Ref No:

<Sri Krishna Institute of Technology, Bangalore>

COURSE PLAN

Academic Year 2019-20

Program:	B E – Electrical and Electronics Engineering
Semester :	8
Course Code:	15EE81
Course Title:	POWER SYSTEM OPERATION AND CONTROL
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	Shweta B

Academic Evaluation and Monitoring Cell

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Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	EE
Semester:	8	Academic Year:	2019-20
Course Title:	Power System Operation and Control	Course Code:	15EE81
Credit / L-T-P:	4-0-0	SEE Duration:	180 Minutes
Total Contact Hours:	50 Hours	SEE Marks:	80 Marks
CIA Marks:	20 Marks	Assignment	1 / Module
Course Plan Author:	Shweta B	Sign ..	Dt:
Checked By:		Sign ..	Dt:
CO Targets	CIA Target : ..... %	SEE Target:	..... %

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute. Identify 2 concepts per module as in G.

Module	Content	Teaching Hours	Identified Module Concepts	Blooms Learning Levels
1	Introduction: Operating States of Power System, Objectives of Control, Key Concepts of Reliable Operation, Preventive and Emergency Controls, Energy Management Centers. Supervisory Control and Data acquisition (SCADA): Introduction to SCADA and its Components, Standard SCADA Configurations, Users of Power Systems SCADA, Remote Terminal Unit for Power System SCADA, Common Communication Channels for SCADA in Power Systems, Challenges for Implementation of SCADA. Unit Commitment: Introduction, Simple Enumeration Constraints, Priority List Method, Dynamic Programming Method for Unit Commitment	14 (8, 6)	-Power System and SCADA -Unit Commitment	UnderstandingL2, Analyzing L4
2	Hydro-thermal Scheduling: Introduction, Scheduling Hydro Systems, Discrete Time Interval Method, Short Term Hydro Thermal Scheduling Using $\gamma - \lambda$ Iterations, Short Term Hydro Thermal Scheduling Using Penalty Factors. Automatic Generation Control (AGC): Introductions, Basic Generator Control Loops, Commonly used Terms in AGC, Functions of AGC, Speed Governors.▮	12 (6, 6)	-Hydro-thermal scheduling -Automatic Generation Control	Understand L2, Analyzing L4
3	Automatic Generation Control (continued): Mathematical Model of Automatic Load Frequency Control, AGC Controller, Proportional Integral Controller. Automatic Generation Control in interconnected Power system: Introductions, Tie – Line Control with Primary Speed Control, Frequency Bias Tie - Line Control, State-Space Models.▮	12 (6, 6)	-Automatic Load Frequency Control -Tie Line	Develop and analyze L3, Develop and analyze L3
4	Automatic Generation Control in interconnected Power system (continued): State-Space Model for Two - Area System, Tie-Line Oscillations, Related Issues in Implementation of AGC. Voltage and Reactive Power Control: Introduction, Production and Absorption of Reactive Power,	14 (6, 8)	-Tie Line -Voltage and Reactive Power Control	Develop and analyze L3, Explaining L3

	Methods of Voltage Control, Dependence of Voltage on Reactive Power , Sensitivity of Voltage to Changes in P And Q, Cost Saving, Methods of Voltage Control by Reactive Power Injection, Voltage Control Using Transformers, Voltage Stability.			
5	Power System Reliability and Security: Introduction, Security Levels of System, Reliability Cost, Adequacy Indices, Functions of System Security, Contingency Analysis, Linear Sensitivity Factors, Contingency Selection and Ranking. State estimation of Power Systems: Introduction, Linear Least Square Estimation, DC State Estimator, Other Issues in State Estimation.	12 (6, 6)	-Power System Reliability and Security -State estimation of Power Systems	ExplainingL2, ExplainingL2
-	**Total**	**64**	**-**	**-**

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).

1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	**-**	**-**
1, 2, 3, 4, 5	Power System Operation and Control, K. Uma Rao, Wiley, 1st Edition, 2012		In Lib
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	**-**	**-**
1, 2	Power System Operation and Control, Allen J Wood etal, Wiley, 2nd Edition,2003	?	In dept
1, 2	Power System Stability and Control, Kundur, McGraw Hill, 8th Reprint, 2009	?	Not Available
C	**Concept Videos or Simulation for Understanding**	**-**	**-**
C1	Power System and SCADA https://www.youtube.com/watch?v=WQWJzgbdq1E – 4.43 Mins https://www.youtube.com/watch?v=e9a78asSQQ0 – 1.26 Mins		
C2	https://nptel.ac.in/courses/108105104/60 -52.41 mins		
C3	https://nptel.ac.in/courses/108102047/35-52.40 mins		
C4	https://www.youtube.com/watch?v=fK_j_3ZJwuk-48.36 mins		
C5	https://nptel.ac.in/courses/108105104/56 -34 mins		
C6	https://nptel.ac.in/courses/108105104/56-34 mins		
C7	https://nptel.ac.in/courses/108105104/56-34 mins		
C8	https://www.youtube.com/watch?v=opocYkK_oSA -46.17		
C9	https://www.youtube.com/watch?v=Z-BQhNCR9pY		
C10	https://www.youtube.com/watch?v=Z-BQhNCR9pY		
D	**Software Tools for Design**	**-**	**-**
	MATLAB SIMULINK		

E	**Recent Developments for Research**	**-**	**-**
	https://ieeexplore.ieee.org/document/8486644		
F	**Others (Web, Video, Simulation, Notes etc.)**	**-**	**-**
1			
?			

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.
Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
1	15EE744	Power System Planning	Power System, Forecasting	7		Understand L2
2	15EE43	Transmission and Distribution	Reliability and quality	4		Understand L2

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.
Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1				
1	Economic Operation of Power Systems, Alternate Approaches to unit Commitment	Advanced Topics		L3,L4
2	Modeling of Power system Components Economic Operation of Power Systems	Advanced Topics		L3,L4
3	Modeling of Power system Components	GATE		L3,L4
4	SIMULINK Model model for a two power system Flexible AC Transmission Controllers	GATE		L3,L4
5	MATLAB Program on DC power Flow, generation shift, sensitivity factors, line outage distribution factors, power flow in various lines Real Time State Estimator	Advanced Topics		L3,L4
-				

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

Modules	Course	Course Outcome	Teach.	Concept	Instr	Assessment	Blooms' Level

	Code.#	**At the end of the course, student should be able to . . .**	Hours		Method	Method	
1	15EE81.1	Understanding the basic structure, operating states, requirements, NERC guidelines for reliable operation of power system and discussing about the preventive and emergency control measures, supervisory control system, components, configuration, RTUs, communication channels, Challenges for Implementation of SCADA.	07	Power System and SCADA	Lecture	unit Test and Assignment	Understand L2
1	15EE81.2	Explain about unit commitment, constraints in unit commitment, analyzing different methods for unit commitment.	03	Unit Commitment	Lecture	unit Test and Assignment	Analyze L4
2	15EE81.3	Discussing about the classification and advantages of hydro plants. Analyzing about the scheduling hydro systems, discrete time interval method and Short Term Hydro Thermal Scheduling Using $\gamma - \lambda$ Iterations and by Penalty Factors.	06	Hydro-thermal scheduling	Lecture	unit Test and Assignment	Analyze L4
2	15EE81.4	Explaining about the basic generator control loops, functions of Automatic generation control and speed governors.	04	Automatic Generation Control	Lecture	unit Test and Assignment	UnderstandL2
3	15EE81.5	Develop and analyze mathematical models of Automatic Load Frequency Control.	04	Automatic Load Frequency Control	Lecture	unit Test and Assignment	Apply L3
3	15EE81.6	Explaining about the tie line, develop and analyze the mathematical model of Tie – Line of two area system	05	Tie Line	Lecture	unit Test and Assignment	Apply L3
4	15EE81.7	Develop and analyze the state space model for a two area system	04	Tie Line	Lecture	unit Test and Assignment	Apply L3
4	15EE81.8	Determine the methods for voltage control and understanding the concept of reactive power and voltage	07	Voltage and Reactive Power Control	Lecture	unit Test and Assignment	Apply L3

		stability.					
\\\5	15EE81.9	Explain about the system adequacy, system security, security levels and functions of system security	06	Power System Reliability and Security	Lecture	unit Test and Assignment	Understand L2
5	15EE81.10	Explain about the state estimation and analyze the formulation of liner least square estimation and DC state estimator.	04	State estimation of Power Systems	Lecture	unit Test and Assignment	Analyze L4
-	**-**	**Total**	**62**	**-**	**-**	**-**	**L2-L4**

