 21.1
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 44 by 47.50 MW to 67.5
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 48 by 16.47 MW to 32.5
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 50 by 25.33 MW to 74.3
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 53 by 126.66 MW to 371.7
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 14 by 1.95 MW to 23.0
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 44 by 8.37 MW to 75.9
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 48 by 2.90 MW to 35.4
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 50 by 4.46 MW to 78.8
5/10/2013 2:56:59 PM AGC in island changed gen 1 at bus 53 by 22.31 MW to 394.0
5/10/2013 2:56:59 PM Generation Change Estimate Completed.
5/10/2013 2:56:59 PM *****
5/10/2013 2:56:59 PM Number: 0 Max P: 299.625 at bus 29 Max Q: 16.528 at bus 29
5/10/2013 2:56:59 PM Number: 1 Max P: 10.405 at bus 29 Max Q: 41.688 at bus 29
5/10/2013 2:56:59 PM Number: 2 Max P: 0.201 at bus 29 Max Q: 0.136 at bus 53
5/10/2013 2:56:59 PM Number: 3 Max P: 0.000 at bus 29 Max Q: 0.000 at bus 29
```

# TOPOLOGYCHECK Demo: L-2\_Roughrider-Raven 2&3

Contingency Record  
elements are applied

TOPOLOGYCHECK is  
done, Open Stampeder  
is met

Action occurs BEFORE  
Power Flow Solution

Power Flow Solution  
Solves

```
5/10/2013 2:56:02 PM *****
5/10/2013 2:56:02 PM ***** Solving contingency L-2_Roughrider-Raven 2&3 *****
5/10/2013 2:56:02 PM *****
5/10/2013 2:56:02 PM APPLYING: OPEN Line Raven_ 69.0 (15) TO Roughrider_ 69.0 (54) CKT 2
5/10/2013 2:56:02 PM APPLYING: OPEN Line Raven_ 69.0 (15) TO Roughrider_ 69.0 (54) CKT 3
5/10/2013 2:56:02 PM SKIPPING: OPEN Gen Stampeder_138.0 (53) #1
5/10/2013 2:56:02 PM SKIPPING: OPEN Gen Cowboy_345.0 (31) #1
5/10/2013 2:56:02 PM SKIPPING: OPEN InjectionGroup Viking G1 and G2
5/10/2013 2:56:02 PM SKIPPING: OPEN Gen Viking_345.0 (28) #1
5/10/2013 2:56:02 PM SKIPPING: OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 1
5/10/2013 2:56:02 PM SKIPPING: OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 2
5/10/2013 2:56:02 PM *****
5/10/2013 2:56:02 PM *****
5/10/2013 2:56:02 PM ***** Applying TOPOLOGYCHECK for Contingency L-2_Roughrider-Raven 2&3 *****
5/10/2013 2:56:02 PM *****
5/10/2013 2:56:02 PM APPLYING: OPEN Gen Stampeder_138.0 (53) #1
5/10/2013 2:56:02 PM SKIPPING: OPEN Gen Cowboy_345.0 (31) #1
5/10/2013 2:56:02 PM SKIPPING: OPEN InjectionGroup Viking G1 and G2
5/10/2013 2:56:02 PM SKIPPING: OPEN Gen Viking_345.0 (28) #1
5/10/2013 2:56:02 PM *****
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 14 by 15.97 MW to 26.0
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 44 by 68.45 MW to 88.4
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 48 by 23.73 MW to 39.7
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 50 by 30.99 MW to 80.0
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 14 by 9.03 MW to 35.0
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 44 by 46.17 MW to 134.6
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 48 by 12.27 MW to 52.0
5/10/2013 2:56:02 PM AGC in island changed gen 1 at bus 44 by 5.48 MW to 140.1
5/10/2013 2:56:02 PM Generation Change Estimate Completed.
