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Note : Remove “Table of Content” before including in CP Book

15EEL76 : Power System Simulation LAB

A. LABORATORY INFORMATION

1. Lab Overview

Degree:	B.E	Program:	EE
Year / Semester :	4 / 7	Academic Year:	2018-19
Course Title:	Power system simulation Lab	Course Code:	15EEL76
Credit / L-T-P:	3 / 0-1-2	SEE Duration:	180 Minutes
Total Contact Hours:	30 Hrs	SEE Marks:	80 Marks
CIA Marks:	20	Assignment	1 / Module
Course Plan Author:	Mrs. shravanthi A	Sign	Dt :
Checked By:		Sign	Dt :

2. Lab Content

Unit	Title of the Experiments	Lab Hours	Concept	Blooms Level
1	Formation for symmetric π /T configuration for Verification of $AD - BC = 1$, Determination of Efficiency and Regulation	3	ABCD Parameters of transmission line	L5
2	Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines	3	Salient and Non-Salient Pole Synchronous Machines	L5
3	To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines.	3	Transient Stability	L5
4	Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.	3	Bus admittance matrix formulation	L5
5	Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.	3	Z-Bus Building Algorithm.	L5
6	Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile	3	Bus current, bus power and line	L5

			flow calculations	
7	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates	3	Jacobian matrix calculation	L5
8	Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQand PV Buses.	3	Load flow analysis	L5
9	To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.	3	Short circuit analysis	L5
10	Optimal Generation Scheduling for Thermal power plants by simulation.	3	Optimal generation scheduling	L5

3. Lab Material

Unit	Details	Available
1	Text books	
	Modern Power System Analysis,D. P. Kothari,McGraw Hill,4 th Edition, 2011	In Lib
2	Reference books	
	Computer Methods in Power Systems Analysis, Glenn W Stagg, Ahmed H Ei – Abiad, McGraw Hill.	In dept
	Power System Analysis,HadiSaadat,McGraw Hill,2ndEdition, 2002	
3	Others (Web, Video, Simulation, Notes etc.)	
		Not Available

4. Lab Prerequisites:

-	-	Base Course:		-	-
SNo	Course Code	Course Name	Topic / Description	Sem	Remarks
1	15EE71	Power system analysis-2	Load Flow Studies, Optimal System Operation, Symmetrical Fault Analysis , Swing Equation	7	
2	15EE43	Transmission and Distribution	Performance of transmission lines	4	Plan Gap Course

Note: If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

5. General Instructions

SNo	Instructions	Remarks
1	Observation book and Lab record are compulsory.	
2	Students should report to the concerned lab as per the time table.	
3	After completion of the program, certification of the concerned staff in-charge in the observation book is necessary.	
4	Student should bring a notebook of 100 pages and should enter the readings /observations into the notebook while performing the experiment.	
5	The record of observations along with the detailed experimental procedure of the experiment in the Immediate last session should be submitted and certified staff member in-charge.	
6	Should attempt all problems / assignments given in the list session wise.	
7	It is responsibility to create a separate directory to store all the programs, so that nobody else can read or copy.	
8	When the experiment is completed, should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.	
9	Any damage of the equipment will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year	
10	Completed lab assignments should be submitted in the form of a Lab Record in which you have to write the algorithm, program code along with comments and output for various inputs given	

6. Lab Specific Instructions

SNo	Specific Instructions	Remarks
1	Enter the command window of the MATLAB.	
2	Create a new M – file by selecting File - New – M – File	
3	Type and save the program in the editor window.	
4	Execute the program by pressing Tools – Run.	
5	View the results.	

B. OBE PARAMETERS

1. Lab / Course Outcomes

#	COs	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
1	Develop a program in MATLAB to assess the performance of medium and long transmission lines by calculating the ABCD parameters	3	ABCD Parameters of transmission line	Black Board + Execution	Slip Test + Viva	L5
2	Develop a program in MATLAB to obtain the power angle characteristics of salient and non-salient pole alternator	06	Salient and Non-Salient Pole Synchronous Machines	Black Board + Execution	Slip Test + Viva	L5
3	Develop a program in MATLAB to assess	07	Transient	Black	Slip Test +	L5

	the transient stability under three phase fault at different locations in a power systems.		Stability	Board + Execution	Viva	
4	Develop a program to compute admittance matrix by inspection & singular transformation method	03	Bus admittance matrix formulation	Black Board + Execution	Slip Test + Viva	L5
5	Develop a program to compute Z-bus using Z- bus algorithm	03	Z-Bus Building Algorithm.	Black Board + Execution	Slip Test + Viva	L5
6	Calculate bus currents, bus power and line flow for given system, develop the program and verify using MATLAB	03	Bus current, bus power and line flow calculations	Black Board + Execution	Slip Test + Viva	L5
7	Use Mi-Power package for the formation of Jacobian	03	Jacobian matrix calculation	Black Board + Execution	Slip Test + Viva	L5
8	Use Mi-Power package to study load flow analysis using NR method, Gauss Siedel Method, Fast Decoupled method	03	Load flow analysis	Black Board + Execution	Slip Test + Viva	L5
9	Use Mi-Power package to study unsymmetrical faults at different locations in radial power systems	03	Short circuit analysis	Black Board + Execution	Slip Test + Viva	L5
10	Use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.	03	Optimal generation scheduling	Black Board + Execution	Slip Test + Viva	L5
-	**Total**	**42**	-	-	-	-

Note: Identify a max of 2 Concepts per unit. Write 1 CO per concept.

2. Lab Applications

SNo	Application Area	CO	Level
1	To assess the performance of transmission lines by calculating ABCD parameters	CO1	L5
2	To study about the power versus torque angle characteristics for given salient pole and non salient synchronous machine.	CO2	L5
3	Since we normally use synchronous generators to generate power in a grid, stability refers to the ability of the synchronous generator to remain in synchronism. A swing curve can be used to see how stable the generator will be after a disturbance. It is basically a plot of the rotor angle with respect to time.	CO3	L5
4	Used to analyse the data that is needed in the load or a power flow study of the buses.	CO4	L5
5	Important tool in other power system studies like short circuit analysis or fault studt . The Zbus matrix can be computed by matrix inversion of the Ybus matrix	CO5	L5
6	Line flow analysis is very important tool for analysis of power systems which is used at operational as well as planning stages of the system, like adding and installation of new generation station, load balancing in dynamic running condition and transmission	CO6	L5

	lines site selection.		
7	Load flow studies are one of the most important aspects of power system planning and operation. Through the load flow studies we can obtain the voltage magnitudes and angles at each bus in the steady state. This is rather important as the magnitudes of the bus voltages are required to be held within a specified limit.	CO7	L5
8	Load flow studies are one of the most important aspects of power system planning and operation. Through the load flow studies we can obtain the voltage magnitudes and angles at each bus in the steady state. This is rather important as the magnitudes of the bus voltages are required to be held within a specified limit.	CO8	L5
9	Determines the magnitude of the currents that flow during an electrical fault. Comparing these calculated values against the equipment ratings is the first step to ensuring that the power system is safely protected.	CO9	L5
10	To allocate the generation to each and every units in a plant for a given load such that fuel cost is minimum subjected to equal and inequality constraints	CO10	L5

Note: Write 1 or 2 applications per CO.

3. Articulation Matrix

(CO – PO MAPPING)

-	Course Outcomes	Program Outcomes												
#	COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	Level
15EEL76.1	Develop a program in MATLAB to assess the performance of medium and long transmission lines by calculating the ABCD parameters	x	x			x								L5
15EEL76.2	Develop a program in MATLAB to obtain the power angle characteristics of salient and non-salient pole alternator	x	x			x								L5
15EEL76.3	Develop a program in MATLAB to assess the transient stability under three phase fault at different locations in a power systems.	x	x			x								L5
15EEL76.4	Develop a program to compute admittance matrix by inspection & singular transformation method	x	x			x								L5
15EEL76.5	Develop a program to compute Z-bus using Z- bus algorithm	x	x			x								L5
15EEL76.6	Calculate bus currents, bus power and line flow for given system, develop the program and verify using MATLAB	x	x			x								L5
15EEL76.7	Use Mi-Power package for the formation of Jacobian	x	x			x								L5
15EEL76.8	Use Mi-Power package to study load flow analysis using NR method, Gauss Siedel Method, Fast Decoupled method	x	x			x								L5
15EEL76.9	Use Mi-Power package to study	x	x			x								L5

	unsymmetrical faults at different locations in radial power systems													
15EEL76.10	Use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.	x	x			x								L5
CS501PC.	Average													

Note: Mention the mapping strength as 1, 2, or 3

4. Mapping Justification

Mapping		Mapping Level	Justification
CO	**PO**	**-**	**-**
CO1	PO1	L2	Knowledge on classification of overhead transmission line, Terms related to performance of transmission line.
CO1	PO2	L5	Analyzing the performance of medium transmission line by determining the voltage regulation and transmission efficiency
CO1	PO5	L3	Develop a program in MATLAB to assess the performance of medium and long transmission lines.
CO2	PO1	L2	Knowledge on Salient and Non-Salient Pole Synchronous alternator.
CO2	PO2	L5	To analyze the power angle characteristics of salient and non-salient pole alternator.
CO2	PO5	L3	Develop a program in MATLAB to obtain the power angle characteristics of salient and non-salient pole alternator.
CO3	PO1	L2	Knowledge on swing curve
CO3	PO2	L5	To assess the transient stability under three phase fault at different locations in a power systems.
CO3	PO5	L3	Develop a program in MATLAB to assess the transient stability under three phase fault at different locations in a power systems.
CO4	PO1	L2	Knowledge on bus admittance and bus impedance matrices of interconnected power systems.
CO4	PO2	L5	Bus admittance matrix formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method
CO4	PO5	L3	Develop programs in MATLAB to formulate bus admittance and bus impedance matrices of interconnected power systems.
CO5	PO1	L2	Knowledge on Z- bus algorithm.
CO5	PO2	L5	Formation of Z Bus using Z bus building algorithm
CO5	PO5	L3	Develop a program for formation of Z Bus using Z bus building algorithm
CO6	PO1	L2	Knowledge on load flow analysis
CO6	PO2	L5	To formulate Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile.
CO6	PO5	L3	To formulate Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile and verify the same by writing a program in MATLAB.
CO7	PO1	L2	Knowledge on load Jacobian matrix calculation
CO7	PO2	L5	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates.
CO7	PO5	L3	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates and verifying the same using Mi- Power package.
CO8	PO1	L2	Knowledge on load Flow Analysis using Gauss Seidel Method, NR Method

			and Fast Decoupled Method.
CO8	PO2	L5	Analyzing the techniques used for solving load flow problem for simple power systems.
CO8	PO5	L3	Analyzing the techniques used for solving load flow problem for simple power systems and verifying the same using Mi- Power package.
CO9	PO1	L2	Knowledge on different types of faults in a power system.
CO9	PO2	L5	To formulate the fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults.
CO9	PO5	L3	To formulate the fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults and verifying the same using Mi- Power package.
CO10	PO1	L2	Knowledge on optimal Generation Scheduling for Thermal power plants.
CO10	PO2	L5	To formulate the optimal generator scheduling for thermal power plants.
CO10	PO5	L3	To formulate the optimal generator scheduling for thermal power plants using Mi Power package.

Note: Write justification for each CO-PO mapping.

