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Load flow analysis using MATLAB /Simulink Software

Modelling Of Load Flow Analysis

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Abstract : ***. A basic power system analysis method used to examine an electrical network's steady-state operational circumstances is called load flow analysis. At various nodes and branches of the system, it entails calculating the voltage magnitudes and angles as well as the active and reactive power flows. For power system engineers to assure the dependable and effective functioning of electrical networks, load flow analysis is a crucial technique. Due to its robust numerical calculation capabilities and user-friendly graphical interface, MATLAB Simulink offers a flexible platform for carrying out load flow analysis. The outcomes of the load flow study offer important details on the voltage profile, power losses, and system stability. This data may be used by engineers to spot possible problems such voltage violations, overloaded equipment, and voltage stability difficulties. Based on these findings, the system can function within acceptable bounds by implementing the proper remedial actions. The modelling and analysis process is made simpler by the user-friendly graphical interface provided by the MATLAB Simulink software. It offers a large variety of power system blocks and libraries that make it possible to precisely represent various components and their relationships. Additionally, the effective computation of the load flow solution is made possible by Simulink's strong numerical solvers.***

Keywords - – Load flow analysis, Gauss-Seidel Method, Newton Raphson method, Slack bus, Load bus ,Generator bus

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1.)INTRODUCTION

The steady-state operating conditions of an electrical power system are ascertained using a computer technique called load flow analysis, sometimes referred to as power flow analysis, in electrical engineering. To determine the magnitude and phase angles of voltages and currents at various places in the system, a series of non-linear equations must be solved.
Assessing the voltage profile, power flows, and system losses within an electrical network is the main goal of load flow analysis. It aids engineers in comprehending how power is distributed across the system, spotting possible bottlenecks, and making sure the system performs within reasonable bounds. An essential technique for examining the steady-state action of electrical power networks is load flow analysis, commonly referred to as power flow analysis. It aids in figuring out the network's voltages, currents, and power flows. In load flow analysis ,two variable are known ,and two are to be determined .Depend on the quantity to be specified the buses are classified into three categories generation bus ,load bus and slack bus .

1.1.)CLASSIFICATION OF BUSES

Buses are categorized in load flow analysis according to their features and the parts of an electrical power system that are linked to them. Power flow issues must be analyzed and solved using the bus categorization. The following are the bus classes that are frequently used in load flow analysis:
1.Slack bus
Slack Bus (or Swing Bus): The voltage magnitude and angle are given with respect to the slack bus, which also serves as a reference bus. It is a representation of the substation or generator supplying electricity to the system. Typically, a constant voltage magnitude and angle are assigned to the slack bus. Swing or Reference Bus are other names for Slack Bus. Slack buses are anticipated rather than actual in order to account for losses that may occur during power transfer. The only buses in the power system that have active power defined are the load bus and the generator bus. Due to the difference between the active

power generated by Generator Bus and the active power used by Load Bus, there is a power loss equal to the difference between Generator Bus P and Load Bus P. This loss can only be determined once the load flow problem has been resolved. As a result, an additional generator bus is taken into consideration to supply power loss, for which bus magnitude and voltage are defined as well as active power and reactive power calculations.

Slack bus

Bus voltage and magnitude known

P,Q unknown

2.PV bus

A PV bus, also known as a voltage-controlled bus, is a generator bus where the voltage magnitude is predetermined but the voltage angle is let to fluctuate. These buses are used to regulate the generators' production of reactive power. Voltage-controlled bus is another name for the generator bus. This bus has a generator connected to it, thus its bus voltage must match the generator's voltage, and its active power production must match the generator's rating.

Generator bus

V,P known

Phase angle and Q unknown

3.PQ bus

PQ Buses (also known as Load Buses): PQ buses are used to depict load buses where both the voltage magnitude and angle are defined. The load linked to these buses determines the actual and reactive power injections or absorptions. Bus Voltage: The magnitude and phase angle of the bus voltage are unknown for the load bus, but actual power P and reactive power Q are known. Bus voltage should be determined using load flow analysis. Voltage at the load bus is permitted to vary up to a certain amount, let's say 5%. Bus voltage is not significant and is thus not stated for this reason.