5/10/2013 2:56:02 PM Number: 0 Max P: 245.042 at bus 53 Max Q: 45.000 at bus 53
5/10/2013 2:56:02 PM Number: 1 Max P: 2.854 at bus 44 Max Q: 16.206 at bus 53
5/10/2013 2:56:02 PM Number: 2 Max P: 0.006 at bus 50 Max Q: 0.005 at bus 54
5/10/2013 2:56:02 PM Gen(s) at bus 48 has backed off var limit
5/10/2013 2:56:02 PM Finished voltage control loop iteration: 1
```



# Dolphin-Raider Related Contingencies



- Dolphin-Raider
  - RAS occurs to Open Viking #1

Contingency	Applied Skipped	Actions	Model Criteria	Status	Brief What Occurred	Origin of Action
1 L_Dolphin-RaiderC1	Applied	OPEN Line Dolphin_138.0 (29) TO Raider_138.0 (41) CKT 1		CHECK	Opened flow of 66.23 MVA	ELEMENT
2 L_Dolphin-RaiderC1	Applied	OPEN Gen Viking_345.0 (28) #1	Dolphin-Raider 1 138 kV Line	TOPOLOGYCHECK	Opened 150.00 MW	GLOBAL
3 L-2_Dolphin-Panther/Dolphin-Raider	Applied	OPEN Line Panther_138.0 (32) TO Dolphin_138.0 (29) CKT 1		CHECK	Opened flow of 93.24 MVA	ELEMENT
4 L-2_Dolphin-Panther/Dolphin-Raider	Applied	OPEN Line Dolphin_138.0 (29) TO Raider_138.0 (41) CKT 1		CHECK	Opened flow of 66.23 MVA	ELEMENT
5 L-2_Dolphin-Panther/Dolphin-Raider	Applied	OPEN InjectionGroup Viking G1 and G2	OPEN Viking G1 and G2	TOPOLOGYCHECK	Opened 300.00 MW	GLOBAL
6 L-2_Dolphin-Panther/Dolphin-Raider	Applied	OPEN Gen Viking_345.0 (28) #1	Dolphin-Raider 1 138 kV Line	TOPOLOGYCHECK	was already open	GLOBAL

- L-2\_Dolphin-Panther/Dolphin-Raider
  - RAS occurs to Open Viking #1 and #2
  - RAS is triggered to Open Viking #1, but it says “was already open”

# Outage Condition: Dolphin-Raider



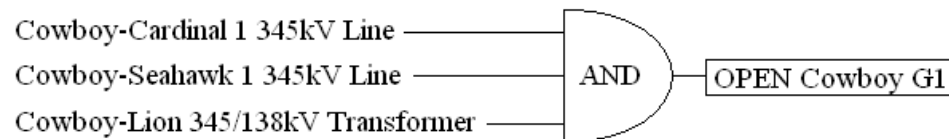
- Restore Contingency Reference
- Take Dolphin-Raider out
- Solve Power Flow
- Set new Contingency Reference
- Resolve all the contingencies
  - Notice “Brief What Occurred”
  - Disable if True in Reference State Matters!
  - Says “Model Criteria disabled...”