5. Curricular Gap and Content

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Unit	Title	Teaching Hours	No. of question in Exam							CO	Levels
			CIA-1	CIA-2	CIA-3	Asg-1	Asg-2	Asg-3	SEE		
1	Formation for symmetric π /T configuration for Verification of $AD - BC = 1$, Determination of Efficiency and Regulation	03	1	-	-	-	-	-	1	CO1	L5
2	Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines	03	1	-	-	-	-	-	1	CO2	L5
3	To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line	03	1	-	-	-	-	-	1	CO3	L5

	Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines.										
4	Y Bus Formation for Power Systems with and without Mutual Coupling, by Singular Transformation and Inspection Method.	03	1	-	-	-	-	-	1	CO4	L5
5	Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.	03	-	1	-	-	-	-	1	CO5	L5
6	Determination of Bus Currents, Bus Power and Line Flow for a Specified System Voltage (Bus) Profile	03	-	1	-	-	-	-	1	CO6	L5
7	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates	03	-	1	-	-	-	-	1	CO7	L5
8	Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQand PV Buses.	03	-	-	1	-	-	-	1	CO8	L5
9	To Determine Fault Currents and Voltages in a Single Transmission Line System with Star-Delta Transformers at a Specified Location for LG and LLG faults by simulation.	03	-	-	1	-	-	-	1	CO9	L5
10	Optimal Generation Scheduling for Thermal power plants by simulation.	03	-	-	1	-	-	-	1	CO10	L5
-	**Total**	**30**	**4**	**3**	**3**	**5**	**5**	**5**	**20**	**-**	**-**

Note: Write CO based on the theory course.

2. Continuous Internal Assessment (CIA)

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	30	CO1, CO2, CO3, CO4	L1, L2, L3,L4
CIA Exam – 2	30	CO5, CO6, CO7,	L5, L6, L7
CIA Exam – 3	30	CO8, CO9,C010	L8, L9, L10
Assignment - 1	05	CO1, CO2, CO3, CO4	L1, L2, L3,L4
Assignment - 2	05	CO5, CO6, CO7,	L5, L6, L7
Assignment - 3	05	CO8, CO9,C010	L8, L9, L10
Other Activities – define – Slip test			
Final CIA Marks	**40**	**-**	**-**

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SNo	Description	Marks
1	Observation and Weekly Laboratory Activities	05 Marks
2	Record Writing	10 Marks for each Expt
3	Internal Exam Assessment	25 Marks
4	Internal Assessment	15 Marks
5	SEE	80 Marks
-	**Total**	**100 Marks**

D. EXPERIMENTS

Experiment 01: Calculation of ABCD parameters

-	**Experiment No.:**	1	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Formation for symmetric π /T configuration for Verification of $AD - BC = 1$, Determination of Efficiency and Regulation.						
2	Course Outcome	Develop a program in MATLAB to assess the performance of medium and long transmission lines by calculating the ABCD parameters						
3	Aim	To Calculate ABCD parameters for a given transmission line and find regulation and efficiency.						
4	Material / Equipment Required	Lab Manual, PC loaded with MATLAB						
5	Theory, Formula, Principle, Concept	The Transmission System can also be assumed to be a four terminal network with two input terminals where power enters the network and two output terminals where power leaves the network. Let V_s= Sending End Voltage; I_s= Sending end current; V_r= Receiving End Voltage; I_r= Receiving end current; The sending end parameters can be expressed in terms of receiving end parameters through the set of parameters known as transmission line parameters or ABCD parameters. Thus, $V_s = AV_r + BI_r$; $I_s = C V_r + DI_r$ The transmission network should be linear, passive and bilateral. The parameters A, B, C and D are complex numbers and are called as generalized circuit constants. The method which is used for analysis of transmission line has influence on these constants. Performance calculation of the line can be done using these constants. Terms Related to Performance of Transmission Line: 1) Voltage Regulation: $\% V_R = 100^* (V_{NL} - V_{FL})/ V_{FL}$ But $V_{NL} = V_s$(as there is no drop) and $V_{FL} = V_R$(on load) , hence percentage voltage regulation equation becomes $\% VR = 100^* (V_s - V_R)/ V_R$. ii)Transmission Efficiency: % Transmission efficiency, η= (receiving end power/sending end power)* 100 receiving end power= $V_r I_r \cos(\varphi_r)$ sending end power= $V_s I_s \cos(\varphi_s)$						

$\cos(\varphi_r)$= receiving end power factor

$\cos(\varphi_s)$=sending end power factor

Case A: To find constants in medium transmission line represented by Nominal ∏ circuit.

In nominal T method of analysis of medium transmission line the total line capacitance is assumed to be lumped or concentrated at the center point of the line whereas the half of the line resistance and reactance are lumped on either side of the line. The constants are:

A=1+(Y*Z)/2

B=Z*(1+Y*Z/4)

C=Y

D= (1+Y*Z/2)

Case B: To find constants in medium transmission line represented by Nominal T circuit.

In nominal ∏ method, the total capacitance is divided into two halves with one half at the receiving end and the other half at the sending end.The constants are:

A=1+(Y*Z)/2

B=Z

C=Y*(1+Y*Z/4)

D= (1+Y*Z/2)

6 Procedure, Program, Activity, Algorithm, Pseudo Code

Enter the command window of the MATLAB.
Create a new M – file by selecting File - New – M – File
Type and save the program in the editor window.
Execute the program by pressing Tools – Run.
View the results.

```
%Determination of ABCD constants,Efficiency and Regulation of given Medium
%Transmission Lines with the help of recieving end data(Nominal-T)

clc
clear all
length=input('Enter the length of medium line in km= ');
z=input('Enter the series impedance of the line per km= ');
y=input('Enter the shunt admittance of the line per km= ');
Z=z*length; Y=y*length;
a=1+(Y*Z)/2; d=a; b=Z*(1+(Y*Z)/4); c=Y;
fprintf('\nA,B,C&D contants are:\n');
fprintf('\nA=%15.4f+%15.4fi',real(a),imag(a));
fprintf('\nB=%15.4f+%15.4fi',real(b),imag(b));
fprintf('\nC=%15.4f+%15.4fi',real(c),imag(c));
fprintf('\nD=%15.4f+%15.4fi',real(d),imag(d));
fprintf('\nAD-BC=%f',a*d-b*c);
Vr=input('\nEnter the receiving end line voltage in kV=');
Pr=input('Enter the receiving end power in MW=');
PF=input('Enter the receiving end power factor =');
pf_a=acos(PF);
vph=Vr*1e3/sqrt(3);
```

```
Ir=(Pr*1e6)/(3*vph*PF);
Irp=Ir*cos(pf_a)-i*Ir*sin(pf_a);
Vs=a*vph+b*Irp;
Is=c*vph+d*Irp;
fprintf('\nSending end voltage/ph =%15.4f+%15.4fi V',real(Vs),imag(Vs));
fprintf('\nSending end current/ph =%15.4f+%15.4fi A',real(Is),imag(Is));
Ps=real(3*Vs*Is)/1e6;
Efficiency=(Pr/Ps)*100;
Regulation=(abs(Vs/a)-abs(vph))*100/abs(vph);
fprintf('\nSending end power =%0.2f MW',Ps);
fprintf('\nEfficiency=%0.2f%%',Efficiency);
fprintf('\nRegulation=%0.2f%%',Regulation);
```

%Determination of ABCD constants,Efficiency and Regulation of given Medium Transmission Lines with the help of recieving end data(Nominal-π)

```
clc
clear all
length=input('Enter the length of medium line in km= ');
z=input('Enter the series impedance of the line per km= ');
y=input('Enter the shunt admittance of the line per km= ');
Z=z*length; Y=y*length;
a=1+(Y*Z)/2; d=a; b=Z; c=Y*(1+(Y*Z)/4);
fprintf('\nA,B,C&D contants are:\n');
fprintf('\nA=%15.4f+%15.4fi',real(a),imag(a));
fprintf('\nB=%15.4f+%15.4fi',real(b),imag(b));
fprintf('\nC=%15.4f+%15.4fi',real(c),imag(c));
fprintf('\nD=%15.4f+%15.4fi',real(d),imag(d));
fprintf('\nAD-BC=%f',a*d-b*c);
Vr=input('\nEnter the receiving end line voltage in kV=');
Pr=input('Enter the receiving end power in MW=');
PF=input('Enter the receiving end power factor =');
pf_a=acos(PF);
vph=Vr*1e3/sqrt(3);
Ir=(Pr*1e6)/(3*vph*PF);
Irp=Ir*cos(pf_a)-i*Ir*sin(pf_a);
Vs=a*vph+b*Irp;
Is=c*vph+d*Irp;
fprintf('\nSending end voltage/ph =%15.4f+%15.4fi V',real(Vs),imag(Vs));
fprintf('\nSending end current/ph =%15.4f%15.4fi A',real(Is),imag(Is));
Ps=real(3*Vs*Is)/1e6;
Efficiency=(Pr/Ps)*100;
Regulation=(abs(Vs/a)-abs(vph))*100/abs(vph);
fprintf('\nSending end power =%0.2f MW',Ps);
fprintf('\nEfficiency=%0.2f%%',Efficiency);
fprintf('\nRegulation=%0.2f%%',Regulation);
```

7	Block, Circuit, Model Diagram, Reaction	• - • -

	Equation, Expected Graph	• -
8	Observation Table, Look-up Table, Output	Enter the length of medium line in km= 100 Enter the series impedance of the line per km= 0.1+0.2i Enter the shunt admittance of the line per km= 4e-13i A,B,C&D contants are: A=1.0000+0.0000i B=10.0000+ 20.0000i C= 0.0000+0.0000i D=1.0000+0.0000i AD-BC=1.000000 Enter the receiving end line voltage in kV=66 Enter the receiving end power in MW=10 Enter the receiving end power factor =0.8 Enter the length of medium line in km= 100 Enter the series impedance of the line per km= 0.15+0.50715i Enter the shunt admittance of the line per km= 2.1615e-6i A,B,C&D contants are: A=0.9945+0.0016i B=15.0000+50.7150i C=-0.0000+0.0002i D=0.9945+0.0016i AD-BC=1.000000 Enter the receiving end line voltage in kV=220 Enter the receiving end power in MW=60 Enter the receiving end power factor =0.85
9	Sample Calculations	• - • - • -
10	Graphs, Outputs	Sending end voltage/ph =40292.0506+1093.4664i V Sending end current/ph =87.4773+-65.6080i A Sending end power =10.79 MW Efficiency=92.69% Regulation=5.78% Sending end voltage/ph =133631.7573+6727.6857i V Sending end current/ph =156.7321 -69.4148i A Sending end power =64.23 MW

		Efficiency=93.41% Regulation=5.92%
11	Results & Analysis	
12	Application Areas	Develop a program in MATLAB
13	Remarks	Thus, the ABCD constants of the given medium transmission line were found using nominal Π and T method. Also, the efficiency and regulation of it were found for the given receiving end data.
14	Faculty Signature with Date	

Experiment 02:Determination of power angle diagram for

a) Salient pole synchronous machine

b) Non salient pole synchronous machine

-	Experiment No.:	2	Marks		Date Planned		Date Conducted	
1	Title	Determination of Power Angle Diagrams, Reluctance Power, Excitation, Emf and Regulation for Salient and Non-Salient Pole Synchronous Machines .						
2	Course Outcomes	Develop a program in MATLAB to obtain the power angle characteristics of salient and non-salient pole alternator						
3	Aim	To determine the power angle diagram, reluctance power, excitation emf and regulation of salient pole and non-salient pole synchronous machine.						
4	Material / Equipment Required	Lab Manual, PC loaded with MATLAB						
5	Theory, Formula, Principle, Concept	For Salient Pole 1. Current $\lvert I \rvert = \frac{P}{\sqrt{3} * V_L * Cos\phi}$ Amperes 2. Current I = |I| ∠– Φ Amperes in case of lagging pf, Current I = |I| ∠Φ Amperes in case of leading pf. 3. The equivalent voltage $V_{eq} = V_{ph} + j (I^* X_q)$ Volts 4. Direct axis current $\lvert I_d \rvert = \lvert I \rvert * \sin [\angle V_{eq} - \angle I]$ Amperes 5. The Excitation EMF or Field effective voltage $\lvert V_{ef} \rvert = \lvert V_{eq} \rvert + [(X_d - X_q) * \lvert I_d \rvert]$ Volts. 6. $\%Regulation = \frac{\lvert V_{ef} \rvert - \lvert V_{ph} \rvert}{\lvert V_{ph} \rvert} \times 100\ \%$ 7. Net Salient (Excitation) Power = $3 * \lvert V_{ef} \rvert * \lvert V_{ph} \rvert * \sin\delta / X_d$ MW 8. Net Reluctance Power = $3 * \frac{\lvert V_{ph} \rvert^2 * (X_d - X_q) * Sin 2\delta}{2 * X_d * X_q}$ MW 9. Net Resultant Power P_{net} = (Net Excitation power + Net Reluctance Power) MW 10. To get the maximum power delivered, $\frac{d}{d\delta} P_{net} = 0$ 11. Solution of $\frac{d}{d\delta} P_{net} = 0$ (Quadratic equation) yields the value of δ at which						

the P_{net} will be maximum. Let this value of δ be δ_{max}.