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level
1	An electric power system is a network of electrical components deployed to supply, transfer, and use electric power. As the power system deals with power generation, transmission and distribution sectors, monitoring is the main aspect in all these areas. Thus the SCADA implementation of power system improves the overall efficiency of the system for optimizing, supervising and controlling the generation and transmission systems. SCADA function in the power system network provides greater system reliability and stability for integrated grid operation.	CO1	L2
1	The Unit commitment plans for the best set of units to be available to supply the forecast load of the system over a future time period.	CO2	L4
2	The operating cost of thermal plant is very high , though their initial cost is low. On the other hand the operating cost is low in case of hydroelectric generation Due the low operating cost in case of hydel plants so we can operate it in conjuction with thermal plants which will lead to save fuel Due the low operating cost in case of hydel plants so we can operate it in conjuction with thermal plants which will lead to save fuel	CO3	L4
2	In An electrical power system, automatic generation control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response to changes in the load	CO4	L2
3	For large scale electric power systems with interconnected areas, Load Frequency Control (LFC) is important to keep the system frequency and the inter - area tie power as near to the scheduled values as possible.	CO5	L3
3	The transmission lines that connect an area to its neighboring area are called tie-lines . Power sharing between two areas occurs through these tie-lines. Load frequency control, as the name signifies, regulates the power flow between different areas while holding the frequency constant.	CO6	L3
4	The transmission lines that connect an area to its neighboring area are called tie-lines . Power sharing between two areas occurs through these tie-lines. Load frequency control, as the name signifies, regulates the power flow between different areas while holding the frequency constant.	CO7	L3
4	To improve the performance of AC systems.	CO8	L3
5	Reliability analysis has to be carried out at regular intervals during operating period of power systems in order to monitor the customer requirement satisfaction at desired level	CO9	L2
5	State estimator is an important tool for online monitoring, analysis and control of power systems. State estimation is used in all Energy Management Systems (EMS) to identify the present operating state of a system.	CO10	L4

3. Mapping And Justification

CO – PO Mappingwith mapping Level along with justification for each CO-PO pair.
To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Modules	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	**CO**	**PO**	-	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	-
1	CO1	PO1	2.3	'Engineering Knowledge:' - Knowledge on the power system	L2
1	CO1	PO2	2.3	'Problem Analysis':- Analyze the operation states of power system and key concepts for reliable operation. Analyze the operation of components of SCADA system, single and multiple SCADA configurations and identifying the users of power system SCADA and communication channels for SCADA in power systems.	L3
1	CO1	PO9	1	'Individual and Teamwork:'-Projects or internship on SCADA.	L3
2	CO2	PO1	2.3	'Engineering Knowledge:' - Knowledge on the power generation.	
2	CO2	PO2	2.3	'Problem Analysis':- Identifying the different issues to be considered in solving the unit commitment problem and different methods available for solving unit commitment problem.	
3	CO3	PO1	2.3	Knowledge on hydro and thermal power stations	L2
3	CO3	PO2	2.3	To identify the issues in hydro thermal scheduling and solutions to hydro thermal problems.	L3
4	CO4	PO1	2.3	Knowledge on the power system.	L2
4	CO4	PO2	2.3	Analyzing the problem of Automatic generation control for stable and efficient operation of a power system.	L3
4	CO4	PO9	1	Projects on Automatic generation control.	L3
5	CO5	PO1	2.3	Knowledge on automatic generation control	L2
5	CO5	PO2	2.3	Develop and analyze mathematical models of Automatic Load Frequency Control	L3
6	CO6	PO1	2.3	Knowledge on automatic generation control	L2
6	CO6	PO2	2.3	Develop and analyze the mathematical model of Tie – Line of two area system.	L3
7	CO7	PO1	2.3	Knowledge on automatic generation control Automatic load frequency control.	L2
7	CO7	PO2	2.3	Develop and analyze the state space model for a two area system	L3
8	CO8	PO1	2.3	Knowledge on Reactive Power	L2
8	CO8	PO2	2.3	Analyzing the concept of reactive power and various elements in a network to absorb or generate reactive power and identifying the different methods of voltage control.	L3
9	CO9	PO1	2.3	Knowledge on the power system	L2
9	CO9	PO2	2.3	Analyzing the two aspects of reliability and security levels of system and analyzing the major functions of system security, factors effecting system security and liner sensitivity factors.	L3
10	CO10	PO1	2.3	Knowledge on the power system reliability and security	L2
10	CO10	PO2	2.3	Analyzing the problem of state estimation of power system.	L3

4. Articulation Matrix

CO – PO Mappingwith mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes														-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1		Understanding	2.3	2.3							1							L2

	15EE81.1	the basic structure, operating states, requirements, NERC guidelines for reliable operation of power system and discussing about the preventive and emergency control measures, supervisory control system, components, configuration, RTUs, communication channels, Challenges for Implementation of SCADA.																
1	15EE81.2	Explain about unit commitment, constraints in unit commitment, analyzing different methods for unit commitment.	2.3	2.3														L4
2	15EE81.3	Discussing about the classification and advantages of hydro plants. Analyzing about the scheduling hydro systems, discrete time interval method and Short Term Hydro Thermal Scheduling Using $\gamma - \lambda$ Iterations and by Penalty Factors.	2.3	2.3														L4
2	15EE81.4	Explaining about the basic generator control loops,	2.3	2.3							1							L2

		functions of Automatic generation control and speed governors.																
3	15EE81.5	Develop and analyze mathematical models of Automatic Load Frequency Control.	2.3	2.3														L3
3	15EE81.6	Explaining about the tie line, develop and analyze the mathematical model of Tie – Line of two area system	2.3	2.3														L3
4	15EE81.7	Develop and analyze the state space model for a two area system	2.3	2.3														L3
4	15EE81.8	Determine the methods for voltage control and understanding the concept of reactive power and voltage stability.	2.3	2.3														L3
5	15EE81.9	Explain about the system adequacy, system security, security levels and functions of system security	2.3	2.3														L2
5	15EE81.10	Explain about the state estimation and analyze the formulation of liner least square estimation and DC state estimator.	2.3	2.3														L4
-	**15EE81**	**Average attainment (1, 2, or 3)**																**-**

-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*

5. Curricular Gap and Content

Topics &contents not covered (from A.4), but essential for the course to address POs and PSOs.

