



Faculty of Engineering and Technology
Electrical and Computer Engineering Department
Power Systems (ENEE4403)

“Power World Simulator Tutorial”

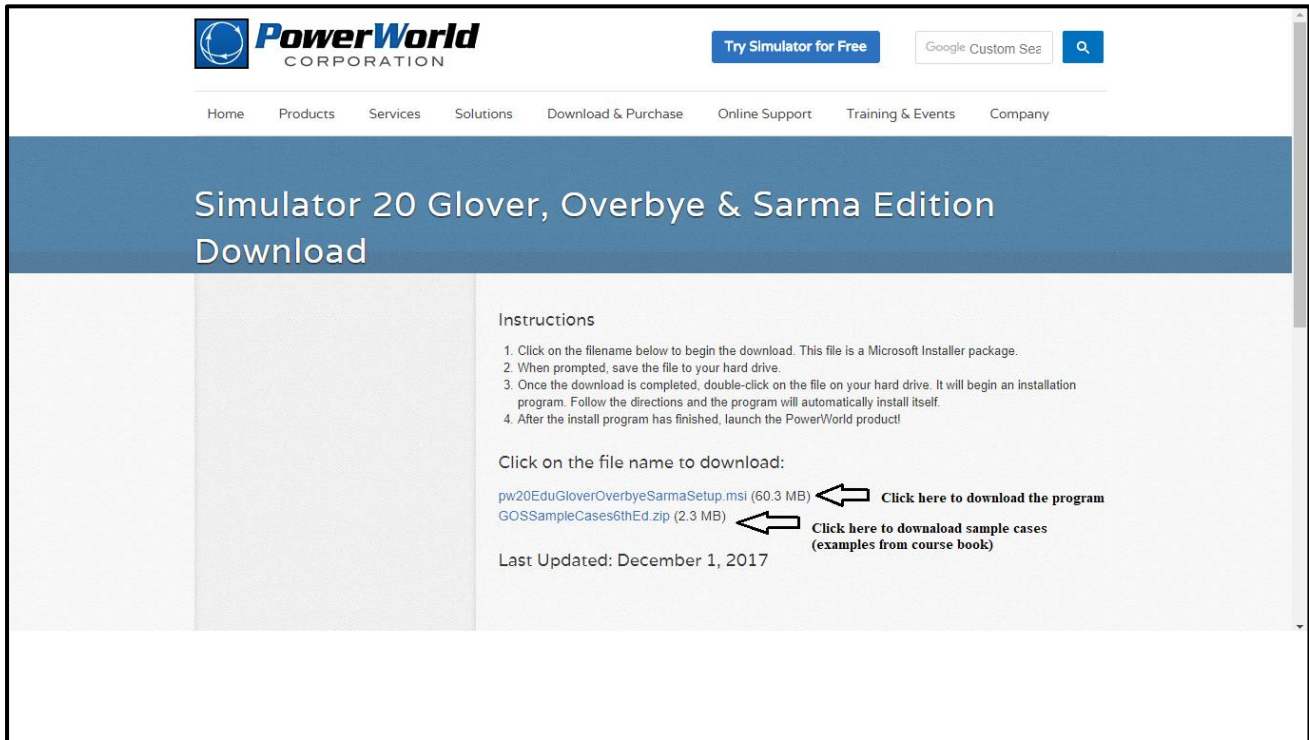
Prepared by: Qais Samara

Date: 3 / 12 / 2017

✚ Downloading and installing the program:

Click on the following link, you will be redirected to the page shown below where you can download the program and sample cases:

<https://www.powerworld.com/download-purchase/demo-software/simulator-20-glover-overbye-sarma-edition-download>



PowerWorld CORPORATION

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Simulator 20 Glover, Overbye & Sarma Edition Download

Instructions

1. Click on the filename below to begin the download. This file is a Microsoft Installer package.
2. When prompted, save the file to your hard drive.
3. Once the download is completed, double-click on the file on your hard drive. It will begin an installation program. Follow the directions and the program will automatically install itself.
4. After the install program has finished, launch the PowerWorld product!

Click on the file name to download:

[pw20EduGloverOverbyeSarmaSetup.msi \(60.3 MB\)](#) ← Click here to download the program

[GOSSampleCases6thEd.zip \(2.3 MB\)](#) ← Click here to download sample cases (examples from course book)

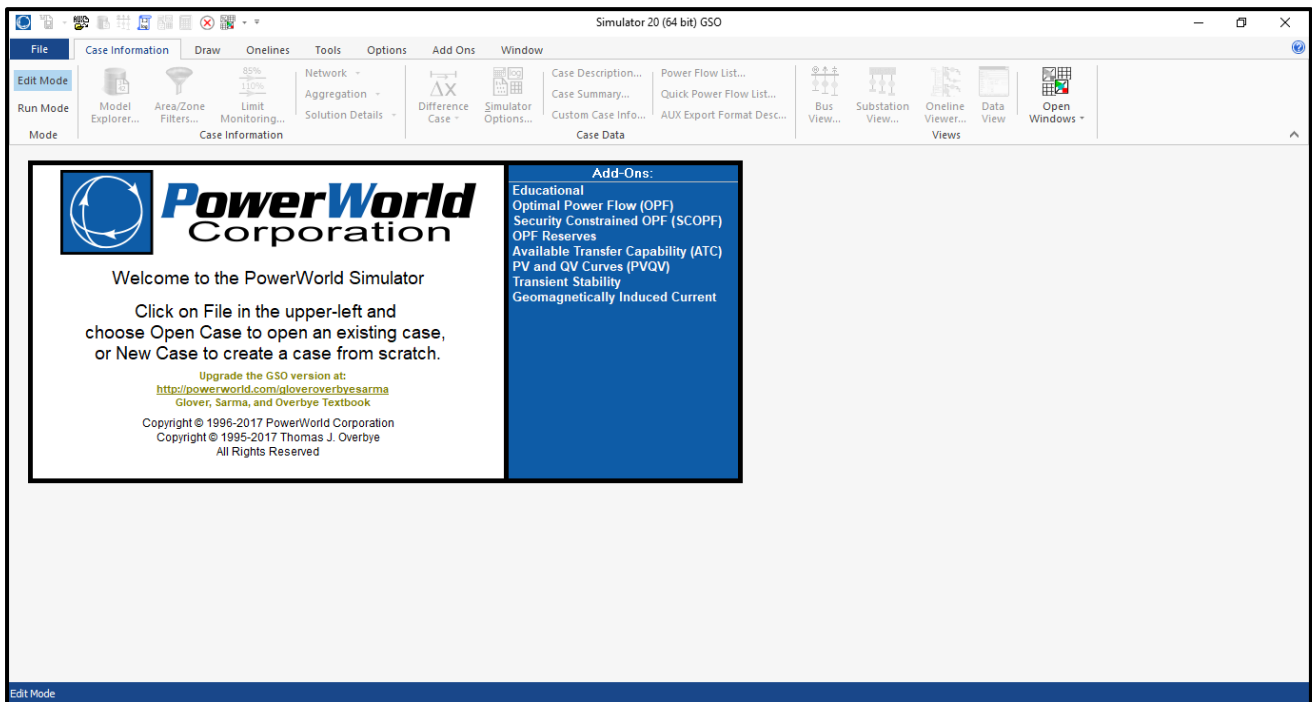
Last Updated: December 1, 2017

Note: you might need to zoom in so you can see some of the figures in this document clearly

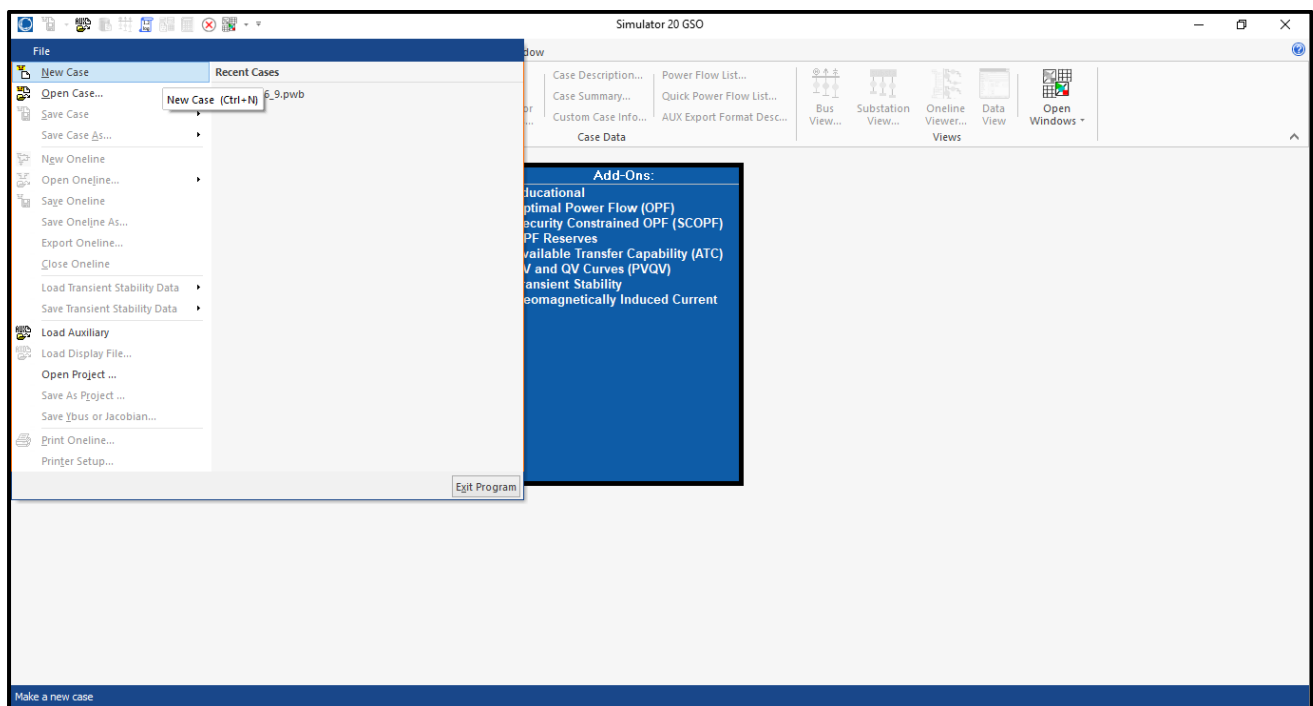
Installing the program is simple! Just keep clicking Next! you do not need to do crack or any other thing, this is a free demo software.

