Introduction to PowerWorld Simulator: Interface and Common Tools

I13: Fault Analysis

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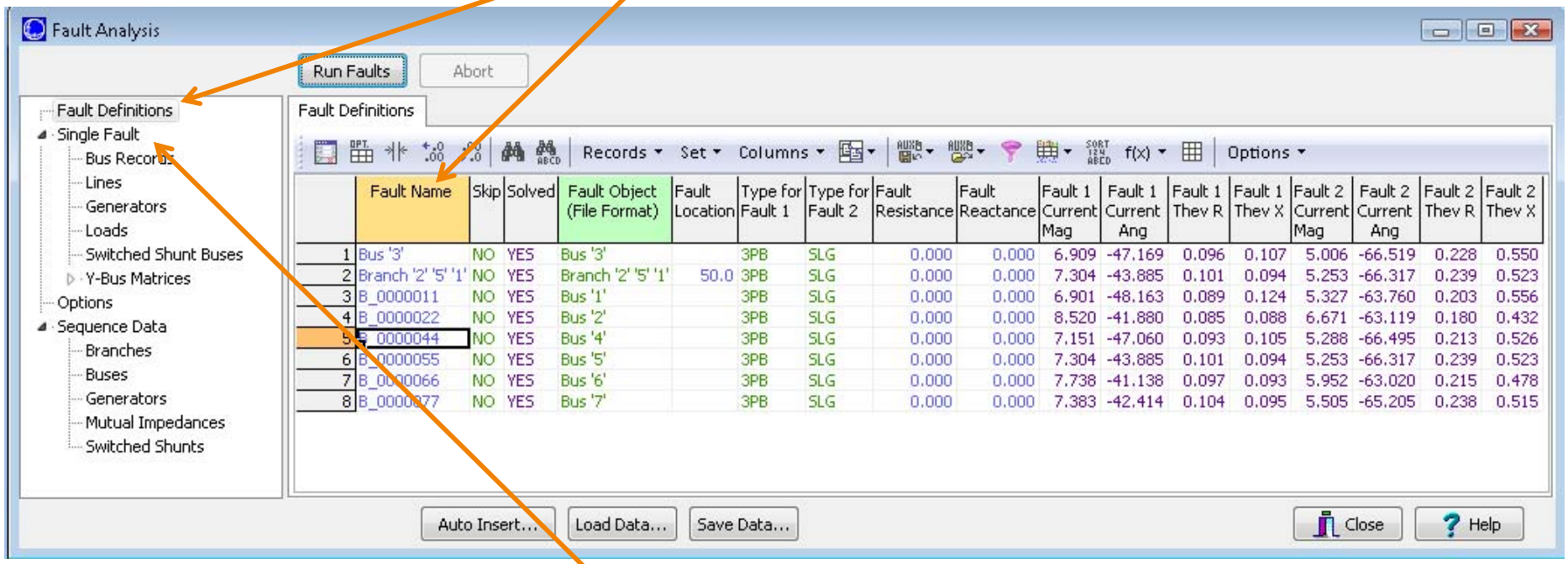
Fault Analysis

- Analysis of power system parameters resulting from a ground or line to line fault somewhere in the system
- Simulator contains a tool for analyzing faults in an automatic fashion
- Can perform single and three phase faults
- Faults may be analyzed one at a time or in a batch mode, similar to Simulator's Contingency Analysis

Fault Analysis Dialog



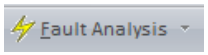
Fault Analysis

- Fault types include:
  - Single line to ground
  - Line to line
  - Double line to ground
  - Three phase balanced
- The general fault analysis tool can be accessed in run mode by: **Tools** ribbon tab →**Fault Analysis**

Example

Open B7FaultExample.pwb

- No sequence data exists, so all fault analysis data fields are set to defaults

- Run the Fault Analysis tool from run mode by: **Tools** ribbon tab →**Fault Analysis** 