Modules	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					

6. Content Beyond Syllabus

Topics &contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Modules	Gap Topic	Area	Actions Planned	Schedule Planned	Resources Person	PO Mapping
2						
2						
3						
3						
4						
4						
5						
5						

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Introduction Supervisory Control and Data acquisition (SCADA) Unit Commitment	14	2	-	-	1	1	2	CO1, CO2	L2, L4
2	Hydro-thermal Scheduling Automatic Generation Control (AGC)	12	2	-	-	1	1	2	CO3, CO4	L4, L2
3	Automatic Generation Control (continued) Automatic Generation Control in	12	-	2	-	1	1	2	CO5, CO6	L3, L3

	interconnected Power system									
4	Automatic Generation Control in interconnected Power system Voltage and Reactive Power Control	14	-	2	-	1	1	2	CO7,CO8	L3, L3
5	Power System Reliability and Security State estimation of Power Systems	12	-	-	4	1	1	2	CO9, CO10	L2,L4
-	**Total**	**54**				**5**	**5**	**10**	**-**	**-**

2.Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Modules	Evaluation	Weightage in Marks	CO	Levels
1, 2	CIA Exam – 1	15	CO1, CO2, CO3, CO4	L2, L4,L4, L2
3, 4	CIA Exam – 2	15	CO5, CO6, CO7, C08	L3, L3,L3,L3
5	CIA Exam – 3	15	CO9,CO10	L2, L4
1, 2	Assignment - 1	05	CO1, CO2, CO3, CO4	L2, L4,L4, L2
3, 4	Assignment - 2	05	CO5, CO6, CO7, C08	L3, L3,L3,L3
5	Assignment - 3	05	CO9,CO10	L2, L4
1, 2	Seminar - 1		-	-
3, 4	Seminar - 2		-	-
5	Seminar - 3		-	-
1, 2	Quiz - 1		-	-
3, 4	Quiz - 2		-	-
5	Quiz - 3		-	-
1 - 5	Other Activities – Mini Project	-		
	Final CIA Marks	**20**	**-**	**-**

D1. TEACHING PLAN - 1

Module - 1

Title:	Introduction, Power system operation and control, Unit Commitment	Appr Time:	12 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Understanding the basic structure, operating states, requirements, NERC guidelines for reliable operation of power system and discussing about the preventive and emergency control measures. Understanding supervisory control system, components, configuration, RTUs, communication channels, Challenges for Implementation of SCADA	CO1	L2
2	Explain about unit commitment, constraints in unit commitment, analyzing different methods for unit commitment.	CO2	L4
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
1	Operating States of Power System, Objectives of Control	C01	L2
2	Key Concepts of Reliable Operation	C01	L2
3	Preventive and Emergency Controls	C01	L2
4	Energy Management Centers.	C01	L2
5	Introduction to SCADA and its Components	C01	L2
6	Standard SCADA Configurations	C01	L2
7	Users of Power Systems SCADA, Remote	C01	L2

8	Terminal Unit for Power System SCADA	CO1	L2
9	Common Communication Channels for SCADA in Power Systems	CO1	L2
10	Challenges for Implementation of SCADA	CO1	L2
11	Introduction	CO2	L4
12	Simple Enumeration Constraints	CO2	L4
13	Priority List Method	CO2	L4
14	Dynamic Programming Method for Unit Commitment.	CO2	L4
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	An electric power system is a network of electrical components deployed to supply, transfer, and use electric power. As the power system deals with power generation, transmission and distribution sectors, monitoring is the main aspect in all these areas. Thus the SCADA implementation of power system improves the overall efficiency of the system for optimizing, supervising and controlling the generation and transmission systems. SCADA function in the power system network provides greater system reliability and stability for integrated grid operation.	CO1	L2
2	The Unit commitment plans for the best set of units to be available to supply the forecast load of the system over a future time period.	CO2	L4
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	What are the different states of power system? Explain.	CO1	L2
2	Explain the fundamental requirements of a power system	CO1	L2
3	Explain the objectives of power system control	CO1	L2
4	Discuss the various levels of controls in a power system	CO1	L2
5	Discuss the guidelines that are framed by NERC for reliable operation	CO1	L2
6	Explain the seven key concepts for reliable operation.	CO1	L2
7	Distinguish between preventive control and emergency control measures. Give examples for each.	CO1	L2
8	List the preventive control measures that are commonly used	CO1	L2
9	List the emergency control measures that are commonly used	CO1	L2
10	Explain the functions of the energy center	CO1	L2
11	Explain major components of energy centers	CO1	L2
12	What are the different supervisory systems available for power system?	CO1	L2
13	Define telemetry	CO1	L2
14	Give a concise definition of SCADA	CO1	L2
15	Breifly describe the major components of a SCADA system	CO1	L2
16	Discuss the standard configurations of SCADA systems	CO1	L2
17	Discuss about the users of power system SCADA	CO1	L2
18	Breifly describe the various components of an RTU	CO1	L2
19	What are the functions of RTU?	CO1	L2
20	Discuss the various options available for communication in SCADA	CO1	L2
21	Discuss about the challenges for implementation of SCADA in power systems	CO1	L2
22	Distinguish between the problem of economic dispatch and unit	CO2	L4

	commitment		
23	What do you mean by the term "commit' a unit?	CO2	L4
24	What are the issues to be considered when UC has to be prepared	CO2	L4
25	Why are heuristic methods popular?	CO2	L4
26	Explain enumeration method and its disadvantages	CO2	L4
27	Define spinning reserve, negative reserve and off-line reserve.	CO2	L4
28	Explain thermal unit constraints	CO2	L4
29	Give the expression for the start up costs associated with thermal units.	CO2	L4
30	At times, it may be necessary to commit more expensive units due to network constaints. Justify	CO2	L4
31	How can security constraints be modeled?	CO2	L4
32	At times, we need to reorder the priority of units. Comment.	CO2	L4
33	Give the flowchart for the priority list method of unit commitment	CO2	L4
34	Give the algorithm for the priority list method of unit commitment	CO2	L4
35	Explain the DP-SC algorithm for UC. Discuss in detail the recursive formula used.	CO2	L4
36	Discuss the assumptions made in dynamic programming method, applied to UC.	CO2	L4
37	Develop the mathematical model for the forward DP algorithm, taking into account the start- up cost of the units	CO2	L4
38	Draw the flowchart forward DP algorithm.	CO2	L4
39	With the help of a flow chart, explain the dynamic programming method in unit commitment.	CO2	L4
40	Explain the problems and constraints found in unit commitment. How they are solved?	CO2	L4
41	Explain the need of an Optimal unit commitment problem.	CO2	L4
42	Using the DP method, how do you find the most economical combination of the units to meet a particular load demand?	CO2	L4
43	What is the role of spinning reserve in unit commitment?	CO2	L4
e	**Experiences**	-	-
1		CO1	L2
2			
3			
4		CO2	L3
5			

