INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Course Title	**ECONOMIC OPERATION OF POWER SYSTEMS**				
Course Code	BPSB02				
Program	M.Tech				
Semester	I	EPS			
Course Type	CORE				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. A Naresh Kumar, Assistant Professor, EEE				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE004	III	DC Machines and Transformers
B.Tech	AEE007	IV	AC Machines
B.Tech	AEE008	VII	Power System Operation and Control

II 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..

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Industrial Load Modelling and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

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 CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

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):
For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Assignment and 05 marks for Alternative Assessment Tool (AAT). Two CIE Tests are Compulsory and sum of the two tests, along with the scores obtained in the assignment / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/Assignment /AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Assignment/AAT is mandatory and the responsibility lies with the concerned course faculty. CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Component	Theory			Total Marks
Type of Assessment	CIE Exam	Assignment	AAT	
CIA Marks	20	5	5	30

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. One assignment has to submit at the end of the CIE2 for the questions provided by the each course coordinator in that semester. Assignments to be handed in as loose paper collection stapled together at the top left corner. The assignment should be presented as a professional report. It must consist of a cover sheet, content page, and should have an introduction, a body, a conclusion or recommendation, and a reference page.

Alternative Assessment Tool (AAT)
In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning center.**The AAT may includes, concept videos, course related term paper, technical seminar, term paper, paper presentations conducted by reputed organizations relevant to the course etc.**

VI COURSE OBJECTIVES:

The students will try to learn:

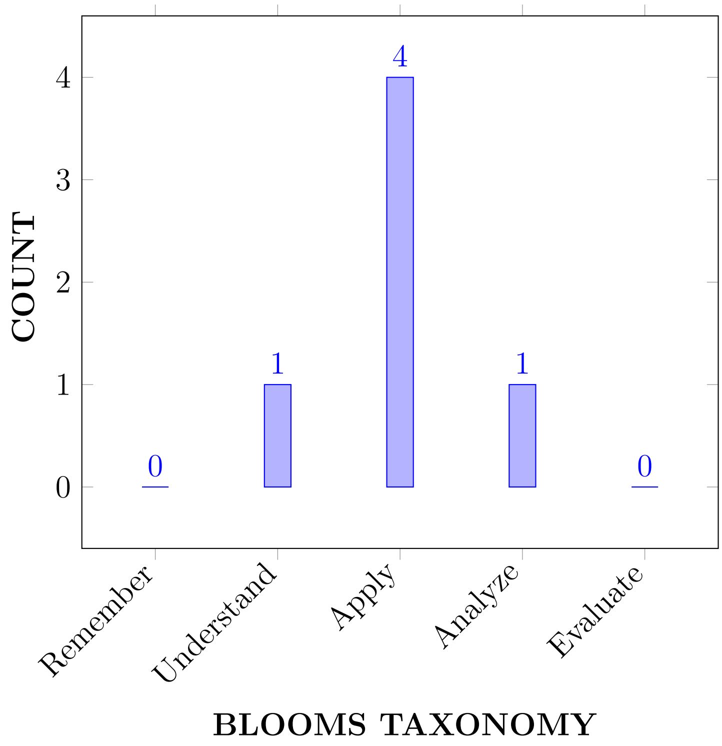
I	To understand the electrical power plant operation and control with respect to its economic aspect.
II	To know the importance of compensation in power system and study the different compensating techniques.
III	Study about different transients and their protection those are introduced in power system.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Compute** the cost of generation, economic dispatch of power among thermal units using incremental cost curves and coordinate equation using iteration method	Apply
CO 2	**Solve** the unit Commitment problem with various constraints using conventional optimization techniques and general transmission line loss formula	Apply
CO 3	**Illustrate** the Optimal scheduling of Thermal and Hydro power stations for ideal economic operation of power systems	Understand
CO 4	**Categorize** single area load frequency control and two area load frequency control to minimize the transient deviations and steady state error to zero	Analyze
CO 5	**Analyse** the importance of Reactive power control and Power Factor in power systems for efficient and reliable operation of power systems.	Apply
CO 6	**Identify** the different types of compensating equipment for reducing reactive power to improve system's efficiency	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	1	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	✓
CO 4	-	-	✓	✓	-	-
CO 5	-	-	-	✓	-	-
CO 6	-	-	✓	✓	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 3	Understand the concept of industrial load and analyze and design innovative models to establish innovative solution.	3
	PO 4	Make use of industrial load management techniques in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation .	3
CO 2	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	3
	PO 4	Understand the concept of industrial load on modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective.	4
CO 3	PO 1	Demonstrate research areas to solve practical problems in power systems and build solutions	2
	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2

	PO 3	Contrast the design process to minimize transmission line losses and energy saving in industries in electrical power systems for Solution development or experimentation / Implementation in Interpretation of results and Validation	4
	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management and the design process.	3
	PO 6	Implementation of real time energy management and the design process.	3
CO 4	PO 3	Demonstrate energy consumption of industrial loads by understanding and analyzing and design innovative solutions and Apply the complex engineering problems and their system components by design for the development of solution.	3
	PO 4	Make use of captive power plants in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	4
CO 5	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management.	4
CO 6	PO 3	Demonstrate operating strategies of power capacitors for integrated load management forapplication and solution of the complex engineering problems for the development of solution.	3
	PO4	Make use of power capacitors in power systems using the concepts of engineering fundamentals to develop the solution of problems and establish innovative solutions.	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	3	3	-	-
CO 2	-	2	3	4	-	-
CO 3	2	2	4	3	-	3
CO 4	-	-	3	4	-	-
CO 5	-	-	-	4	-	-
CO 6	-	-	3	3	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	42.8	42.8	-	-
CO 2	-	28.57	42.8	57.1	-	-
CO 3	50	28.57	57.1	42.8	-	50
CO 4	-	-	42.8	57.1	-	-
CO 5	-	-	-	57.1	-	-
CO 6	-	-	42.8	42.8	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -$5 < C \leq 40\%$ – Low/ Slight
2 - $40\% < C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	-
CO 2	-	1	2	2	-	-
CO 3	2	1	2	2	-	2
CO 4	-	-	2	2	-	-
CO 5	-	-	-	2	-	-
CO 6	-	-	2	2	-	-
TOTAL	2	2	10	12	-	2
AVERAGE	2	1	2	2	-	2

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	✓
Quiz	-	Tech-Talk	-	Certification	-
Term Paper	-	Seminars	-	Student Viva	-
Laboratory Practice	-	5 Minutes Video / Concept Video	✓	Open Ended Experiments	-
Micro Projects	-	-	-	-	

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE 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.
MODULE II	UNIT COMMITMENT
	UNIT Commitment, definition, constraints in UNIT commitment, UNIT commitment solution methods, priority, list methods, dynamic programming solution.
MODULE 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.
MODULE 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.
MODULE 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.

TEXTBOOKS

1. J J Grainger W DStevenson, "Power system analysis", McGraw Hill,2nd Edition, 2003.
2. Allen J Wood, 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.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE)		
	CONTENT DELIVERY (THEORY)		
1	Need for Electric Energy Scenario.	CO 1	T2:1.1,1.2
2	Need for Electric Energy Scenario.	CO 1	T2:1.1,1.2
3	Basic demand side management.	CO 1	T2:1.3,1.4
4	Basic demand side management.	CO 1	T2:1.3,1.4

5	Illustrate characteristics of steam turbine.	CO 1	T2: 1.1.1 –1.1.2
6	Illustrate characteristics of steam turbine.	CO 1	T2: 1.1.1 –1.1.2
7	Explain variations in steam unit characteristics.	CO 1	T2: 1.3.1
8	Explain variations in steam unit characteristics.	CO 1	T2: 1.3.1
9	Describe the operation of economic dispatch with piecewise linear cost functions.	CO 1	T2: 1.3.3
10	Describe the operation of economic dispatch with piecewise linear cost functions.	CO 1	T2: 1.3.3
11	Discuss the operation of Lambda iterative method.	CO 2	T1: 1.3.2 - 1.3.4
12	Discuss the operation of Lambda iterative method.	CO 2	T1: 1.3.2 - 1.3.4
13	Discuss the operation of s LP method.	CO 2	T2: 1.3.8
14	Discuss the operation of s LP method.	CO 2	T2: 1.3.8
15	Analyse the economic dispatch under composite generation production cost function.	CO 2	T1: 2.1 – 2.4
16	Analyse the economic dispatch under composite generation production cost function.	CO 2	T1: 2.1 – 2.4
17	Analyse base point and participation factors.	CO 2	T3: 5.2
18	Analyse base point and participation factors.	CO 2	T3: 5.2
19	Illustrate the thermal system dispatching with network losses considered.	CO 2	T1: 5.7
20	Illustrate the thermal system dispatching with network losses considered.	CO 2	T1: 5.7
21	Describe the UNIT Commitment.	CO 3	T3: 5.7
22	Describe the UNIT Commitment.	CO 3	T3: 5.7
23	Understand the definition and constraints in UNIT commitment.	CO 3	T2: 5.7
24	Understand the definition and constraints in UNIT commitment.	CO 3	T2: 5.7
25	Implement UNIT commitment solution methods.	CO 3	T3: 5.7
26	Implement UNIT commitment solution methods.	CO 3	T3: 5.7
27	Justify the priority list methods of unit commitment.	CO 3	T1: 9.1 -9.4
28	Justify the priority list methods of unit commitment.	CO 3	T1: 9.1 -9.4
29	Write about dynamic programming solution.	CO 3	T1: 9.1 -9.4
30	Write about dynamic programming solution.	CO 3	T1: 9.1 -9.4
31	Explain hydro thermal scheduling.	CO 4	T1: 9.1 -9.4
32	Explain Characteristics of Hydroelectric UNITs.	CO 4	T1: 9.1 -9.4