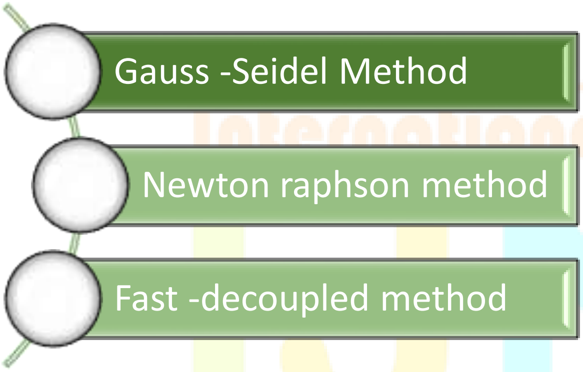
Load bus

P,Q

Voltage magnitude and phase angle unknown

1.2)METHODS OF LOAD FLOW ANALYSIS

.The Gauss Seidel (GS), Newton Raphson (NR), and fast decoupling methods are utilised to solve load flow issues. These are crucial techniques that are excellent for solving issues.



Gauss-Seidel Method: The load flow equations are successively solved using the iterative Gauss-Seidel method. Based on the previously determined values, it updates the bus voltages, progressively increasing the accuracy. Although relatively easy to construct, this approach might converge slowly or become stuck in local solutions under certain system circumstances.

Newton-Raphson method-It converges more quickly than the Gauss-Seidel method and is a more effective iterative strategy. By linearizing the system equations around an initial hunch and then iteratively updating the bus voltages until convergence is reached, it solves the load flow equations concurrently. The Newton-Raphson approach necessitates an initial guess and may experience convergence problems for systems that are under- or overloaded.

The Newton-Raphson technique is modified by the rapid decoupled load flow approach, which makes the computations easier to do while keeping a respectable level of accuracy. By separating the real and reactive power equations from the power flow equations, it enables quicker convergence by updating only a portion of the variables during each iteration. Due to the rapid decoupling method's ability to balance accuracy and computing economy, it is often employed in practice.

Since the load flow equations are nonlinear algebraic equations, there is no way to explicitly solve them .Only iterative numerical techniques may be used to solve nonlinear equations. The analysis of alternative power system network solutions is known as a load flow study .Power flowing in various lines, voltage at various buses, and line losses are provided by the solution .A load flow analysis will reveal the amplitude and phase angle of voltages, the actual and reactive power flowing in each line, as well as the line losses. Also provided by the load flow solution is the starting circumstances of the system during the time that the system's transient action is being investigated .To determine how to operate a current power system and to plan for future system growth, a load flow analysis is crucial. Additionally, it is for creating a new power system..

Bus types	Quantities specified	Unknown values
Generator Bus	$\lvert V_i \rvert$, P_i	Q_i , δ_i
Load Bus	P_i , Q_i	$\lvert V_i \rvert$, δ_i
Slack Bus	$\lvert V_i \rvert$, δ_i	P_i , Q_i

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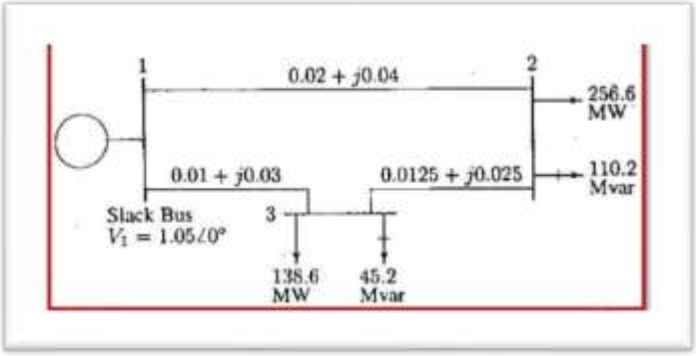
Power engineers frequently employ analysis to determine a power system's steady state operation and to design new projects. In order to calculate the various bus voltages, phase angles, active and reactive power flows across various branches, generators, transformer settings, and loads under steady state conditions, power flow studies offer a systematic mathematical technique. significant impact on operational planning for future expansion, stability studies, and finding the most cost-effective operation for current power systems. Additionally, load flow findings are highly helpful in determining how to configure the right protective devices to guarantee the safety of the power system network.
The magnitudes and phase angles of load bus voltages, reactive powers and voltage phase angles at generator buses, real and reactive power flows on transmission lines, together with power at the reference bus, are the main data obtained from the load flow or power flow analysis; other variables are specified