Module – 2

Title:	Hydro thermal Scheduling and AGC	Appr Time:	7 Hrs

a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Discussing about the classification and advantages of hydro plants. Analyzing about the scheduling hydro systems, discrete time interval method and Short Term Hydro Thermal Scheduling Using γ –λ Iterations and by Penalty Factors.	CO3	L4
2	Explaining about the basic generator control loops, functions of Automatic generation control and speed governors.	CO4	L2
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
15	Introduction, Scheduling Hydro Systems	CO3	L4
16	Discrete Time Interval Method,	CO3	L4
17	Discrete Time Interval Method,	CO3	L4
18	Short Term Hydro Thermal Scheduling Using γ – λ Iterations	CO3	L4
19	Short Term Hydro Thermal Scheduling Using γ – λ Iterations	CO3	L4
20	Short Term Hydro Thermal Scheduling Using Penalty Factors.	CO3	L4
21	Short Term Hydro Thermal Scheduling Using Penalty Factors.	CO3	L4
22	Introductions, Basic Generator Control Loops	CO4	L2
23	Commonly used Terms in AGC,	CO4	L2
24	Functions of AGC,	CO4	L2
25	Speed Governors.	CO4	L2
26	Speed Governors.	CO4	L2
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	The operating cost of thermal plant is very high , though their initial cost is low. On the other hand the operating cost is low in case of hydroelectric generation Due the low operating cost in case of hydel plants so we can operate it in conjuction with thermal plants which will lead to save fuel Due the low operating cost in case of hydel plants so we can operate it in conjuction with thermal plants which will lead to save fuel	CO3	L4
2	In An electrical power system, automatic generation control (AGC) is a system for adjusting the power output of multiple generators at different power plants, in response to changes in the load	CO4	L2
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
44	List the advantages and disadvantages of hydroelectric power systems.	CO3	L4
45	Discuss about the classification of hydro plants	CO3	L4
46	Derive an expression for power in hydro systems.	CO3	L4
47	Explain hydro systems scheduling.	CO3	L4
48	Differentiate long range and short range scheduling	CO3	L4
49	List the four algorithms for hydro thermal scheduling	CO3	L4
50	Explain discrete time interval method for hydro thermal scheduling	CO3	L4
51	Explain γ – λ Iterations algorithm for short term hydro thermal	CO3	L4

	scheduling		
52	Draw the flowchart for $\gamma - \lambda$ Iterations for short term hydro thermal scheduling	CO3	L4
53	Explain short term hydro thermal scheduling using penalty factors.	CO3	L4
54	What are the basic control loops of a generator?	CO4	L2
55	What are the functions of AGC?	CO4	L2
56	Why it is necessary to have two control loops for ALFC?	CO4	L2
57	Define control area	CO4	L2
58	What is tie line?	CO4	L2
59	Differentiate between system frequency, standard frequency and scheduled frequency	CO4	L2
60	What is frequency bias?	CO4	L2
61	Why does time deviation occur?	CO4	L2
62	What is station control error?	CO4	L2
63	What are the functions of ALFC?	CO4	L2
64	What factors determine the response of the generating units to AGC signals?	CO4	L2
65	Draw the block diagram of a steam turbine governing system and explain the function of the various components.	CO4	L2
66	What are the two modes of governor operation?	CO4	L2
67	Explain the parallel operation of generators, with relevant droop characteristic graph	CO4	L2
68	Explain the objectives and functions of Automatic Generation Control (AGC) in a power system.	CO4	L2
69	Explain how mathematical model of speed governing system is developed for Automatic Generation Control.	CO4	L2
70	Distinguish between AVR and ALFC control loops of a generator.	CO4	L2
71	Describe the function of AVR with a neat block diagram	CO4	L2

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	15EE81	Sem:	VIII	Marks:	30	Time:	75 minutes		
Course:	Power System Operation and Control								
-	**-**	**Note: Answer all questions, each carry equal marks. Module : 1, 2**					**Marks**	**CO**	**Level**
1	a	What are the different states of power system? Explain.					7	CO1	L2
	b	Breifly describe the major components of a SCADA system					8	CO1	L2
		OR							
1	a	Breifly describe the various components of an RTU					7	CO1	L2
	b	Give the algorithm for the priority list method of unit commitment					8	CO2	L4
2	a	Explain discrete time interval method for hydro thermal scheduling					8	CO3	L4
	b	Why it is necessary to have two control loops for ALFC?					7	CO4	L2
		OR							
2	a	What are the two modes of governor operation?					7	CO4	L2
	b	Draw the flowchart forward DP algorithm.					8	CO3	L4

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions									
Crs Code:	15EE81	Sem:	VIII	Marks:	5	Time:	90 – 120 minutes		
Course:	Power System Operation and Control			Module : 1, 2					
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.									
SNo	**USN**	**Assignment Description**					**Marks**	**CO**	**Level**
1	1KT15EE007	What are the different states of power system? Explain.					5	CO1	L2
2	1KT15EE009	Explain the fundamental requirements of a power system					5	CO1	L2
3	1KT15EE012	Explain the objectives of power system control					5	CO1	L2
4	1KT15EE014	Discuss the various levels of controls in a power system					5	CO1	L2
5	1KT15EE016	Discuss the guidelines that are framed by NERC for reliable operation					5	CO1	L2
6	1KT15EE020	Explain the seven key concepts for reliable operation.					5	CO1	L2
7	1KT15EE021	Distinguish between preventive control and emergency control measures. Give examples for each.					5	CO1	L2
8	1KT14EE022	List the preventive control measures that are commonly used					5	CO1	L2
9	1KT14EE024	List the emergency control measures that are commonly used					5	CO1	L2
10	1KT14EE033	Explain the functions of the energy center					5	CO1	L2

11	1KT16EE408	Explain major components of energy centers	5	C01	L2
12	1KT16EE406	What are the different supervisory systems available for power system?	5	CO1	L2
13	1KT16EE409	Define telemetry	5	CO1	L2
14	1KT15EE007	Give a concise definition of SCADA	5	CO1	L2
15	1KT15EE009	Breifly describe the major components of a SCADA system	5	CO1	L2
16	1KT15EE012	Discuss the standard configurations of SCADA systems	5	CO1	L2
17	1KT15EE014	Discuss about the users of power system SCADA	5	CO1	L2
18	1KT15EE016	Breifly describe the various components of an RTU	5	CO1	L2
19	1KT15EE020	What are the functions of RTU?	5	CO1	L2
20	1KT15EE021	Discuss the various options available for communication in SCADA	5	CO1	L2
21	1KT14EE022	Discuss about the challenges for implementation of SCADA in power systems	5	CO1	L2
22	1KT14EE024	Distinguish between the problem of economic dispatch and unit commitment	5	CO2	L4
23	1KT14EE033	What do you mean by the term “commit’ a unit?	5	CO2	L4
24	1KT16EE408	What are the issues to be considered when UC has to be prepared	5	CO2	L4
25	1KT16EE406	Why are heuristic methods popular?	5	CO2	L4
26	1KT16EE409	Explain enumeration method and its disadvantages	5	CO2	L4
27	1KT15EE007	Define spinning reserve, negative reserve and off-line reserve.	5	CO2	L4
28	1KT15EE009	Explain thermal unit constraints	5	CO2	L4
29	1KT15EE012	Give the expression for the start up costs associated with thermal units.	5	CO2	L4
30	1KT15EE014	At times, it may be necessary to commit more expensive units due to network constaints. Justify	5	CO2	L4
31	1KT15EE016	How can security constraints be modeled?	5	CO2	L4
32	1KT15EE020	At times, we need to reorder the priority of units. Comment.	5	CO2	L4
33	1KT15EE021	Give the flowchart for the priority list method of unit commitment	5	CO2	L4
34	1KT14EE022	Give the algorithm for the priority list method of unit commitment	5	CO2	L4
35	1KT14EE024	Explain the DP-SC algorithm for UC. Discuss in detail the recursive formula used.	5	CO2	L4
36	1KT14EE033	Discuss the assumptions made in dynamic programming method, applied to UC.	5	CO2	L4