12. The maximum net resultant power delivered is,

$$P_{max} = 3 * \left\{ \frac{|V_{ref}| * |V_{ph}| * \sin(\delta_{max})}{X_d} + \frac{|V_{ph}|^2 * (X_d - X_q) * Sin(2 * \delta_{max})}{2 * X_d * X_q} \right\}$$

Where, P = Power output of the given salient synchronous machine in W

Φ = Power Factor angle = Cos^{-1} (PF)

V_L= Terminal voltage (line) of the given salient synchronous machine in Volts.

V_{ph}= Terminal voltage (per phase) of the given salient synchronous machine in Volts.

X_d = Direct axis reactance of the given salient synchronous machine in Ω

X_q = Quadrature axis reactance of the given salient synchronous machine in Ω

δ = Angle by which Excitation EMF (V_{ef}) leads Terminal Voltage (V_{ph}), load angle or torque angle.

For non salient Pole

Current $|I| = \frac{P}{\sqrt{3} * V_L * Cos\phi}$ Amperes

Current I = |I| ∠– Φ Amperes

The Excitation EMF or Field effective voltage | V_{ef} | = | (V_{ph} + j I * X) | Volts.

$$\%Regulation = \frac{|V_{ef}| - |V_{ph}|}{|V_{ph}|} \times 100\,\%$$

Net Non–Salient (Excitation) Power = 3 * | V_{ef} | * | V_{ph} | * Sin δ / X MW

Where, P = Power output of the given salient synchronous machine in MW

Φ = Power Factor angle = Cos^{-1} (PF)

V_L = Terminal voltage (line) of the given salient synchronous machine in Volts.

V_{ph} = Terminal voltage (per phase) of the given salient synchronous machine in Volts.

X = Synchronous reactance of the given non – salient pole synchronous machine in Ω

δ = Angle by which Excitation EMF (V_{ef}) leads Terminal Voltage (V_{ph}), load angle or torque angle.

6	Procedure, Program, Activity, Algorithm, Pseudo Code	Enter the command window of the MATLAB. Create a new M – file by selecting File- New – M – File. Type and save the program in the editor Window. Execute the program by pressing Tools – Run.

View the results.

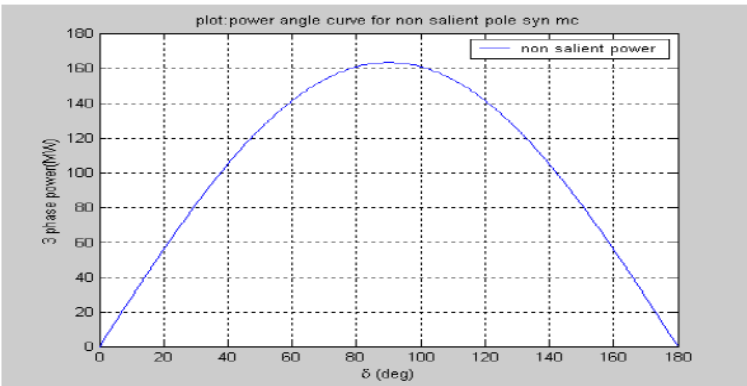
%POWER ANGLE CURVE FOR NON-SALIENT POLE SYNCHRONOUS MACHINES

```
clc
clear all
P=input('Enter the power output in MW=');
PF=input('Enter the power factor=');
Vt=input('Enter the line to line voltage in KV=');
X=input('Enter the Synchronous reactance of the given machine in ohms=');
Vph=(Vt*1e3)/sqrt(3);
PF_A=acos(PF);
I1=P*1e6/(3*Vph*PF);
I=I1*cos(PF_A)-i*I1*sin(PF_A);
Delta=0:1:180;
Delta_rad=Delta*(pi/180);
Vef=abs(Vph+(i*I*X));
Reg=((Vef-Vph)*100)/Vph;
NetPowerNonSalient=(3*Vef*Vph*sin(Delta_rad))/X;
plot(Delta,NetPowerNonSalient,'r');
xlabel('Delta (deg.)');
ylabel('Three phase power (MW)');
title('Plot:Power angle curve for non salient pole synchronous machine');
legend('Net Non Salient Power');
fprintf('\nExcitation EMF =%0.4f Volts/phase',Vef);
fprintf('\nRegulation =%0.4f %%',Reg);
Pmax=(3*Vef*Vph)/(X*1e6);
fprintf('\nThe max. power delivered by the given machine=%0.4f MW',Pmax);
del=input('\n\nenter the torque angle delta=');
del_rad=del*(pi/180);
p1=(3*Vef*Vph*sin(del_rad)/X)/1e6;
fprintf('Three phase power delivered =%0.4f MW',p1);
```

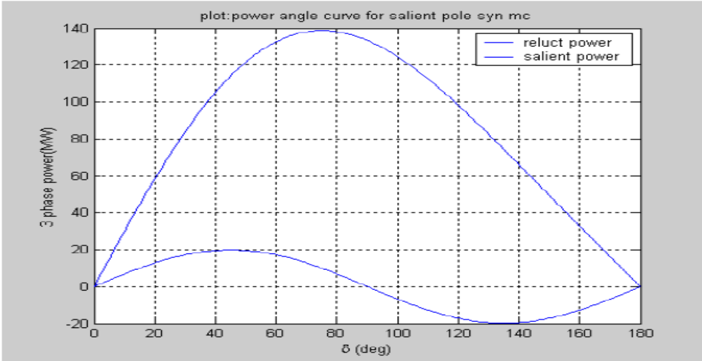
%POWER ANGLE CURVE FOR SALIENT POLE SYNCHRONOUS MACHINES

```
clc
clear all
P=input('Enter the power output of the given machine in MW=');
Vt=input('Enter the line to line terminal voltage in KV=');
Xd=input('Enter the Xd in ohms=');
Xq=input('Enter the Xq in ohms=');
PF=input('Enter the power factor=');
Vt_ph=(Vt*1e3)/sqrt(3);
PF_A=acos(PF);
I=P*1e6/(3*Vt_ph*PF);
I_ph= I*cos(PF_A)-i*I*sin(PF_A);
Delta=0:1:180;
Delta_rad=Delta*(pi/180);
Veq=Vt_ph+(i*I_ph*Xq);
```

```
Id=abs(I_ph)*sin(angle(Veq)-angle(I_ph));
Vef=abs(Veq)+((Xd-Xq)*Id);
Reg=(Vef-Vt_ph)*100/Vt_ph;
Net_NonSalienpower=(3*Vef*Vt_ph*sin(Delta_rad))/(Xd*1e6);
Net_Reluctpower=(3*Vt_ph^2*(Xd-Xq)*sin(2*Delta_rad))/(2*Xd*Xq*1e6);
Resultantpower =(Net_NonSalienpower + Net_Reluctpower);
plot(Delta,Net_NonSalienpower,'r');
hold on
plot(Delta,Net_Reluctpower,'y');
hold on
plot(Delta,Resultantpower,'b');
xlabel('Delta (deg.) ----->');
ylabel('Three phase power (MW) ----->');
title('Plot: Power angle curve for salient pole synchronous machine');
legend('Net_NonSalienpower','Net_Reluctpower','Resultant Power')
fprintf('\nExcitation EMF =%0.4f Volts/phase',Vef);
fprintf('\nRegulation =%0.4f %%',Reg);
dP=input('\n\nEnter the coefficients of quadratic equation dPnet/d=');
dP1=roots(dP);
Delta_max=acos(dP1(2,:));
Pmax=(3*((Vef*Vt_ph*sin(Delta_max))/Xd)+(3*Vt_ph^2*(Xd-Xq)*sin(2*Delta_max))/
(2*Xd*Xq))/1e6;
fprintf('The max. power delivered by the given machine=%0.4f MW',Pmax);
del=input('\nenter the torque angle delta=');
del_rad=del*(pi/180);
p1=(3*((Vef*Vt_ph*sin(del_rad))/Xd)+(3*Vt_ph^2*(Xd-Xq)*sin(2*del_rad))/
(2*Xd*Xq))/1e6;
fprintf('\nThree phase power delivered =%0.4f MW',p1);
```

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	

graph-1



graph-2

8	Observation Table, Look-up Table, Output	Enter the power output in MW=60 Enter the power factor=0.8 Enter the line to line voltage in KV=34.64 Enter the Synchronous reactance of the given machine in ohms=13.5 **Non Salient Pole** Enter the power output of the given machine in MW=60 Enter the line to line terminal voltage in KV=34.64 Enter the Xd in ohms=13.5 Enter the Xq in ohms=9.83 Enter the power factor=0.8
9	Sample Calculation	
10	Graphs, Outputs	Excitation EMF =33011.4960 Volts/phase Regulation =65.0623 % The max. power delivered by the given machine=146.7135 MW enter the torque angle delta=70 Three phase power delivered =137.8656 MW>> **Non Salient Pole** Excitation EMF =32914.8841 Volts/phase Regulation =64.5792 % Enter the coefficients of quadratic equation dPnet/d=[66.38 146.28 -33.18] The max. power delivered by the given machine=149.8361 MW enter the torque angle delta=100 Three phase power delivered =138.3868 MW
11	Results & Analysis	Thus, the power angle curves of a given salient pole synchronous machine were drawn. Also, the excitation emf, Max. power delivered (P_{max}), Non–Salient power, reluctance power, resultant power and regulation of it were found. Excitation EMF = _____________ Volts

		Regulation = ___________ % Max. power delivered (P_{max}) = __________ MW. Non Salient Pole Thus, the power angle curves of a given non – salient pole synchronous machine were drawn. Also, the excitation emf, Non – Salient power and regulation of it were found. Excitation EMF = _____________ Volts Regulation = ___________ % Max. power delivered = ______________ MW
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 03: Determination of swing curve

-	**Experiment No.:**	3	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	To obtain Swing Curve and to Determine Critical Clearing Time, Regulation, Inertia Constant/Line Parameters /Fault Location/Clearing Time/Pre-Fault Electrical Output for a Single Machine connected to Infinite Bus through a Pair of identical Transmission Lines Under 3-Phase Fault On One of the two Lines.						
2	Course Outcomes	Develop a program in MATLAB to assess the transient stability under three phase fault at different locations in a power systems.						
3	Aim	To determine the Swing curve of a single machine connected to infinite bus						
4	Material / Equipment Required	Lab Manual, PC loaded with MATLAB						
5	Theory, Formula, Principle, Concept	Swing Equation describes the relative motion of the rotor (load angle or torque angle or power angle δ) with respect to the stator field as a function of time. It is the fundamental equation governing the rotor dynamics of the synchronous machine. The solution of swing equation gives the relation between rotor angle δ as a function of time t. Normally, it is solved in digital computers using step-by- step method or employing numerical solution techniques like Euler's method or Runge-Kutta's method. The Plot of δ versus t is called as the swing curve. For simple systems like single machine connected to infinite bus or a two machine system, it is not necessary to solve the swing equation for finding the transient stability. It can be conveniently determined using the method known as Equal Area Criterion. Swing curves are useful in designing the protective devices for the system. Even in an						