Opening the program, and starting a new case:

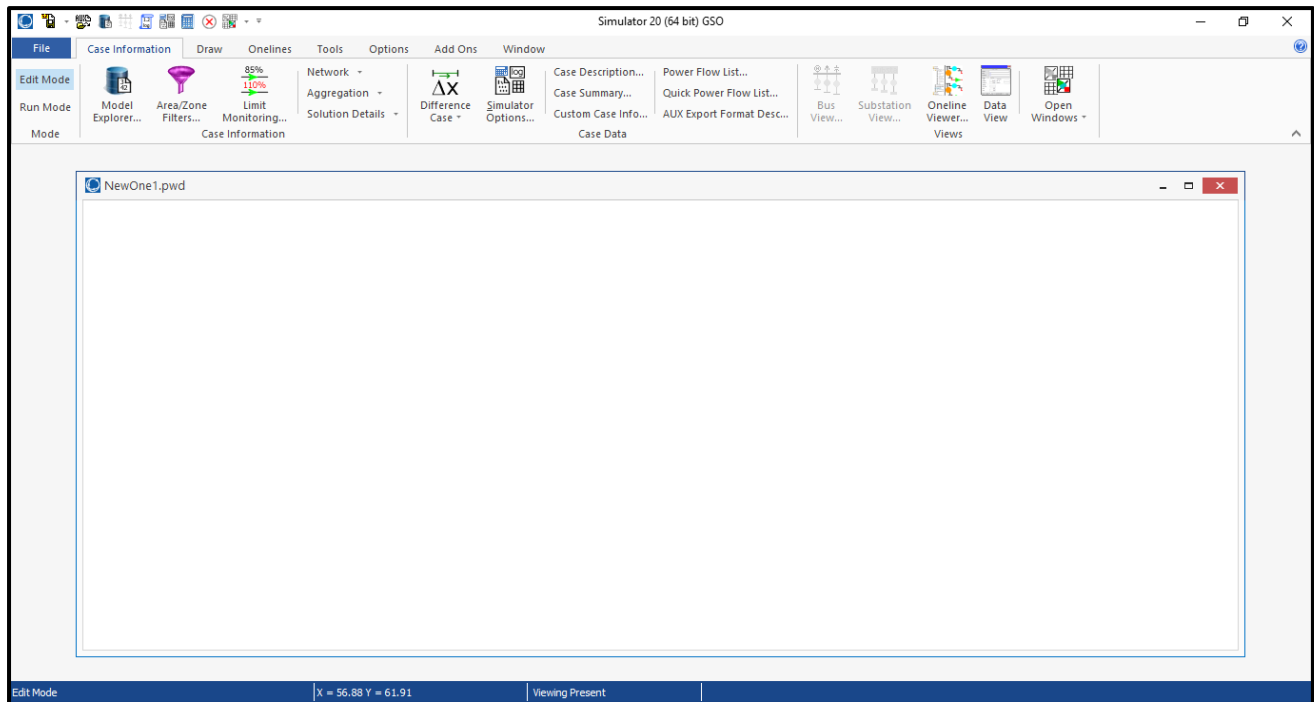
Once you have installed the program, open the start menu and search for “simulator GOS education 20” then open the program and you will see the following window:



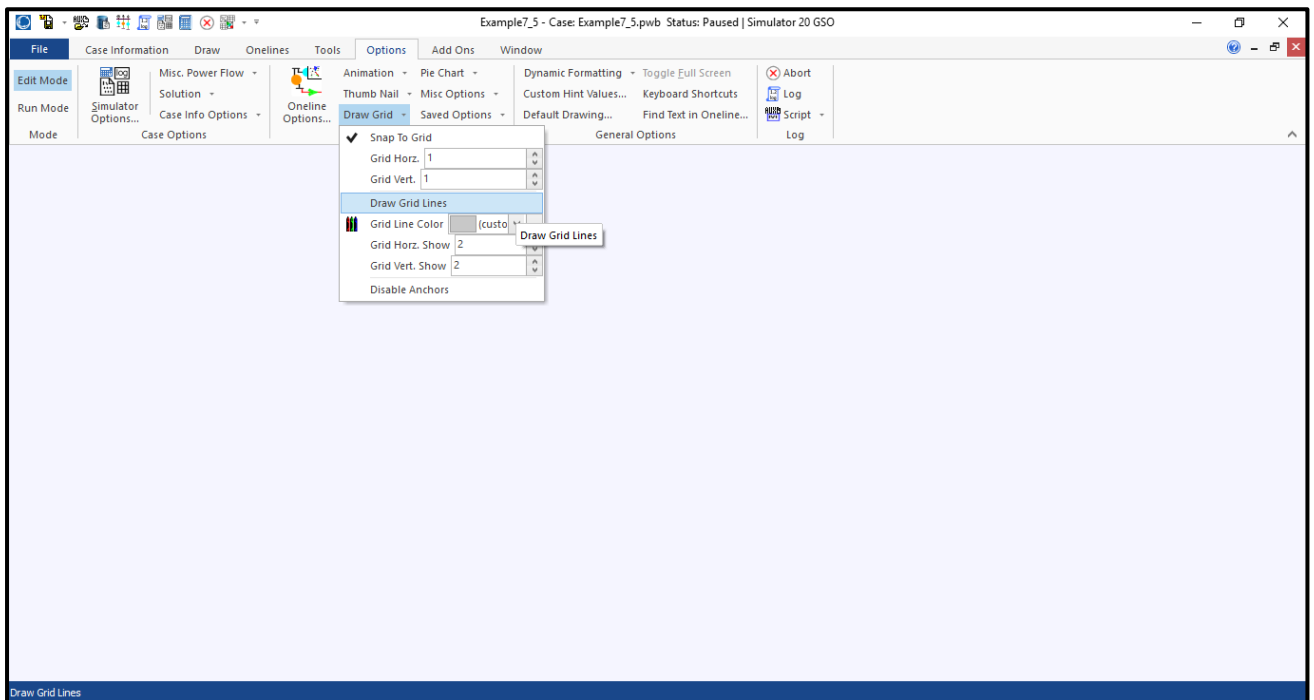
To start a new case, click on file then new case as shown below:



Once you have opened a new case you will see the following window, Maximize the case window:



Lets add a grid to the background, click on options then draw grid as shown below, note that you can modify grid spacing e.g. I have selected 2x2 grid:



Building a system: inserting components

We will build the system shown below which is taken from example 6.9 in course book, data tables of the system are given below.

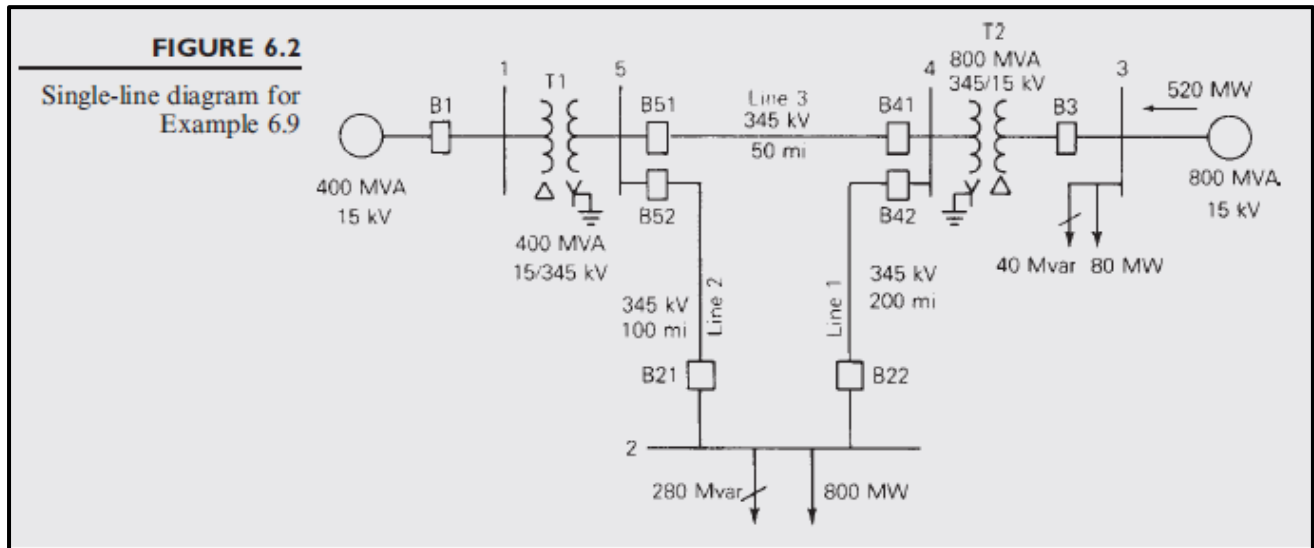


TABLE 6.1		V	δ	P_G	Q_G	P_L	Q_L	Q_{Gmax}	Q_{Gmin}
Bus input data for Example 6.9*		per unit	degrees	per unit	per unit	per unit	per unit	per unit	per unit
1	Swing	1.0	0	—	—	0	0	—	—
2	Load	—	—	0	0	8.0	2.8	—	—
3	Constant voltage	1.05	—	5.2	—	0.8	0.4	4.0	-2.8
4	Load	—	—	0	0	0	0	—	—
5	Load	—	—	0	0	0	0	—	—
* $S_{base} = 100$ MVA, $V_{base} = 15$ kV at buses 1, 3, and 345 kV at buses 2, 4, 5									

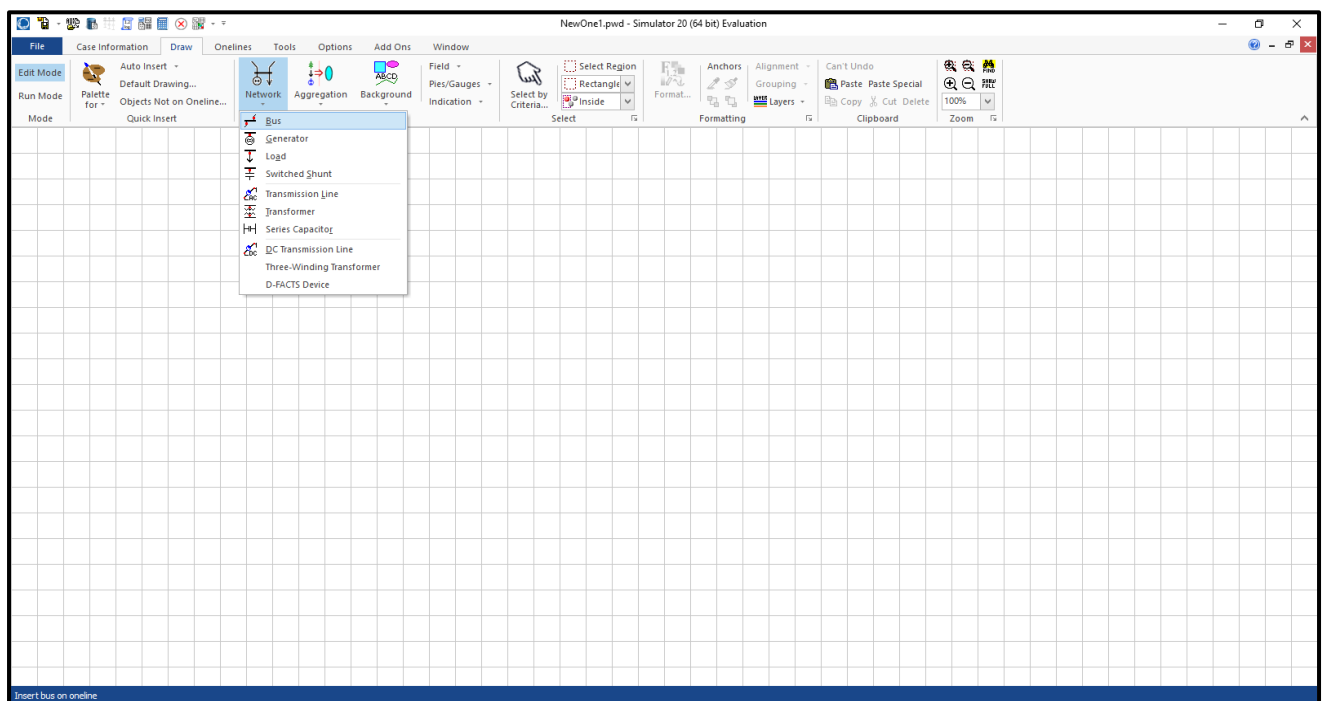
TABLE 6.2		R'	X'	G'	B'	Maximum MVA
Line input data for Example 6.9		per unit	per unit	per unit	per unit	per unit
2-4		0.0090	0.100	0	1.72	12.0
2-5		0.0045	0.050	0	0.88	12.0
4-5		0.00225	0.025	0	0.44	12.0

