PowerWorld Simulator

Quick-Start Guide

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Purpose

- This quick-start guide is intended to provide a brief explanation of the essentials to analyzing power systems with PowerWorld Simulator
- It is not comprehensive
- Greater detail is available in our full-length training, on-line or in-person
- Other quick-start guides discuss specific advanced features of Simulator
- For more details, visit http://www.powerworld.com/training/online-training

Outline

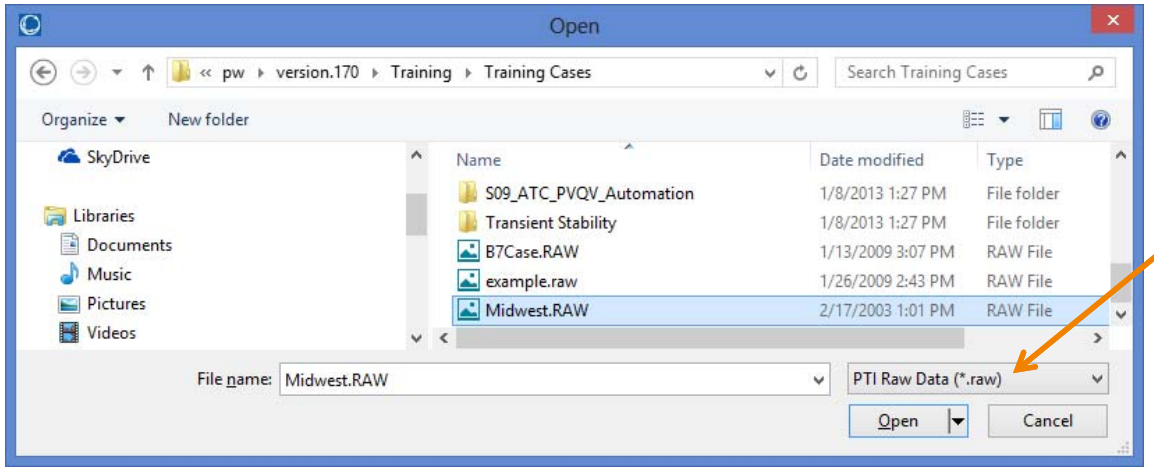
- Opening a power flow case (raw, epc, pwb)
- Solving a case
- Browsing power system elements with the Model Explorer
- One-line diagrams
- Limit Monitoring Settings

Opening an Existing Power Flow Case

- PowerWorld Simulator can open files in the following text-based formats:
  - Siemens PTI PSS/E
    - *.raw file extension
    - Common with FERC 715 filings and ISO cases
  - GE PSLF
    - *.epc file extension
    - Common in the North American WECC
  - Other specific formats for real-time EMS models
- Simulator also has a proprietary binary format with *.pwb extension

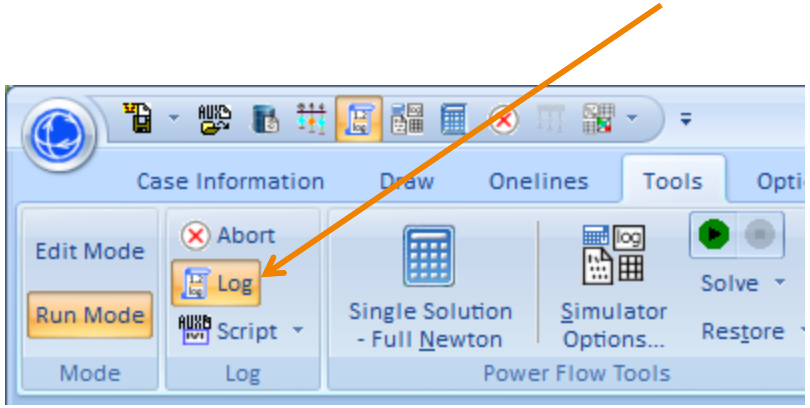
Example

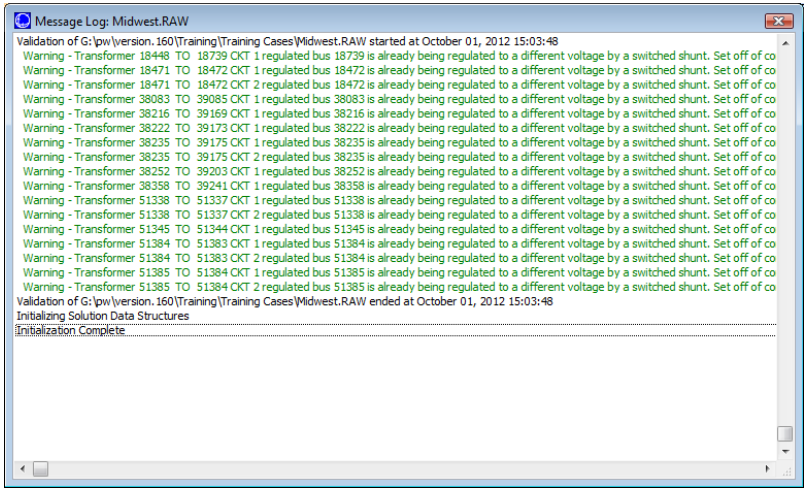
- Click the **File Menu** in the upper left
- Choose **Open Case…**
- From the drop-down box in the lower right, choose *PTI Raw Data (.raw)*
- Open the sample case **Midwest.raw** (available from the PowerWorld training website), or open any case that you need to analyze



Solving the Case

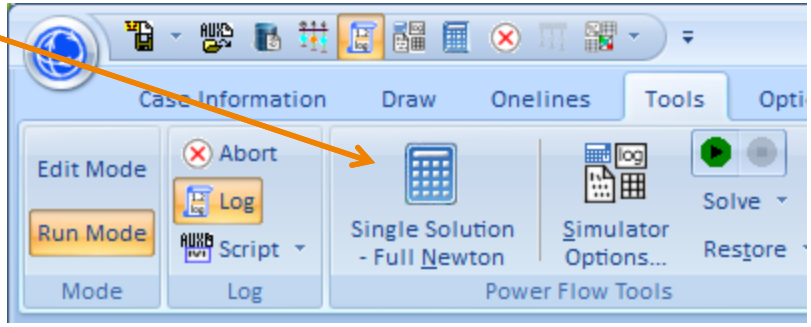
- For the data in a power flow case to be considered valid, a set of non-linear equations must be solved
- First, open the **Message Log** from the **Tools** ribbon tab (**Tools → Log**)

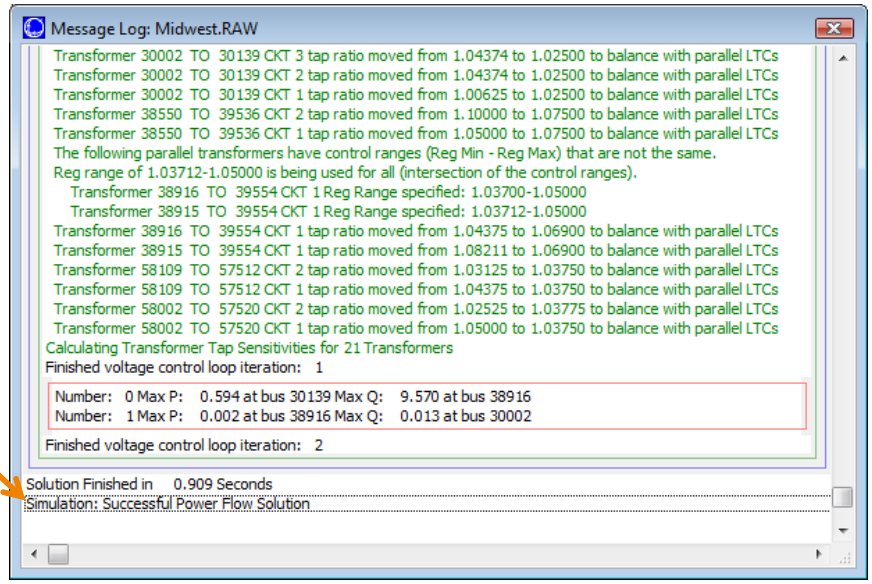




Solving the Case

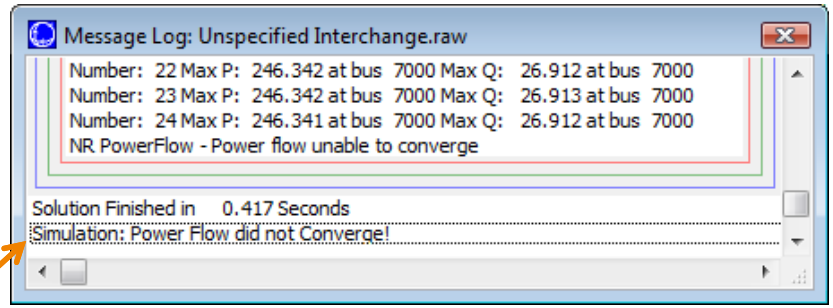
- Next, choose **Single Solution – Full Newton**, also on the **Tools** ribbon tab
- A series of nested loops should solve and a successful solution should be reported in the **Message Log**
- If the solution is successful, proceed to slide 15

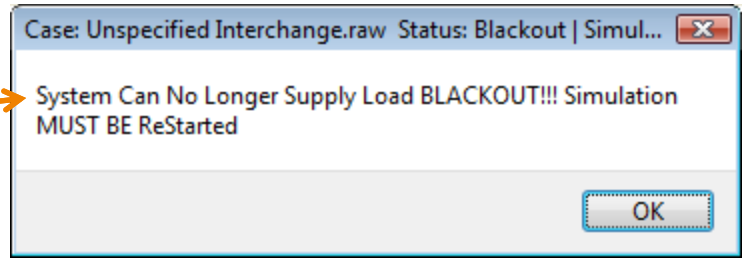




What if the Case Does not Solve?

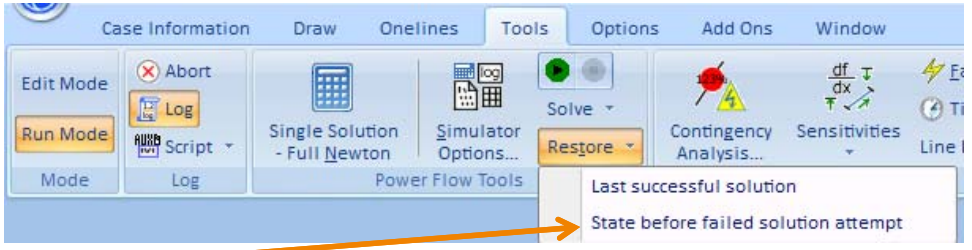
- The case may not solve if:
  - It was not solved by the entity that created the file
  - It was solved, but with different controller settings than the Simulator defaults
  - There are certain kinds of data errors
- If the case fails to solve, you will see a message in the log and a pop-up window

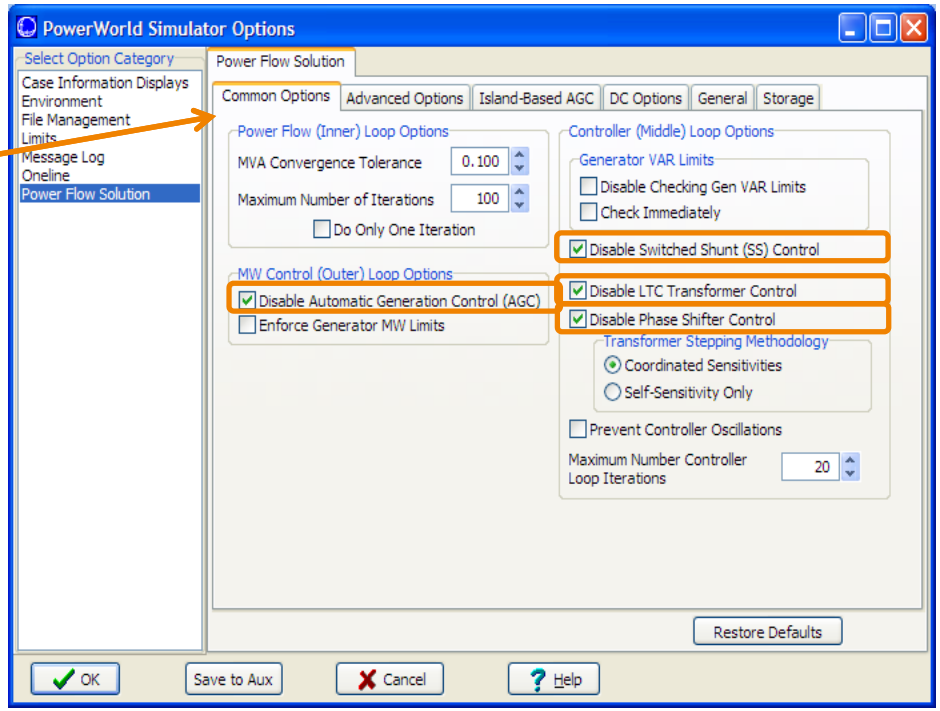




Try to Solve with Controllers Disabled

- Unless the case was not solved by the entity that created the file, this will normally work
- Choose **Tools → Restore → State before failed solution attempt**
- Open **Tools → Simulator Options…**
- Check boxes
  - Disable Automatic Generation Control (AGC)
  - Disable Switched Shunt (SS) Control
  - Disable LTC Transformer Control
  - Disable Phase Shifter Control
- Click OK, then solve the case (**Single Solution – Full Newton**)





