Introduction to PowerWorld Simulator: Interface and Common Tools

I1: The PowerWorld Simulator Case Editor and One-line Diagrams

PowerWorld Corporation

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

support@powerworld.com
http://www.powerworld.com

Background

PowerWorld Simulator

- User-friendly and highly interactive power system analysis and visualization platform.
- Integrates many commonly performed power system analysis tasks
- PowerWorld Simulator runs on all Microsoft Windows operating systems 2008 R2/7 and newer (both server and client versions, 64-bit editions only).

PowerWorld Simulator

- Simulator seamlessly integrates two functions once commonly separated in power flow software:
  - Graphical power system case editor (one-line diagrams)
  - Power Flow package with many related analysis tools:
    - Contingency Analysis (including Remedial Action Schemes), Time-Step Simulation, Fault Analysis, Sensitivity Analysis, Loss Analysis, Optimal Power Flow (OPF/SCOPF), Available Transfer Capability (ATC), Steady-State Voltage Stability (PVQV), Transient Stability, Geomagnetic Induced Currents (GIC)
    - Distributed Computing option for contingency analysis, Transient Stability, ATC, PVQV

PowerWorld Simulator History

- Version 1.0 created in May 1994 at the University of Illinois Urbana-Champaign by Professor Thomas Overbye (Ph.D.)

- Impetus for early versions was to teach power system operation to non-technical audiences.

PowerWorld Simulator History

- PowerWorld Corporation was formed in 1996 with the goal of further developing and commercializing the Simulator tool.
- Simulator version 23:
  - Virtually unrecognizable from the early versions of the software.
  - Has evolved into a powerful power system analysis and visualization environment capable of solving very large systems.

Training Goals

- Provide a better understanding of how to use PowerWorld Simulator for power system analysis and visualization.
- Provide techniques for building good power system models and show how these techniques can be used to analyze system issues.
- Provide opportunities for hands-on examples, if you wish to participate
- Slides marked with red dot are intended for
- reference and may be skipped to stay on schedule

Training Goals

- Primary Goal: Make you aware of the capabilities of Simulator
  - We are frequently asked to add features to Simulator that are already available.
  - We want you to make the most of our software.

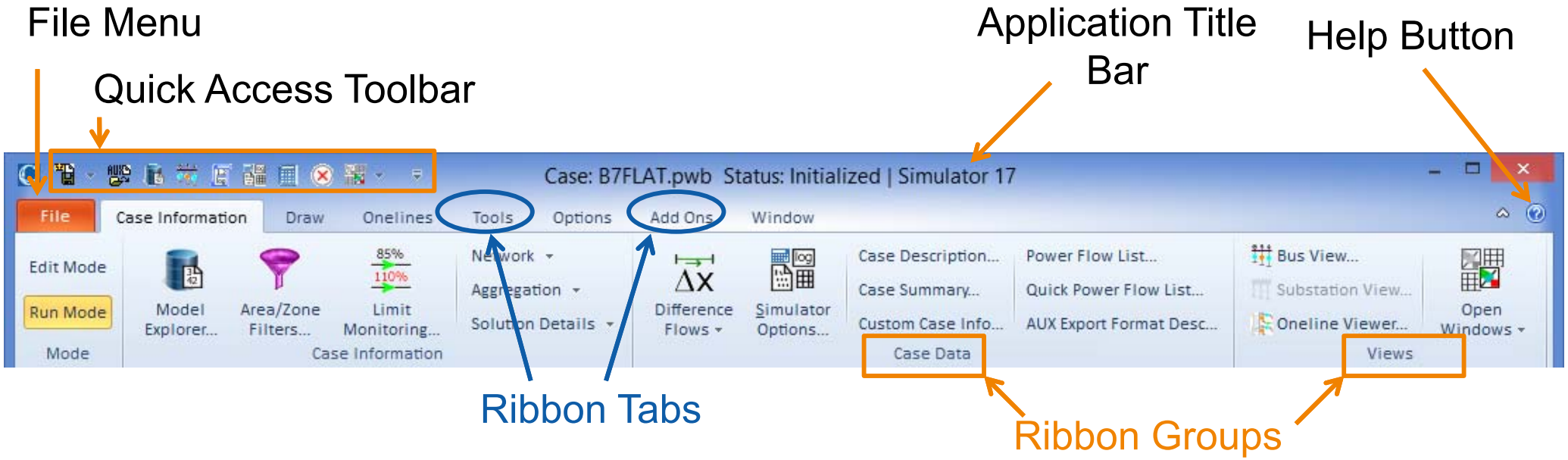
PowerWorld Simulator Model Architecture and GUI

Editing and Analyzing an Existing Power Flow Case

- PowerWorld Simulator cases can be easily created from existing text-based power flow cases stored in the following formats:
  - PTI RAW version 23 - 35
    - Used with public cases
      - FERC 715 cases
      - NERC ERAG, WECC, and ERCOT
      - Files obtained from ISOs and Market Operators
  - GE PSLF text format (up to EPC version 23)
    - Also used with some public cases, especially WECC
  - EMS formats (read-only in Simulator)
    - Areva hdbexport (csv)
    - ABB Spider (dat)
    - Siemens (txt)
    - OpenNet (txt)
  - UCTE Data Exchange (European standard, read-only in Simulator)
  - Others: MATPOWER, IEEE Common Format, BPA IPF, PowerSim

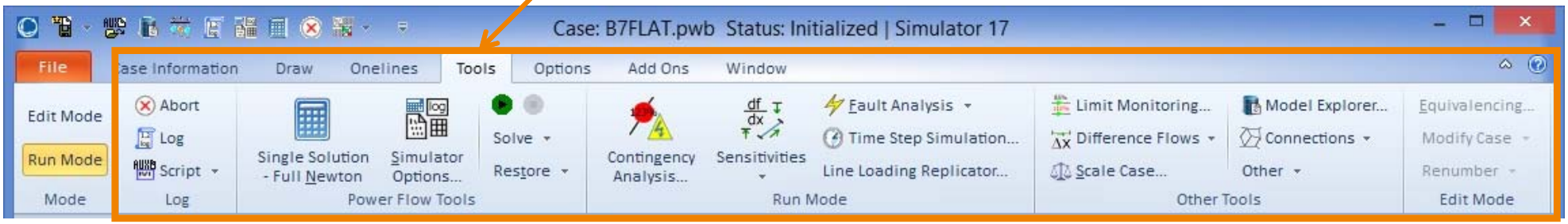
Ribbon Interface

- Menus are integrated in the Ribbon interface



Ribbon Interface

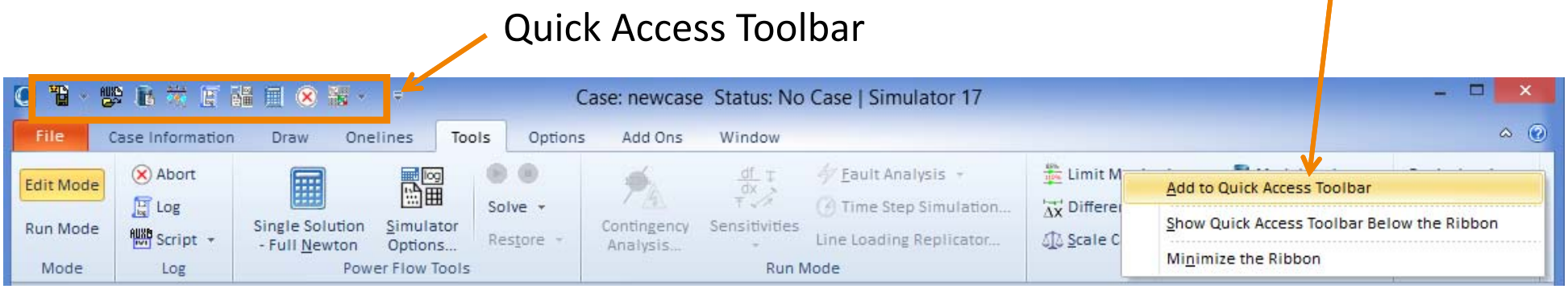
- Selecting a menu item from the Ribbon reveals a set of task-specific buttons
  - Previous Slide shows the Case Information ribbon tab
  - Change to the Tools ribbon tab



  - Interface is simplified by presenting only the buttons relevant to the selected menu item.

Ribbon Interface:
Quick Access Toolbar

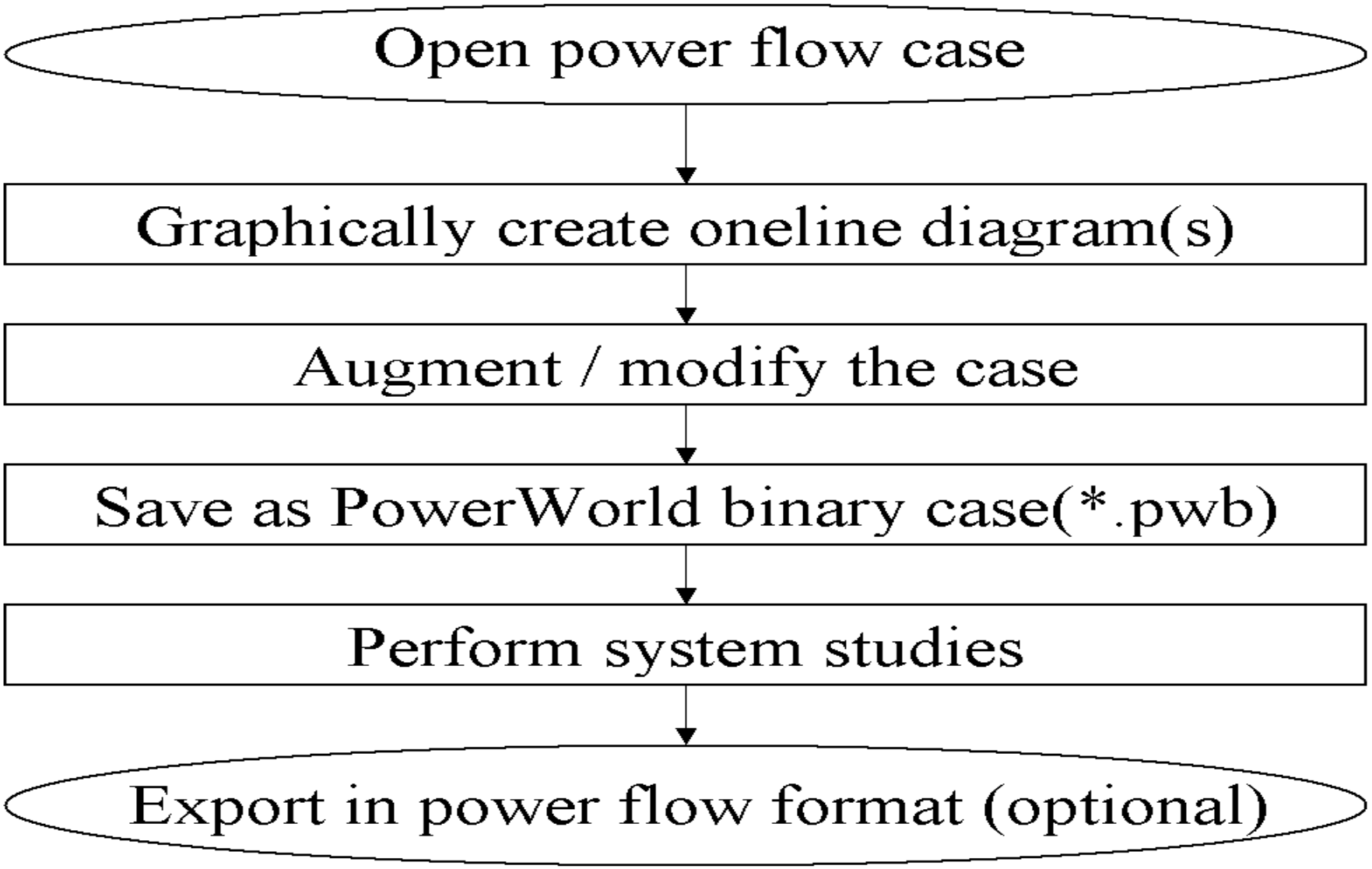
- Frequently-used buttons may be added to the **Quick Access Toolbar**, which is always visible
- Right click on button to add, then select “Add to Quick Access Toolbar”



Power Flow Data

- Provides static model of power system
- For some studies this model is sufficient
- For other studies model needs to be augmented
  - Generator cost information
  - Reactive capability curve
  - PowerWorld Simulator case options
  - Interface definitions
  - Injection group definitions
  - Contingency Definitions
  - Etc… and Much more

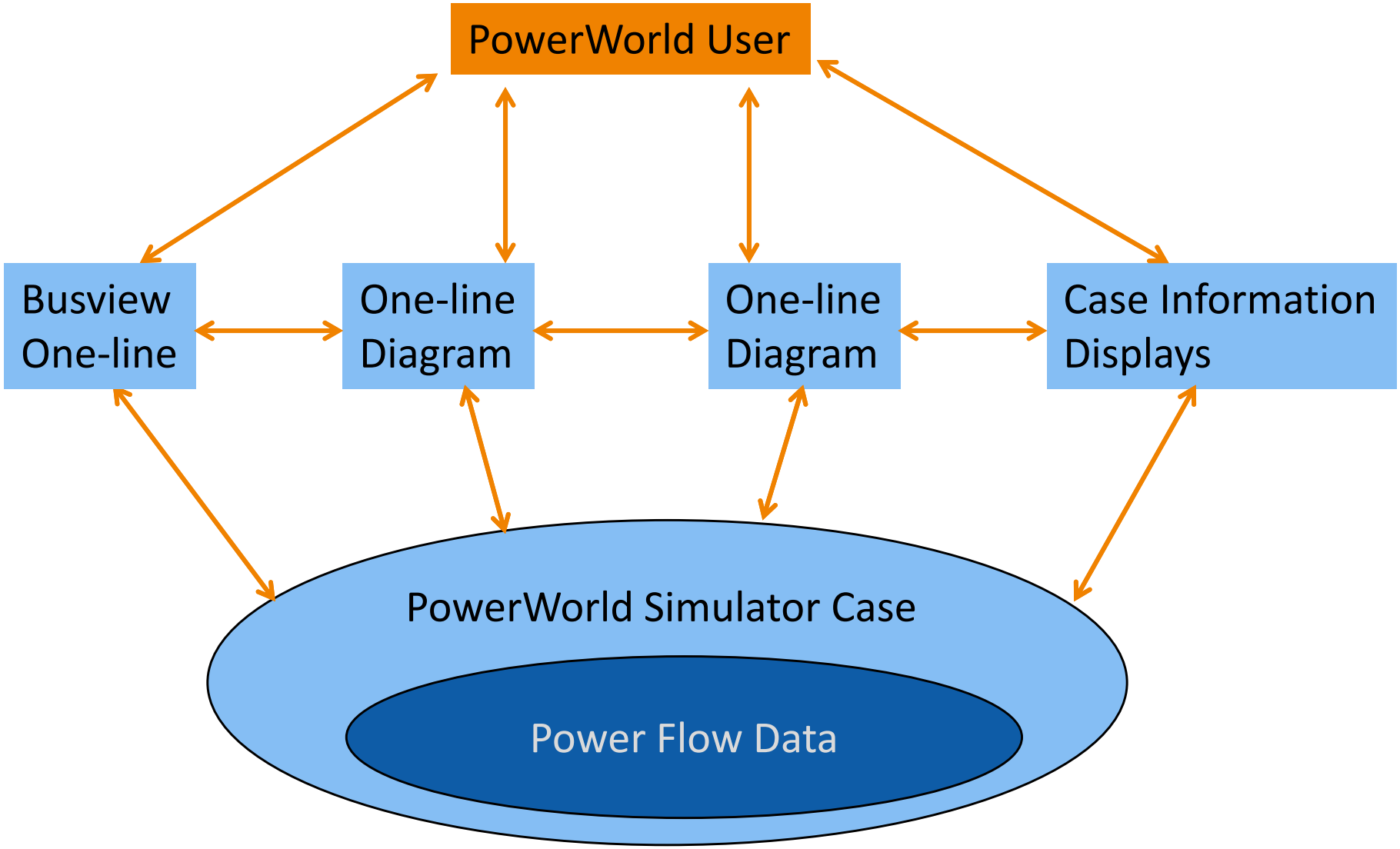
Analysis Flow Chart



Display/Model Relationships

- Single system model
- Power flow data is subset of system model
- Text-based Case Information Displays are always provided
- Oneline diagrams may optionally be created and can be used with different cases

Display/Model Relationships

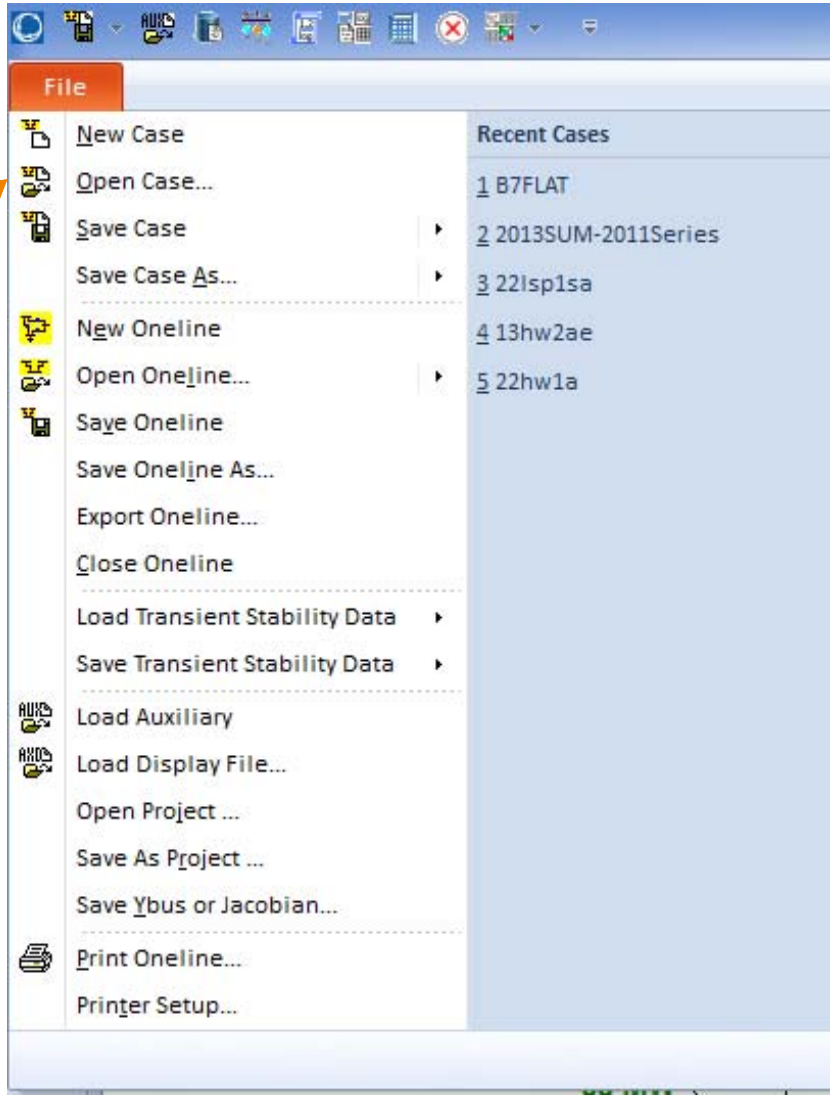


Display/Model Relationships

- Relationship between oneline objects and system model is NOT a one-to-one mapping
  - multiple oneline objects can be linked to the same system model object
- This is a more powerful approach, but introduces ambiguity when deleting objects
  - delete just the oneline display object
  - delete oneline display object and model object

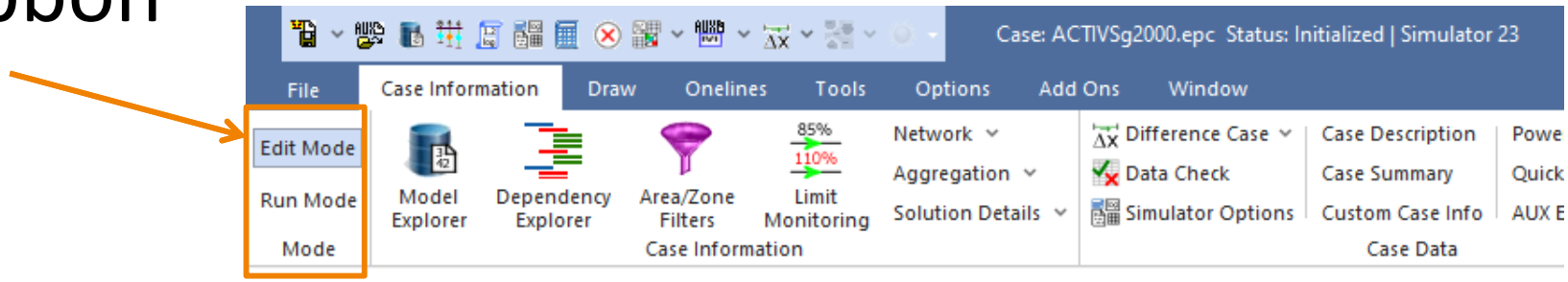
Texas Example

- Example: 2,000 bus synthetic Texas case saved in PSLF version 21 format.
- Click the **File Menu** and choose **Open Case** to view open dialog
- Choose case *ACTIVSg2000.epc*



Modes of Operation

- The graphical power system case editor and the power flow package are implemented in Simulator's two distinct modes:
  - Edit Mode
  - Run Mode
- Mode is always visible on the left edge of the Ribbon

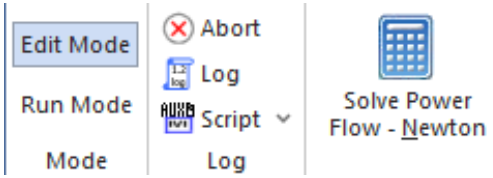


Run Mode

- Stand alone power flow
- Power flow analysis tools and sensitivities
  - Contingency Analysis
  - Time-Step Simulation
  - Optimal Power Flow (OPF) and Security-Constrained OPF (SCOPF)
  - PV and QV Curve Tools (PVQV)
  - Available Transfer Capability (ATC)
  - Sensitivity Analysis
  - Loss Analysis
  - Fault Analysis
  - Transient Stability
  - Geomagnetically Induced Current (GIC)

Edit Mode

- Used to create a new case or modify an existing case.
- Use the Ribbon buttons to switch between modes.
- You can switch to Edit Mode at just about any time during a simulation.
- The tools and techniques of Edit Mode will be introduced by creating a oneline diagram and using it to interact with a case.

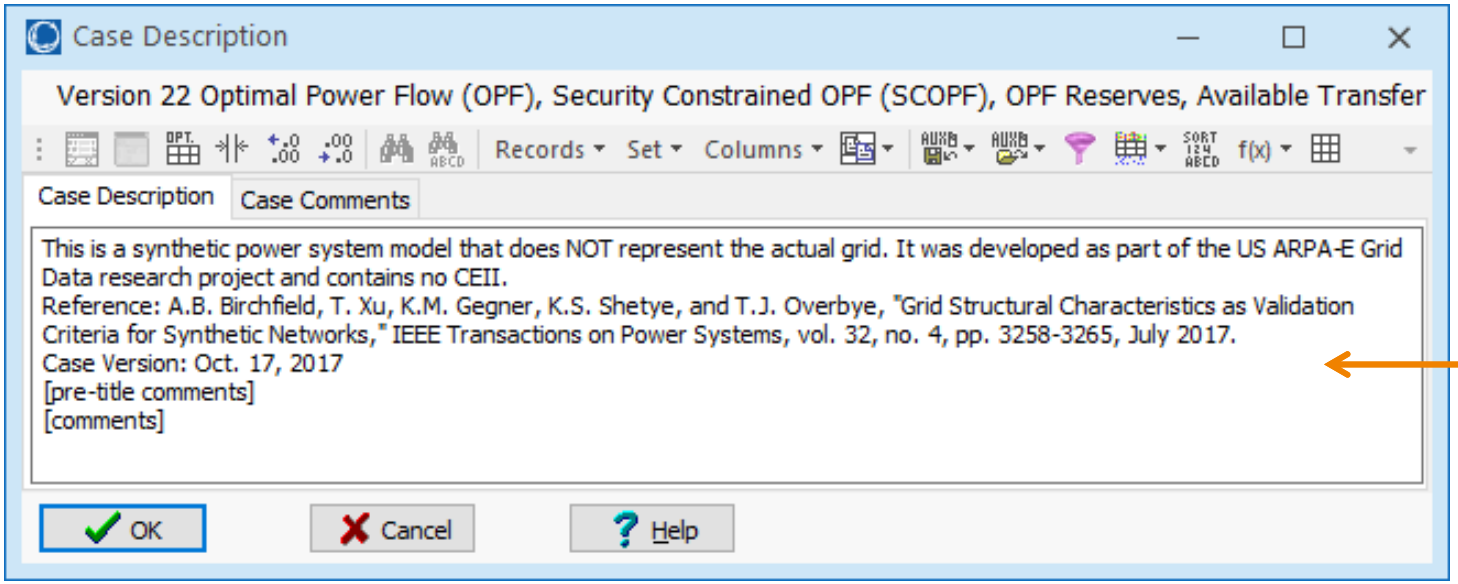


Solving the Case

- Show the **Message Log** (**Tools** Ribbon or Quick Access Toolbar) to view iterations.
- To perform a single power flow solution, click the **Solve Power Flow** button (**Tools** Ribbon or Quick Access Toolbar).
  - mode is automatically switched to **Run** (if there are no validation errors, such as a system slack bus not set)
  - case should converge within several iterations

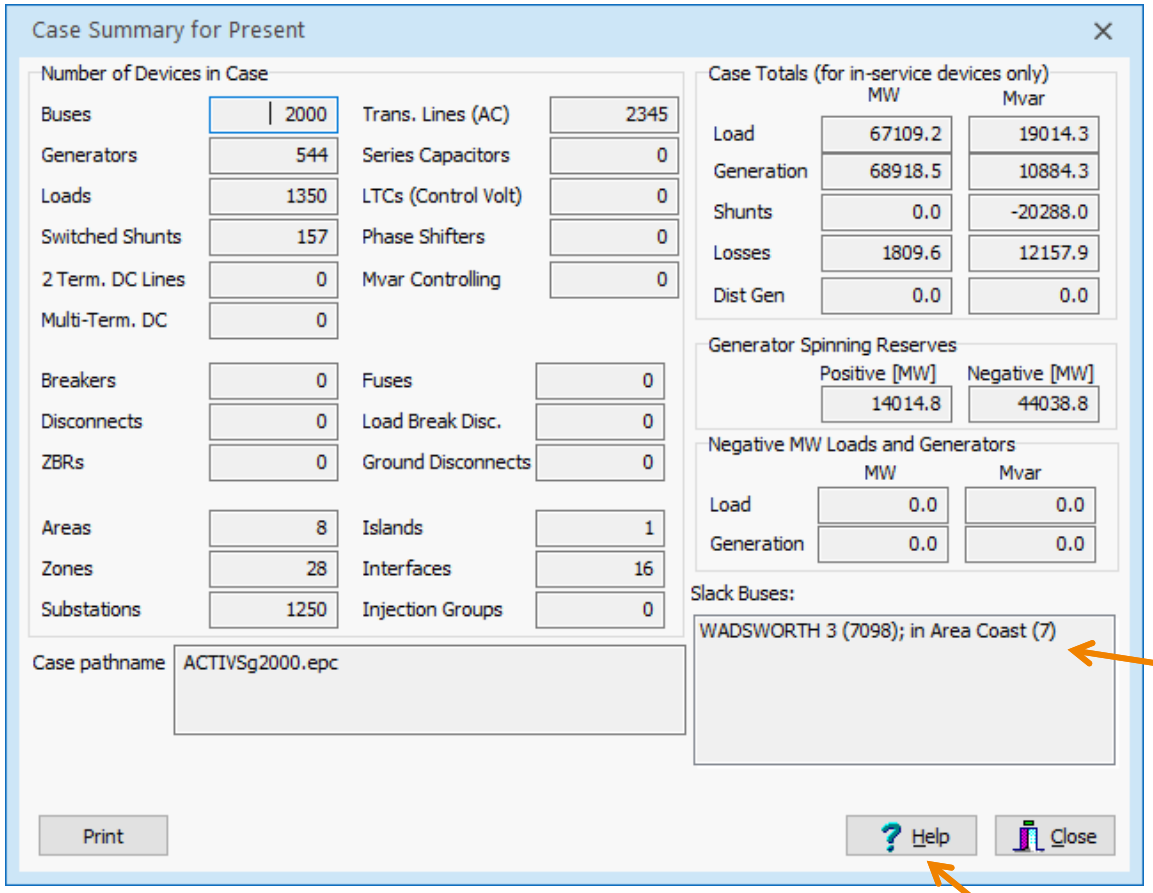
Case Information Displays

- Provide text-based view of the case
- Select **Case Information** ribbon tab → **Case Description** to view an enterable description of the case
- Discussed in greater detail in another section



PTI (raw) format allows 2 lines; PWB and epc formats allow unlimited number

Case Summary Dialog



Summary of total case Load, shunts, and generation

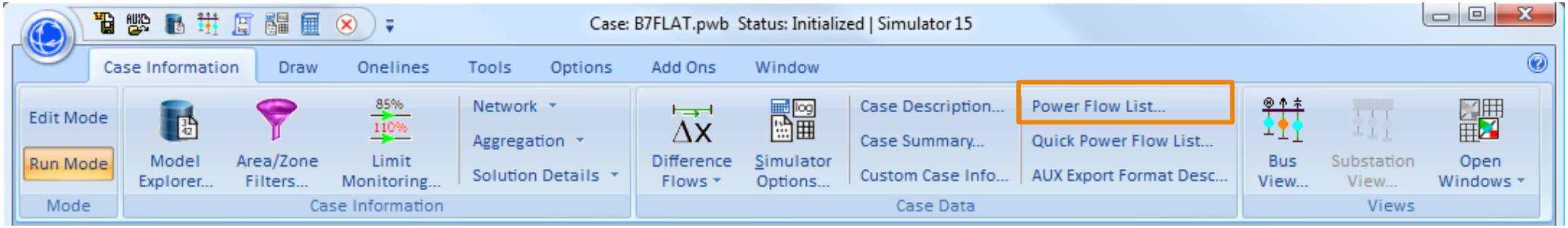
List of slack Bus(es)

NOTE: There are no changeable fields on this dialog

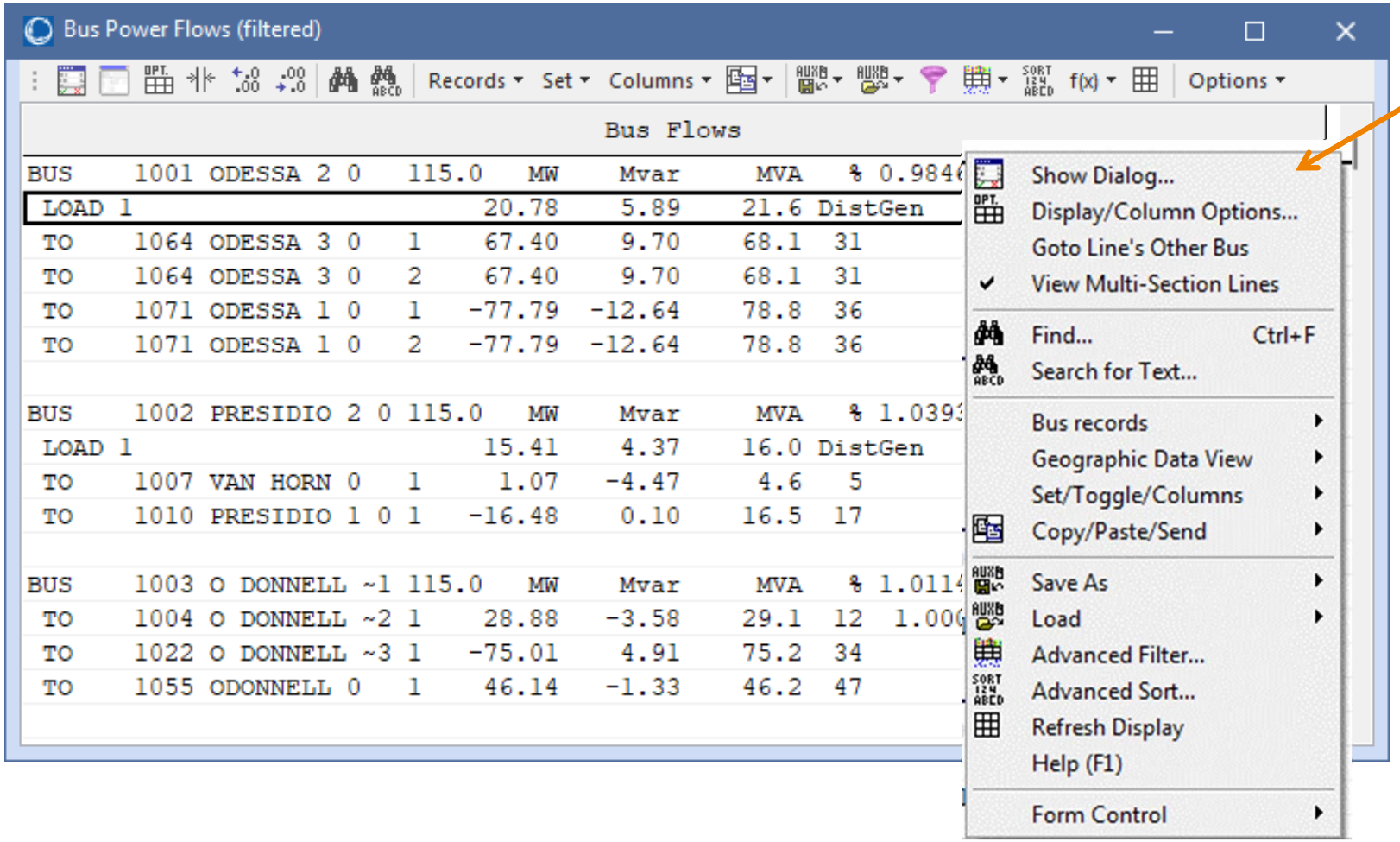
Select for Help, or press F1 key

Power Flow List

- Shows complete power flow information for all buses with **Area/Zone/Owner/DataMaintainer Filter** set to *Yes*.
- To display use **Case Information** ribbon tab → **Power Flow List**.
- Display has its own local menu. To view, right click anywhere on the list.



