Course Plan

FMTC0302/Rev.1.0

Semester: VII Year: 2022-23

Course Title: **POWER SYSTEM ANALYSIS – 2**	*Course Code*: 18EE71
Total Contact Hours: 50	*Duration of USE*: 03 Hour
USE Marks: 60	*IA Marks*: 40
Lesson Plan Author: Mallikarjun G Hudedmani	*Date*: 20-09-2022
Checked By: Dr. Vinoda S	*Date*: 24-09-2022

Prerequisites

The subject requires the student to possess good knowledge of network analysis, operations related to matrices, numerical analysis, power system analysis-1 and knowledge of computer programming.

Course Learning Outcomes-(CO)

At the end of the course student will be able to

i. Formulate network matrices and models for solving load flow problems
ii. Perform steady state power flow analysis of power systems using numerical iterative Techniques
iii. Solve issues of economic load dispatch and unit commitment problems
iv. Analyze short circuit faults in power system networks using bus impedance matrix
v. Perform numerical solution of swing equation using Point by Point method and Runge Kutta Methods

Course Articulation Matrix: Mapping of Course Learning Outcomes (CO) with Program outcomes

Course Title: **POWER SYSTEM ANALYSIS – 2** Course code: 18EE71
Semester: VII Year:2022-23

Course Learning Outcomes-CO	1	2	3	4	5	6	7	8	9	10	11	12
	Engineering knowledge	Problem analysis	Design/development of solutions	Conduct investigations of complex problems	Modern tool usage	The engineer and society	Environment and sustainability	Ethics	Individual and team work	Communication	Project management and finance	Life-long learning
i Formulate network matrices and models for solving load flow problems.	3	2	2		2				2	1		
ii Perform steady state power flow analysis of power systems using numerical iterative techniques	2	2	2	1	2				2	1		2
iii Solve issues of economic load dispatch and unit commitment problems	2	2	2	2	2			2	2	1		2
iv Analyze short circuit faults in power system networks using bus impedance matrix	2	3	2	2	3			2	2	1		3
v Perform numerical solution of swing equation using Point by Point method and Runge Kutta Methods	2	2	2		3			1	2	1		2

Degree of compliance **1**: Slight **2**: Moderate **3**: Substantial

Course Articulation Matrix: Mapping of Course Learning Outcomes (CO) with Program specific outcomes (PSO)

Course Title: **POWER SYSTEM ANALYSIS – 2** Course code: 18EE71
Semester: VII Year: 2022-23

CO's	PSO 1	PSO 2	PSO 3
i Formulate network matrices and models for solving load flow problems.	**1**	**2**	**2**
ii Perform steady state power flow analysis of power systems using numerical iterative techniques	**2**	**2**	**2**
iii Solve issues of economic load dispatch and unit commitment problems	**1**	**2**	**2**
iv Analyze short circuit faults in power system networks using bus impedance matrix	**2**	**2**	**2**
v Perform numerical solution of swing equation using Point by Point method and Runge Kutta Methods	**2**	**2**	**2**

Degree of compliance **1: Slight** **2: Moderate** **3: Substantial.**

Course Content

Course Code: **18EE71**	Course Title: **POWER SYSTEM ANALYSIS – 2**	
L-T-P: **4-0-0**	Teaching Hrs: 50	Exam Duration: 03
IA Marks: 40	USE Marks: 60	Total Marks: 100

Content

Module	Load Flow Studies	Hrs
1	**Network Topology**: Introduction and basic definitions of Elementary graph theory Tree, cut-set, loop, analysis. Formation of Incidence Matrices. Primitive network- Impedance form and admittance form, Formation of Y Bus by Singular Transformation. Ybus by Inspection Method. Illustrative examples.	
	Load Flow Studies	
2	**Load Flow Studies:** Introduction, Classification of buses. Power flow equation, Operating Constraints, Data for Load flow, Gauss Seidal iterative method. Illustrative examples.	10
	Load Flow Studies	
3	**Load Flow Studies(continued)** Newton-Raphson method derivation in Polar form, Fast decoupled load flow method, Flow charts of LFS methods. Comparison of Load Flow Methods. Illustrative examples.	10
	Optimal System Operation	
4	**Economic Operation of Power System:** Introduction and Performance curves Economic generation scheduling neglecting losses and generator limits Economic generation scheduling including generator limits and neglecting losses Economic dispatch including transmission losses Derivation of transmission loss formula. Illustrative examples. **Unit Commitment:** Introduction, Constraints and unit commitment solution by prior list method and dynamic forward DP approach (Flow chart and Algorithm only).	10
	Symmetrical Fault Analysis and Power System Stability	
5	Z Bus Formulation by Step by step building algorithm without mutual coupling between the elements by addition of link and addition of branch. Illustrative examples on .Z bus Algorithm for Short Circuit Studies excluding numerical.	10

Text book

1 Modern Power System Analysis by D. P. Kothari McGraw Hill 4th Edition, 2011
2 Computer Methods in Power Systems Analysis by Glenn W Stagg, Ahmed H Ei – Abiad, Scientific International Pvt. Ltd. 1st Edition, 2019
3 Power Generation Operation and Control by Allen J Wood etal, Wiley, 2nd Edition,2016