Now Restore the Voltage Controllers

- Turn on the Switched Shunt Controllers First (uncheck the box in **Tools → Simulator Options…**)
- Solve Power Flow (**Single Solution – Full Newton**)
- Then turn on the LTCs
- Solve Power Flow
- Then turn on the Phase Shifters
- Solve Power Flow
- If the power flow fails to solve at any of these stages, it is likely that the controller option was not applied in the original solution
  - Restore the system state, uncheck the last option, and re-solve
  - You may still try enabling the other controllers

Automatic Generation Control (AGC)

- Before you try to enable the AGC, ensure that the case was truly solved with AGC control
- The best way to check:
  - Open Model Explorer (**Case Information → Model Explorer…**)
  - Open the folder **Aggregations**, then choose **Areas**
  - Look at the "ACE MW" column
  - If values are very large, then the case was probably not solved with AGC

Automatic Generation Control (AGC)

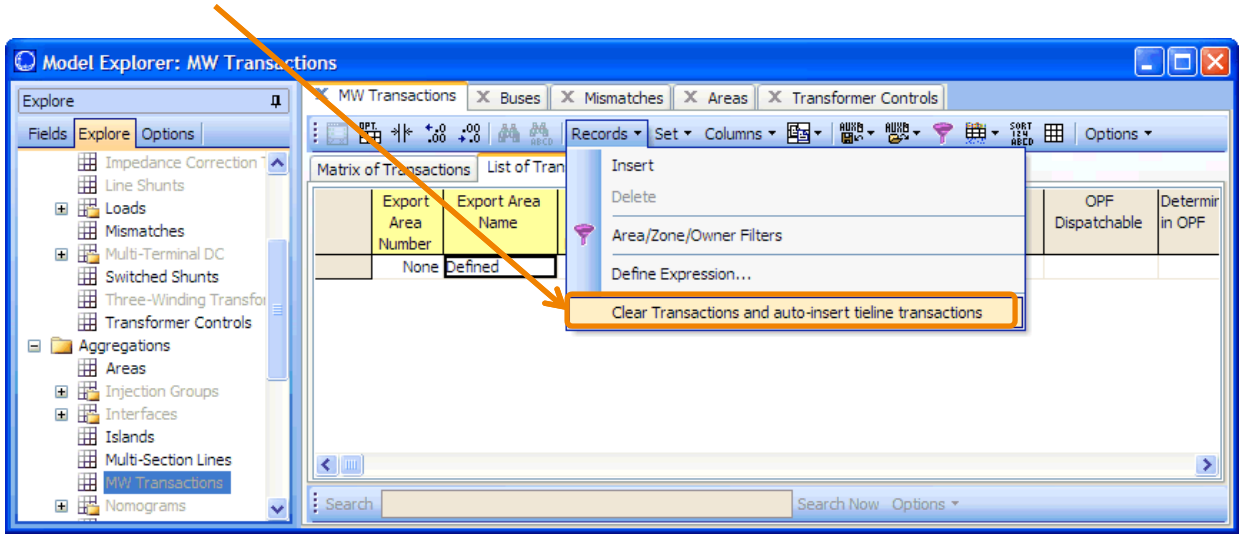
- If the ACE values are small, you can probably enable the AGC and solve the case
- Otherwise, you can either leave the AGC disabled, or enable it and adjust the area interchange

Area Unspecified MW Interchange

- Each Area can have an export specified which does not have a “receiving” end specified
- The Area display in the Model Explorer includes a column “Unspec. MW Inter.”, usually on the far right
- These unspecified values should sum to zero.
  - If they do not sum to zero, you have an “export to nowhere”
  - When this occurs, the Area with the slack bus will be turned off AGC and all unspecified interchange will be sent to the island slack bus

What if Interchanges Don't Look Right or ACE Values are Large?

- In the Model Explorer, Open the folder **Aggregations**, then choose **MW Transactions**
- On the Case Info Toolbar, choose Records, Clear Transactions and auto-insert tie-line transactions
- Now try to re-enable AGC and re-solve the case

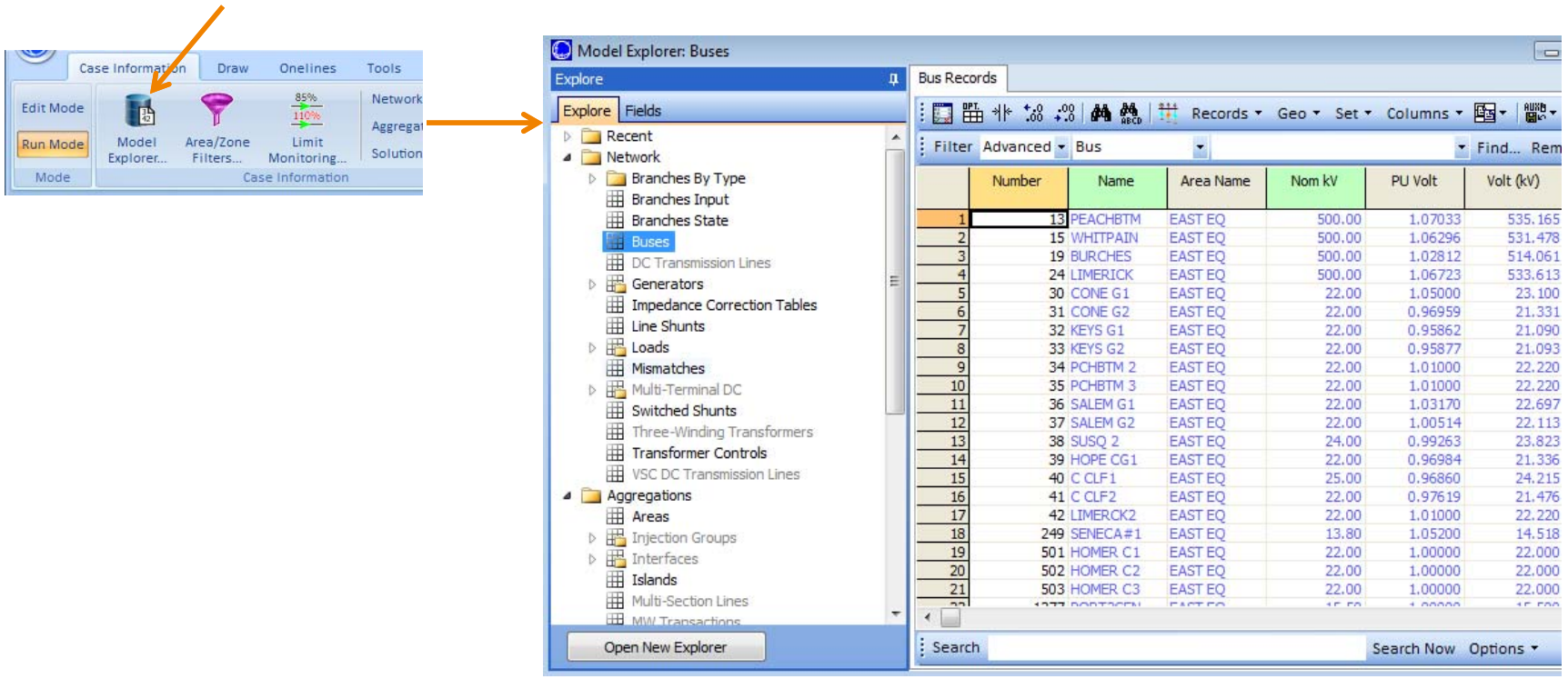


Examining the Data in the Case

- There are 3 primary ways to interact with the power flow case
  - Model Explorer: spreadsheet-like tabular displays
  - Bus-view one-line diagrams (automatically generated)
  - Other one-line diagrams (user-generated)
- We will next examine the use of the **Model Explorer**