33	Write down the introduction to hydrothermal coordination.	CO 4	T1: 9.1 -9.4
34	Define long range and short range hydro scheduling.	CO 4	T1: 6.2 – 6.3
35	Describe Hydroelectric plant models.	CO 4	T1: 7.1 – 7.5
36	Describe hydrothermal scheduling with storage limitations.	CO 5	T1: 7.1 – 7.5
37	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
38	Describe models of power system elements.	CO 5	T1: 7.2 -7.4
39	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4
40	Explain generation control with PID controller.	CO 5	T1: 7.2 -7.4
41	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
42	Know about AGC features.	CO 5	T1: 6.1 – 6.10
43	Explain the Optimal power flow problem.	CO 5	T1: 5.7
44	OPF calculations combining economic dispatch and power flow.	CO 6	T1: 2.2
45	Explain OPF using DC power flow.	CO 6	T1: 2.3
46	Describe the algorithms for solution of the ACOPF.	CO 6	T1: 5.7
47	Explain about optimal reactive power dispatch.	CO 6	T2: 2.1 - 2.4
48	Case studies, Captive power UNITs.	CO 5	R1:6.3
49	Operating and control strategies, Power pooling	CO 5	T2:13.7
50	Operating and control strategies, Power pooling	CO 4	T2:13.7
51	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
52	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
53	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
54	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
55	Develop Control of generation.	CO 5	T1: 7.1 – 7.5
41	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4
42	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4
43	Describe single area and two area block diagrams.	CO 5	T1: 7.2 -7.4

44	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
45	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
46	Describe implementation of Automatic Generation control (AGC).	CO 5	T1: 6.1 – 6.10
47	Explain the Optimal power flow problem.	CO 5	T1: 5.7
48	Explain the Optimal power flow problem.	CO 5	T1: 5.7
49	Explain the Optimal power flow problem.	CO 5	T1: 5.7
50	OPF calculations combining economic dispatch and power flow.	CO 6	T1: 2.2
51	OPF calculations combining economic dispatch and power flow.	CO 6	T1: 2.2
52	Describe the algorithms for solution of the ACOPF.	CO 6	T1: 5.7
53	Problems	CO 6	T1:486
54	Problems	CO 6	T1:486
55	Problems	CO5	R2:11.8
56	Describe the algorithms for solution of the ACOPF.	CO 6	T1: 5.7
57	Explain about optimal reactive power dispatch.	CO 6	T2: 2.1 - 2.4
58	Explain about optimal reactive power dispatch.	CO 6	T2: 2.1 - 2.4
59	Problems	CO6	T1:9.7, 9.8
60	Problems	CO6	T1:9.9
DISCUSSION OF QUESTION BANK			
1	MODULE:I-ECONOMIC LOD SHEDDING	CO1	-
2	MODULE:II- UNIT COMMITMENT	CO2,CO3	-
3	MODULE:III-HYDRO THERMAL SCHEDULING	CO4	-
4	MODULE:IV-LOAD FREQUENCY CONTROL	CO5	-
5	MODULE:V-OPTIMAL POWER FLOW	CO6	-

Signature of Course Coordinator **HOD,EEE**

Dr.A Naresh Kumar,Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**HVDC Transmission**				
Course Code	BPSB03				
Program	M.Tech				
Semester	I				
Course Type	Program Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr. P Sridhar, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB20	V	Power Electronics
B.Tech	AEEB22	VI	Power system Analysis
B.Tech	AEEB47	VII	High Voltage Engineering

II COURSE OVERVIEW:

This course deals with the importance of HVDC transmission, analysis of HVDC converters, Harmonics and Filters, Reactive power control and Power factor improvements of the system. It also deals with basic modeling nd analysis of HVDC system power flow regulation.

III MARKS DISTRIBUTION:

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HVDC Transmission	70 Marks	30 Marks	100

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x	Seminars	x	Others				

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Table 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} week of the semester respectively. The CIE exam is conducted for for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

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VI COURSE OBJECTIVES:

The students will try to learn:

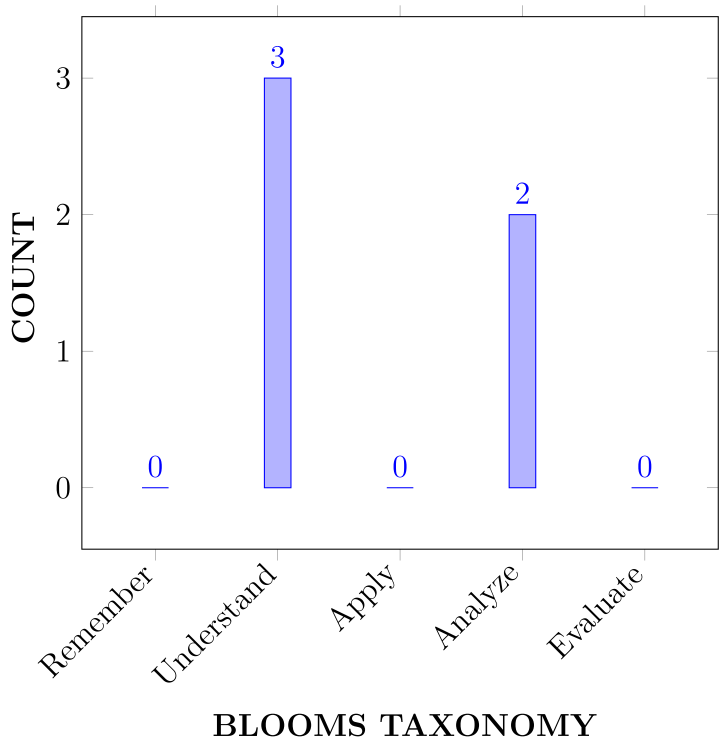
I	The basic concepts of HVDC system, components used in HVDC system and advantages of DC over AC transmission systems.
II	The analysis of Line Commuted Converter and Voltage Source Converter with and without effect of commutation overlap.
III	The functioning of components of HVDC system and various controlling techniques for stability enhancement in HVDC links.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Classify** AC and DC transmission and understand control characteristics of HVDC system.	Understand
CO 2	**Explain** the working of HVDC converter in rectifier and inverter modes of operation.	Understand
CO 3	**Compare** different control techniques used in HVDC converters.	Analyze
CO 4	**Interpret** the nature of faults happening on both the AC and DC sides of the converters and formulate protection schemes for the same.	Understand
CO 5	**Develop** harmonic models and use the knowledge of circuit theory to develop filters and assess the requirement and type of protection for the filters.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



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Program Outcomes	
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PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	1	SEE/CIE/AAT
PO 2	An ability to write and present a substantial technical report / document.	2	SEE/CIE/AAT
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	1	SEE/CIE/AAT
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	SEE/CIE/AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	SEE/CIE/AAT

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	✓	✓	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	-	✓	✓	✓	-	-
CO 4	-	✓	✓	✓	-	-
CO 5	✓	✓	✓	✓	-	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 2	Apply the concepts (knowledge) of HVDC systems using their control characteristics by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and communicate effectively in writing / orally societal problems.	4
	PO 3	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	1
	PO 4	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system for solving society relevant complex problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	3
CO 2	PO 2	Apply the concepts (knowledge) of HVDC converter using their rectifier and inverter operations by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	4
	PO 3	Demonstrate the working of HVDC converter and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	2
	PO 4	Demonstrate the working of HVDC converter and design new innovative products for solving society relevant complex problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	3

CO 3	PO 2	Apply the concepts (knowledge) of HVDC converter and its different control schemes by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design and communicate effectively in writing / orally societal problems science and engineering fundamentals.	4
	PO 3	Demonstrate the importance of HVDC converter and different control schemes for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions.	2
	PO 4	Demonstrate the importance of HVDC converter and different control schemes for solving society relevant complex problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions.	1
CO 4	PO 2	Apply the concepts (knowledge) of design protection schemes for faults using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and and communicate effectively in writing / orally societal problems.	4
	PO 3	Apply the concepts (knowledge) of design protection schemes for faults using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design.	2
	PO 4	Apply the concepts (knowledge) of design protection schemes for faults using their architectures by using Scientific principles and methodology and complex problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design.	2
CO 5	PO 1	Develop harmonic models and use the knowledge of circuit theory to develop filters for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions.	1