Reference Books

1 Computer Techniques in Power System Analysis M.A. Pai McGraw Hill 2nd Edition, 2012
2 Power System Analysis Hadi Saadat McGraw Hill 2nd Edition, 2002

Evaluation Scheme

IA Exam Scheme

Assessment	**Weightage in Marks**
Internal Assessment 1	10
Internal Assessment 2	10
Internal Assessment 3.	10
Total I.A. Marks	30
Unit Test & Assignment Marks	10
Average of Highest of two Total (max)	40

Course Unitization for Internal Assessment Exams and University Semester Examination

Module	Chapter	Teaching Hours	No. of Questions in			No. of Questions in USE
			IA I	IA 2	IA 3	
I	**Network Topology**	10	1			1
II	**Load Flow Studies**	10	1	1		1
III	**Load Flow Studies**	10		1		1
IV	**Optimal System Operation**	10			1	1
V	**Symmetrical Fault Analysis and Power System Stability**	10			1	1

Note:

For I.A :

- Each IA is conducted for 40 marks and reduced to 10 marks.
- 3 unit test are conducted (Any 3 Modules)
- 2 Assignments (Any 2 modules)
- 3 Questions carrying 20 marks each and up to 3 sub questions are allowed.
- Answer any 2 full questions of 20 marks each (***Two full questions from Q1,Q2 and Q3)***

For U.S.E :

- The question paper will have 10 questions. Two questions from each module.
- Students need to answer 5 full questions completely, selecting one question from each module.
- Each question carries 20 marks.

Date: 24-09-2022

Head of Department

Chapter wise Plan

Course Code and Title: **18EE71 POWER SYSTEM ANALYSIS – 2**	
Chapter Number and Title: ***1.*** **NETWORK TOPOLOGY**	*Planned Hours: 10*

Learning Outcomes:

At the end of the topic student should be able to:

Sl.No	TLO's	CO's	B L
1	Define elementary graph theory – oriented graph, tree, co-tree, basic cut-sets, basic loops; Incidence matrices.	i	L1
2	Define and distinguish primitive network elements.	I	L2
3	Obtain and prove the relationship between the different matrices.	i	L2
4	Obtain Y_{BUS} – by method of singular transformation and Inspection method	i	L3
5	Solve problems related to various matrices of graph.	i	L3

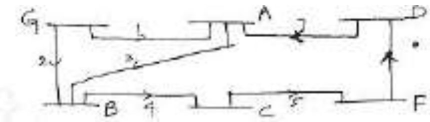
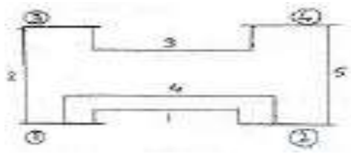
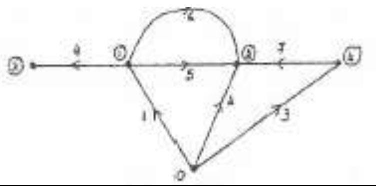
Lesson Schedule

Class No. Portion covered per hour

1. Introduction to elementary graph theory, Incidence matrices.
2. Oriented graph, tree, co-tree
3. Basic cut-sets, basic loops.
4. Element-node, bus incidence, Tree-branch path, basic cut-set.
5. Augmented cut-set, basic loop and augmented loop.
6. Primitive network in impedance form and admittance form.
7. Formation of Y_{BUS} – by method of singular transformation ($Y_{BUS} = A^T yA$).
8. Formation of Y_{BUS} – by method of Inspection.
9. Solution of Numerical problems.
10. Solution of Numerical problems.

Review Questions

Sl.No	Questions	TLO	B L
1	Define and explain the following: i) Oriented graph ii) Tree iii) Co-tree iv) Basic cut-sets v) Basic loops vi) Incidence matrices.	1	L1
2	What is primitive network ? Explain its significance with a circuit and equations of it both in impedance form and admittance form.	2	L2
3	Obtain For the basic cut set matrix B for the above problem show that $\mathbf{A}_l = \mathbf{B}_l \mathbf{A}_t$	3	L3
4	Explain and obtain Y_{BUS} matrix – by method of inspection in general.	4	L2
5	Explain and obtain Y_{BUS} matrix – by singular transformation method with suitable example.	4	L3

<table>
<tr><td>6</td><td>The bus incidence matrix of a 7 element, 5 node system is shown below. Obtain the element node incidence matrix. Hence draw the corresponding oriented graph system.
A =
<table>
<tr><td>A</td><td>1</td><td>0</td><td>0</td><td>-1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>B</td><td>-1</td><td>-1</td><td>-1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>C</td><td>0</td><td>0</td><td>1</td><td>0</td><td>-1</td><td>1</td><td>0</td></tr>
<tr><td>D</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-1</td><td>-1</td></tr>
</table></td><td>5</td><td>L3</td></tr>
<tr><td>7</td><td>For the system defined by the line data shown below, determine the bus admittance matrix using singular transformation analysis.
<table>
<tr><td>Line No</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Bus Code p-q</td><td>0-1</td><td>1-2</td><td>2-3</td><td>3-0</td><td>2-0</td></tr>
<tr><td>Admittance in pu</td><td>1.4</td><td>1.6</td><td>2.4</td><td>2.0</td><td>1.8</td></tr>
</table></td><td>5</td><td>L3</td></tr>
<tr><td>8</td><td>For the given power system obtain A, B and C matrices and assume G as reference