2.) MATLAB/SIMULINK SOFTWARE

Information - In order to model and simulate electrical power networks, load flow analysis may be done using the MATLAB Simulink programme. To ascertain the steady-state operating conditions of a power system, load flow analysis, sometimes referred to as power flow analysis, is carried out. Following are some load flow analysis applications for MATLAB Simulink:
2.)System modelling: For modelling power systems, MATLAB Simulink offers a graphical platform. You may use preset blocks or custom models to represent a variety of components, including generators, transformers, transmission lines, loads, and control systems.
3.).Simulink gives you the ability to simulate a system's power flow by using a set of nonlinear algebraic equations. These equations reflect the voltage and power balancing circumstances at various network buses. Simulink offers There are efficient methods and solvers for these equations.
4.) It enables you to carry out load flow analyses to examine the power flow, voltage profiles, and losses in a system under various operating circumstances. You may investigate the effects on voltage stability, power losses, and other system features by changing the load demand, generation levels, or system factors.
5.)Simulink is useful for designing and analyzing voltage regulation and control strategies in power systems. In order to maintain the required voltage levels and boost system stability, you may mimic the action of voltage regulators, tap-changing transformers, and other control devices.
6.)Integration of Renewable Energy Sources: Simulink may be used to investigate the effects of integrating renewable energy sources as they become more widely used.
6.)Simulink enables you to model and analyze fault situations in power systems. You may test the system's action under unusual circumstances by adding problems, including short circuits or line outages. This aids in spotting possible issues and building safeguards and relays.
7.)Designing and evaluating control systems for power systems is made easier by Simulink. For voltage regulation, reactive power management, frequency control, and other control techniques, control loops can be modelled and simulated. Simulink offers a variety of control system building components including instruments to evaluate these control systems' performance.
8.)Overall, MATLAB Simulink provides a complete framework for system modelling, simulation, and analysis, making it a flexible tool for load flow analysis. It aids in comprehending and improving the functionality of electrical power systems under various operating conditions.

3.) MODELLING OF 3_BUS SYSTEM
Example :figure Shows the one line diagram of a simple power three bus power system with generation at bus 1.The magnitude of voltage at bus 1 is adjusted to 1.05 P.U. the scheduled loads at buses 2 and 3 are as marked on the diagram .Line impedance are marked in per unit on a 100 MVA base and the line charging susceptance are neglected.
(a)Using the Gauss- seidel method ,determine the phasor values of the voltage at the load buses(P-Q buses)
2 and 3 accurate to four decimal places.
(b)Find the slack bus real and reactive power. In the figure, we need a voltage source such as a three-phase voltage source, three buses, three transmission lines, three-phase loads, and three-phase measurement blocks. At first, we just bring all the components from the Simulink library, then connect one to another and put the values in. Therefore, first we need a voltage source. To get this, Go to the Simulink library and go to SIMSCAPE, then click on power system, click on specialised technology, now click on fundamental blocks, and click on electrical sources. You can see here that the voltage sources block is available. Take this block and bring it into the model.

Now take the three-phase series RLC branch from here to represent the transmission line and bring it into the model. Now take the three-phase parallel RLC load from here to represent the loads and bring it into the model.