Model Explorer

- Choose the **Case Information** ribbon tab, then **Model Explorer…**



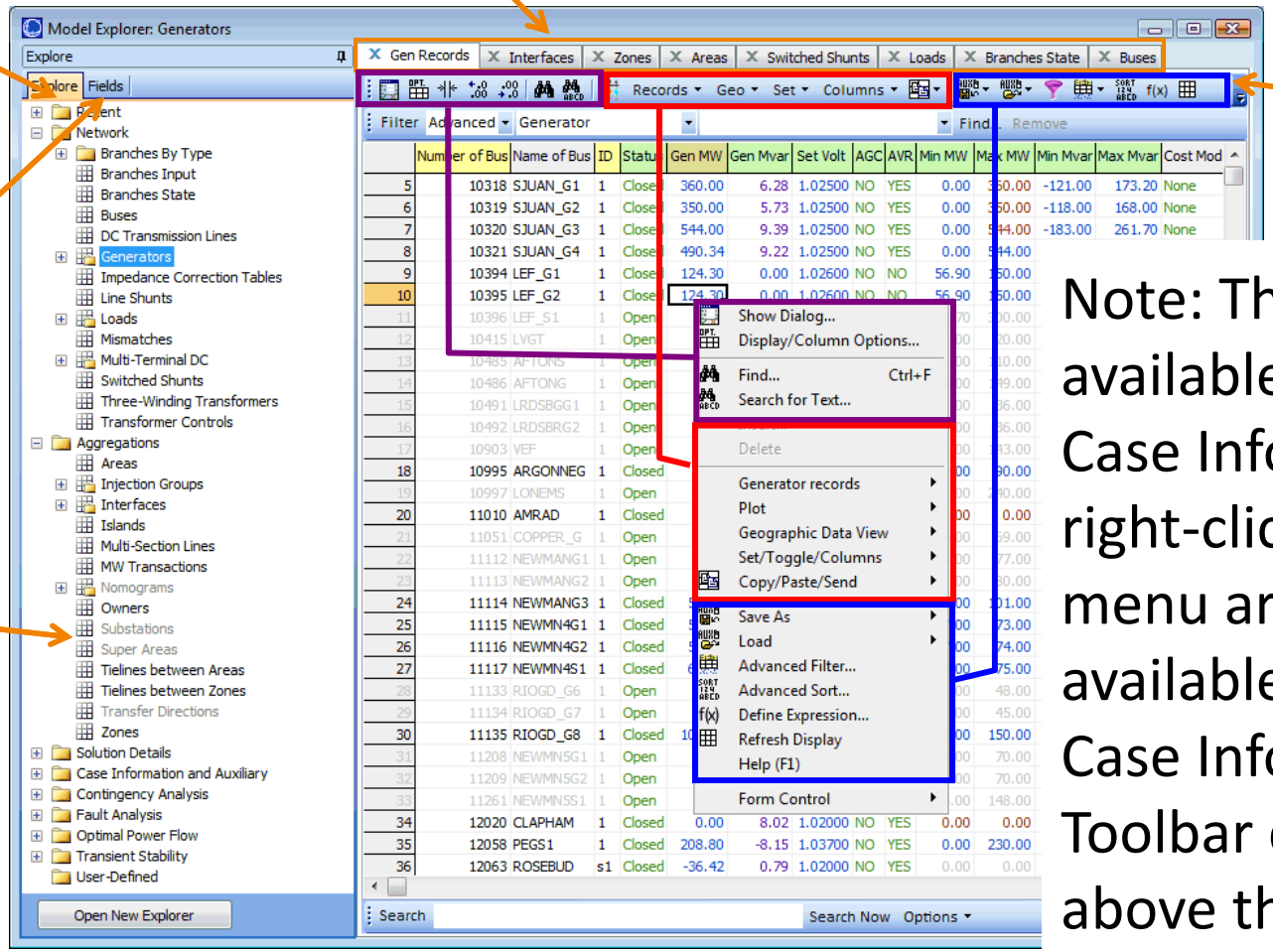
Model Explorer

Recent Tabs

Explore Pane

Fields Pane

Object Types with no data grayed-out

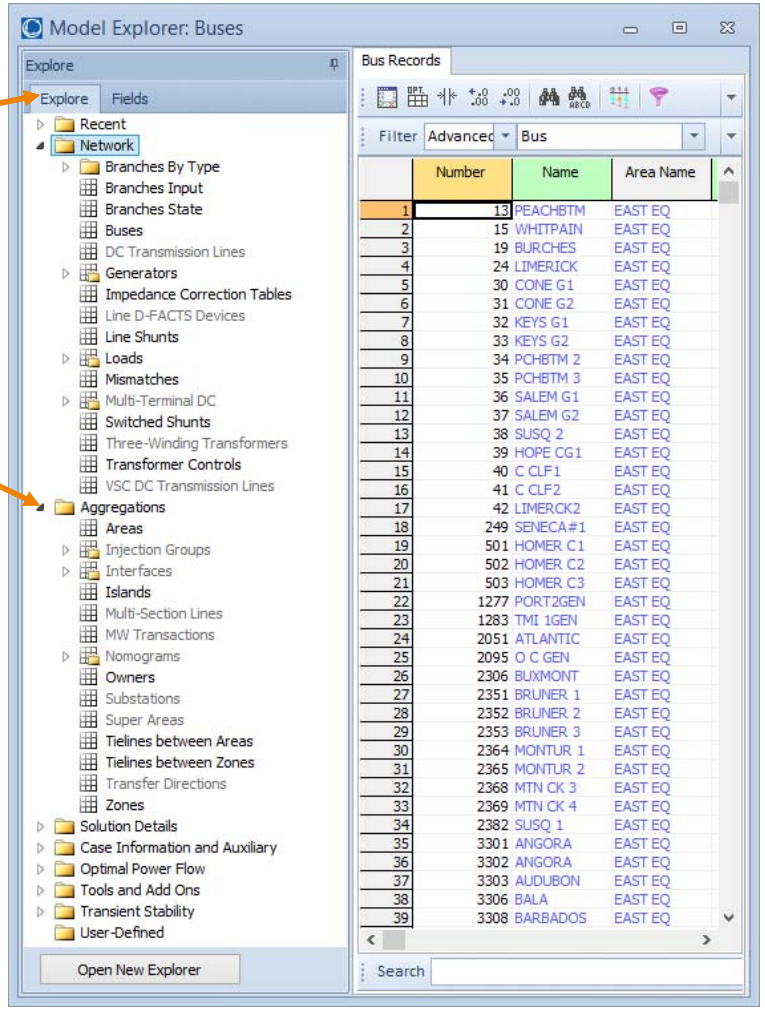


Toolbar

Note: The options available on the Case Information right-click local menu are also available on the Case Information Toolbar directly above the display

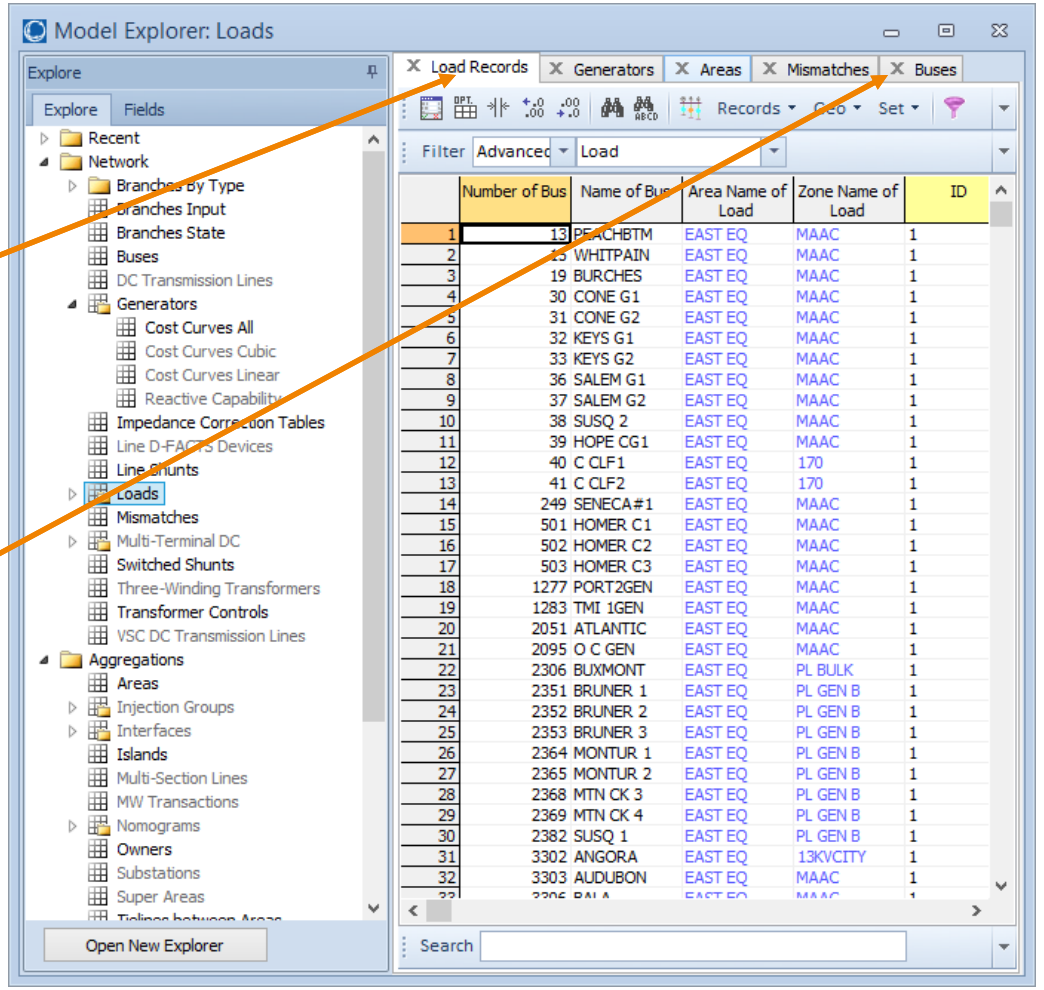
Model Explorer

- The left side initially contains the Explore pane
- Spreadsheet-like **case information displays** are organized in folders that can be expanded or collapsed
- Click on an item with a  grid symbol to open the corresponding case information display



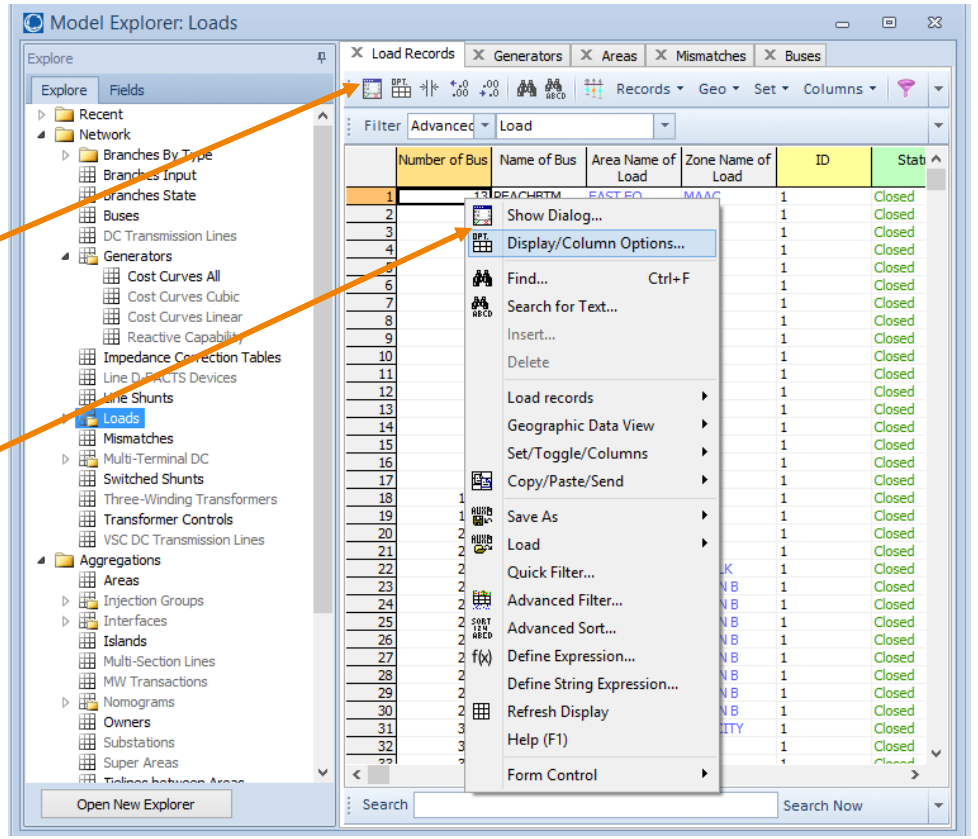
Model Explorer

- Once opened, a case information display is contained within its own tab
- To close a case information display, click its "X"



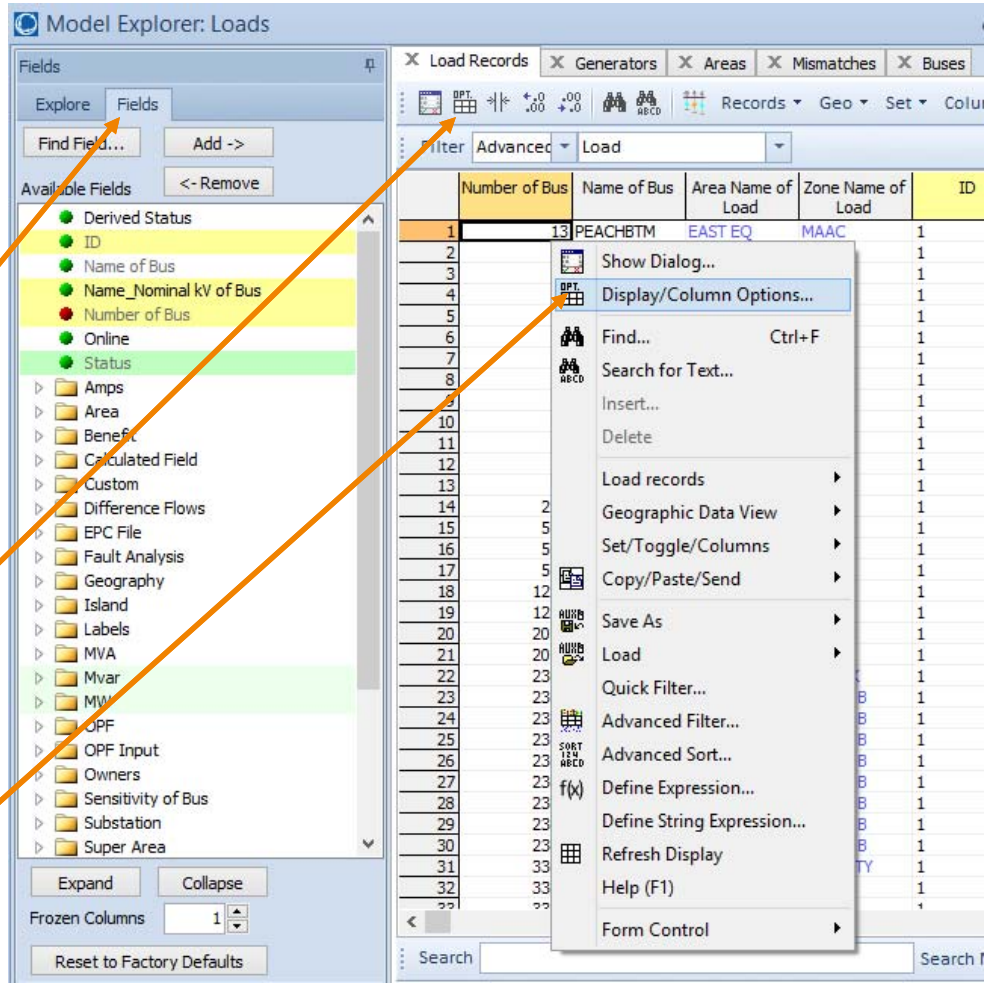
Toolbar and Local Menu

- Many functions in Case Information Displays can be accessed by:
  - Case Information Toolbar
  - Local Menu (right-click)
- Mouse over the buttons on the toolbar for a description of their function



Columns and Appearance

- All displays have a set of default fields
- These can be modified
  - from the Fields pane, or
  - with the Display/Column options on the toolbar or local (right click) menu