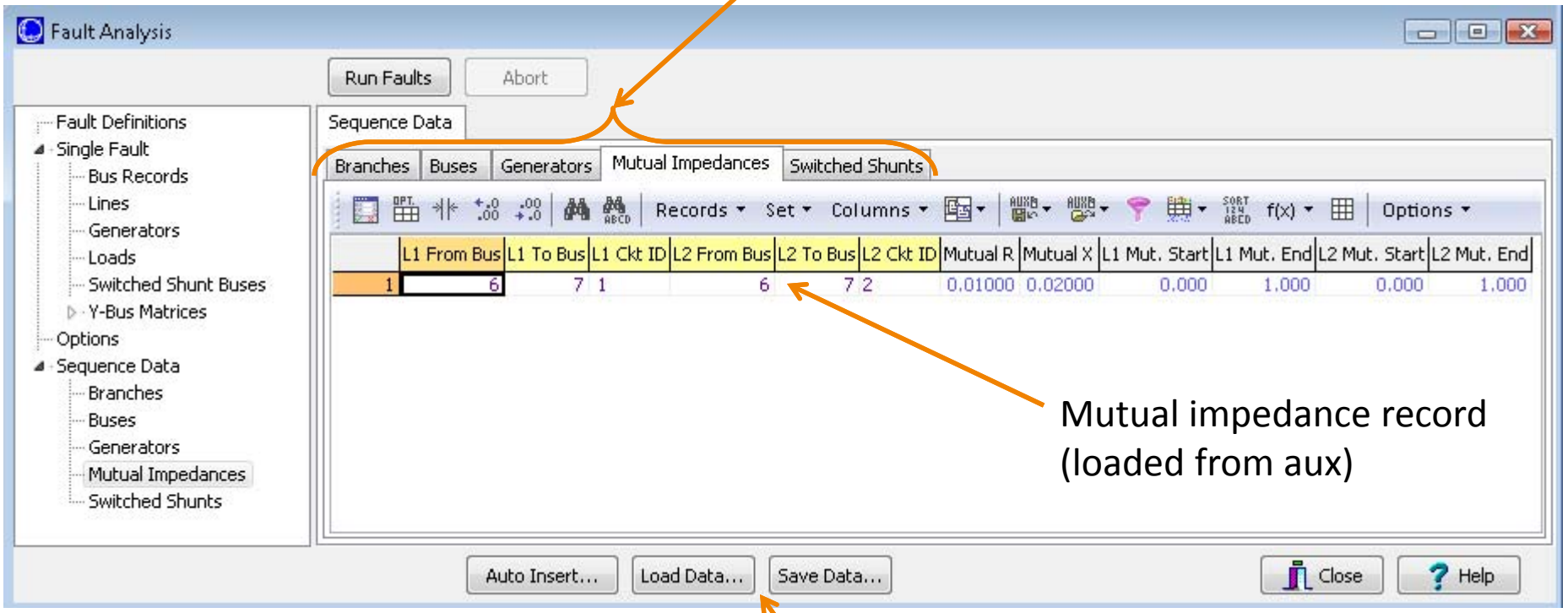
- Click the **Load Data…** button
  - Confirm replacing sequence data
  - Load B7FaultExample.aux

Sequence Data for Fault Analysis

- Formats
  - PowerWorld Auxiliary file (*.aux)
  - PTI Sequence Data file (*.seq)
- Sequence data can similarly be saved to the same types of external files; however, Simulator will store sequence data with the load flow case (*.pwb) if you save the case after loading the sequence data

Fault Dialog: Sequence Data

Specific data for each object type on these tabs



Mutual impedance record (loaded from aux)

Load and save sequence data as a text file (*.aux or PTI *.seq)

Sequence Data for Fault Analysis

- Simulator defaults zero-sequence parameters to 2.5 times the positive sequence impedances
- PTI assumes that are open in the zero-sequence model if no zero-sequence data is specified in the *.seq data file
  - When reading in *.seq files, Simulator gives the ability to assume this behavior

Sequence Data for Fault Analysis

- Sequence data is required for various devices:
  - Generators
    - Internal sequence impedances
    - Neutral to ground impedance
  - Transmission Lines
    - Zero sequence impedance
    - Zero sequence line shunt admittance

Sequence Data for Fault Analysis

- Transformers
  - Zero sequence impedance and line shunt admittance
  - Phase shifts, entered as Phase in the load flow data
  - Transformer grounding configuration, as a combination of Wye, Grounded Wye, and Delta connections
- Loads
  - Negative and zero sequence load, as an admittance
  - Set on a bus-basis, with admittance given is total admittance for all loads at that bus

Sequence Data for Fault Analysis

- Transmission line mutual impedance (zero sequence mutual impedance between part or all of two transmission lines)
- Fault data for all devices (except mutual impedances) can be entered on the Information Dialogs