Contingency	Applied or Skipped	Actions	Model Criteria	Status	Brief What Occurred	Origin of Action
1 L-2_Roughrider-Raven 2&3	Applied	OPEN Line Raven_69.0 (15) TO Roughrider_69.0 (54) CKT 2		CHECK	Opened flow of 41.52 MVA	ELEMENT
2 L-2_Roughrider-Raven 2&3	Applied	OPEN Line Raven_69.0 (15) TO Roughrider_69.0 (54) CKT 3		CHECK	Opened flow of 41.33 MVA	ELEMENT
3 L-2_Roughrider-Raven 2&3	Applied	OPEN Gen Stampeder_138.0 (53) #1	OPEN Stampeder G1	TOPOLOGYCHECK	Opened 245.04 MW	GLOBAL
4 L-2_Roughrider-Raven 2&3	Skipped	OPEN Gen Cowboy_345.0 (31) #1	OPEN Cowboy G1	TOPOLOGYCHECK		GLOBAL
5 L-2_Roughrider-Raven 2&3	Skipped	OPEN InjectionGroup Viking G1 and G2	OPEN Viking G1 and G2	TOPOLOGYCHECK		GLOBAL
6 L-2_Roughrider-Raven 2&3	Skipped	OPEN Gen Viking_345.0 (28) #1	Dolphin-Raider 1 138 kV Line	TOPOLOGYCHECK	Model Criteria disabled because true in reference state	GLOBAL
7 L-2_Roughrider-Raven 2&3	Skipped	OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 1	Viking-Dolphin 1 345/138 Over 135%	POSTCHECK		GLOBAL
8 L-2_Roughrider-Raven 2&3	Skipped	OPEN Transformer Viking_345.0 (28) TO Dolphin_138.0 (29) CKT 2	Viking-Dolphin 2 345/138 Over 135%	POSTCHECK		GLOBAL

# Outage Condition: Cowboy-Lion 345 kV/138kV Bank



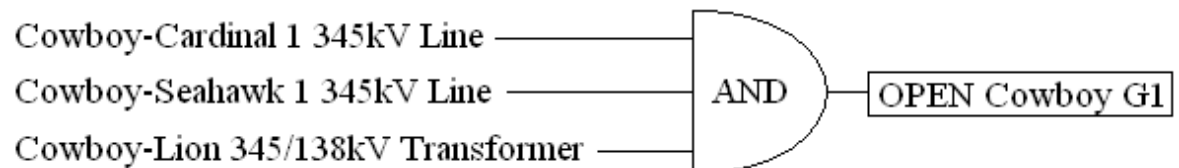
- Reopen case to start over
- Take Cowboy-Lion outage
- Solve Power Flow
- Set as Contingency Reference
- What happens for Contingency  
L-2\_Cowboy-Cardinal\Cowboy-Seahawk