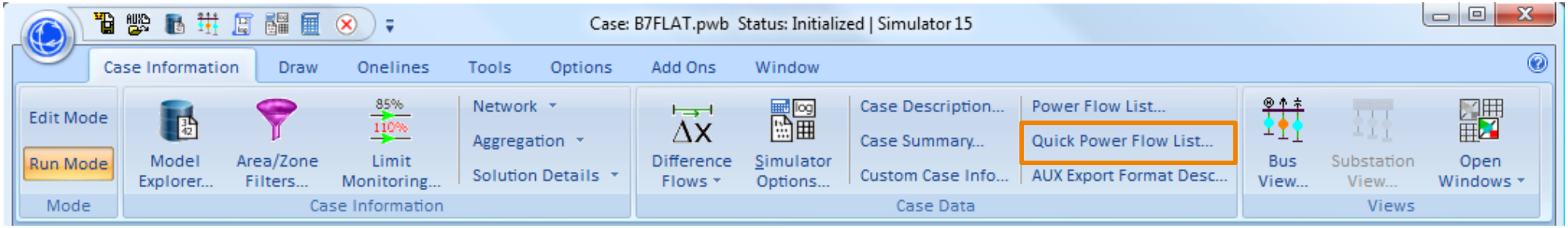
Power Flow List



Local Menu of Power Flow List

Quick Power Flow List

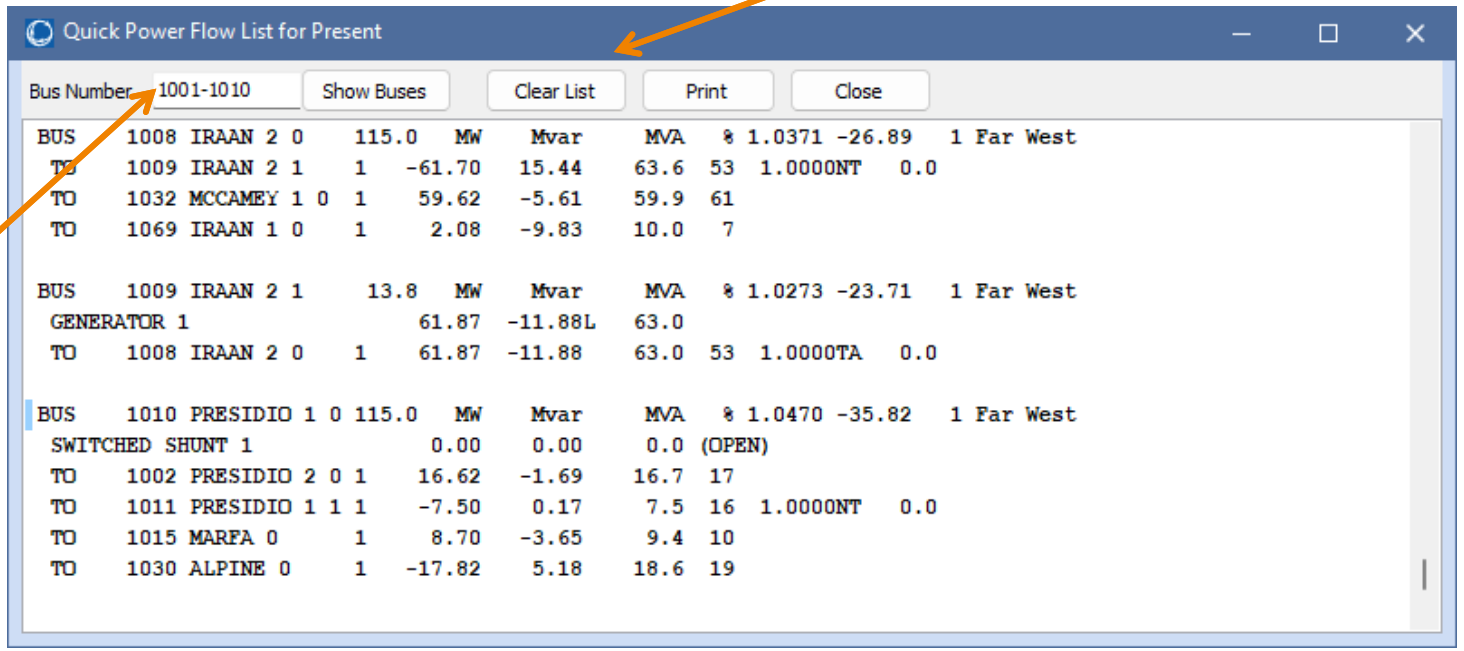
- Similar to Power Flow List, except list can be used to show flow at individual or a set of buses
- To display use **Case Information** ribbon tab → **Quick Power Flow List**.
- Enter number or range of numbers of buses to view
- Double-click to move to desired bus, or right-click for information.
- Area/Zone/Owner/DataMaintainer filters are not used.



Quick Power Flow List

Clears the list

Enter either a single bus, a set of buses separated by commas, or a range of buses



Circuit identifier *99* indicates an equivalent line

New buses appear at the end of the list

Format is similar to Power Flow List

Bus View

- Graphical replacement for Quick Power Flow List
  - Easier to use
  - Much more powerful approach
  - Allows user to navigate through buses like web pages
- To display, use **Onelines** ribbon tab → **Bus View**
- Auto-generates oneline diagrams at each bus, one at a time, showing all devices connected to bus and all flows.
- Operations just like other oneline diagrams in Simulator

Bus View Oneline

Back and forward buttons

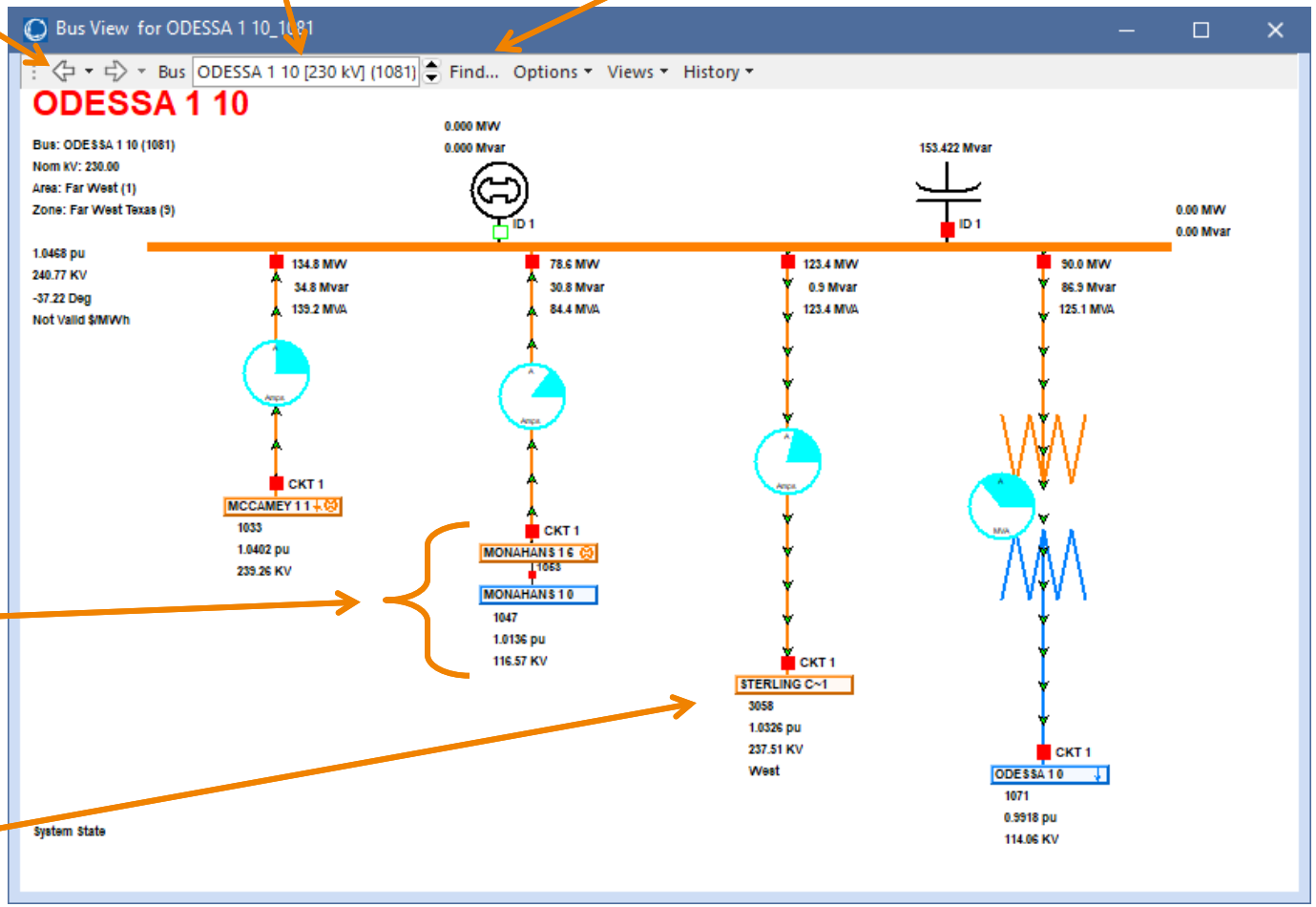
Enter a name or number to go to a bus

Click to find a bus

Bus and Flow information

Serial buses are shown automatically

Click links to jump to new bus



Bus View Oneline

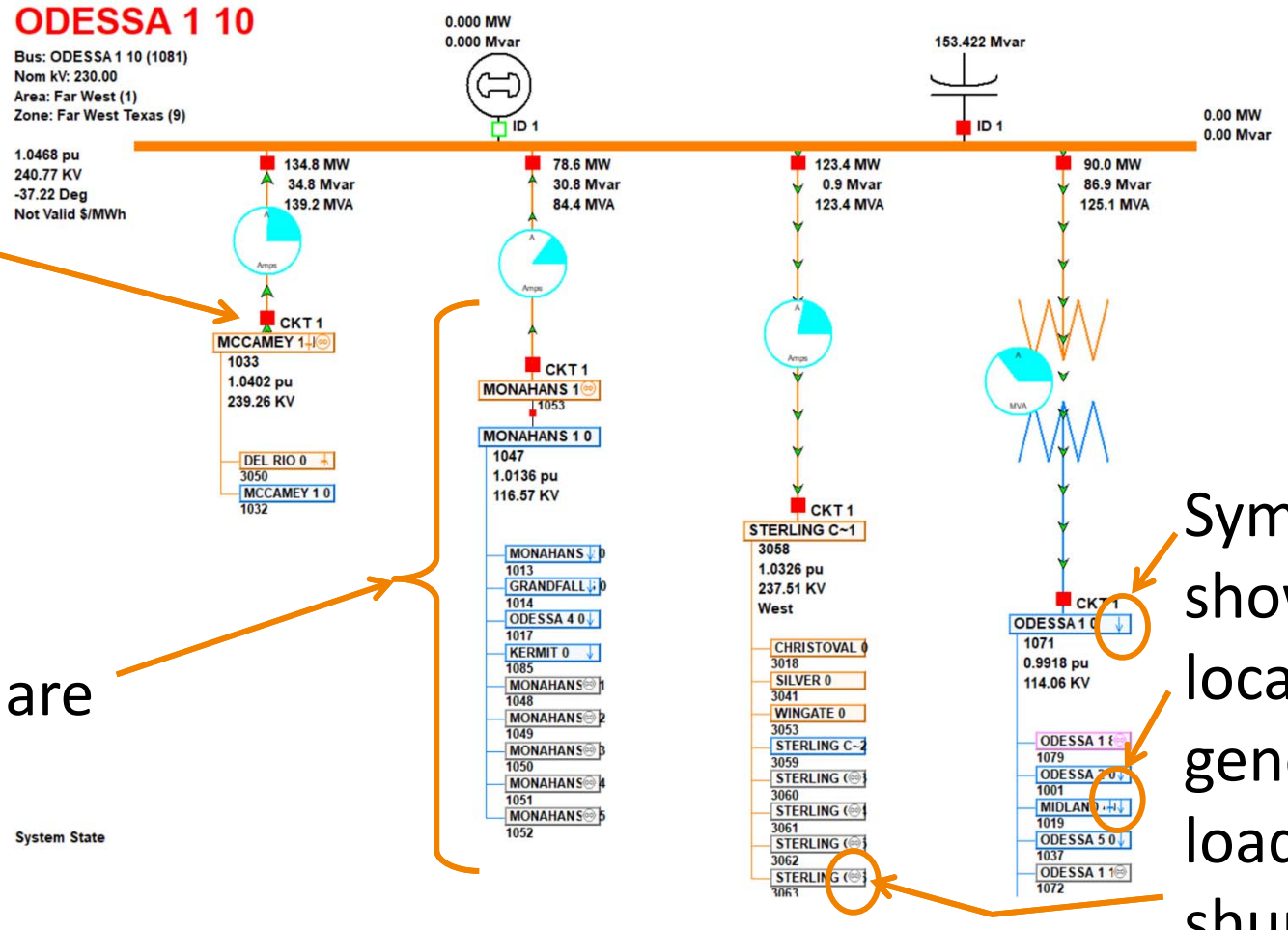
Colors are set by the **Default Drawing Values**

Left-click circuit breaker to open/close

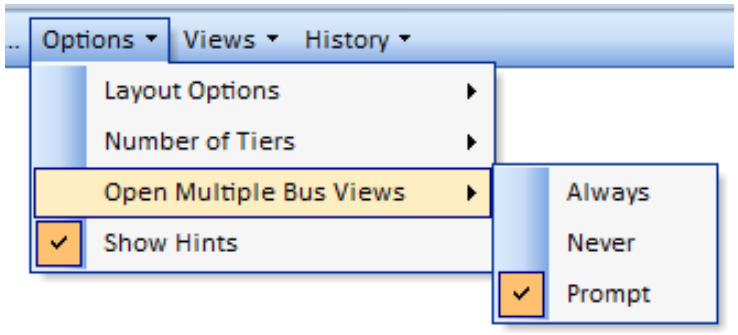
Right-click elements for information

2 tiers are shown

Symbols show locations of generators, loads, shunts

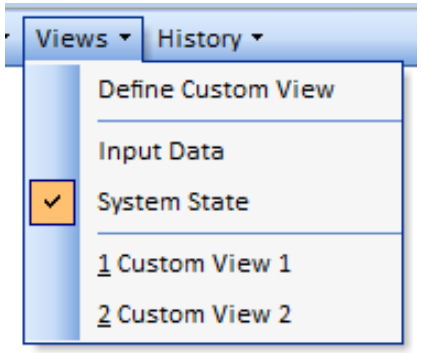


Bus View Oneline:
Click Options > to reveal



- 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

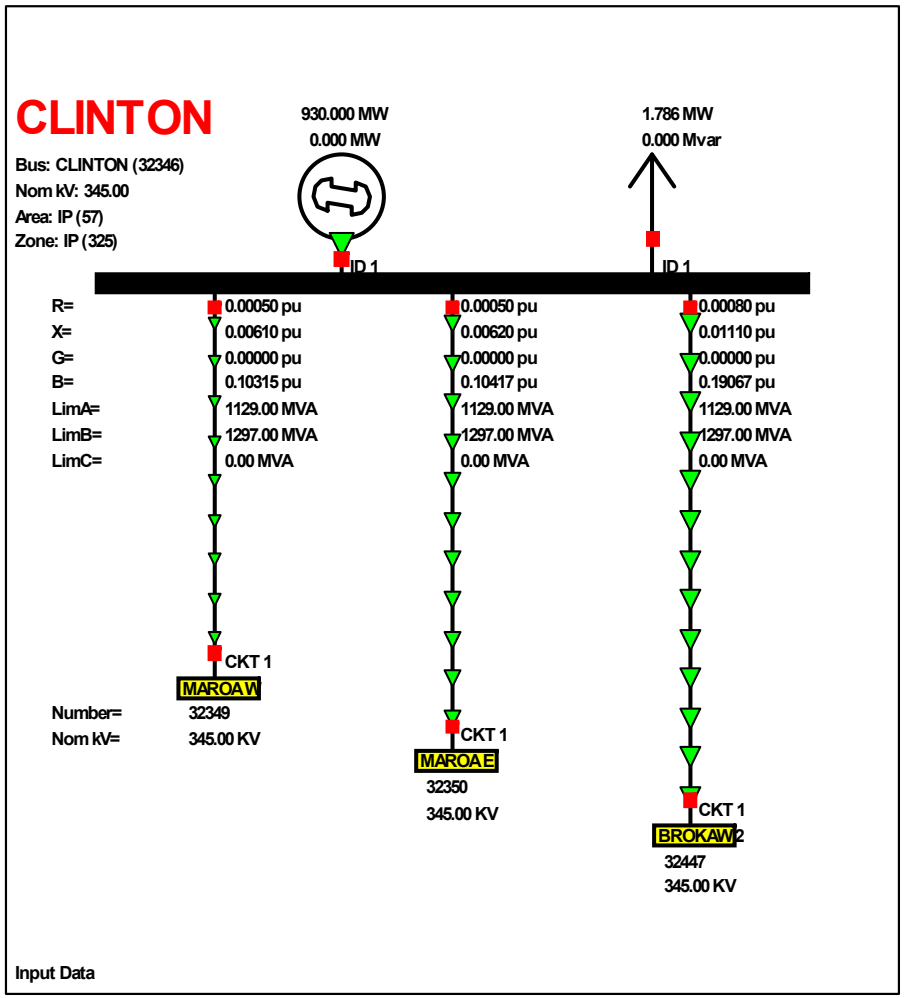
Bus View Oneline
Click Views > to reveal



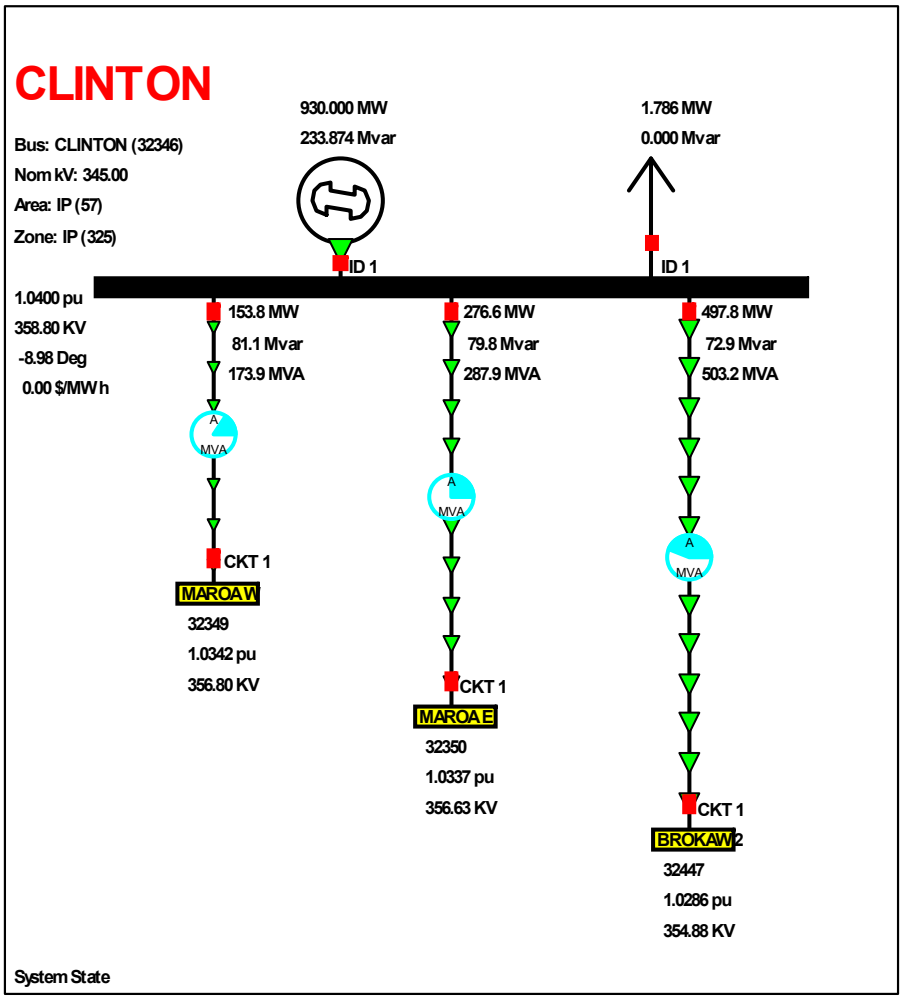
- Define Custom View
  - Will discuss next
- Input Data – pre-defined view
  - Shows information related to input parameters
- System State – pre-defined view
  - Shows information about the system state
- If Custom Views are defined, they will appear at the bottom of this list

Bus Views: Input Data and System State

Input Data

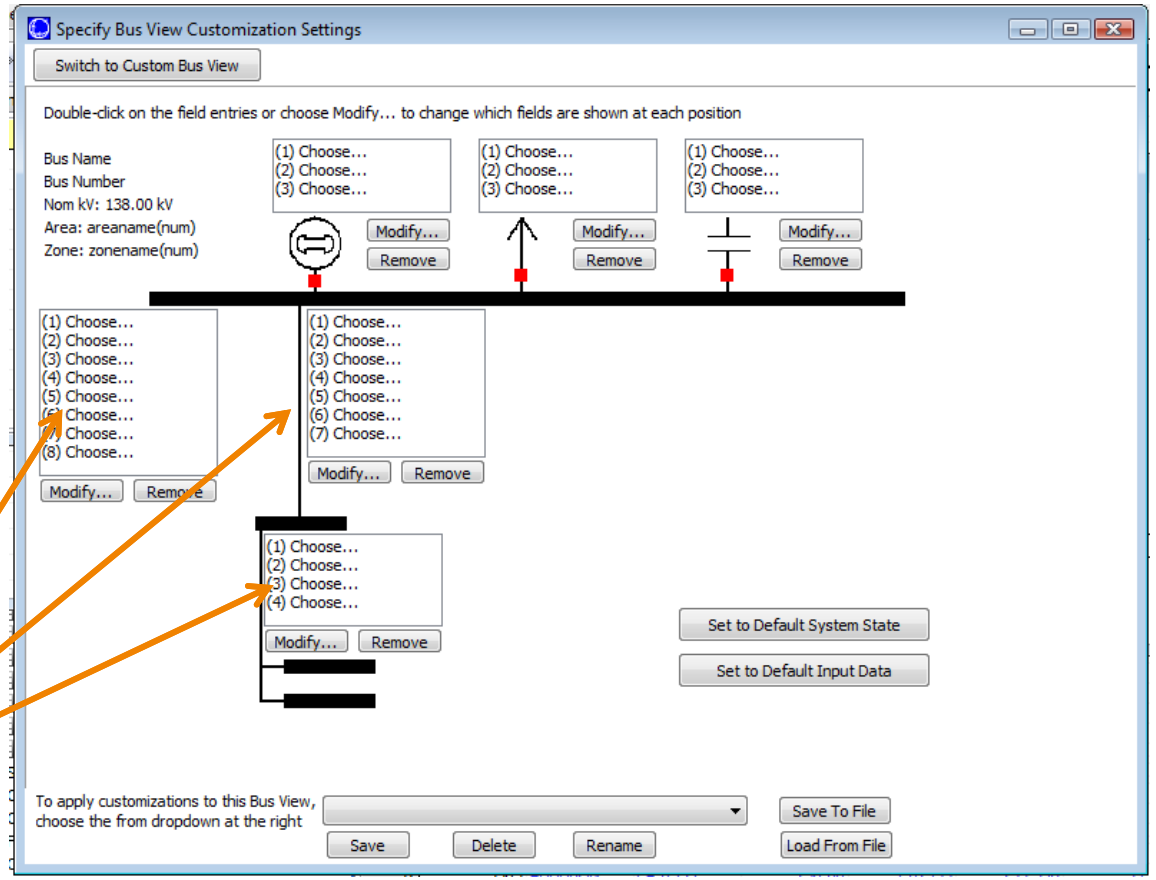


System State



Custom Bus View

- Add custom fields to bus view oneline
- Select **Views → Define Custom View** from bus view oneline



Add new object fields to certain positions

Oneline Diagram Creation and Tools

Building Onelines

- Oneline diagrams enable easy visualization of power flow and other analysis results.
- A diagram need only be created for a desired subset of the system; Simulator always models the ENTIRE system in calculations.
- Simulator will automatically link an open oneline to the existing power system model.
- A power flow case can be modified from diagrams or text-based Case Information Displays (more in the next section).

Building Onelines

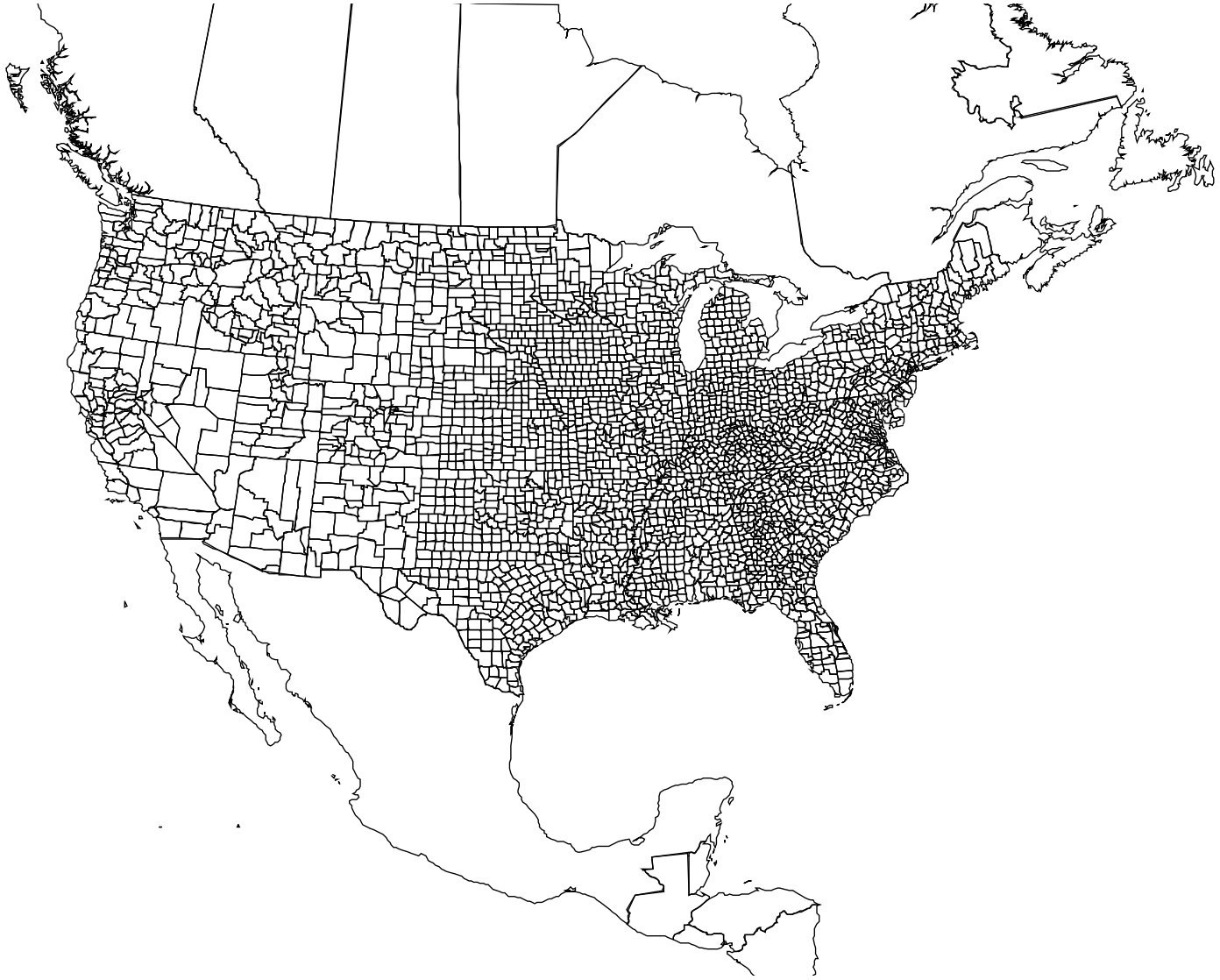
- Click the **File Menu** and choose **New Oneline**
- Simulator will switch to Edit Mode if not already
- Includes the ability to insert pre-defined
  - U.S. state and county borders
  - Canadian Province borders
  - World Country borders
- Select **Draw** ribbon tab → **Auto Insert** → **Borders**
  - Select **Options** tab. Adjust line color and thickness if desired.
  - Choose **TX – Texas** from the **PowerWorld Library** → **United States** tab
  - Select the borders and map projection (under the respective tab). Click **OK**.
  - Repeat for Texas Counties

Map Projection

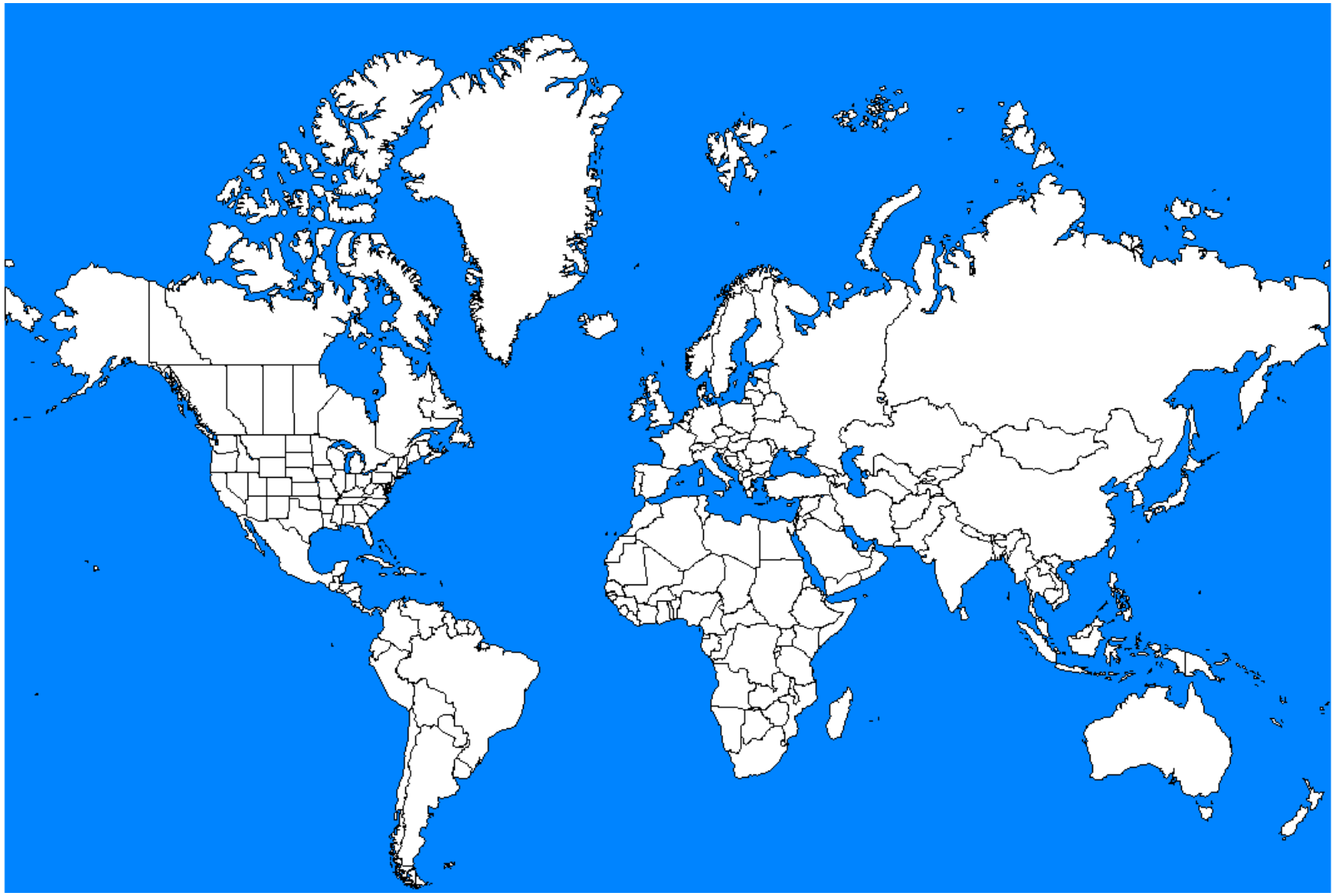
- Simulator supports three projections for representing earth in two-dimensional space
  - Simple conic
    - Suitable for North America only
    - Latitude lines are curved; longitude lines are radial
  - Mercator: Latitude lines are straight, form rectangles with longitude lines
  - Alaska (Albers Conic): similar to simple conic, but longitude is centered on Alaska
- Once a projection is selected for a oneline, it should be used for all mapping and GIS functions so that objects are drawn in proper relation to one another