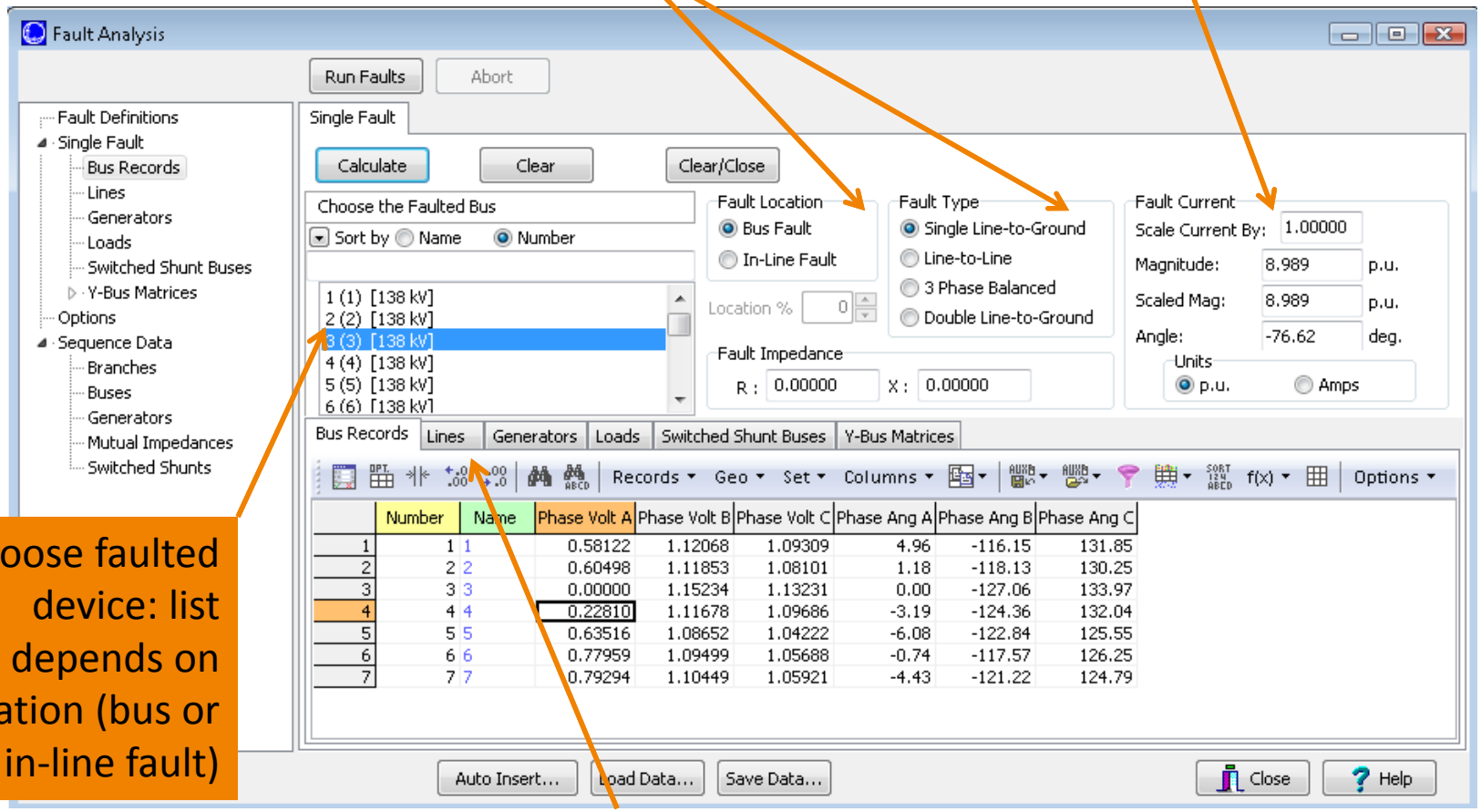
Single Fault

- Switch to the **Single Fault** page, and choose Faulted Bus number 3
- Leave as bus fault, single line to ground, zero fault impedance
- Click **Calculate**
  - The case will be solved first to make sure the analysis will be valid
  - The fault analysis calculation is a linearized calculation about the operating point

Fault Dialog: Single Fault

Location and type of fault

Summary Results: Fault Current



Choose faulted device: list depends on location (bus or in-line fault)

Detailed Results: Displayed in the grids on these tabs

Fault Type

- Determines which calculations to perform
  - Single line to ground: assumes phase A to ground
  - Line to line: assumes phase B to phase C
  - Double line to ground: assumes phase B to phase C to ground
  - Three phase balanced
- A non-zero impedance to ground may also be specified; default is 0 (except for line to line)

Single Fault: Results

- Results are displayed on six tab sheets on the **Single Fault** page
  - Per phase bus voltage magnitude (p.u.), angle (deg.), and Thevenin Impedance (at the fault bus, add columns to display)
  - Per phase branch from and to bus current magnitude, with current direction at BOTH ends defined AWAY from the terminal bus
  - Per phase generator current magnitude and angle (deg.), with current direction defined OUT of the generator
  - Per phase load and switched shunt magnitude, with current direction defined AWAY from the terminal bus
  - Y-bus matrices

Visualization of Results

- Fault voltages and currents can be visualized on a oneline diagram
  - On the **Options** page, select a single phase or All Phases from the **Oneline Display** option group
  - When a single phase or All Phases is selected, Simulator searches for and replaces the following types of text fields on the oneline diagram:

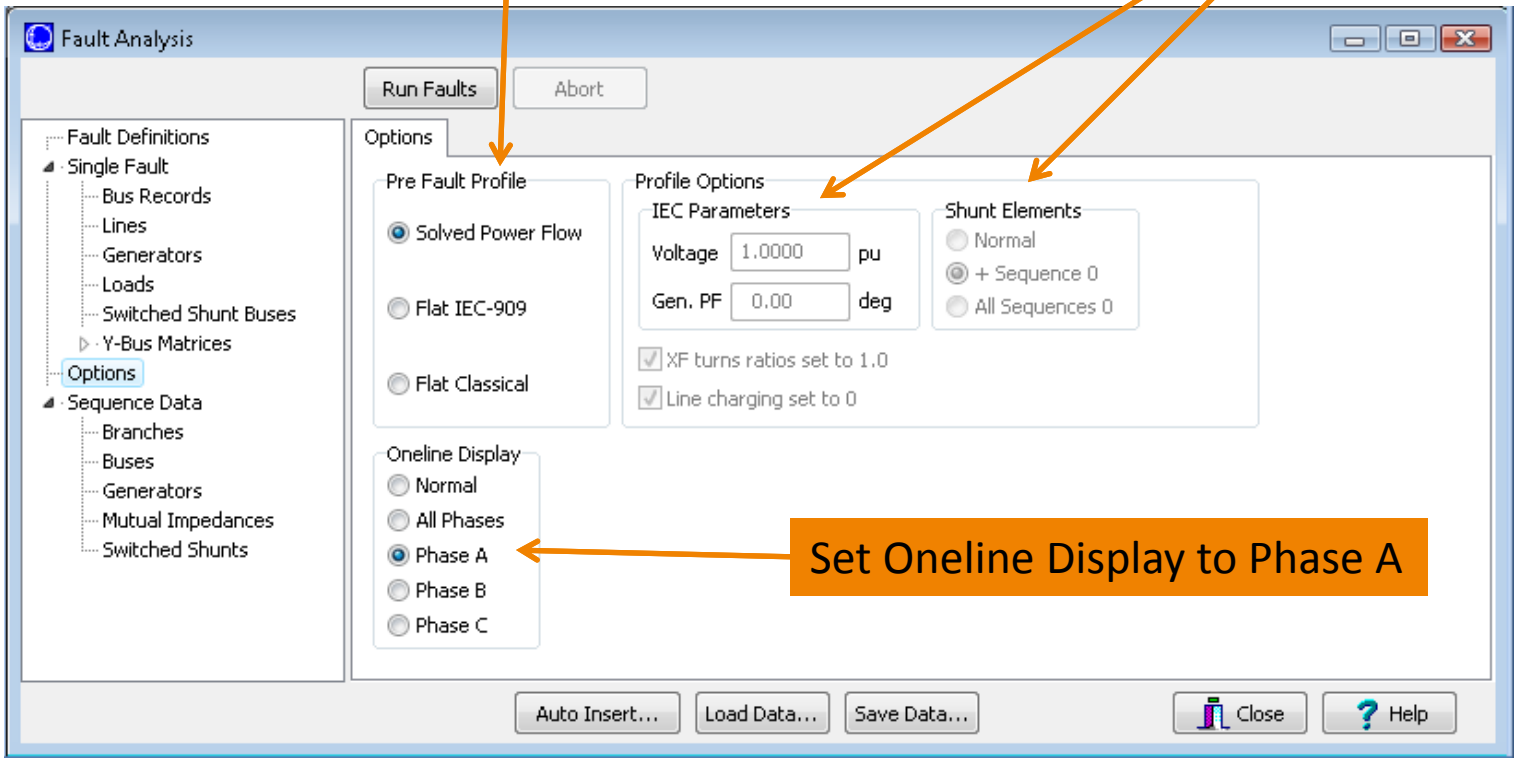
Visualization of Results

- Bus voltage fields replaced with phase voltage magnitude(s) in p.u.
- Bus angle fields replaced with phase voltage angle(s) in degrees
- Branch MW or Amp fields replaced with phase current magnitude(s) in Amps or p.u., as specified
- Branch MVAR fields replaced with phase current angle(s) in degrees
- Generator MW fields replaced with phase current magnitude(s) in Amps or p.u., as specified
- Generator MVAR fields replaced with phase current angle(s) in degrees

Fault Dialog: Options

Can choose Pre Fault Profile (default is Solved Power Flow); re-calculate fault if changes are made