</td><td>5</td><td>L3</td></tr>
<tr><td>9</td><td>For the system shown obtain A ,B,C and K matrices
</td><td>5</td><td>L3</td></tr>
<tr><td>10</td><td>Obtain B and C matrices for the given oriented graph
</td><td>5</td><td>L3</td></tr>
<tr><td>11</td><td>The bus incidence matrix is given below and draw the oriented graph and augmented incidence matrix
$$\begin{vmatrix} 1 & 0 & 0 & 0 & -1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 & -1 & -1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 & 1 & 0 \end{vmatrix}$$</td><td>5</td><td>L3</td></tr>
<tr><td>12</td><td>Obtain A, B, C,K and augmented A, B, C matrices for the example below.</td><td>5</td><td>L3</td></tr>
</table>

Course Code and Title: 18EE71 POWER SYSTEM ANALYSIS – 2	
Module : *2.* Load Flow Studies	*Planned Hours: 10*

Learning Outcomes:

At the end of the topic student should be able to:

Sl.No	TLO's	CO's	B L
1	Justify the need for the load flow and list various constraints related to load flow	i	L1
2	Obtain mathematical formulations for the load flow study	ii	L2
3	Obtain the solution of nonlinear static load flow equations by different numerical techniques	ii	L3

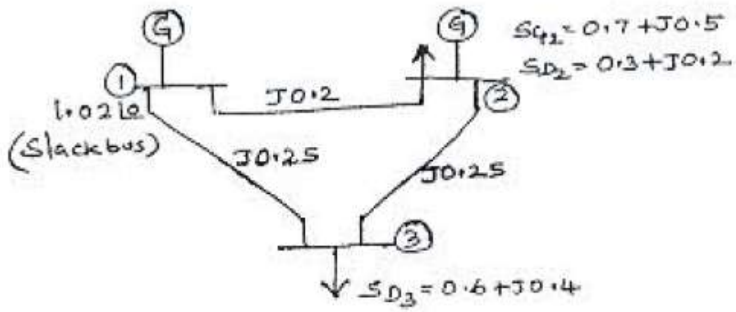
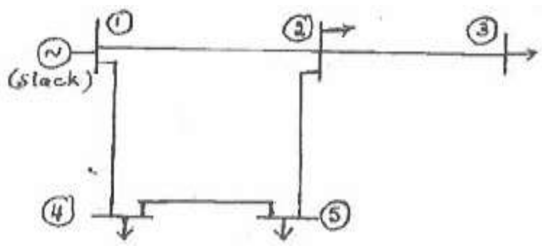
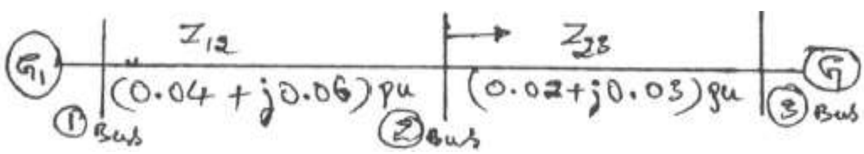
Lesson Schedule

Class No. Portion covered per hour

1. Introduction to Load flow
2. Net work model formulation, Complex power, Net work graph, Tree and relationship
3. Load flow problem, bus classification
4. Constraints in load flow study
5. Data for load flow study
6. Gauss seidel method of solution of Load flow
7. Algorithm for GSLF, Acceleration of convergence
8. Modification of algorithm for PV buses
9. Solution of Numerical problems.
10. Solution of Numerical problems.

Review Questions

Sl.No	Questions	TLO	B L
1	Define and justify necessity of load flow study.	1	L1
2	Generate mathematical equations related to load flow study.	1	L2
3	List and brief various constraints related to load flow study.	1	L2
4	List and brief various data required for the load flow study.	1	L2
5	Obtain the solution of nonlinear static load flow equations by different numerical techniques	2	L2
6	Define and justify the necessity of Load flow study and classify the buses in order to carry out load flow analysis in power system	2	L2

<table>
<tr><td>7</td><td>With the help of a flow chart and equations explain the Gauss-seidel method for load flow analysis with P-Q and P-V buses</td><td>2</td><td>L2</td></tr>
<tr><td>8</td><td>Using G-S load flow procedure determine the bus voltages at the end of first iteration. All the line datas are in impedance form.

</td><td>3</td><td>L3</td></tr>
<tr><td>9</td><td>Using GS load flow solve for the voltages at the end of first iteration. All the buses are PQ except bus 1.
Table Line Data
<table>
<tr><th>S.B</th><th>E.B</th><th>$R_{(p.u)}$</th><th>$X_{(p.u)}$</th></tr>
<tr><td>1</td><td>2</td><td>0.05</td><td>0.15</td></tr>
<tr><td>1</td><td>3</td><td>0.1</td><td>0.3</td></tr>
<tr><td>2</td><td>3</td><td>0.15</td><td>0.45</td></tr>
<tr><td>3</td><td>4</td><td>0.05</td><td>0.15</td></tr>
</table>
Table Bus Data
<table>
<tr><th>Bus No.</th><th>$P_{i(p.u)}$</th><th>$Q_{i(p.u)}$</th><th>V_i</th></tr>
<tr><td>1</td><td>-</td><td>-</td><td>1.04∠0°</td></tr>
<tr><td>2</td><td>0.5</td><td>-0.2</td><td>-</td></tr>
<tr><td>3</td><td>-1.0</td><td>0.5</td><td>-</td></tr>
<tr><td>4</td><td>-0.3</td><td>-0.1</td><td>-</td></tr>
</table></td><td>3</td><td>L3</td></tr>
<tr><td>10</td><td>Using GS load flow obtain equations of the voltages at the end of first iteration

</td><td>3</td><td>L3</td></tr>
<tr><td>11</td><td>Using GS load flow solve for the voltages at the end of first iteration, Use flat start.