Built-In Geographic Borders

Built-In Geographic Borders: With US Counties



Built-In Geographic Borders: Entire World



Zooming

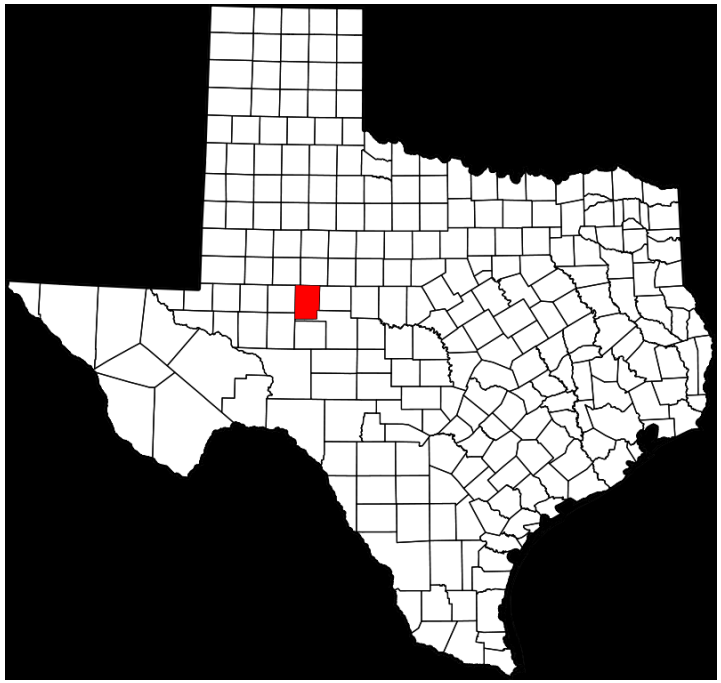
- **Zoom** ribbon group under the **Onelines** ribbon tab
  - Zoom in and out buttons
  - Rectangular zoom selector
  - Zoom percentage
- Mouse wheel zooming
  - "Enable Mouse Wheel Zooming" checkbox on **Simulator Options** dialog, **Oneline → Visualization** page
- Zoom In
  - Ctrl-Up Arrow key
  - Ctrl-Page Up key zooms in quickly
  - Ctrl-Alt and use left mouse button to select region on which to zoom in
- Zoom Out
  - Ctrl-Down Arrow key
  - Ctrl-Page Down key zooms out quickly
  - Ctrl-Alt and use right mouse button to select region on which to zoom out

Panning

- Left-click and drag on empty space in the one-line
- Keyboard Shortcuts
  - Pan Up
    - Up Arrow key
    - Page Up key pans quickly
  - Pan Down
    - Down Arrow key
    - Page Down key pans quickly
  - Pan Left
    - Left Arrow key
    - Home key pans quickly
  - Pan Right
    - Right Arrow key
    - End key pans quickly

Building Onelines

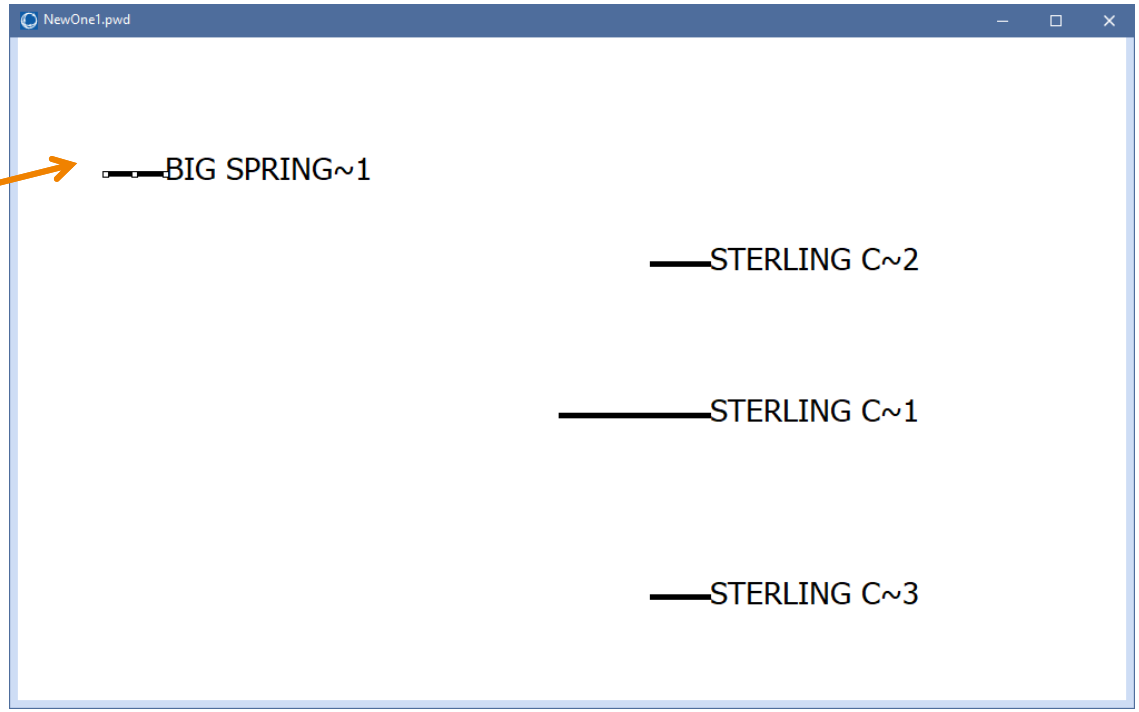
- Zoom in, centered on Sterling County (OK if not exact)
- Select **Draw → Network → Bus**
- Click on the oneline
- Enter 3058 in Bus Number
  - select **Find by Number,** if necessary, to view bus info
- Select **OK** to place the bus

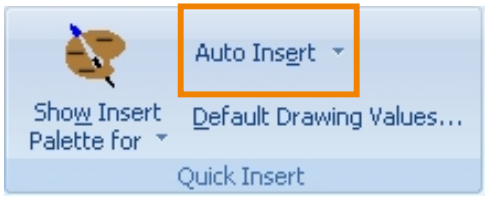


Building Onelines

- Repeat this procedure, entering buses 3059, 3060, and 1020.
- Oneline should look similar to the following

Left-click a bus and drag to relocate it. When "handles" are active, you can also click and drag an endpoint to stretch the length of the bus





Automatic Line Insertion

- Lines between buses can be inserted manually.
- It is easier to use automatic line insertion.
- Select **Draw → Auto Insert → Lines**
  - Clear "Insert Text Fields" checkbox
  - click **OK**
  - lines joining buses are automatically added, optionally with circuit breakers and pie charts

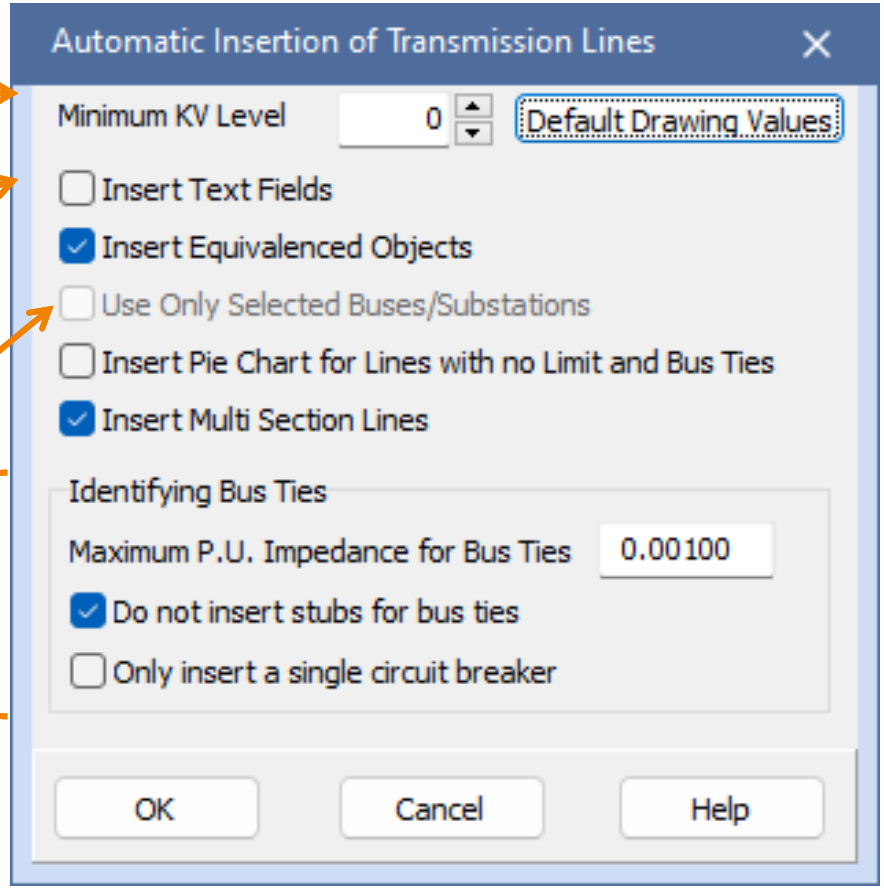
Automatic Line Insertion

Optionally set a minimum kV level of lines to be inserted

Clear “Insert Text Fields” for this example

Optionally use only selected buses (available if a selection is active)

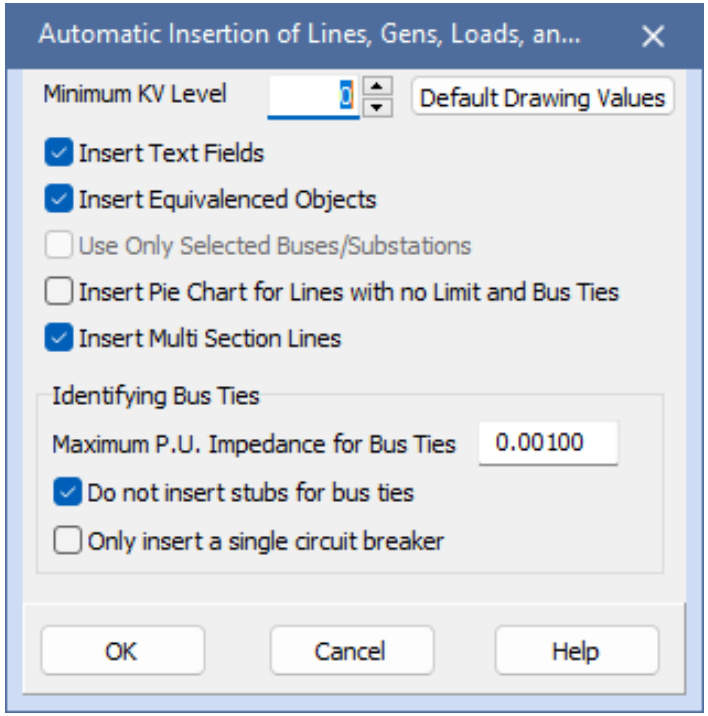
Options for branches with very low impedance

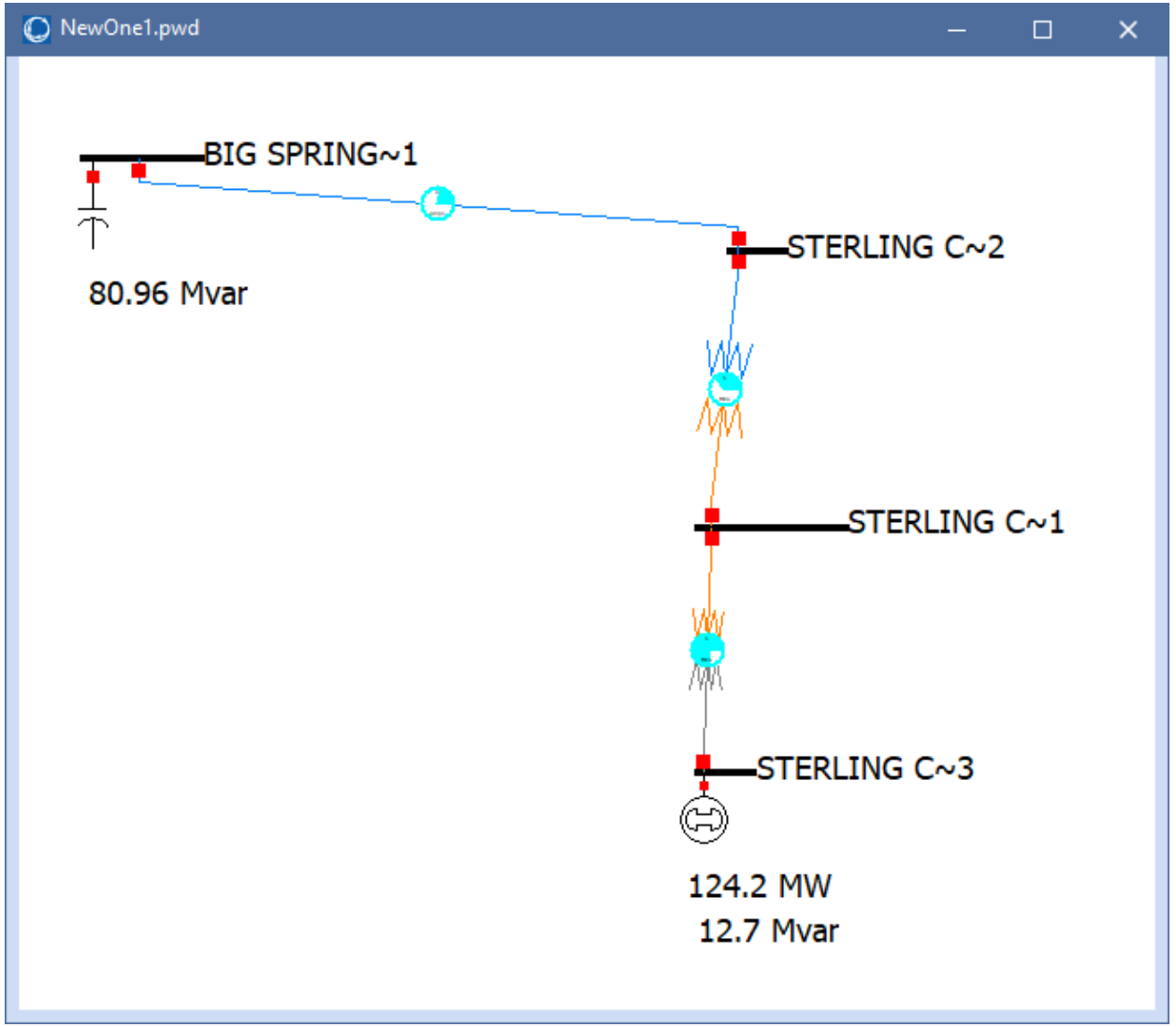


Automatic Load, Generator, and Shunt Insertion

- Loads can be inserted manually using **Draw → Network → Load**
- Easier to use automatic load insertion
- Select **Draw → Auto Insert → Generators…**
  - Select default options
  - Click **OK** to automatically add generators to displayed buses
- Automatic Load and Switched Shunt Insertion are also available, as is **Lines, Gens, Loads, and Shunts** in a single action

Auto Insert Lines, Gens, Loads, and Shunts





Moving Oneline Objects

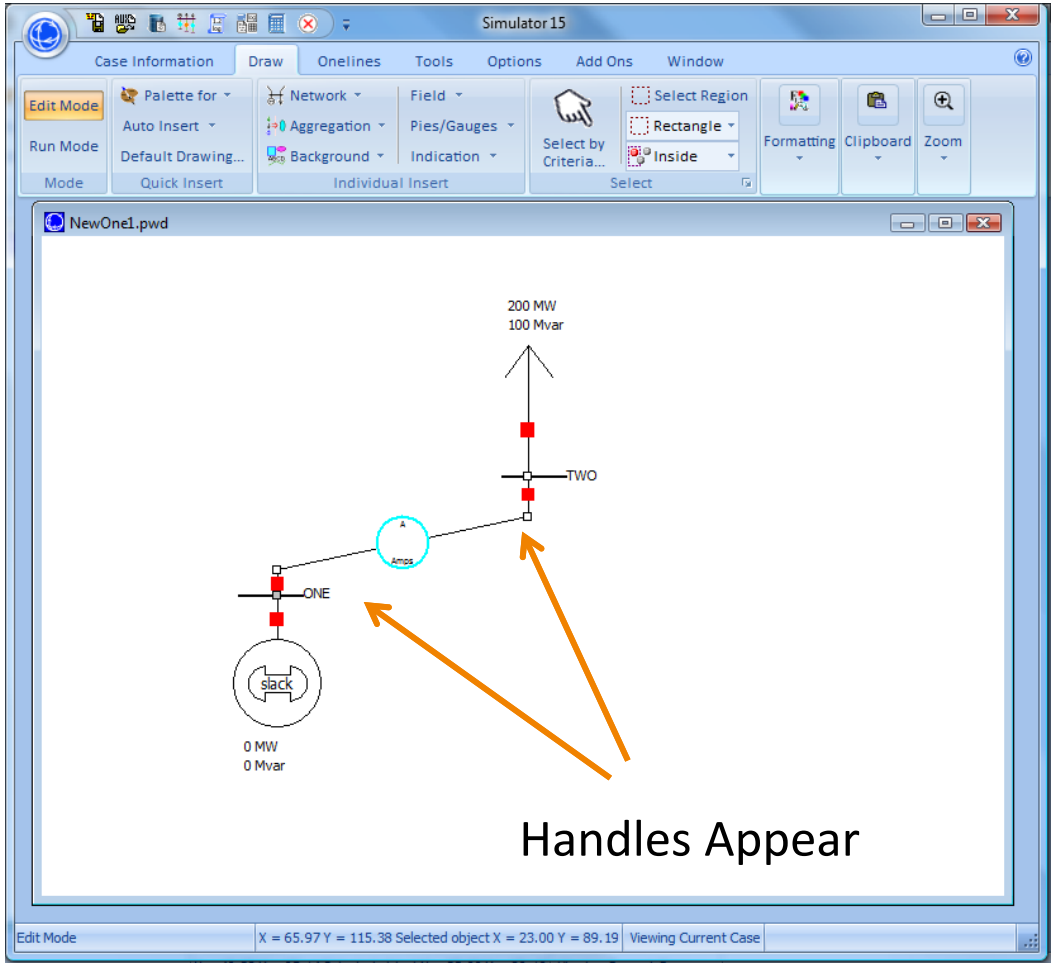
- To reposition a bus, left-click and hold the left mouse button, drag the bus to the desired location, and release the left mouse button.
  - Note that all attached (and anchored) objects move with the bus.
  - Individual objects such as generators and loads can be repositioned similarly.
- To reposition the entire oneline, click on the diagram (not on a specific object) and drag.

Moving Oneline Objects

- Keyboard shortcuts
  - Left-click on and select object(s) to move
  - Shift-arrow keys (up, down, left, right) move in small steps
  - Shift-Page Up moves object(s) up in larger steps
  - Shift-Page Down moves object(s) down in larger steps
  - Shift-Home moves object(s) left in larger steps
  - Shift-End moves object(s) right in larger steps

Modifying Line Routing

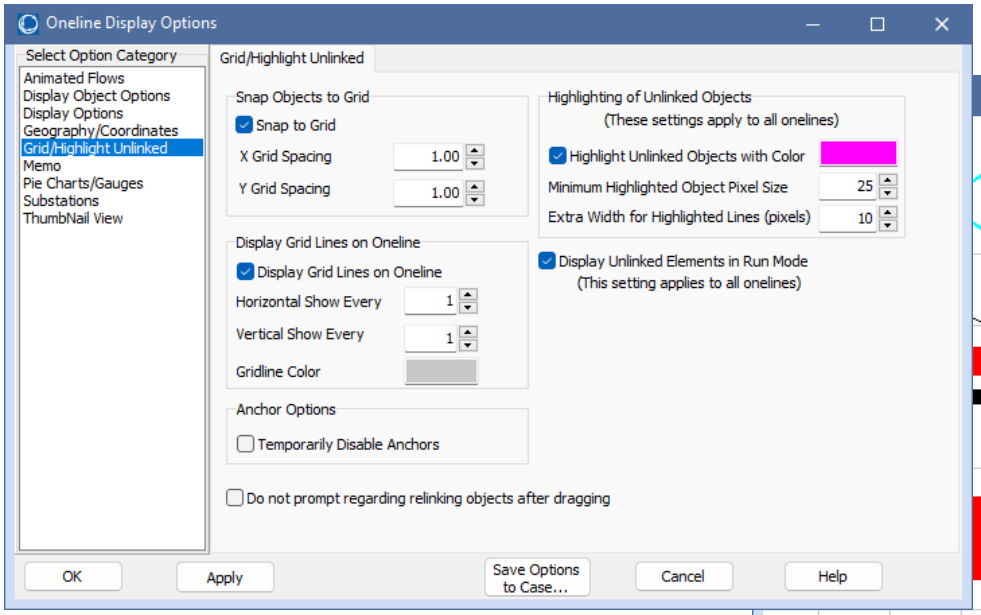
- After selecting a line, handles appear at each vertex
  - The cursor changes to a “cross-hair” symbol when moved over a handle.
  - Click and drag to move the vertex
- To add a vertex, hold down the Ctrl key and left-click at the desired insertion point
- To delete a vertex, hold down the Ctrl key and left-click on the vertex

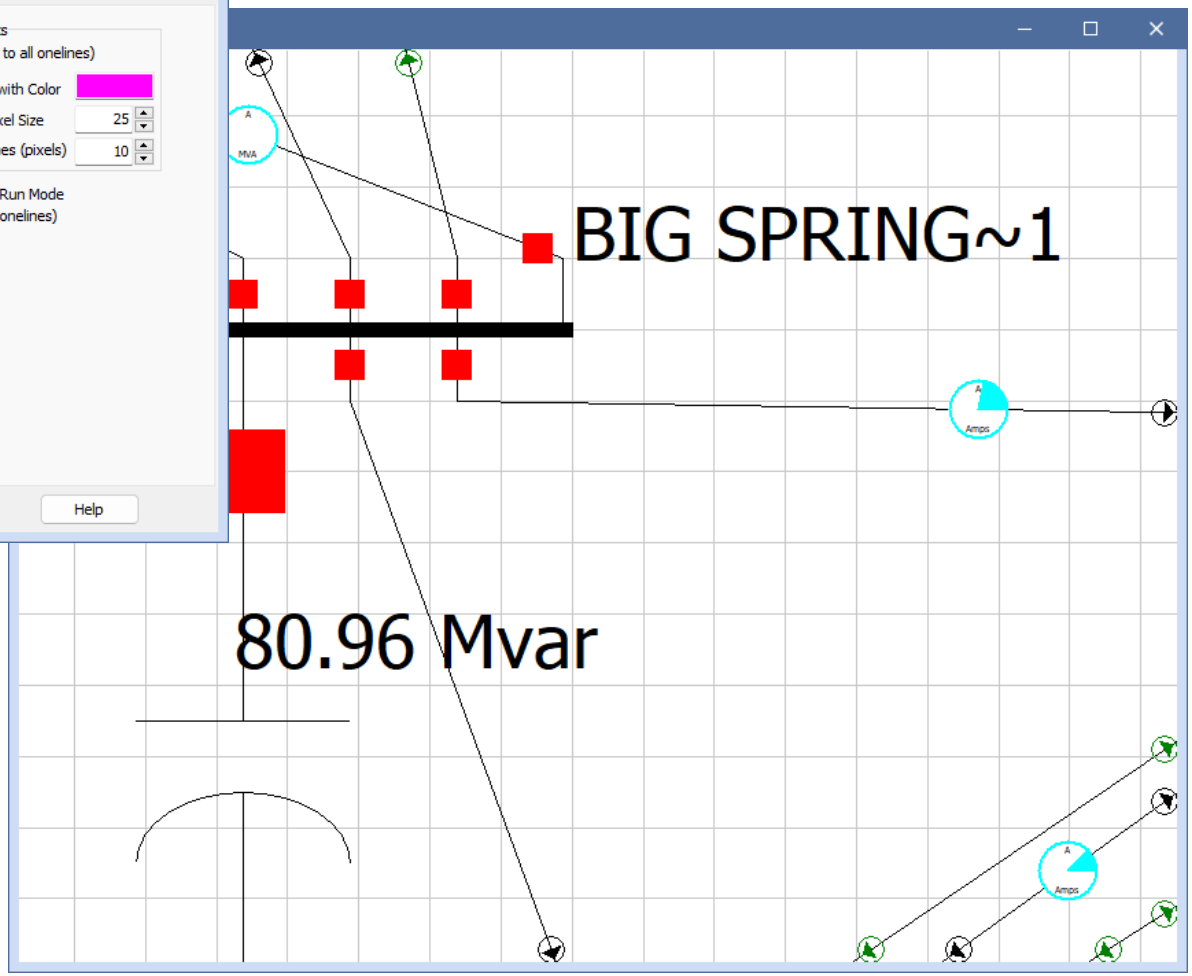


Drawing Grid

- An invisible drawing grid helps align oneline objects. By default, all objects snap to this grid.
- Hold done the ALT key while moving an object to temporarily disable “snap-to-grid”.
- To enable/disable the grid:
  - Select the **Options** ribbon tab → **Oneline Display Options**
  - See **Snap Objects to Grid** section on the **Grid/Highlight Unlinked** page.
  - Can change the spacing, display grid lines, etc.

Display Grid Lines





Adding Circuit Breakers

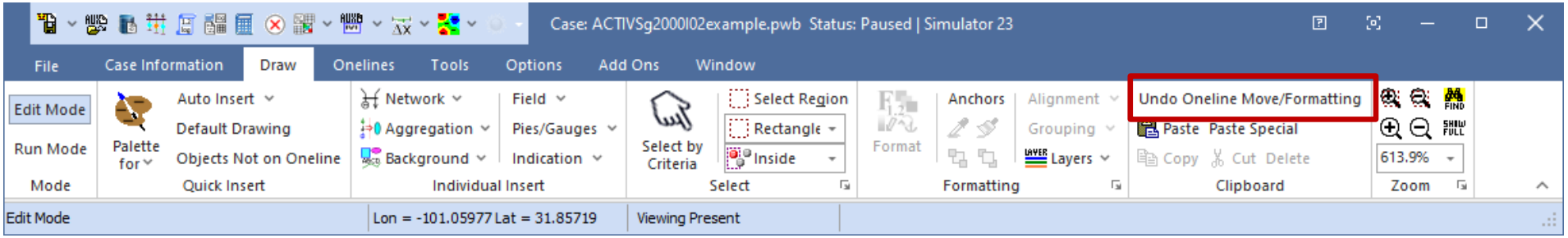
- Circuit breakers are used to indicate status of lines and transformers (not true breaker representation).
- Location of circuit breaker on the line does not matter. Typically one at each end, automatically inserted.
-  To Insert, select **Indication → Circuit Breaker**, then click on desired location on transmission line. Verify the **Near Bus** and **Far Bus** values are correct

Inserting Pie Charts

- Pie charts are usually automatically inserted.
  - An exception: Equivalent lines or other lines with no MVA limits do not have a pie chart
- For manually inserting, select the **Draw** ribbon tab, **Pies/Gauges → Line Flow Pie Chart**. Then click on the line midpoint.
- The pie charts are used to graphically indicate the percentage loading of each line.

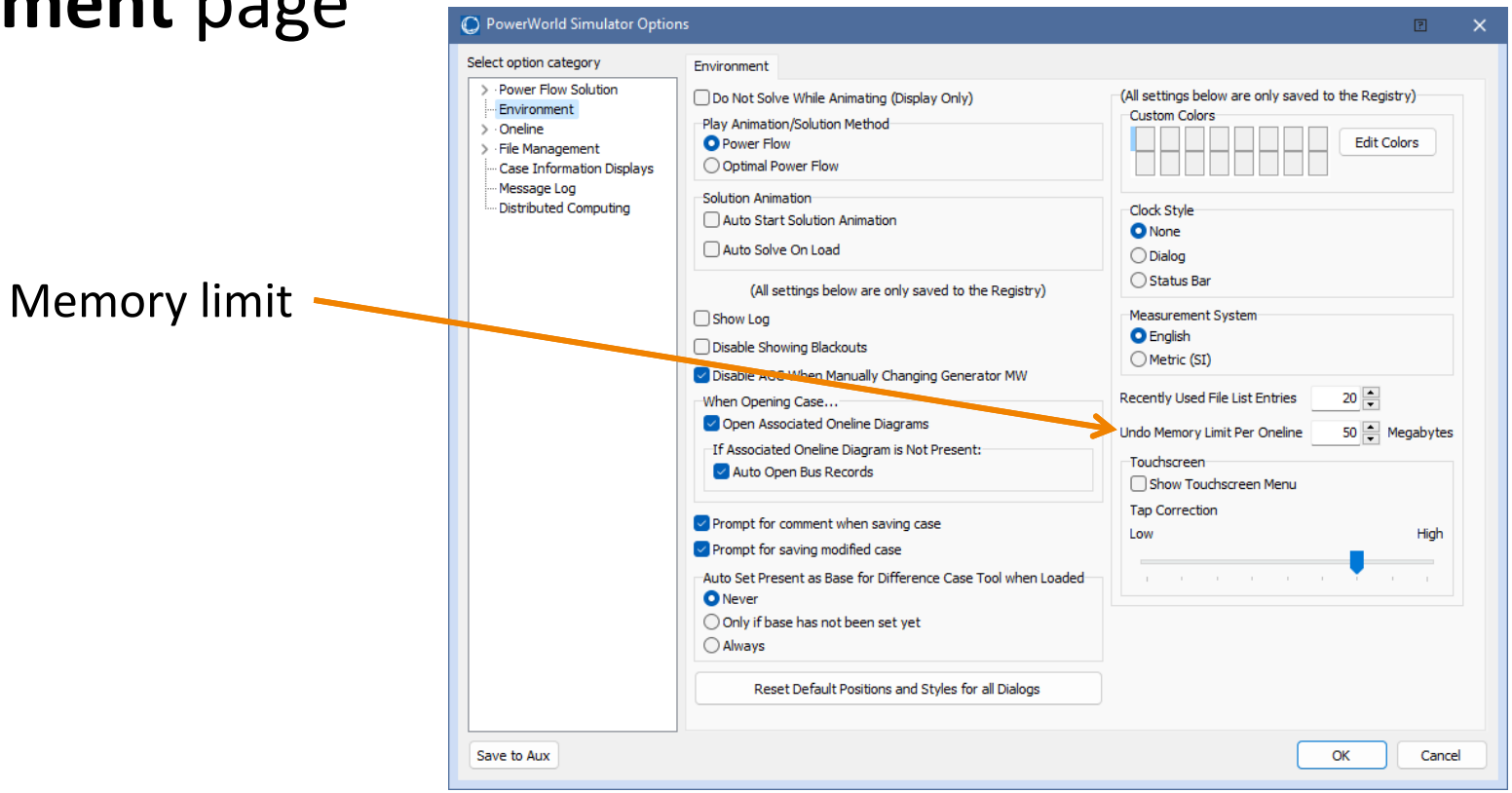
Undo Oneline Actions

- Accidental edits on oneline diagram can be undone
- Found on **Draw** ribbon tab (or use Ctrl+Z)
- Does not work with Case Information Displays
- Does not affect changes to power flow case (e.g. Deleting Object(s) and Record(s))



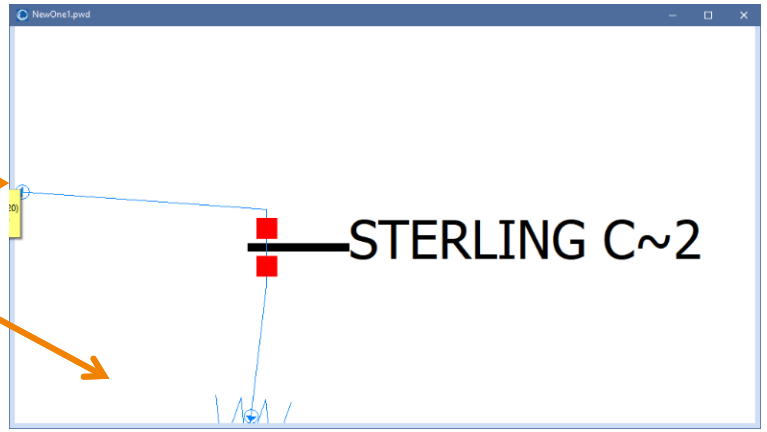
Undo Oneline Actions

- Oneline actions are stored in system memory
- Memory limit for undo action can be adjusted in the **Options** ribbon tab→ **Simulator Options** → **Environment** page