	PO 2	Apply the concepts (knowledge) of filters for harmonics in HVDC converters by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and and communicate effectively in writing / orally societal problems	3
	PO 3	Develop harmonic models and use the knowledge of circuit theory to develop filters for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions and make the experimental design with manage the design process and evaluate outcomes using modern tools to get the solution development.	2
	PO 4	Apply the concepts (knowledge) of filters for harmonics in HVDC converters by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design.	2
	PO 6	Apply the concepts (knowledge) of filters for harmonics in HVDC converters by using Scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development.	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	4	1	3	-	-
CO 2	-	4	2	3	-	-
CO 3	-	4	2	1	-	-
CO 4	-	4	2	2	-	-
CO 5	1	3	2	2	-	3

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	57.14	14.28	75.0	-	-
CO 2	-	57.14	28.57	75.0	-	-
CO 3	-	57.14	28.57	25.0	-	-
CO 4	-	57.14	28.57	50.0	-	-
CO 5	25.0	42.86	28.57	50.0	-	60.0

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 - $5 < C \leq 40\%$ – Low/ Slight

2 - $40\ \% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	1	3	-	-
CO 2	-	2	1	3	-	-
CO 3	-	2	1	1	-	-
CO 4	-	2	1	2	-	-
CO 5	1	2	1	2	-	2
TOTAL	1	10	5	11	-	2
AVERAGE	0.2	2.0	1.0	2.2	-	0.4

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech-Talk	-	Certification	-
Term Paper	✓	Seminars	-	Student Viva	-
Laboratory Practice	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**GENERAL ASPECTS OF HVDC TRANSMISSION**
	Evolution of HVDC transmission, comparision of HVDC and HVAC systems, types of DC link, components of HVDC system, value characteristics, properties of converter circuits, assumptions, single phase and three phase converters, pulse number, choice of best circuit for HVDC converters.
MODULE II	**ANALYSIS OF BRIDGE CONVERTER**
	Analysis of simple rectifier circuit, required features of rectification circuits for HVDC transmission, Analysis of HVDC converter, different modes of converter operation, output voltage waveform and DC voltage in rectification, output voltage waveforms and DC in inverter operation, thyristor/ valve voltages, equivalent electrical circuit.

MODULE III	**HVDC CONTROL TECHNIQUES**
	Grid control, basic means of control, power reversal, limitations of manual control, constant current versus constant voltage, desired features of control, actual control characteristics. Constant minimum ignition angle control: Constant current control, constant extinction angle control, stability of control, tap changer control, power control and current limits, frequency control.
MODULE IV	**CONVERTER FAULTS AND PROTECTION**
	Converter mal-operations, commutation failure, starting and shutting down the converter bridge, converter protection.
MODULE V	**REACTIVE POWER MANAGMENT**
	Smoothing reactor and DC Lines, reactive power requirements, harmonic analysis, filter design, power flow analysis in AC, DC systems, modeling of DC links, solutions of AC, DC Power flow.

TEXTBOOKS

1. J Arrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1st Edition, 1983.
2. K R Padiyar, "HVDC Power Transmission Systems", Wiley Eastern Ltd., 1st Edition, 1990.

REFERENCE BOOKS:

1. E. W. Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, 1st Edition, 1971.
2. Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 1st Edition, 2004.
3. SN Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi, 2nd Edition, 2008.
4. 4. V Kamaraju, "HVDC Transmission" Tata McGraw-Hill Education Pvt Ltd, New Delhi, 2nd Edition, 2011.

WEB REFERENCES:

1. . https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education(OBE)		

CONTENT DELIVERY (THEORY)			
1	Introduction of DC power transmission technology	CO 1	T4:9.41, R1:3.1-3.2
2	Understand Economics of HVDC transmission	CO 1	T4:9.4.1, R1:3.1-3.2
3	Comparison of AC and DC Transmission	CO 1	T4:9.4.3, R1:3.3-3.5
4	Terminal equipment of HVDC	CO1	T4:9.2, R1:3.3-3.5
5	Application of DC transmission system	CO 1	T4:9.2, R1:3.3-3.5
6	Reliability of HVDC systems, limitation of HVDC transmission	CO 2	T4:9.2, R1:3.3-3.5
7	Modern trends in DC transmission	CO 3	T4:9.4, R1:4.1
8	Single phase and three phase converters	CO 2	T4:9.3-9.5, R1:4.2
9	Properties and characteristics of HVDC converter	CO 3	T4: 9.3-9.5, R1:4.3-4.4
10	Choice of converter configuration	CO 3	T4: 9.3-9.5, R1:4.3-4.4
11	Planning for HVDC transmission, modern trends in DC transmission.	CO 2	T4: 9.3-9.5, R1:4.3-4.4
12	Simplified analysis of Graetz circuit	CO 2	T4:9.1, R1:8.1
13	Features of rectification circuit for HVDC transmission	CO 2	T4:9.8, R1:8.2
14	Different modes of operation of converter	CO 2	T4:9.9.1, R1:9.2
15	Characteristics of a twelve-pulse converter	CO 4	T4:9.8, R1:9.2
16	Output voltage waveforms in rectification process	CO 4	T4:9.10, R1:9.2
17	Output voltage waveforms in inverter operation	CO 4	T4:9.10, R1:9.2

18	Introduction to grid control	CO 4	T4:9.11.2, R1:9.2
19	Limitations in manual control and development of control schemes	CO 4	T4:9.12, R1:9.2
20	Constant current vs constant voltage	CO 4	T4:9.4.12, R1:9.2
21	Desired features of converter	CO 3	T4:10.3, R1:6.1-6.3
22	Control schemes of HVDC converter	CO 5	T4:10.4, R1:6.4
23	Principle of DC Link Control	CO 4	T4:10.5, R1:6.4
24	Converter control characteristics	CO 5	T4:10.6, R1:6.3
25	Firing angle control	CO 5	T4:10.7, R1:6.3
26	Current and extinction angle control	CO 5	T4:10.7, R1:6.3
27	Effect of source inductance on the system	CO 4	T4:10.5, R1:6.3
28	Stability of control and tap changer control	CO 4	T4:10.13, R1:6.3
29	Power control, current limits and Frequency control	CO 4	T4:10.16, R1:6.1-6.3
30	Converter mal operations	CO 4	T4:10.17, R1:6.1-6.3
31	Reasons for commutation failure and its effects on equipment	CO 3	T4:13.1, R1:10.1
32	Starting and shutting down of converter bridge	CO 3	T4:13.2, R1:10.3
33	Protection against over current and over voltage in converter station	CO 4	T4:13.2, R1:6.4
34	Sources of reactive power	CO 5	T4:13.2, R1:10.3
35	AC Filters	CO 4	T4:13.3, R1:10.2
36	Modeling of DC Links	CO 5	T4:13.6, R1:10.5
37	DC Network-DC Converter-Controller Equations	CO 5	T4:13.7, R1:10.5
38	solution of DC load flow	CO 5	T4:13.6, R1:10.5
39	Solution of AC-DC power flow	CO 5	T4:13.7, R1:10.5

40	Simultaneous method.	CO 5	T4:13.7, R1:10.5
41	Discuss about Sequential method	CO5	T1: 7.1
42	Discuss about Converter faults	CO5	T3: 5.7
43	Discuss about Generation of harmonics.	CO4	T2: 5.7
44	Discuss about Characteristics harmonics, calculation of AC harmonics	CO4	T1: 9.1
45	Discuss about Non characteristics of Harmonics, adverse effects of harmonics.	CO4	T1: 6.2
46	General Aspects Of HVDC Transmission	CO1, CO2	T1: 2.1
47	Analysis of Bridge Converter	CO3	T1: 3.2
48	HVDC Control Techniques	CO4	T1: 4.2
49	Converter Faults And Protection	CO5	T1: 5.2
50	Reactive Power Management	CO5	T1: 6.2
51	Discuss about Sequential method	CO5	T1: 7.1
52	Discuss about Converter faults	CO5	T3: 5.7
53	Discuss about Generation of harmonics.	CO4	T2: 5.7
54	Discuss about Characteristics harmonics, calculation of AC harmonics	CO4	T1: 9.1
55	Discuss about Non characteristics of Harmonics, adverse effects of harmonics.	CO4	T1: 6.2
56	General Aspects Of HVDC Transmission	CO1, CO2	T1: 2.1
57	Analysis of Bridge Converter	CO3	T1: 3.2
58	HVDC Control Techniques	CO4	T1: 4.2
59	Converter Faults And Protection	CO5	T1: 5.2
60	Reactive Power Management	CO5	T1: 6.2
DISCUSSION OF QUESTION BANK			
61	General Aspects Of HVDC Transmission	CO1 CO2	-
62	Analysis of Bridge Converter	CO3	-
63	HVDC Control Techniques	CO4	-
64	Converter Faults And Protection	CO5	-
65	Reactive Power Management	CO5	-