TABLE 6.3		R	X	G_c	B_m	Maximum MVA	Maximum TAP Setting
Transformer input data for Example 6.9		per unit	per unit	per unit	per unit	per unit	per unit
1-5		0.00150	0.02	0	0	6.0	—
3-4		0.00075	0.01	0	0	10.0	—

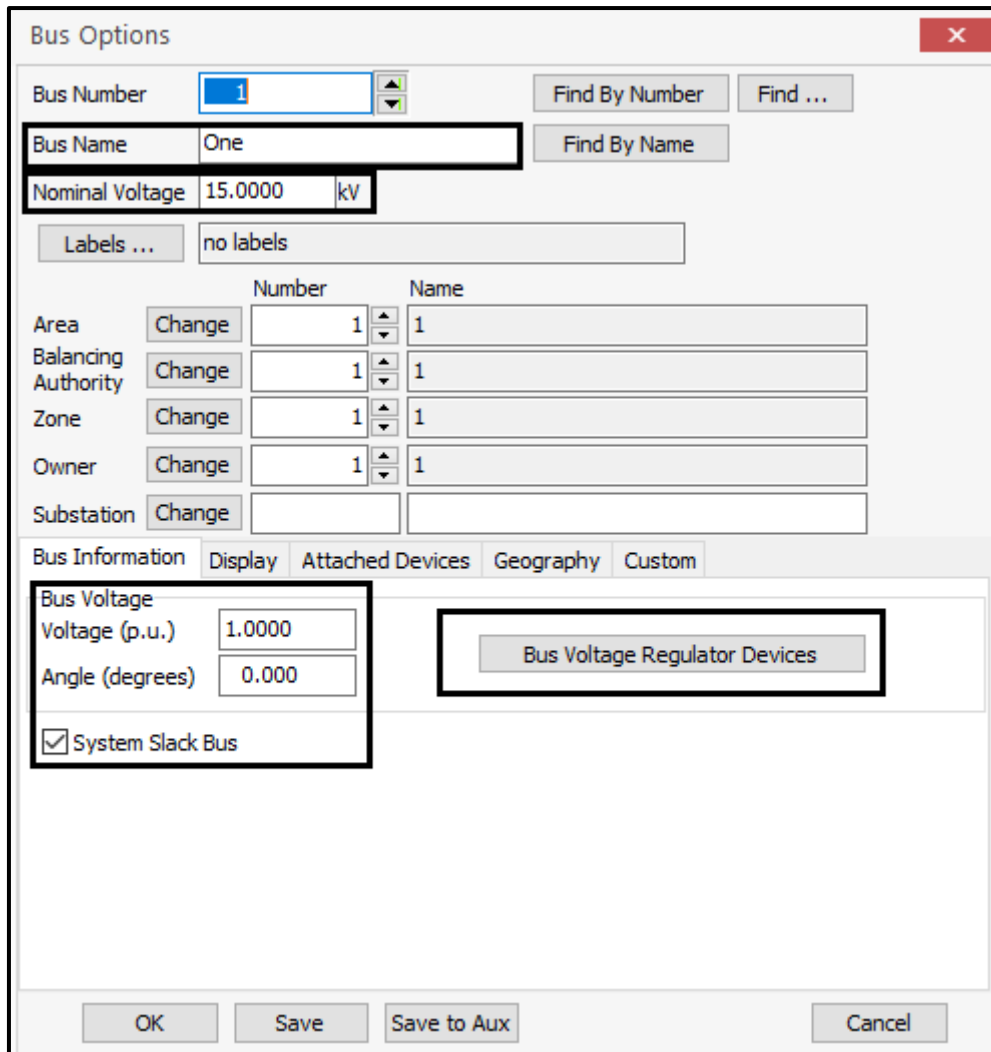
TABLE 6.4			
Input data and unknowns for Example 6.9	Bus	Input Data	Unknowns
	1	$V_1 = 1.0, \delta_1 = 0$	P_1, Q_1
	2	$P_2 = P_{G2} - P_{L2} = -8$ $Q_2 = Q_{G2} - Q_{L2} = -2.8$	V_2, δ_2
	3	$V_3 = 1.05$ $P_3 = P_{G3} - P_{L3} = 4.4$	Q_3, δ_3
	4	$P_4 = 0, Q_4 = 0$	V_4, δ_4
	5	$P_5 = 0, Q_5 = 0$	V_5, δ_5

➤ First: inserting buses

1. To be able to add components you must be in the “Edit mode” selected at the left top corner of the program window.
2. The simulator has two distinct modes: “Edit Mode” and “Run Mode”. The Edit Mode is used to construct new simulation cases or to modify existing cases, while the Run Mode is used to perform the actual power system simulation. You can easily switch between the modes using the Edit Mode and Run Mode buttons
3. Always start by adding system buses, as other components (loads, generators, transformers ... etc.) are attached to buses.
4. To add a bus, click on “draw” tab, “network” list then select “bus” as shown below:



5. When you select “bus” a “cross cursor (+)” will show up inside the work window, just click once and the following window will show up:

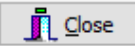
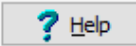


6. The data you have to insert is the bus “base voltage or nominal voltage”, and you can add a bus name
7. You may need to insert other data depending on the type of the bus:
 - If the bus is a slack bus, then you have to tick the “system slack bus box” and by default the voltage is 1_{PU} and the angle is zero.
 - If the bus is a voltage controlled bus (a bus to which a generator is connected), then you have to insert the bus voltage by clicking the button then the window on the next page will show up:

Bus Voltage Regulating Devices Dialog

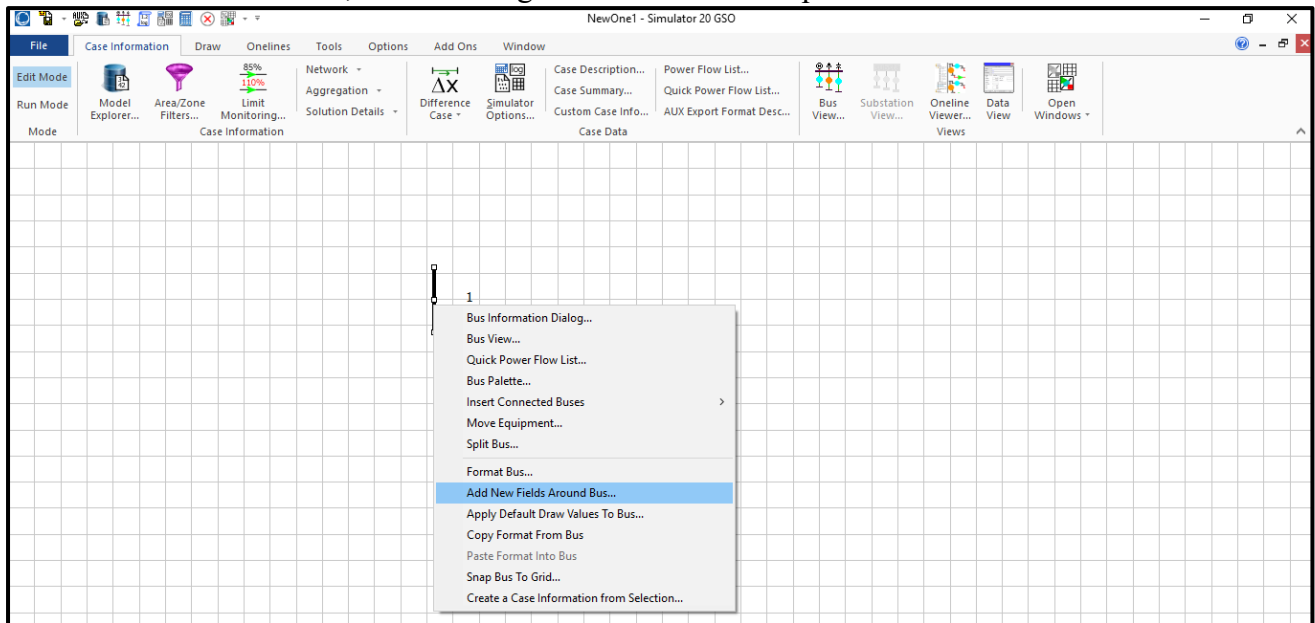
Bus	3	Name	Three
Area	1		1
Zone	1		1
Owner	1		1
Substation	not assigned to substa		not assigned to substation
Voltage (p.u.)	1.0000	Voltage (kV)	15.0000

	Device	Device Type	Reg Voltage Max	Reg Voltage Min	Device Voltage Target	Transformer Regulation Target Type	Device Voltage Target High
1	3 (Three 15.0) #1	Generator			1.0500		

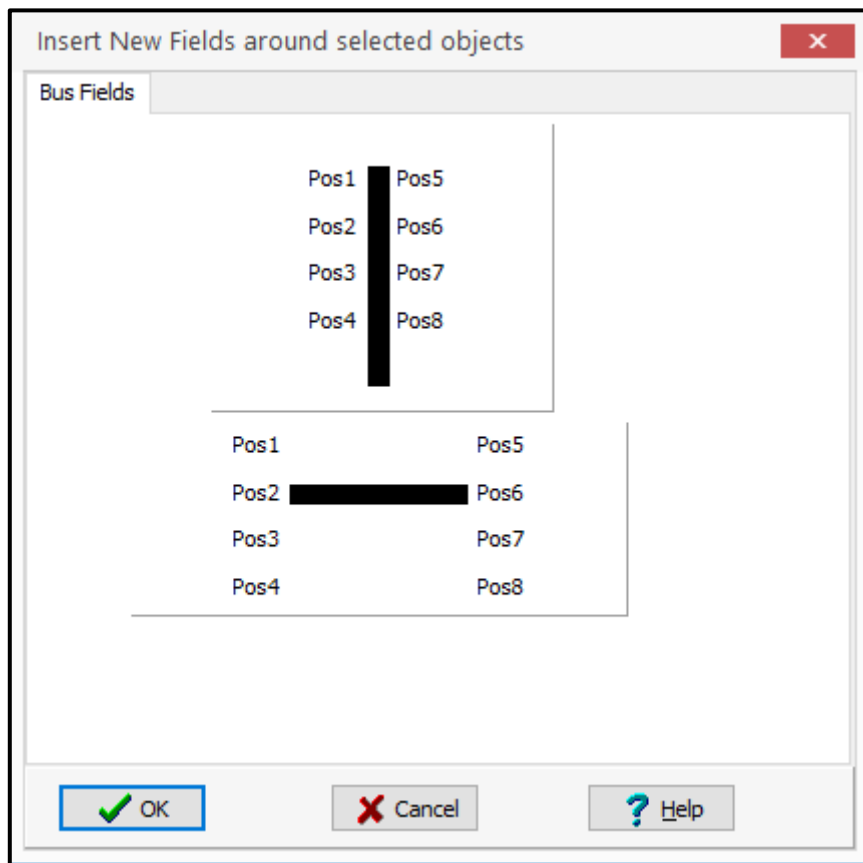



- The bus voltage is inserted in the indicated field shown on the figure.
 - For other buses, the bus voltage is left as default and when you run the program it will calculate the bus voltage.
8. If you select “display” tab in the bus options window, you can modify bus size and orientation.