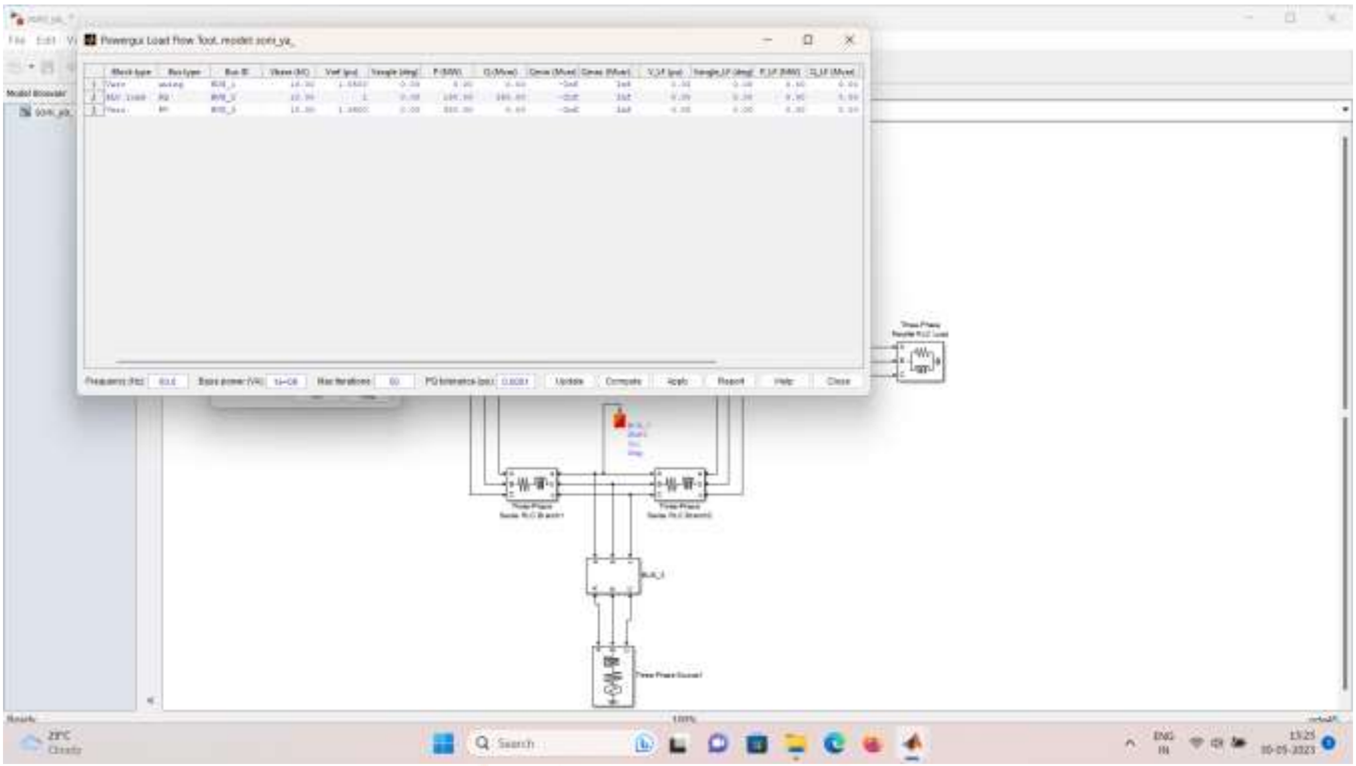


Now take the three phase measurement block from here for voltage measurements and bring it in the model .Similarly ,bring the load flow bus from here and put it in the model .Bring the RMS block from here and put it in the model .bring the display from here and put it in the model .Now we are going to put the values in these blocks according to the example data .Just double click on the three phase source ,a window will open .It ask about the three phase voltage .As we know that bus 1 in slack bus ,its base voltage is not given the example .Therefore, keep the voltage as it is .keep the frequency 60 HZ and angle 0.as we are not going to perform short circuit analysis ,therefore ,uncheck this internal resistance icon .Click on the load flow and if it is swing otherwise change it to swing and click ok. .Now connect this three phase source with three phase measurements block. Now ,connect this load flow bus here and double click on it .Keep the bus name as it is ,because this is bus no.1 and is working as slack bus .Base voltage by default is 25 kV so keep as it is. Per unit voltage of slack bus as given in the example data is 1.05 and angle is zero degree. Therefore ,change these values here and click ok. .As slack bus voltage is 1.05 per unit, ,for three phase voltage source ,we have to multiple it with 1.05 otherwise ,the answer will be wrong. Now double click on three phase measurements block and window will open. Change the voltage measurement to phase .It shows other options ,just click on voltage in per unit because we are measuring voltage in per unit .Click no for current measurement .To convert the voltage in per unit ,it ask again the base voltage .Put here 25kv as the base voltage and click ok . connect the rms block with three phase measurements and connect the display with it. Double click on the rms block and change the initial rms value to zero and press OK.Now connect the three phase measurement block with the three phase series RLC branch .Double click it a window will open .Change the branch type to RL. Just look at the figure ,transmission line from bus 1 to bus 2 has the resistance of 0.02 and reactance of 0.04 per unit .These values are given on a base of 100 MVA .Therefore ,we have to calculate actual impedance to put it in the model. We know that actual impedance is given by To calculate actual impedance ,we need the based impedance .The Base impedance is given by: Base MVA is given as 100MVA and base kV is not given in the example .However ,to put the values in MATLAB / Simulink, we need the base kV .The default base kV in MATLAB /Simulink is 25kV. Therefore ,we assume base kV as 25kV.However ,you may choose any base kV values ,it will have no effect in the MATLAB /Simulink Results .Therefore ,putting these values in the expression ,we get base impedance equal to 6.25 as below .Now ,Actual Resistance is given as below :The MATLAB /Simulink ask the value of inductance in Henry instead of Inductive reactance .We know that Therefore, actual inductance will be Therefore ,put these values of resistance and inductance in the model and click ok. Now copy the three phase measurement block and connect it here. now connect the three phase parallel load block. Double click on the block a window will open .just look at the figure, the load connected on bus 2 is 256.6 MW and 110.2 MVAR .Now come to window again .Put here voltage 25 KV .Frequency to 60 HZ Put here 256.6 MW and 110.2 MVAR .Make capacitive load to zero .Go to load flow tab and change this load type to PQ .Because bus 2 is PQ bus and click ok. Now copy the load flow bus and connect here .Double click on it. A window will open and change the bus name to bus 2,and per unit voltage to 1.0 and click ok. Just look at the figure ,now we have to connect transmission line from bus 1 to bus 3 having resistance of 0.01 per unit and reactance of 0.03 per unit .To do this ,copy the three phase series RLC branch and connect it in this way. Double click on it,a window will open ,just change 0.02 with o.o1 and 0.04 with 0.03 and click ok. Now copy the three phase measurement block and connect it here .Just look at figure ,the load connected on bus 3 is 138.6 MW and 45.2 MVAR .Now copy the three phase parallel RLC load block and connect it .Double click on the block, a window will open MW and here 45.2 MVAR Go to load flow tab and change this load type to PQ .Because bus 3 is PQ bus and click on ok.