# Compare TOPOLOGYCHECK and POSTCHECK implementation



- TOPOLOGYCHECK
  - Apply 2 lines out
  - TOPOLOGYCHECK captures that three lines are out now, so the Open Cowboy G1 occurs
  - Power Flow Solves
  - POSTCHECK captures that Viking-Dolphin transformers are overloaded
  - Etc...
- POSTCHECK
  - Apply 2 Lines out
  - Nothing happens for TOPOLOGYCHECK
  - **Power Flow Fails!**
  - TOPOLOGYCHECK is necessary for solution to be reached.





# Alternatives for Relay Action



- Viking-Dolphin POSTCHECK RAS is essentially an over-current relay
- As an alternative, Simulator allows you to define the Transient Stability Relay model
  - Define Transient Stability Relay Model
  - Inside Power Flow Contingency Analysis, choose Modeling Option to use this model

# Define TIOCRS Relay Model



Branch Information Dialog

Transformer	From Bus	To Bus	Circuit
Number	28	29	1
Name	Viking	Dolphin	
Area	1 (1)	1 (1)	
Nominal kV	345.0	138.0	
Voltage Angle	1.03000 -50.0346	1.02261 -52.5182	

Labels ... Viking\_Dolphin\_1

Parameters Transformer OPF Fault Info Area, Zone, Owner, Sub, PTDF Custom Stability GIC

Line Relay Model Tap/Phase Delays

Insert Delete Show Block Diagram Show Relay Zones

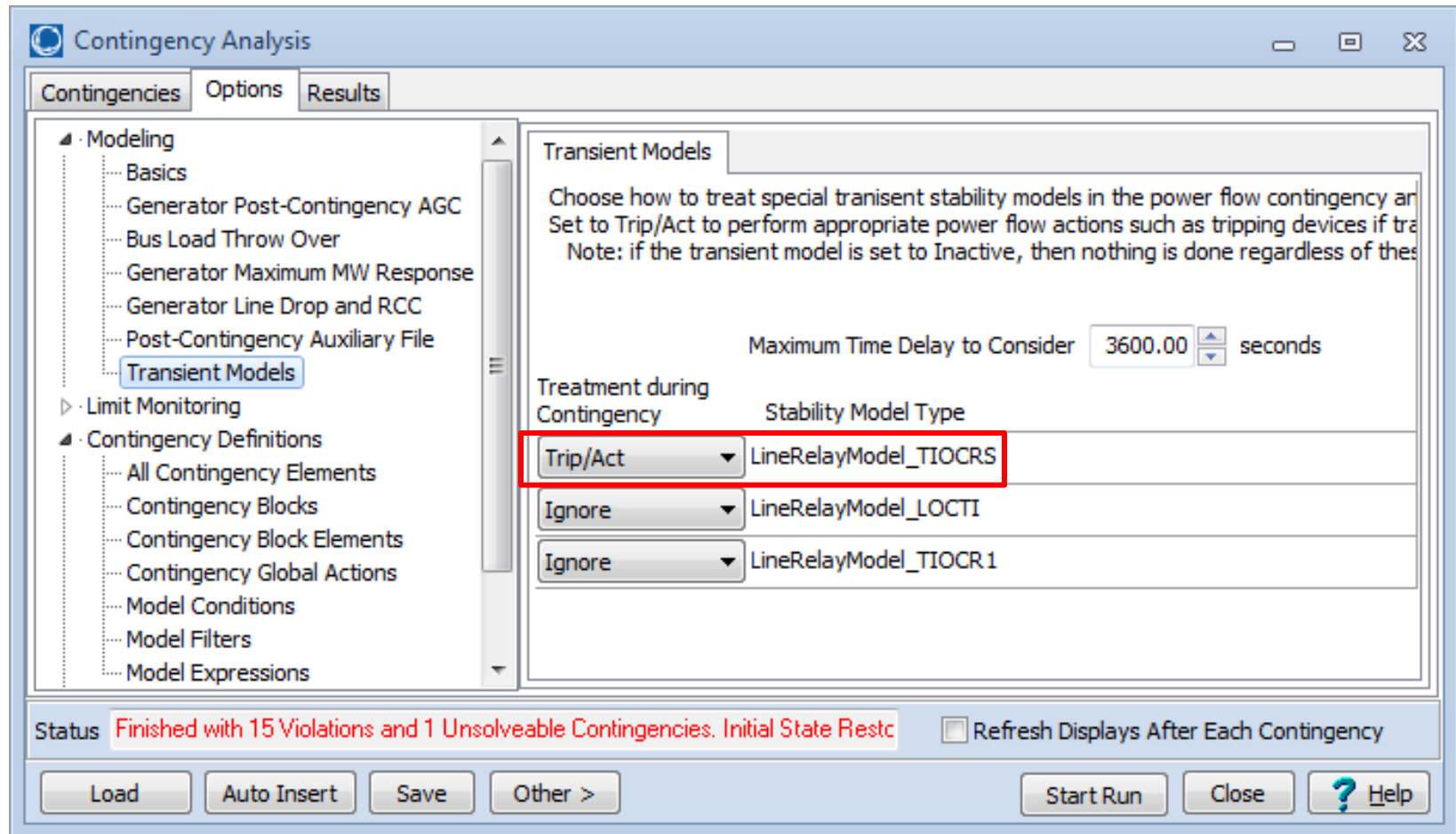
Type Active - TIOCRS (From End) Active Device is at From End of Line (otherwise at To End)

Parameters

Tran Trip Line 1	none	Choose...			
Tran Trip Line 2	none	Choose...			
Tran Trip Line 3	none	Choose...			