</td><td>3</td><td>L3</td></tr>
</table>

Course Code and Title: **18EE71 POWER SYSTEM ANALYSIS – 2**	
Module : *2.* Load Flow Studies	*Planned Hours: 10*

Learning Outcomes:

At the end of the topic student should be able to:

Sl.No	TLO's	CO's	B L
1	Explain and formulate network matrices for solving load flow problems.	i	L2
2	Obtain the solution of nonlinear static load flow equations by different numerical techniques	ii	L3
3	Compare and contrast different methods.	ii	L3

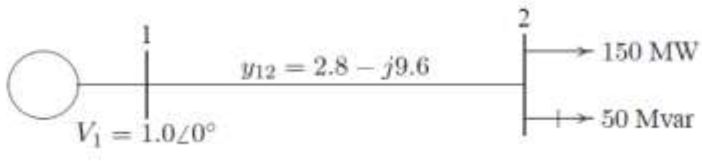
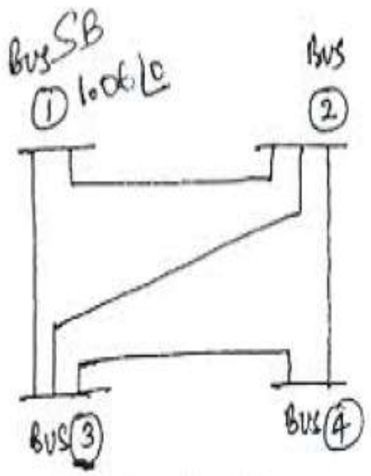
Lesson Schedule

Class No. Portion covered per hour

1. Introduction to Newton Raphson load flow study
2. Algorithm and iterative solution
3. Rectangular power mismatches
4. Load flow solutions using NRLF
5. Decoupled load flow and FDLF
6. FDLF Algorithm
7. Load flow solutions using FDLF
8. Comparison of load flow methods
9. Control of voltage and solution of a problem
10. Solution of numerical problems.

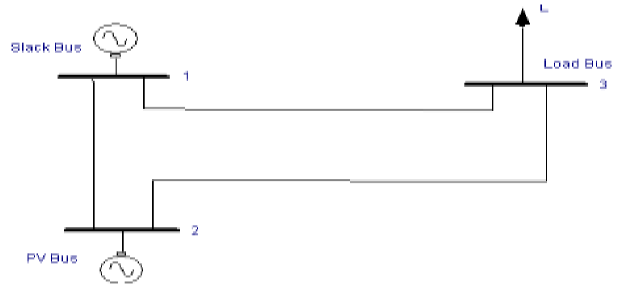
Review Questions

Sl.No	Questions	TLO	B L
1	With the help of a flow chart and equations explain the Newton Raphson method for load flow analysis with P-Q and P-V buses	1	L2
2	Discus briefly the significance and properties of Jacobian Matrix of the Newton Raphson method for load flow analysis.	2	L2
3	Explain the procedure of Fast Decoupled load flow analysis with the help of flow chart.	2	L2
4	Compare the load flow methods with standard features	3	L2

<table>
<tr><td>5</td><td>In the two-bus system shown in Figure , bus 1 is a slack bus with V_1=1.0 0 pu. A load of 150MWand 50 Mvar is taken from bus 2. The line admittance isY_{12}= 10 -73.74^0 pu on a base of 100 MVA. Calculate the value of voltage and delta value for bus 2 after one iteration. Use NRLF.

</td><td>3</td><td>L3</td></tr>
<tr><td>6</td><td>Using NR load flow solve for the voltages at the end of first iteration. All the buses are PQ except bus 1.
Table Line Data
<table>
<tr><th>S.B</th><th>E.B</th><th>R(p.u)</th><th>X(p.u)</th></tr>
<tr><td>1</td><td>2</td><td>0.05</td><td>0.15</td></tr>
<tr><td>1</td><td>3</td><td>0.1</td><td>0.3</td></tr>
<tr><td>2</td><td>3</td><td>0.15</td><td>0.45</td></tr>
<tr><td>3</td><td>4</td><td>0.05</td><td>0.15</td></tr>
</table>
Table Bus Data
<table>
<tr><th>Bus No.</th><th>P i(p.u)</th><th>Q i(p.u)</th><th>V i</th></tr>
<tr><td>1</td><td>-</td><td>-</td><td>1.04∠0°</td></tr>
<tr><td>2</td><td>0.5</td><td>-0.2</td><td>-</td></tr>
<tr><td>3</td><td>-1.0</td><td>0.5</td><td>-</td></tr>
<tr><td>4</td><td>-0.3</td><td>-0.1</td><td>-</td></tr>
</table></td><td>3</td><td>L3</td></tr>
<tr><td>7</td><td>Using NR load flow procedure determine the bus voltages at the end of first iteration. Take flat start and assume suitable missing data