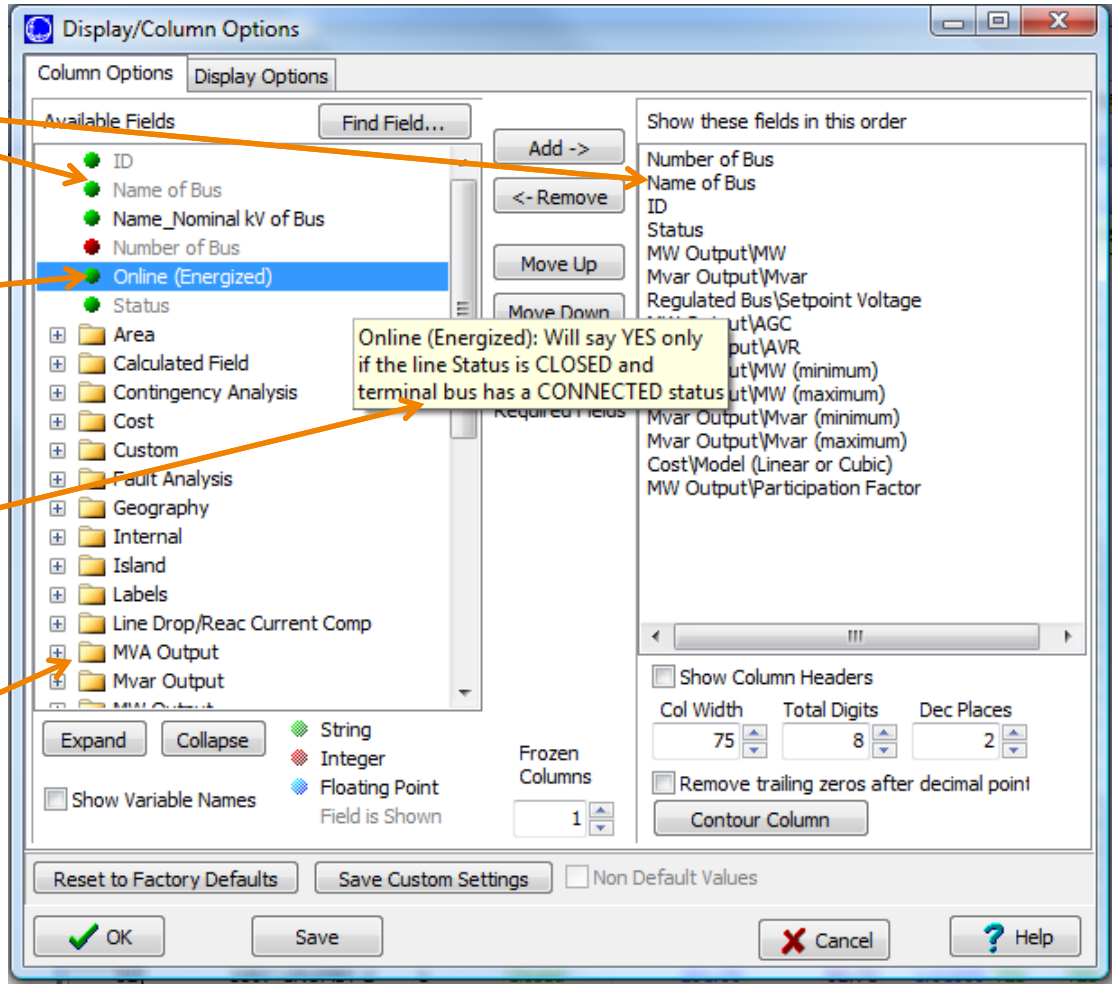
Display/Column Options
Column Options

Gray text means the field is already shown

Colored Dots represent the field type

Hints automatically appear giving a description of the field

Fields organized by folder



Display/Column Options
Column Options

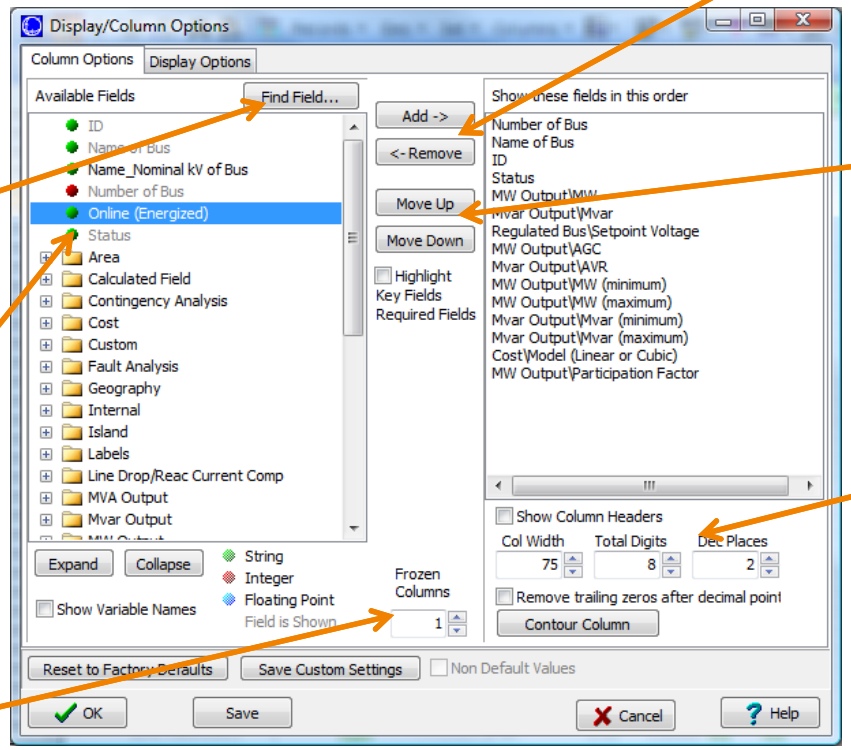
- Choose fields from the **Available Fields** list. Then left-click and drag into the **Show these fields in this order** list

Also can click the **Add →** or **←Remove** Buttons to modify the fields shown

Use a wildcard find for a particular field

Fields grayed out if already in display

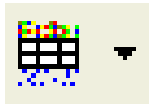
Number of frozen columns

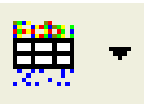


Click **Move Up** and **Move Down** to change the order of the columns

Change attributes of the display columns. Also, use toolbar buttons

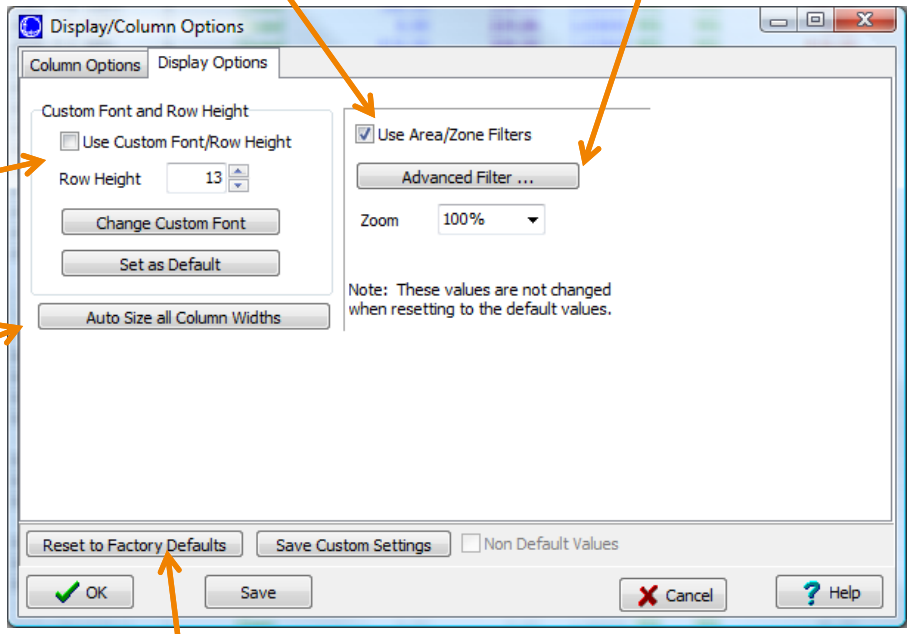
Display/Column Options
Display Options

Will disable the area/zone filtering for a single case info display. Also available via a toolbar button 

Define a custom filter
Also available via a toolbar button 

Change custom fonts and row heights

Auto resize all column widths. Also available via a toolbar button 



Reset all values to default

Simple Sorting

- To sort a column, left-click on the column heading. Click again to sort in the opposite direction
- SHIFT + Left-Click will sort by Absolute Value

Sorted Descending by Gen MW

Note: Arrow showing sort direction

	Number	Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar	Gen MW ▼	Gen Mvar	Switched Shunts Mvar	Act G Shu MW
1	14931	PALOVRD1	ARIZONA	24.00	1.00652	24.157	-40.10	61.76	46.36	1382.00	354.38		0.
2	14933	PALOVRD3	ARIZONA	24.00	1.00651	24.156	-40.08	61.76	46.36	1382.00	354.38		0.
3	14932	PALOVRD2	ARIZONA	24.00	1.00642	24.154	-40.19	61.76	46.36	1379.00	354.38		0.
4	36412	DIABLO 2	PG AND E	25.00	1.03000	25.750	-50.82	47.40	9.62	1200.00	-20.62		0.
5	36411	DIABLO 1	PG AND E	25.00	1.03000	25.750	-51.15	47.40	9.62	1180.00	-34.56		0.
6	40063	CGS	NORTHWEST	25.00	0.99601	24.900	-10.30	54.55	37.49	1155.00	-152.83		0.
7	24130	S.ONOFR3	SOCALIF	22.00	0.97937	21.546	-69.92			1080.00	127.08		0.

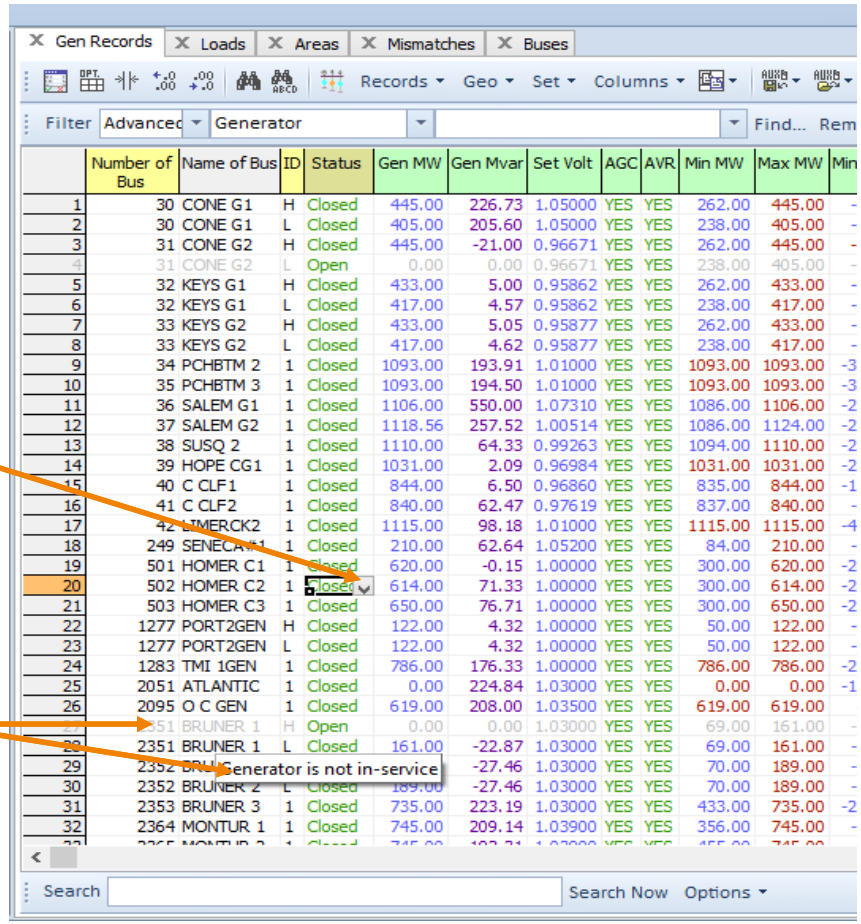
Absolute Value Sort

Click here to remove sorting

	Number	Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Load MW	Load Mvar	Gen MW	Gen Mvar ▼	Switched Shunts Mvar	Act G Sh MW
1	14932	PALOVRD2	ARIZONA	24.00	1.00642	24.154	-40.19	61.76	46.36	1379.00	354.38		0
2	14931	PALOVRD1	ARIZONA	24.00	1.00652	24.157	-40.10	61.76	46.36	1382.00	354.38		0
3	14933	PALOVRD3	ARIZONA	24.00	1.00651	24.156	-40.08	61.76	46.36	1382.00	354.38		0
4	30000	PTSB 7	PG AND E	20.00	1.05000	21.000	-62.54	16.10	3.27	710.00	214.61		0
5	26040	INTERM2G	LADWP	26.00	1.03668	26.954	-54.44	53.00	40.00	950.00	188.81		0
6	26039	INTERM1G	LADWP	26.00	1.03668	26.954	-54.44	53.00	40.00	950.00	188.81		0
7	40063	CGS	NORTHWEST	25.00	0.99601	24.900	-10.30	54.55	37.49	1155.00	-152.83		0