Relay Slot	1	Reset time	4.8500	E	0.00000
Monitor	1	p	0.02000	Load Shed %	1.0000
Curve Type	1	A	0.05150		
Threshold Current	1.3500	B	0.1140		
Breaker Time	0.00000	C	0.00000		
Tdm	1.0000	D	0.00000		

OK Save Cancel Help Print

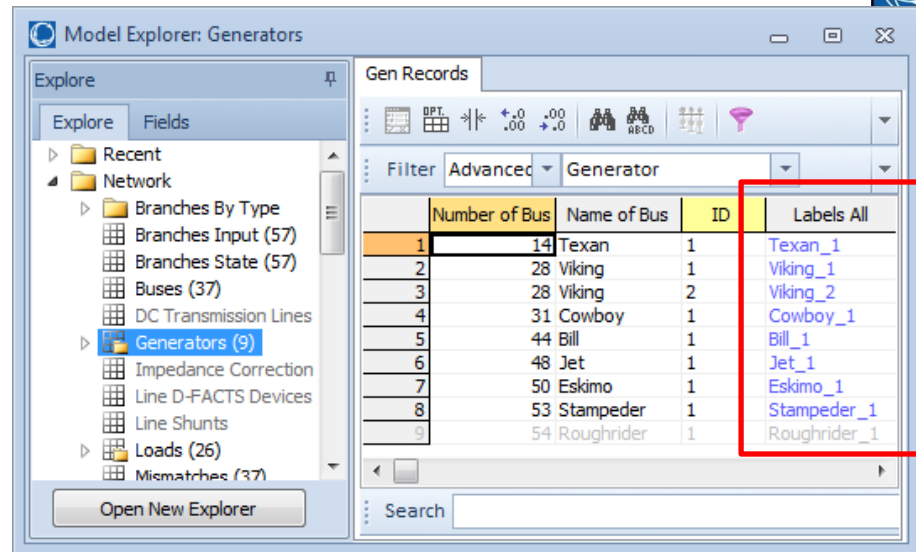
# Contingency Analysis Options: Modeling\Transient Models



# Object Labels

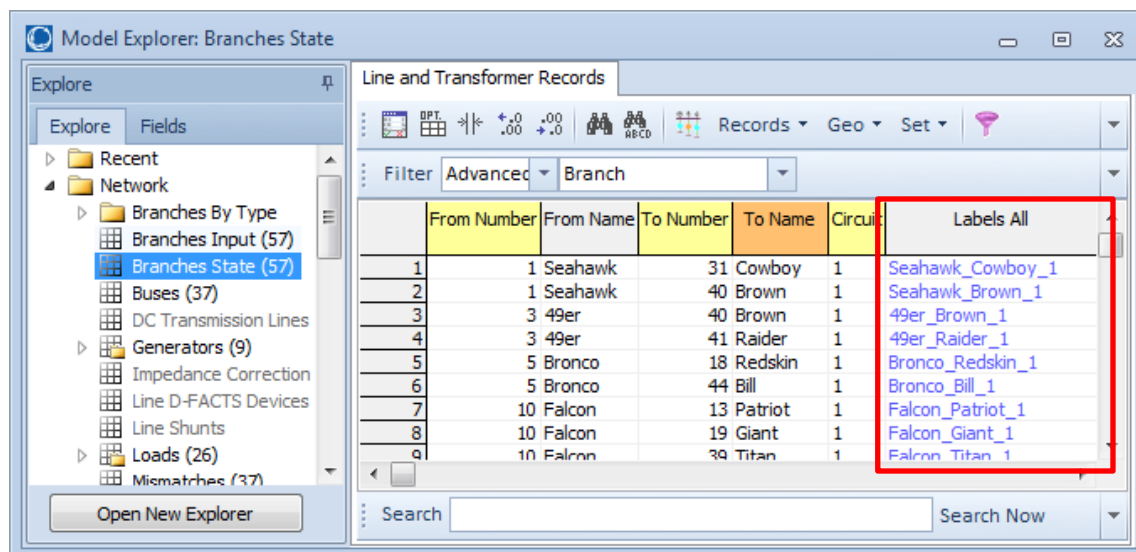
## → Unique Identifiers

- Generator Labels
- Branch Labels



The screenshot shows the 'Model Explorer: Generators' window. The 'Explore' pane on the left shows the 'Generators (9)' folder selected. The 'Gen Records' table on the right displays a list of generators with columns for 'Number of Bus', 'Name of Bus', 'ID', and 'Labels All'. A red box highlights the 'Labels All' column, which contains unique identifiers for each generator.