Line data table
<table>
<tr><th>Line from bus to bus</th><th>R in Pv</th><th>X in Pv</th></tr>
<tr><td>1-2</td><td>0.05</td><td>0.15</td></tr>
<tr><td>1-3</td><td>0.10</td><td>0.30</td></tr>
<tr><td>2-3</td><td>0.15</td><td>0.45</td></tr>
<tr><td>2-4</td><td>0.10</td><td>0.30</td></tr>
<tr><td>3-4</td><td>0.05</td><td>0.15</td></tr>
</table></td><td>3</td><td>L3</td></tr>
</table>

<table>
<tr>
<td>8</td>
<td>
Obtain the solutions of voltage magnitude and delta for the buses



and slack bus power after one iteration using Gauss-Seidel method

<table>
<tr><th rowspan="2">Buscode</th><th colspan="2">Generation</th><th colspan="2">load</th></tr>
<tr><th>MW(pu)</th><th>MVAR(pu)</th><th>MW(pu)</th><th>MVAR(pu)</th></tr>
<tr><td>1</td><td>----------</td><td>-----------</td><td>0</td><td>0</td></tr>
<tr><td>2</td><td>0.50</td><td>0.30</td><td>3.056</td><td>1.402</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>1.386</td><td>0.452</td></tr>
</table>

<table>
<tr><th colspan="2">Line Data</th></tr>
<tr><th>p-q</th><th>Ypq (mho)</th></tr>
<tr><td>1-2</td><td>10-j 20</td></tr>
<tr><td>1-3</td><td>10-j 30</td></tr>
<tr><td>2-3</td><td>16-j 32</td></tr>
</table>

<table>
<tr><th>Bus code</th><th>Bus Voltage</th></tr>
<tr><td>1(slack)</td><td>1.05+j0</td></tr>
<tr><td>2 PV</td><td>1+j0</td></tr>
<tr><td>3 PQ</td><td>1+j0</td></tr>
</table>
</td>
<td>3</td>
<td>L3</td>
</tr>
</table>

Course Code and Title: **18EE71 POWER SYSTEM ANALYSIS – 2**	
Module : *3.* Optimal System Operation	*Planned Hours: 10*

Learning Outcomes:

At the end of the topic student should be able to:

Sl.No	TLO's	CO's	B L
1	Explain optimal operation of generators on a bus bar and associated considerations and able to understand performance curves.	iii	L2
2	Explain optimal unit commitment and reliability of power system	iii	L3
3	Solve numerical problems related to optimal operation of generators	iii	L3

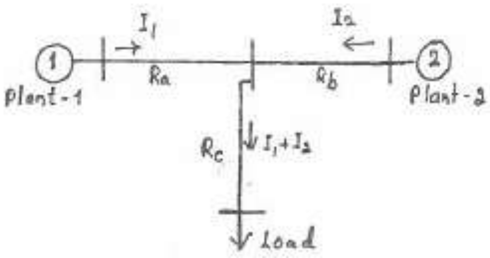
Lesson Schedule

Class No. Portion covered per hour

1. Introduction to Economic operation of power system. Performance curves Characteristic curves and cost generation
2. Formulation of Economic generation scheduling neglecting losses and generator limits Optimal unit commitment and Dynamic programming method
3. Economic generation scheduling including generator limits and neglecting losses Reliability and security constrained optimal unit commitment
4. Economic Dispatch including transmission losses Derivation of transmission loss formula and finding loss coefficients
5. Derivation of transmission loss formula
6. Unit Commitment, Constraints in Unit Commitment
7. Unit Commitment solution by Priority lists method
8. Unit Commitment solution by Dynamic Programming method (Flow chart and Algorithm only)
9. Numerical solution of problems related to Economic operation of power system
10. Numerical solution of problems related to Economic operation of power system

Review Questions

Sl.No	Questions	TLO	B L
1	What is the necessity of economic operation and performance curves of thermal systems.	1	L1
2	Explain unit commitment related to thermal units	2	L2
3	Define EIC- equal incremental cost criteria related to thermal units and its importance in economic operation.	2	L2
4	Explain economic scheduling up of thermal unit with different sub cases.	2	L2
5	Explain Dynamic programming with the help of flow chart	2	L2
6	Incremental fuel costs in rupees per MWh for a plant consisting of two units are : dc1 / dPG1 = 0.20PG1 + 40.0 dc2 / dPG2 = 0.25PG2 + 30.0 Assume that both unites are operating at all times and total load varies from 40 MW to 250 MW and the maximum and minimum loads on each unit are to be 125 MW and 20 MW respectively. How will the load be shared between the unites as the system varies over full range? What are their plant incremental costs?	3	L3
7	The fuel cost of two units is given by following equations. $C_1 = 350 + 7.20P_{G1} + 0.0040\,P_{G1}^2$ Rs/ hr	3	L3