		SMIB system, we have to resort to a numerical technique to evaluate the variation of δ with time and to determine CCT. All numerical methods use the concept of discretization of the variables, over suitable time intervals.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	Excitation EMF E and transfer reactance X_0 between line generators and infinite bus are determined for the specified output of the generator taking infinite bus voltage V as reference. 2. Pre-fault power characteristics is determined as $P_a = (\|E\|^* \|V\| \ * \sin \delta) / X_0$ Where E and V are magnitude of excitation EMF and voltage of infinite bus. 3. Pre-fault power angle is obtained as $\delta_0 = \sin^{-1} (P_{mech} / P_m)$ where P_{mech} is electrical output of generator before fault. 4. For the specified fault location the new transfer reactance X_1 is determined assuming constant excitation EMF and infinite bus voltage. The P- δ characteristics during the fault is obtained as $P_1 = (\|E\|^* \|V\| \ * \sin \delta) / X_1 = P_{1m} \sin \delta$ 5. For the system configuration after the isolation of faulty line, the transfer reactance X_2 and the corresponding post fault. The P- δ characteristics during the fault is obtained as $P_2 = (\|E\|^* \|V\| \ * \sin \delta) / X_2 = P_{2m} \sin \delta$ 6. The total time of transient stability study T, time at the instant of fault clearance t_c, inertia constant H of the generator and normal system frequency f are all identified from the system data. 7. Critical clearing time is determined from the equation 8. For determining critical clearing time, solution for swing equation is obtained for sustained fault using point by point method for above equations. Critical clearing time is taken for the time corresponding to δ_c. 9. For calculation of swing curve for sustained fault, it is enough to assume $t_c > T$ for ex: $t_c = T+0.01s$

10. For obtaining swing curve when the fault is cleared the procedure is similar, i.e., modified Euler method is applied to equations. to obtain incremental value of rotor swing during successive time steps and the rotor swing at the end of respective slips. It is important to use $P_c = P_1$ for intervals before fault clearance and $P_c = P_2$. for intervals after fault clearance.

11. A plot of δ vs t gives the swing curve in both cases (sustained fault /fault cleared).

12. Procedure is repeated for different values of inertia constant, fault location, fault clearing time, line reactance and pre-fault electrical output to study their effect on swing curve by changing the value of one of them at a time keeping other constant.

```
 %Program to find Swing curve critical clearing time for a single machine
%connected to infinite bus through a pair transmission line 3 phase fault on
%one of the line away from the sending end
clear all;
clc;
tfc=input('\nEnter fault clearing time=');
mi=input('\nEnter momentum constant=');
pm=input('\nEnter the mechanical power=');
pmbf=input('\nEnter the value of maximum power before fault=');
pmdf=input('\nEnter the value of maximum power during fault=');
pmaf= input('\nEnter the value of maximum power after fault=');
d=input('\nEnter the value of delta=');
w=input('\nEnter the value of angular velocity omega=');
h=input('\nEnter inertia constant=');
dmax=pi-asin(pm/pmaf);
cosdc=(pm*(dmax-d)+pmaf*cos(dmax)-pmdf*cos(d))/(pmaf-pmdf);
cc_angle=acos(cosdc)*180/pi;
cc_time=sqrt(2*h*((cc_angle*pi/180)-d)/(pi*50*pm));
disp('\nCRITICAL CLEARING ANGLE(IN DEG)');
disp(cc_angle);
disp('\nCRITICAL CLEARING TIME(IN SEC)');
disp(cc_time);
fprintf('\n\t TIME(IN SEC)\t DELTA(IN DEG)\n');
%finding ouot swing curve by Runge-Kutta Method
for t=0:0.05:0.5
   if t<tfc
      pmax=pmdf;
   elseif t>=tfc
         pmax=pmaf;
      end
      k1=w*0.05;
      l1=(pm-pmax*sin(d))*0.05/mi;
      k2=(w+0.5*l1)*0.05;
      l2=(pm-pmax*sin(d+0.5*k1))*0.05/mi;
      k3=(w+0.5*l2)*0.05;
      l3=(pm-pmax*sin(d+0.5*k2))*0.05/mi;
      k4=(w+l3)*0.05;
```

		l4=(pm-pmax*sin(d+k3))*0.05/mi;
		deld=(k1+2*k2+2*k3+k4)/6;
		delw=(l1+2*l2+2*l3+l4)/6;
		d=d+deld;
		dg=(d*180)/pi;
		fprintf('\t%6.3f\t\t%6.3f\n',t,dg)
		w=w+delw;
		end

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Enter fault clearing time=0.12 Enter momentum constant=0.0331 Enter the mechanical power=0.8 Enter the value of maximum power before fault=1.714 Enter the value of maximum power during fault=0.63 Enter the value of maximum power after fault=1.333 Enter the value of delta=0.485 Enter the value of angular velocity omega=0 Enter inertia constant=5.2 \nCRITICAL CLEARING ANGLE(IN DEG) 91.0818
9	Sample Calculation	
10	Graphs, Outputs	\nCRITICAL CLEARING TIME(IN SEC) 0.3024 TIME(IN SEC) DELTA(IN DEG) 0.000 28.880 0.050 32.110 0.100 37.346 0.150 43.424 0.200 49.005 0.250 53.702 0.300 57.220 0.350 59.358 0.400 60.001

		0.450 59.117 0.500 56.751
11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 04: Ybus formation by

1. Inspection method.

2. Singular transformation method with and without Mutual coupling.

-	**Experiment No.:**	4	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Y Bus Formation for Power Systems with and without Mutual Coupling by Singular Transformation and Inspection Method.						
2	Course Outcomes	Develop a program to compute admittance matrix by inspection & singular transformation method						
3	Aim	Bus admittance matrix (Ybus) formation for power systems using inspection method and by singular transformation method with and without Mutual coupling.						
4	Material / Equipment Required	Lab Manual, PC loaded with MATLAB						
5	Theory, Formula, Principle, Concept	Bus admittance matrix or Ybus is matrix which gives the information about the admittances of lines connected to the node as well as the admittance between the nodes. Principal diagonal elements are called self admittances of node and is equal to the algebraic sum of all the admittances terminating at the node. Off diagonal elements are called mutual admittances and are equal to the admittances between the nodes. The size of ybus is n*n where n is the number of buses in the system and m= n+1(the total number of buses including the reference buses). $I_{bus} = Y_{bus} * V_{bus}$ where I_{bus} = vector of impressed bus currents Y_{bus} = bus admittance matrix. V_{bus} = vector of bus voltages measured with respect to reference bus. Inspection method makes use of KVL at all the nodes to get the current equations. From these equations, Y_{bus} can be directly written. It is the simplest and direct method of obtaining all the diagonal elements as well as off diagonal elements in the matrix of any power system. Bus admittance matrix is a sparse matrix. It is often used in solving load flow problems. Sparsity is one of its greatest advantages as it heavily reduces computer memory and time requirements. The Y Matrix is designated by Ybus and called the bus admittance matrix. Y matrix is a symmetric and square matrix that completely describes the configuration of power transmission lines. In realistic systems which are quite large containing						

thousands of buses, the Y matrix is quite sparse. Each bus in a real power system is usually connected to only a few other buses through the transmission lines. The Y Matrix is designated by Ybus and called the bus admittance matrix. Y matrix is a symmetric and square matrix that completely describes the configuration of power transmission lines. In realistic systems which are quite large containing thousands of buses, the Y matrix is quite sparse. Each bus in a real power system is usually connected to only a few other buses through the transmission lines. Ybus can be alternatively assembled by use of singular transformation given by a graph theoretical approach. This alternative approach is of great theoretical and practical significance.

Steps involving singular transformation:

1. Obtain the oriented graph for the given system.
2. Get the bus incidence matrix which is the one which indicates the incidence of all the elements to nodes in connected graph. The size of this matrix is e*(n-1) where e is the number of elements in the graph and n is the number of nodes (A)
3. Get the primitive admittance matrix from the graph of size e*e. If mutual coupling between the lines is neglected then the resulting primitive matrix is a diagonal matrix(off diagonal elements are zero)([y]) 4. Ybus can be obtained from the equation, Ybus = A^t * [y] *A

Inspection method.

1. Line impedance $z_{ik} = (R_{ik} + j X_{ik})\ \Omega$
2. Line Admittance $y_{ik} = 1/z_{ik} = 1/(R_{ik} + j X_{ik})$ mho.
3. The diagonal elements of Bus Admittance Matrix (self admittance or driving point admittance) are,

$$Y_{ii} = \sum_{k=1}^{n} y_{ik},$$

4. The off diagonal elements of Bus Admittance Matrix (mutual admittance or transfer admittance) are, $Y_{ik} = Y_{ki} = -y_{ik}$

   Where, i and k are the buses in the given network.

   n is the no. of buses.

SINGULAR TRANSFORMATION METHOD (WITHOUT MUTUAL COUPLING)

1. Primitive Impedance matrix [Zprim] = [(R + j X)]
2. Primitive Admittance matrix Y = [Yprim] = 1 / [Zprim]
3. Bus Admittance Matrix $Y_{BUS} = A^T * Y * A$

Where, A – Bus incidence matrix and Y – Primitive admittance matrix

SINGULAR TRANSFORMATION METHOD (WITH MUTUAL COUPLING)

1. Primitive Impedance matrix [Zprim] = [(R + j X)]
2. Primitive Admittance matrix Y = [Yprim] = 1 / [Zprim]
3. Bus Admittance Matrix $Y_{BUS} = A^T * Y * A$

   Where, A – Bus incidence matrix and Y – Primitive admittance matrix

6	Procedure, Program, Activity,	<u>%FORMATION OF Y–BUS BY INSPECTION METHOD</u>

Algorithm, Pseudo Code

```
clc
clear all
e=input('\n enter the number of elements:=');
n=input('\n enter the number of nodes:=');
ybd=input('\n enter the oriented graph:=');
from=ybd(:,1);to=ybd(:,2);rse=ybd(:,3);xse=ybd(:,4);y=ybd(:,5);
nl=length(from);
nb=max(max(from,to));
z=rse+i*xse;
ybus=zeros(nb);
for a=1:nl
   yse=1/z(a);
    ybus(from(a),from(a))=ybus(from(a),from(a))+i*y(a)+yse;
    ybus(to(a),to(a))=ybus(to(a),to(a))+i*y(a)+yse;
    ybus(from(a),to(a))=ybus(from(a),to(a))-yse;
    ybus(to(a),from(a))=ybus(from(a),to(a));
    end
    ybus

% FORMATION OF Y–BUS BY SINGULAR TRANSFORMATION METHOD(WITHOUT MUTUAL COUPLING)

clear
e=input('\n Enter the number of elements=');
n=input('\n Enter the number of nodes=');
ybd=input('\n Enter the oriented graph=');
from=ybd(:,1);to=ybd(:,2);rse=ybd(:,3);
xse=ybd(:,4);
nl=length(from);
nb=max(max(from,to));
yp=zeros(e*e);
A=zeros(nl,nb);
zse=rse+i*xse;
nrow=nl+1;
for a=1:nl;
   yp(a,a)=1/zse(a);
   A(a,from(a))=1;
   A(a,to(a))=-1;
   A(nrow,from(a))=1;
   A(nrow+1,to(a))=1;
   nrow=nrow+2;
end
ybus=A'*yp*A;
bus_admittance_matrix=ybus

% FORMATION OF Y–BUS BY SINGULAR TRANSFORMATION METHOD(WITH MUTUAL COUPLING)

clc;
clear;
e=input('\nenter the number of elements=');
```

```
n=input('\nenter the number of nodes=');
dm=input('\nenter the oriented graph=');
R=input('\nEnter the reference node=');
from=dm(:,1);
to=dm(:,2);
zse=dm(:,3);
nl=length(from);
nb=max(max(from,to));
A=zeros(nl,nb);
zp=diag(zse);
zp(2,3)=input('\nenter mutual impedence=' );
zp(3,2)=zp(2,3);
yp=inv(zp);
for a=1:nl;
  A(a,from(a))=1;
  A(a,to(a))=-1;
end
A;
A(:,R)=[];
A1=A;
Ybus=A1'*yp*A
```