37	1KT16EE408	Develop the mathematical model for the forward DP algorithm, taking into account the start- up cost of the units	5	CO2	L4
38	1KT16EE406	Draw the flowchart forward DP algorithm.	5	CO2	L4
39	1KT16EE409	With the help of a flow chart, explain the dynamic programming method in unit commitment.	5	CO2	L4
40	1KT15EE007	Explain the problems and constraints found in unit commitment. How they are solved?	5	CO2	L4
41	1KT15EE009	Explain the need of an Optimal unit commitment problem.	5	CO2	L4
42	1KT15EE012	Using the DP method, how do you find the most economical combination of the units to meet a particular load demand?	5	CO2	L4
43	1KT15EE014	What is the role of spinning reserve in unit commitment?	5	CO2	L4
44	1KT15EE016	List the advantages and disadvantages of hydroelectric power systems.	5	CO3	L4
5	1KT15EE020	Discuss about the classification of hydro plants	5	CO3	L4
46	1KT15EE021	Derive an expression for power in hydro systems.	5	CO3	L4
47	1KT14EE022	Explain hydro systems scheduling.	5	CO3	L4
48	1KT14EE024	Differentiate long range and short range scheduling	5	CO3	L4
49	1KT14EE033	List the four algorithms for hydro thermal scheduling	5	CO3	L4
50	1KT16EE408	Explain discrete time interval method for hydro thermal scheduling	5	CO3	L4
51	1KT16EE406	Explain $\gamma - \lambda$ Iterations algorithm for short term hydro thermal scheduling	5	CO3	L4
52	1KT16EE409	Draw the flowchart for $\gamma - \lambda$ Iterations for short term hydro thermal scheduling	5	CO3	L4
53	1KT15EE007	Explain short term hydro thermal scheduling using penalty factors.	5	CO3	L4
54	1KT15EE009	What are the basic control loops of a generator?	5	CO4	L2
55	1KT15EE012	What are the functions of AGC?	5	CO4	L2
56	1KT15EE014	Why it is necessary to have two control loops for ALFC?	5	CO4	L2
57	1KT15EE016	Define control area	5	CO4	L2

58	1KT15EE020	What is tie line?	5	CO4	L2
59	1KT15EE021	Differentiate between system frequency, standard frequency and scheduled frequency	5	CO4	L2
60	1KT14EE022	What is frequency bias?	5	CO4	L2
61	1KT14EE024	Why does time deviation occur?	5	CO4	L2
62	1KT14EE033	What is station control error?	5	CO4	L2
63	1KT16EE408	What are the functions of ALFC?	5	CO4	L2
64	1KT16EE406	What factors determine the response of the generating units to AGC signals?	5	CO4	L2
65	1KT16EE409	Draw the block diagram of a steam turbine governing system and explain the function of the various components.	5	CO4	L2
66	1KT15EE007	What are the two modes of governor operation?	5	CO4	L2
67	1KT15EE009	Explain the parallel operation of generators, with relevant droop characteristic graph	5	CO4	L2
68	1KT15EE012	Explain the objectives and functions of Automatic Generation Control (AGC) in a power system.	5	CO4	L2
69	1KT15EE014	Explain how mathematical model of speed governing system is developed for Automatic Generation Control.	5	CO4	L2
70	1KT15EE016	Distinguish between AVR and ALFC control loops of a generator.	5	CO4	L2
71	1KT15EE020	Describe the function of AVR with a neat block diagram	5	CO4	L2

D2. TEACHING PLAN - 2

Module – 3

Title:	AGC and AGC in interconnected power systems	Appr Time:	12 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Develop and analyze mathematical models of Automatic Load Frequency Control.	CO5	L3
2	Explaining about the tie line, develop and analyze the mathematical model of Tie – Line of two area system	CO6	L3
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
27	Mathematical Model of Automatic Load Frequency Control	CO5	L3

28	Mathematical Model of Automatic Load Frequency Control	CO5	L3
29	AGC Controller,	CO5	L3
30	AGC Controller,	CO5	L3
31	Proportional Integral Controller	CO5	L3
32	Proportional Integral Controller	CO5	L3
33	Introductions, Tie – Line Control with Primary Speed Control	CO6	L3
34	Tie – Line Control with Primary Speed Control	CO6	L3
35	Frequency Bias Tie - Line Control,	CO6	L3
36	Frequency Bias Tie - Line Control,	CO6	L3
37	State-Space Models.	CO6	L3
38	State-Space Models.	CO6	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	For large scale electric power systems with interconnected areas, Load Frequency Control (LFC) is important to keep the system frequency and the inter - area tie power as near to the scheduled values as possible.	CO5	L3
2	The transmission lines that connect an area to its neighboring area are called tie-lines . Power sharing between two areas occurs through these tie-lines. Load frequency control, as the name signifies, regulates the power flow between different areas while holding the frequency constant.	CO6	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
29	Obtain the mathematical model of ALFC	CO5	L3
30	Obtain the block diagram of AGC with integral controller and explain.	CO5	L3
31	With a block diagram representation, explain tie line control with speed control.	CO6	L3C
32	With a block diagram representation, explain tie line bias control.	CO6	L3
33	With a block diagram representation, explain state space model of an isolated system.	CO6	L3
34	Explain pole placement design.	CO6	L3
e	**Experiences**	-	-
1		CO6	L2
2			
3			
4		CO6	L3
5			

Module – 4

Title:	AGC in interconnected power systems and voltage and reactive power control	Appr Time:	13 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Develop and analyze the state space model for a two area system	CO7	L3
2	Determine the methods for voltage control and understanding the concept of	CO8	L3

	reactive power and voltage stability.		
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
39	State-Space Model for Two - Area System	CO7	L3
36	Tie-Line Oscillations	CO7	L3
37	Related Issues in Implementation of AGC.	CO7	L3
38	Introduction, Production and Absorption of Reactive Power	CO8	L3
39	Introduction, Production and Absorption of Reactive Power	CO8	L3
40	Methods of Voltage Control	CO8	L3
41	Methods of Voltage Control	CO8	L3
42	Dependence of Voltage on Reactive Power	CO8	L3
43	Dependence of Voltage on Reactive Power	CO8	L3
44	Sensitivity of Voltage to Changes in P And Q	CO8	L3
45	Sensitivity of Voltage to Changes in P And Q	CO8	L3
46	Cost Saving	CO8	L3
47	Methods of Voltage Control by Reactive Power Injection	CO8	L3
48	Methods of Voltage Control by Reactive Power Injection	CO8	L3
49	Voltage Control Using Transformers	CO8	L3
50	Voltage Control Using Transformers	CO8	L3
51	Voltage Stability	CO8	L3
52	Voltage Stability	CO8	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	The transmission lines that connect an area to its neighboring area are called tie-lines . Power sharing between two areas occurs through these tie-lines. Load frequency control, as the name signifies, regulates the power flow between different areas while holding the frequency constant.	CO7	L3
2	To improve the performance of AC systems.	CO8	L3
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
35	Obtain the state space model for a two area system.	CO7	L3
36	Discuss about tie line oscillatios.	CO7	L3
37	Discuss about the issues in Implementation of AGC	CO7	L3
38	Explain different sources of reactive power generation and absorbers of reactive power in a power system.	CO8	L3
39	List the devices used for voltage control.	CO8	L3
40	Derive the equations to get the relation between voltage between voltage, power and reactive power at a node.	CO8	L3
41	Show that the real power flow between two nodes in determined by the transmission angle '∂' and the reactive power flowis determined by the scalar voltage difference between two nodes.	CO8	L3
42	Explain Sensitivity of Voltage to Changes in P and Q.	CO8	L3
43	Briefly explain the different methods of reactive power injection in the power system.	CO8	L3
44	Discuss about the methods of Voltage Control by reactive power injection.	CO8	L3
45	Briefly explain the voltage control using tap changing transformers	CO8	L3
46	Briefly explain the voltage control using booster transformers	CO8	L3
47	Briefly explain the voltage control using phase shifting transformers	CO8	L3
48	Define voltage stability.	CO8	L3
49	Discuss the mechanism which cause voltage instability.	CO8	L3
50	What parameters can be used to measure the voltage strength of a system?	CO8	L3
51	Derive the P-V and V-Q curves for a radial system.	CO8	L3
52	What is the significance of voltage collapse proximity factor?	CO8	L3

e	Experiences	-	-
1		CO7	L2
2			
3			
4		CO8	L3
5			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	15EE81	Sem:	VIII	Marks:	30	Time:	75 minutes
Course:	Power System Operation and Control						