Line Navigation Arrows

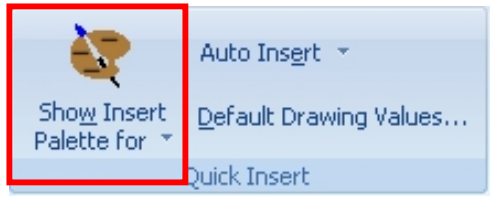
- Used with branches whose end points are not visible
- Small arrows appear where the branch exits the present window
- Clicking on arrow will pan to the other end of the branch
- Options for using navigation arrows found at **Simulator Options → Oneline → Line Navigation Arrows**



How fast to pan

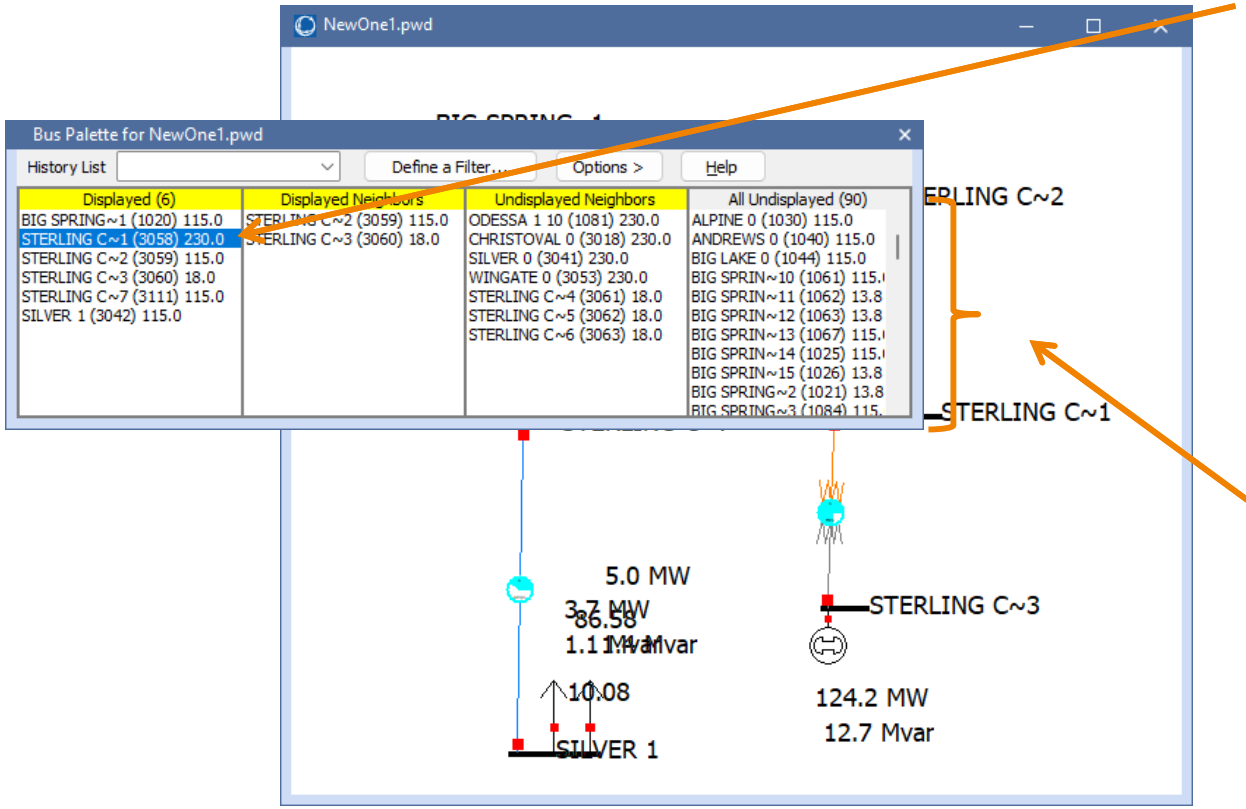
Set to 0 to disable

Show hints about other end of the line



Bus Palette

- Select **Draw → Palette For → Buses**
- select a displayed bus to see its displayed and undisplayed neighbors

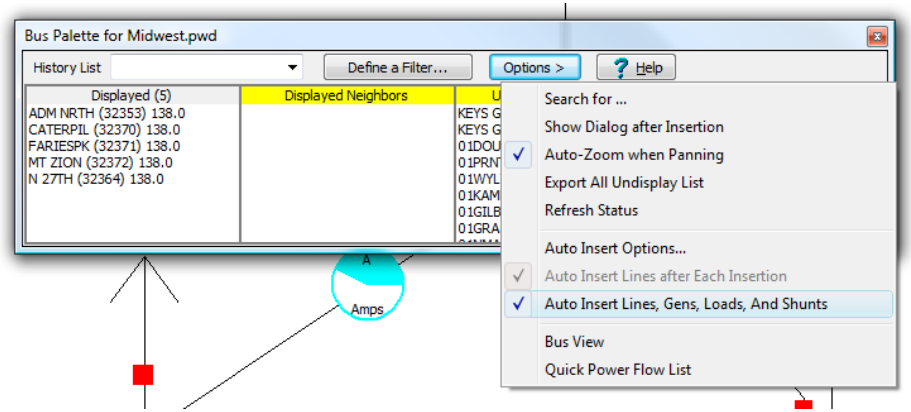


Select a displayed bus; see displayed and undisplayed neighbors

Insert undisplayed buses by dragging from the palette to the oneline

Bus Palette

- Add buses 3111 and 3042
  - select STERLING C~2 115 bus (3059), drag STERLING C~7 115 bus (3111) over bus 3059
  - select STERLING C~7 115 bus (3111) , drag SILVER 1 115 bus (3042) to oneline over bus 3111
- Lines and Loads are auto inserted by default



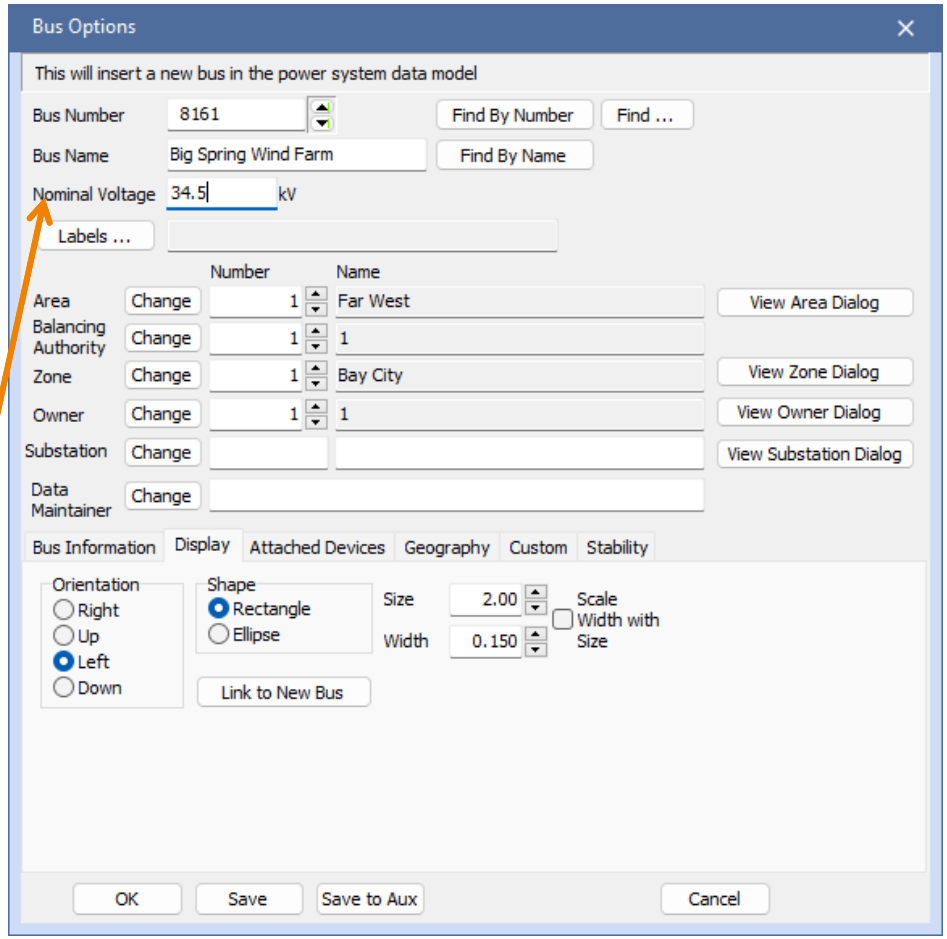
Default can be changed by clicking options

Simulator Online Help Files: Context Sensitive

- Move your cursor over one of the generator objects on the oneline diagram.
- Press **F1** key.
- This will bring up the online help for Simulator and take you to the help regarding that particular object
- Try this for loads, lines, etc…
- This will also work for
  - Object Dialogs
  - Case information displays
  - and everywhere throughout Simulator

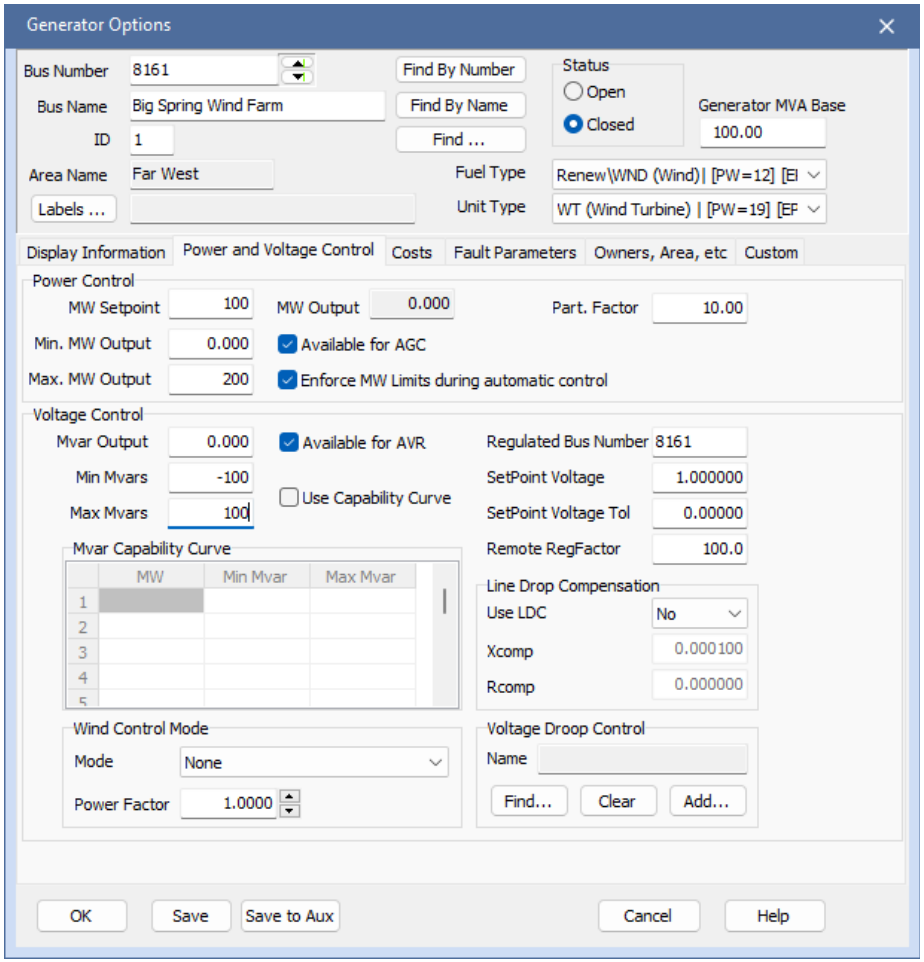
Add a New Bus

- Oneline diagrams can also be used as case editors to add or remove power system objects
- Example: add a new generator at Big Spring
  - Switch to Edit Mode
  - Choose **Draw → Network → Bus**
  - Click on the diagram near Big Spring
  - Simulator suggests a new bus number, 8161
  - Give it a name, e.g. "Big Spring Wind Farm"
  - Set Nominal Voltage to 34.5 kV



Add a Generator

- Choose **Draw → Network → Generator**
- Click on the new bus
- Enter parameters
  - MW setpoint
  - MW limits
  - Mvar limts
  - Fuel and Unit Type
- On **Display Information** tab, optionally change Orientation to “Up”

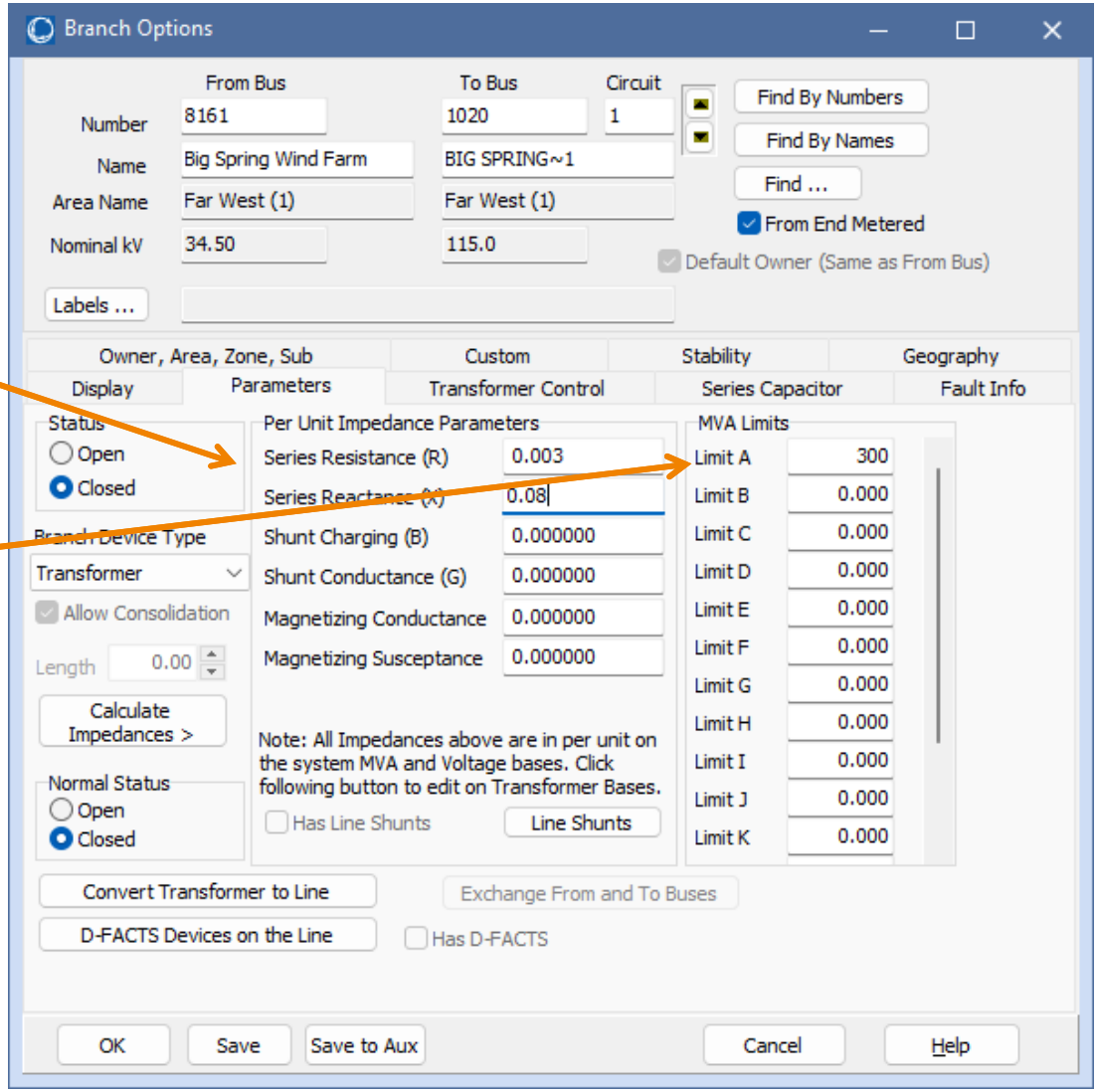


Add a Transformer

- Choose **Draw → Network → Transformer**.
- Click on the new bus. This begins process of inserting the transformer.
  - Branches are drawn as a series of line segments
  - Optionally move cursor to desired location, then left-click to enter a segment. (Sometimes useful for lines, but transformers often look better without intermediate segments)
  - Double-click on Big Spring~1 bus to terminate.
- **Note**: Clicking and dragging mouse when drawing transmission lines is usually NOT recommended. This will produce a curved line with many segments.

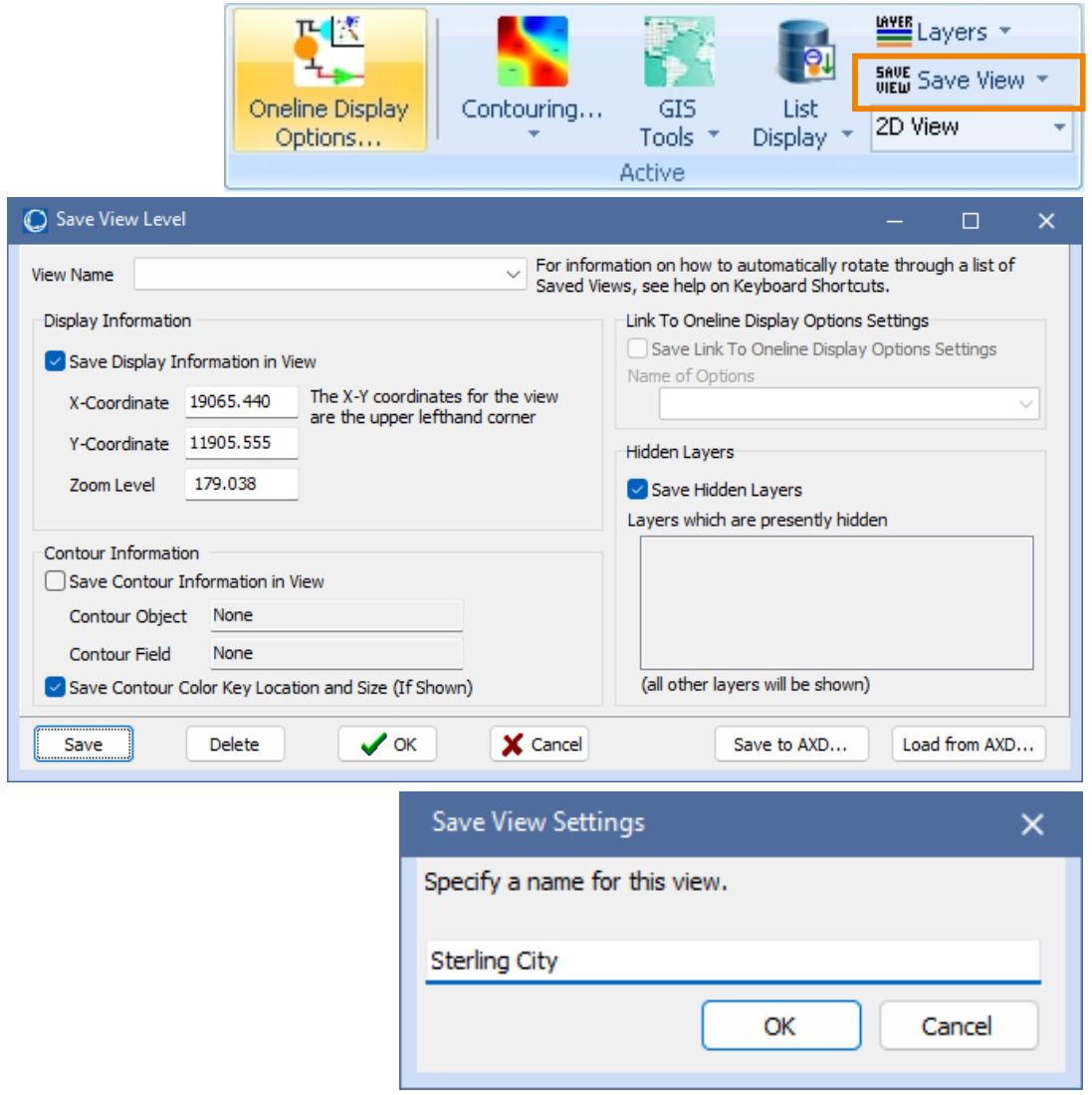
Add a Transformer

- Enter parameters
  - X = 0.08
  - R = 0.003
  - Limit A = 300



Saving Views

- Save favorite settings of oneline location, zoom levels, and other parameters
  - right-click, save/edit/delete view, or toolbar button
  - identified by a specified name
  - accept current settings, or specify your own
- Example: Save Current View as “Sterling City”



Showing Entire One-line

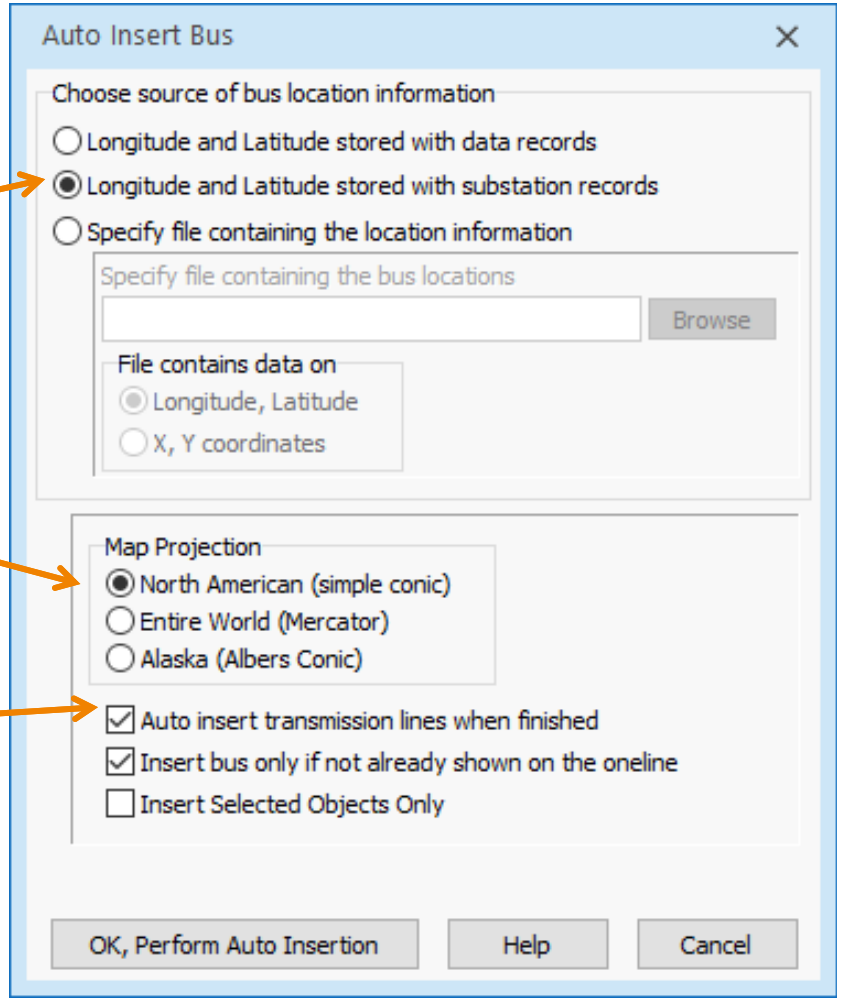
- To view the entire oneline, click the **Show Full** button on toolbar.
- Zooming level and screen center is immediately changed so all objects on the oneline are visible.
- Can return to “Sterling City” View from **Onelines → Save View → Sterling City**

Auto-Inserting Buses

- Buses and substations may also be auto-inserted if geographic coordinates are available
- PowerWorld Simulator's pwb format has long supported geographic coordinates for buses, substations, and other basic network elements
- EPC file format has recently added geographic support – most WECC cases have at least partial geographic coverage

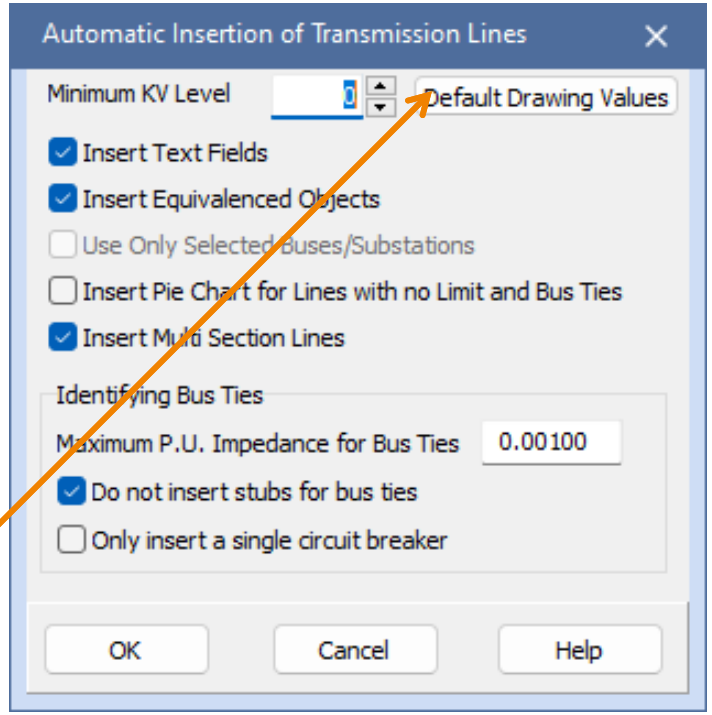
Auto-Inserting Buses

- Choose **Draw → Auto Insert → Buses…**
- Select "Longitude and Latitude stored with substation records"
- Make sure you use the same map projection the rest of the diagram uses
- Select "Auto insert transmission lines when finished"
- Choose **OK, Perform Auto Insertion**



Automatic Insertion of Transmission Lines

- From here, if we wish, we can edit the **Default Drawing Values** (also available from the **Draw** and **Options** Ribbons)
- Click the button to open **Default Drawing Values**

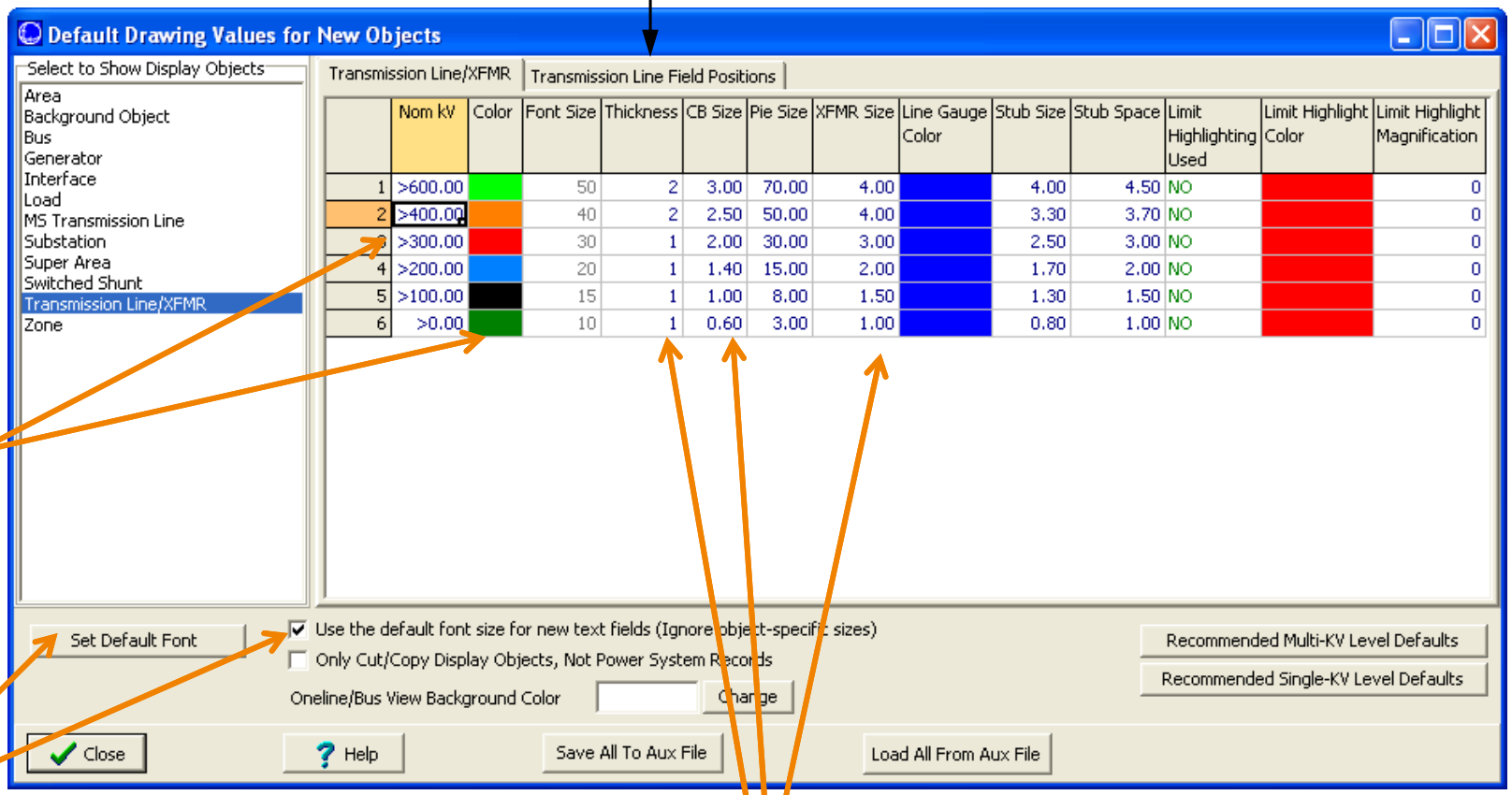


Drawing Defaults: Formatting FUTURE Oneline Display Objects

- Changes made here affect only FUTURE oneline display object insertions, not EXISTING objects.
- Click the **Field Positions** tab choose how fields are automatically inserted around an object.
- Position columns appear in grid. Double-click a position field to choose the type of field to display, or use the **Field Positions** diagram to set displayed fields.