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	enter the number of elements:=7 enter the number of nodes:=5 enter the oriented graph:=[1 2 0.02 0.06 0.030;1 3 0.08 0.24 0.025;2 3 0.06 0.18 0.020;2 4 0.06 0.18 0.020;2 5 0.04 0.12 0.15;3 4 0.01 0.03 0.01;4 5 0.08 0. 24 0.025]; SINGULAR TRANSFORMATION METHOD(WITHOUT MUTUAL COUPLING) enter the number of elements=3 Enter the number of nodes=3 Enter the oriented graph=[1 2 0.02 0.08;1 3 0.02 0.08;2 3 0.02 0.08] SINGULAR TRANSFORMATION METHOD(WITH MUTUAL COUPLING) enter the number of elements=4

		enter the number of nodes=5 enter the oriented graph=[1 5 i;2 1 0.4i;3 1 0.5i;3 4 0.2i;4 2 0.25i] Enter the reference node=1 enter mutual impedence=0.2i
9	Sample Calculation	
10	Graphs, Outputs	ybus = 6.2500-18.6950i -5.0000+15.0000i -1.2500+3.7500i 0 0 -5.0000+15.0000i 10.8333-32.2800i -1.6667+5.0000i -1.6667+5.0000i -2.5000+7.5000i -1.2500+3.7500i -1.6667+5.0000i 12.9167-38.6950i -10.0000+30.0000i 0 0 -1.6667+5.0000i -10.0000+30.0000i 12.9167-38.6950i -1.2500+3.7500i 0 -2.5000+7.5000i 0 -1.2500+3.7500i 3.7500-11.0750i bus_admittance_matrix = 5.8824 -23.5294i -2.9412 +11.7647i -2.9412 +11.7647i -2.9412 +11.7647i 5.8824 -23.5294i -2.9412 +11.7647i -2.9412 +11.7647i -2.9412 +11.7647i 5.8824 -23.5294i Ybus = 0 - 7.1250i 0 + 1.2500i 0 + 4.0000i 0 0 + 1.2500i 0 - 7.5000i 0 + 5.0000i 0 0 + 4.0000i 0 + 5.0000i 0 - 9.0000i 0 0 0 0 0 - 1.0000i
11	Results & Analysis	Thus, the Bus Admittance matrix (Y–Bus) for a given power system is determined by using inspection method. Y_{Bus} = ______________________. Thus, the Bus Admittance matrix (Y – Bus) for a given power system without mutual coupling was determined by using singular transformation method. Y_{Bus} = ______________________. Thus, the Bus Admittance matrix (Y – Bus) for a given power system with and without mutual coupling is determined by using singular transformation method.

		Y_{Bus} = ________________________.
12	Application Areas	
13	Remarks	
14	Faculty Signature' with Date	

Experiment 05: Z-Bus Building Algorithm.

-	**Experiment No.:**	5	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.						
2	Course Outcomes	Develop a program to compute Z-bus using Z- bus algorithm						
3	Aim	Formation of Z Bus(without mutual coupling) using Z-Bus Building Algorithm.						
4	Material / Equipment Required	Lab Manual, PC loaded with MATLAB						
5	Theory, Formula, Principle, Concept							
6	Procedure, Program, Activity, Algorithm, Pseudo Code	(see code below)						

```
%Z-Bus Building Algorithm
clc
clear
z=input('\n enter the bus data:');
[m n]=size(z);
zbus=[];
currentbusno=0;
for a=1:m
    [rows cols]=size(zbus);
    fb=z(a,2);
    tb=z(a,3);
    value=z(a,4);
    newbus=max(fb,tb);
    ref=min(fb,tb);
    % type 1 modification
    if newbus>currentbusno & ref==0
        type=1
        zbus=[zbus zeros(rows,1)
            zeros(1,cols) value]
        currentbusno=newbus;
        continue
    end
     % type 2 modification
      if newbus>currentbusno & ref~=0
     type=2
```

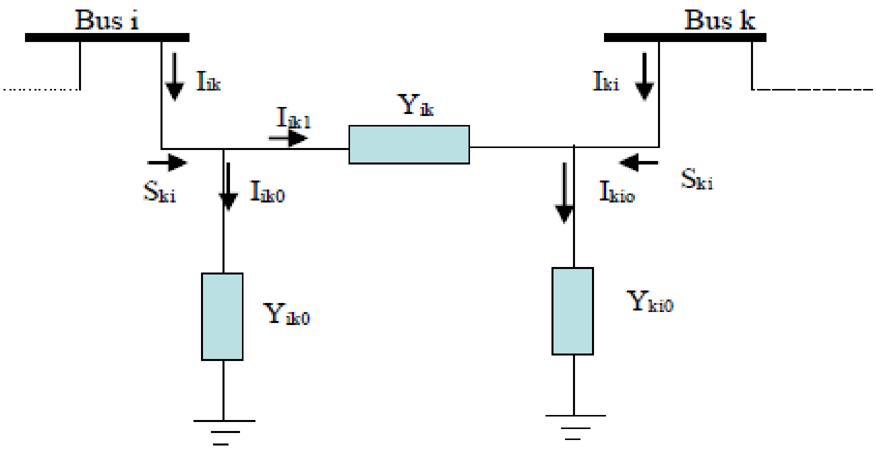
		zbus=[zbus zbus(:,ref) zbus(ref,:) value+zbus(ref,ref)] currentbusno=newbus continue end % type 3 modification if newbus<=currentbusno & ref==0 type=3 zbus=zbus-1/(zbus(newbus,newbus)+value)*zbus(:,newbus)*zbus(newbus,:) continue end % type 4 modification if newbus<=currentbusno & ref~=0 type=4 zbus=zbus-1/(value+zbus(fb,tb)+zbus(tb,tb)-2*zbus (fb,tb))*((zbus(:,fb)- zbus(:,tb))*((zbus(fb,:)-zbus(tb,:)))) continue end end
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	enter the bus data:[1 1 0 0.25;2 2 1 0.1;3 3 1 0.1;4 2 0 0.25;5 2 3 0.1] type =1 zbus = 0.2500 type =2 zbus = 0.2500 0.2500 0.2500 0.3500 currentbusno = 2 type =2
9	Sample Calculation	
10	Graphs, Outputs	zbus = 0.2500 0.2500 0.2500 0.2500 0.3500 0.2500

```
   0.2500    0.2500    0.3500

currentbusno = 3

type = 3

zbus =

   0.1458    0.1042    0.1458
   0.1042    0.1458    0.1042
   0.1458    0.1042    0.2458

type = 4

zbus =

   0.1386    0.1114    0.1214
   0.1114    0.1386    0.1286
   0.1214    0.1286    0.1628
```

11	Results & Analysis	
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 06: Determination of bus currents, bus power and line flows for a specified Bus system profile.

-	**Experiment No.:**	6	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Determination of bus currents, bus power and line flows for a specified Bus system profile.						
2	Course Outcomes	Calculate bus currents, bus power and line flow for given system, develop the program and verify using MATLAB						
3	Aim	To determine the bus currents, bus power and line flows for any power system						
4	Material / Equipment Required	Lab Manual/PC loaded with MATLAB						
5	Theory, Formula, Principle, Concept	The last step in the load flow analysis is computing the power flows, bus currents and bus power on the various lines of the network. Consider the line connecting buses i and k. The line and transformer at each end can be represented by a circuit with series admittance Y_{ik} and two shunt admittances Y_{iko} and Yk_{io} as shown below.						



The current fed by bus I into the line can be expressed as,

$I_{ik} = I_{ik1} + I_{iko} = (V_i – V_k)Y_{ik} + V_i\, Y_{ik0}$

The power fed into the line from bus i is

$S_{ik} = P_{ik} + jQ_{ik} = V_i I_{ik}^* = V_i(V_i^* - V_k^*)\, Y_{ik}^* + V_i V_i^* Y_{iko}^*$

The power fed into the line from bus k is

$S_{ki} = P_{ki} + jQ_{ki} = V_K I_{ki}^* = V_k(V_k^* - V_i^*)\, Y_{ik}^* + V_k V_k^* Y_{kio}^*$

The power loss in the (i-k) the line is the sum of the power flows determined from the last two equations. The transmission loss can be computed by summing all line flows (i.e S_{ik} + S_{ki} for all i, k). The slack bus power can also be found by summing the flows on the lines terminating at the slack bus.

Formula used

1. Line currents $I_{ik} = (V_i – V_k) * Y_{ik} + V_i * (YSh_{ik} / 2)$ and $I_{ki} = (V_k – V_i) * Y_{ik} + V_k * (YSh_{ik} / 2)$ Amperes
2. Complex power flow $S_{ik} = V_i * I_{ik}'$ and $S_{ki} = V_k * I_{ki}'$
3. Line losses $S_L = S_{ik} + S_{ki}$
4. Bus power $S_i = \sum_{k=1}^{n} S_{ik}$
5. Bus current $I_i = \sum_{k=1}^{n} I_{ik}$

Where, n = the number of PQ buses in the given network,

V_i = Voltage at the bus i,

Y_{ik} = Mutual admittance between buses i and k,

YSh_{ik} = Total line charging admittance between buses i and k,

I_{ik}' = Conjugate of line current flowing from bus i to bus k.

6	Procedure, Program, Activity, Algorithm, Pseudo Code	clc clear all linedata=input('\nEnter the line data ----->');

```
busdata=input('\nEnter the bus data ----->');
fr=linedata(:,1);
to=linedata (:,2);
r=linedata (:,3);
x=linedata (:,4);
b=linedata(:,5);
z=r+i*x;
y=1./z;
ysh=i*b;
nbr=length(fr);
nbus=max(max(fr),max(to));
bus_no=busdata(:,1);
volt_mag=busdata(:,2);
angle_d=busdata(:,3);
%bus voltages in rectangular form
for n=1:nbus
    v_bus(n)=(volt_mag(n)*cos(angle_d(n)*pi/180))
+i*(volt_mag(n)*sin(angle_d(n)*pi/180));
end
v_bus
%line current
for m=1:nbr
    Iik(m)=(v_bus(fr(m))-v_bus(to(m)))*y(m)+ (v_bus(fr(m))*ysh(m));
    Iki(m)=(v_bus(to(m))-v_bus(fr(m)))*y(m)+(v_bus(to(m))*ysh(m));
end
Iik
Iki
%complex power flow
for m=1:nbr
    Sik(m)=v_bus(fr(m))*conj(Iik(m));
    Ski(m)=v_bus(to(m))*conj(Iki(m));
end
Sik
Ski
%line losses
for m=1:nbr
    Sl(m)=Sik(m)+Ski(m);
end
Sl
```

```
%bus power
s_bus=zeros(nbus,1);
for n=1:nbus
   s_bus(n)=0;
   for m=1:nbr
      if fr(m)==n
         s_bus(n)=s_bus(n)+Sik(m);
      elseif to(m)==n
         s_bus(n)=s_bus(n)+Ski(m);
      end
   end
end
s_bus
%bus current
i_bus=zeros(nbus,1);
for n=1:nbus
   i_bus(n)=0;
   for m=1:nbr
      if fr(m)==n
         i_bus(n)=i_bus(n)+Iik(m);
      elseif to(m)==n
         i_bus(n)=i_bus(n)+Iki(m);
      end
   end
end
i_bus
```