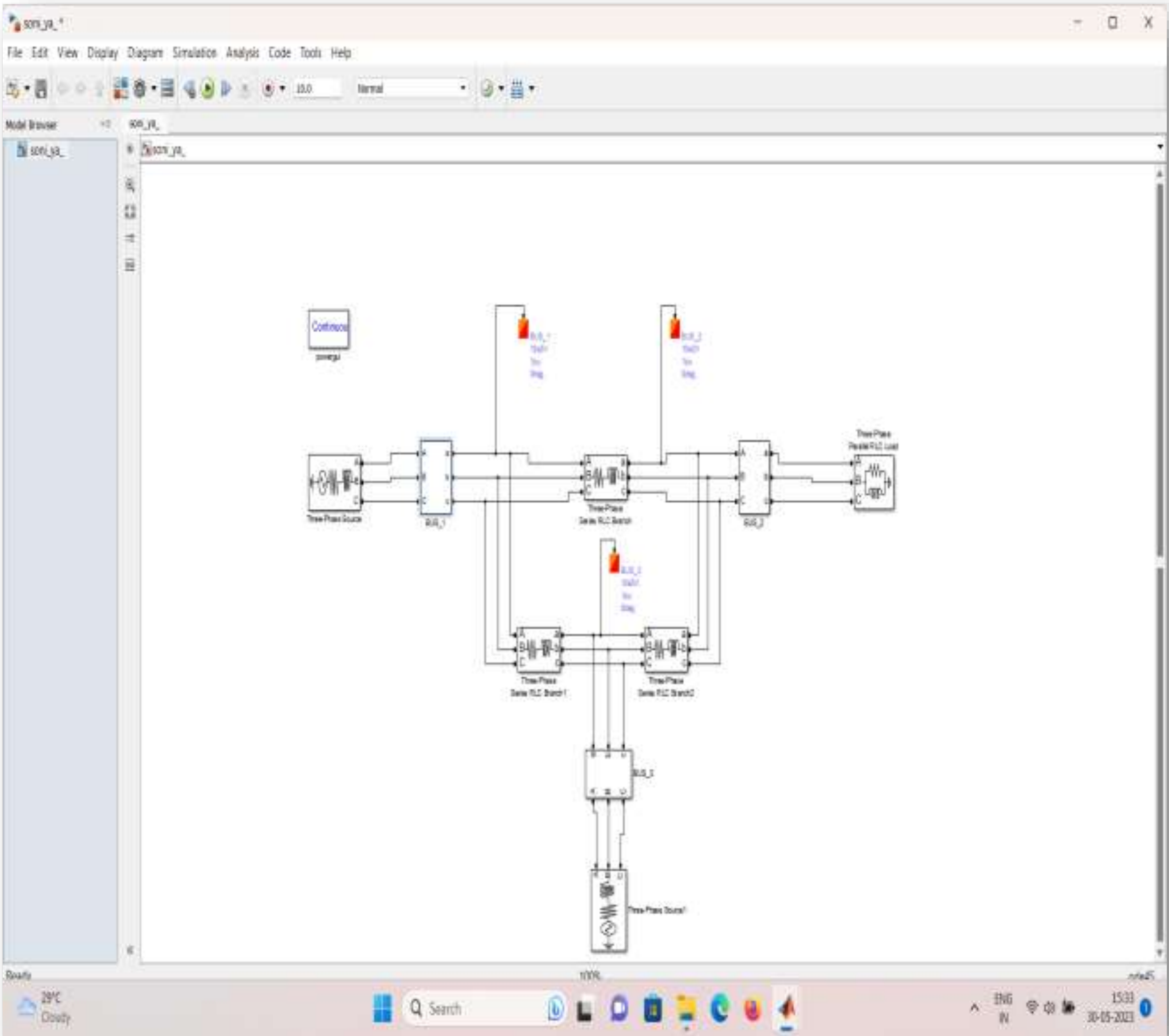
Now copy the load flow bus and connect here. Double click on it .A window will open and change the bus name to bus 3, and per unit voltage to 1.0 and click ok. Just look at the figure ,now we have to connect transmission line from bus 2 to bus 3 having resistance of 0.0125 per unit and reactance of 0.025 per unit .To do this ,copy the three phase series RLC branch and connect it in this way . Just double click on it ,a window will open ,we have to put the values Just change 0.02 with 0.0125 and 0.04 with 0.025 and click ok.