Enabled Options depend on selected Pre Fault Profile

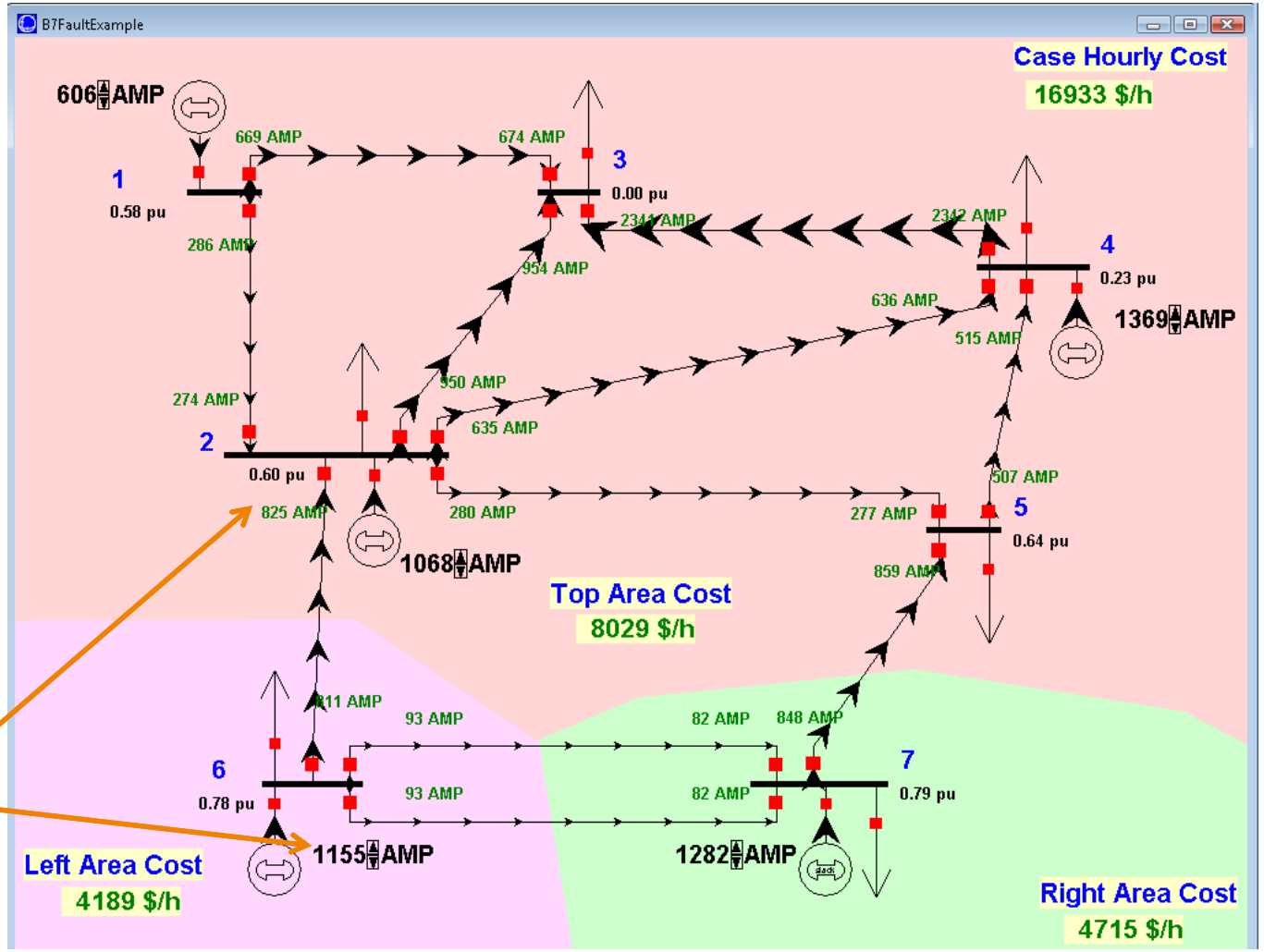


Visualization of Results

Only fields switched to fault analysis results will remain on oneline

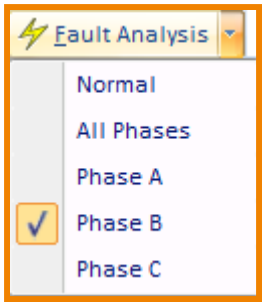
Currents shown are magnitude only; would need to include angles to determine direction

Option on **Single Fault** page to set Units to Amps



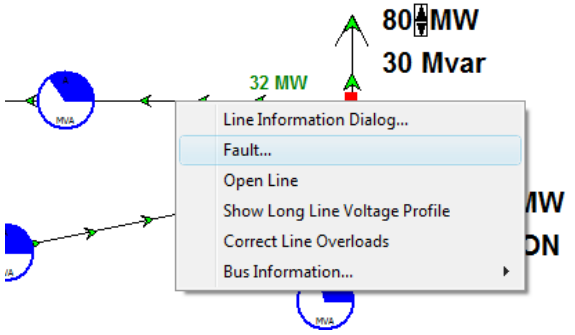
Visualization of Results

- The phase of the fault data displayed on the diagram can be quickly toggled to a different phase by clicking on the drop-down arrow on the Fault Analysis toolbar button and choosing a new visualization setting