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	enter the line data=[1 2 0 0.2 0;1 3 0 0.15 0;1 4 0 0.1 0;2 3 0 0.1 0;2 4 0 0.15 0] enter the bus data=[1 1 0;2 1 4.41;3 1 -4.24;4 1 -5.1]
9	Sample Calculation	
10	Graphs, Outputs	vb = 1.0000 0.9970 + 0.0769i 0.9973 - 0.0739i 0.9960 - 0.0889i I =

```
      0           -0.3845 - 0.0148i   0.4929 - 0.0182i   0.8889 - 0.0396i
   0.3845 + 0.0148i        0            1.5083 + 0.0022i   1.1052 - 0.0067i
  -0.4929 + 0.0182i  -1.5083 - 0.0022i        0                  0
  -0.8889 + 0.0396i  -1.1052 + 0.0067i        0                  0


S =

      0           -0.3845 + 0.0148i   0.4929 + 0.0182i   0.8889 + 0.0396i
   0.3845 + 0.0148i        0            1.5040 + 0.1137i   1.1015 + 0.0916i
  -0.4929 + 0.0182i  -1.5040 + 0.1137i        0                  0
  -0.8889 + 0.0396i  -1.1015 + 0.0916i        0                  0


Sl =

   0 + 0.0296i   0 + 0.0365i    0 + 0.0792i    0 + 0.2275i    0 +
0.1832i


bp =

   0.9974 + 0.0726i   2.9899 + 0.2202i  -1.9969 + 0.1320i  -1.9904 + 0.1312i


ibus =

   0.9974 - 0.0726i   2.9980 + 0.0104i  -2.0012 + 0.0160i  -1.9942 + 0.0462i
```

11	Results & Analysis	Thus, the line currents, line losses, bus currents, bus power and line flow for a power system network with a specified system voltage (bus) profile were determined. Line Currents I_{ik} = Bus currents I_i = Line Currents I_{ki} = Bus power S_i = Line power S_{ik} = Line losses S_L = Line power S_{ki}=
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 07: Jacobian Matrix Calculation

-	**Experiment No.:**	7	**Marks**		**Date Planned**		**Date Conducted**	

1	Title	Formation of Jacobian for a System not Exceeding 4 Buses (No PV Buses) in Polar Coordinates
2	Course Outcomes	formation of Jacobian
3	Aim	Formation of Jacobian for a system not exceeding 4 buses *(no PV buses) in polar coordinates
4	Material / Equipment Required	Lab manual, PC loaded with MATLAB
5	Theory, Formula, Principle, Concept	1. Real Power $P_i = \lvert V_i\rvert * \sum_{k=1}^{n} \lvert V_k\rvert * \lvert Y_{ik}\rvert * \cos(\theta_{ik} + \delta_k - \delta_i)$. 2. Reactive Power $Q_i = -\lvert V_i\rvert * \sum_{k=1}^{n} \lvert V_k\rvert * \lvert Y_{ik}\rvert * \sin(\theta_{ik} + \delta_k - \delta_i)$. 3. Jacobian elements $H_{ii} = -Q_i - (B_{ii} * \lvert V_i\rvert^2)$, $N_{ii} = P_i + (G_{ii} * \lvert V_i\rvert^2)$, $J_{ii} = P_i - (G_{ii} * \lvert V_i\rvert^2)$ and $L_{ii} = Q_i - (B_{ii} * \lvert V_i\rvert^2)$. 4. Jacobian elements $H_{ij} = \partial P_i / \partial \delta_j = L_{ij} = \partial Q_i / \partial \lvert V_j\rvert = -\lvert V_i\rvert * \lvert V_j\rvert * \lvert Y_{ij}\rvert * \sin(\theta_{ij} - \delta_i + \delta_j)$. $N_{ij} = \partial P_i / \partial \lvert V_j\rvert = -J_{ij} = -\partial Q_i / \partial \delta_j = \lvert V_i\rvert * \lvert Y_{ij}\rvert * \cos(\theta_{ij} - \delta_i + \delta_j)$. 5. Jacobian matrix = $\begin{bmatrix} H & N \\ J & L \end{bmatrix}$ Where, i & k are no. of buses, V_i is the bus voltage at bus i, Y_{ik} is the corresponding element in bus admittance matrix, θ_{ik} is angle of Y_{ik} in the corresponding element of bus admittance matrix, δ_i is the angle of bus voltage at bus i, B_{ii} is the susceptance of bus i = $\lvert Y_{ii}\rvert * \sin\theta_{ii}$, G_{ii} is the conductance of bus i = $\lvert Y_{ii}\rvert * \cos\theta_{ii}$,

6	Procedure, Program, Activity, Algorithm, Pseudo Code	clc
		clear all
		y_bus=input('Enter the bus admittance matrix ==>');
		busdata=input('\nEnter the bus data ==>');
		y=abs(y_bus);
		th=angle(y_bus);
		bus_no=busdata(:,1);

```
v_mag=busdata(:,2);
v_ang=busdata(:,3);
nbus=max(bus_no);
slackbus=1;
for p=1:nbus
    pc(p)=0;
    qc(p)=0;
    for q=1:nbus
        if(p~=slackbus)
            pc(p)=pc(p)+(v_mag(p)*v_mag(q)*y(p,q)*cos(th(p,q)+v_ang(q)-v_ang(p)));
            qc(p)=qc(p)-(v_mag(p)*v_mag(q)*y(p,q)*sin(th(p,q)+v_ang(q)-v_ang(p)));
        end
    end
end
for p=1:nbus
    p_cal(p)=pc(p);
    q_cal(p)=qc(p);
end
p_cal
q_cal
%formation of H N J L
i=1;
for p=1:nbus
    j=1;
    for q=1:nbus
        if(p~=q)&(p~=slackbus)&(q~=slackbus)
        H(i,j)=-v_mag(p)*v_mag(q)*y(p,q)*sin(th(p,q)-v_ang(p)+v_ang(q));
        N(i,j)=(v_mag(p)*y(p,q))*cos(th(p,q)-v_ang(p)+v_ang(q));
        J(i,j)=-N(i,j);
        L(i,j)=H(i,j);
        j=j+1;
        end
        if(p==q)&(p~=slackbus)&(q~=slackbus)
        H(i,i)=-q_cal(p)-(y(p,p)*sin(th(p,p))*v_mag(p)^2);
        N(i,i)=p_cal(p)+(y(p,p)*cos(th(p,p))*v_mag(p)^2);
        J(i,i)=p_cal(p)-(y(p,p)*cos(th(p,p))*v_mag(p)^2);
        L(i,i)=q_cal(p)-(y(p,p)*sin(th(p,p))*v_mag(p)^2);
```

		j=j+1;
		end
		end
		if(p~=q)&(p~=slackbus)&(q~=slackbus)
		i=i+1;
		end
		end
		H
		N
		J
		L
		Jacobian = [H N; J L]

7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	Enter the bus admittance matrix ==>[6.25-18.75i -1.25+3.75i -5+5i; -1.25+3.75i 2.916667-8.75i -1.6667+5i;-5+15i -1.6667+5i 6.6667-20i] Enter the bus data ==>[1 1.04 0;2 1 0;3 1 0]
9	Sample Calculation	
10	Graphs, Outputs	p_cal = 0 -0.0500 -0.2000 q_cal = 0 -0.1500 -0.6000 H = 8.9000 -5.0000 -5.0000 20.6000 N = 2.8666 -1.6667 -1.6667 6.4667 J = -2.9667 1.6667

		1.6667 -6.8667 L = 8.6000 -5.0000 -5.0000 19.4000 Jacobian = 8.9000 -5.0000 2.8666 -1.6667 -5.0000 20.6000 -1.6667 6.4667 -2.9667 1.6667 8.6000 -5.0000 1.6667 -6.8667 -5.0000 19.4000
11	Results & Analysis	Thus, the Jacobian matrix for a power system which has only PQ buses was formed. P = Q = Matrix H = Matrix N = Matrix J = Matrix L = Jacobian Matrix =
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 08: Load Flow Analysis

-	**Experiment No.:**	8	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Load Flow Analysis using Gauss Siedel Method, NR Method and Fast Decoupled Method for Both PQand PV Buses.						
2	Course Outcomes	Use Mi-Power package to study load flow analysis using NR method, Gauss Siedel Method, Fast Decoupled method						
3	Aim	Load flow analysis using Newton Raphson Method/Gauss seidel method.						
4	Material / Equipment Required	Lab Manual, P.C loaded with Mipower package						

5	Theory, Formula, Principle, Concept	Load flow solution is a solution of a network under steady state condition subjected to certain inequality constraints under which the system operates. These constraints can be in the form load nodal voltages, reactive power generation of the generators, the tap setting of the tap changing transformer under load conditions. The load flow solution gives the nodal voltages and phase angles and hence the power injection at all the buses and power flows through interconnecting power channels (through transmission line). Load flow solution is essential for designing a new power system and for planning extension of the existing one for increased load demand. These analysis require the calculations numerous load flows under both normal and abnormal operating conditions. Load flow solution also gives the initial conditions of the systems in the transient behavior of the system is to be obtained. Load flow solution for power network can be worked out both ways accordingly as it is operating under balanced and unbalanced conditions. The following treatment will be for a system operating under balanced conditions. For such a system single phase representation is adequate. A load flow solution of the power system requires mainly the following steps. 1) formulation or network equation 2) Suitable mathematical technique for solution of the equation. 3) The load and hence the generation are continuously varying in a real power system. We will assume here that loads and hence generations are fixed at a particular value over a suitable period of time. Example (½ hr) Bus classification In a power system each bus or a node is associated with four quantities a) real power b) reactive power c) bus voltage magnitude d) phase angle of the voltage. In a load flow solution two out of four quantities are specified and remaining two are required to be obtained. Depending upon which quantities are specified buses are classified as 1) generator bus 2) slack bus 3) load bus Generator bus (voltage controlled bus) Any bus of the system at which voltage magnitude is kept constant is called voltage controlled bus. At each bus to which there is a generator connected, the megawatt generation can be controlled by adjusting the prime mover and the voltage magnitude can be controlled by adjusting the generator excitation. Therefore at each generator bus we may properly specify Pgi and $\|Vi\|$. Thus at the bus I angle delta and Qgi are the unknown quantities. Therefore it is also called as PV Bus. Load bus (PQ bus) At each non generator bus called bus both Pgi and Qgi are zero and real power Pdi and reactive power Qdi are drawn from the system by the load. The two unknown quantities are voltage magnitude and voltage angle (V and δ) Slack bus The losses remain unknown until the load flow solution is complete. It is for this reason generally one of the generator buses is made to take the additional real and reactive power to supply transmission losses that is why this bus is known as slack bus or swing bus. At this bus the voltage magnitude V and phase angle δ are specified where as Pgi and Qgi are unknown. The voltage angle of the slack bus serves as a reference for the angles of all other bus voltages. Techniques of solving load flow problems The development of any method for the load flow studies on the digital computer requires the following main consideration

		1) mathematical formulation of the load flow problem 2) application of numerical technique to solve these problems The mathematical formulation of load flow problem is a system of non linear algebraic equations. The non-linear algebraic equations can be solved by the solution techniques such as iterative methods 1) Gauss method 2) Gauss- Seidel method 3) Newton Raphson method Gauss Seidel method In this method the value of bus voltages calculated for any bus immediately replace the previous values in the next step while in case of gauss method the calculated bus voltage replace the earlier value only at the end of iteration. Due to this Gauss Siedel method converges faster than that of Gauss method. This method solves the power flow equation in rectangular co-ordinates until the differences in the bus voltages from one iteration another are sufficiently small. Newton Raphson method It's a powerful method of solving non-linear algebraic equation. It works faster and is sure to converge in most of the cases as compared to the GS method. It is indeed a practical method of load flow solution of large power networks. Its only drawback is the large requirement of computer memory. Convergence can be considerably speeded up by performing the first iteration through the GS method and using the values so obtained for starting the NR iterations. This method solves the polar form of the power flow equations until δp and δq mismatches, at all buses fall within the tolerance. Fast Decoupled NR method When solving large scale power transmission systems strategy for improving computational efficiency and reducing computer storage requirements is the decoupled load flow method. Incorporation of approximations of the decoupled method into the jacobian matrix makes the elements of the sub matrices J_{12} and J_{21} zero. Therefore the modified jacobian now consists of the sub matrices J_{11} and J_{22}.However J_{11} and J_{22} are still interdependent. The complications in solving J_{11} and J_{12} can be overcome by introducing further simplifications which are justified by the physics of transmission line power flow. Such a method is called as fast de coupled method.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**Gauss Siedel Method** To begin, double-click on the "PowerWorld Simulator icon". This starts Simulator. Simulator is used to create new cases. 2.Select Network > required components from the Individual Insert ribbon group on the Draw ribbon tab. This prepares Simulator to insert a new components. 3.Left-click on the oneline background at the location where you want to place the new bus. This invokes the component Option Dialog.