Color Coding and Drawing Values

Field Positions tab sets text fields automatically inserted (next slide)



kV Range and Color

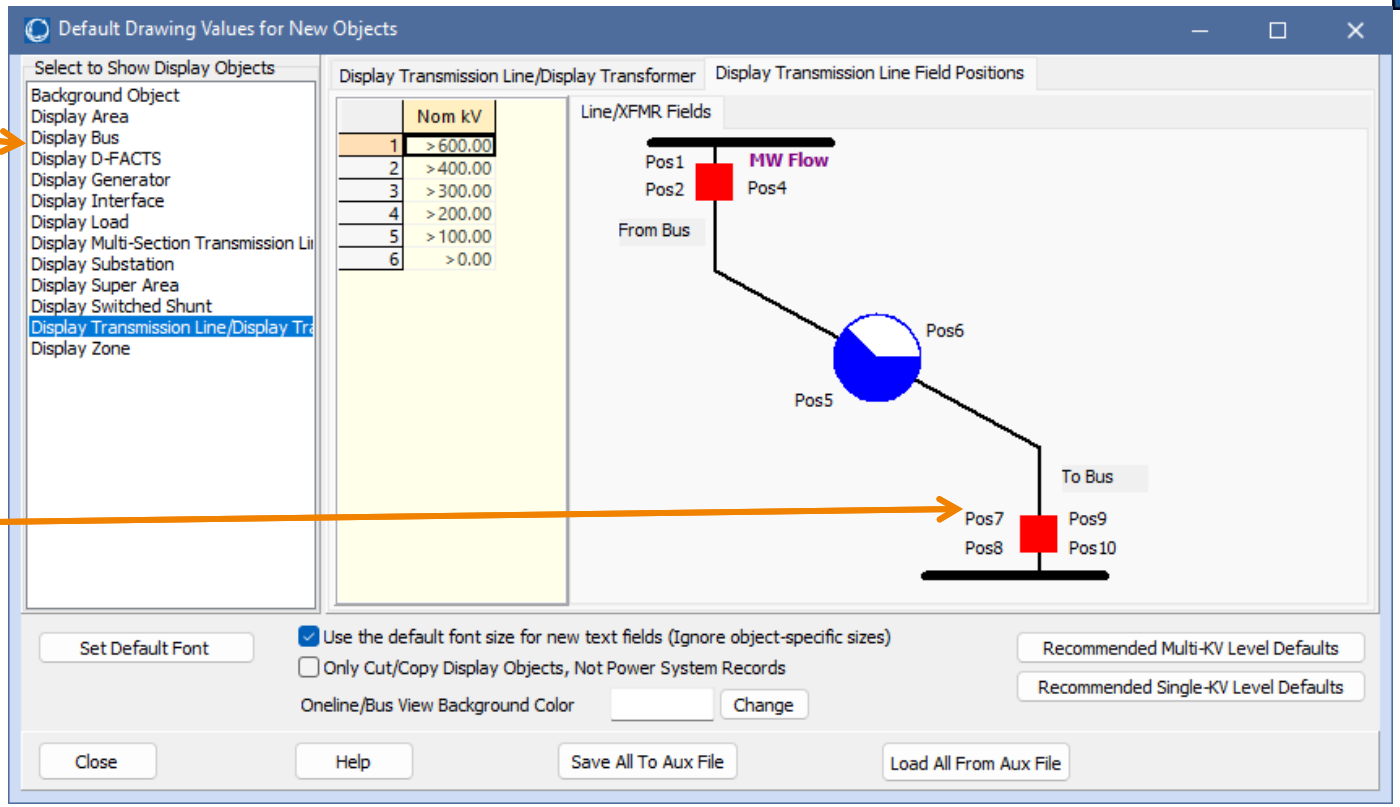
Set a default font size for all new text fields

Object default drawing values for kV range

Auto Field Insertion
Click the Field Positions Tab

Object Type of fields being modified

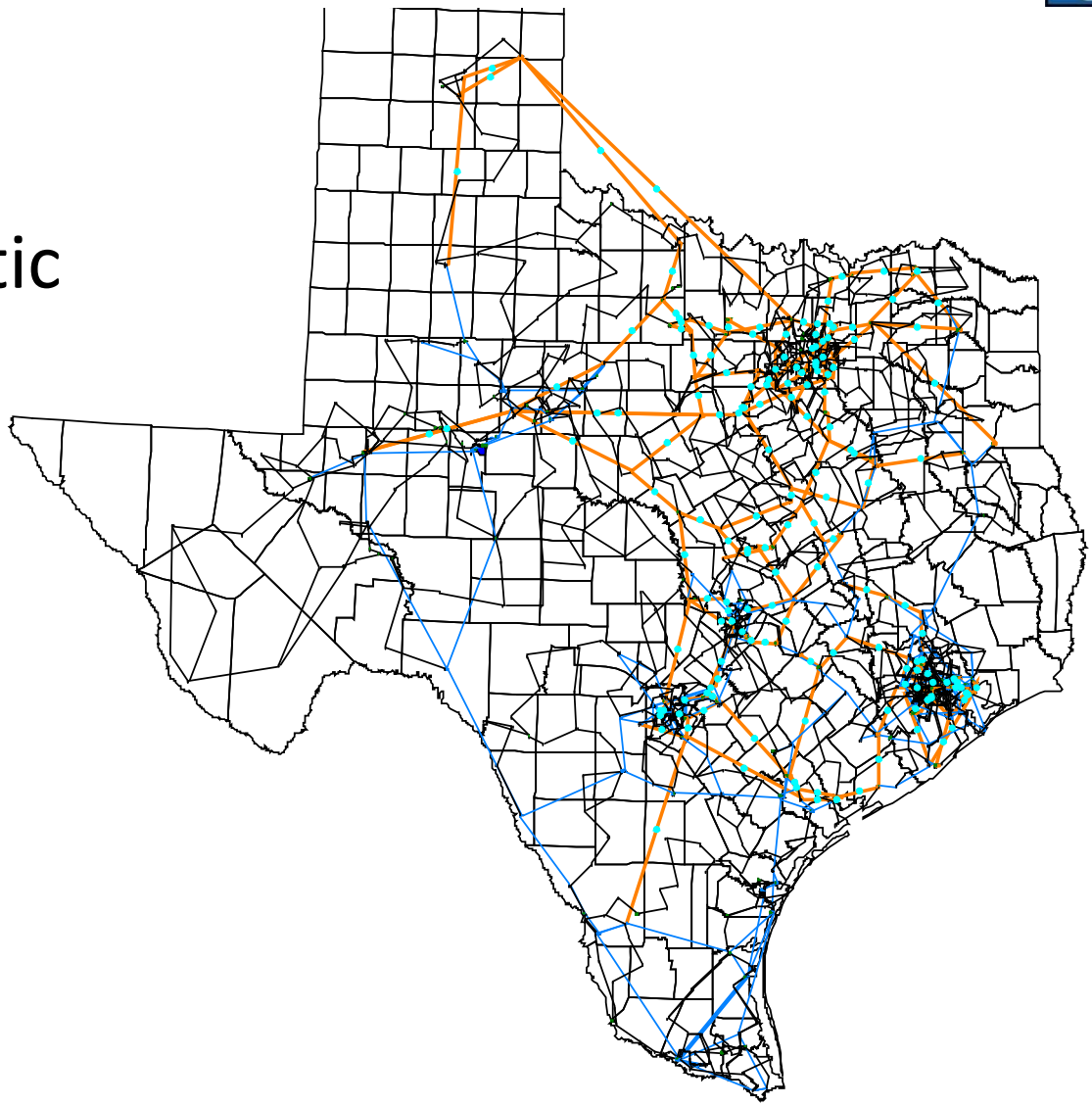
Click on Positions to Add, Change, or Remove Field Type Displayed



- For example, to clear all fields from Display Transmission Line/Display Transformer
  - Click on a field, then choose **Remove Field** on dialog
  - On confirmation for showing field for all voltage levels, choose **Yes**

Full Oneline with Auto-Insertion

- Close the **Default Drawing Values** and complete the Automatic Insertion of Transmission Lines

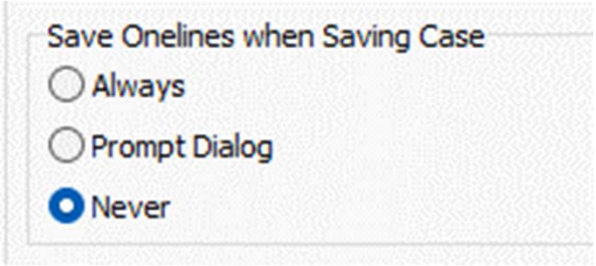


Saving Cases and Onelines

- Cases are normally saved in PowerWorld Binary (pwb) format
- Onelines are saved in separate files (pwd), which enables them to be used across cases
- A single case may also have multiple associated onelines (e.g. one with buses, lines, and transformers, another with substations and lines only, and another with areas and interfaces)

Saving Cases and Onelines

- Save the case with **File → Save Case As…**
  - Use the pwb format
  - Give it a unique name, such as *ACTIVSg2000BigSpringWind.pwb*
- Simulator will ask if you want to change the name of the oneline. Choose **Yes**.
- The oneline may or may not save when the case is saved.
  - Check the log to see if it saved.
  - This is a user option in **Simulator Options → Oneline → File**.



- To save the oneline explicitly, choose **File → Save Oneline**

Finding Buses on Onelines

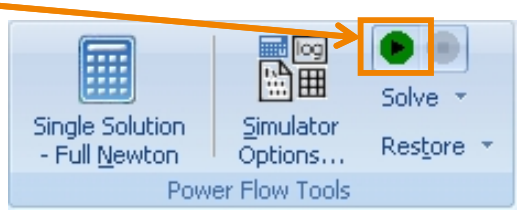
- On large onelines, sometimes it is time consuming to find a particular bus. Rather, you can use the **Find Object on Oneline** option from the local-menu.
- This displays the Zoom, Pan and Find Objects dialog.

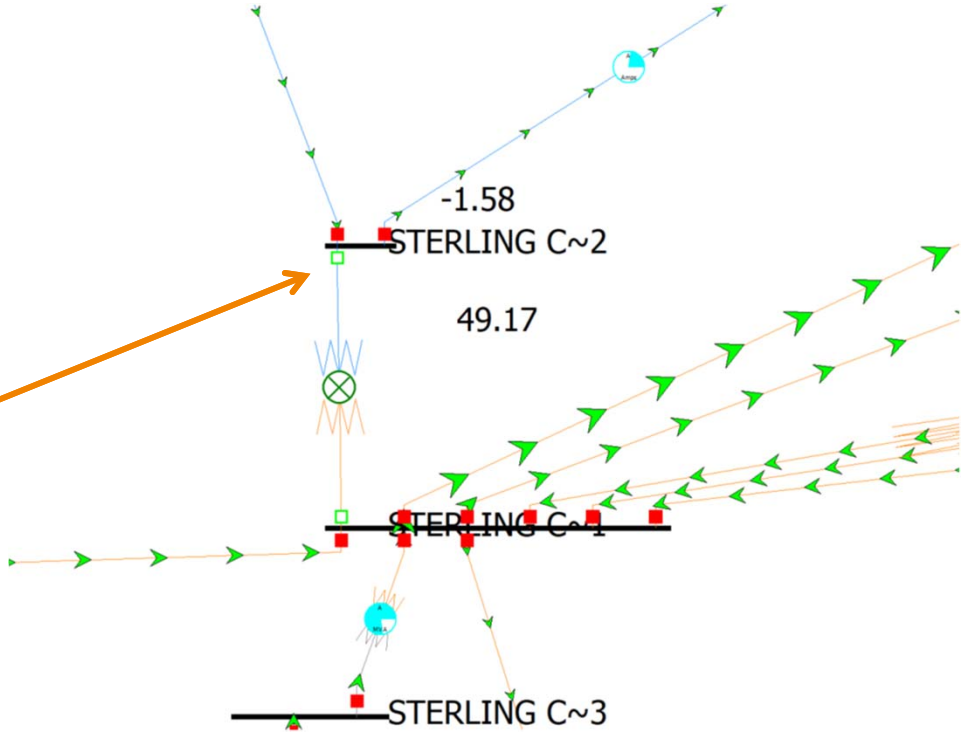
Finding Buses on Onelines

- To find a particular bus
  - set **Object Type** to *Buses*
  - use advanced search engine to locate the desired bus by number or name
  - select **Pan to Object on Oneline** to center the oneline on the specified bus
- Find does not change the current zoom level, unless **Auto-Zoom when Panning** is checked.

Simulating the Case (Play Mode)

- Go to Run Mode and select **Tools → Play**.
- Can interact with the oneline such as opening a circuit breaker; note how flows redistribute
- For example, return to Sterling City view and open transformer between Sterling C~1 and Sterling C~2





Run-time Object Dialogs

- Pause the Simulation (next to the Play button)

- To view/modify parameters for any oneline object, right-click on the object and show its information dialog (specific text varies by object type).
- Many of these parameters can be modified, with the results taken into account when the simulation is resumed.

Formatting EXISTING Oneline Display Objects

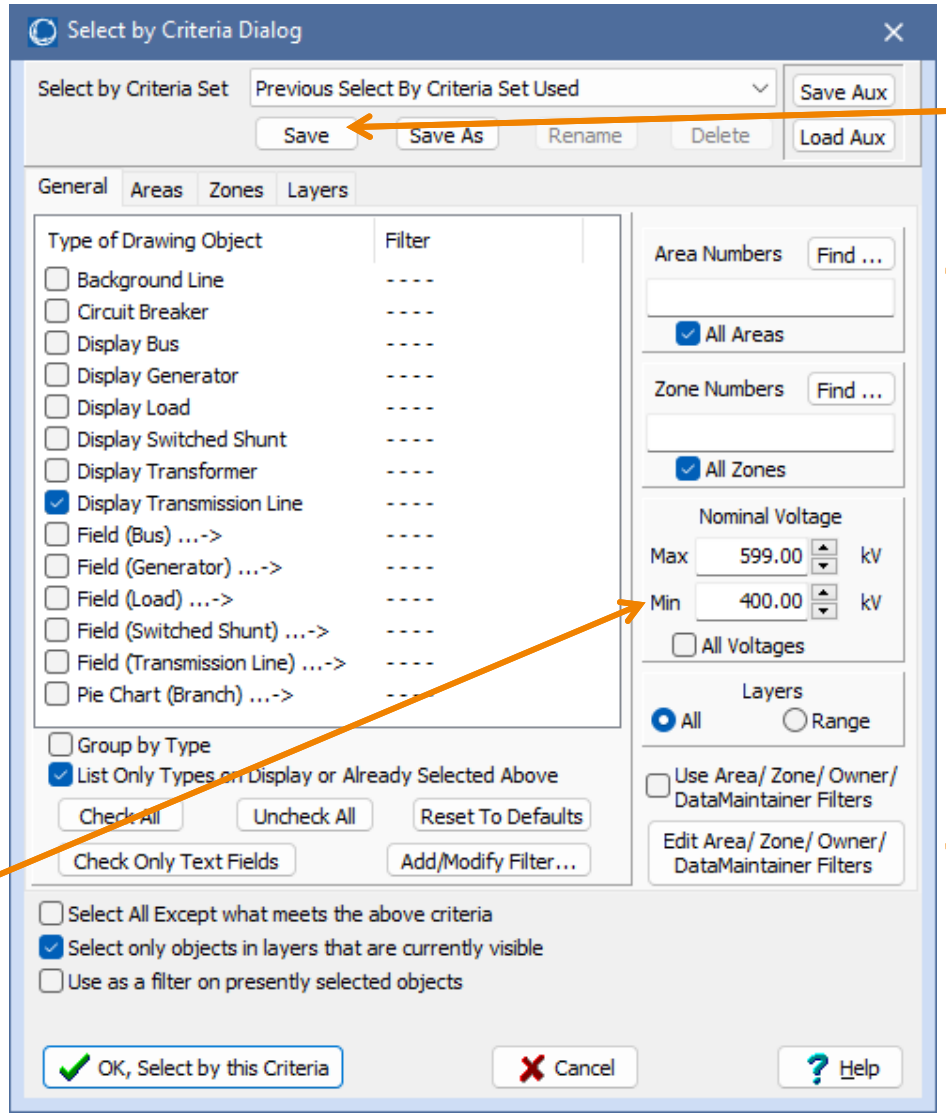
- **Default Drawing Values** allow you to change the default appearance of FUTURE display objects
- To move, remove, or change formatting of EXISTING display objects, make use of the following to features:
  - Selecting Multiple Objects
  - Formatting of Selected Objects

Selecting Multiple Objects

- Multiple oneline objects can be selected by different mechanisms:
  - Individually by left-clicking on objects while holding down Shift key
  - 
    Using the **Select** buttons to select all objects in a region, available in the **Select** ribbon group under the **Draw** ribbon tab.
    - Hold Shift-Ctrl and drag with the left mouse button to select area that encompasses desired objects
    - Hold Shift-Ctrl and drag with the right mouse button to select area that encompasses desired objects and to retain currently selected objects
  - 
    Using **Select by Criteria,** available in the **Select** ribbon group under the **Draw** ribbon tab
- Suppose we wish to change the color of all 500 kV lines.

Select by Criteria Dialog

- On the **Draw** Ribbon, choose **Select by Criteria**
- Select “Display Transmission Line”
- Select a Voltage Range between 400 and 599

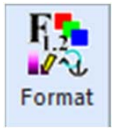


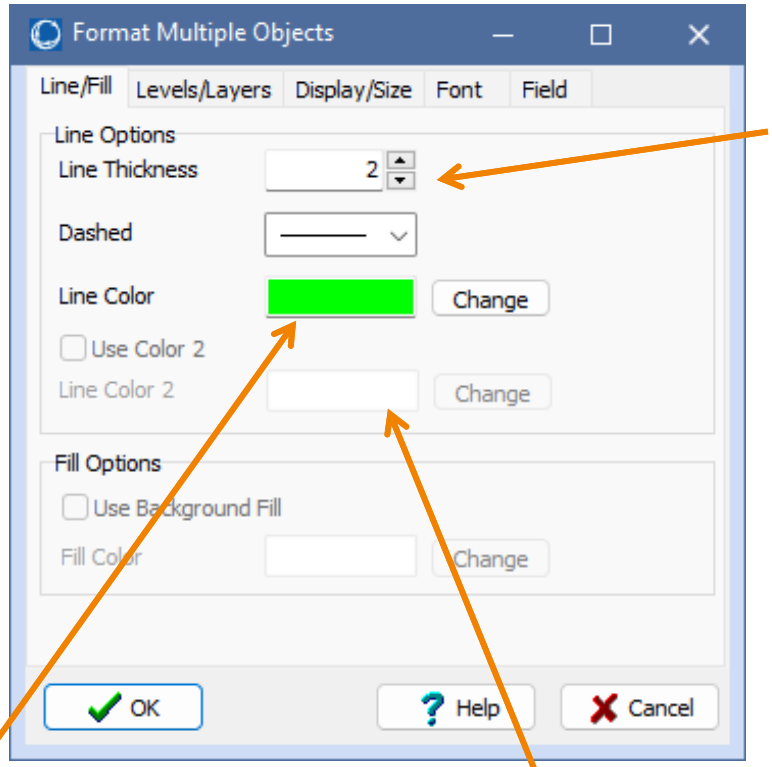
Criteria sets may be saved for easy re-use.

Objects can either be selected for entire case, or by specific areas/zones/ layers and by voltage level

Changing the Format: Line/Fill

- Right-click on any line that is already selected to bring up the local menu and choose **Format Selection…**
- Could also use the **Format** option from the **Draw** Ribbon
- On the Line/Fill tab, change Line Color





Line Information

Color 2, used with transformers (i.e. for different voltage levels)

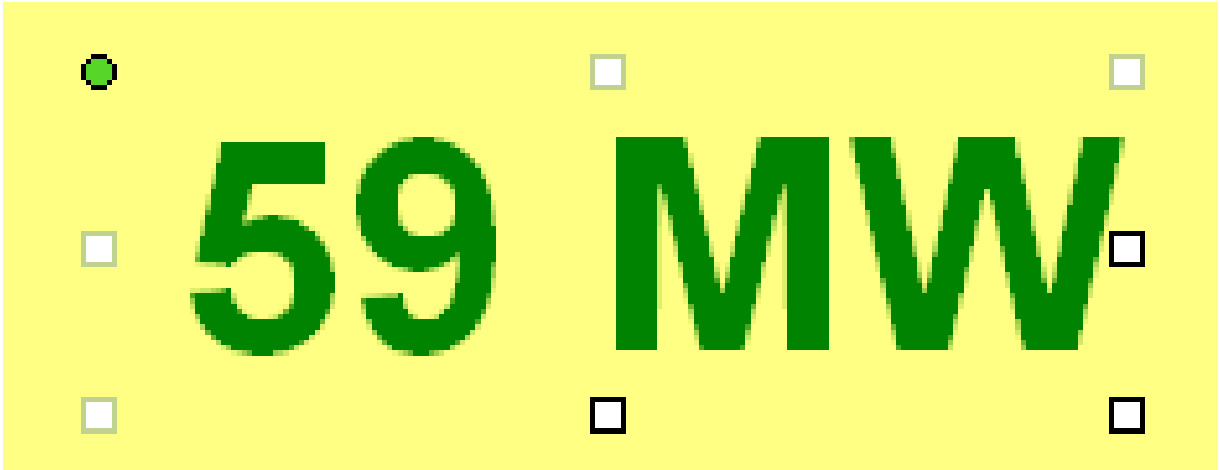
Oneline Diagram Enhancements: Resize/Rotate Objects

- Ability to resize and rotate oneline objects easily with your mouse.

Green Circle:
Rotation Point

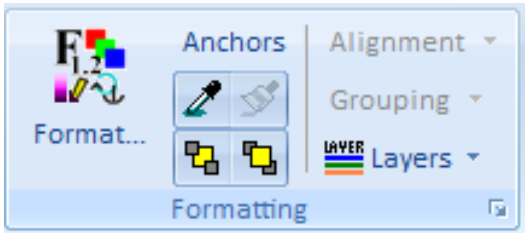
Gray Square:
For looks only

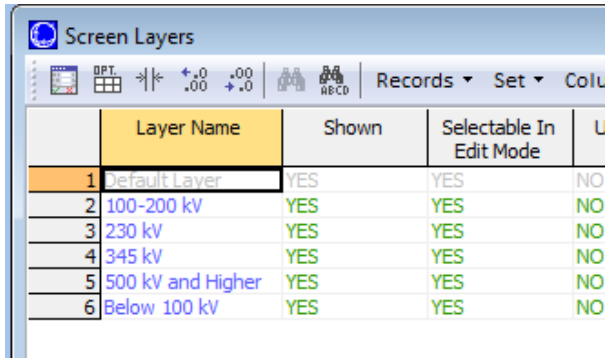
Black Square:
Resize Handle

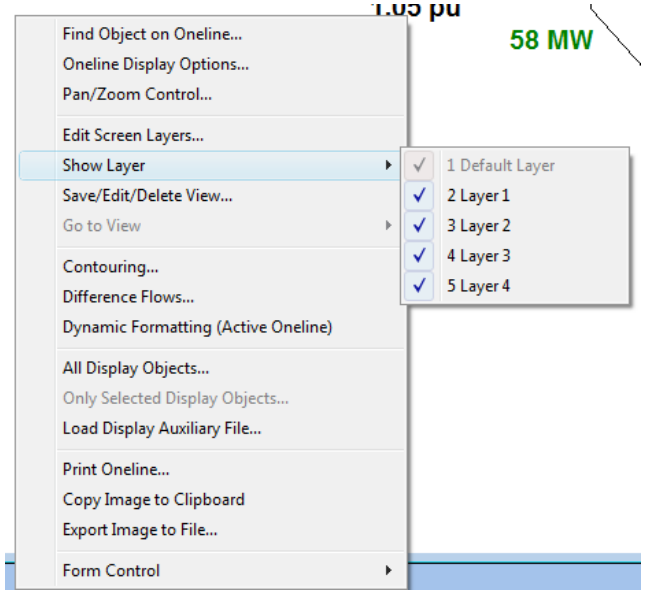


Screen Layers

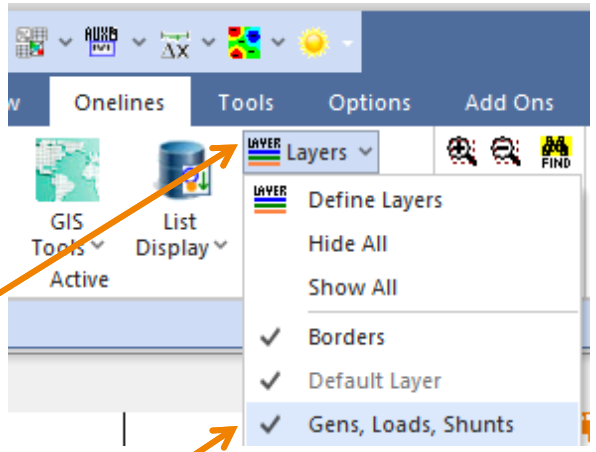
- Add oneline objects to layers for customized views. Select the **Onelines** ribbon tab → **Layers** → **Define Layers** to create or modify screen layers
- Assign objects to layers using the **Levels/Layers** button on the Formatting ribbon group on the **Draw** ribbon tab







Screen Layers



- Borders are normally added to a Screen Layer called "Borders" (option for this during auto-insertion)
- View the existing Layers from the dropdown
- Check or de-check Layer Name to show or hide the layer
- Example: move all Generator, Load, and Shunt Objects to a new Layer (tip: use Select by Criteria)

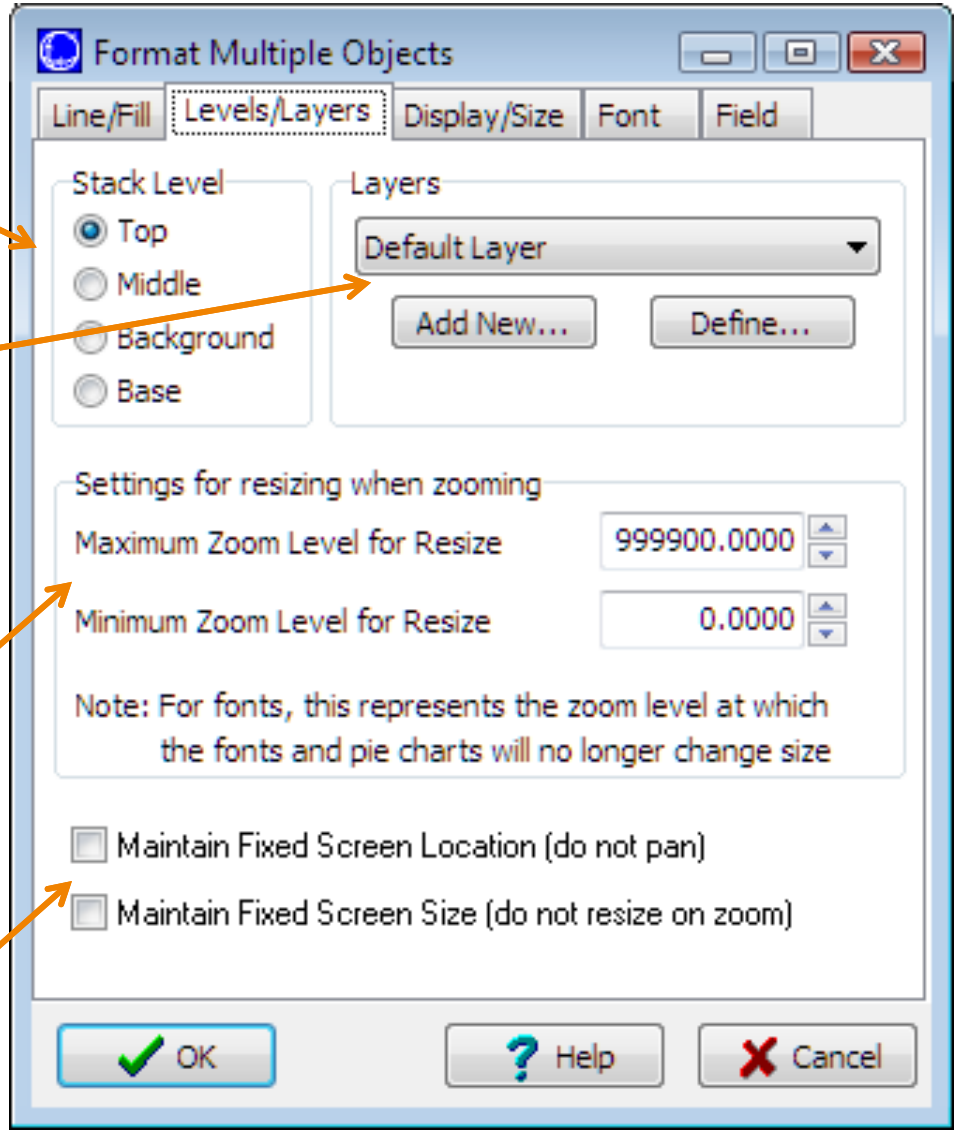
Format Selected Object: Level/Layers

Change Stack Level

Screen Layers

Fonts and Pie Charts can be set so that they only resize between particular zoom levels

Set these values to force a display object to not move or resize



Object Oneline Display Levels

- Objects are shown on oneline using four different stack levels, base, background, middle and top.
- By default, different types of objects can have different levels. For example, transmission lines are level middle, while circuit breakers are level top.

Stack level can be changed by first selecting an object, then using the **Levels/Layers** button on the **Formatting** ribbon group under the **Draw** ribbon tab.

Bring To Front / Send To Back

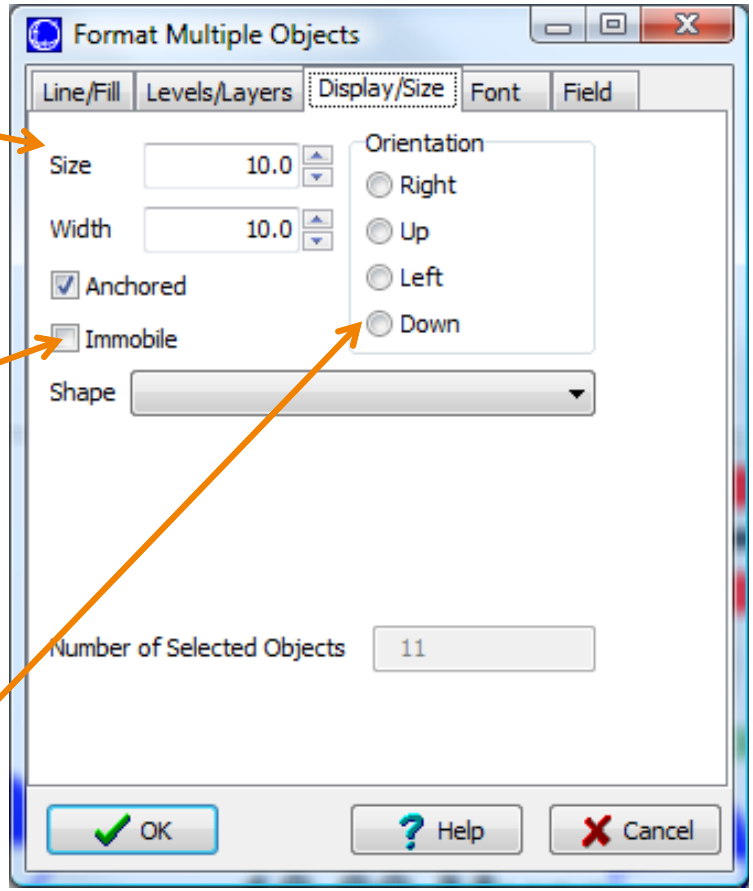
- What is shown on top is first governed by the stack level
- Objects within the same stack level can be moved relative to one another. Go to the **Draw** ribbon tab and choose the **Bring to Front** or **Send to Back** buttons from the **Formatting** ribbon group.

Format Selected Object: Display/Size

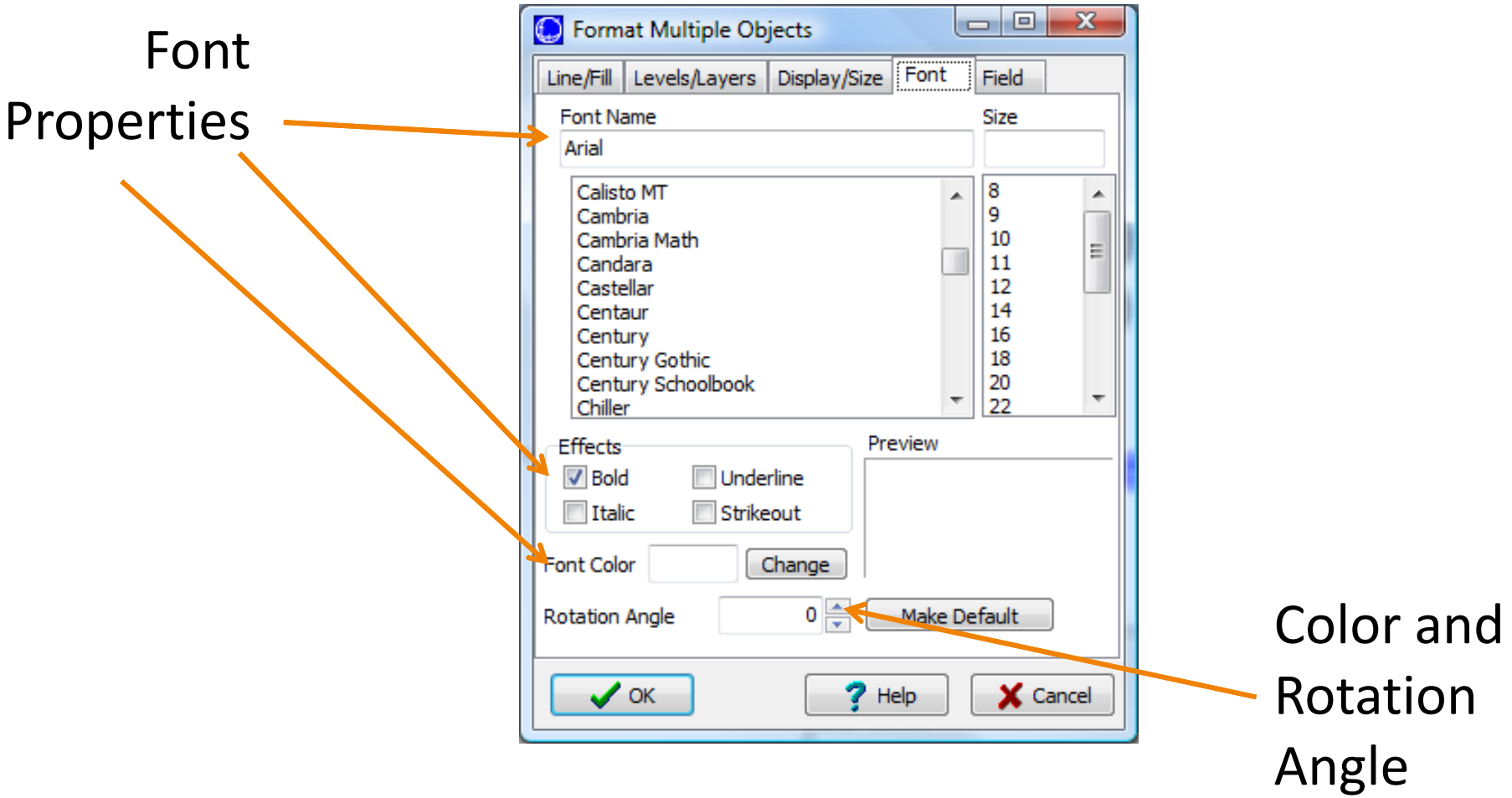
Size of an object can be changed

Setting an object as immobile will prevent you from moving the object by dragging it with the mouse.