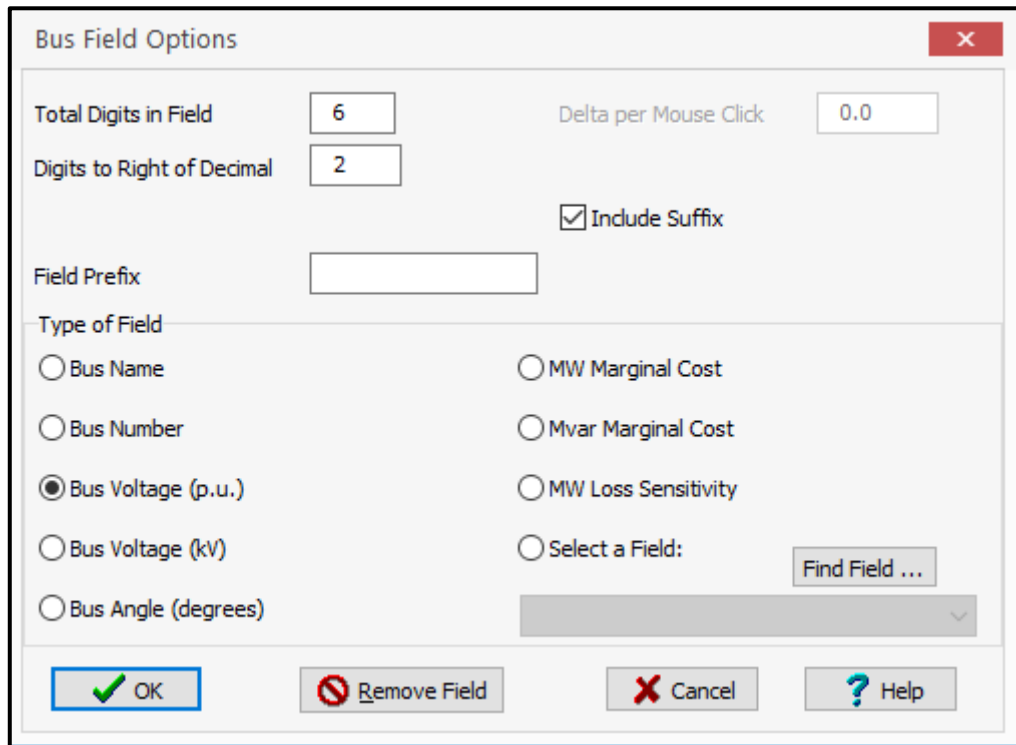
9. to show the bus voltage in the work window, right click on the bus and select “add new field around bus”, the following window will show up:



10. Select the position where you want the bus voltage to be placed by clicking on it.



11. Select the data that you want to be displayed.

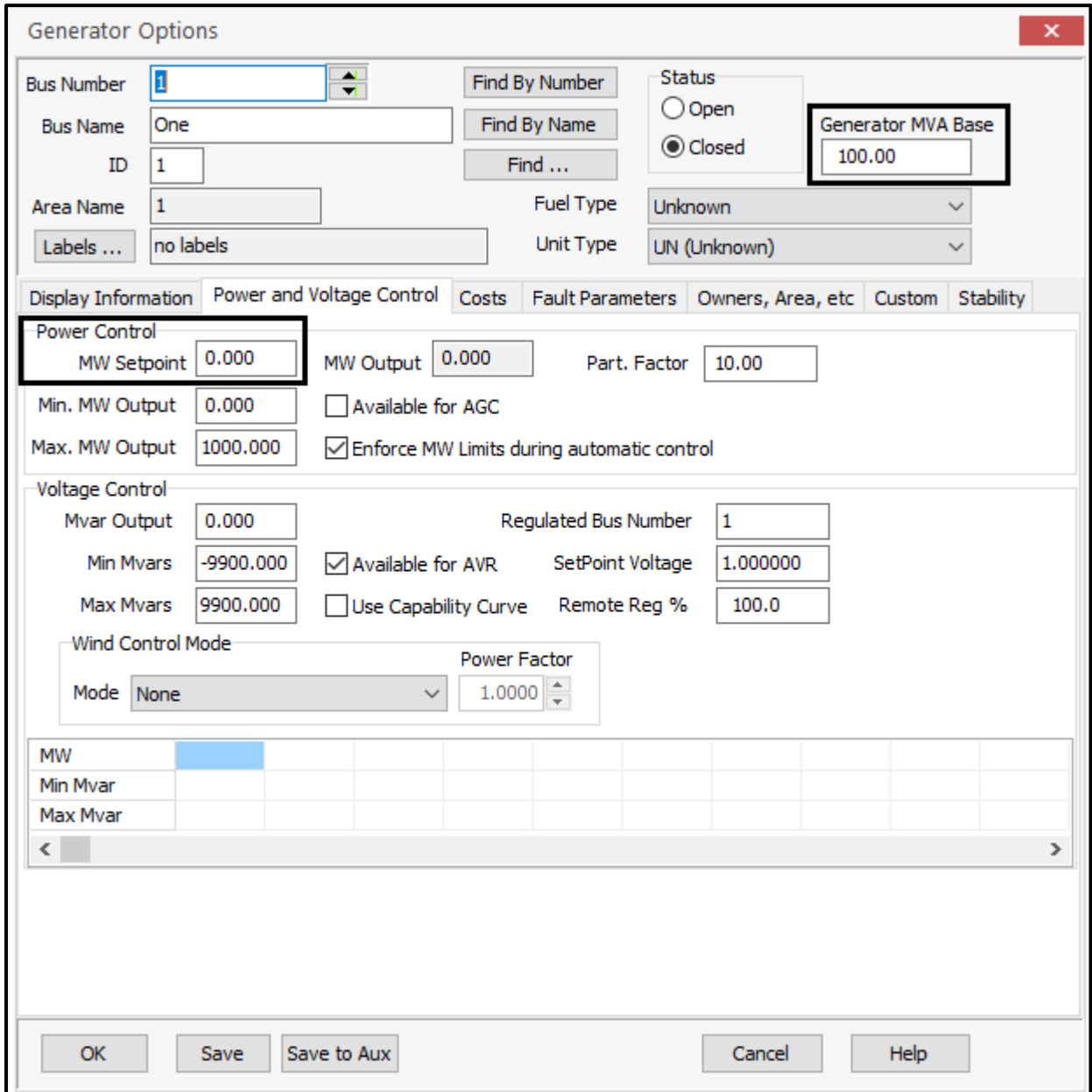


The image shows a 'Bus Field Options' dialog box with the following fields and controls:

- Total Digits in Field:** A text box containing the value '6'.
- Delta per Mouse Click:** A text box containing the value '0.0'.
- Digits to Right of Decimal:** A text box containing the value '2'.
- Include Suffix:** A checked checkbox.
- Field Prefix:** An empty text box.
- Type of Field:** A section containing several radio button options:
 - ☐ Bus Name
 - ☐ Bus Number
 - ☒ Bus Voltage (p.u.)
 - ☐ Bus Voltage (kV)
 - ☐ Bus Angle (degrees)
 - ☐ MW Marginal Cost
 - ☐ Mvar Marginal Cost
 - ☐ MW Loss Sensitivity
 - ☐ Select a Field:
- Select a Field:** A dropdown menu with a 'Find Field ...' button next to it.
- Buttons:** At the bottom, there are four buttons: 'OK' (with a green checkmark icon), 'Remove Field' (with a red 'X' icon), 'Cancel' (with a red 'X' icon), and 'Help' (with a blue question mark icon).

➤ **Second: inserting generators**

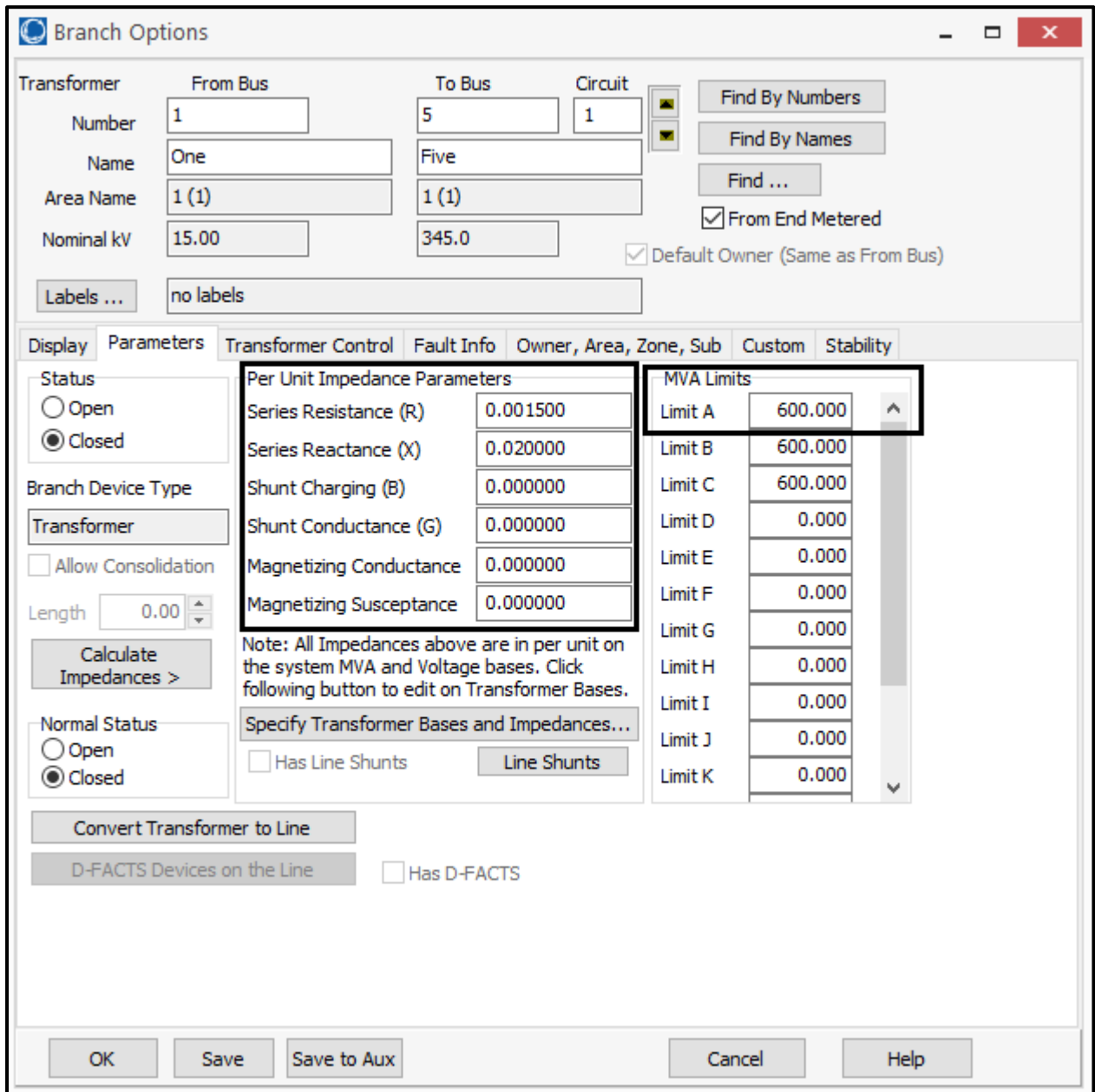
1. To insert a generator, go to draw tab (the same tab from where you have inserted bus) and select generator, then click on the bus you want to add a generator to, the following window will show up:



2. The data you have to insert is generator MVA base only.
3. If the generator is connected to a voltage controlled bus, then you have to insert real power in the “MW set point” field.
4. If the generator is connected to a slack bus, then you do not have to insert the power values, leave them zero, and when you run the program it will calculate power values.