4 .Draw the given single line diagram using suitable components with their specification.

5 .Run the system by Click on Run Mode button in the Mode ribbon group.

6 .Press the Play button in the Power Flow Tools ribbon group on the Tools ribbon tab to begin the simulation. Alternatively, to perform a Power Flow Solution, click on Gauss Seidel power flow option in the solve ribbon group.

7 .It will solve the network and update all the filed values as per solution results on single line diagram.

8 .Click on model explore to check the results. The corresponding bus voltages, Y-bus are noted down and verified.

Newton raphson method

1.To begin, double-click on the "PowerWorld Simulator icon". This starts Simulator. Simulator is used to create new cases.

2. Select Network > required components from the Individual Insert ribbon group on the Draw ribbon tab. This prepares Simulator to insert a new components.

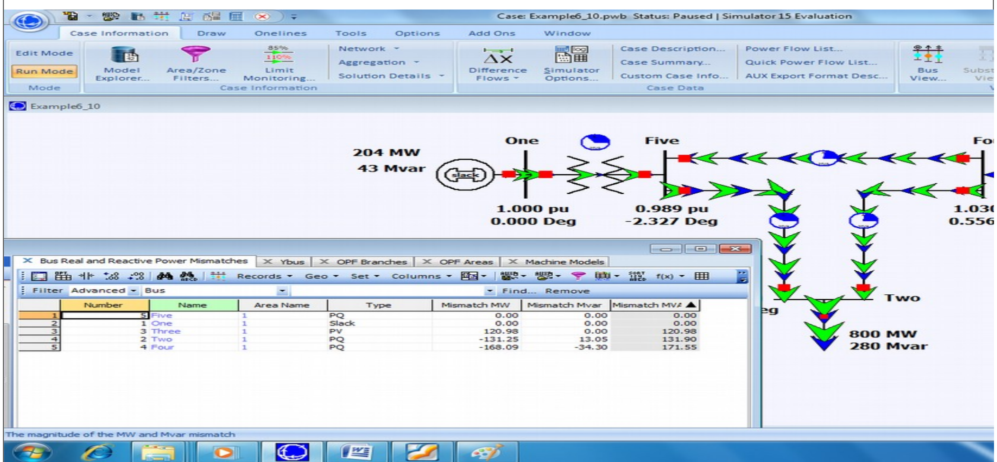
3. Left-click on the online background at the location where you want to place the new bus. This invokes the component Option Dialog.

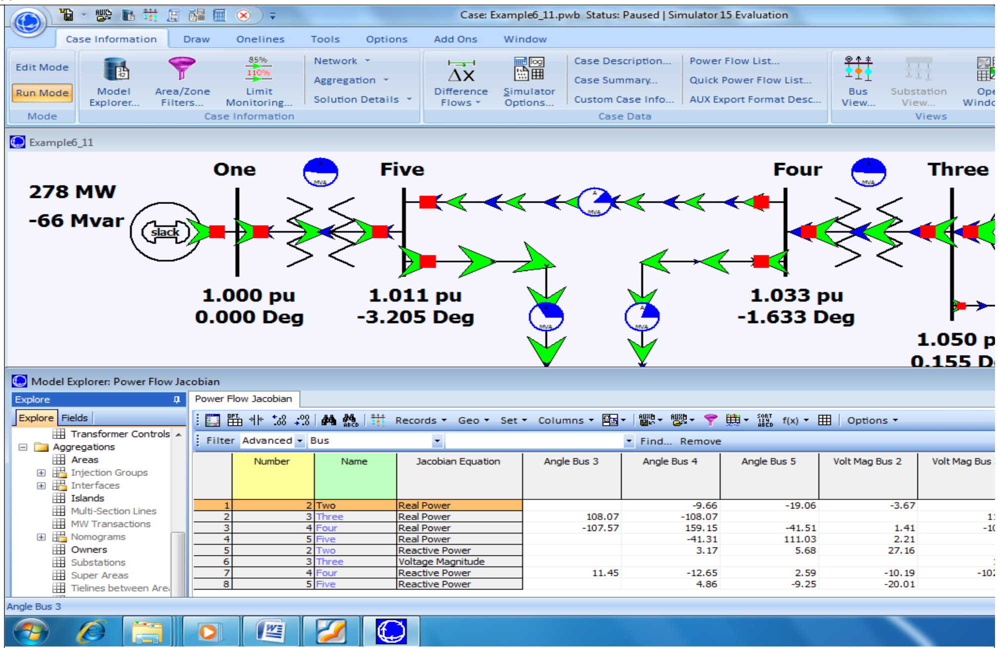
4. Draw the given single line diagram with the specification of components.

5. Run the system by Click on Run Mode button in the Mode ribbon group.

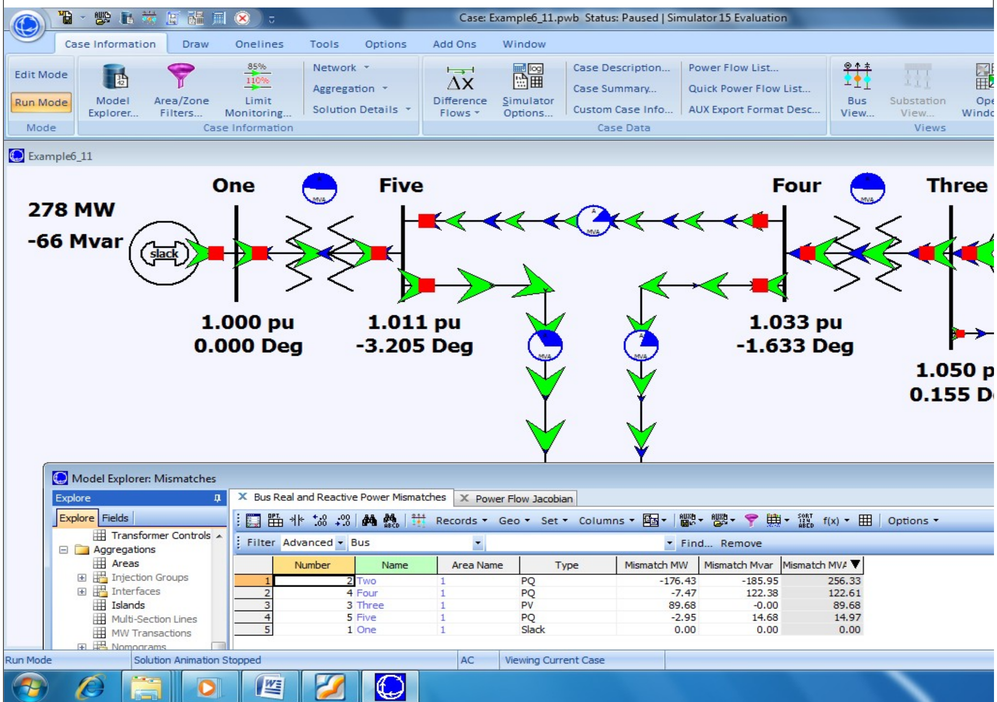
6. Press the Play button in the Power Flow Tools ribbon group on the Tools ribbon tab to begin the simulation. Alternatively, to perform a Power Flow Solution, click on newton raphson power flow option in the solve ribbon group.

7 . It will solve the network and update all the filed values as per solution results on

		single line diagram. 8. Click on model explore to check the results. The corresponding bus voltages, Y-bus are noted down and verified.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	
9	Sample Calculation	
10	Graphs, Outputs	**Example**:-The computations are performed at buses 3, 4 and 5 to complete the first Gauss Seidel iteration. And the results are displayed as shown below: **Screen showing mismatches after first iteration:**  Newton raphson method **Example:** **Screen showing jacobian matrix at first iteration:**



Screen showing mismatches after first iteration:

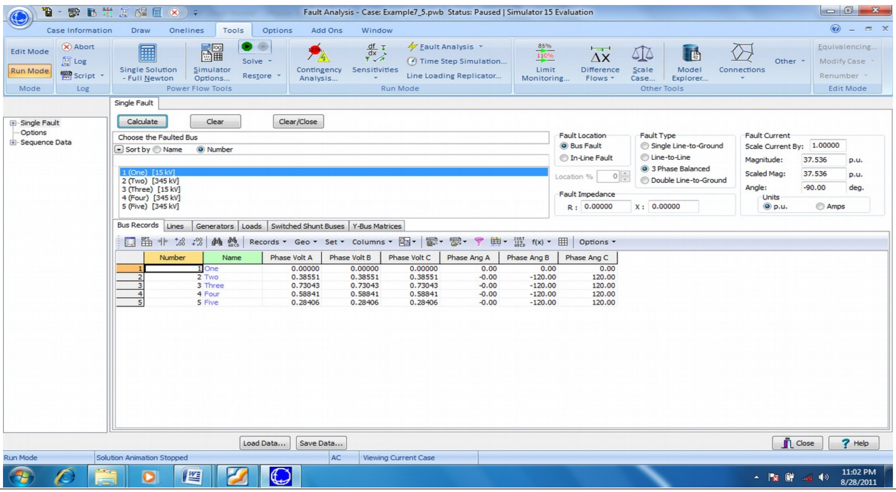


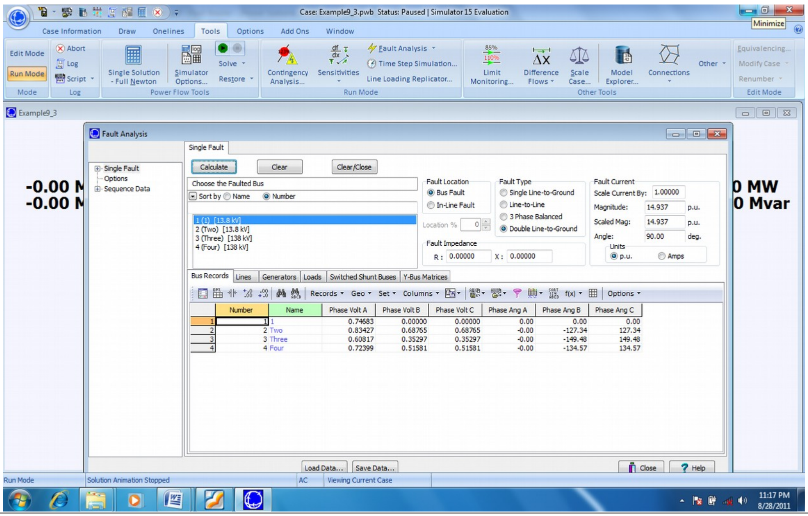
11	Results & Analysis	Thus, the load flow solution for a given power system network using Gauss Seidel method was performed with the help of Powerworld software package.