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**Modern Power System Analysis**				
Course Code	BPSB01				
Program	M.Tech				
Semester	I				
Course Type	Professional Core				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr.M. Pala Prasad Reddy, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC34	VII	Power system Protection

II COURSE OVERVIEW:

Power system analysis deals formation impedance and admittance matrices for power system network, finding different electrical parameters for various buses in power system, study fault analysis and represent power system using per unit system, understand steady state and transient stability of power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Modern Power System Analysis	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. 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):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

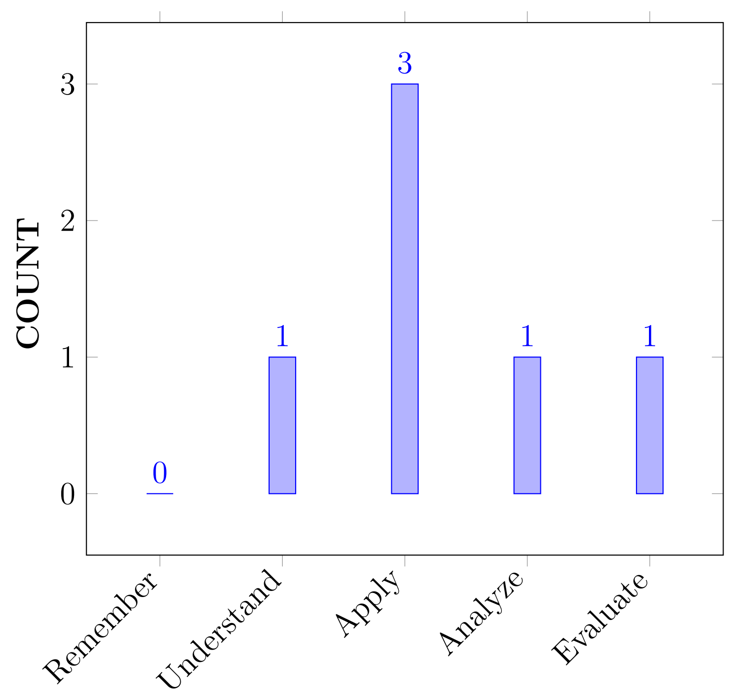
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Utilize** the representation of basic components and single line diagram of power system for understanding the restructuring of system	Apply
CO 2	**Examine** the optimal power flow solution using FACTS devices to solve power flow analysis problems using various methods.	Apply
CO 3	**Analyse** the new bus voltages contingency by adding/removal of lines for illustrating the various techniques for contingency evaluation and analysis.	Analyse
CO 4	**Evaluate** the operating states and security monitoring of power systems to describe its contingency analysis.	Evaluate
CO 5	**Understand** the importance of power flow analysis in planning and operation of power systems.	Understand
CO 6	**Apply** the various algorithms for state estimation to estimate different components and states of power systems.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



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VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	3	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	✓	✓	-	-
CO 2	✓	✓	-	✓	-	-
CO 3	✓	✓	-	-	-	✓
CO 4	✓	✓	-	-	-	-
CO 5	✓	✓	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 6	✓	✓	-	-	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 2	**Elucidate Term paper** on planning and power flow studies and semminer has been given .	3
	PO 3	**Make use of basics of basics power system analysis** .	7
	PO 4	Make use of basics of MATLAB for Y bus calculation .	4
CO 2	PO 1	textbfRecall the load flow analysis using GS-, NR for further research .	4
	PO 2	**Elucidate Term paper** on FACTS devices	4
	PO 4	**Illustrate** the use of PSCAD and MATLAB for power flow analysis.	3
	PO 5	**Demonstrate the graph theory** for Bus clculation .	2
CO 3	PO 1	Understand the behavior of current carrying conductor placed in magnetic field and the principle of induction effect with the help of basic fundamentals of mathematics science and engineering fundamentals.	1
	PO 2	Derive the expression for torque in wattmeter to solve complex engineering problems using basic mathematics and engineering principles.	4
	PO 6	**Determine fault calculation** for further reserch.	2
CO 4	PO 1	Explain the concept of Unsymmetrical fault.	1
	PO 2	**Elucidate Term paper** on fault calculation	4
CO 5	PO 1	Identify the different Contigency methods the working of cathode ray oscilloscope applying basic knowledge of science and engineering fundamentals.	2
	PO 2	**Elucidate Term paper** on contigency analysis for multiple lines	4
cline2-4 CO 6	PO 1	Identify the state estimation applying basic knowledge of science and engineering fundamentals.	2
	PO 2	textbf Elucidate Term paper on different algorithm for state estimation	4

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	3	7	4	-	-
CO 2	1	4	-	4	-	-
CO 3	1	4	-	-	-	2
CO 4	1	4	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 5	2	3	-	-	-	-
CO 6	2	4	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	43	100	100	-	-
CO 2	25	57	-	100	-	-
CO 3	25	57	-	-	-	50
CO 4	25	57	-	-	-	-
CO 5	50	43	-	-	-	-
CO 6	50	57	-	-	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	3	3	-	-
CO 2	1	2	-	3	-	-
CO 3	1	2	-	-	-	2
CO 4	1	2	-	-	-	-
CO 5	2	2	-	-	-	-
CO 6	2	2	-	-	-	-
TOTAL	7	12	3	6	-	2
AVERAGE	1.4	2	3	3	-	2

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVIII SYLLABUS:

MODULE I	**PLANNING AND OPERATIONAL STUDIES OF POWER SYSTEMS**
	Need for system planning and operational studies, basic components of a power system, introduction to restructuring, single line diagram, per phase and per UNIT analysis, generator, transformer, transmission line and load representation for different power system studies, primitive network, construction of Y-bus using inspection and singular transformation methods, Z-bus.
MODULE II	**POWER FLOW ANALYSIS**
	Importance of power flow analysis in planning and operation of power systems, statement of power flow problem, classification of buses, development of power flow model in complex variables form, iterative solution using Gauss-Seidel method, Q-limit check for voltage controlled buses, power flow model in polar form, iterative solution using Newton-Raphson method, decoupled and fast decoupled power flow solutions, DC power flow solution, power flow solution using FACTS devices, optimal power flow solution
MODULE III	**SHORTCIRCUITANALYSIS**
	Balanced faults: Importance of short circuit analysis, assumptions in fault analysis, analysis using Thevenins theorem, Z-bus building algorithm, fault analysis using Z-bus, computations of short circuit capacity, post fault voltage and currents. Unbalanced faults: Introduction to symmetrical components, sequence impedances, sequence circuits of synchronous machine, transformer and transmission lines, sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenins theorem and Z-bus matrix.
MODULE IV	**CONTINGENCY ANALYSIS**
	Contingency Evaluation: Operating states of a power system, concept of security monitoring, techniques for contingency evaluation, Importance of contingency analysis, addition / removal of one line, construction of a column of bus impedance matrix from the bus admittance matrix, calculation of new bus voltages due to addition / removal of one line, calculation of new bus voltages due to addition / removal of two lines .
MODULE V	**STATE ESTIMATION**
	Principles of transformer protection, digital protection of Transformer using FIR filter-based algorithm, least squares curve fitting based algorithms, Fourier-based algorithm, flux-restrained current differential relay; Digital Line differential protection: Current-based differential schemes, Composite voltage-and current- based scheme.