Setting the Fault Location: Bus or In-Line

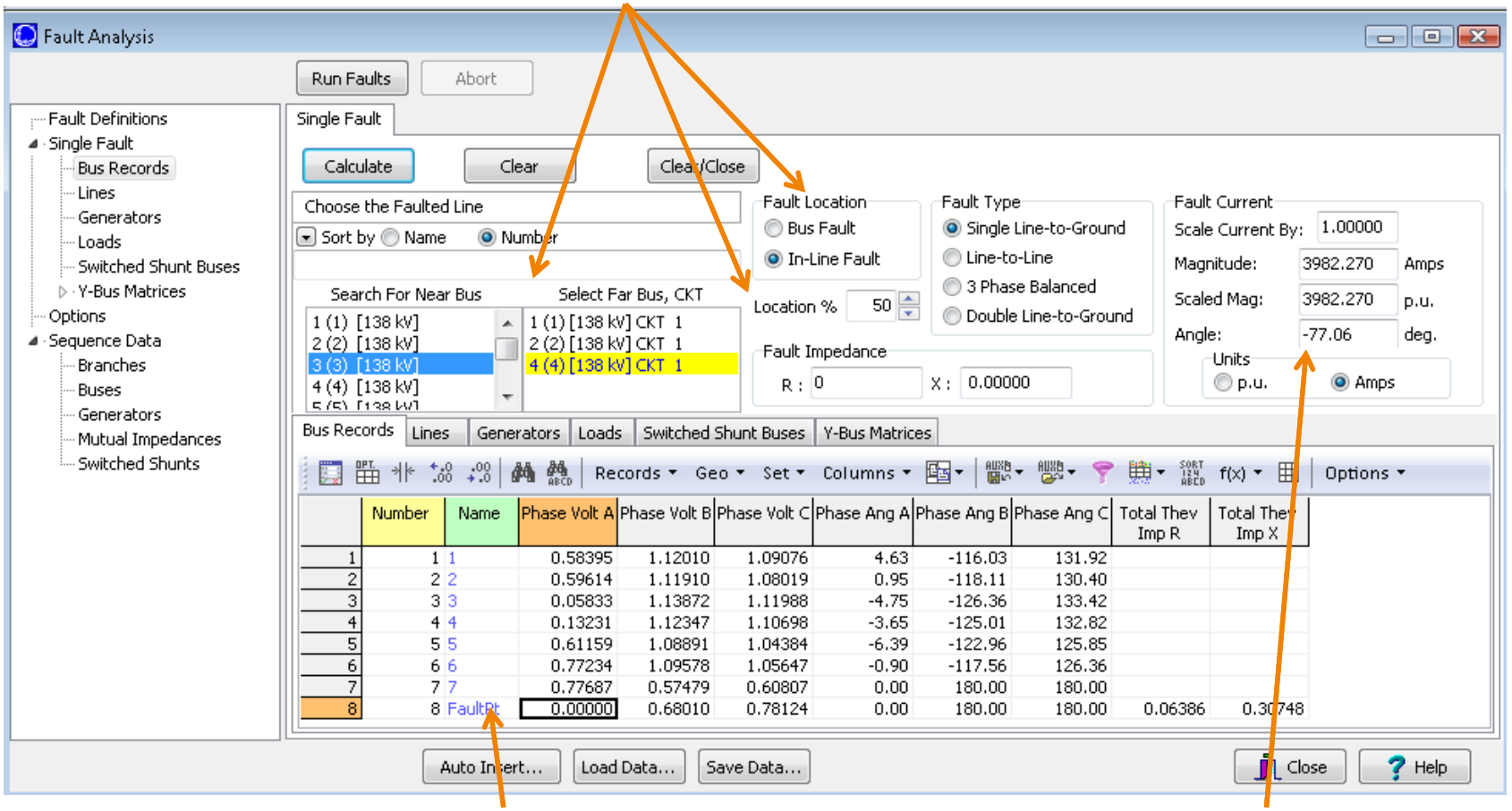
- Fault Location may be set on the Fault Analysis Dialog → **Single Fault** page
- Alternately, you can right-click on a bus or transmission line on the oneline diagram, and select **Fault**… from the menu to have the fault location fields automatically set
  - Selecting **Fault**… for a bus will set the bus number field
  - Selecting **Fault**… for a transmission line will set the from and to bus numbers, the circuit identifier, and the approximate line location as a percentage of the length of the line
  - Any of these fields can still be changed manually