➤ **Third: inserting transformers**

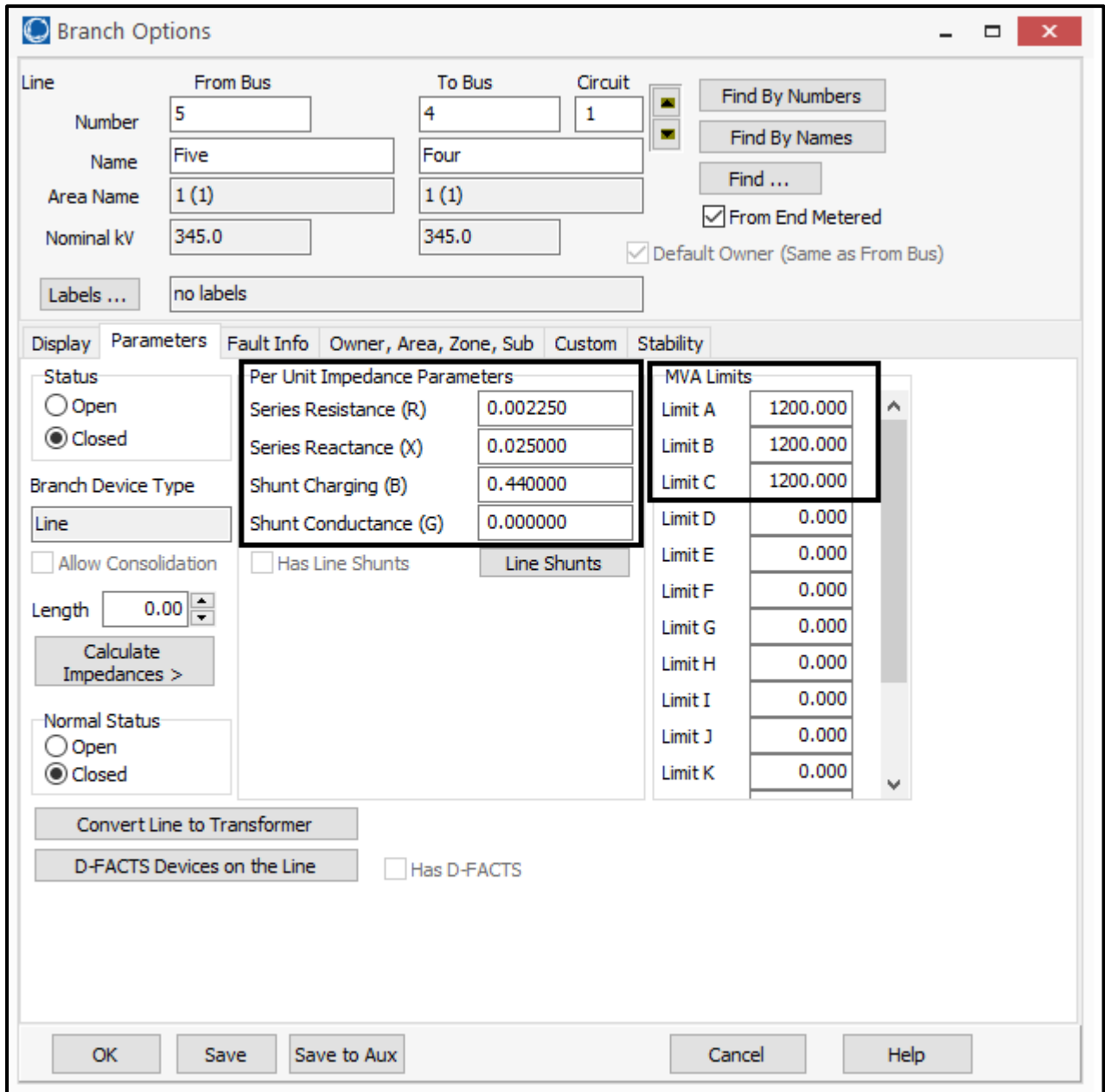
1. To insert a transformer, go to draw tab (the same tab from where you have inserted bus) and select transformer:
 - Single click on the first bus to which the transformer is connected.
 - Drag the cursor to the second bus where the transformer is connected, then **double click on it** and the following window will show up:



2. The data you have to insert is shown in the indicated boxes in the figure above, this data is taken from tables of example 6.9.
3. Note that the number and voltages of buses to which the transformer is connected are loaded automatically.
4. Other transformers are inserted similarly.

➤ **Fourth: inserting transmission line**

1. To insert transmission line, follow the same steps of inserting transformer after selecting transmission line from draw tab.
2. When you finish drawing the transmission line, the following window will show up:



Series Resistance (R)	0.002250
Series Reactance (X)	0.025000
Shunt Charging (B)	0.440000
Shunt Conductance (G)	0.000000

Limit A	1200.000
Limit B	1200.000
Limit C	1200.000
Limit D	0.000
Limit E	0.000
Limit F	0.000
Limit G	0.000
Limit H	0.000
Limit I	0.000
Limit J	0.000
Limit K	0.000

3. The data you have to insert is shown in the indicated boxes in the figure above, this data is taken from tables of example 6.9.
4. If transmission line per unit impedances are not give, you can calculate them using the program by clicking on “calculate impedances>” which will open the following window:

Line Per Unit Impedance Calculator

Actual Impedance and Current Limits

R (Ohms/mile)

X (Ohms/mile)

B (Mhos/mile) $\times 10^{-6}$

G (Mhos/mile) $\times 10^{-6}$

Limit A (Amps)

Limit B (Amps)

Limit C (Amps)

Limit D (Amps)

Limit E (Amps)

Limit F (Amps)

Limit G (Amps)

Limit H (Amps)

Conductor Type

Tower Configuration

Calculate PU Impedances From
Conductor Type and Tower
Configuration

OK

Line Length

miles

When changing convert:

☒ PU/MVA --->

☐ <--- Electrical

Length Units

☒ miles

☐ kilometers

System Base Values

Power Base (MVA)

Voltage Base (kV)

Impedance Base (Ohms)

Admittance Base (Mhos)

Per Unit Impedance and MVA Limits

R (pu)

X (pu)

B (pu)

G (pu)

Limit A (MVA)

Limit B (MVA)

Limit C (MVA)

Limit D (MVA)

Limit E (MVA)

Limit F (MVA)

Limit G (MVA)

Limit H (MVA)

Limit I (MVA)

Limit J (MVA)

Limit K (MVA)

Limit L (MVA)

Limit M (MVA)

Limit N (MVA)

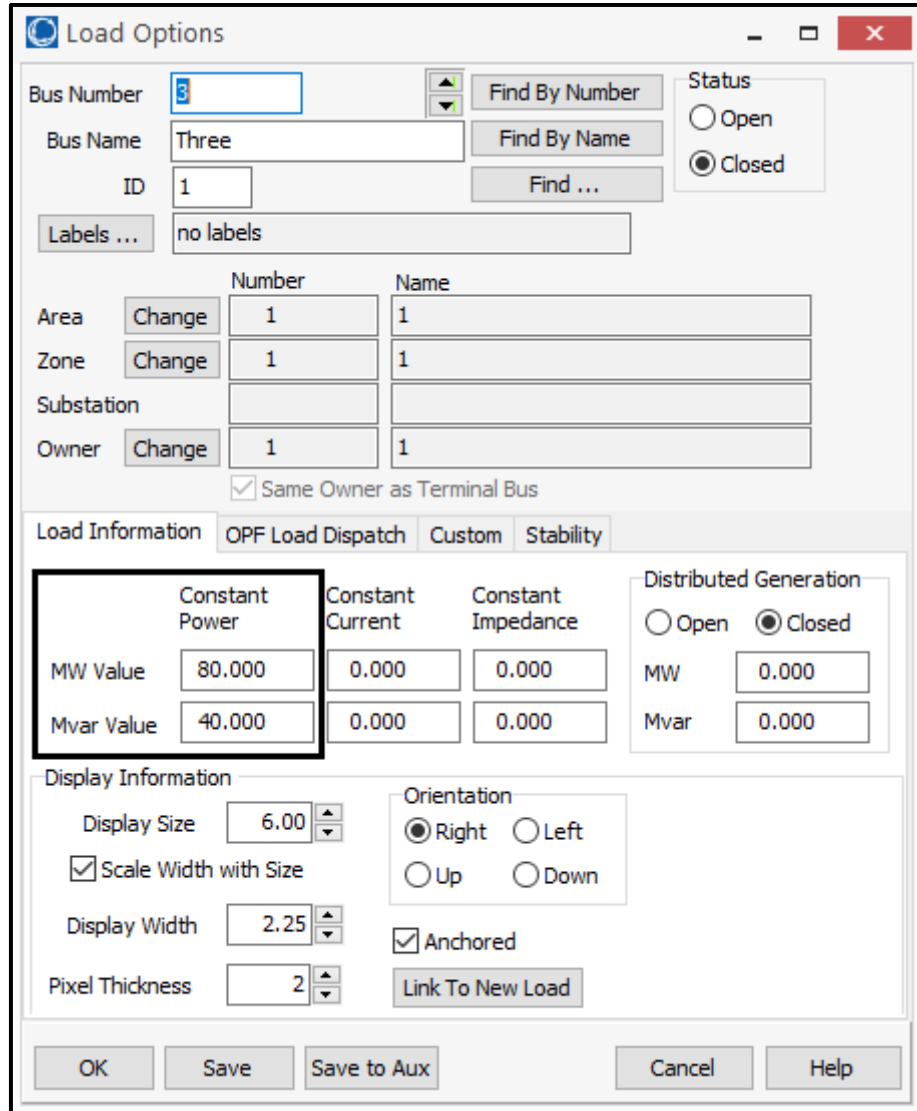
Help

Cancel

5. Other transmission lines are inserted similarly.

➤ **Fifth: inserting loads**

1. To insert a load, go to draw tab (the same tab from where you have inserted bus) and select load, then click on the bus you want to add a load to, the following window will show up:

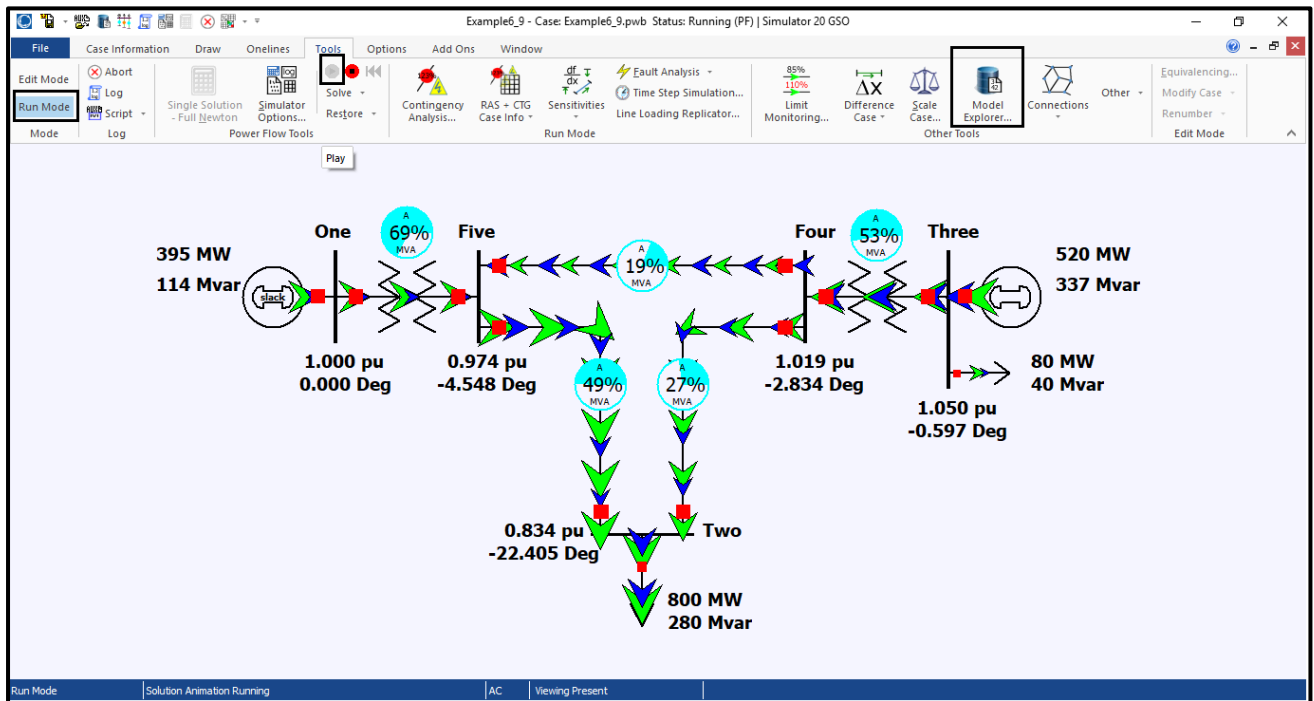
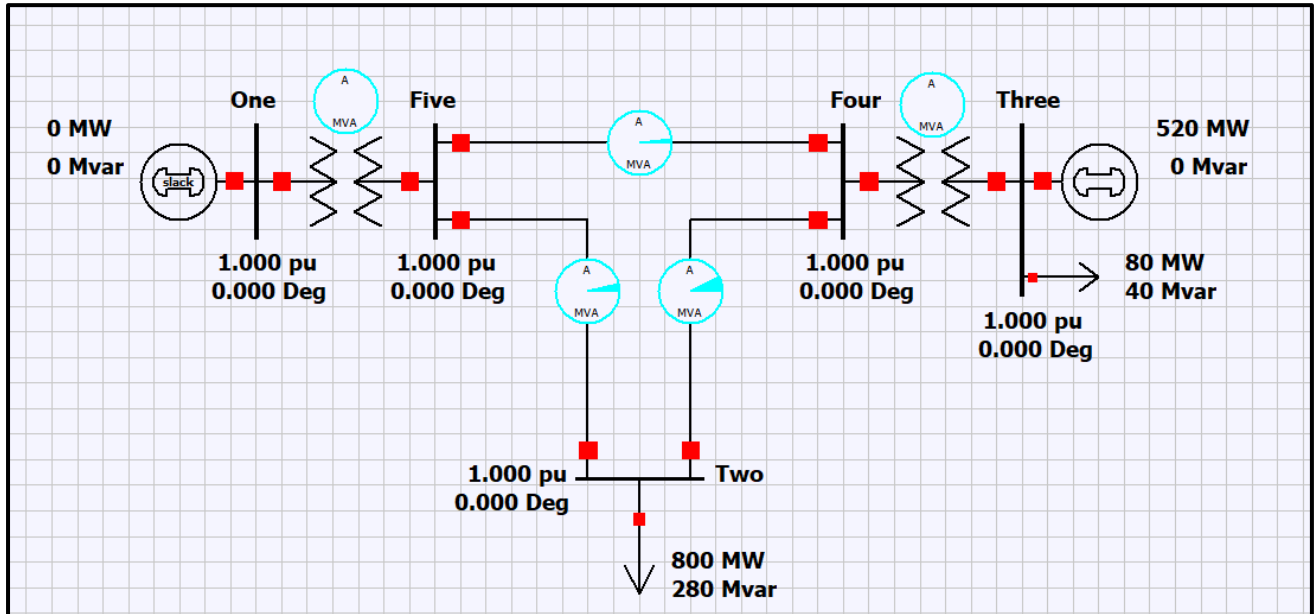


	Constant Power	Constant Current	Constant Impedance
MW Value	80.000	0.000	0.000
Mvar Value	40.000	0.000	0.000

2. The data you have to insert is shown in the indicated boxes in the figure above, this data is taken from tables of example 6.9.
3. Other loads are inserted similarly.

Running the program and solving the case:

After you have finished building the system, your window should be similar to the following figure.



To solve the case, first select “Run mode”, then go to “Tools” tab and select the green play button as shown below:

To show the percentage of loading on pie charts above transmission line and transformers as in the figure in the previous page right click on the pie chart and the following window will show up: tick the box show in the figure below.

Line/Transformer Flow Pie Chart
X

	Near Bus	Far Bus	Circuit
Number	5	4	1
Name	Five	Four	
Nom kV	345.0000	345.0000	
Substation			
Labels			

Find ...
Switch Near/Far

MVA Rating

1200.000

Percent

18.8

Size

10.0

☐ Ignore Dynamic Sizing
☐ Ignore Dynamic Open Sizing

☒ Always Show Value (Percent)
☒ Anchored

Style

☒ * Use Online Options
☐ Total power (MVA)
☐ Real power (MW)
☐ Reactive power (Mvar)

☐ Line Amp, Transf. MVA
☐ Max % Load Cont.
☐ PTDF

* recommended setting

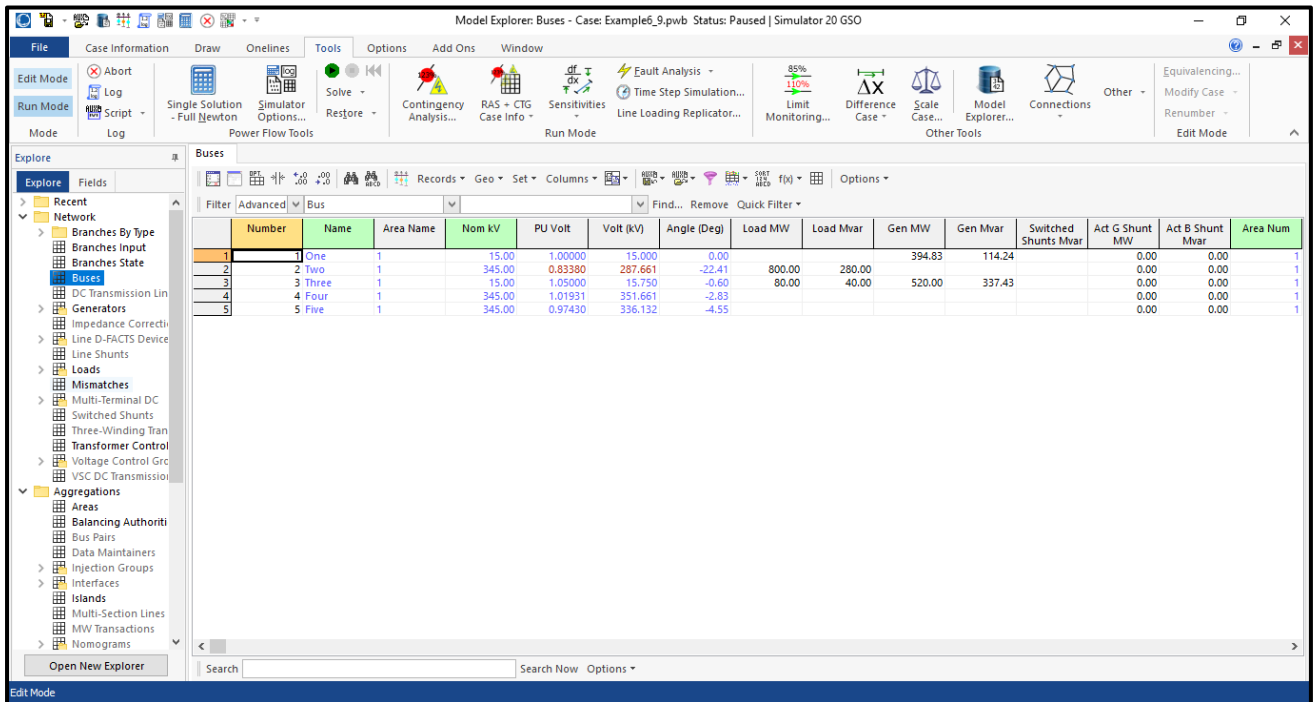
View Pie Chart Display Options

✓ OK

X Cancel

? Help

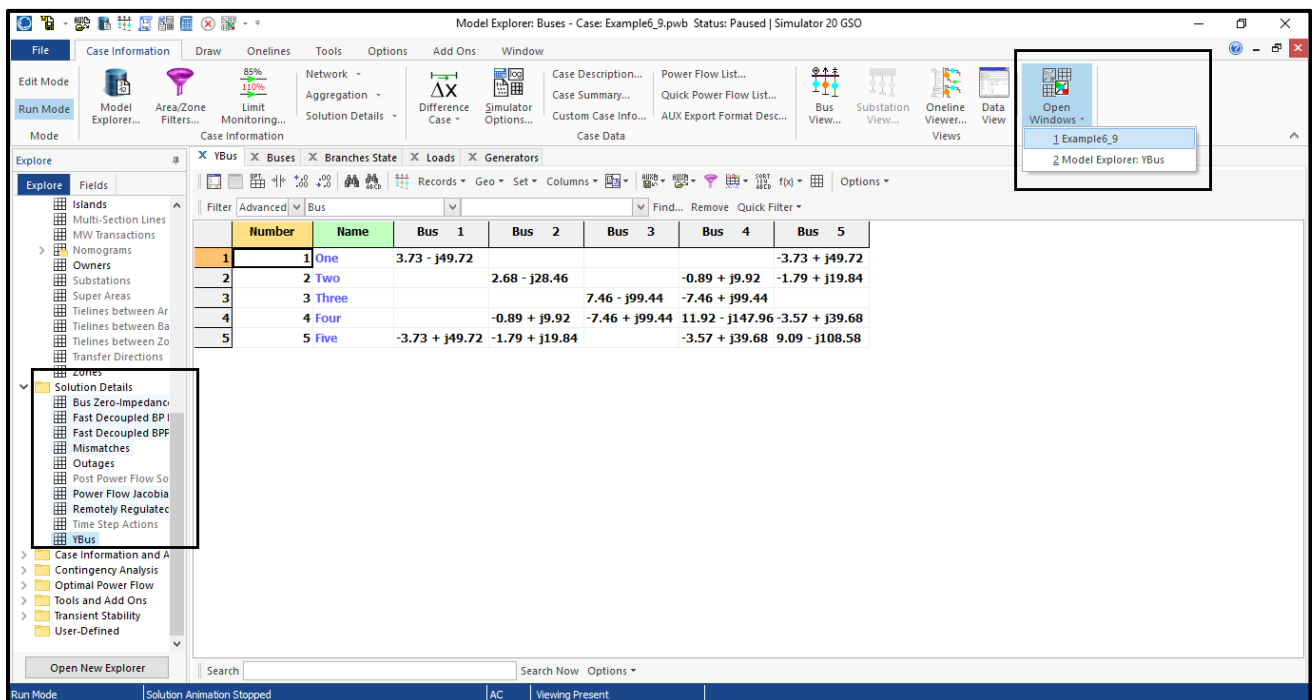
This figure just shows the direction of power flow, the solution details can be reached by clicking on the “model explorer” button shown above, which will show the following window:



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 Shunt MW	Act B Shunt Mvar	Area Num
1	One	1	15.00	1.00000	15.000	0.00			394.83	114.24		0.00	0.00	1
2	Two	1	345.00	0.83380	287.661	-22.41	800.00	280.00				0.00	0.00	1
3	Three	1	15.00	1.05000	15.750	-0.60	80.00	40.00	520.00	337.43		0.00	0.00	1
4	Four	1	345.00	1.01931	351.661	-2.83						0.00	0.00	1
5	Five	1	345.00	0.97430	336.132	-4.55						0.00	0.00	1