TEXTBOOKS

1. AG Phadke and J S Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 1st Edition, 2009.

2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1st Edition, 1999

REFERENCE BOOKS:

1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public Corporate Publishing, 1st Edition, 2006.
2. SRB hide "Digital Power System Protection" PHI Learning Pvt.Ltd. 3rd Edition, 2014

WEB REFERENCES:

1. . https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

XIX COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE)		
	CONTENT DELIVERY (THEORY)		
1	Introduction to graph theory.	CO 1	T4:9.41, R1:3.1-3.2
2	Solve numerical problems on graph theory.	CO 1	T4:9.4.1, R1:3.1-3.2
3	Building bus incidence matrix.	CO 1	T4:9.4.3, R1:3.3-3.5
4	Forming Y bus formation by direct method.	CO1	T4:9.2, R1:3.3-3.5
5	Forming Y bus formation by singular transformation. methods,	CO 1	T4:9.2, R1:3.3-3.5
6	Solve numerical problems on bus matrices.	CO 2	T4:9.2, R1:3.3-3.5
7	Formation of ZBUS: Partial network.	CO 3	T4:9.4, R1:4.1
8	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to reference.	CO 2	T4:9.3-9.5, R1:4.2
9	Algorithm for the Modification of Z Bus Matrix for addition element from a new bus to an old bus.	CO 3	T4: 9.3-9.5, R1:4.3-4.4

11	Algorithm for the Modification of Z Bus Matrix for addition element between an old bus to reference Addition of element between two old busses (Derivations and Numerical Problems without mutual coupling).	CO 2	T4: 9.3-9.5, R1:4.3-4.4
12	Study of necessity of power flow studies – Data for power flow studies – derivation of static load flow equations.	CO 2	T4:9.1, R1:8.1
13	Solution of load flow solutions using Gauss Seidel Method: Acceleration Factor.	CO 2	T4:9.8, R1:8.2
14	Load flow solution with and without P- V buses, Algorithm and Flowchart.	CO 2	T4:9.9.1, R1:9.2
15	Find numerical load flow solution for simple power systems (Max. 3- Buses): Determination of bus voltages, injected active and reactive powers (Sample One Iteration only).	CO 1	T4:9.8, R1:9.2
16	Per Unit System	CO 1	T4:9.8, R1:9.2
17	Problems on Per Unit System	CO 1	T4:9.8, R1:9.2
18	Importance of Power flow.	CO 2	T4:10.6, R1:6.3
19	classification of buses	CO2	T4:10.6, R1:6.3
20	IDevelopment of power flow model	CO 2	T4:10.6, R1:6.3
21	Iterative solution using G-S method	CO2	T5:10.6, R1:7.3
22	Problems on Iterative solution using G-S method	CO2	T5:10.6, R1:7.3
23	Q-limit check using G-S method	CO2	T5:10.6, R1:7.3
24	Discuss on newton raphson method in rectangular form: load flow, solution with or without PV busses- Derivation of jacobian elements.	CO 4	T4:9.10, R1:9.2
25	Discussion newton raphson method in polar co- ordinates form: load flow solution with or without pv busses-Derivation of jacobian elements.	CO 4	T4:9.11.2, R1:9.2
26	Study on decoupled and fast decoupled methods for load flow solution.	CO 4	T4:9.12, R1:9.2
27	Problem discussion on decoupled and fast decoupled methods for load flow solution.	CO 4	T4:9.12, R1:9.2
28	Comparison of Different Methods – DC load Flow.	CO 4	T4:9.4.12, R1:9.2
29	Short Circuit Analysis: Short Circuit Current and MVA Calculations.	CO 3	T4:10.3, R1:6.1-6.3
30	Solving numerical problems (Symmetrical fault Analysis).	CO 6	T4:10.4, R1:6.4
31	Understand symmetrical component transformation, positive, negative and zero sequence components.	CO 4	T4:10.5, R1:6.4

32	Draw sequence networks.	CO 5	T4:10.6, R1:6.3
33	Derive sequence voltages, currents and impedances.	CO 6	T4:10.7, R1:6.3
34	Solving numerical problems on symmetrical components.	CO 4	T4:10.5, R1:6.3
35	Understand LG fault with and without fault impedance and numerical problems.	CO 4	T4:10.13, R1:6.3
36	Study fault with and without fault impedance and numerical problems.	CO 4	T4:10.13, R1:6.1-6.3
37	Determine LLG fault with and without fault impedance and numerical problems.	CO 4	T4:10.16, R1:6.1-6.3
38	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 4	T4:10.17, R1:6.1-6.3
39	Contigency Evaluation.	CO 4	T4:10.17, R1:6.1-6.3
40	Introduction to steady state, dynamic and transient stabilities.	CO 3	T4:13.1, R1:10.1
41	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 3	T4:13.2, R1:10.3
42	Plot Power Angle Curve and determination of steady state,. stability.	CO 4	T4:13.2, R1:6.4
43	Explain methods to improve steady state stability.	CO 5	T4:13.2, R1:10.3
44	Derivation of swing equation.	CO 8	T4:13.3, R1:10.2
45	Determination of transient stability by equal area criterion.	CO 5	T4:13.6, R1:10.5
46	Application of equal area criterion to different cases.	CO 5	T4:13.7, R1:10.5
47	Discuss importance of FIR based method.	CO 5	T4:13.6, R1:10.5
48	Solving numerical problems on equal area criteria.	CO 5	T4:13.7, R1:10.5
49	Current based differential scheme.	CO 5	T4:13.7, R1:10.5
50	Composite voltage and Current based differential scheme.	CO 5	T4:13.7, R1:10.5
51	Discuss about Fourier-based algorithm	CO5	T1: 7.1
52	Discuss about flux-restrained current differential relay	CO5	T3: 5.7
43	Discuss about Digital Line differential protection	CO6	T2: 5.7
53	Discuss about Current-based differential schemes	CO6	T1: 9.1
54	Discuss about Composite voltage- and current- based scheme.	CO6	T1: 6.2

55	Mathematical Background To Digital Protection	CO1, CO2	T1: 2.1
56	Basic Elements Of Digital Protection of tranformer	CO3	T1: 3.2
57	FIR based Algorithms-I	CO4	T1: 4.2
58	Curve fitting algorithm	CO5	T1: 5.2
59	flux restrained current rely	CO6	T1: 6.2
60	flux restrained current rely	CO6	T1: 6.2
DISCUSSION OF QUESTION BANK			
61	Operational Studies of Power systems	CO1 CO2	-
62	Power flow analysis	CO1 CO2	-
63	Short Circuit Analysis	CO3, CO4	-
64	Contigency Analysis	CO5	-
65	State estimation	CO6	-

Signature of Course Coordinator **HOD,EEE**

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**Reactive Power Compensation and Management**				
Course Code	BPSB07				
Program	M.Tech				
Semester	I				
Course Type	Professional Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. P Shiva Kumar,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEE010	V	Power Electronics
B.Tech	AEE012	VI	Power System Analysis

II COURSE OVERVIEW:

The aim of this course is to enable the students to have an in-depth understanding of the applications, overall theory and essential issues relevant to daily operation and maintenance of reactive power management.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Reactive power compensation and management	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. 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):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

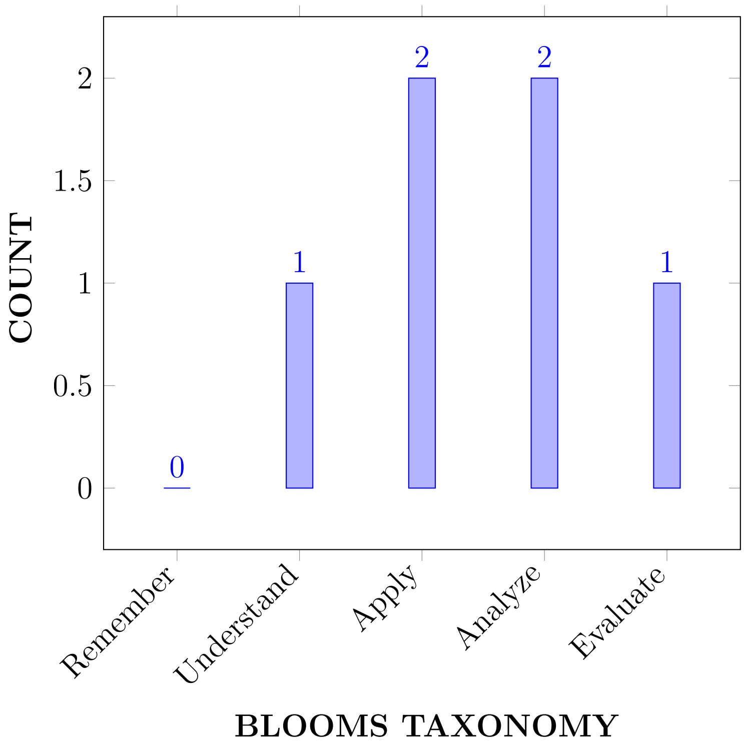
I	The concept of load compensation and necessity of reactive power compensation.
II	the various types of reactive power compensation in transmission systems.
III	The fundamentals of reactive power coordination system.
IV	The distribution side and utility side reactive power management.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Explain** the objectives and specifications of reactive compensation for designing the compensating equipment.	Understand
CO 2	**Analyze** the power factor correction and phase balancing techniques used in load compensation.	Analyze
CO 3	**Illustrate** the characteristics of an uncompensated line and a compensated line which are used for evaluating the performance of lines.	Apply
CO 4	**Select** the proper compensating equipment among passive and dynamic compensators to achieve the steady state and transient state reactive power compensation.	Apply
CO 5	**Examine** the mathematical modelling, operation planning and transmission benefits in reactive power coordination.	Analyze
CO 6	**Evaluate** the effects of under voltages, frequency, harmonics, radio frequency and electromagnetic interferences to give the quality power supply to the consumers.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	1	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	-
CO 4	-	-	✓	✓	-	-
CO 5	-	-	-	✓	-	-
CO 6	-	-	✓	✓	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 3	Understand the concept of industrial load and analyze and design innovative models to establish innovative solution.	3
	PO 4	Make use of industrial load management techniques in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation .	3
CO 2	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	3
	PO 4	Understand the concept of industrial load on modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective.	4
CO 3	PO 1	Demonstrate research areas to solve practical problems in power systems and build solutions	2
	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Contrast the design process to minimize transmission line losses and energy saving in industries in electrical power systems for Solution development or experimentation / Implementation in Interpretation of results and Validation	4
	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management and the design process.	3
CO 4	PO 3	Demonstrate energy consumption of industrial loads by understanding and analyzing and design innovative solutions and Apply the complex engineering problems and their system components by design for the development of solution.	3
	PO 4	Make use of captive power plants in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	4
CO 5	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management.	4

