INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

ELECTRICAL POWER SYSTEMS

COURSE DESCRIPTOR

Course Title	**ECONOMIC OPERATION OF POWER SYSTEMS**				
Course Code	**BPSB02**				
Programme	M.Tech				
Semester	I	EPS			
Course Type	Core				
Regulation	IARE - R18				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	0	3	3	2
Chief Coordinator	Dr. V. Chandra Jagan Mohan, Associate Professor				
Course Faculty	Dr. V. Chandra Jagan Mohan, Associate Professor				

I. COURSE OVERVIEW:

The course is intended to present fundamentals as well as state-of-the-art techniques for economic operation and control of electric power systems. The prerequisite for this course is a good background in power system fundamentals (e.g. undergraduate course on power system analysis). Details of the course assessment plans are given at the end. Much emphasis is given on the course project. The course project is different from the usual term papers. Unlike in the term papers, you are required to search for a suitable research topic related to the course content, and work on the problem throughout the semester. At the end of the semester, you are required to present a seminar on the chosen topic and submit a brief report. Guidance will be provided to you, if needed, in choosing and conducting the course project. The intention is to provide exposure to the methods of conducting a research work, and also to encourage independent and innovative ideas, which is also the main theme of this course.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AEE004	III	DC Machines and Transformers	4
UG	AEE007	IV	AC Machines	4
UG	AEE008	VII	Power System Operation and Control	4

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Economic Operation Of Power Systems	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✘	Mini Project	✔	Videos
✔	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two session examinations.

Semester End Examination (SEE): The SEE shall be conducted for 70 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE UNITs and each UNIT carries equal weight age in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with „either‟ „or‟ choice will be drawn from each UNIT. Each question carries 14 marks. There could be a maximum of three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept
30 %	To test the analytical skill of the concept
20 %	To test the application skill of the concept

Continuous Internal Assessment (CIA):

The CIA shall be conducted by the faculty/teacher handling the course as given in Table 1. CIA is conducted for a total of 30 marks, with 25 marks for Continuous Internal Examination (CIE) and 05 marks for Technical Seminar and Term Paper.

Table 1: Assessment pattern for CIA

Component	Theory		Total marks
Type of Assessment	CIE Exam	Technical Seminar and Term paper	
CIA marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 9th and 17th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration, consisting of 5 one mark compulsory questions in part-A and 4 questions in part-B. The student has to answer any 4 questions out of five questions, each carrying 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Technical Seminar and Term Paper:
Two seminar presentations are conducted during I year I semester and II semester. For seminar, a student under the supervision of a concerned faculty member, shall identify a topic in each course and prepare the term paper with overview of topic. The evaluation of Technical seminar and term paper is for maximum of 5 marks. Marks are awarded by taking average of marks scored in two Seminar Evaluations.

VI. HOW PROGRAM OUTZOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Discussion and Seminars
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Seminars
PO 3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Laboratory Practice
PO 4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Assignments, Mock tests
PO 5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	2	Laboratory Practice
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	-	-
PO 7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	-	-
PO 8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	-	-
PO 9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	-	-
PO 10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	-	-
PO 11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	1	Assignments, Mock tests

PO 12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change**.**	2	Assignments, Mock tests

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO1	Talented to analyze, design and implement electrical & electronics systems and deal with the rapid pace of industrial innovations and developments.	2	Assignments, Internships, Projects
PSO2	Skillful to use application and control techniques for research and advanced studies in Electrical and Electronics engineering domain.	3	Assignments, Projects

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	To understand the electrical power plant operation and control with respect to its economic aspect.
II	To know the importance of compensation in power system and study the different compensating techniques.
III	Study about different transients and their protection those are introduced in power system.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
BPSB02.01	CLO 1	Identify and explain the different methods of generation, distribution, control and compensation involved in the operation of power systems.	PO1	2
BPSB02.02	CLO 2	Design the mathematical models of the mechanical and electrical components involved in the operation of power systems and demonstrate the understanding of the open loop and closed loop control practices associated with the voltage and frequency control of single area or interconnected multi area power systems.	PO2	2
BPSB02.03	CLO 3	Specify the equivalent electrical parameters of transmission line to prepare and analyze models to predict the range and ratings of the equipments to be used, the protection required against line transients and determine the appropriate methods of compensation required for operational stability.	PO3	2

BPSB02.04	CLO 4	Solve the problems related to the economic dispatch of power, plant scheduling, unit commitment and formulate strategies to minimize transmission line losses and penalties imbibed. .	PO4	2
BPSB02.05	CLO 5	Devise protection schemes required for the system to safeguard against transients after identifying and determining the severity of the transients occurring during the period of operation and design testing strategies to determine the performance characteristics of the compensating equipment to be used in the system.	PO4	2
BPSB02.06	CLO 6	Assess the different methods of control and compensation to choose the best option so that social and environmental problems are minimized and recognize the need to continuously follow the advancements in technology and incorporate them in the present system to improve efficiency and increase the flexibility and quality of operation	PO5	2

3 = High; 2 = Medium; 1 = Low

X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

XI.