In-Line Fault

- Calculated based on a location given as a percentage distance from the From end of the line
- Inserts a temporary bus and line segments representing the fault point of the line; reflected on the oneline diagram
- Calculations performed the same as a bus fault at the temporary bus
- Example: set Fault Location as in-line, on the branch between buses 3 and 4, at 50% down the line

In-Line Fault

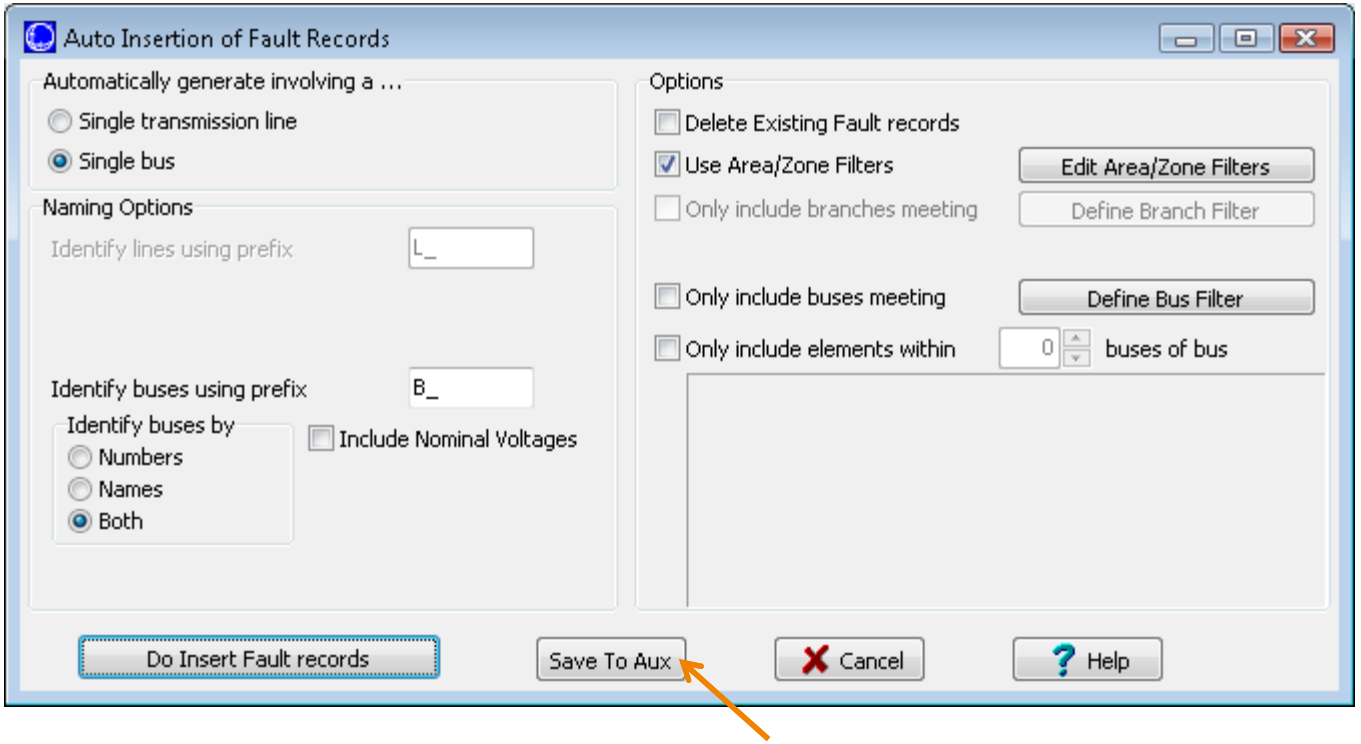


Processing Multiple Faults: Fault Definitions

- Select the **Fault Definitions** page to analyze multiple faults in batch mode, similar to Contingency Analysis
- Click the **Auto-insert**… button
  - Choose **Single-bus** and keep the other defaults
  - Click **Do Insert Fault records**
- Can also insert faults manually