		Thus, the load flow solution for a given power system network using newton raphson method was performed with the help of Powerworld software package.
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 09: Short Circuit Analysis

-	Experiment No.:	9	Marks		Date Planned		Date Conducted	
1	Title	To determine fault currents and voltages in a single transmission line systems with star-delta transformers at a specified location for SLGF, DLGF.						
2	Course Outcomes	Use Mi-Power package to study unsymmetrical faults at different locations in radial power systems						
3	Aim	To determine fault currents and voltages in a single transmission line systems with star-delta transformers at a specified location for SLGF, DLGF.						
4	Material / Equipment Required	Lab Manual, P.C loaded with Mipower package						
5	Theory, Formula, Principle, Concept	Short circuit studies and hence the fault analysis are very important for the power system studies since they provide data such as voltages and currents during and after the various types of faults which are necessary in designing the protective schemes of the power system. There are different types of faults in a power system which can be broadly divided into symmetrical and unsymmetrical faults. Symmetrical fault is the solid short circuit. This is an abnormal system behavior. Such conditions are caused in the system accidentally through insulation failure of equipment or flash over of lines initiated by a lightning stroke or through accidental faulty operation. The system must be protected against flow of heavy short circuit currents by disconnecting the faulty part of the system by means of circuit breaker operated by protective relaying. The unsymmetrical faults require special tools like symmetrical components to analyze the unbalanced operation of the system. Though symmetrical faults are rare, this leads to most severe fault current flow against which the system must be protected.						
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1 To begin, double-click on the "PowerWorld Simulator icon". This starts Simulator. Simulator is used to create new cases. 2. Select Network > required components from the Individual Insert ribbon group on the Draw ribbon tab. This prepares Simulator to insert a new components. 3. Left-click on the online background at the location where you want to place						

		the new bus. This invokes the component Option Dialog. 4. Draw the given single line diagram using suitable components with their specification. 5. Set the software to the 'Run Mode' & select 'Fault Analysis' option from 'Tool Menu'. It will open 'Fault Analysis' window. 6. Click on 'Fault Options'tab to enter the fault impedance value(if any), pre fault profile and conditions. 7. Click on 'Fault Data' tab, select the fault location(Bus or In-line faults), Fault type, faulted busor line and unit type for fault current. Then click on 'calculate' tab to run analysis. 8. Tabular report of the fault analysis for all the network element can be seen by selecting different elements. 9. Click on 'Matrices' tab to see Positive, Negative and Zero sequence currents. 10. Click on 'Fault data' tab and select 'online Display' to visualize fault currents on single line diagram for all phases or individual phase wise.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	
9	Sample Calculation	
10	Graphs, Outputs	Fault Analysis Dialog (fault at bus 1): 

		Unsymmetrical faults: 
11	Results & Analysis	Thus, the fault currents and voltages in single transmission line systems with star-delta transformers at a specified location for SLGF, DLGF were determined.
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	

Experiment 10: Optimal Generation Scheduling

-	**Experiment No.:**	10	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Optimal Generation Scheduling for Thermal power plants by simulation.						
2	Course Outcomes	Use of Mi-Power package to study optimal generation scheduling problems for thermal power plants.						
3	Aim	To determine the economic load dispatch or optimum generation schedule for a given power system.						
4	Material / Equipment Required	PC loaded with Mipower, Lab manual						
5	Theory, Formula, Principle, Concept	For a power plant the total cost of operation includes fuel, maintenance, and labor costs, but we will assume that changes in output are relatively small, so that fuel cost is the only important one. If we let P stand for the power output in megawatts MW) and C be the fuel cost, then Fig. shows a typical curve of cost versus power output.						

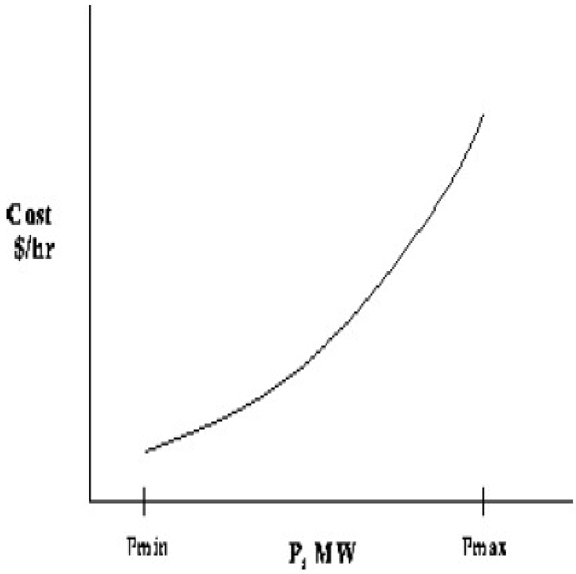


Figure: Typical Fuel-Cost curve for a single power plant

It is seen that the cost curve is increasing and concave upward. In practice, a quadratic polynomial is often used to fit fuel-cost data. There are minimum and maximum values of P, Pmax and Pmin, corresponding to feasible limits of operation of the plant. The need for an upper limit should be clear; a given plant can't produce more power than it is designed for. The lower limit usually comes from thermodynamic and/or practical considerations, e.g. the fuel burning rate has to be above a certain value or the flame goes out.

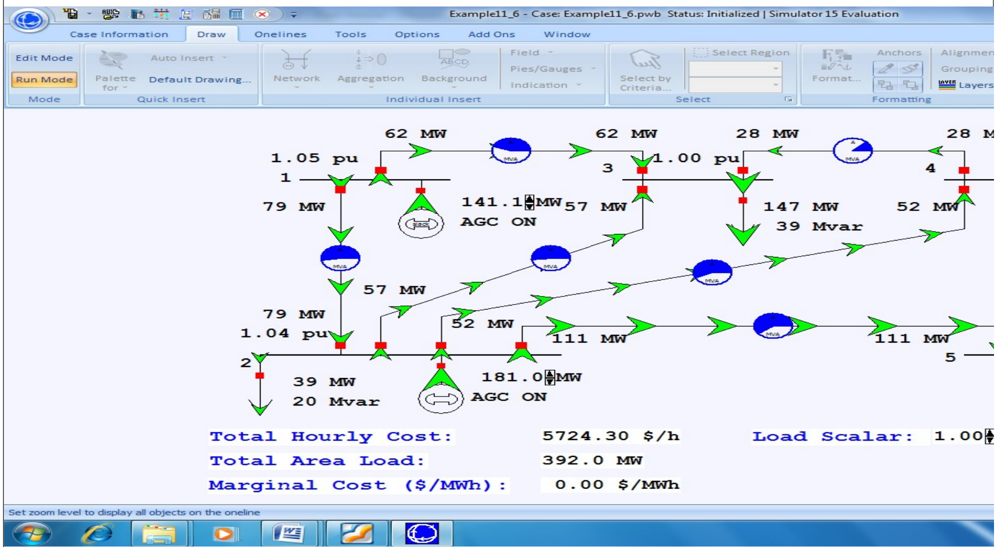
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1. To begin, double-click on the “PowerWorld Simulator icon”. This starts Simulator. Simulator is used to create new cases. 2. Select Network > required components from the Individual Insert ribbon group on the Draw ribbon tab. This prepares Simulator to insert a new components. 3. Left-click on the oneline background at the location where you want to place the new bus. This invokes the component Option Dialog. 4. Draw the given single line diagram with the specification of components. 5. Select fields around generator ‘IC’(Incremental cost of generator-λ) by right clicking on generator symbol and selecting the field IC. 6. Right click anywhere on the single line diagram except on symbols, select ‘Area information Dilog from the pop up menu. Select ‘Economic Dispatch Control ’ in the window and enable different types of controls for the study. Then click OK.

7. Run the system by Click on Run Mode button in the Mode ribbon group.

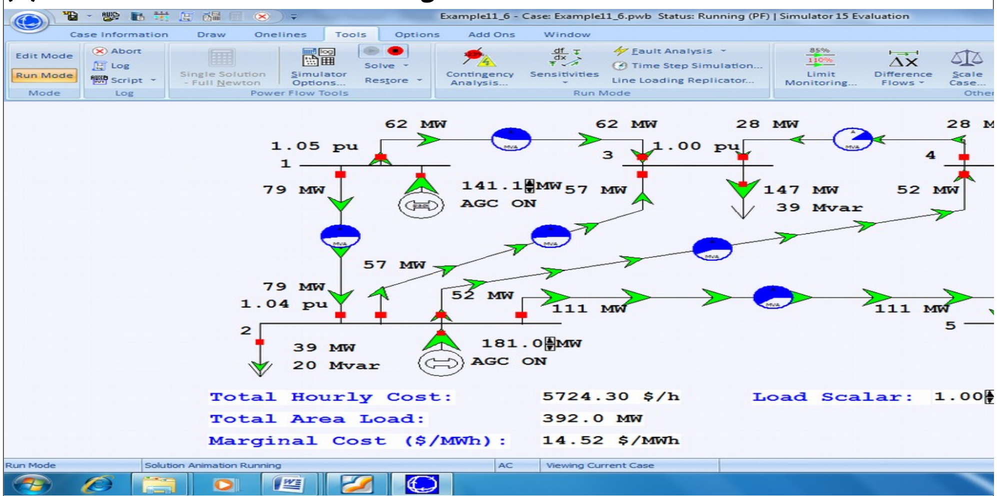
8. Now change the load values manually by left clicking on the load fields(MW/MVAR). It will distribute the power generation among all generators in the network keeping incremental cost(λ)
Same for all the generators.

9 . Economic load dispatch study results can be seen in tabular form.

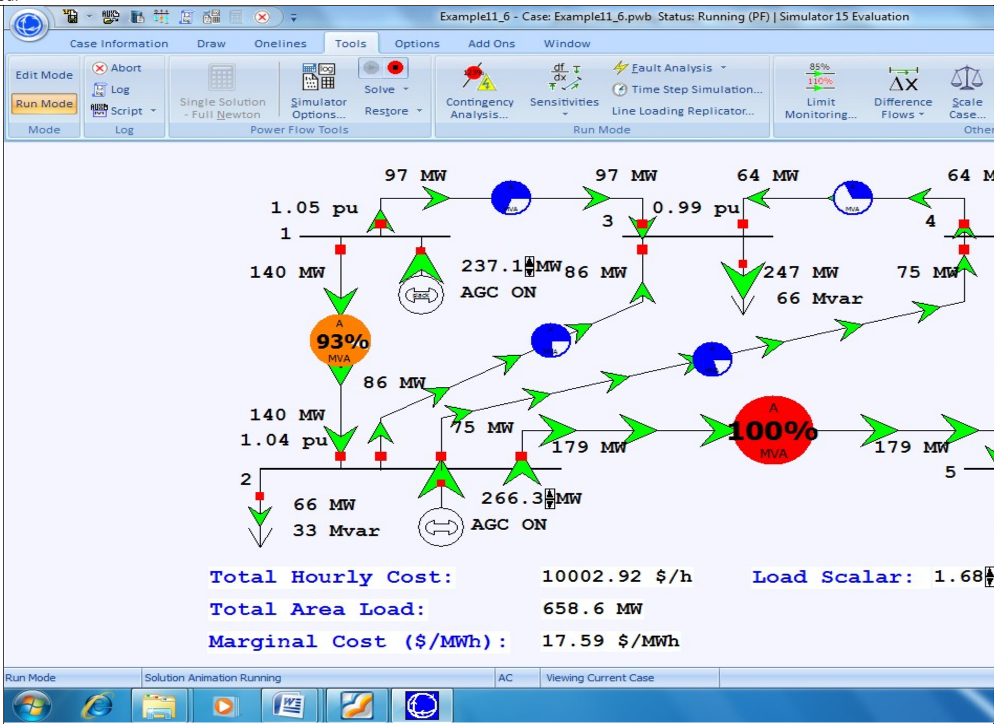
Example: Power world simulator- economic dispatch, including generator limits:



(ii) With Minimum economic loading:



With maximum economic loading

		
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	
9	Sample Calculation	
10	Graphs, Outputs	
11	Results & Analysis	Thus, the economic load dispatch or optimum generation schedule for a given power system was determined.
12	Application Areas	
13	Remarks	
14	Faculty Signature with Date	