Now connect the rms block and display block here for voltage measurement. Similarly repeat the steps to connect the rms block and display block at bus 3.Now you can run the simulation .Before running the simulation, we need, POWERGUI block to run it .Otherwise it will give error .To get this block ,just write it in search term of Simulink library ,and enter, It will show the POWERGUI block .Copy this block and paste it in your model .Set the simulation time to 1 second .Now ,you can run the simulation ,it can noticed that voltage measurements are not correct. It is due to the reason that for load flow analysis ,This is another level 4 heading: It's also possible to add bullet points when appropriate, using the "bullet list" style: ,we have to change the setting of POWERGUI block .Just double on it.. you can see ,it is fixed .To make it flexible so that we can change the settings, we have to change solver. To do this ,go to simulation, and click on model configuration parameters .A new window will open .At solver tab ,change the auto solver to ode45 here and click ok. Now double click on POWERGUI block .You can see ,now you can change simulation type from continuous to phasor .now go to tools ,click on load flow setting ,it will show you the max iterations frequency ,base MVA ,PQ tolerance , Voltage units and power units. Keep as it is and press ok. One more thing we have to change .Just double click on three phase measurement block and change this complex into magnitude and press ok. Repeat the same procedure for other two three phase measurements blocks .Now you can run the simulation .Compare the voltage magnitude with the magnitudes in the example solution . It can be noticed that both answers are correct .Now double click on the POWERGUI block and go to tools and click on load flow to perform the load flow analysis. Automatically a window will open .Just look at the window ,it shows different bus types ,bus names ,their base voltages ,given per units voltages ,angles ,given loads connected at different buses .Other parts are empty