CO 6	PO 3	Demonstrate operating strategies of power capacitors for integrated load management forapplication and solution of the complex engineering problems for the development of solution.	3
	PO4	Make use of power capacitors in power systems using the concepts of engineering fundamentals to develop the solution of problems and establish innovative solutions.	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	3	3	-	-
CO 2	-	2	3	4	-	-
CO 3	2	2	4	3	-	-
CO 4	-	-	3	4	-	-
CO 5	-	-	-	4	-	-
CO 6	-	-	3	3	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	42.8	42.8	-	-
CO 2	-	28.57	42.8	57.1	-	-
CO 3	50	28.57	57.1	42.8	-	-
CO 4	-	-	42.8	57.1	-	-
CO 5	-	-	-	57.1	-	-
CO 6	-	-	42.8	42.8	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation
1 -5 $< C \leq 40\%$ – Low/ Slight
2 - 40 % $< C < 60\%$ –Moderate
3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	-
CO 2	-	1	2	2	-	-
CO 3	2	1	2	2	-	-
CO 4	-	-	2	2	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 5	-	-	-	2	-	-
CO 6	-	-	2	2	-	-
TOTAL	2	2	10	12	-	-
AVERAGE	2	1	2	2	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**LOAD COMPENSATION**
	Objectives and specification: Reactive power characteristics, inductive and capacitive approximate biasing, load compensator as a voltage regulator, phase balancing and power factor correction of unsymmetrical loads examples
MODULE II	**STEADYSTATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM**
	Uncompensated line: Types of compensation, passive shunt and series and dynamic shunt compensation, examples transient state reactive power compensation in transmission systems: Characteristic time periods, passive shunt compensation, static compensations, series capacitor compensation, compensation using synchronous condensers, examples.
MODULE III	**REACTIVE POWER COORDINATION**
	Objective, mathematical modeling, operation planning, transmission benefits, basic concepts of quality of power supply, disturbances steady, state variations. Effects of under voltages, frequency, harmonics, radio frequency and electromagnetic interferences.
MODULE IV	**DEMAND SIDE MANAGEMENT**
	Load patterns, basic methods load shaping, power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels; Distribution side reactive power management: System losses, loss reduction methods, examples, reactive power planning, objectives, economics planning capacitor placement, retrofitting of capacitor banks..

MODULE V	**USER SIDE REACTIVE POWER MANAGEMENT**
	Requirements for domestic appliances, purpose of using capacitors, selection of capacitors, deciding factors, types of available capacitor, characteristics and Limitations; Reactive power management in electric traction systems and are furnaces: Typical layout of traction systems, reactive power control requirements, distribution transformers, Electric arc furnaces, basic operations- furnaces transformer, filter requirements, remedial measures, power factor of an arc furnace.

TEXTBOOKS

1. TJE Miller, "Reactive power control in Electric power systems", Wiely Publication, 1St Edition, 1982
2. D M Tagare, "Reactive power Management", by Tata McGraw Hill, 1St Edition, 2004.

REFERENCE BOOKS:

1. 1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just "Reactive Power Compensation: A practical Guide", Wiely publication, 4th Edition, 2012.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Objectives and specification	CO 1	T2:1.1,1.2
2	inductive approximate biasing.	CO 1	T2:1.3,1.4
3	inductive approximate biasing.	CO 1	T2:1.3,1.4
4	inductive approximate biasing	CO 1	T2:1.5,1.6
5	Capacitive approximate biasing.	CO 1	T2:3.1
6	Capacitive approximate biasing.	CO 1	T2:3.1
7	Capacitive approximate biasing. load compensator as a voltage	CO 1	T1:4.3 T2:5.2
8	phase balancing, power factor correction of unsymmetrical loads examples	CO 2	T2:2.1
9	phase balancing, power factor correction of unsymmetrical loads examples	CO 3	T2:2.1.3
10	power factor correction of unsymmetrical loads examples Problems	CO 2	T1:9.3-9.5, R1:4.2
11	power factor correction of unsymmetrical loads examples Problems	CO 2	T1:9.3-9.5, R1:4.2
12	Introduction of reactive power compensation, Types of compensation.	CO 3	T2: 9.3-9.5

13	Introduction of reactive power compensation, Types of compensation.	CO 3	R1:4.3-4.4
14	passive shunt and series compensation	CO 2	T1: 9.3-9.5, R1:4.3-4.4
15	passive shunt and series compensation	CO 2	T1: 9.3-9.5, R1:4.3-4.4
16	passive shunt and series compensation	CO 2	T1: 9.3-9.5, R1:4.3-4.4
17	dynamic shunt compensation.	CO 2	T2:9.1, R1:8.1
18	dynamic shunt compensation.	CO 2	T2:9.1, R1:8.1
19	dynamic shunt compensation.	CO 2	T2:9.1, R1:8.1
20	examples of transient state reactive power compensation	CO 2	T2:9.8, R1:8.2
21	Characteristic time periods, Passive shunt compensation.	CO 2	T2:9.9.1, R1:9.2
22	Characteristic time periods, Passive shunt compensation.	CO 2	T2:9.9.1, R1:9.2
23	Characteristic time periods, Passive shunt compensation.	CO 2	T2:9.9.1, R1:9.2
24	static compensations, series capacitor compensation	CO 4	T2:9.8, R1:9.2
25	static compensations, series capacitor compensation	CO 4	T2:9.8, R1:9.2
26	Compensation using synchronous condensers, Examples	CO 4	T2:9.10
27	Compensation using synchronous condensers, Examples	CO 4	T2:9.10
28	Introduction of reactive power coordination	CO 4	T1:9.10
29	Introduction of reactive power coordination	CO 4	T1:9.10
30	Objective of reactive power coordination	CO 4	T1:9.11.2
31	Objective of reactive power coordination	CO 4	T1:9.11.2
32	mathematical modeling	CO 4	T1:9.12
33	operation planning ,transmission benefits	CO 4	T1:9.4.12, R1:9.2
34	operation planning ,transmission benefits	CO 4	T1:9.4.12, R1:9.2
35	basic concepts of quality of power supply.	CO 3	T2:10.3, R1:6.1-6.3
36	disturbances steady, Effects of under voltages	CO 6	T2:10.4, R1:6.4

37	disturbances steady, Effects of under voltages	CO 6	T2:10.4, R1:6.4
38	frequency, harmonics	CO 4	T1:10.5, R1:6.4
39	Introduction of demand side management, Load patterns	CO 5	T1:10.6, R1:6.3
40	basic methods load shaping, power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels;	CO 6	T1:10.7, R1:6.3
41	basic methods load shaping, power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels;	CO 6	T1:10.7, R1:6.3
42	System losses, loss reduction methods	CO 4	T1:10.5, R1:6.3
43	examples, reactive power planning	CO 4	T2:10.13, R1:6.3
44	objectives, economics planning capacitor placement	CO 4	T2:10.13, R1:6.3
45	retrofitting of capacitor banks.	CO 4	T1:10.13, R1:6.3
46	retrofitting of capacitor banks.	CO 4	T1:10.13, R1:6.3
47	Requirements for domestic appliances	CO 4	T1:10.13
48	purpose of using capacitors, selection of capacitors	CO 5	R1:6.3
49	deciding factors, types of available capacitor, characteristics and Limitations	CO 5	T2:13.7
50	deciding factors, types of available capacitor, characteristics and Limitations	CO 4	T2:13.7
51	Reactive power management in electric traction systems and are furnaces	CO 5	T1:13.6, R1:10.5
52	Reactive power management in electric traction systems and are furnaces	CO 5	T1:13.6, R1:10.5
53	Typical layout of traction systems, reactive power control requirements	CO 6	T1:13.6
54	distribution transformers	CO 6	T2:13.7
55	Electric arc furnaces, basic operations- furnaces .	CO 6	R1:11.5
56	filter requirements	CO 6	T1:13.7
57	filter requirements.	CO 6	T1:13.7
58	remedial measures	CO 6	T1:13.7
59	power factor of an arc furnace.	CO 6	T2:13.7
60	problems	CO 6	T2:13.7