Course Learning Outcomes	Program Outcomes (POs)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CLO 1	2						
CLO 2		2					
CLO 3			2				
CLO 4							
CLO 5				2			
CLO 6					2		
CLO 7							
CLO 8						2	
CLO 9	2	2	2				2
CLO 10					2		
CLO 11							
CLO 12		2		2		2	

3 = High; 2 = Medium; 1 = Low

XII. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3, PO5, PSO2,PSO3	SEE Exams	PO1, PO2, PO3, PO5, PSO2,PSO3	Assignments	PO2, PO3, PO5	Seminars	PO2, PO5
Laboratory Practices	PO3, PSO3	Student Viva	PO2, PO3, PSO3	Mini Project	-	Certification	-
Term Paper	-						

XIII. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIV. SYLLABUS

UNIT-I	**ECONOMIC LOAD SCHEDULING**
Characteristics of steam turbine, variations in steam UNIT characteristics, economic dispatch with piecewise linear cost functions, Lambda iterative method, LP method, economic dispatch under composite generation production cost function, base point and participation factors, thermal system dispatching with network losses considered.	
UNIT-II	**UNIT COMMITMENT**
UNIT Commitment, definition, constraints in UNIT commitment, UNIT commitment solution methods, priority, list methods, dynamic programming solution.	
UNIT-III	**HYDRO THERMAL SCHEDULING**
Characteristics of Hydroelectric UNITs, introduction to hydrothermal coordination, long range and short range hydro scheduling. Hydroelectric plant models, hydrothermal scheduling with storage limitations, dynamic programming solution to hydrothermal scheduling.	
UNIT-IV	**LOAD FREQUENCY CONTROL**
Control of generation, models of power system elements, single area and two area block diagrams, generation control with PID controllers, implementation of Automatic Generation control (AGC), AGC features.	
UNIT-V	**OPTIMAL POWER FLOW**
Introduction to Optimal power flow problem, OPF calculations combining economic dispatch and power flow, OPF using DC power flow, algorithms for solution of the ACOPF, optimal reactive power dispatch.	
Text Books:	
1. J J Grainger & W DStevenson, “Power system analysis”, McGraw Hill,2nd Edition, 2003. 2. Allen JWood, Bruce F Wollenberg, Gerald B Sheblé, “Power Generation, Operation and Control”, WileyInterscience2nd Edition, 2013.	
Reference Books:	
1. Olle, Elgerd, “Electric Energy Systems Theory an Introduction”, TMH, 2nd Edition, 1983.	
Web References:	
1. https://pdfs.semanticscholar.org/b99b/cedc7f9e06d8b21d910767bb886a6d038283.pdf 2. https://core.ac.uk/download/pdf/33363832.pdf	
e-text books:	
1. https://core.ac.uk/download/pdf/33363832.pdf 2. http://vbn.aau.dk/files/226382872/seyedmostafa_farashbashiastaneh.pdf	

XV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	CLOs	Reference
1	Understand the benefits of economic operation in power system.	CLO 1	T1: 1.1 – 1.5
2	Know the architecture economic load scheduling.	CLO 1	T1: 1.1 – 1.5
3	Illustrate characteristics of steam turbine.	CLO 1	T2: 1.1.1 –1.1.2
4	Explain variations in steam unit characteristics.	CLO 1	T2: 1.3.1
5	Describe the operation of economic dispatch with piecewise linear cost functions.	CLO 1	T2: 1.3.3
6	Discuss the operation of Lambda iterative method.	CLO 2	T1: 1.3.2 - 1.3.4
7	Discuss the operation of s LP method.	CLO 2	T2: 1.3.8
8	Analyse the economic dispatch under composite generation production cost function.	CLO 2	T1: 2.1 – 2.4
9	Analyse base point and participation factors.	CLO 2	T3: 5.2
10	Illustrate the thermal system dispatching with network losses considered.	CLO 2	T1: 5.7
11	Describe the UNIT Commitment.	CLO 3	T3: 5.7
12	Understand the definition and constraints in UNIT commitment.	CLO 3	T2: 5.7
13	Implement UNIT commitment solution methods.	CLO 3	T3: 5.7
14	Justify the priority list methods of unit commitment.	CLO 3	T1: 9.1 -9.4
15	Write about dynamic programming solution.	CLO 3	T1: 9.1 -9.4
16	Explain hydro thermal scheduling.	CLO 4	T1: 9.1 -9.4
17	Explain Characteristics of Hydroelectric UNITs.	CLO 4	T1: 9.1 -9.4
18	Write down the introduction to hydrothermal coordination.	CLO 4	T1: 9.1 -9.4
19	Define long range and short range hydro scheduling.	CLO 4	T1: 6.2 – 6.3
20	Describe Hydroelectric plant models.	CLO 4	T1: 7.1 – 7.5
21	Describe hydrothermal scheduling with storage limitations.	CLO 5	T1: 7.1 – 7.5
22	Develop Control of generation.	CLO 5	T1: 7.1 – 7.5
23	Describe models of power system elements.	CLO 5	T1: 7.2 -7.4
24	Describe single area and two area block diagrams.	CLO 5	T1: 7.2 -7.4

Lecture No	Topics to be covered	CLOs	Reference
25	Explain generation control with PID controller.	CLO 5	T1: 7.2 -7.4
26	Describe implementation of Automatic Generation control (AGC).	CLO 5	T1: 6.1 – 6.10
27	Know about AGC features.	CLO 5	T1: 6.1 – 6.10
28	Explain the Optimal power flow problem.	CLO 6	T1: 5.7
29	OPF calculations combining economic dispatch and power flow.	CLO 6	T1: 2.2
30	Explain OPF using DC power flow.	CLO 6	T1: 2.3
31	Describe the algorithms for solution of the ACOPF.	CLO 6	T1: 5.7
32	Explain about optimal reactive power dispatch.	CLO 6	T2: 2.1 - 2.4

XVI. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Introduction to Human Machine Interface (HMI) and its interfacing with PLC	Seminars, Open ended experiments	PSO 2, PO5	PSO 3
2	Controlling of Variable frequency Drive (VFD) through PLC	Seminars, Open ended experiments	PSO 2, PO5	PSO 3

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