Objects such as generators have an orientation which may be changed



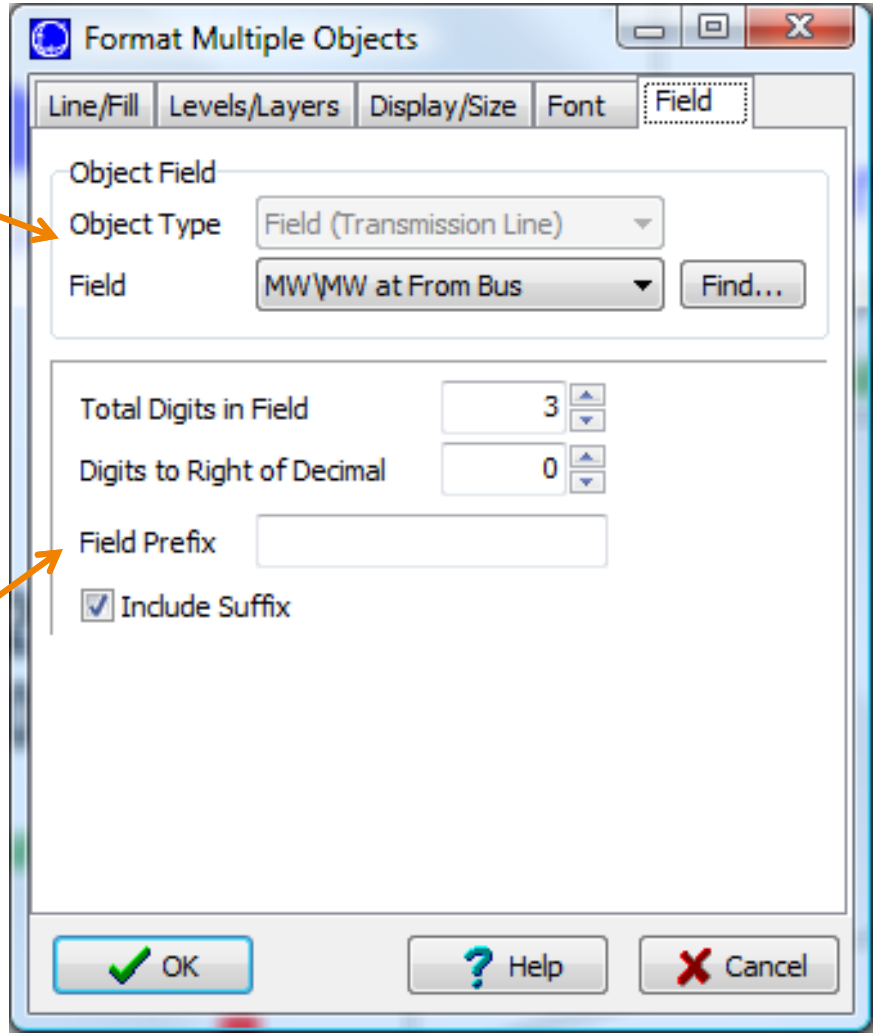
Format Selected Object: Font



Format Selected Object: Field

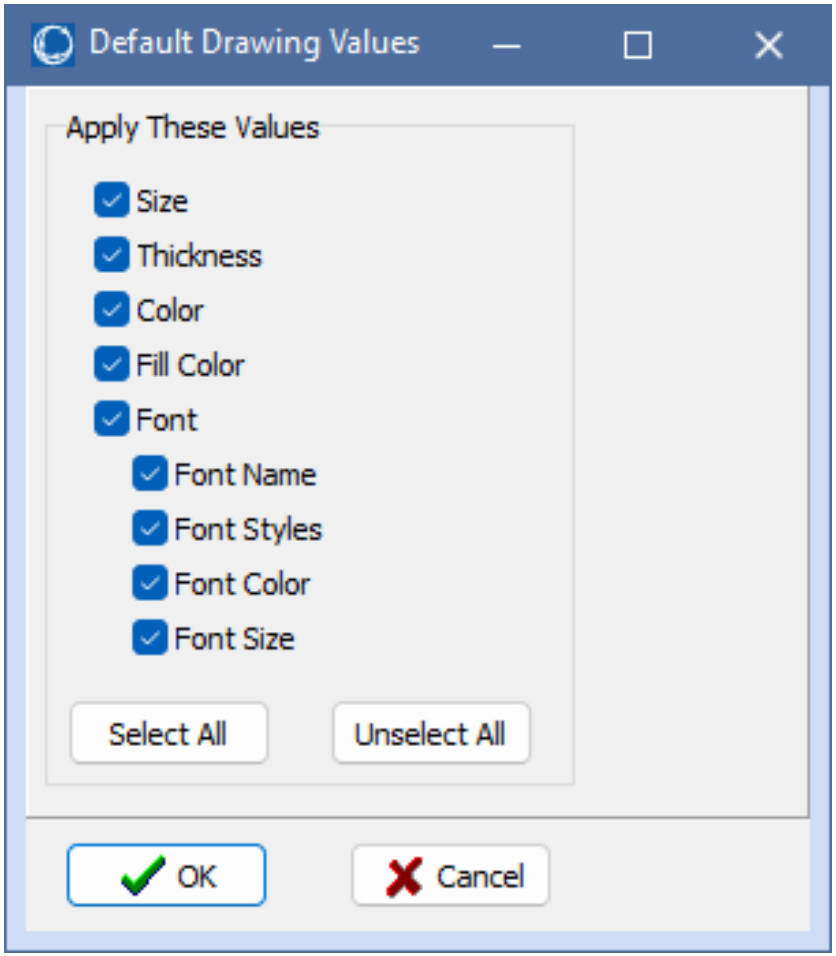
Field Information

Change how the field looks: digits, decimal and suffix



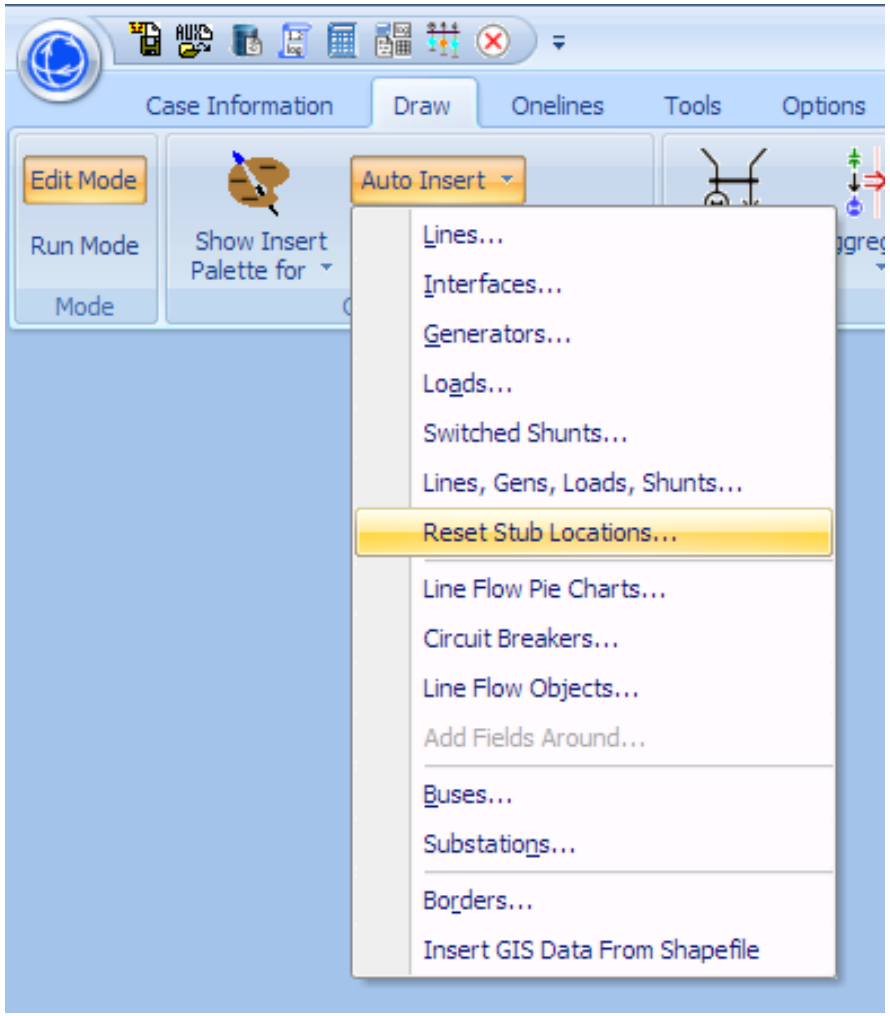
Changing to Match Default Draw Values

- If you change the Default Drawing Values, and then wish to apply them to EXISTING objects
  - Select one or more objects
  - Right-click on a selected object to bring up the local menu and choose **Apply Default Draw Values…**
  - Select All and choose OK



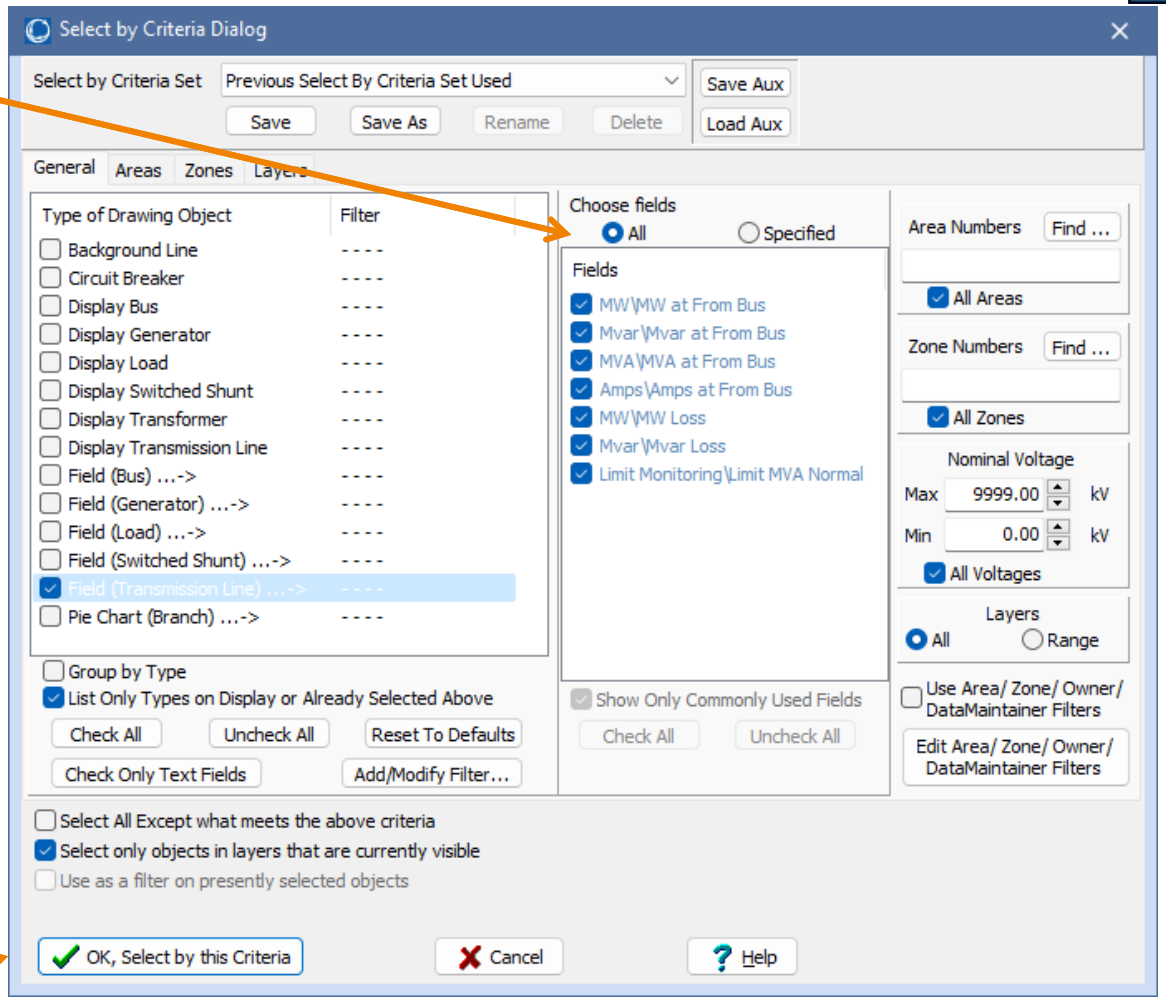
Reset Stub Locations

- After lines have already been inserted, stub locations can be redone
  - Reopen **Default Drawing Values**
  - Change the Stub Size and Stub Spacing for Display Transmission Line… for appropriate Nom kV level(s)
  - Choose **Auto Insert > Reset Stub Locations…** and **OK**



Select by Criteria: Choosing specific fields

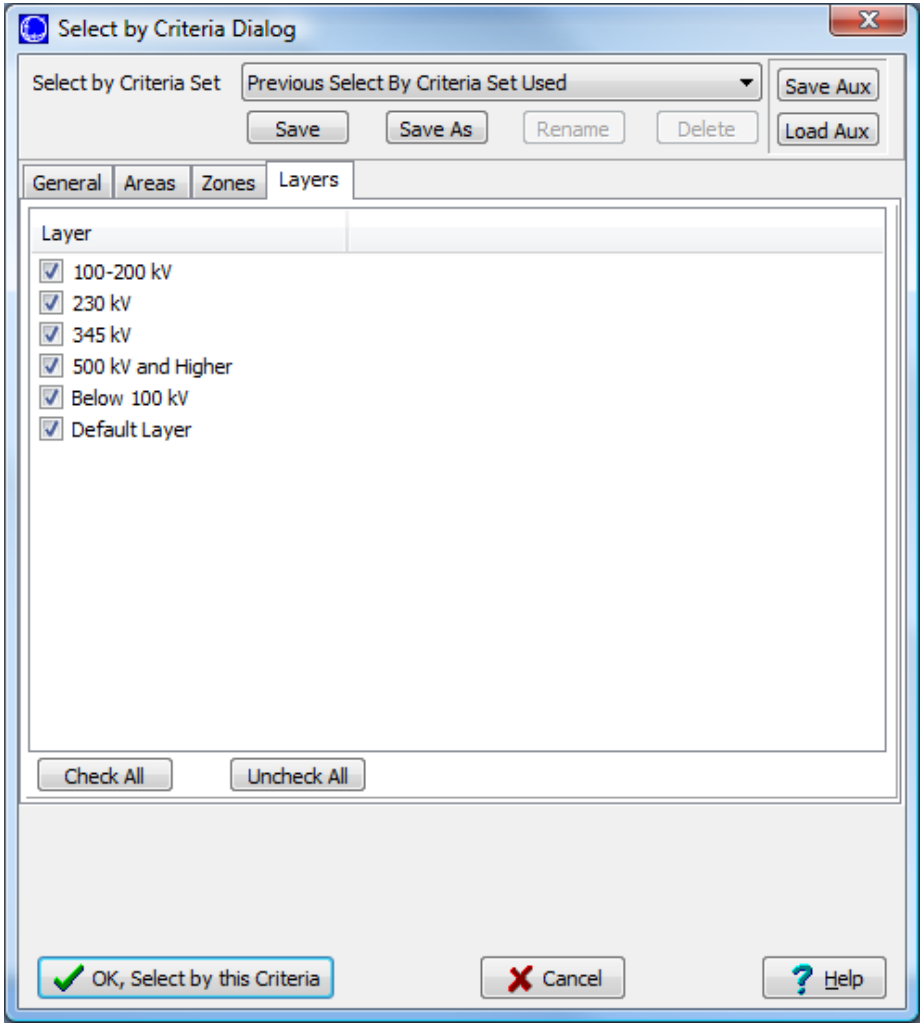
- Selecting an object type with an arrow opens a pane with specific options.
- Example: Transmission Line Fields.



Click OK to select all objects meeting the criteria.

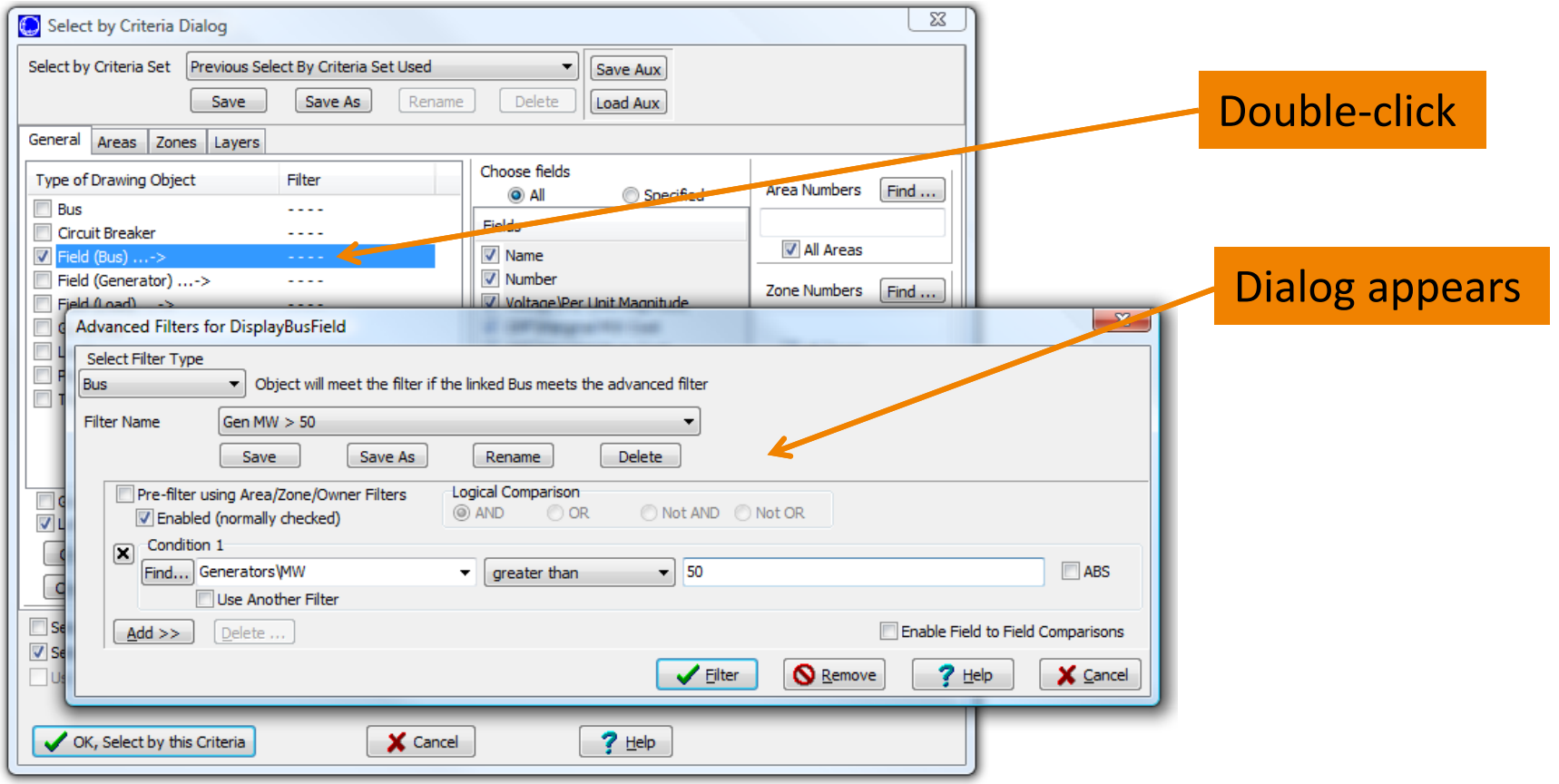
Choose specific Areas, Zones, or Screen Layers

- Choose the Tabs and check what you want



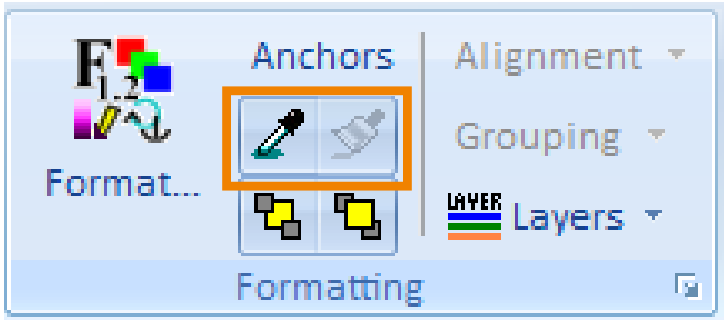
Use Advanced Filtering in Conjunction with Select By Criteria

- Click on the type of object you're interested in and click Add/Modify Filter… (or just double-click on the Filter column)



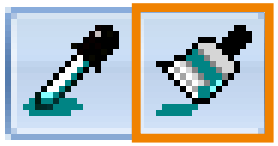
Applying the format of one object to another: Copy Format

- Select a group of oneline objects and then click the button Copy Format 
  - This will copy all the attributes that are the same across the selected objects
    - For example: If all objects have a fill color (suppose they are RED), then it will copy this. But if some objects are RED while others are BLUE, it will not copy this attribute.

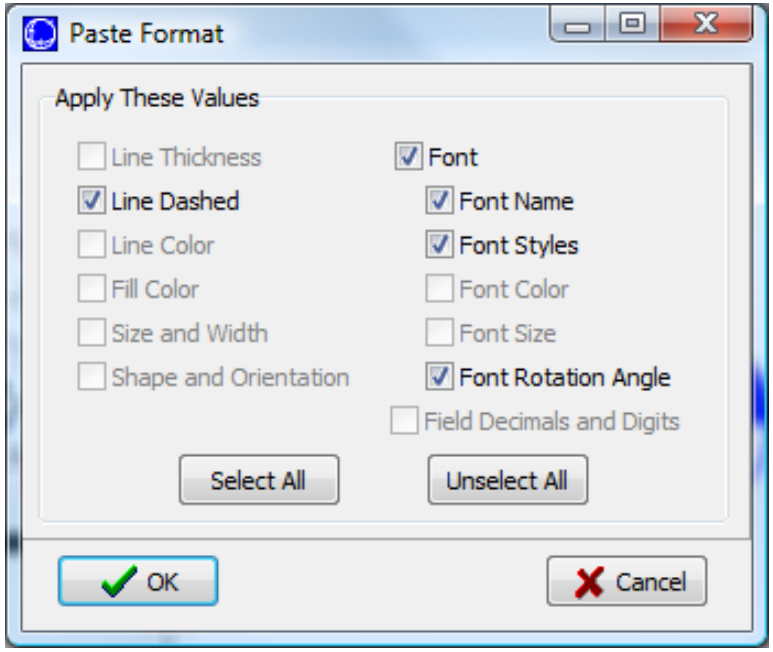


Paste Format

- After you have chosen to Copy Format, then the Paste Format button will be enabled.

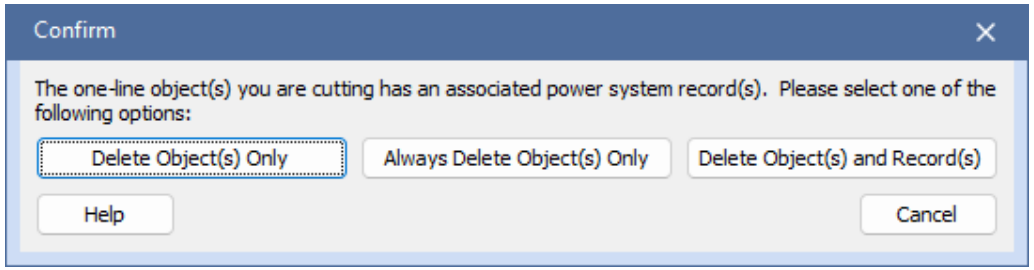


- Now select another group of objects to apply the copied formatting to and click the Paste Format button
  - Only attributes that were the same across the copied selection will be enabled.
  - Check the attributes you would like to paste and click OK



Deleting Objects

- If you press the Delete key (or choose **Delete** from the **Draw** Ribbon) with one or more oneline objects selected, Simulator gives the options:
  - **Delete Object(s) Only**: remove the oneline object, but do not change the system model
  - **Always Delete Object(s) Only**: also sets an option so the confirmation dialog will no longer display (can reverse this in **Default Drawing Values**)
  - **Delete Object(s) and Record(s)**: also removes the object from the power system model
- Example
  - delete the Big Spring shunt, object only
  - It is removed from the oneline, but still present in Case Information Display and Bus View Oneline



Bus Fields

- Fields can be entered automatically (**Default Drawing Values**) or manually by
  - choosing **Field** and then a specific type from the **Draw** ribbon tab.
  - Making a selection on the diagram, then right-clicking for the local menu, then **Add New Fields Around Selection…**
- Bus fields show information about bus devices, including loads and generators.

  - Can choose type of field, digits to right and left of decimal, and whether or not it is anchored.
  - Example: Add “Bus Voltage (p.u.)” at Big Spring

Line Fields

Line fields show information about transmission lines and transformers.

- For line fields, flow is always specified at an end of the transmission line or transformer.
- End is normally determined automatically by insertion point.
- Fields are available for many other types of power system objects (generators, loads, DC lines, and many more)

Oneline Local Menu

- Right-clicking on an empty portion of the oneline displays its local menu. The local menu is used to
  - Print the oneline
  - Save entire screen to file as a bitmap
  - Copy/save oneline in Windows metafile format, which is more versatile than a bitmap
  - Open Display Explorer

Oneline Local Menu

- Find objects on the oneline
- Pan/Zoom Control
- Show Oneline Display Options; this display is used to customize the appearance of the oneline
- Edit screen layers and show layers
- Perform contouring (covered in a later section)

Oneline Local Menu

- View difference flows (covered in a later section)
- Toggle flow visualization; switch between displaying actual flows and PTDF flows (covered in a later section)
- Save/edit/delete view
- Go to view

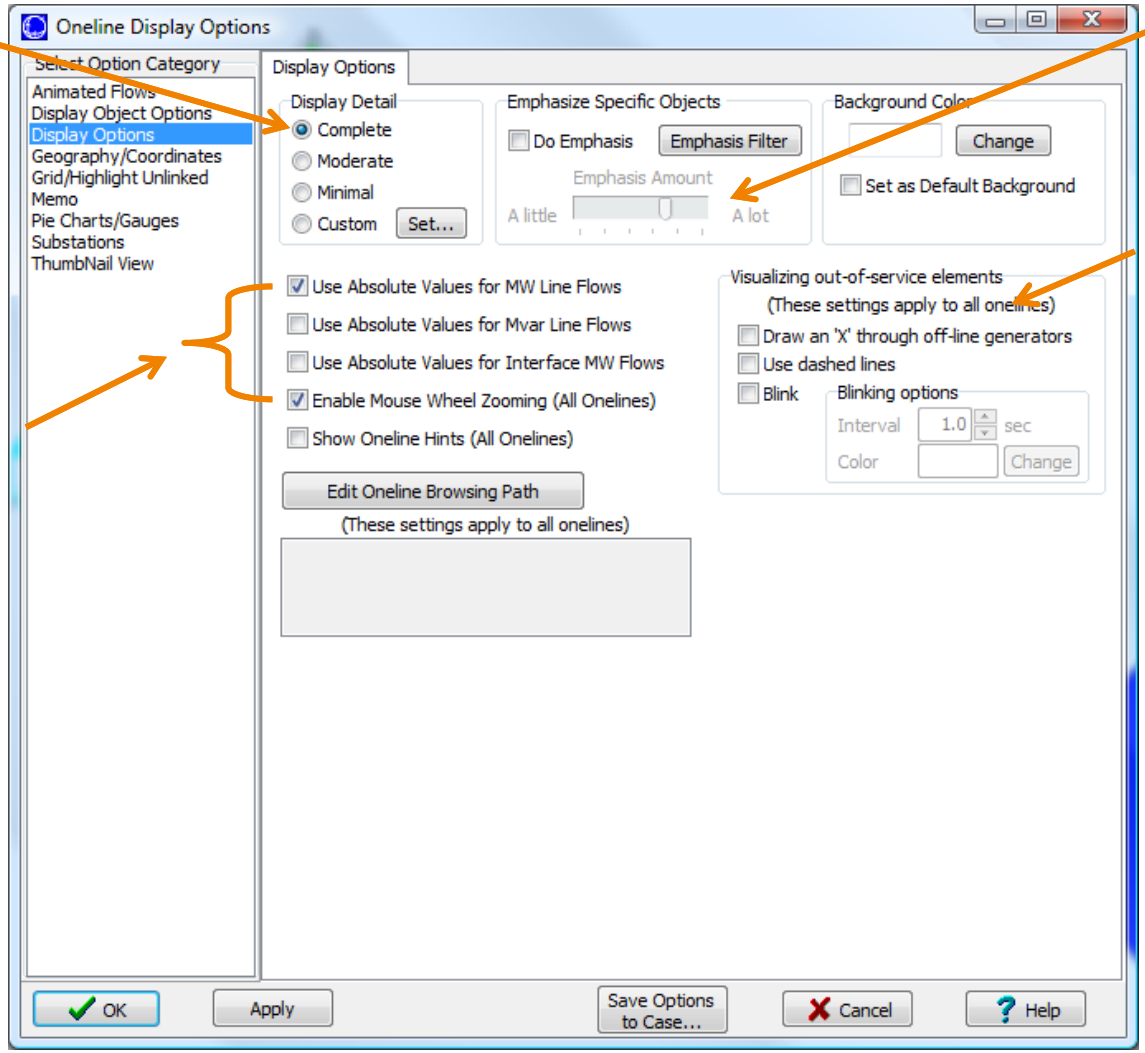
Oneline Display Options:
Display Options Page

Another Slide explains

Covered in later section

Options for visualizing out-of-service elements

Flow fields specify a near and far bus. This implies a direction, so a negative sign is normally displayed for flows in the opposite direction. Check this box to NOT show the negative sign.