DISCUSSION OF QUESTION BANK			
1	Load compensation	CO1	-
2	Steady state reactive power compensation	CO2,CO3	-
3	Reactive power coordination	CO4	-
4	Demand side management.	CO5	-
5	User side reactive power management	CO6	-

Signature of Course Coordinator **HOD,EEE**
Mr.P Shiva Kumar,Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	INTERNET OF THINGS LABORATORY				
Course Code	BPSB10				
Program	M.Tech				
Semester	I	EEE			
Course Type	Laboratory				
Regulation	IARE - PG18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Dr. P Sridhar, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECC05	VI	Microcontrollers and Digital Signal Processing Laboratory

II COURSE OVERVIEW:

The main objective of the course is to provide knowledge on internet of things and how important it is in present scenario. IoT is a connecting bridge between physical world and cyber world and Machine to Machine communication i.e. with automation as one subset. IoT refers to uniquely identifiable objects and their virtual representations in an Internet like structure. Measurement of various electrical quantities and functioning of induction motor in the case of over voltage, current is using arduino. Design a relay to protect the home appliances from over currents, under voltages and over voltages.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Internet of Things Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

x	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		**Total Marks**
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

I	Understand the IoT using Arduino programming
II	Explain the interfacing of data, I/O devices with Arduino UNO
III	Describe the digital protection schemes in power system relays.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**List** the different IOT applications and importance of IOT in present scenario	Remember
CO 2	**List** the application of Arduino forNode MCU	Remember
CO 3	**Know** the different sensors available to measure the current and voltage	Remember
CO 4	**Design** the digital voltmeter and ammeter for both AC and DC circuits	Analyse
CO 5	**Design** a digital frequency meter to measure the frequency in an AC circuit.	Analyse
CO 6	**Measure** the power and energy consumption in a home using Arduino	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document.	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	4	-	-	-	-
CO 2	3	-	2	-	-	-
CO 3	2	-	4	-	-	-
CO 4	3	-	1	-	-	-
CO 5	3	4	-	-	-	-
CO 6	3	-	1	-	-	-

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIII SYLLABUS:

WEEK I	**DESIGN OF DIGITAL DC VOLTMETER AND AMMETER**
	Design a Digital DC Voltmeter and Ammeter to measure the voltage and current in DC electrical circuits using Arduino and display the values in LCD display
WEEK II	**DESIGN OF DIGITAL AC VOLTMETER AND AMMETER.**
	Design a Digital AC Voltmeter and Ammeter to measure the voltage and current in AC electrical circuits using Arduino and display the values in LCD display.
WEEK III	**DIRECTION CONTROL OF THREE PHASE INDUCTION MOTOR**
	Design a system to control the direction of three phase induction motor through IOT
WEEK IV	**MEASUREMENT OF POWER AND ENERGY**
	Design a Digital frequency meter to measure the frequency in any AC electrical circuit using Arduino and display the values in LCD display
WEEK V	**DESIGN OF DIGITAL FREQUENCY METER**
	Measure the power and energy in electrical circuit using Arduino and display the values in LCD display
WEEK VI	**MEASUREMENT OF PHASE SHIFT AND POWER FACTOR**
	Measure the phase shift and power factor in an electrical circuit for different loads using Arduino and display the value in LCD display
WEEK VII	**IMPLEMENTATION OF OVER CURRENT RELAY**
	Design an over current relay for distribution system and displaying the tripping status of the relay in substation through IOT
WEEK VIII	**OVER UNDER VOLTAGE PROTECTION OF HOME APPLIANCES**
	Design a system to protect home appliances from over and under voltages using Arduino.
WEEK IX	**PROTECTION OF THREE PHASE INDUCTION MOTOR**
	Design a system for protecting the three phase induction motor from over voltages, over currents, temperature and displaying the status of the motor at remote location using IOT.
WEEK X	**TRAFFIC SIGNAL CONTROL**
	Design a traffic control system using IOT
WEEK XI	**RAILWAY GATE CONTROL BY STEPPER MOTORS**
	Design a railway gate control using stepper motor using IOT
WEEK XII	**DIRECTION AND SPEED CONTROL OF DC MOTOR**
	Control the speed and direction of a DC motor using Arduino and display the status of the motor at the remote location using IOT.

TEXTBOOKS

1. Samuel Greengard, K B Kanchandhani, “The Internet of Things”, Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.

2. Cuno Pfister, "Getting started with Internet of Things", Khanna Publishers, 5th Edition, 2012. Edition, Engineering Education Systems (2000).

REFERENCE BOOKS:

1. Vedam Subramanyam, "Learning Internet of Things", New Age International Limited, 2nd Edition, 2006.
2. Klaus Schwab, "The Fourth Industrial Revolution", New Age International Limited, 2nd Edition, 2008.

XIV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Design of digital DC voltmeter and ammeter	CO 1	T1:3.1
2	Design of digital AC voltmeter and ammeter	CO 2	T1:3.11
3	The direction control of three phase induction motor	CO 3	T1:4.8
4	Design of digital frequency meter	CO 2	T1:4.8
5	Measurement of power and energy	CO 3	T1.5.5
6	Measurement of phase shift and power factor	CO 4	T1:5.6
7	Implementation of over current relay	CO 4	T1:8.3
8	Over under voltage protection of home appliances.	CO 5	T1:8.3
9	Protection of three phase induction motor	CO 3	T1:9.2
10	Traffic signal control	CO 5	T1:9.3
11	Railway gate control by stepper motors	CO 3	T1:10.6
12	Direction and speed control of dc motor	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Determine the over current relay for distribution system
2	Determine the direction of a DC motor.
3	Determine the direction of three phase induction motor
4	Determine the traffic control system.
5	Determine the phase shift and power factor

Signature of Course Coordinator **HOD, EEE**
Dr. P Sridhar, Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

<table>
<tr><td>Course Title</td><td colspan="5">POWER SYSTEM COMPUTATIONALLABORATORY</td></tr>
<tr><td>Course Code</td><td colspan="5">BPSB09</td></tr>
<tr><td>Program</td><td colspan="5">M.Tech</td></tr>
<tr><td>Semester</td><td>I</td><td colspan="4">EEE</td></tr>
<tr><td>Course Type</td><td>Core</td><td colspan="4"></td></tr>
<tr><td>Regulation</td><td>IARE - PG18</td><td colspan="4"></td></tr>
<tr><td rowspan="3">Course Structure</td><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Lecture</td><td>Tutorials</td><td>Credits</td><td>Laboratory</td><td>Credits</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>4</td><td>2</td></tr>
<tr><td>Course Coordinator</td><td colspan="5">Mr. P. Shivakumar, Assistant Professor</td></tr>
</table>

I COURSE OVERVIEW:

The objective of power system computational laboratory is to analyze electrical power system in steady state and transient state. In steady state the power system parameters are obtained by different load flow methods. In transient state the system stability is analyzed. Also, the formation of Ybus and Zbus is explained. In addition to this, the other methods of power system analysis mentioned here are unit commitment and state estimation. The simulation tool adopted is MATLAB.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB09	III	Electronic Devices and Circuits Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Computational laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	Viva	-

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

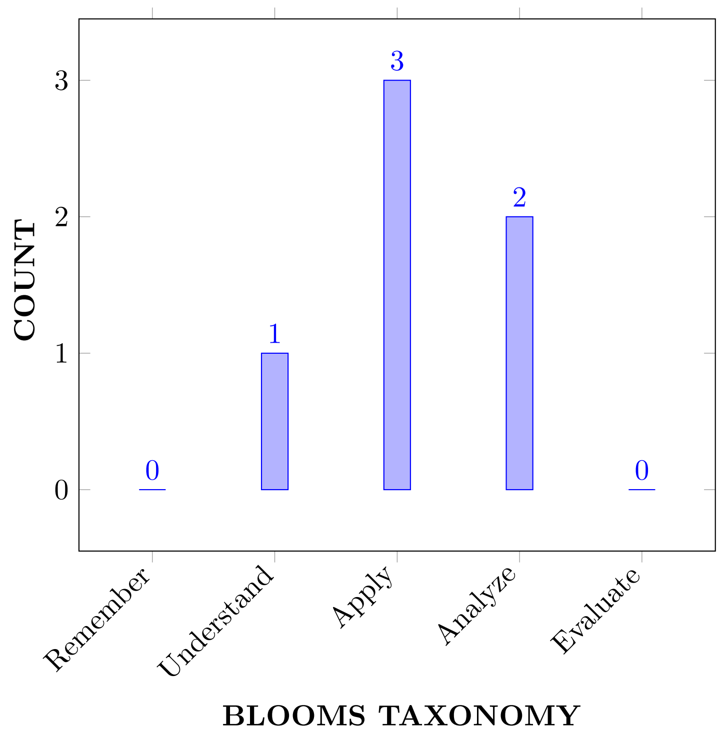
I	Construct Y bus, Z bus for a n bus system and analyze various load flow studies.
II	Understand the steady state, transient stability analysis and economic load dispatch problem.
III	State estimation of power system and unit commitment problem.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Understand** the concept of Admittance matrix for the formulation of various inspection and transformation methods.	Understand
CO 2	**Develop** the programming for load flow algorithms.	Apply
CO 3	**Analyze** the characteristics of fast decoupled loaf flow methods for developing algorithm.	Analyze
CO 4	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Apply
CO 5	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Analyze
CO 6	**Analyze** the various iterative methods applicable for state estimation of the power system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document..	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	Lab Exercises
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment..	2	Lab Exercises
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	3	2	2