Auto Insert…

- Auto-Insert options similar to those in Contingency Analysis



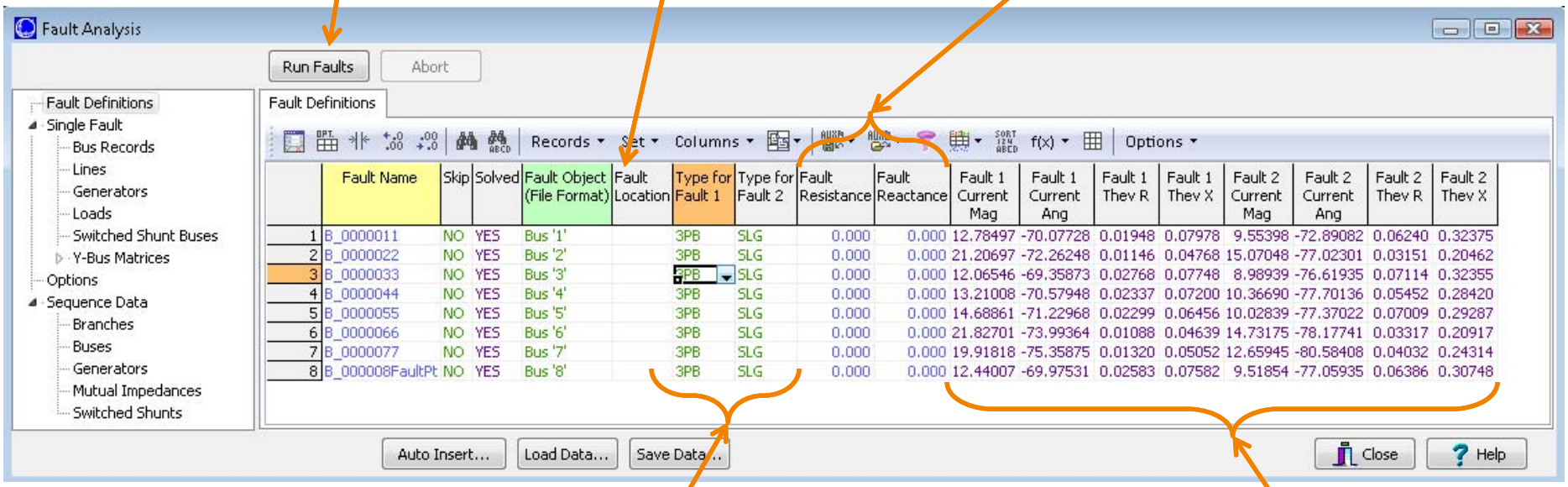
Save auto-insert options to aux file

Fault Definitions

- Click **Run Faults**

Specify location (In-line faults only)

Fault impedance



	Fault Name	Skip	Solved	Fault Object (File Format)	Fault Location	Type for Fault 1	Type for Fault 2	Fault Resistance	Fault Reactance	Fault 1 Current Mag	Fault 1 Current Ang	Fault 1 Thev R	Fault 1 Thev X	Fault 2 Current Mag	Fault 2 Current Ang	Fault 2 Thev R	Fault 2 Thev X
1	B_0000011	NO	YES	Bus '1'		3PB	SLG	0.000	0.000	12.78497	-70.07728	0.01948	0.07978	9.55398	-72.89082	0.06240	0.32375
2	B_0000022	NO	YES	Bus '2'		3PB	SLG	0.000	0.000	21.20697	-72.26248	0.01146	0.04768	15.07048	-77.02301	0.03151	0.20462
3	B_0000033	NO	YES	Bus '3'		3PB	SLG	0.000	0.000	12.06546	-69.35873	0.02768	0.07748	8.98939	-76.61935	0.07114	0.32355
4	B_0000044	NO	YES	Bus '4'		3PB	SLG	0.000	0.000	13.21008	-70.57948	0.02337	0.07200	10.36690	-77.70136	0.05452	0.28420
5	B_0000055	NO	YES	Bus '5'		3PB	SLG	0.000	0.000	14.68861	-71.22968	0.02299	0.06456	10.02839	-77.37022	0.07009	0.29287
6	B_0000066	NO	YES	Bus '6'		3PB	SLG	0.000	0.000	21.82701	-73.99364	0.01088	0.04639	14.73175	-78.17741	0.03317	0.20917
7	B_0000077	NO	YES	Bus '7'		3PB	SLG	0.000	0.000	19.91818	-75.35875	0.01320	0.05052	12.65945	-80.58408	0.04032	0.24314
8	B_000008FaultPt	NO	YES	Bus '8'		3PB	SLG	0.000	0.000	12.44007	-69.97531	0.02583	0.07582	9.51854	-77.05935	0.06386	0.30748

Select 2 different Fault Types; defaults are 3-phase balanced and single line to ground

Only specific results available: fault currents and Thevenin impedances

Fault Analysis: Final Notes

- The fault analysis form can be closed while a fault is calculated without clearing the fault; the values will remain in memory until manually cleared or the case is saved or closed
- A Double Line fault automatically uses a Fault Impedance of 999+j999 and ignores the Fault Impedance settings; use a Double Line to Ground fault to specify a desired Fault Impedance

Fault Analysis: Final Notes

- Before visualizing fault analysis currents in p.u., you may need to first change the number of decimal places for the branch and generator MW and MVAR fields
- Once Sequence Data is loaded from an external file, saving the case file will store the sequence data with the *.pwb as well