Display Object Options:
General Options

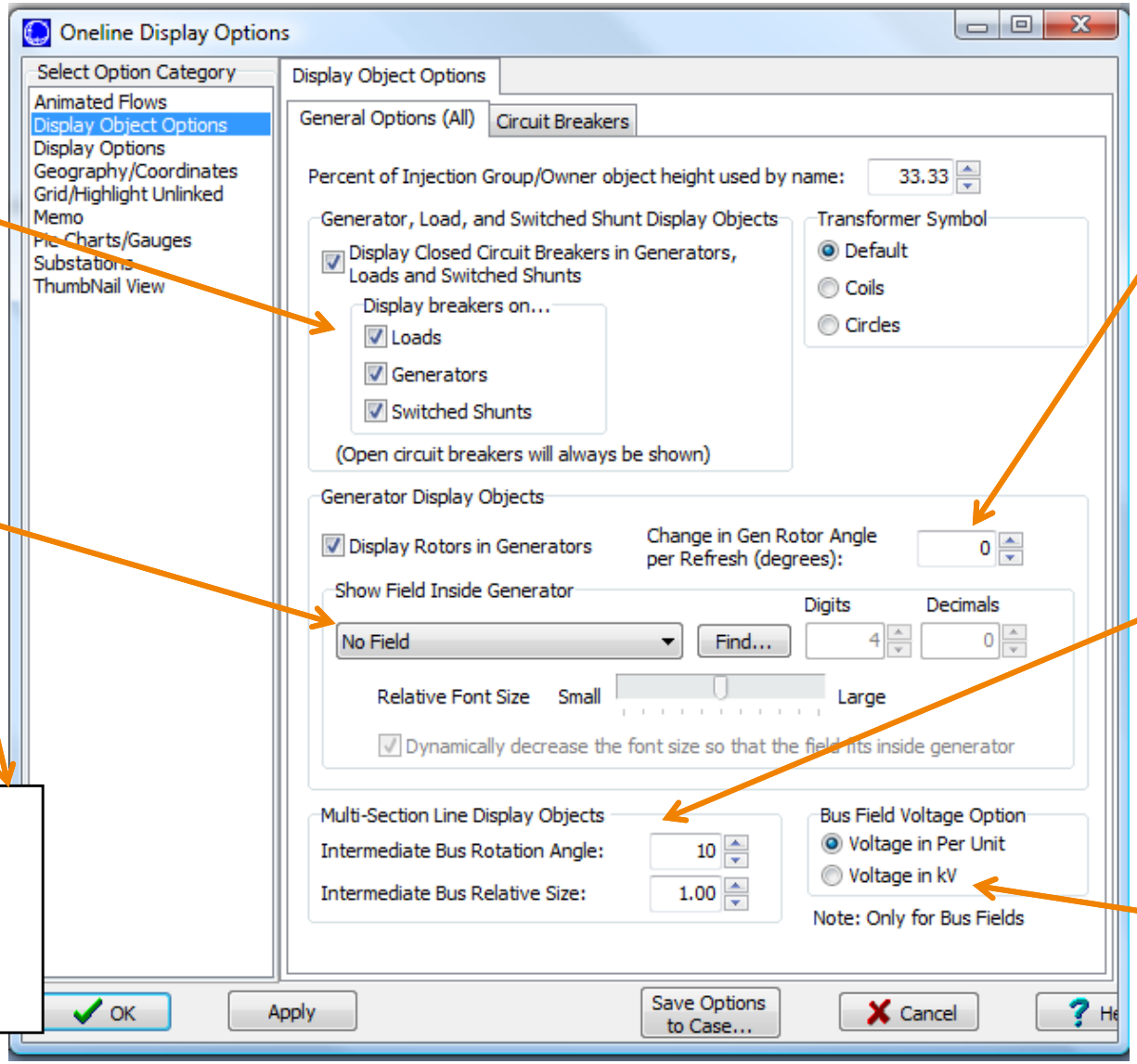
Choose where to show circuit breakers

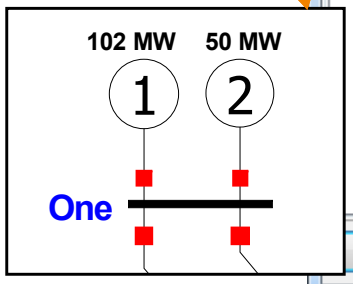
Show selected field inside generator

Each time the display refreshes, the generators "rotor" will rotate this amount

Change appearance of MS Line intermediate buses, relative to end buses

Only affects Bus Voltage Fields

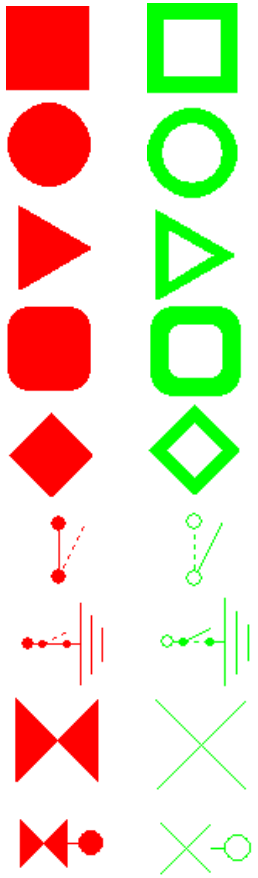


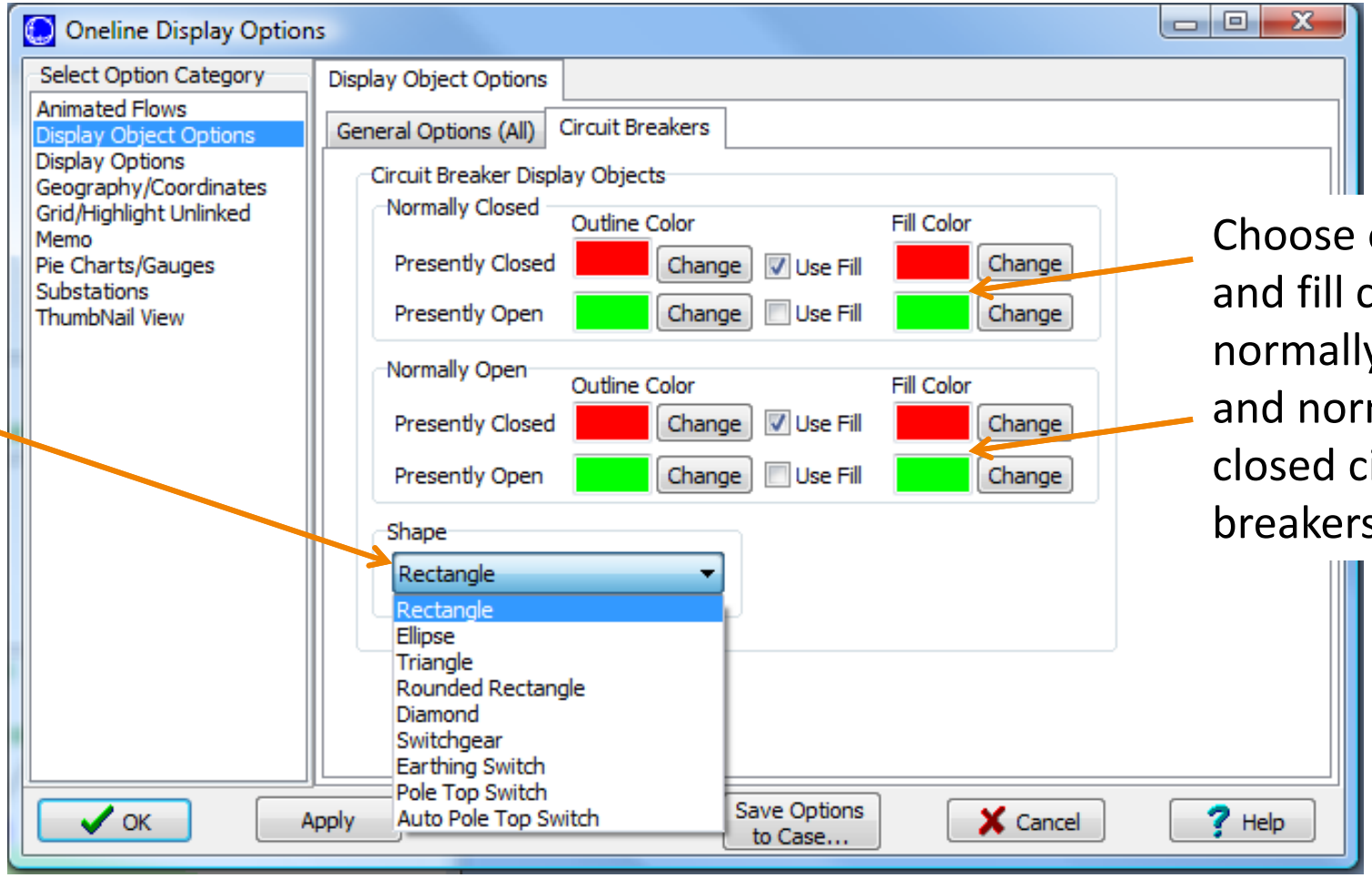


Display Object Options:

Circuit Breakers

Choose the circuit breaker shape

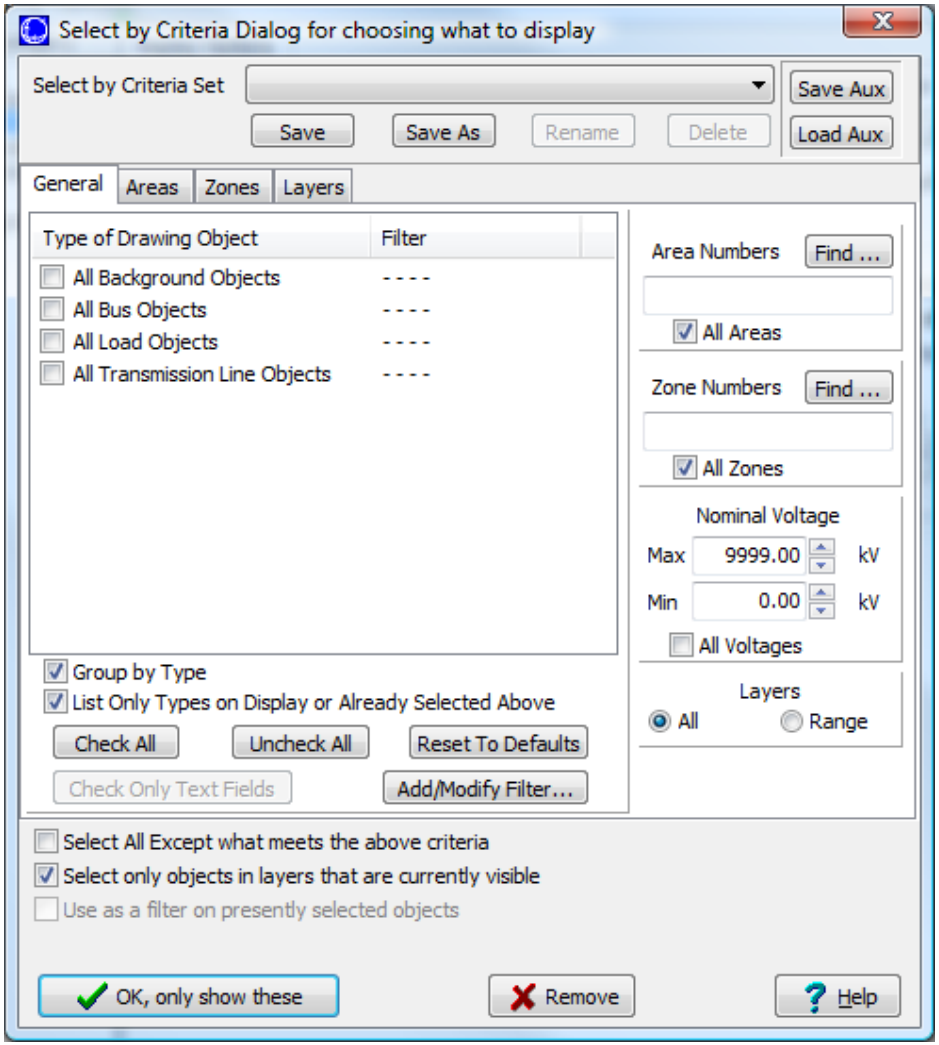




Choose outline and fill color for normally open and normally closed circuit breakers

Display Options Tab:
Set Custom Detail

- Display Detail
  - Complete: show everything
  - Moderate: remove pie charts and line fields
  - Minimal: remove pie charts and all fields except those associated with generators, loads, or shunts
  - Custom Detail: opens the Select by Criteria dialog (pictured) to specify a custom display detail by area, zone, layer, and other criteria



Oneline Display Options:
Pie Charts/Gauges Page

Pie chart percentage based on

Separate options for lines and interfaces

Default styles for Generator, LTC, and Shunt and user defined styles (Used with pie chart/gauges other than lines and interfaces)

Gauge value based on

Line flows are different at each end of the line, this specifies to always using Limiting Flow

Limiting Flow is normally the higher value, but this can be changed in the Limit Monitoring Settings

Display percentages in gauge instead of unit values

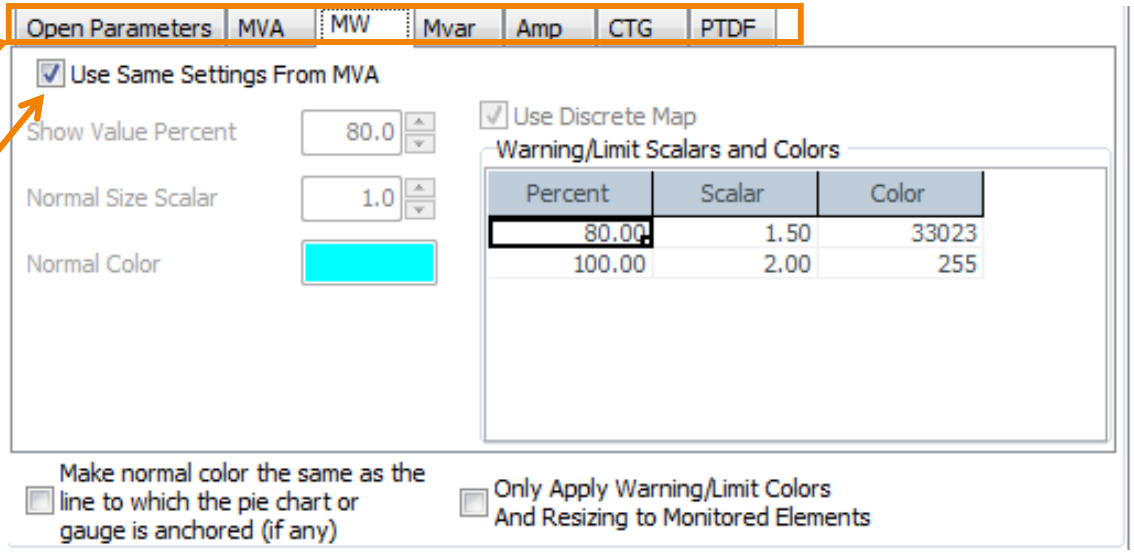
When values are higher than this percent, the number will appear inside the pie chart

Specifies the colors and scales of pie charts when values are higher than the percentage breakpoint.

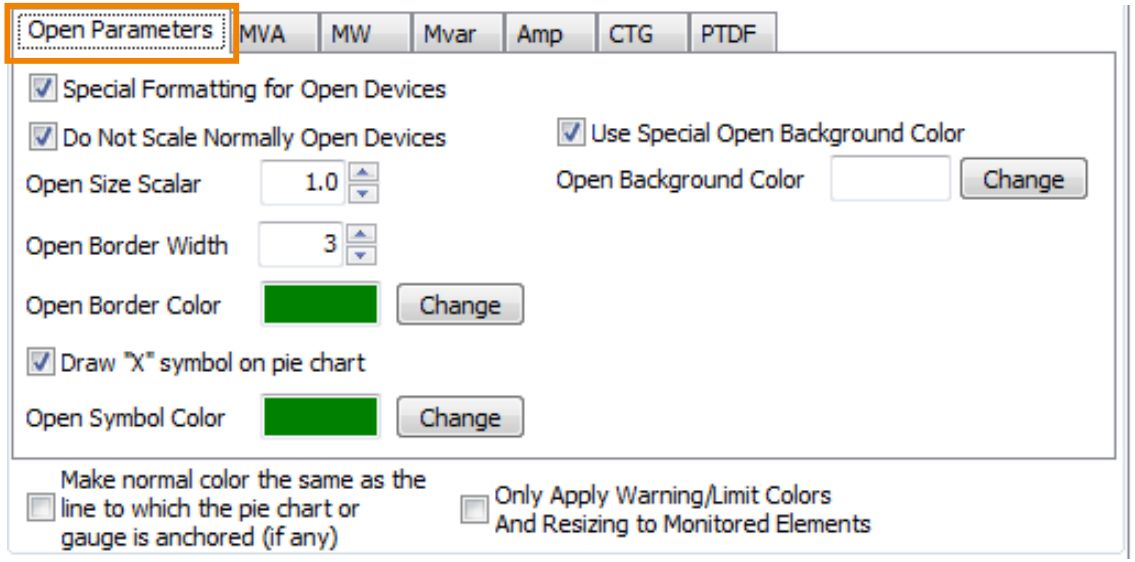
Oneline Display Options:
Pie Charts/Gauges Page, Lines Tab

Sub-tabs allow separate breakpoints for different measurement types

Uses same settings as MVA measurements, so fields are grayed out



Special formatting options for open lines



Oneline Display Options:
Pie Charts Page, General Options Tab

Show current limit set (selected in limit monitoring settings)

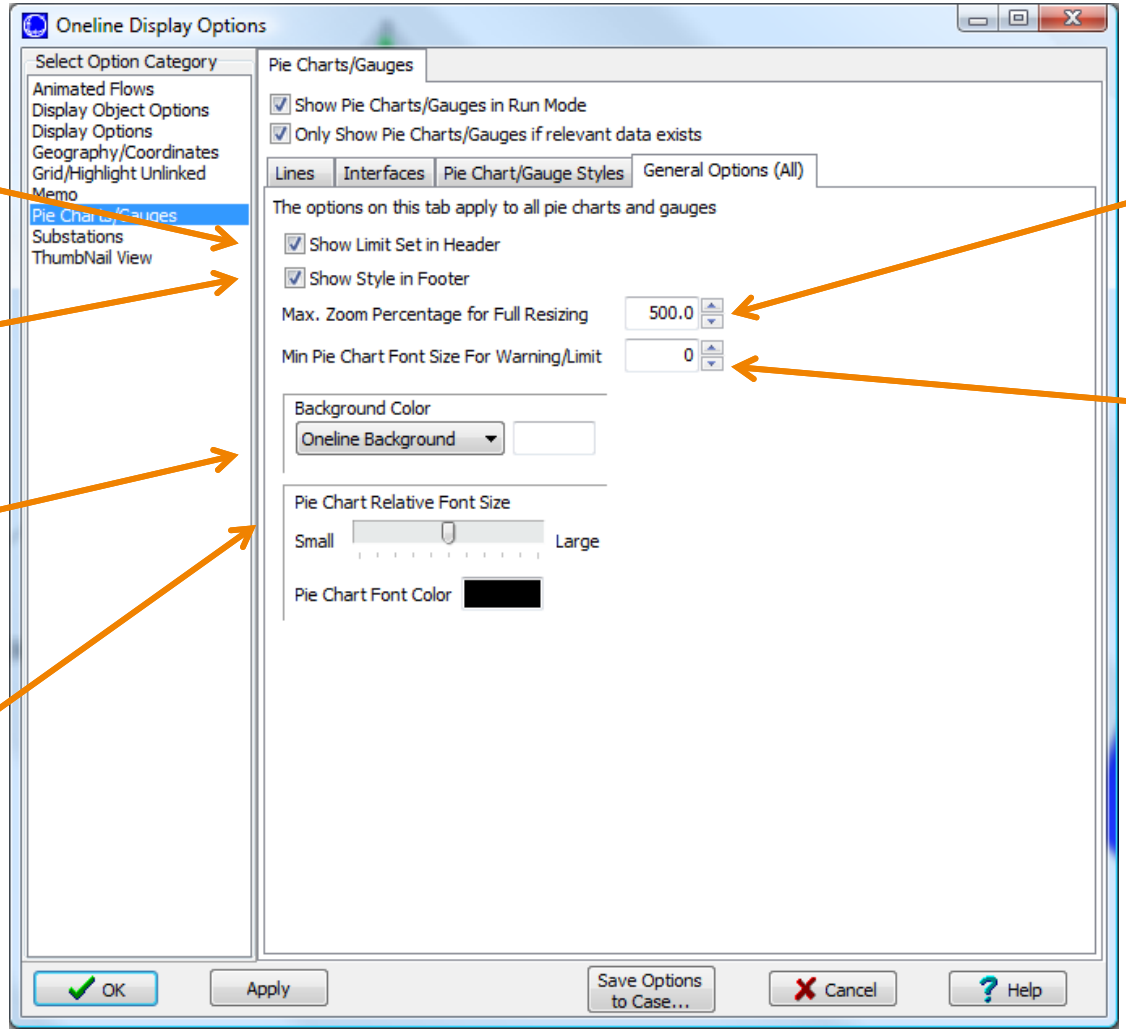
Show what is being measured

Internal pie chart background fill

Text font size relative to pie chart size

Highest zoom level for resizing

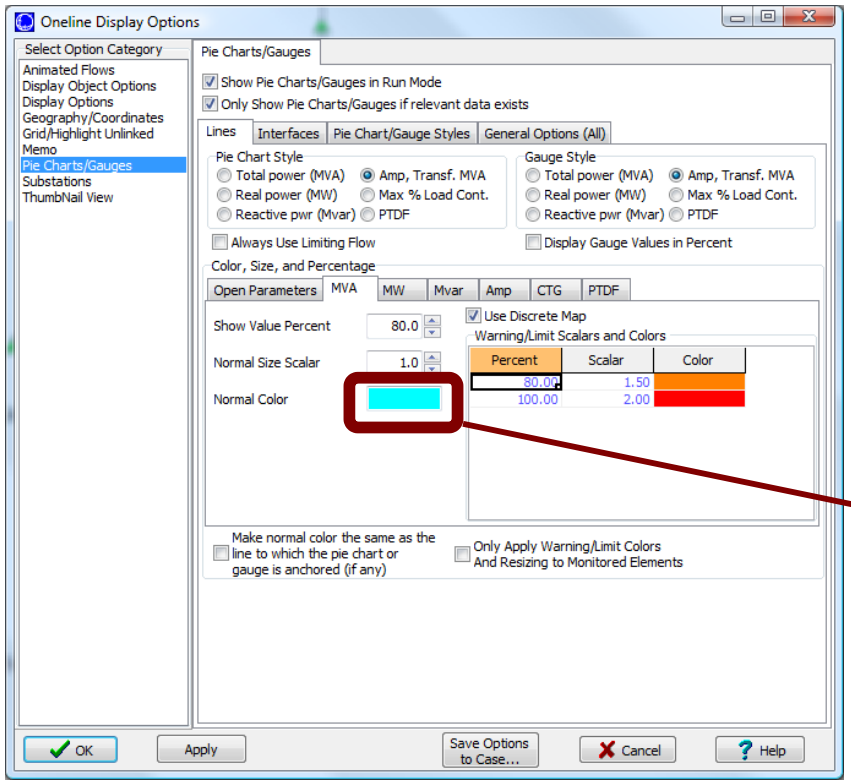
Minimum font size in the pie chart



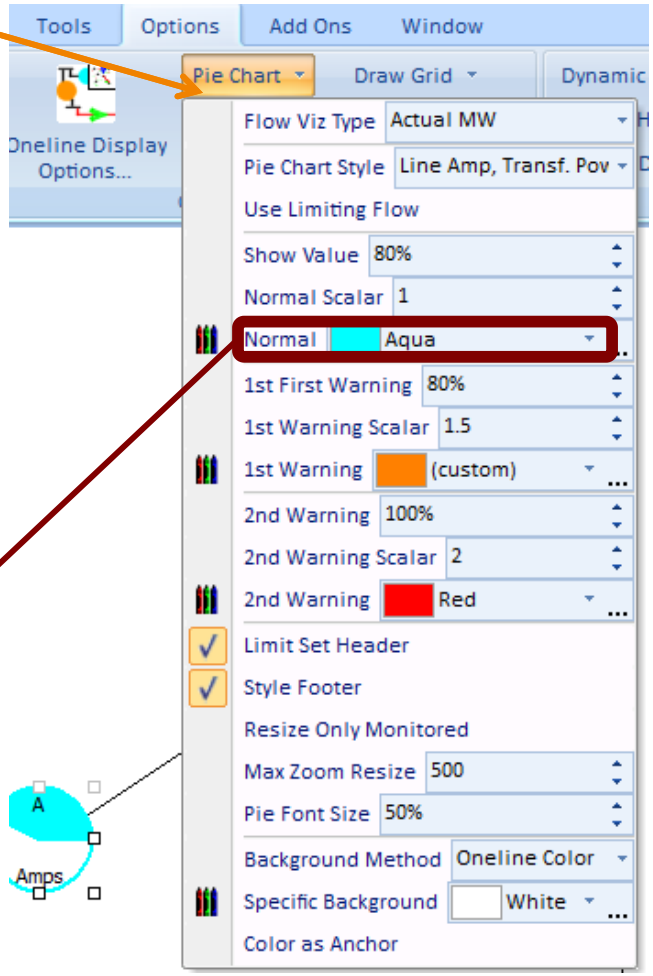
These options only apply to Line and Interface pie chart/gauges

Pie Charts Options Ribbon

Click **Options → Pie Chart** to reveal



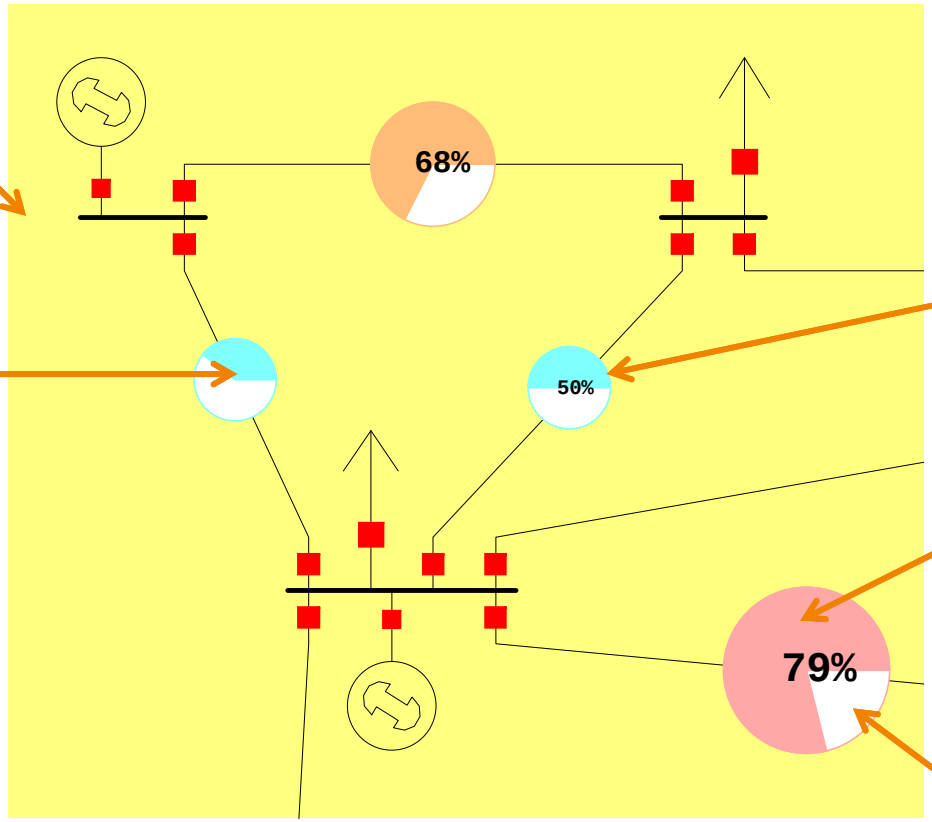
Same Setting



Background and Pie Chart Color Example

Warning Percent = 60
Warning Color = Orange
Warning Scalar = 1.5

Background Color for Oneline = Yellow



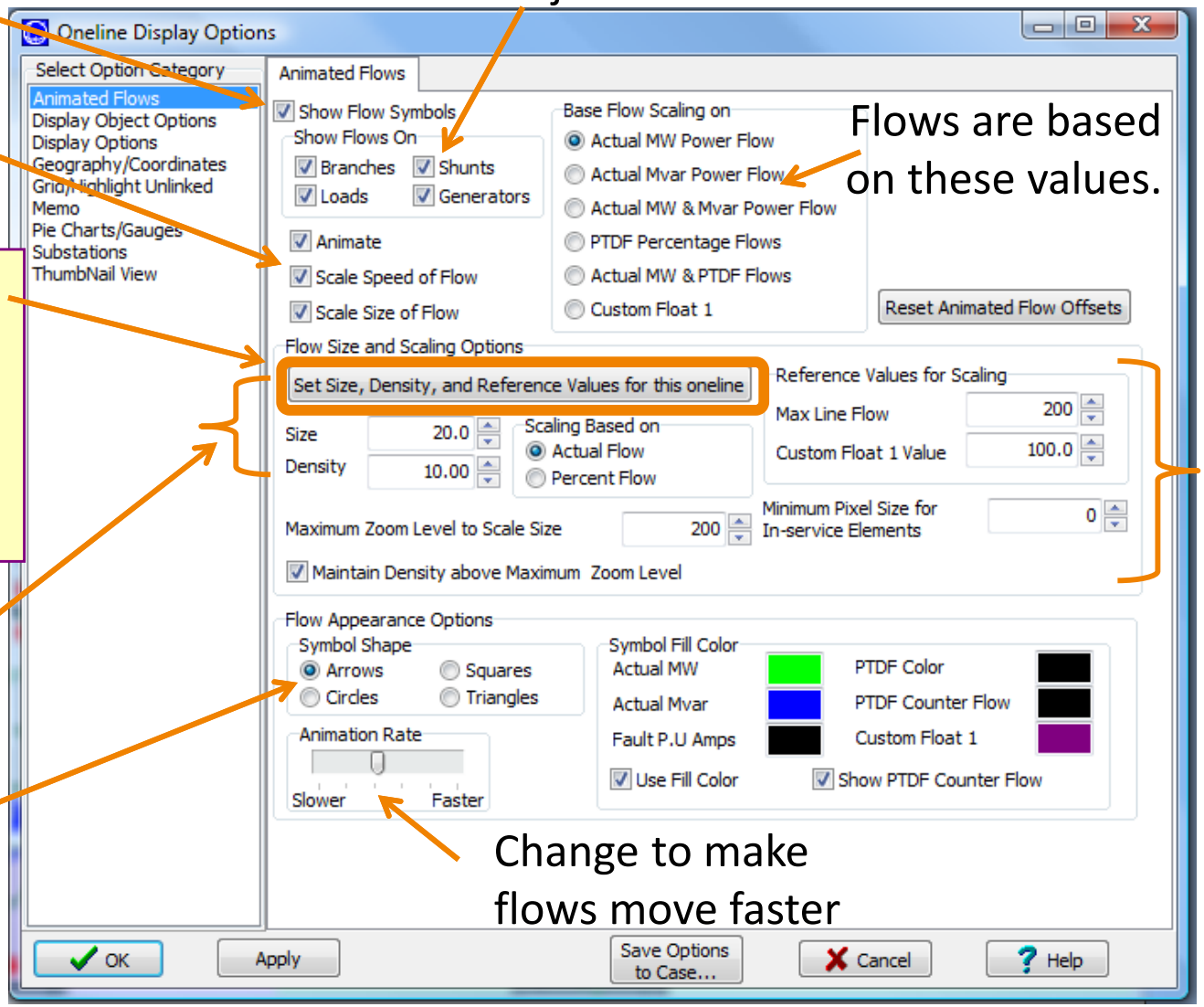
Show Value Percent = 45

Normal Color = Blue
Normal Scalar = 1.0

Limit Percent = 70
Limit Color = Red
Limit Scalar = 2.0

Pie Chart Background Color = White

Oneline Display Options: Animated Flows Page



Show Animated Flows

Select Objects

Make Arrows move

Flows are based on these values.

Click this button to initialize the arrows to reasonable numbers.

Parameters used when Animating Size. See the next slide for more info.