Color Conventions

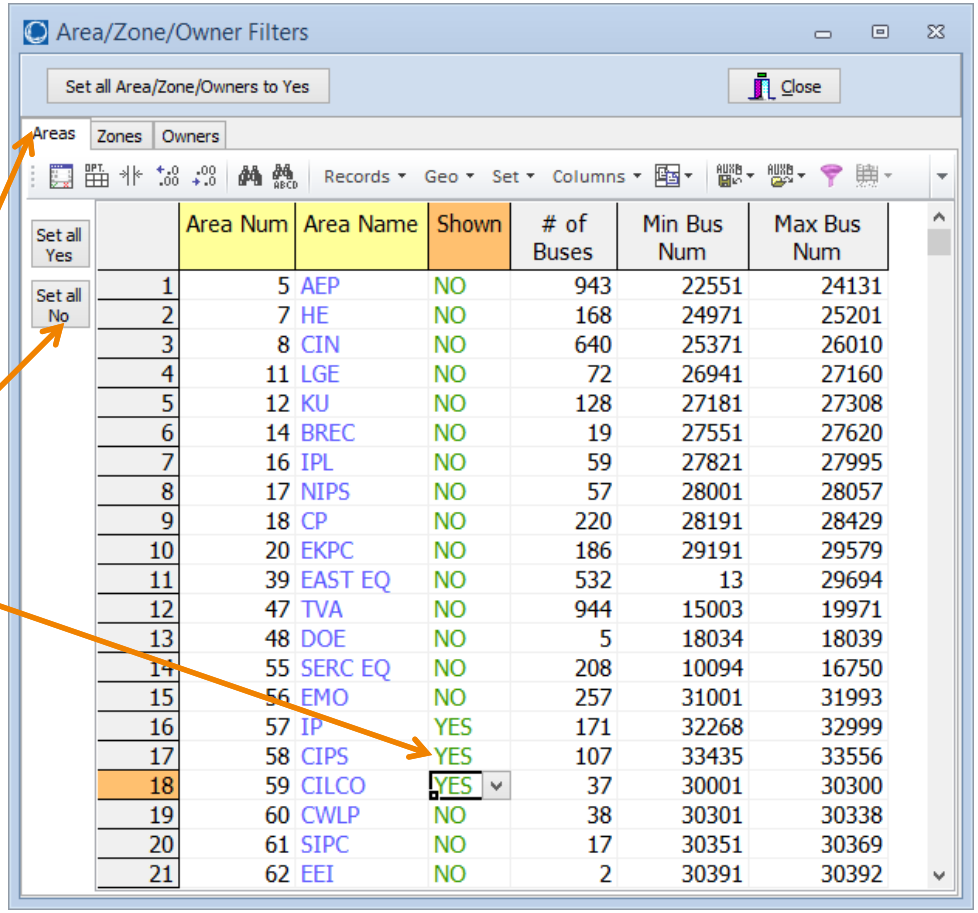
- Font color denotes type of cell
  - Black: read-only
  - Green: toggle between a set of allowable values (double-click or click drop-down to change)
  - Blue: user-enterable
  - Red: value at a limit
  - Gray: disabled (mouse over for explanation)
  - Purple: special or calculated



	Number of Bus	Name of Bus	ID	Status	Gen MW	Gen Mvar	Set Volt	AGC	AVR	Min MW	Max MW	Min
1	30	CONE G1	H	Closed	445.00	226.73	1.05000	YES	YES	262.00	445.00	-
2	30	CONE G1	L	Closed	405.00	205.60	1.05000	YES	YES	238.00	405.00	-
3	31	CONE G2	H	Closed	445.00	-21.00	0.96671	YES	YES	262.00	445.00	-
4	31	CONE G2	L	Open	0.00	0.00	0.96671	YES	YES	238.00	405.00	-
5	32	KEYS G1	H	Closed	433.00	5.00	0.95862	YES	YES	262.00	433.00	-
6	32	KEYS G1	L	Closed	417.00	4.57	0.95862	YES	YES	238.00	417.00	-
7	33	KEYS G2	H	Closed	433.00	5.05	0.95877	YES	YES	262.00	433.00	-
8	33	KEYS G2	L	Closed	417.00	4.62	0.95877	YES	YES	238.00	417.00	-
9	34	PCHBTM 2	1	Closed	1093.00	193.91	1.01000	YES	YES	1093.00	1093.00	-3
10	35	PCHBTM 3	1	Closed	1093.00	194.50	1.01000	YES	YES	1093.00	1093.00	-3
11	36	SALEM G1	1	Closed	1106.00	550.00	1.07310	YES	YES	1086.00	1106.00	-2
12	37	SALEM G2	1	Closed	1118.56	257.52	1.00514	YES	YES	1086.00	1124.00	-2
13	38	SUSQ 2	1	Closed	1110.00	64.33	0.99263	YES	YES	1094.00	1110.00	-2
14	39	HOPE CG1	1	Closed	1031.00	2.09	0.96984	YES	YES	1031.00	1031.00	-2
15	40	C CLF1	1	Closed	844.00	6.50	0.96860	YES	YES	835.00	844.00	-1
16	41	C CLF2	1	Closed	840.00	62.47	0.97619	YES	YES	837.00	840.00	-
17	42	LIMERCK2	1	Closed	1115.00	98.18	1.01000	YES	YES	1115.00	1115.00	-4
18	249	SENECA#1	1	Closed	210.00	62.64	1.05200	YES	YES	84.00	210.00	-
19	501	HOMER C1	1	Closed	620.00	-0.15	1.00000	YES	YES	300.00	620.00	-2
20	502	HOMER C2	1	Closed	614.00	71.33	1.00000	YES	YES	300.00	614.00	-2
21	503	HOMER C3	1	Closed	650.00	76.71	1.00000	YES	YES	300.00	650.00	-2
22	1277	PORT2GEN	H	Closed	122.00	4.32	1.00000	YES	YES	50.00	122.00	-
23	1277	PORT2GEN	L	Closed	122.00	4.32	1.00000	YES	YES	50.00	122.00	-
24	1283	TMI 1GEN	1	Closed	786.00	176.33	1.00000	YES	YES	786.00	786.00	-2
25	2051	ATLANTIC	1	Closed	0.00	224.84	1.03000	YES	YES	0.00	0.00	-1
26	2095	O C GEN	1	Closed	619.00	208.00	1.03500	YES	YES	619.00	619.00	
	2351	BRUNER 1	H	Open	0.00	0.00	1.03000	YES	YES	69.00	161.00	-
28	2351	BRUNER 1	L	Closed	161.00	-22.87	1.03000	YES	YES	69.00	161.00	-
29	2352	BRUNER 2	H	Closed	189.00	-27.46	1.03000	YES	YES	70.00	189.00	-
30	2352	BRUNER 2	L	Closed	189.00	-27.46	1.03000	YES	YES	70.00	189.00	-
31	2353	BRUNER 3	1	Closed	735.00	223.19	1.03000	YES	YES	433.00	735.00	-2
32	2364	MONTUR 1	1	Closed	745.00	209.14	1.03900	YES	YES	356.00	745.00	-

Area/Zone/Owner Filters

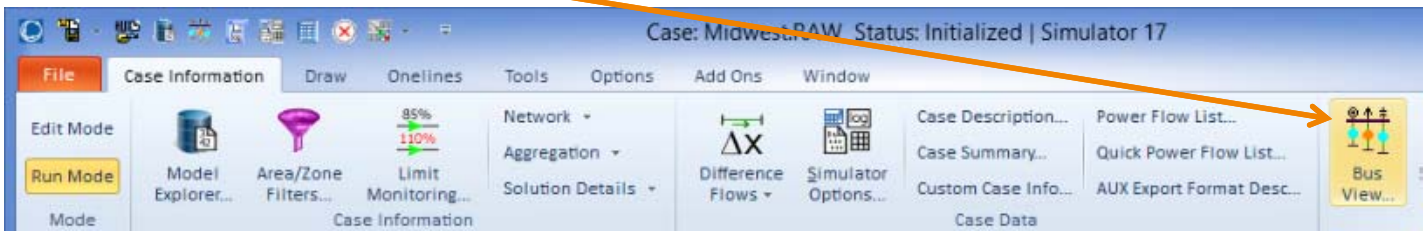
- Filtering can be applied to Areas, Zones, and Owners to simplify the Case Information Displays to show only parts of the system of interest
- Select **Area/Zone Filters** from the **Case Information** ribbon or the case information toolbar
- Example: set all areas to NO except a few of interest
  - Click **Set all No** on Areas tab
  - Toggle *NO* to *YES* in the "Shown" column by double-clicking the cell.
- An element will appear in Case Information Displays if its Area, Zone, and Owner "Shown" fields are all set to YES



	Area Num	Area Name	Shown	# of Buses	Min Bus Num	Max Bus Num
1	5	AEP	NO	943	22551	24131
2	7	HE	NO	168	24971	25201
3	8	CIN	NO	640	25371	26010
4	11	LGE	NO	72	26941	27160
5	12	KU	NO	128	27181	27308
6	14	BREC	NO	19	27551	27620
7	16	IPL	NO	59	27821	27995
8	17	NIPS	NO	57	28001	28057
9	18	CP	NO	220	28191	28429
10	20	EKPC	NO	186	29191	29579
11	39	EAST EQ	NO	532	13	29694
12	47	TVA	NO	944	15003	19971
13	48	DOE	NO	5	18034	18039
14	55	SERC EQ	NO	208	10094	16750
15	56	EMO	NO	257	31001	31993
16	57	IP	YES	171	32268	32999
17	58	CIPS	YES	107	33435	33556
18	59	CILCO	YES	37	30001	30300
19	60	CWLP	NO	38	30301	30338
20	61	SIPC	NO	17	30351	30369
21	62	EEI	NO	2	30391	30392

Bus View One-Line Diagrams

- Another useful way to interface with a power system model
- Auto-generates one-line diagrams at each bus, one at a time, showing all devices connected to bus and all flows.
- Choose the **Case Information** ribbon tab, then **Bus View…**