-	-	**Note: Answer all questions, each carry equal marks. Module : 3, 4**	**Marks**	**CO**	**Level**
1	a	Obtain the mathematical model of ALFC	8	CO5	L3
	b	Obtain the block diagram of AGC with integral controller and explain.	7	CO5	L3
		OR			
1	a	With a block diagram representation, explain state space model of an isolated system.	8	CO7	L3
	b	Discuss about the issues in Implementation of AGC	7	CO7	L3
2	a	Show that the real power flow between two nodes in determined by the transmission angle '∂' and the reactive power flowis determined by the scalar voltage difference between two nodes.	8	CO8	L3
	b	Explain different sources of reactive power generation and absorbers of reactive power in a power system.	7	CO8	L3
		OR			
2	a	With a block diagram representation, explain tie line bias control.	8	CO7	L3
	b	Discuss the mechanism which cause voltage instability.	7	CO8	L3

b. Assignment – 2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15EE81	Sem:	8	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Power System Operation and control						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT15EE007	Obtain the mathematical model of ALFC	5	CO5	L3
2	1KT15EE009	Obtain the block diagram of AGC with integral controller and explain.	5	CO5	L3

3	1KT15EE012	With a block diagram representation, explain tie line control with speed control.	5	CO6	L3C
4	1KT15EE014	With a block diagram representation, explain tie line bias control.	5	CO6	L3
5	1KT15EE016	With a block diagram representation, explain state space model of an isolated system.	5	CO7	L3
6	1KT15EE020	Explain pole placement design.	5	CO7	L3
7	1KT15EE021	Obtain the state space model for a two area system.	5	CO7	L3
8	1KT14EE022	Discuss about tie line oscillatios.	5	CO7	L3
9	1KT14EE024	Discuss about the issues in Implementation of AGC	5	CO7	L3
10	1KT14EE033	Explain different sources of reactive power generation and absorbers of reactive power in a power system.	5	CO8	L3
11	1KT16EE408	List the devices used for voltage control.	5	CO8	L3
12	1KT16EE406	Derive the equations to get the relation between voltage between voltage, power and reactive power at a node.	5	CO8	L3
13	1KT16EE409	Show that the real power flow between two nodes in determined by the transmission angle 'ð' and the reactive power flowis determined by the scalar voltage difference between two nodes.	5	CO8	L3
14	1KT15EE007	Explain Sensitivity of Voltage to Changes in P and Q.	5	CO8	L3
15	1KT15EE009	Briefly explain the different methods of reactive power injection in the power system.	5	CO8	L3
16	1KT15EE012	Discuss about the methods of Voltage Control by reactive power injection.	5	CO8	L3
17	1KT15EE014	Briefly explain the voltage control using tap changing transformers	5	CO8	L3
18	1KT15EE016	Briefly explain the voltage control using booster transformers	5	CO8	L3
19	1KT15EE020	Briefly explain the voltage control using phase shifting transformers	5	CO8	L3
20	1KT15EE021	Define voltage stability.	5	CO8	L3
21	1KT14EE022	Discuss the mechanism which cause voltage instability.	5	CO8	L3
22	1KT14EE024	What parameters can be used to measure the voltage strength of a system?	5	CO8	L3
23	1KT14EE033	Derive the P-V and V-Q curves for a radial system.	5	CO8	L3
24	1KT16EE408	What is the significance of voltage collapse proximity factor?	5	CO8	L3

D3. TEACHING PLAN - 3

Module – 5

Title:	Power system reliability and security and State estimation of power system	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
1	Explain about the system adequacy, system security, security levels and functions of system security	CO9	L2
2	Explain about the state estimation and analyze the formulation of liner least square estimation and DC state estimator.	CO10	L4
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
53	Introduction, Security Levels of System	CO9	L2
54	Reliability Cost, Adequacy Indices	CO9	L2
55	Functions of System Security	CO9	L2
56	Contingency Analysis	CO9	L2
57	Linear Sensitivity Factors	CO9	L2
58	Contingency Selection and Ranking	CO9	L2
59	Contingency Selection and Ranking	CO9	L2
60	Introduction, Linear Least Square Estimation	CO10	L4
61	Linear Least Square Estimation	CO10	L4
62	DC State Estimator	CO10	L4
63	Other Issues in State Estimation.	CO10	L4
64	Other Issues in State Estimation.	CO10	L4
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Reliability analysis has to be carried out at regular intervals during operating period of power systems in order to monitor the customer requirement satisfaction at desired level	CO9	L2
2	State estimator is an important tool for online monitoring, analysis and control of power systems. State estimation is used in all Energy Management Systems (EMS) to identify the present operating state of a system.	CO10	L4
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
53	Distinguish between adequacy and security.	CO9	L2
54	What are the levels of system security?	CO9	L2
55	Discuss about the requirements for power system adequacy assessment.	CO9	L2
56	What are indices that are commonly used in HL1 level.	CO9	L2
57	What are indices that are commonly used in HL2 level.	CO9	L2
58	What are indices that are commonly used in HL3 level.	CO9	L2
59	What are the major functions of system security?	CO9	L2

60		What is system monitoring?	CO9	L2
61		Why contingency evaluation is important?	CO9	L2
62		Explain security constrained optimal power flow (SCOPF) function of power system security with an example.	CO9	L2
63		What factors effect security of the system?	CO9	L2
64		Draw the flowchart for contingency.	CO9	L2
65		What are generator shift factors? Derive expression for it	CO9	L2
66		Draw the flowchart for the analysis of generator outages/transmission line outages.	CO9	L2
67		Derive an expression for line outage distribution factors.	CO9	L2
68		Explain the contingency analysis for detection of network problems.	CO9	L2
69		Explain AC power flow security analysis.	CO9	L2
70		Explain DC load flow	CO9	L2
71		What is meant by contingency selection and ranking?	CO9	L2
72		Explain system PI for line power flows.	CO9	L2
73		Explain system PI for voltage analysis	CO9	L2
74		What is 1P1Q method for selection?	CO9	L2
75		Briefly state the problem of state estimation in general terms	CO10	L4
76		Obtain the expression a general LSE problem. Determine the expression for the gain matrix	CO10	L4
77		Describe DC state estimator.	CO10	L4
78		What determines the choice of state variables in a practical system?	CO10	L4
79		Explain the issues in state estimation.	CO10	L4
e	**Experiences**		-	-
1			CO10	L2
2			CO9	
3				
4			CO9	L3
5				