4.) 3 BUS SYSTEM PERFORM IN MATLAB/SIMULINK SOFTWARE



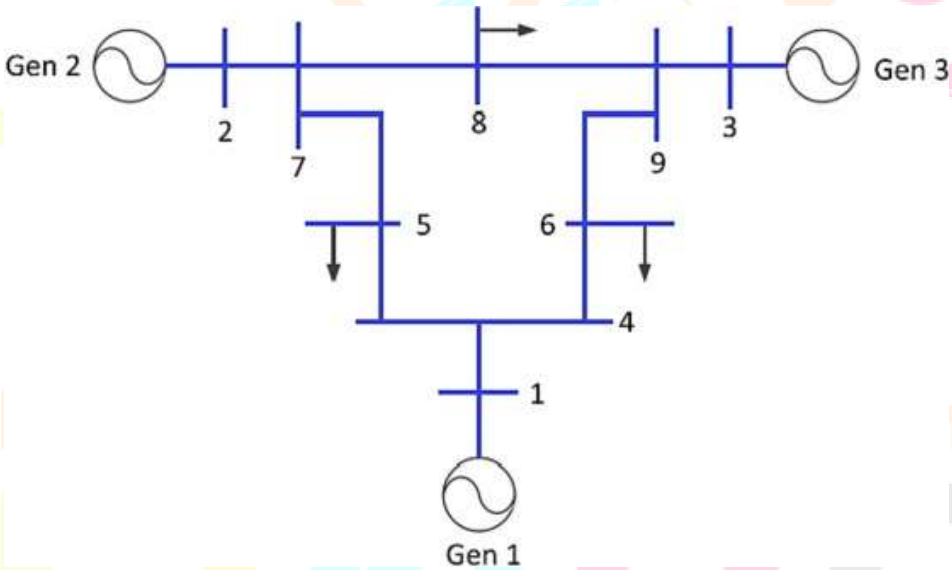
4.1.) MODELLING OF 3_BUS SYSTEM

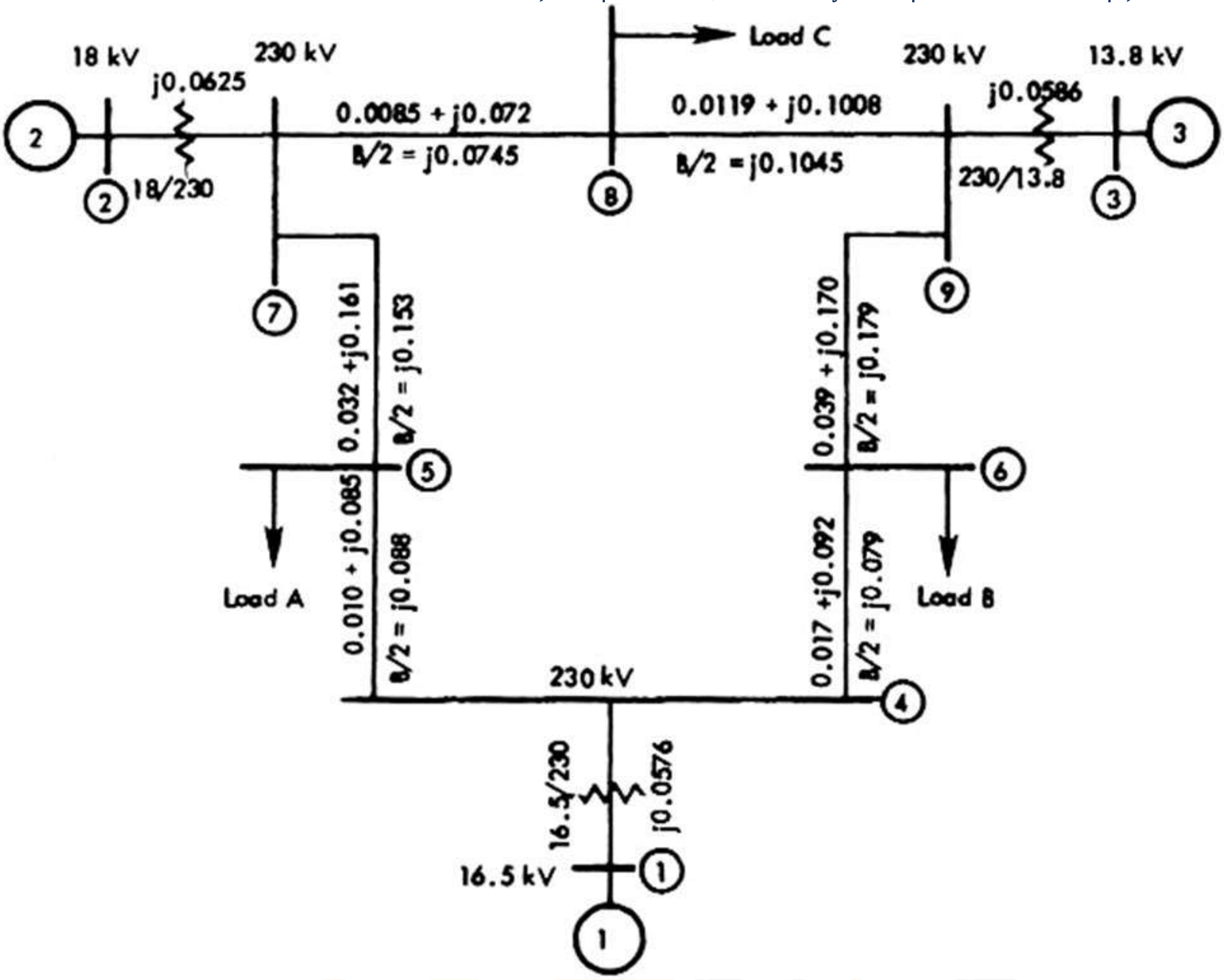


4.2). RESULTS AND DISCUSSION

	Bus ID	**V Base(KV)**	**V Ref (p u)**	**P(MW)**	**Q(M var)**	**Block name**
1	Bus_1	25.00	1.0500	0.01	0.00	Three phase source
2	Bus_2	25.00	1	256.60	110.20	Three phase parallel RLC load
3	Bus_3	25.00	1	138.60	45.20	Three phase parallel RLC load