	Number of Bus	Name of Bus	ID	Labels All
1	14	Texan	1	Texan_1
2	28	Viking	1	Viking_1
3	28	Viking	2	Viking_2
4	31	Cowboy	1	Cowboy_1
5	44	Bill	1	Bill_1
6	48	Jet	1	Jet_1
7	50	Eskimo	1	Eskimo_1
8	53	Stampeder	1	Stampeder_1
9	54	Roughrider	1	Roughrider_1



The screenshot shows the 'Model Explorer: Branches State' window. The 'Explore' pane on the left shows the 'Branches State (57)' folder selected. The 'Line and Transformer Records' table on the right displays a list of branches with columns for 'From Number', 'From Name', 'To Number', 'To Name', 'Circuit', and 'Labels All'. A red box highlights the 'Labels All' column, which contains unique identifiers for each branch.

	From Number	From Name	To Number	To Name	Circuit	Labels All
1	1	Seahawk	31	Cowboy	1	Seahawk_Cowboy_1
2	1	Seahawk	40	Brown	1	Seahawk_Brown_1
3	3	49er	40	Brown	1	49er_Brown_1
4	3	49er	41	Raider	1	49er_Raider_1
5	5	Bronco	18	Redskin	1	Bronco_Redskin_1
6	5	Bronco	44	Bill	1	Bronco_Bill_1
7	10	Falcon	13	Patriot	1	Falcon_Patriot_1
8	10	Falcon	19	Giant	1	Falcon_Giant_1
9	10	Falcon	39	Titan	1	Falcon_Titan_1

# Miscellaneous

## Definitions in an Auxiliary File



```
//-----  
// Set the participation factor for all generators equal to the maximum MW output  
//-----  
SCRIPT  
{  
SetData(GEN, [GenParFac], ["@GenMWMax"], All);  
}  
//-----  
// Specify that all generators in the island response in proportion to their size  
//-----  
DATA (CTG_OPTIONS, [UseAreaPartsMakeUpPower])  
{  
"Gen Part Factors"  
}  
  
//-----  
// This creates an injection group containing both Viking Generators  
//-----  
DATA (PARTPOINT, [PPntType:1,PPntType,BusName_NomVolt,PPntID,PPntPFInit,PPntParFac,PPntUseFixedParFac],  
AUXDEF, YES)  
{  
"Viking G1 and G2" "GEN" "Viking_1" "" "SPECIFIED" 150.00 "NO"  
"Viking G1 and G2" "GEN" "Viking_2" "" "SPECIFIED" 150.00 "NO"  
}
```

# Model Condition Definitions in an Auxiliary File



```
DATA (MODELCONDITION, [FilterName,WhoAmI,ObjectType,FilterLogic,FilterPre,
                        DisableIfTrueInCTGReferenceState,EvaluateInRef],AUXDEF,YES)
{
"Cowboy-Cardinal 1 345kV Line"          "BRANCH 'Cowboy_Cardinal_1'"  "Branch" "AND" "NO" "YES" "NO"
  <SUBDATA Condition>
    BusObjectOnline = "NO"
  </SUBDATA>
"Cowboy-Line 345/138kV Transformer"      "BRANCH 'Lion_Cowboy_1'"      "Branch" "AND" "NO" "YES" "NO"
  <SUBDATA Condition>
    BusObjectOnline = "NO"
  </SUBDATA>
"Cowboy-Seahawk 1 345kV Line"           "BRANCH 'Seahawk_Cowboy_1'"  "Branch" "AND" "NO" "YES" "NO"
  <SUBDATA Condition>
    BusObjectOnline = "NO"
  </SUBDATA>
"Dolphin-Panther 1 138kV Line"          "BRANCH 'Panther_Dolphin_1'" "Branch" "AND" "NO" "YES" "NO"
  <SUBDATA Condition>
    BusObjectOnline = "NO"
  </SUBDATA>
"Dolphin-Raider 1 138 kV Line"          "BRANCH 'Dolphin_Raider_1'"  "Branch" "AND" "NO" "YES" "NO"
  <SUBDATA Condition>
    BusObjectOnline = "NO"
  </SUBDATA>
"Viking-Dolphin 2 345/138 Over 135%"    "BRANCH 'Viking_Dolphin_2'"  "Branch" "AND" "NO" "NO" "NO"
  <SUBDATA Condition>
    LineLimitPercent:2 > 135.00000
  </SUBDATA>
Etc...