	$C_2 = 500 + 7.30P_{G2} + 0.0025\,P_{G2}^2$ Rs/ hr $C_3 = 600 + 6.74P_{G3} + 0.0030\,P_{G3}^2$ Rs/ hr Where P_{G1} , P_{G2} and P_{G3} are power MW. For the load of 450MW obtain saving in cost per hour by comparing the cost of production on equal sharing basis and equal incremental cost basis.		
8	Two bus system is shown below. If 100 MW is transmitted from plant 1 to the load a transmission loss of 10 MW is incurred. Find the required generation for each plant and the power received by the load when system lambda is Rs 25/MWh. The incremental fuel costs of two are given by dc1 / dPG1 = 0.020PG1 + 16.0 Rs /MWh. dc2 / dPG2 = 0.040PG2 + 20.0 Rs /MWh. 	3	L3
9	For the given system obtain B coefficients 	3	L3

Course Code and Title: **18EE71 POWER SYSTEM ANALYSIS – 2**	
Module : *5* Symmetrical Fault Analysis and Power System Stability	*Planned Hours: 10*

Learning Outcomes:

At the end of the topic student should be able to:

Sl.No	TLO's	CO's	B L
1	Explain how to obtain bus impedance matrix for the use in short circuit studies on power systems.	iv	L2
2	Obtain Z_{Bus} of a given system using step by step build algorithm.	iv	L3
3	Obtain swing equation and analyze stability of the system	v	L3
4	Solve the numerical problems related to swing equation	v	L3

Lesson Schedule *Class No. Portion covered per hour* 1. Introduction to the Algorithm for short circuit studies,,ZBus formation by step by step building algorithm without mutual coupling between the elements by addition of link . 2. ZBus by Zbuild Technique addition of branch (continuation) 3. ZBus by Zbuild Technique (continuation) 4. ZBus by Zbuild Technique (continuation and completion) 5. Numerical problem solution on ZBus formation 6. Numerical problem solution on ZBus formation 7. Solution of swing equation by Point by Point method 8. Numerical problem solution using point by point method 9. Numerical problem solution 10. Numerical problem solution

Review Questions

Sl.No	Questions	TLO	B L
1	Explain the necessity of short circuit study in power system analysis	1	L1
2	Explain the method to obtain Z_{Bus} by Y_{Bus} inversion, and current injection	1	L2
3	Explain the method to obtain Z_{Bus} by current injection	1	L2
4	Explain Zbuild algorithm for the addition of a branch with possible sub cases.	2	L2
5	Explain Zbuild algorithm for the addition of a link with possible sub cases.	2	L2
6	Explain Zbuild algorithm for the deletion of a branch/ link		L2
7	Define stability and classify with sub types.	3	L1
8	List the factor affecting transient stability and method to overcome the same.	3	L2
9	Explain the analysis of transient stability using point by point method.	3	L3
10	Explain the analysis of transient stability using Runhe Kutta method	3	L3
11	The swing equation is given by $\frac{d\delta}{dt} = \omega - 377$ rad/sec ; $\frac{d\omega}{dt} = 32[1 - 0.4 \sin \delta]$ At t=0.0 sec, ω=377 rad/sec and delta=0,523 rad. Determine the values of ω and delta at 0.1 sec. Assume Delta t= 0.1 sec	4	L3

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First Internal Assessment Test

Sem/Div: 7 EEE

Sub: POWER SYSTEM ANALYSIS – 2	**Date:**
Sub Code: 18EE71	**Time: 1 Hr 15 min**
Faculty Incharge: M G Hudedmani	**Max Marks: 40**

Note: 1) Answer any TWO questions 2) All questions carry equal marks

Q No	Sub Qtn	Question	Marks	BL	CO
1	a	What is all incidence matrix A (Element - node) . Explain the mechanism to obtain the bus incidence matrix A for the graph shown below Fig 1a	10	L2	i

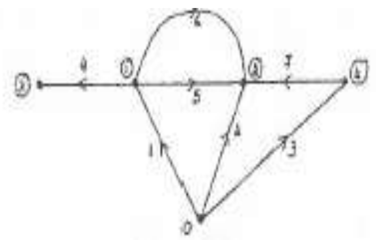
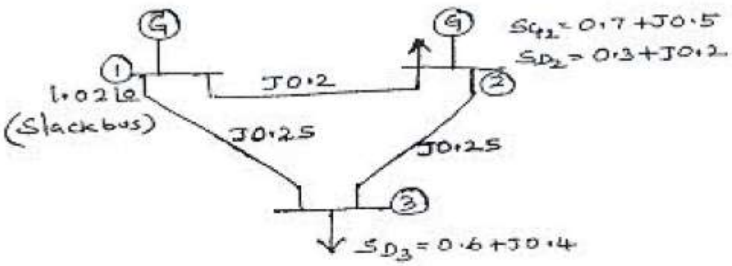


Fig 1 a

Q No	Sub Qtn	Question	Marks	BL	CO
	b	Explain the Singular transformation method of formation of Ybus with general notations.	10	L2	i
2	a	Define and justify the necessity of Load flow study and classify the buses in order to carry out load flow analysis in power system	10	L2	ii
	b	Using G-S load flow procedure determine the bus voltages at the end of first iteration. All the line data's are in impedance form.	10	L3	ii