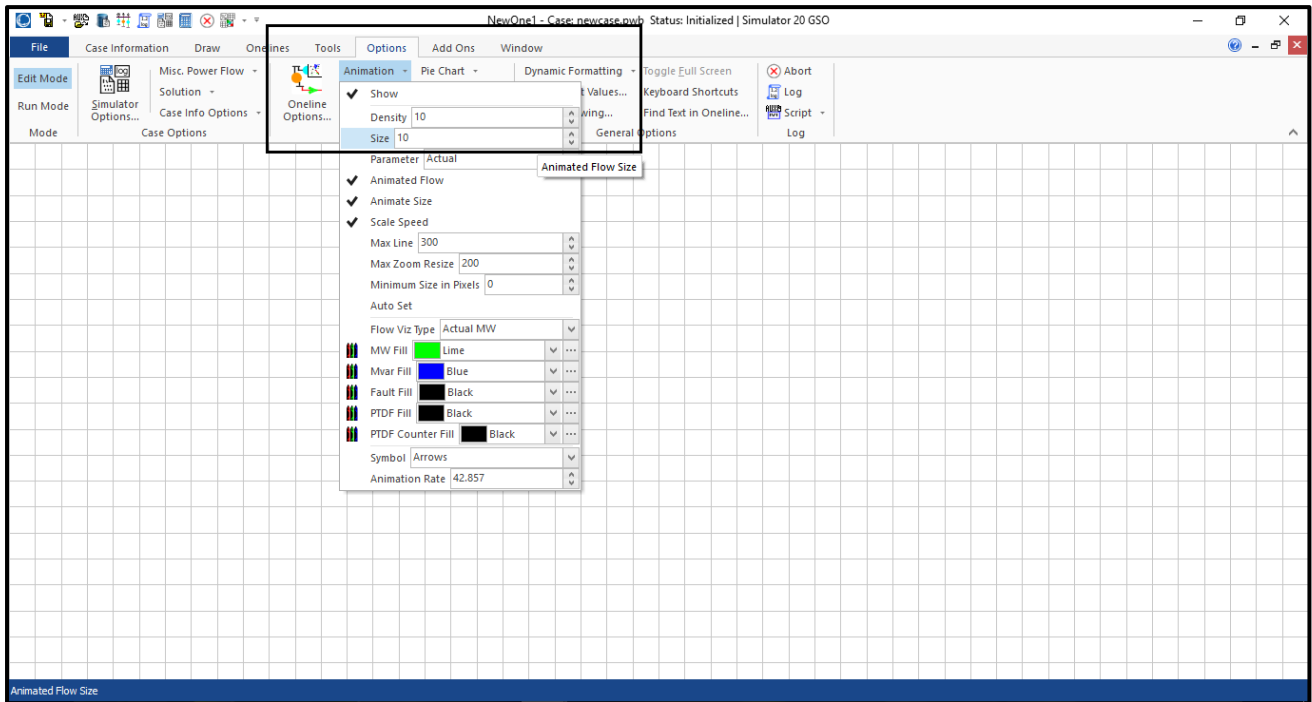
You can find other information regarding the system e.g. to view the bus admittance matrix Y matrix by scrolling down to “solution details” and selecting Ybus.

to return to the one-line diagram go to case information tab and click on “open windows” then select the name of your project from the list.



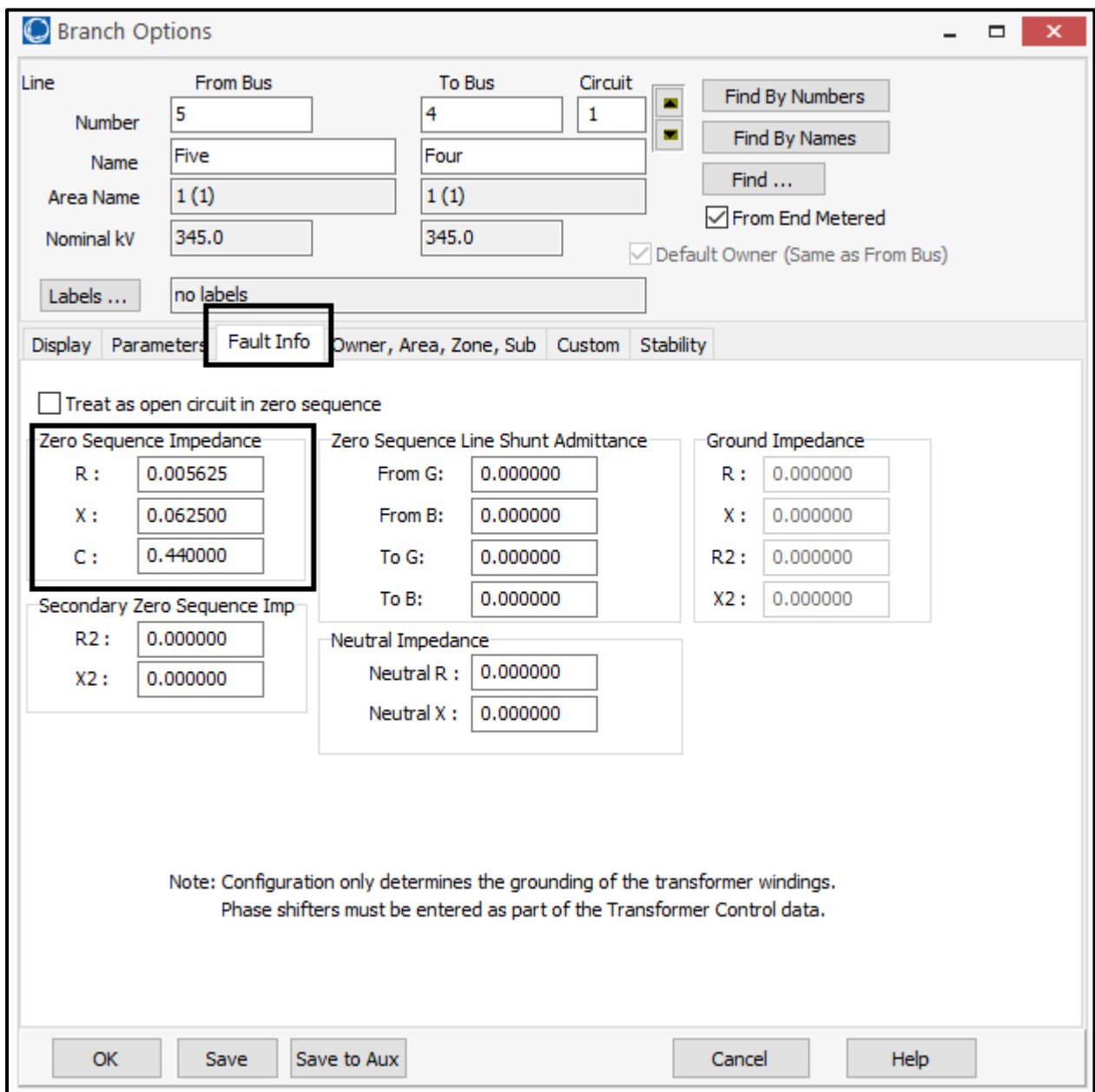
Number	Name	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5
1	One	3.73 - j49.72				-3.73 + j49.72
2	Two		2.68 - j28.46		-0.89 + j9.92	-1.79 + j19.84
3	Three			7.46 - j99.44	-7.46 + j99.44	
4	Four		-0.89 + j9.92	-7.46 + j99.44	11.92 - j147.96	-3.57 + j39.68
5	Five	-3.73 + j49.72	-1.79 + j19.84	-3.57 + j39.68	9.09 - j108.58	

You might face the problem that you run the program, but you do not see power flow arrows to solve this go to options tab and increase the animation size as shown below:



Fault analysis:

- Three phase symmetrical fault:
 1. Fault analysis can only be performed when Simulator is in Run Mode.
 2. To perform a 3-phase symmetrical fault you need to insert the sequence specific data for generators, transformers, and transmission lines.
 3. This data is loaded by double clicking on each component e.g. double click on a transmission line to open the “branch options” window, then select “fault info” tab as shown in the figure below:



Branch Options

Line Number: 5, Name: Five, Area Name: 1 (1), Nominal kV: 345.0

To Bus: 4, Circuit: 1

Find By Numbers, Find By Names, Find ...

☒ From End Metered

☒ Default Owner (Same as From Bus)

Labels ...: no labels

Display Parameters **Fault Info** Owner, Area, Zone, Sub Custom Stability

☐ Treat as open circuit in zero sequence

Zero Sequence Impedance

R: 0.005625, X: 0.062500, C: 0.440000

Secondary Zero Sequence Imp

R2: 0.000000, X2: 0.000000

Zero Sequence Line Shunt Admittance

From G: 0.000000, From B: 0.000000, To G: 0.000000, To B: 0.000000

Ground Impedance

R: 0.000000, X: 0.000000, R2: 0.000000, X2: 0.000000

Neutral Impedance

Neutral R: 0.000000, Neutral X: 0.000000

Note: Configuration only determines the grounding of the transformer windings.
Phase shifters must be entered as part of the Transformer Control data.

OK Save Save to Aux Cancel Help

4. Note that we have not inserted any data in this tab previously, typically simulator assumes that if no zero-sequence data is given for a branch that the zero-sequence impedance is defaulted to 2.5 times the positive sequence impedance, this is where this data came from.
5. An example of sequence data is given in tables below which was taken from example 7.5 in the course book.

TABLE 7.3 Synchronous machine data for SYMMETRICAL SHORT CIRCUITS program*	<table> <tr> <th>Bus</th><th>Machine Subtransient Reactance—X_d'' (per unit)</th></tr> <tr> <td>1</td><td>0.045</td></tr> <tr> <td>3</td><td>0.0225</td></tr> </table>	Bus	Machine Subtransient Reactance— X_d'' (per unit)	1	0.045	3	0.0225		
Bus	Machine Subtransient Reactance— X_d'' (per unit)								
1	0.045								
3	0.0225								
TABLE 7.4 Line data for SYMMETRICAL SHORT CIRCUITS program	<table> <tr> <th>Bus-to-Bus</th><th>Equivalent Positive-Sequence Series Reactance (per unit)</th></tr> <tr> <td>2-4</td><td>0.1</td></tr> <tr> <td>2-5</td><td>0.05</td></tr> <tr> <td>4-5</td><td>0.025</td></tr> </table>	Bus-to-Bus	Equivalent Positive-Sequence Series Reactance (per unit)	2-4	0.1	2-5	0.05	4-5	0.025
Bus-to-Bus	Equivalent Positive-Sequence Series Reactance (per unit)								
2-4	0.1								
2-5	0.05								
4-5	0.025								
TABLE 7.5 Transformer data for SYMMETRICAL SHORT CIRCUITS program	<table> <tr> <th>Bus-to-Bus</th><th>Leakage Reactance—X (per unit)</th></tr> <tr> <td>1-5</td><td>0.02</td></tr> <tr> <td>3-4</td><td>0.01</td></tr> </table>	Bus-to-Bus	Leakage Reactance— X (per unit)	1-5	0.02	3-4	0.01		
Bus-to-Bus	Leakage Reactance— X (per unit)								
1-5	0.02								
3-4	0.01								

- To insert this data, you have to double click on each component, and go to the “fault info” tab, then inset the data there. For example, the data for the generator is shown below

Generator Options X

Bus Number Find By Number

Bus Name Find By Name

ID Find ...