}
```

# Model Filter

## Definitions in an Auxiliary File



```
DATA (MODELFILTER, [FilterName,FilterLogic], AUXDEF, YES)
{
"OPEN Cowboy G1" "AND"
  <SUBDATA ModelCondition>
    "Cowboy-Cardinal 1 345kV Line"      "No"
    "Cowboy-Seahawk 1 345kV Line"      "No"
    "Cowboy-Line 345/138kV Transformer"  "No"
  </SUBDATA>
"OPEN Stampeders G1" "OR"
  <SUBDATA ModelCondition>
    "Roughrider-Raven 1 & 2"  "No"
    "Roughrider-Raven 2 & 3"  "No"
  </SUBDATA>
"OPEN Viking G1 and G2" "AND"
  <SUBDATA ModelCondition>
    "Dolphin-Raider 1 138 kV Line"  "No"
    "Dolphin-Panther 1 138kV Line"  "No"
  </SUBDATA>
"Roughrider-Raven 1 & 2" "AND"
  <SUBDATA ModelCondition>
    "Roughrider-Raven 1 69kV Line"  "No"
    "Roughrider-Raven 2 69kV Line"  "No"
  </SUBDATA>
"Roughrider-Raven 2 & 3" "AND"
  <SUBDATA ModelCondition>
    "Roughrider-Raven 2 69kV Line"  "No"
    "Roughrider-Raven 3 69kV Line"  "No"
  </SUBDATA>
}
```

# Global Contingency Actions Definitions in an Auxiliary File



```
//-----  
// THE FOLLOWING SECTION CONTAINS THE LIST OF GLOBAL CONTINGENCY ACTIONS  
// These essentially function like "RAS" objects  
//-----  
DATA (GLOBALCONTINGENCYACTIONSELEMENT, [WhoAmI:1,FilterName,ActionStatus], AUXDEF, YES)  
{  
"GEN 'Stampeder_1' OPEN"                "OPEN Stampeder G1"                "TOPOLOGYCHECK"  
"GEN 'Cowboy_1' OPEN"                  "OPEN Cowboy G1"                  "TOPOLOGYCHECK"  
"INJECTIONGROUP 'Viking G1 and G2' OPEN" "OPEN Viking G1 and G2"            "TOPOLOGYCHECK"  
"GEN 'Viking_1' OPEN"                  "Dolphin-Raider 1 138 kV Line"      "TOPOLOGYCHECK"  
"BRANCH 'Viking_Dolphin_1' OPEN"        "Viking-Dolphin 1 345/138 Over 135%" "POSTCHECK"  
"BRANCH 'Viking_Dolphin_2' OPEN"        "Viking-Dolphin 2 345/138 Over 135%" "POSTCHECK"  
}
```