Bus View One-Line

Back and forward buttons

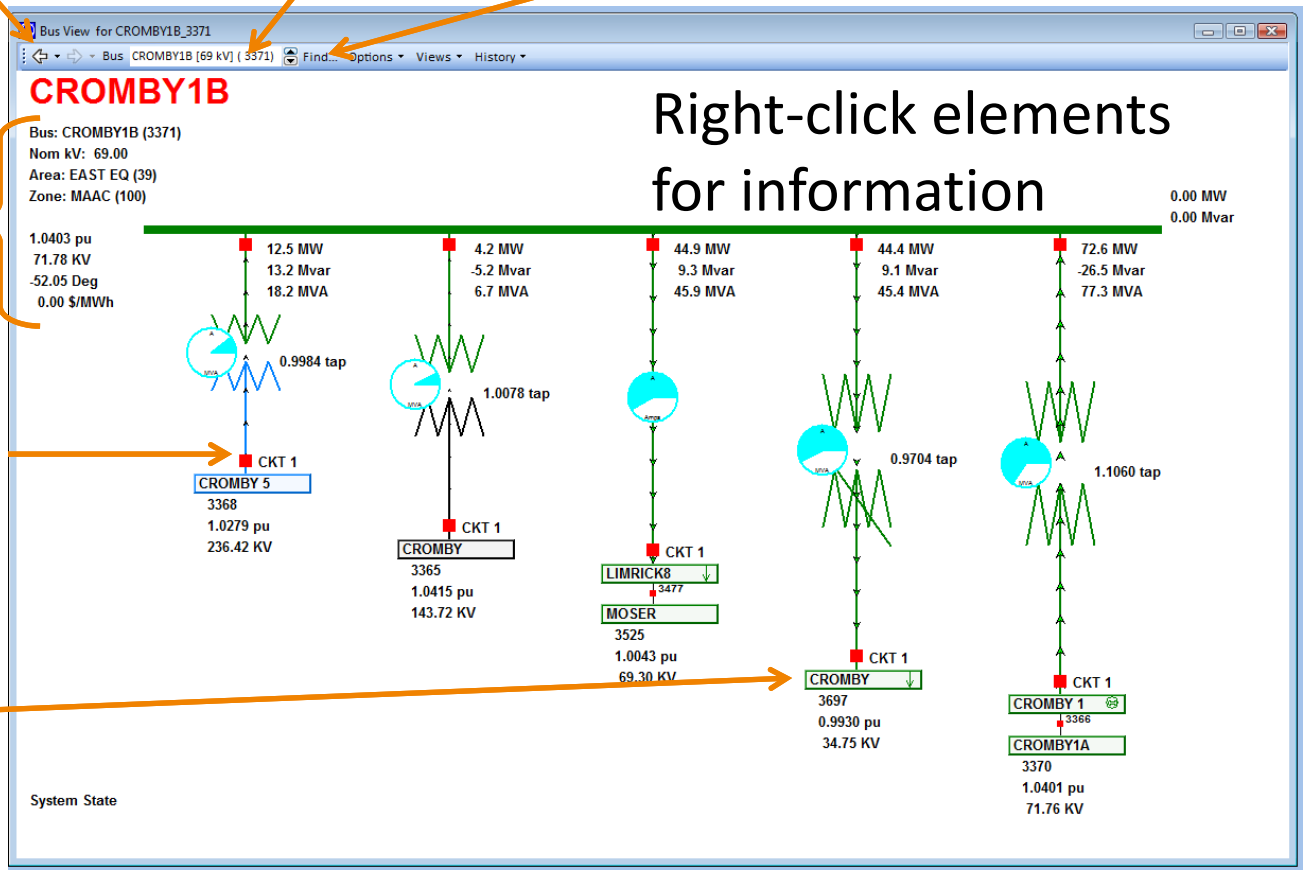
Enter a name or number to go to a bus

Click to find a bus

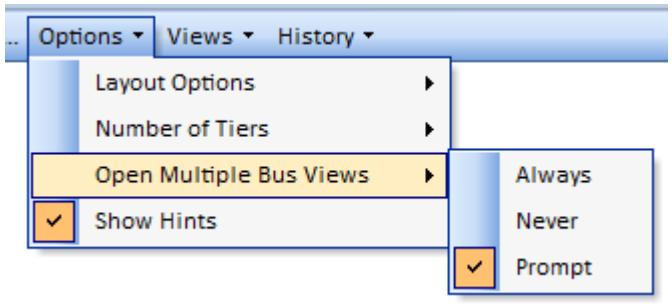
Bus and Flow information

Left-click circuit breaker to open/close

Click links to jump to new bus



Bus View Oneline:
Click Options > to reveal



- Number of Tiers – specify 1 or 2
- Show Hints
  - As you move your cursor over an object it will show information
- Show Serial Buses
  - Buses that are in series will be cascaded
- Show Equivalent Lines
  - Change to hide/show equivalent lines
- Represent Multi Section Line Objects
  - Show endpoints of MS Lines without intermediate buses
- Open Multiple Bus views
  - Specify whether to create a new Bus View when a new one is requested.
  - Choosing Prompt means you will be prompted each time
- Include Field Labels
  - A description of what each field is will be shown.
- Change Bus Link Color
  - The fill color of the bus links can be changed

One-Line Diagrams

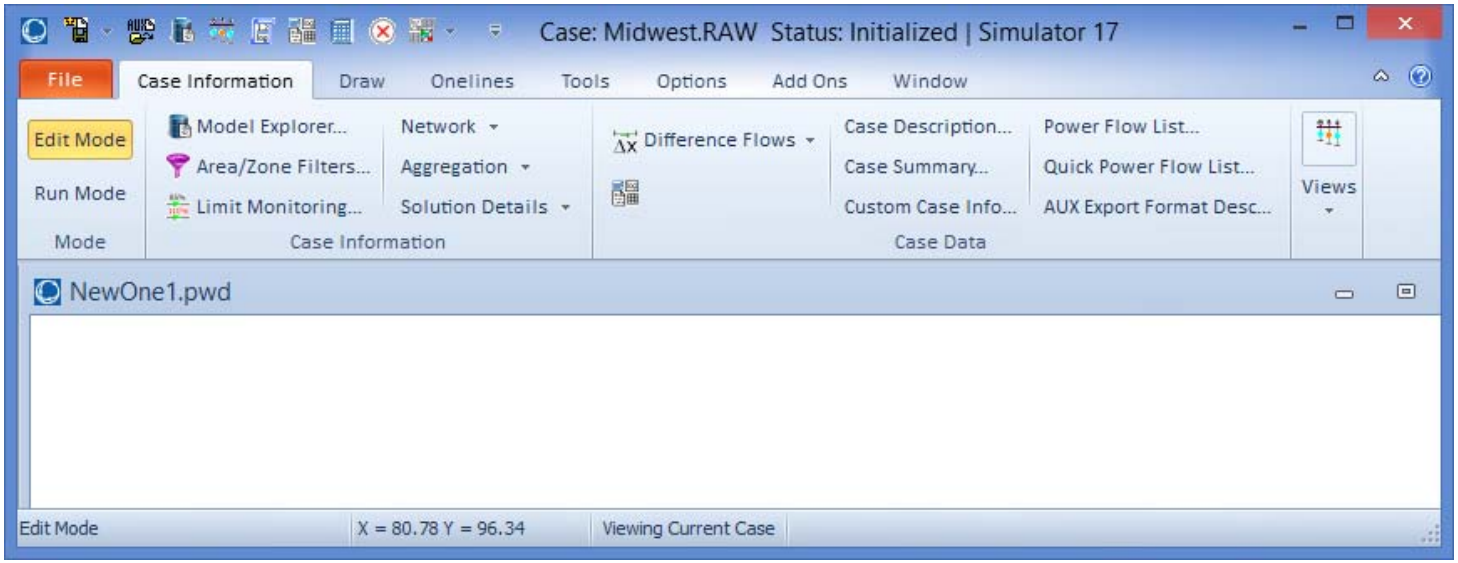
- Custom one-line diagrams may also be created and edited by the user
- One-line diagrams are well-suited for wide-area, regional, or local power system visualization
- One-lines need only be created for the portion of the system of interest, but Simulator always models the ENTIRE system in calculations
- Simulator automatically links diagrams to the opened power system model

One-Line Diagrams

- One-lines may be geographic or schematic in nature
- For geographic diagrams, Simulator has built-in borders for US states and counties, Canadian Provinces, and entire countries for the rest of the world
- For schematic diagrams, simply omit the borders and arrange system elements as desired

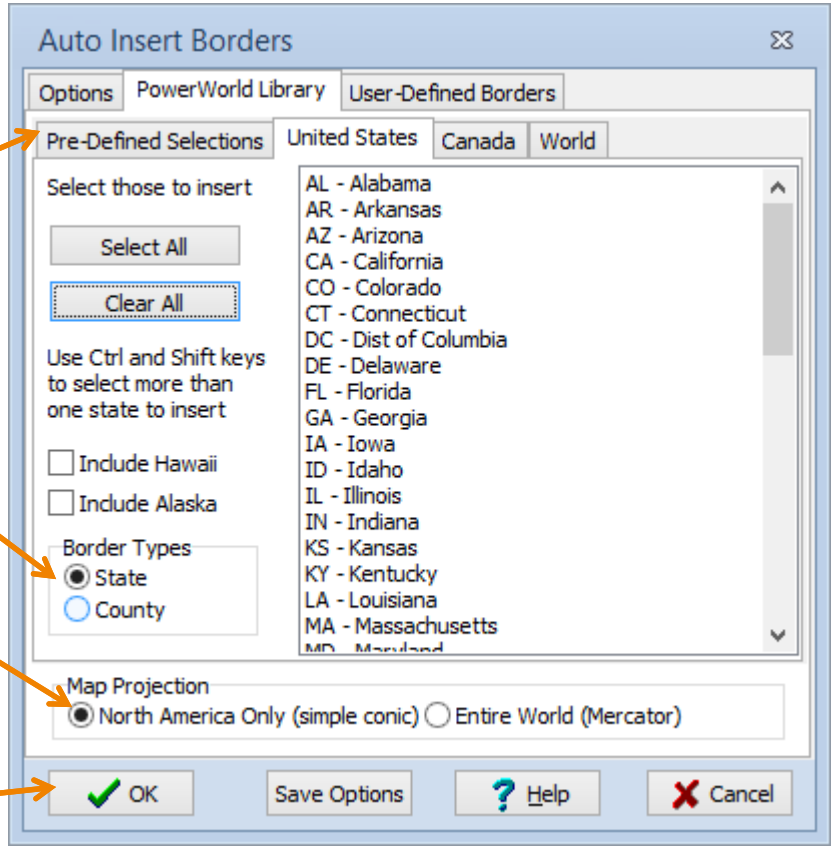
Creating a One-Line Diagram

- Choose the **File Menu**, then **New Oneline…**
- Simulator will automatically switch to **Edit Mode** if necessary and open a blank window to draw objects on the one-line diagram



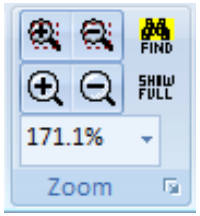
Insert Borders

- From the **Draw** Ribbon, choose **Auto Insert → Borders**
- Select Region
- State or County for US
- Choose Map Projection (once set, do not change)
- Click OK to insert



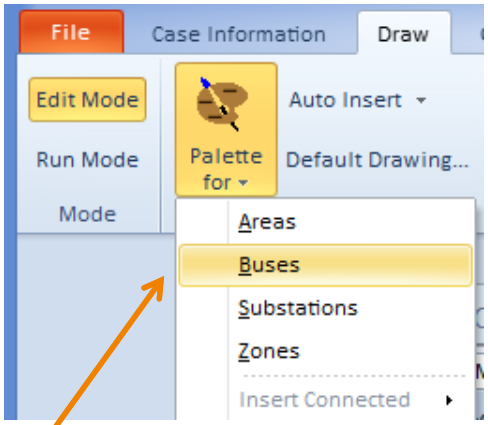
Panning and Zooming

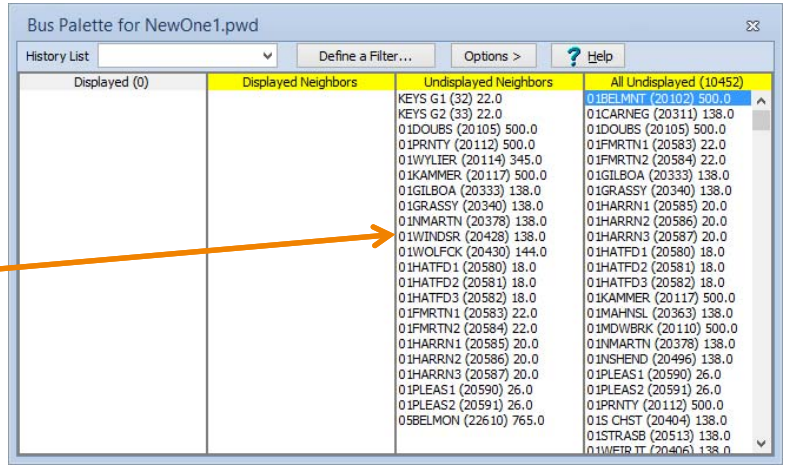
- Pan and Zoom to navigate around the one-line diagram
- Panning
  - Click and drag the one-line background (not on any particular object)
  - Use Arrow Keys (up, down, left, right) or Home, End, Page Up, Page Down to move more quickly
- Zooming
  - Group of buttons on the **Draw** and **Onelines** Ribbons
  - "Zoom In" with Ctrl-Up Arrow key (or Ctrl-Page Up to zoom more quickly)
  - "Zoom Out" with Ctrl-Down Arrow key (or Ctrl-Page Down to zoom more quickly)



Object Palettes

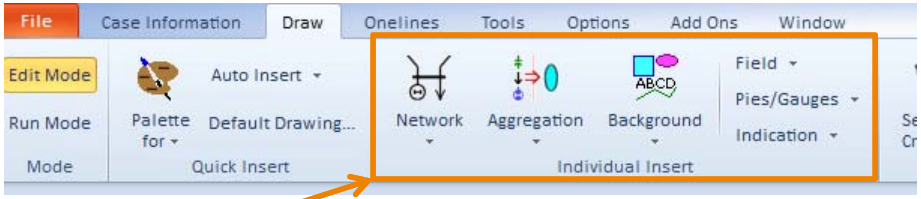
- Use the **Draw** ribbon to add objects to the one-line
- Drag-and-drop pallets are available for several object types
  - Buses (common)
  - Substations
  - Areas
  - Zones
- Choose **Palette for → Buses**
- Drag-and-drop buses from Palette onto the Diagram