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	15EE81	Sem:	VIII	Marks:	30	Time:	75 minutes		
Course:	Power System Operation and Control								
-	**-**	**Note: Answer all questions, each carry equal marks. Module : 5**					**Marks**	**CO**	**Level**
1	a	Explain security constrained optimal power flow (SCOPF) function of power system security with an example.					8	CO9	L2
	b	Derive an expression for line outage distribution factors.					7	CO9	L2
		OR							
1	a	What factors effect security of the system?					8	CO9	L2
	b	Explain AC power flow security analysis.					7	CO9	L2
2	a	Obtain the expression a general LSE problem. Determine the expression for the gain matrix					9	CO10	L4
	b	Explain the issues in state estimation.					6	CO10	L4
		OR							
2	a	What is meant by contingency selection and ranking?					8	CO9	L2
	b	What determines the choice of state variables in a practical system?					7	CO10	L4

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	15EE81	Sem:	VIII	Marks:	5	Time:	90 – 120 minutes
Course:	Power System Operation and control			Module : 5			
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT15EE007	Distinguish between adequacy and security.	5	CO9	L2
2	1KT15EE009	What are the levels of system security?	5	CO9	L2
3	1KT15EE012	Discuss about the requirements for power system adequacy assessment.	5	CO9	L2
4	1KT15EE014	What are indices that are commonly used in HL1 level.	5	CO9	L2
5	1KT15EE016	What are indices that are commonly used in HL2 level.	5	CO9	L2
6	1KT15EE020	What are indices that are commonly used in HL3 level.	5	CO9	L2
7	1KT15EE021	What are the major functions of system security?	5	CO9	L2
8	1KT14EE022	What is system monitoring?	5	CO9	L2
9	1KT14EE024	Why contingency evaluation is important?	5	CO9	L2
10	1KT14EE033	Explain security constrained optimal power flow (SCOPF) function of power system security with an example.	5	CO9	L2
11	1KT16EE408	What factors effect security of the system?	5	CO9	L2
12	1KT16EE406	Draw the flowchart for contingency.	5	CO9	L2
13	1KT16EE409	What are generator shift factors? Derive expression for it	5	CO9	L2
14	1KT15EE007	Draw the flowchart for the analysis of generator outages/transmission line outages.	5	CO9	L2
15	1KT15EE009	Derive an expression for line outage distribution factors.	5	CO9	L2
16	1KT15EE012	Explain the contingency analysis for detection of network problems.	5	CO9	L2
17	1KT15EE014	Explain AC power flow security analysis.	5	CO9	L2
18	1KT15EE016	Explain DC load flow	5	CO9	L2
19	1KT15EE020	What is meant by contingency selection and ranking?	5	CO9	L2
20	1KT15EE021	Explain system PI for line power flows.	5	CO9	L2
21	1KT14EE022	Explain system PI for voltage analysis	5	CO9	L2
22	1KT14EE024	What is 1P1Q method for selection?	5	CO9	L2
23	1KT14EE033	Briefly state the problem of state estimation in general terms	5	CO10	L4
24	1KT16EE408	Obtain the expression a general LSE problem. Determine the expression for the gain matrix	5	CO10	L4
25	1KT16EE406	Describe DC state estimator.	5	CO10	L4
26	1KT16EE409	What determines the choice of state variables in a practical system?	5	CO10	L4
27	1KT16EE406	Explain the issues in state estimation.	5	CO10	L4

F. EXAM PREPARATION

1. University Model Question Paper

Course:	Power System Operation and Control	Month / Year	May /2019

Crs Code:		15EE81	Sem:	VIII	Marks:	80	Time:		180 minutes	
Module	**Note**	Answer all FIVE full questions. All questions carry equal marks.						**Marks**	**CO**	**Level**
1	a	What are the different states of power system? Explain.						8	C01	L2
	b	Develop the mathematical model for the forward DP algorithm, taking into account the start- up cost of the units						8	CO2	L4
		OR								
1	a	Breifly describe the major components of a SCADA system						9	CO1	L2
	b	Breifly describe the various components of an RTU						8	CO1	L2
2	a	List the four algorithms for hydro thermal scheduling						8	CO3	L4
	b	Explain discrete time interval method for hydro thermal scheduling						8	CO3	L4
		OR								
2	a	Explain short term hydro thermal scheduling using penalty factors.						8	CO3	L4
	b	What are the basic control loops of a generator?						8	CO4	L2
3	a	Obtain the block diagram of AGC with integral controller and explain.						8	CO5	L3
	b	With a block diagram representation, explain tie line control with speed control.						8	CO6	L3
		OR								
3	a	With a block diagram representation, explain state space model of an isolated system.						9	CO7	L3
	b	Explain pole placement design.						7	CO7	L3
4	a	Discuss about tie line oscillatios.						8	CO7	L3
	b	Discuss about the issues in Implementation of AGC						7	CO7	L3
		OR								
4	a	Explain different sources of reactive power generation and absorbers of reactive power in a power system.						8	CO8	L3
	b	Show that the real power flow between two nodes in determined by the transmission angle 'ə' and the reactive power flow is determined by the scalar voltage difference between two nodes.						7	CO8	L3
5	a	Explain security constrained optimal power flow (SCOPF) function of power system security with an example.						8	CO9	L2
	b	What factors effect security of the system?						7	CO9	L2
		OR								
5	a	Obtain the expression a general LSE problem. Determine the expression for the gain matrix						8	CO10	L4

	b	Explain the issues in state estimation.	7	CO10	L4

2. SEE Important Questions

Course:		Power System Operation and control						Month / Year	May /2018	
Crs Code:		15EE81	Sem:	8	Marks:	80		Time:	180 minutes	
	Note	Answer all FIVE full questions. All questions carry equal marks.						-	-	
Module	Qno.	Important Question						**Marks**	**CO**	**Year**
1	a	What are the different states of power system? Explain.						7	CO1	2004
	b	Discuss the standard configurations of SCADA systems						8	CO2	2013
	c	What are the functions of RTU?						7	CO2	2013
	d	Define spinning reserve, negative reserve and off-line reserve.						6	CO3	2013
	e	With the help of a flow chart, explain the dynamic programming method in unit commitment.						8	CO3	2012
2	a	Explain discrete time interval method for hydro thermal scheduling						8	CO4	2012
	b	Explain $\gamma - \lambda$ Iterations algorithm for short term hydro thermal scheduling						8	CO4	2010
	c	What are the basic control loops of a generator?						7	CO5	2010
	d	Draw the block diagram of a steam turbine governing system and explain the function of the various components.						8	CO5	2012
	e	Explain the objectives and functions of Automatic Generation Control (AGC) in a power system.						7	CO5	2012
3	a	Obtain the block diagram of AGC with integral controller and explain.						7	CO6	2012
	b	With a block diagram representation, explain tie line control with speed control.						7	CO7	2012
	c	Obtain the state space model for a two area system.						8	CO7	2013
	d	Discuss about tie line oscillatios.						7	CO7	2010
	e	Discuss about the issues in Implementation of AGC						7	CO7	2014
4	a	Explain the objectives and functions of Automatic Generation Control (AGC) in a power system.						8	CO5	2009
	b	Explain pole placement design.						7	CO7	2009
	c	Derive the equations to get the relation between voltage between voltage, power and reactive power at a node.						6	CO8	2011
	d	Show that the real power flow between two nodes in determined by						8	CO8	2009

		the transmission angle 'ϑ' and the reactive power flowis determined by the scalar voltage difference between two nodes.			
	e	Derive the equations to get the relation between voltage between voltage, power and reactive power at a node.	7	CO8	2009
5	a	What are generator shift factors? Derive expression for it	8	CO9	2011
	b	Draw the flowchart for the analysis of generator outages/transmission line outages.	7	CO9	2011
	c	Derive an expression for line outage distribution factors.	7	CO9	2010
	d	Obtain the expression a general LSE problem. Determine the expression for the gain matrix	8	CO10	2012
	e	Describe DC state estimator.	6	CO10	2009