Area Name Fuel Type

Labels ... Unit Type

Status
☐ Open
☒ Closed

Generator MVA Base

Display Information
Power and Voltage Control
Costs
Fault Parameters
Owners, Area, etc
Custom
Stability

Generator Impedances

☒ Neutral Grounded

Internal Sequence Impedances

	R :	X :
Positive	<input type="text" value="0.00000"/>	<input type="text" value="0.04500"/>
Negative	<input type="text" value="0.00000"/>	<input style="border: 2px solid blue;" type="text" value="0.00"/>
Zero	<input type="text" value="0.00000"/>	<input type="text" value="0.0"/>

Generator Step Transformer

R:

X:

Tap:

Neutral-to-Ground Impedance

R :

X :

OK
Save
Save to Aux
Cancel
Help

7. The sequence data for a transformer is shown below:

Branch Options

☐
☐
☐

Transformer	From Bus	To Bus	Circuit
Number	3	4	1
Name	Three	Four	
Area Name	1 (1)	1 (1)	
Nominal kV	15.00	345.0	

☐ Find By Numbers
☐ Find By Names

☒ From End Metered
☒ Default Owner (Same as From Bus)

no labels

Display

Parameters

Transformer Control

Fault Info

Owner, Area, Zone, Sub

Custom

Stability

☐ Treat as open circuit in zero sequence

Zero Sequence Impedance

R : 0.000000

X : 0.010000

C : 0.000000

Zero Sequence Line Shunt Admittance

From G: 0.000000

From B: 0.000000

To G: 0.000000

To B: 0.000000

Ground Impedance

R : 0.000000

X : 0.000000

R2 : 0.000000

X2 : 0.000000

Secondary Zero Sequence Imp

R2 : 0.000000

X2 : 0.000000

Neutral Impedance

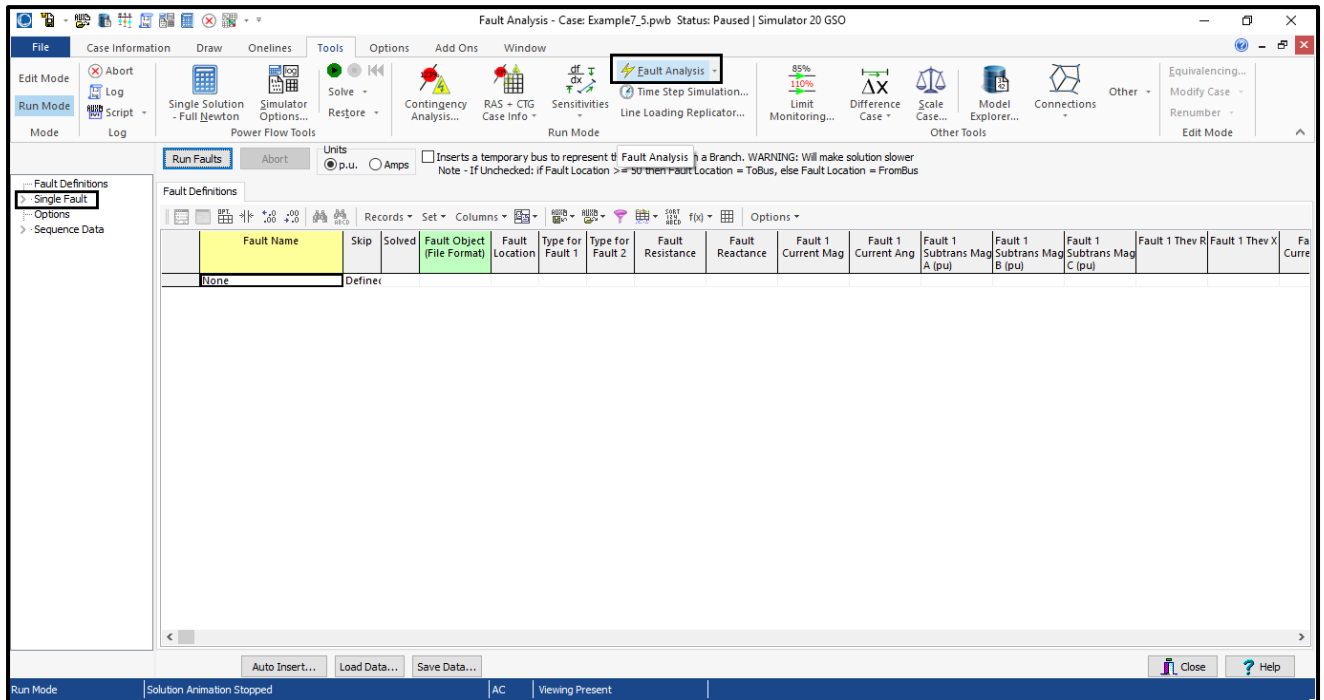
Neutral R : 0.000000

Neutral X : 0.000000

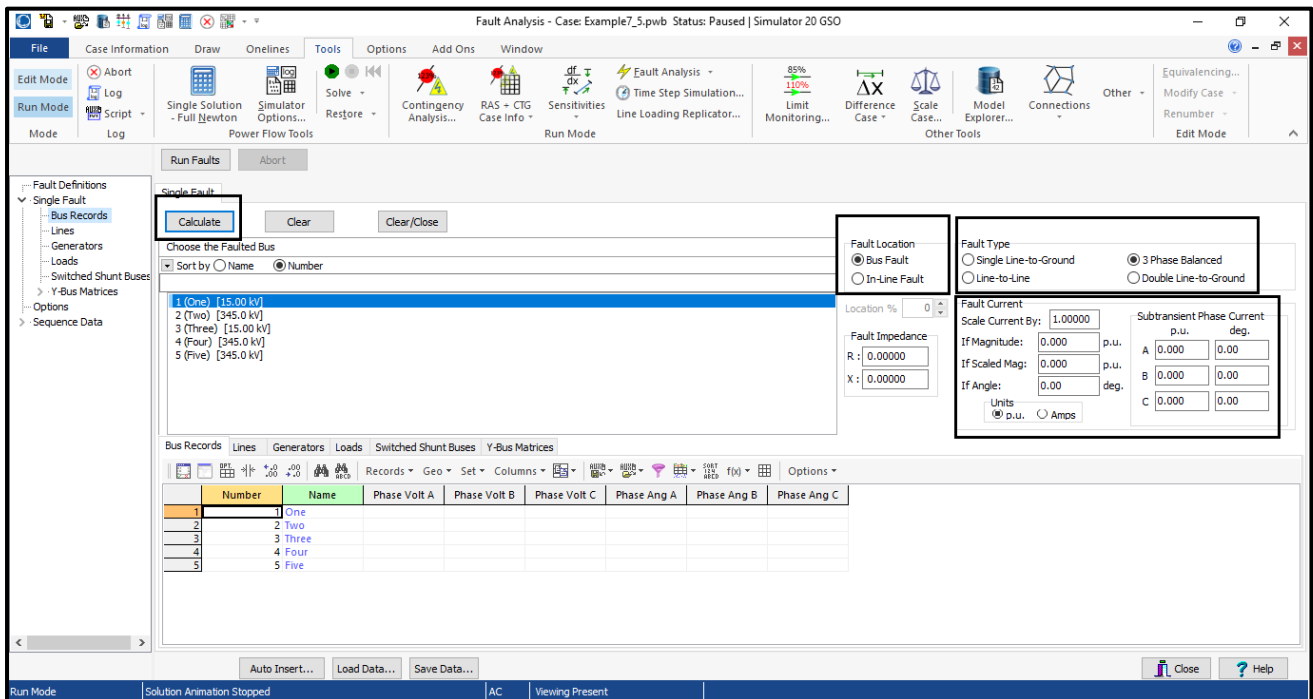
Configuration: Unknown

Note: Configuration only determines the grounding of the transformer windings.
Phase shifters must be entered as part of the Transformer Control data.

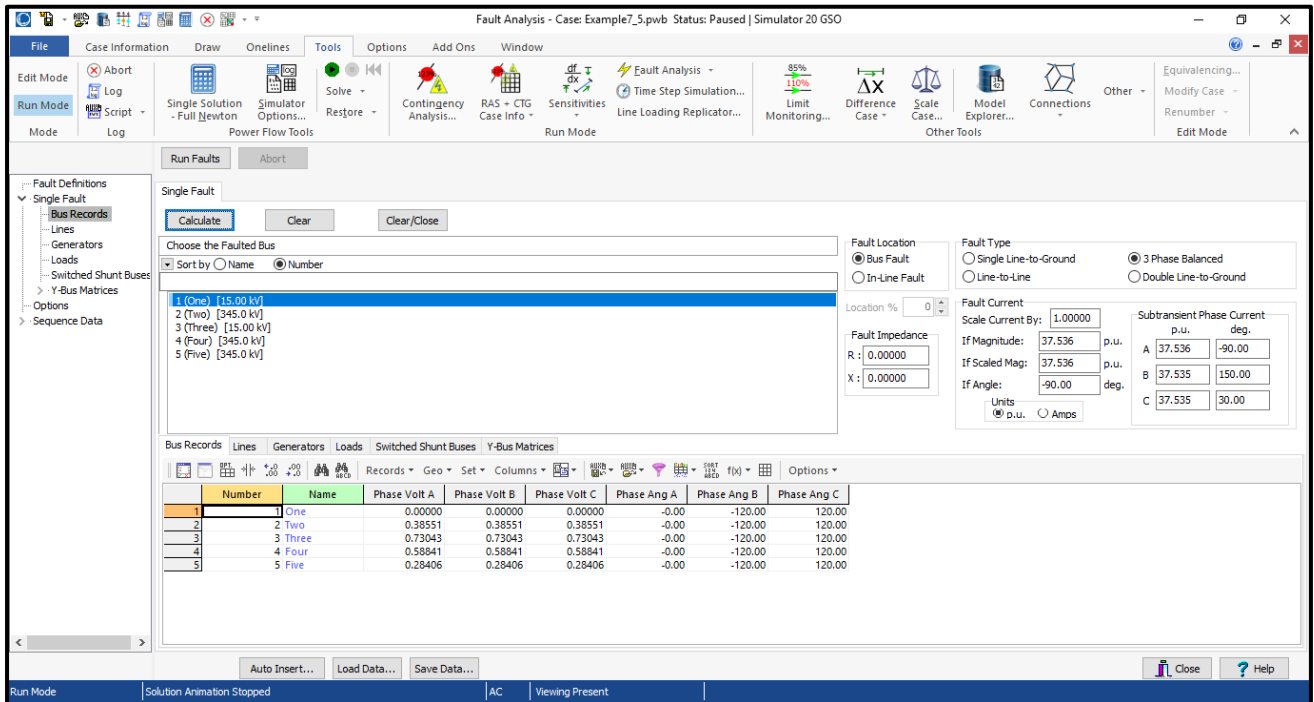
8. To start fault analysis, make sure that you select the run mode, then go to tools tab and select “fault analysis”, then the following window will show up:



9. Click on single fault then select “bus records”, and you will see the following window:



10. Note the indicated fields in the previous figure, you can select the fault type, and the faulted bus, after that click calculate, and note the results as shown in the next figure



Note: in the following link you can find a useful video tutorial as an additional help:

<https://www.youtube.com/watch?v=q4Deo2324Ck>

References:

1. Glover, J. and Sarma, M. (2012). Power System Analysis and Design, 5th Edition. Brooks/Cole. Pacific Grove, California.
2. https://www.powerworld.com/files/Simulator16_Help_Printed.pdf

The End 😊