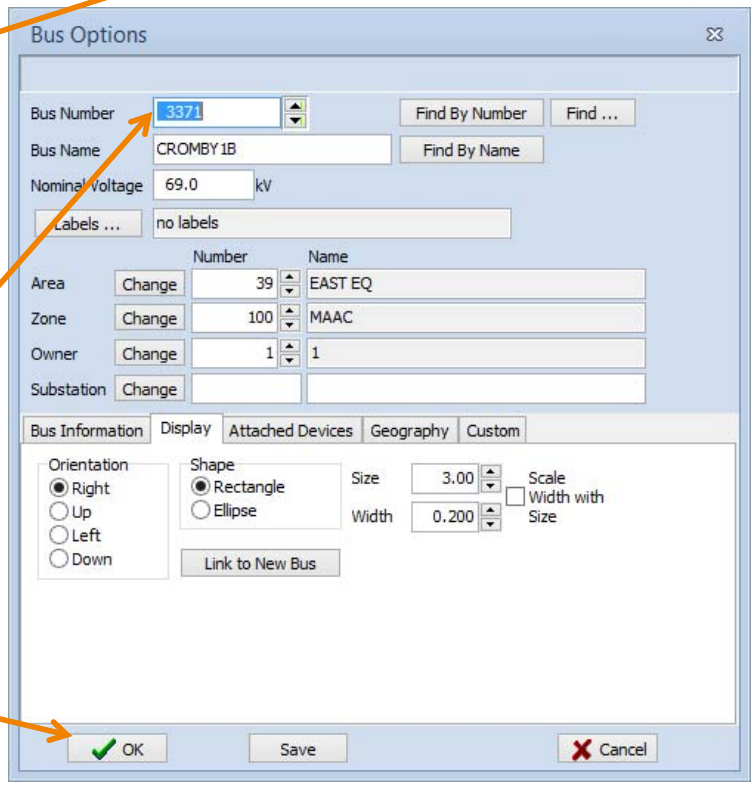




Individual Insertion

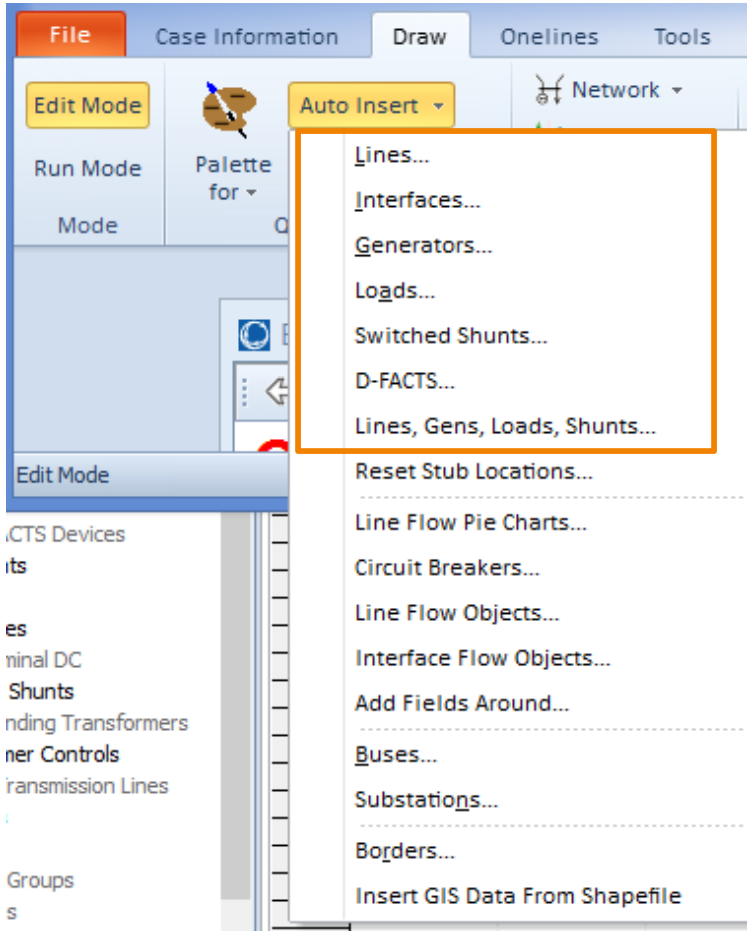
- Objects may also be added to the diagram individually
- Objects are grouped by type, as in the Model Explorer
- For example, choose **Network → Bus**, then click on the diagram where you would like to place the bus
- If necessary, change the bus number and other options, then click OK





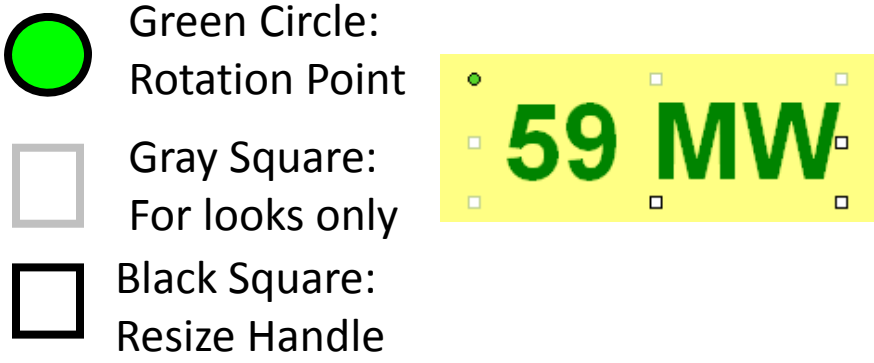
Auto-Insertion

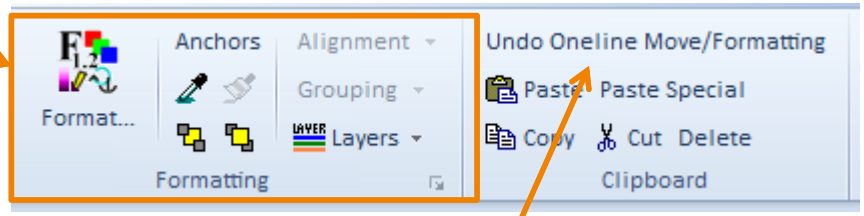
- The layout of a one line diagram is generally determined by the location of buses, substations, areas, or zones
- Once these are in place, other objects that attached to them may be automatically placed



Arranging Objects on a Diagram

- You can generally relocate or reposition objects by clicking and dragging
- Certain "object handles" may be used for stretching, resizing, or rotating
- The **Formatting** group has options for changing the appearance of selected objects
- If you make a mistake, choose **Undo Oneline…**





Scaling Load

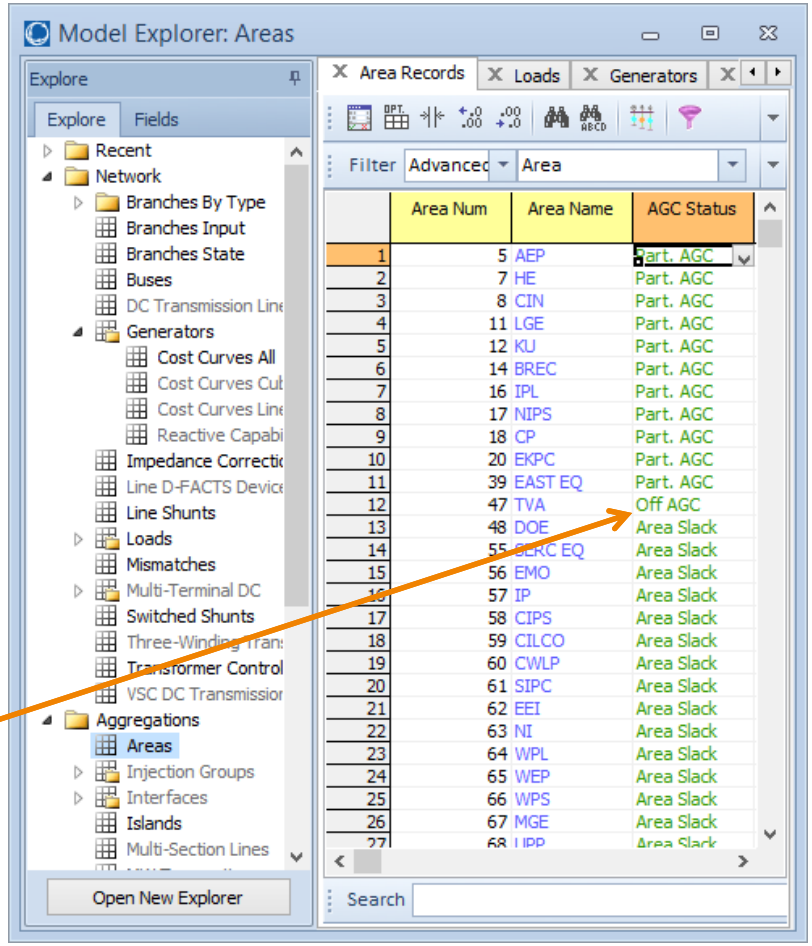
- It is often desirable to change the power system load from initial levels in the power flow case
- It is usually a good idea to begin with a case with load as close to the desired level as possible
  - Small changes (about +/- 10% or less) can usually be performed without too much manipulation
  - Larger changes often require adjustments, such as voltage controller settings, area transactions, generator unit commitment, and/or the use of the DC power flow. These topics are discussed in greater depth in our full training curricula.

Area AGC Settings

- Before scaling load, it may be desirable to change some default settings
- *.raw and *.epc files commonly use “Area Slack” control
  - “Area Slack” means changes in area load are absorbed by generators at a single bus, the area slack bus
  - This may be useful for holding constant the output of all other generators, but may not be realistic when making large changes to load
- “Participation Factor” control may be used to distribute the “make-up power” requirement across the system

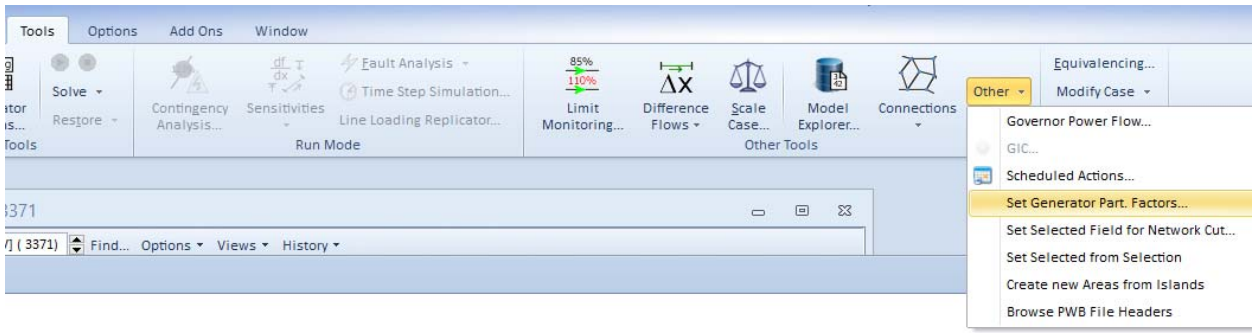
Participation Factor Control

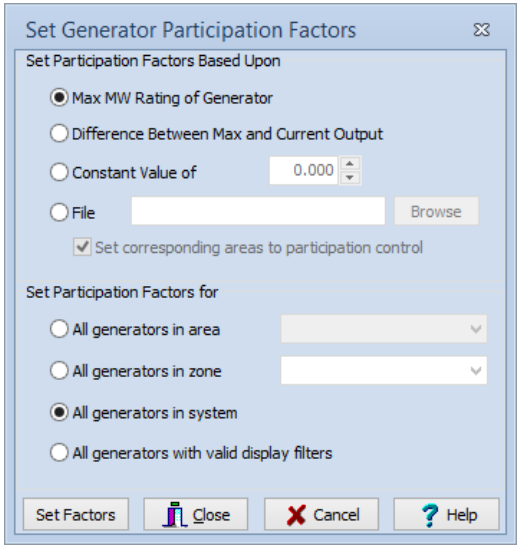
- In the Model Explorer, open **Aggregations → Areas**
- If desired, toggle the AGC Status field to “Part. AGC”
  - Hint: click and drag from the lower left of a cell to fill other cells with the same value
- Areas that are initially “Off AGC” should normally remain “Off AGC”, as they often contain island slack buses or swing buses



Participation Factor Control

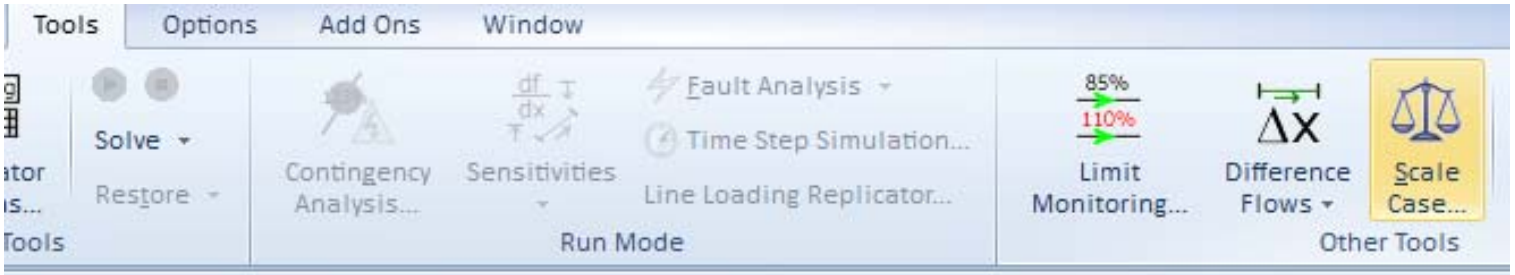
- To set generator participation factors, from the Tools Ribbon, choose **Other → Set Generator Part. Factors…**
- The default options are usually appropriate