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	Introduction:Operating States of Power System, Objectives of Control, Key Concepts of Reliable Operation, Preventive and Emergency Controls, Energy Management Centers. Supervisory Control and Data acquisition (SCADA):Introduction to SCADA and its Components, Standard SCADA Configurations, Users of Power Systems SCADA, Remote Terminal Unit for Power System SCADA, Common Communication Channels for SCADA in Power Systems, Challenges for Implementation of SCADA.	07	- L1 - L2	L2	-Remembering - Understanding	- Lecture	-Unit Test - Assignment
1	Unit Commitment:Introduction, Simple Enumeration Constraints, Priority List Method, Dynamic Programming Method for Unit Commitment	03	- L2 - L4	L4	- Understanding -Analyzing	- Lecture	-Unit Test - Assignment
2	Hydro-thermal Scheduling: Introduction, Scheduling Hydro Systems, Discrete	06	- L2 - L4	L4	- Understanding -Analyzing	- Lecture	-Unit Test - Assignment

	Time Interval Method, Short Term Hydro Thermal Scheduling Using $\gamma - \lambda$ Iterations, Short Term Hydro Thermal Scheduling Using Penalty Factors.						
2	Automatic Generation Control (AGC): Introductions, Basic Generator Control Loops, Commonly used Terms in AGC, Functions of AGC, Speed Governors.	04	- L1 - L2	L2	-Remembering - Explaining	- Lecture -	-Unit Test - Assignment
3	Automatic Generation Control (AGC):Mathematical Model of Automatic Load Frequency Control, AGC Controller, Proportional Integral Controller.	04	- L2 - L3	L3	- Understanding -Develop and analyze	- Lecture -	-Unit Test - Assignment
3	Automatic Generation Control in interconnected Power system: Introductions, Tie – Line Control with Primary Speed Control, Frequency Bias Tie - Line Control, State-Space Models.	05	- L2 - L3	L3	- Understanding -Develop and analyze	- Lecture -	-Unit Test - Assignment
4	Automatic Generation Control in interconnected Power system:State-Space Model for Two - Area System, Tie-Line Oscillations, Related Issues in Implementation of AGC.	4	- L3 - L1	L3	- Remembering -Develop and analyze	- Lecture	-Unit Test - Assignment
4	Voltage and Reactive Power Control: Introduction, Production and Absorption of Reactive Power, Methods of Voltage Control, Dependence of Voltage on Reactive Power , Sensitivity of Voltage to Changes in P And Q, Cost Saving, Methods of Voltage Control by Reactive Power Injection, Voltage Control Using Transformers, Voltage Stability.	07	- L2 - L3	L3	- Understanding - Explaining	- Lecture	-Unit Test - Assignment
5	Power System Reliability and Security: Introduction, Security Levels of System, Reliability Cost, Adequacy Indices, Functions of System Security, Contingency Analysis, Linear Sensitivity Factors, Contingency Selection and Ranking.	06	- L1 - L2	L2	-Remembering - Explaining	- Lecture - -	-Unit Test - Assignment

5	State estimation of Power Systems: Introduction, Linear Least Square Estimation, DC State Estimator, Other Issues in State Estimation.	04	- L2 - L4	L4	- Understanding - Explaining	- Lecture - -	-Unit Test - Assignment

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module-#	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. Ashort word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	- Study of Power System - Study of SCADA	- Power System -SCADA	Power System and SCADA	Operating States and NERC Guidelines for reliable operation SCADA system and all associated issues like guidelines for installation and Constraints in application	-Understanding -Power System, SCADA -Operating States of power system Components, communication channels for SCADA	Understanding the basic structure, operating states, requirements, NERC guidelines for reliable operation of power system and discussing about the preventive and emergency control measures, supervisory control system, components, configuration, RTUs, communication channels, Challenges for Implementation of SCADA.
1	-Study of Unit Commitment -Study of Different methods for unit commitment.	-Unit Commitment -	Unit Commitment	Unit commitment, Constraints, Different methods for unit commitment.	-Explaining -Unit commitment -Constraints, Different methods for unit commitment.	Explain about unit commitment, constraints in unit commitment, analyzing different methods for unit commitment.
2	-Study of	-Hydro-	Hydro-	Hydro-thermal	-Analyzing	Discussing about

	Hydro-thermal scheduling -Study of Solutions to hydro thermal problems	thermal scheduling	thermal scheduling	scheduling, Discrete time interval method, $\gamma - \lambda$ Iterations, Penalty Factors.	-Hydro-thermal scheduling -Discrete time interval method, $\gamma - \lambda$ Iterations, Penalty Factors.	the classification and advantages of hydro plants. Analyzing about the scheduling hydro systems, discrete time interval method and Short Term Hydro Thermal Scheduling Using $\gamma - \lambda$ Iterations and by Penalty Factors.
2	-Study of Automatic Generation Control -Study of Speed Governors	-Automatic Generation Control -speed governors	Automatic Generation Control	Importance of having AGC to keep down frequency deviations & speed governors	-Explaining -Automatic Generation Control, Speed Governors -Modes of governors operation	Explaining about the basic generator control loops, functions of Automatic generation control and speed governors.
3	-Study of Automatic Load Frequency Control -Study of Mathematical model of Automatic Load Frequency Control	-Automatic Generation Control -Automatic Load Frequency Control	Automatic Load Frequency Control	Mathematical models of Automatic Load Frequency Control	-Develop and analyze -Automatic Load Frequency Control -Mathematical modelof Automatic Load Frequency Control	Develop and analyze mathematical models of Automatic Load Frequency Control.
3	-Study of Automatic Generation Control in interconnected power systems -Study of tie line	-Automatic Generation Control -Tie Line	Tie Line	Tie – Line, Load frequency control of interconnected systems	-Develop and analyze -Tie – Line -Load frequency control of interconnected systems	Explaining about the tie line, develop and analyze the mathematical model of Tie – Line of two area system
4	-Study of Automatic Generation Control in interconnected power systems -Study of tie line	-Automatic Generation Control -Tie Line	Tie Line	Tie – Line, Load frequency control of interconnected systems	-Develop and analyze -Tie – Line -Load frequency control of interconnected systems	Develop and analyze the state space model for a two area system
4	-Study of Voltage and Reactive Power Control -Study of voltage stability	-Voltage and Reactive Power Control -voltage stability	Voltage and Reactive Power Control	Components which effect reactive power &methods of voltage control	-Understanding -Voltage and Reactive Power Control -Methods for voltage control	Determine the methods for voltage control and understanding the concept of reactive power and voltage stability.
5	Study of Power	-Power	Power	Study of power	-Explaining	Explain about

	System Reliability -Study of power system security	System Reliability -power system security	System Reliability and Security	system reliability, security and contingency analysis.	-Power System Reliability and Security -Security levels and functions	the system adequacy, system security, security levels and functions of system security
5	Study of Voltage and Reactive Power Control -Study of power system security	-Power System Reliability -power system security	State estimation of Power Systems	State estimation and related issues in power system	-Explaining -State estimation of Power Systems -Formulation of liner least square estimation.	Explain about the state estimation and analyze the formulation of liner least square estimation and DC state estimator.