Q No	Sub Qtn	Question	Marks	BL	CO
3	a	Obtain Y_{bus} by singular transformation method for the system having the data as shown in the table. Take bus 6 as reference	10	L2	i

Line No.	1	2	3	4	5	6	7
Bus code p-q	1-6	2-6	2-5	1-3	3-4	4-5	3-6
Impedance (Z_{pq}) in pu	0.05	0.0286	0.1	0.2	0.05	0.1	0.04

Q No	Sub Qtn	Question	Marks	BL	CO
	b	Obtain the solution of nonlinear static load flow equations by Gauss seidel technique with the help of flow chart	10	L2	ii

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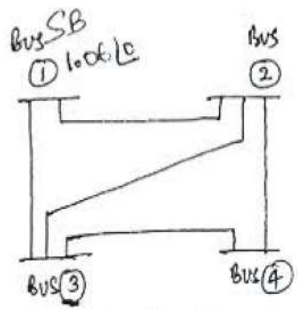
Second Internal Assessment Test
Sem/Div: 7 EEE

Sub: POWER SYSTEM ANALYSIS – 2 **Date:**
Sub Code: 18EE71 **Time: 1 Hr 15 min**
Faculty Incharge: M G Hudedmani **Max Marks: 40**

Note: 1) Answer any TWO questions 2) All questions carry equal marks

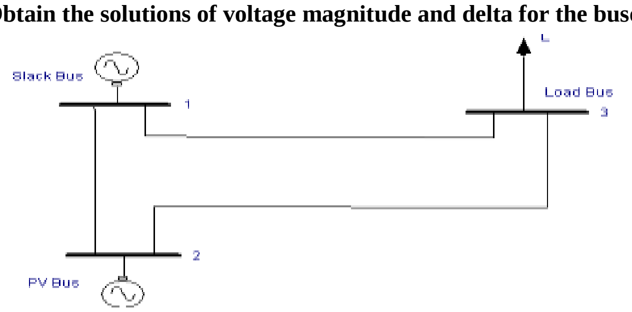
Q No	Sub Qtn	Question	Marks	BL	CO
1.	a	**With the help of Flow chart explain NRLF load flow method in brief.**	10	L1	ii
	b	**Using NR load flow procedure determine the bus voltages at the end of first iteration. Take flat start and assume suitable missing data**	10	L3	ii



Line data table

Line from bus to bus	R in Pu	X in Pu
1-2	0.05	0.15
1-3	0.10	0.30
2-3	0.15	0.45
2-4	0.10	0.30
3-4	0.05	0.15

Q No	Sub Qtn	Question	Marks	BL	CO
2.	a	**List the dat required for the Load flow study**	10	L2	ii
	b	**Define and explain Jacobian elements and importance. Derive the diagonal elements of Jacobian matrices.**	10	L2	ii
3.	a	**With the help of standard features compare Load Flow methods.**	10	L2	ii
	b	**Obtain the solutions of voltage magnitude and delta for the buses**	10	L3	ii



and slack bus power after one iteration using Gauss-Seidel method

Buscode	Generation		load	
	MW(pu)	MVAR(pu)	MW(pu)	MVAR(pu)
1	----------	-----------	0	0
2	0.50	0.30	3.056	1.402
3	0	0	1.386	0.452

Bus code	Bus Voltage
1(slack)	1.05+j0
2 PV	1+j0
3 PQ	1+j0

Line Data	
p-q	Ypq (mho)
1-2	10-j 20
1-3	10-j 30
2-3	16-j 32

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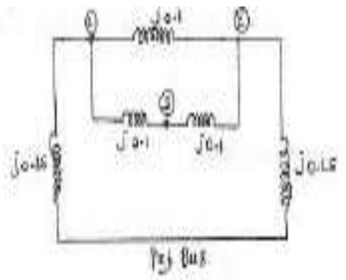
Third Internal Assessment Test
Sem/Div: 7 EEE

Sub: POWER SYSTEM ANALYSIS – 2 — **Date:**
Sub Code: 18EE71 — **Time: 1 Hr 15 min**
Faculty Incharge: M G Hudedmani — **Max Marks: 40**

Note: 1) Answer any TWO questions 2) All questions carry equal marks

Q No	Sub Qtn	Question	Marks	BL	CO
1.	a	**Explain penalty factor, approximate penalty factors and interpretation of penalty factor.**	5	L1	iii
	b	**What are B coefficients ? derive necessary equations for them (Krons Model)..**	8	L2	iii
	c	$IC1 = 50 + 5P_{G1}$ **Rs/ MWhr** $IC2 = 40 + 10P_{G2}$ **Rs/ MWhr** **The incremental fuel cost functions of two units are as shown above. Obtain economic scheduling for a demand of 120MW and cost of production at each unit as well as total cost.**	7	L3	iii
2.	a	**Explain the method of formation of Z_{BUS} by step by step method**	10	L2	iv
	b	**Obtain Z_{BUS} by Z_{build} technique take ' O' as reference bus** 	10	L3	iv
3.	a	**Explain the Point by point method of solution of swing equation with suitable representations.**	10	L2	v
	b	**Explain the Runge Kutta method of solution of swing equation with suitable representations.**	10	L2	v