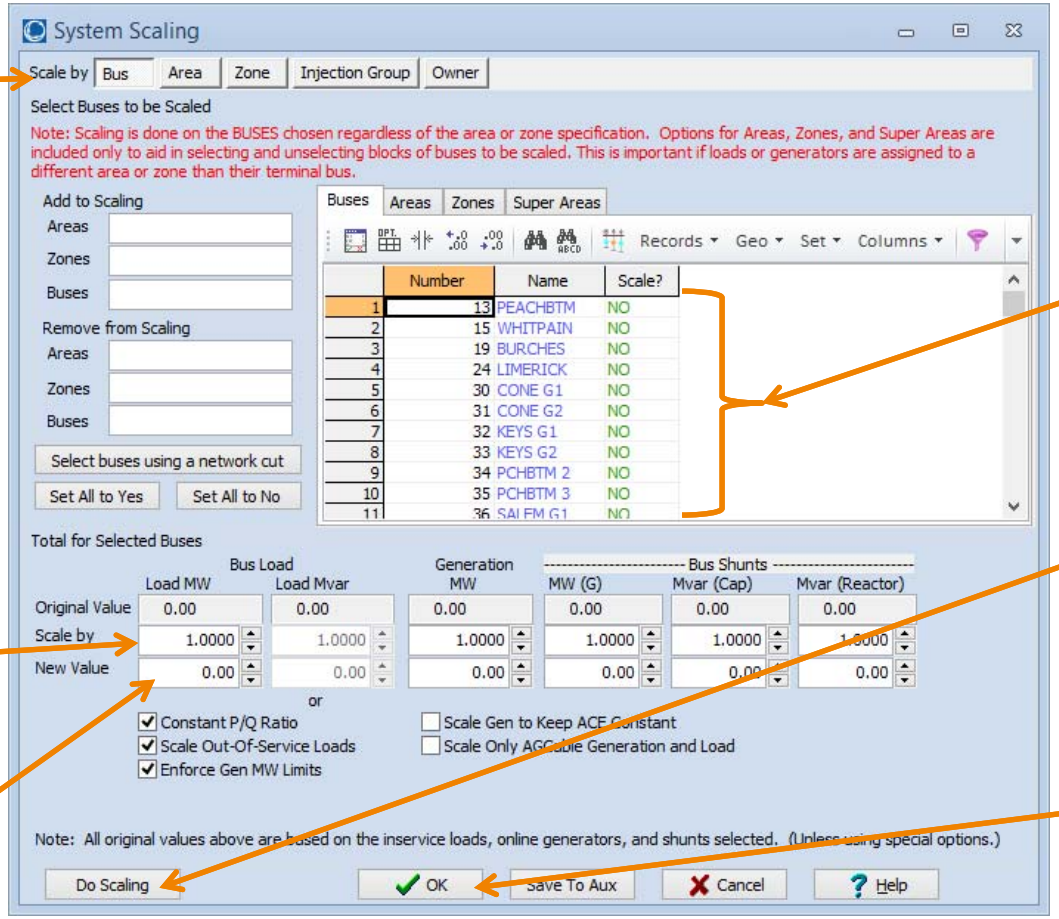
Scaling Load

- Loads may be scaled individually
  - from **Model Explorer → Network → Loads**
  - usually edit the "S MW" and "S Mvar" columns
- Or in bulk from **Scale Case…** on the **Tools** Ribbon



System Scaling Display

Choose object to scale by



Select specific objects to scale

Enter either a scaling factor

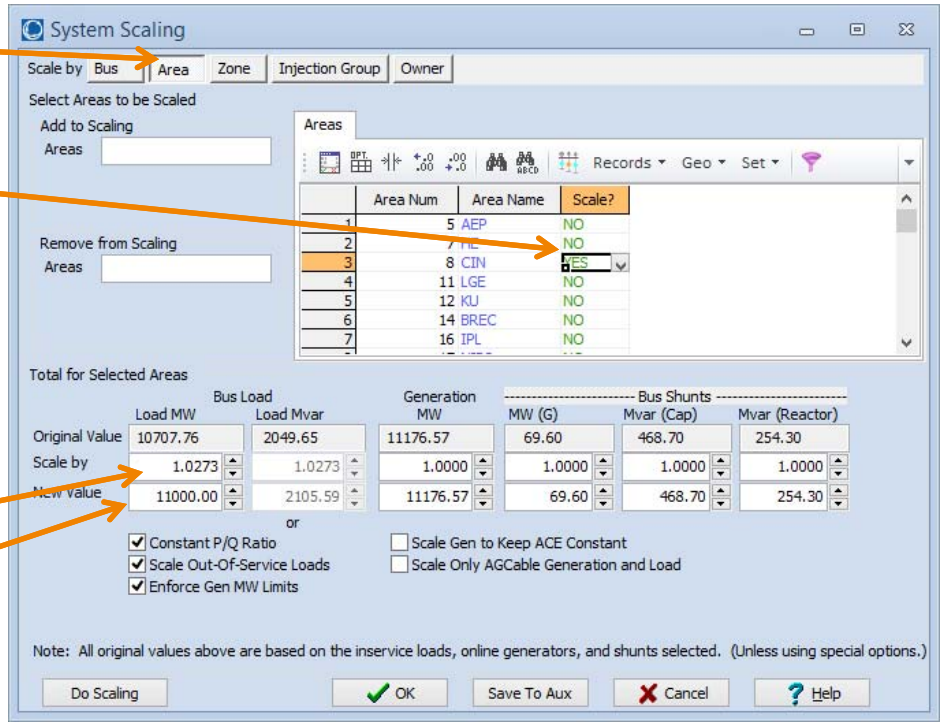
Or directly enter a new value

"Do Scaling" scales the values, but leaves dialog open

"OK" also scales the values, then closes the dialog

Scaling Example

- Scale by Area
- Choose one or more areas by toggling "Scale?" field to "YES"
- Specify new load with either
  - Scaling multiplier, OR
  - New MW value
- Click OK
- Re-Solve the Power Flow (**Single Solution – Full Newton**)



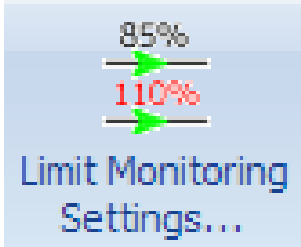
NOTE: With Participation Factor AGC, it is usually not necessary to scale generation; this will occur on power flow solution. However, you may optionally scale generation on the System Scaling display

Scaling Notes

- With the AC power flow, several iterations of partial scaling followed by solving the power flow may be required to achieve a desired load
- With Participation Factor AGC, it is usually not necessary to scale generation; this will occur automatically with the power flow solution.
- You may optionally scale generation by
  - Entering a “Scale by” factor or “New Value” for Generation, OR
  - Check the box “Scale Gen to Keep ACE Constant”

Limit Monitoring

- Most power systems analysis tools make use of limits to define boundaries of safe, reliable operation
- Define settings for monitoring limits by selecting the **Tools** ribbon tab, then **Limit Monitoring Settings**.



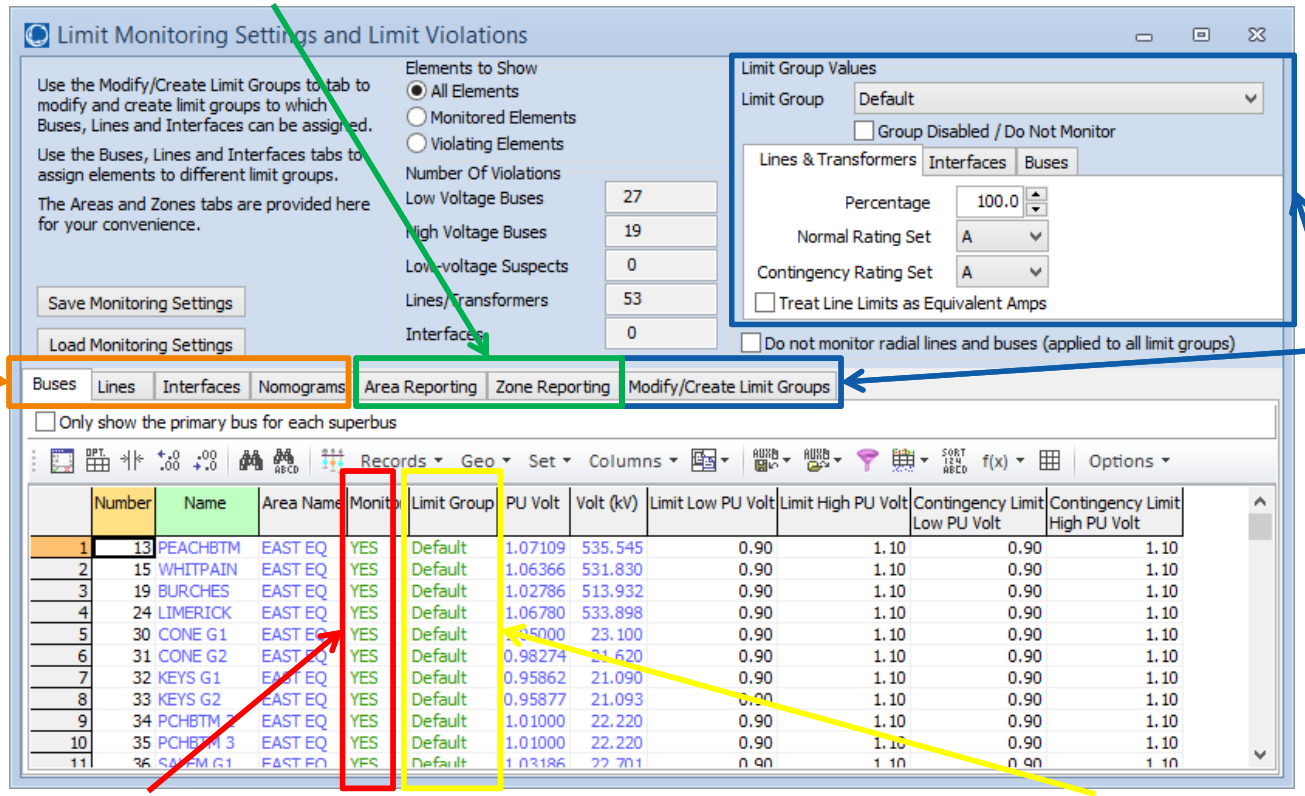
- By default, **ALL** elements in the power system are monitored
- Use **Limit Monitoring Settings** to exclude power system elements that are of no interest for a particular study
- Different Line, Interface and Voltage limits can be assigned to each Limit Group, and each device within a Limit Group will adhere to its own Limit Group Settings

Limit Monitoring

- Monitoring may be done on buses (voltage), lines (MVA or Amps), transformers (MVA), interfaces (MW)
- An element is monitored only if ALL of the following conditions are met:
  - Its "Monitor" field is set to YES
  - Its assigned "Limit Group" is Enabled
  - Its Area's "Report Limits" field is set to YES and its nominal kV is between its Area's "Report Min kV" and "Report Max kV"
  - Its Zone's "Report Limits" field is set to YES and its nominal kV is between its Zone's "Report Min kV" and "Report Max kV"

Limit Monitoring: Key Components

Area and
Zone settings



Monitored element types

Limit Group settings

Element's "Monitor" Field (YES/NO)

Element's assigned Limit Group (all initially belong to "Default")

Limit Monitoring: Tabs

- Buses, Lines, Interfaces, and Nomograms
  - show the individual elements of the power system
  - important columns
    - Monitor: specifies whether to monitor that specific element
    - Limit Group: specifies the Limit Group that the element belongs to
- Area Reporting and Zone Reporting
  - Specify which areas and zones to monitor
  - Specify nominal kV range to monitor in each
- Modify/Create Limit Groups
  - Specify limit levels and rating sets for lines, buses, and interfaces under normal and contingency conditions
  - Most fields also present in the upper-right corner of the dialog (Limit Group Values)

Limit Monitoring Example

- Use the “B” rating set for Lines & Transformers during Contingencies
- Ignore all radial lines and buses
- Report Limits only in a few areas, at 100 kV and above