Density and Size of Arrows

Symbol used to show flows- almost always use Arrows

Change to make flows move faster

How do these parameters affect the Arrow Size and Spacing

- Arrow Size
  - Arrow Size when NOT Animating Size
  - Arrow Size when Animating Size
    - Actual Flow

$$ArrowArea \sim Size$$

      - Actual flows higher than 2 times the FlowReference will not appear larger than a flow 2 times the FlowReference
    - Percent Flow

$$ArrowArea \sim Size * \left(\frac{FlowOnElement}{FlowReference} \right)$$

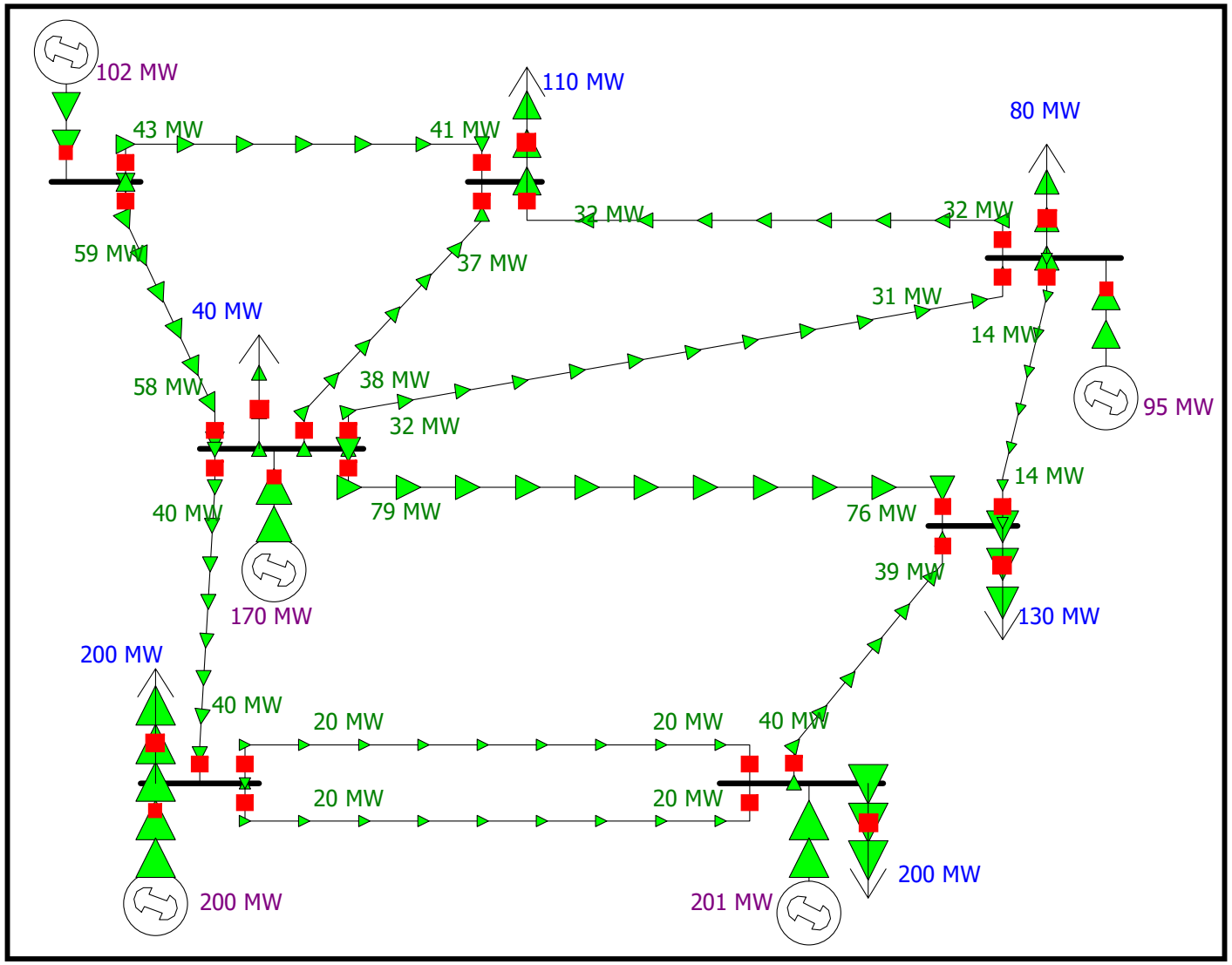
- Arrow Spacing

$$ArrowArea \sim Size * ElementPercentageFlow$$

$$ArrowSpacing \sim \frac{1}{Density}$$

Click the button **Automatically Set Size, Density, and Parameters for this oneline** to get values that look reasonable for your oneline

Example Variable Flow Size

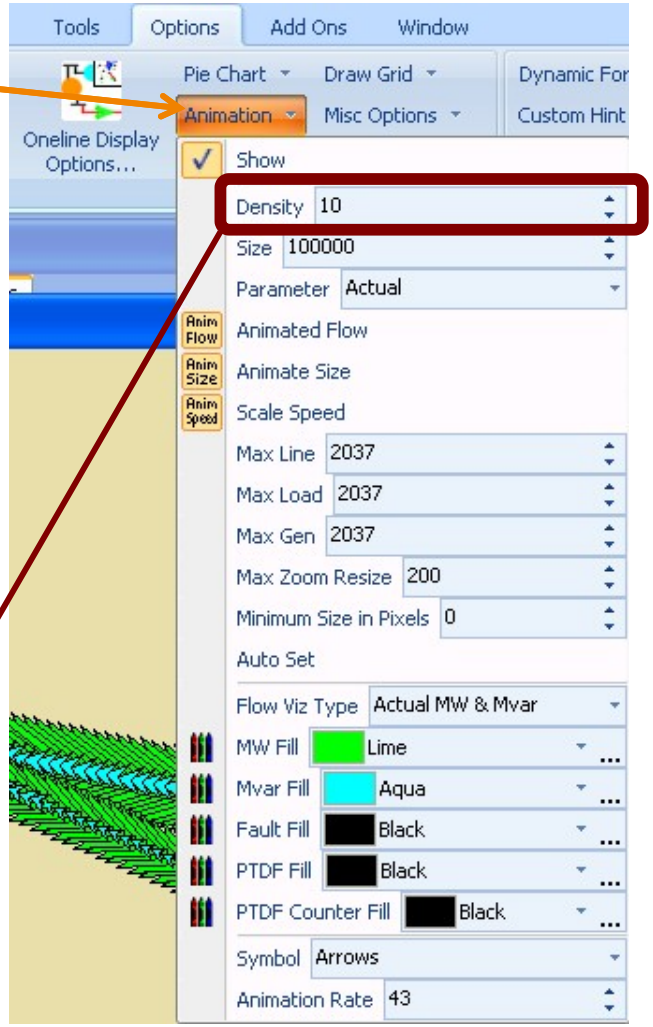


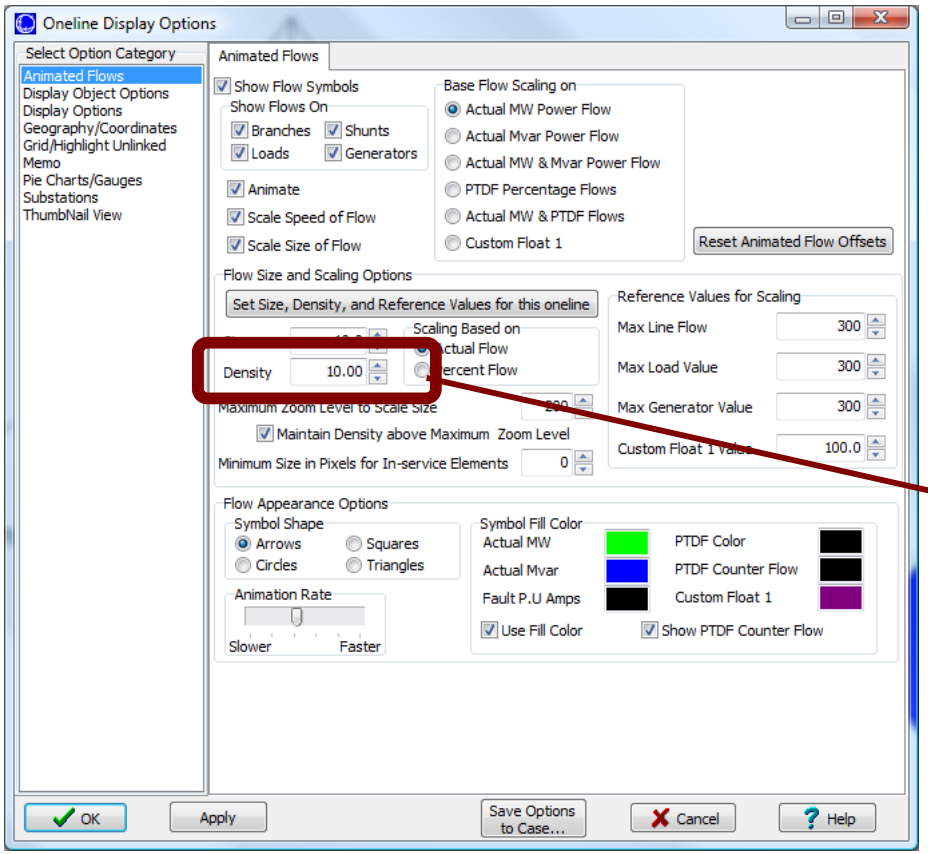
Animate Size = TRUE
Reference Size = 200 MVA

Animated Flow Options Ribbon

- Notice that all the settings on the dialog are available

Click **Options** → **Animation** to reveal

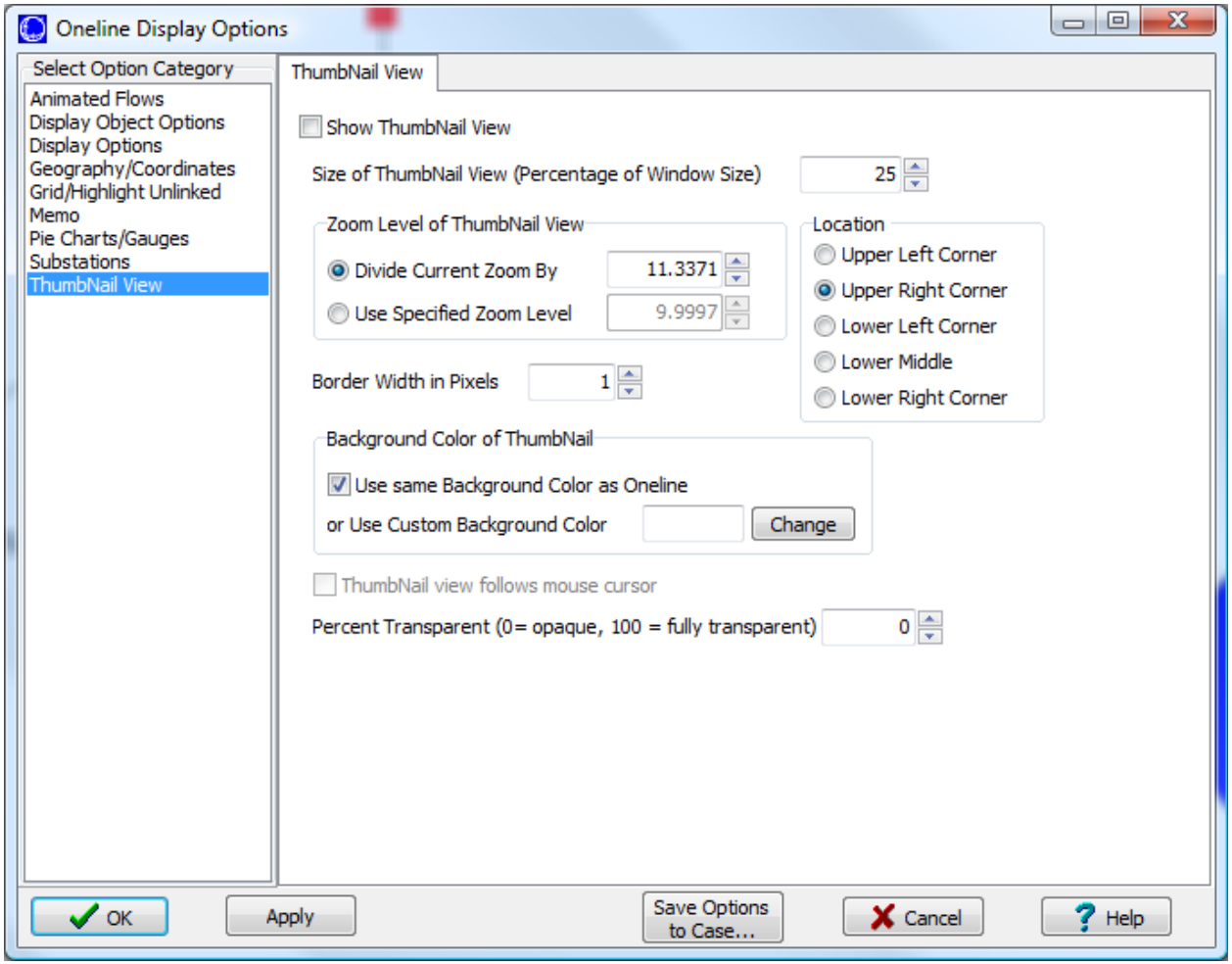




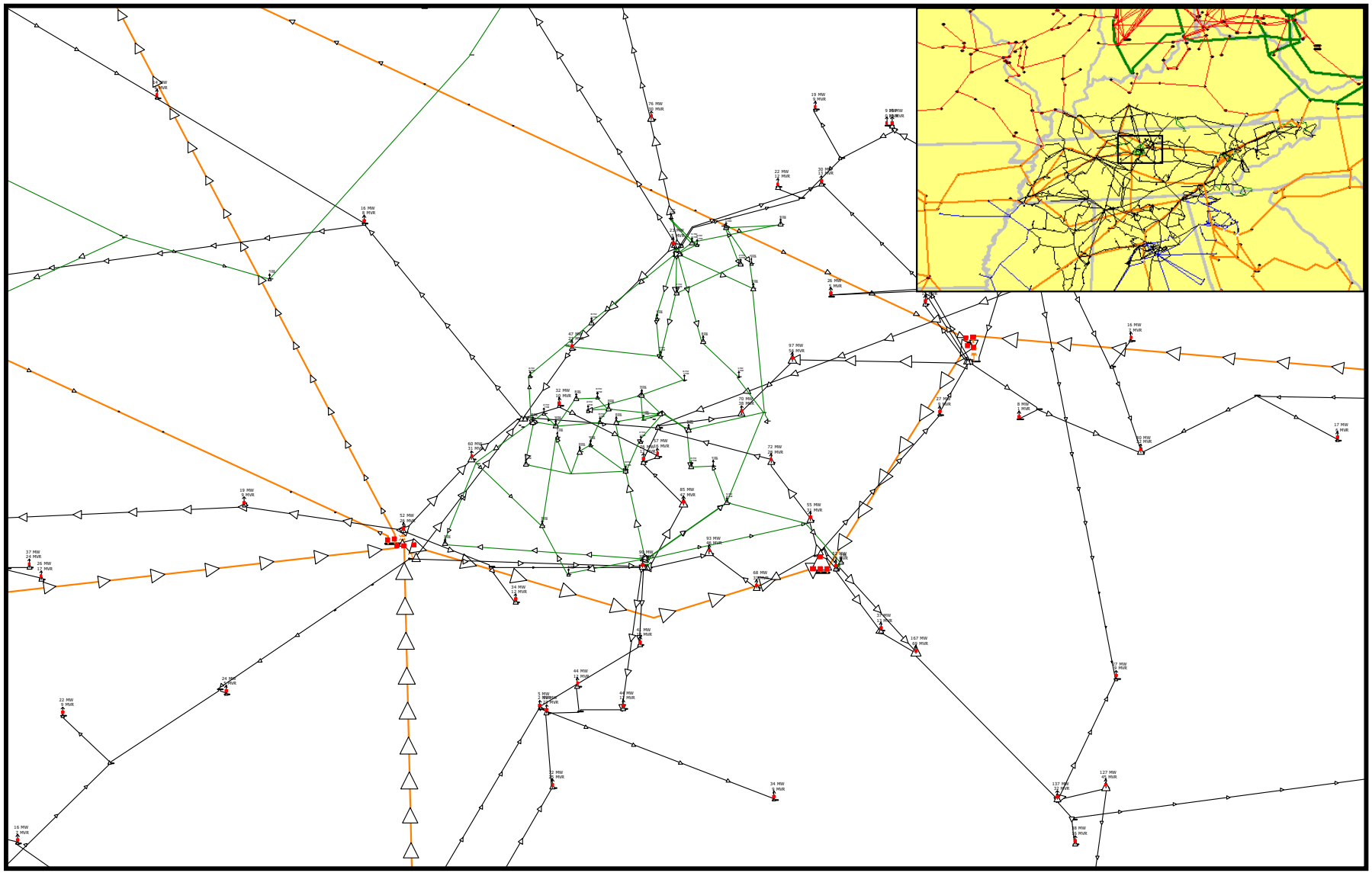
Same Setting

Oneline Display Options: Thumbnail View Page

- Use to show an overview window for the oneline

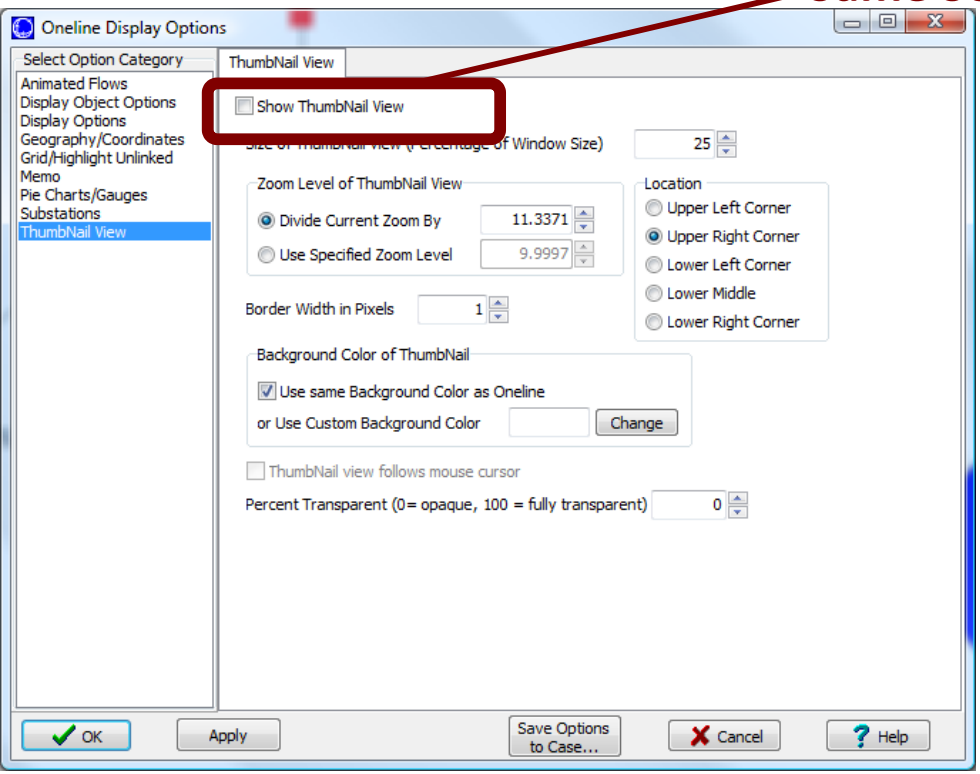


Thumbnail Example

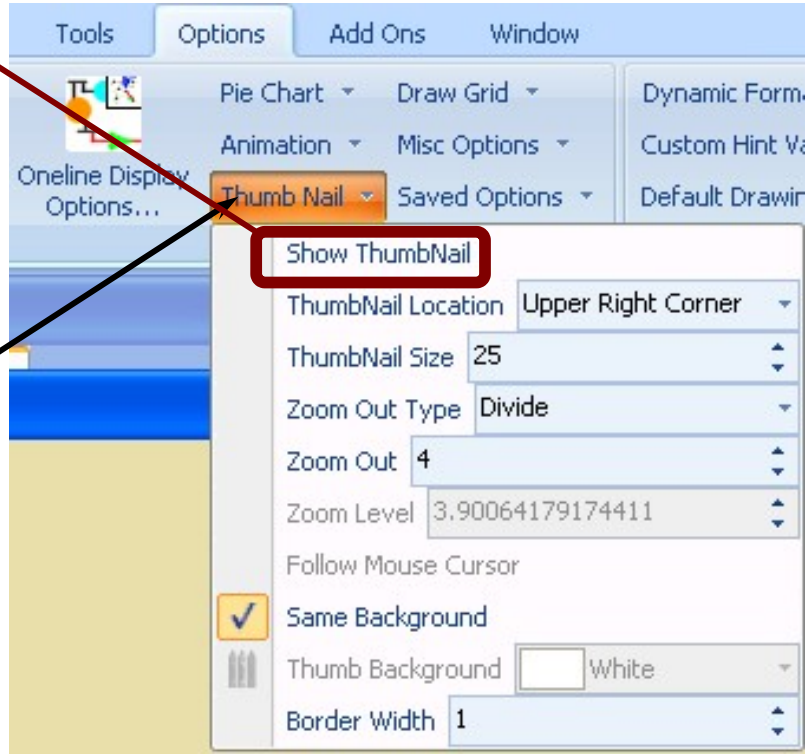


Thumbnail View Options Toolbar

- Right Click in the toolbar region and Choose the ThumbNail View Options Toolbar to make it visible if needed
- Notice that all the settings on the dialog are available

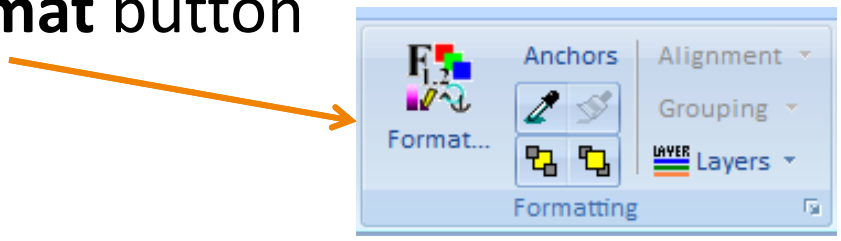


Click **Options → Thumb Nail** to reveal



Text Fields

- Descriptive text fields, unlinked to specific power system objects, can be added to the oneline by selecting **Background → Text** or **Memo Text** from the **Draw** ribbon tab.
- To change font and background color of text fields:
  - Select the text field
  - Select the **Format** button



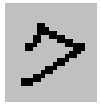
Oneline and Document Links

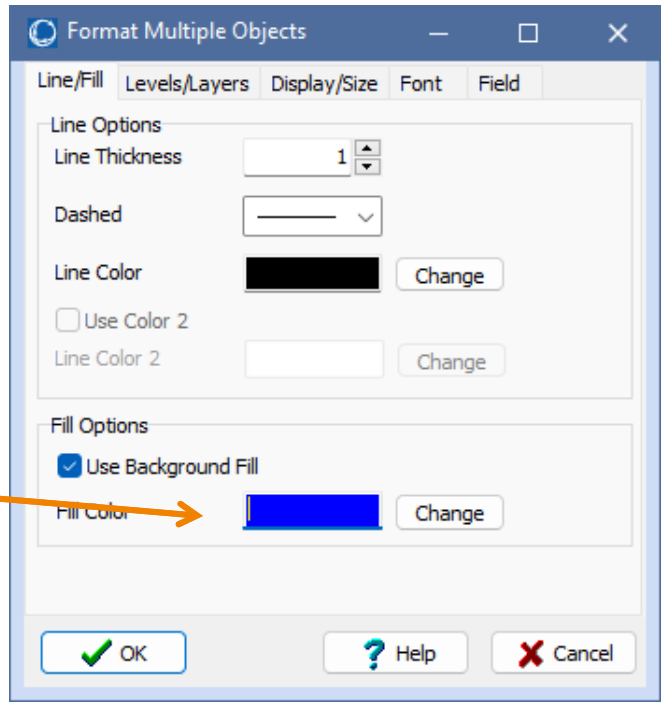
- Create a link to another oneline by selecting the **Draw** ribbon tab, **Background** button → **Oneline Link**

  - Clicking on this word will open up the other oneline
- Any file can be linked and its associated application will automatically open.

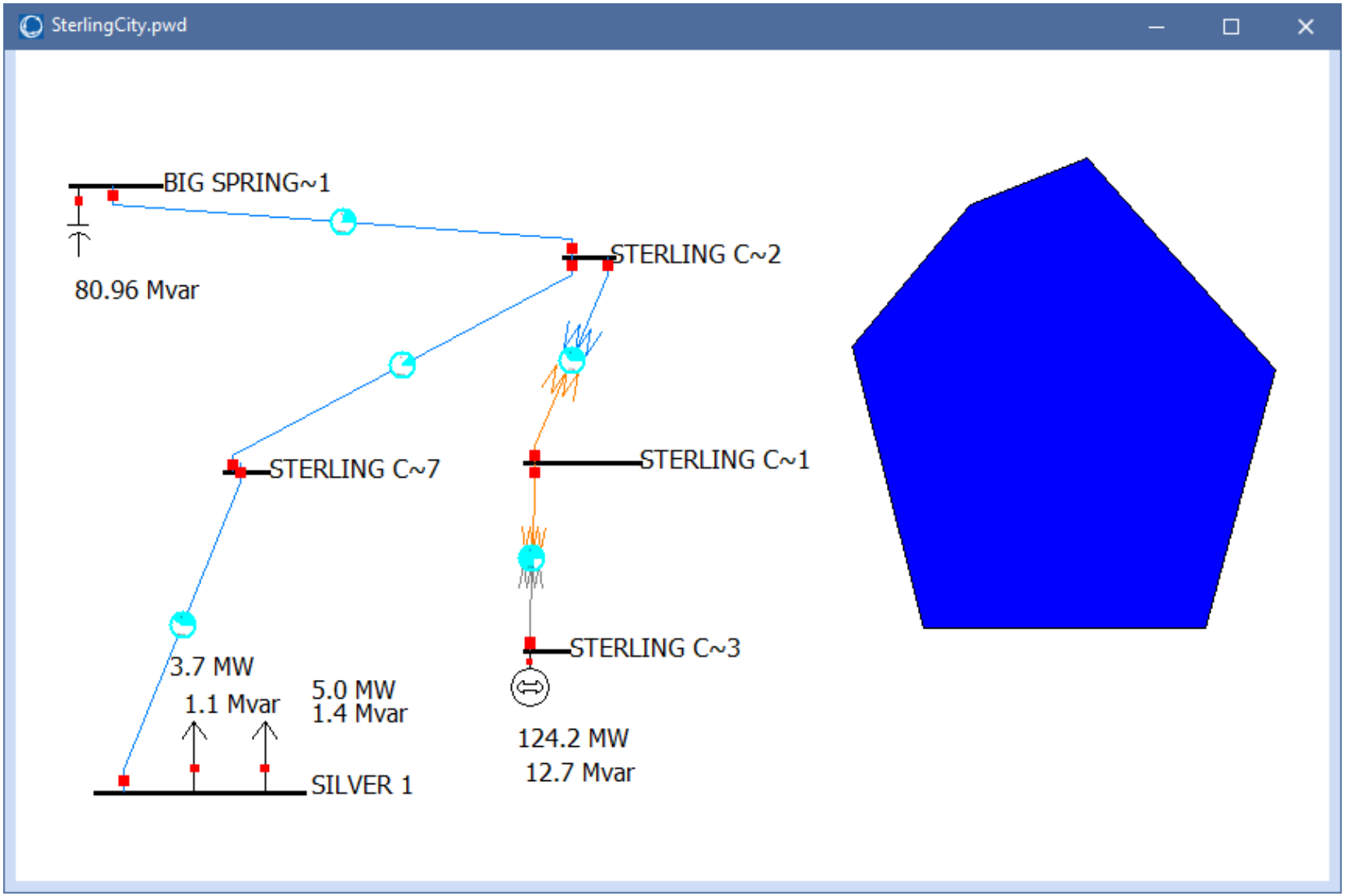
  - This means that power point files or word documents or spreadsheets can all be linked

Adding Background

- To show static background line on the one-line, select  **Draw → Background → Background Line**
  - click to start the background line and to add segments.
  - double click to end
- Use **Draw → Format** to edit appearance.
  For this example, apply blue fill for a lake.



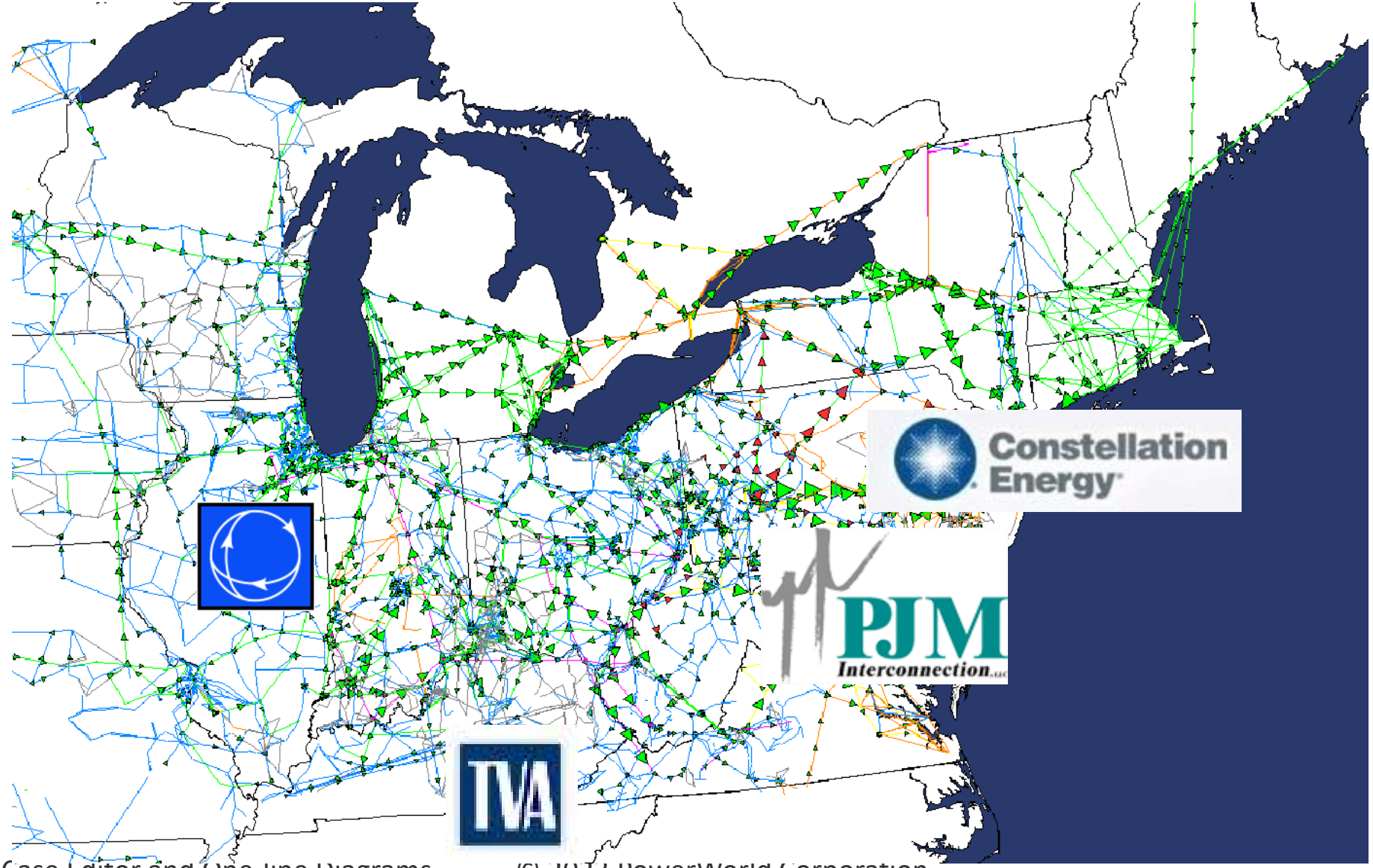
Sterling City Oneline



Adding Pictures to the Oneline

- To include pictures, such as bitmaps, JPEGs, or metafiles, on the oneline, select the **Draw** ribbon tab, **Background** button → **Picture**.
  - Use Open Picture Dialog to find desired picture
  - Dialog provides a preview window
- You can also use the Window's Clipboard to copy objects from other programs, such as a graph from a spreadsheet or image from web.

Example: Company Logos



Using An Existing Oneline with a New Power System Case

Situation

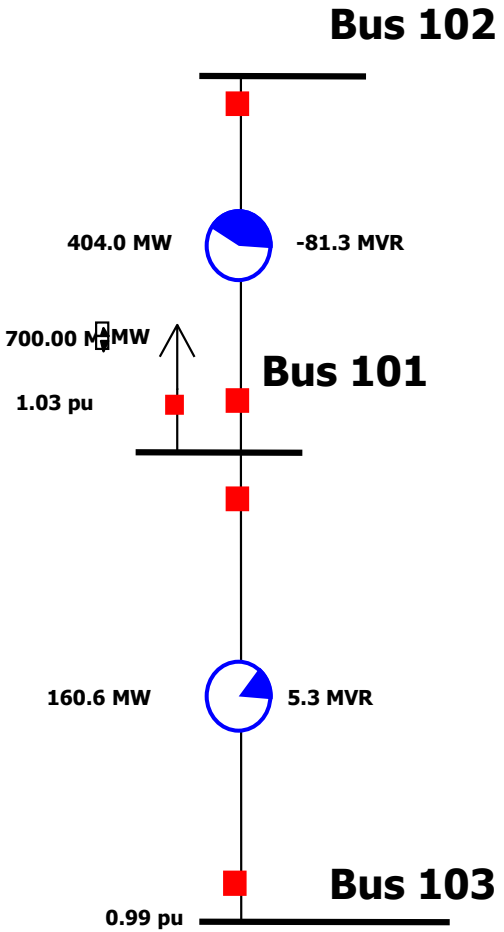
- You've created a detailed oneline of your system and it matches your current case
- A new power system case is issued a year later, but topology differences mean the original oneline no longer matches perfectly
  - System elements are reconfigured
  - Bus numberings change
  - More detail or less detail in the case

Integrating an old Oneline with a new Case

- Open the new power system case
- Choose **Open Oneline** from the **File Menu** to open your old oneline
- Now, find out if all the elements on the oneline are still linked up with the case
- Choose **Onelines → List Display → Unlinked Display Objects**
  - This gives you a list of display objects that have no corresponding data in the case

Fixing a Few Unlinked Oneline Objects

- "Few" may mean less than 500
  - If Bus 101 were removed in case at right there would be 17 unlinked objects created by this!
- If only have a few, easiest process is to
  - Delete unlinked all objects
  - Fix up the areas on the oneline affected



Integrated Bus Renumbering

- When saving a diagram (*.pwd) file, Simulator automatically includes a table inside this file which stores data necessary to do the renumbering routine
- Can renumber based on Name_KV or Label linking
- This allows you to perform the renumbering automatically when you open the diagram
  - Choose **Open Oneline** from the **File Menu**
  - Change **Files of type** to *Oneline Display File (Name_KV linking)* or *Oneline Display File (Label linking)*
  - Choose the file to open
- This automatically renumbers the diagram
  - BE CAREFUL. If the case does not have unique “name-nominal kV” values this can cause incorrect linking.
  - All objects should have labels defined for label linking to work

Fixed A Lot of Unlinked Objects: Bus Renumbering

- If you have a lot of unlinked objects, then the case bus numberings have probably changed
- Best option is to attempt to “renumber” the buses on the oneline

Bus Renumbering

- Open the old oneline with the OLD CASE
- In Edit Mode, choose **Tools → Renumber → Renumber Buses**
- Select **Load Only Buses on Oneline** and press the **Setup Bus Swap List** button
- Right Click on the table and choose **Save As → Auxiliary File…**
  - Select a name such as (oldscheme.aux)
- Close Renumber Buses dialog

Bus Renumbering (cont)

- Open the NEW CASE and the old oneline
- Choose **Tools → Renumber → Renumber Buses**
- Select **Freshen Current Oneline** and specify the file you saved (oldscheme.aux)
- Click the **Setup Swap List** Button
  - Simulator will match the old numbering scheme used in the oneline with elements in the new case by BUS NAME and KV.
  - Tie breakers will use the BUS AREA NAME
  - If it still can't figure it out, it puts in both options

Bus Renumbering (cont)

- Go through the new list and make sure you want to swap as they are listed
- Change the **Swap?** field for those you want to switch
- When you've selected what you want to swap, click **Change Bus Numbers** at the bottom of the form
- NOTE: It will take a long time to renumber a big oneline

One-line Diagrams for FERC 715

- Our affiliate, Energy Visuals, provides geographic-based one-line diagrams as a subscription service
  - Updated annually
  - Let them worry about bus renumbering!
- +1 (217) 398-8035, Tim Born
- http://www.energyvisuals.com
- Energy Visuals also provides generator cost models for use with Optimal Power Flow (OPF)

Blank Page

Blank Page

Blank Page