9 BUS SYSTEM IN MATLAB/SIMULINK SOFTWARE



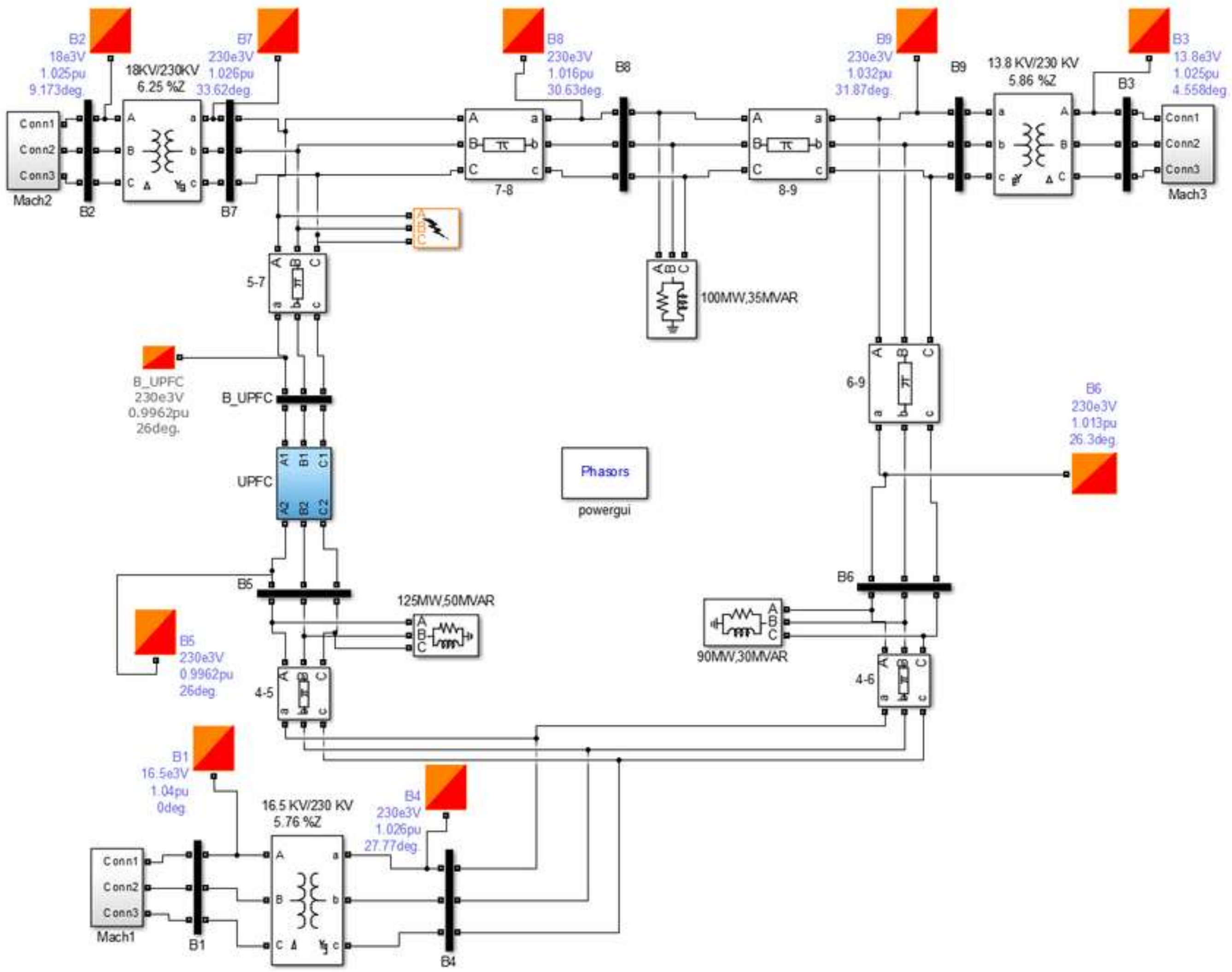


. RESULTS AND DISCUSSION

1 Tr.Line	2 R(p.u)	3 X(p.u)	4 B(p.u)
5 1-4	6 0	7 0.0576	8 0
9 2-7	10 0	11 0.0625	12 0
13 3-9	14 0	15 0.0586	16 0
17 4-5	18 0.010	19 0.085	20 0.176
21 4-6	22 0.017	23 0.092	24 0.158
25 7-5	26 0.032	27 0.161	28 0.306
29 7-8	30 0.0085	31 0.072	32 0.149
33 9-8	34 0.0119	35 0.1008	36 0.209
37 9-6	38 0.0390	39 0.17	40 0.358

	Bus type	Bus voltag e Kv	Set voltag e	Angle degree
	Slack	16.5	1.04	0
	Voltage	18	1.025	0
	Voltage	13.8	1.025	0
	Load	230	1	0
	Load	230	1	0
	Load	230	1	0
	Load	230	1	0
	Load	230	1	0
	Load	230	1	0

MODELLING OF 9_BUS SYSTEM



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Additionally, we want to thank our friends.

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