Model Question Paper

Subject: Power System Analysis – 2 Subject Code: 18EE71

Q. No.	Question	Marks
1. a	What is all incidence matrix A (Element - node) . Explain the mechanism to obtain the bus incidence matrix A for the graph shown below Fig 1a	8

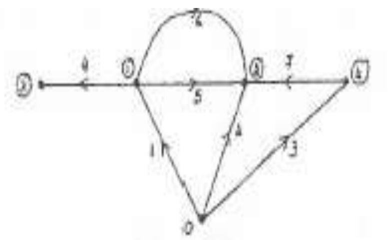


Fig 1 a

b	Define a primitive network. Formulate Y_{Bus} by singular transformation method.	8

Or

2 a	Determine Y_{Bus} by singular transformation for the system with data as below:	8

Element No.	1	2	3	4	5
Bus Code p-q	0-1	0-2	2-3	3-0	2-0
Self-admittance in pu	1.4	1.6	2.4	2.0	1.8

b	Define and explain the following: i) Oriented graph ii) Tree iii) Co-tree iv) Basic cut-sets v) Basic loops vi) Incidence matrices.	8

Or

3a	Develop the Gauss-Seidel load flow model for a power system with a slack bus and (n-1) number of PQ buses. Write the flow chart of the algorithm.	
b.	In a two bus system shown in Fig. Q3(b), bus 1 is slack bus with $V_1=1.0\angle 0$ pu and bus 2 is a load bus with P = 100 MW, Q = 50 MVar. The line impedance is (0.12+j0.16) pu on a base of 100 MVA. Using NR load flow method compute $\vert V_2\vert$ and δ_2 after one iteration.	8

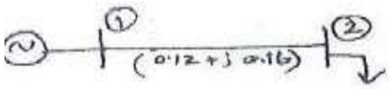


Fig. Q3(b)

Or

4.a	Explain the algorithm with fast decoupled load flow analysis, clearly stating all the assumptions made.	8
b.	In the power system shown in Fig. Q1(b), line 1-2 has the series impedance of (0.04+j0.12) pu with negligible line charging. The generation and load data is given in the table.	8

Bus No.	Type	Generation (pu)		Load (pu)	
1	Slack	-	-	-	-
2	PV	0.3	-	0.6	0.2

The slack bus voltage is (1+j0). The voltage magnitude at bus 2 is to be maintained at 1.05 pu and the generator at this bus has Q-generation limits between 0 and 0.5 pu. With (1+ j0) pu initial voltage at bus 2, determine its voltage at the end of first iteration, using GS load flow model.

Fig. Q4(b)

5.a.	With the help of a flow chart and equations explain the Newton Raphson method for load flow analysis with P-Q and P-V buses	8
b.	Discus briefly the significance and properties of Jacobian Matrix of the Newton Raphson method for load flow analysis.	8
	Or	
6.a.	Compare the load flow methods with standard features	8
b.	In the two-bus system shown in Figure , bus 1 is a slack bus with V_1=1.0 0 pu. A load of 150MWand 50 Mvar is taken from bus 2. The line admittance isY_{12}= 10 -73.74^0 pu on a **base of 100 MVA**. Calculate the value of **voltage** and **delta** value for bus 2 after one iteration**. Use NRLF.**	8

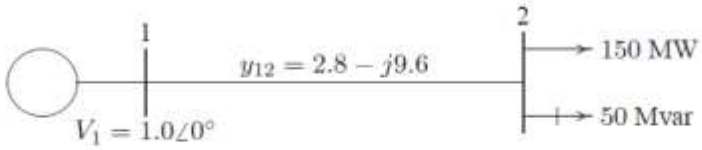


Fig Q6 (b)

7.a Draw and explain the following: 8

i) Input-Output curve
ii) Cost Curve
iii) Incremental cost curve
v) Heat rate curve

b. The incremental fuel costs in Rs/MWh for a plant consisting of two units are 8

$$\frac{dF_1}{dP_{G1}} = 0.1P_{G1} + 20, \quad \frac{dF_2}{dP_{G2}} = 0.12P_{G2} + 15.$$

Assume that both units are operating at all times.
Determine

i) The most economical division of load between the generators for a constant load of 300 MW.
ii) The saving in Rs./ day obtained compared to equal load sharing between them.

Or

8.a.	Derive the coordination equations for economic load dispatch in a thermal power system with the consideration of transmission losses.	8
b.	Describe dynamic programming method for computation of optimal Unit Commitment.	8
9.a.	Derive the generalized algorithm for finding the elements of bus impedance matrix when a link is added.	8
b.	Explain Runge Kutta method of solving swing equation.	8
	Or	
10.a.	Explain point by point method of solving swing equation.	8
b.	Form the Z_{Bus} for the power system shown in Fig. Q10 (b) using Z_{Bus} building algorithm. Select ground node as reference. The line reactances are in pu.	8

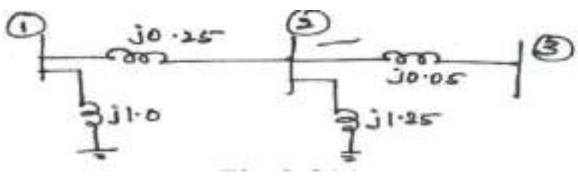


Fig Q10 b