CO 2	3	3	3	-	2	-
CO 3	3	3	3	-	2	2
CO 4	-	-	3	3	-	-
CO 5	3	-	-	-	2	2
CO 6	-	3	-	3	2	2

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-
Assignments	-				

XII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIII SYLLABUS:

WEEK I	**FORMATION OF BUS ADMITTANCE MATRIX**
	Develop program for Ybusformation by direct inspection method..
WEEK II	**SINGULAR TRANSFORMATION**
	Develop program for Ybus formation by singular transformation method.
WEEK III	**GAUSS - SEIDAL LOAD FLOW METHOD**
	Develop program for G-S load flow algorithm.
WEEK IV	**NEWTON - RAPHSON LOAD FLOW METHOD**
	Develop program for N-R load flow algorithm in polar coordinates.
WEEK V	**FAST DECOUPLED LOAD FLOW METHOD**
	Develop program for FDLF algorithm
WEEK VI	**DC LOAD FLOW**
	Develop program for DC load flow algorithm.
WEEK VII	**BUILDING ALGORITHM**
	Develop Program for ZBUS building algorithm.
WEEK VIII	**SHORT CIRCUIT ANALYSIS**
	Develop program for short circuit analysis using ZBUS algorithm.
WEEK IX	**TRANSIENT STABILITY**
	Develop program for transient stability analysis for single machine connected to infinite bus.

WEEK X	**LOAD DISPATCH PROBLEM**
	Develop program for economic load dispatch problem using lambda iterative method.
WEEK XI	**DYNAMIC PROGRAMMING METHOD**
	Develop program for unit commitment problem using forward dynamic programming method.
WEEK XII	**STATE ESTIMATION**
	Develop program for state estimation of power system.

TEXTBOOKS

1. 1. DP Kothari, B S Umre, "Lab manual for Electrical Machines", IK International Publishing House Pvt. Ltd, 1st Edition, 1996.

REFERENCE BOOKS:

1. MariesaLCrow, "Computational Methods for Electric Power Systems (Electric Power Engineering Series)", CRC Press Publishers, 1st Edition, 1992.

XIV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Develop program for Y-busformation by direct inspection method.	CO 1	T1:3.1
2	Develop program for Y-bus formation by singular transformation method.	CO 2	T1:3.11
3	Develop program for G-S load flow algorithm.	CO 3	T1:4.8
4	Develop program for N-R load flow algorithm in polar coordinates.	CO 2	T1:4.8
5	Develop program for FDLF algorithm.	CO 3	T1.5.5
6	Develop program for DC load flow algorithm.	CO 4	T1:5.6
7	Develop Program for Z-BUS building algorithm.	CO 4	T1:8.3
8	Develop program for short circuit analysis using ZBUS algorithm.	CO 5	T1:8.3
9	Develop program for transient stability analysis for single machine connected to infinite bus.	CO 3	T1:9.2
10	Develop program for economic load dispatch problem using lambda iterative method.	CO 5	T1:9.3
11	Develop program for unit commitment problem using forward dynamic programming method.	CO 3	T1:10.6
12	Develop program for state estimation of power system.	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Develop program for Gaauss saidel load flow algorithm.
2	Develop program for Y-bus formation by singular transformation method
3	Develop program for short circuit analysis using Z-BUS algorithm.
4	Develop program for economic load dispatch problem using lambda iterative method
5	Develop program for state estimation of power system.

Signature of Course Coordinator **HOD,EEE**
Mr. P Shiva Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**Electrical and Electronics Engineering**				
Course Title	**Digital Protection of Power System**				
Course Code	BPSB11				
Program	M.Tech				
Semester	II				
Course Type	Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.P. Shiva kumar , Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC34	VII	Power system Protection

II COURSE OVERVIEW:

This course will provide the mathematical background of digital protection and understanding the importance of Digital Relays. It will also develop various protection algorithms. It will also cover the application of digital protection.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Digital Protection of Power System	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. 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):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

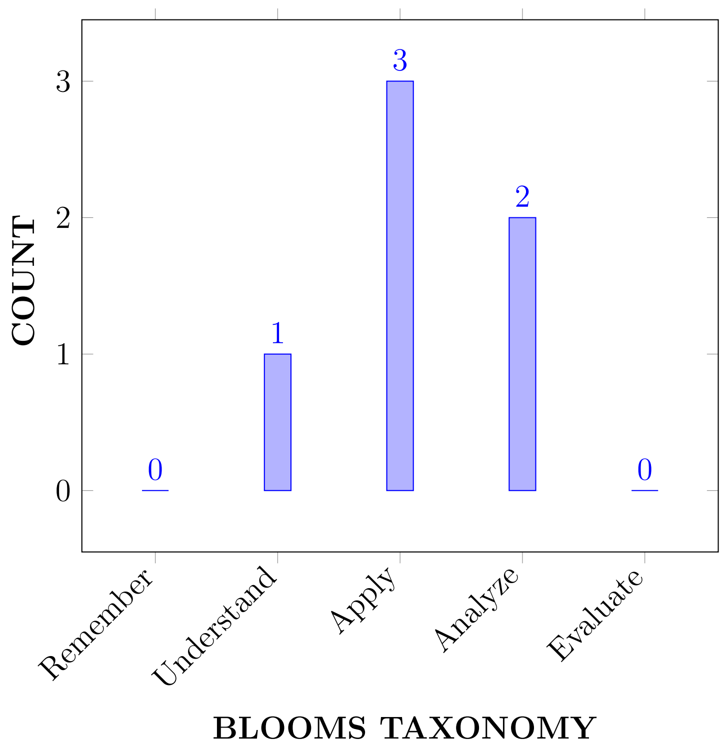
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the significance of protection systems and elements involved in protection of the power system.	Understand
CO 2	**Develop** the structures, mathematical models and formulae of digital relays for mathematical analysis of the system.	Apply
CO 3	**Identify** the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.	Apply
CO 4	**Develop** the mathematical models for analysis of the relying algorithms to address the various types of faults in the power system.	Apply
CO 5	**Categorize** the digital relying algorithms to minimize the transient deviations and steady state error to zero	Analyze
CO 6	**Analyze** the various algorithms applicable for protection of Transformers and transmission lines.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

	Program Outcomes
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	2	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	1	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	1	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	-
CO 2	✓	✓	✓	-	-	-
CO 3	✓	✓	-	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	✓	✓	-	-	-	-
CO 5	✓	✓	-	✓	-	✓
CO 6	✓	✓	-	✓	-	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Power semi conductor devices are described (Knowledge) through **mathematically** sound and **physics-based models** and circuits made with these devices, capacitor and inductor are analyzed by the **application of first order differential equations**.	3
	PO 2	Understand the given **problem** and **choose** appropriate devices to achieve **desired output** based on performance characteristics of devices.	3
CO 2	PO 2	**Identify** the suitable commutation technique, protection and the isolation techniques of thyristors and understand their operation by applying the **principles of mathematics science and engineering fundamentals**. Principles of **energy efficiency** and **heat transfer** are also addressed.	3
	PO 3	Understand problems associated with SCRs during turn on/off and apply this knowledge in design and analysis of protection circuits and commutation circuits by using **first principles of mathematics and engineering sciences**.	3
	PO 4	**Recognize** the need for and having the preparation and ability to engage in independent and life-long learning in the context of energy conversion systems.	2
CO 3	PO 2	AC-DC converters comprises of semiconductor devices, resistors, capacitors and inductors. The principle of operation and characteristics of such devices are explained by **applying engineering fundamentals including device physics** and deduce the expressions using **mathematical principles**.	3
	PO 4	Design (formulate) ac-dc converter for power electronics systems to meet given objectives (problem statement & formulation) under realistic constraints. Designs are tested (validation) through numerical simulation or hardware implementation (experimental design), and modifications are implemented as needed (interpretation of results) using **first principles of mathematics and engineering sciences**.	
CO 4	PO 1	Identify (Knowledge) suitable switching techniques and control strategies to operate DC-DC converters with the **Knowledge of mathematics, science and engineering fundamentals related to electrical engineering**.	3

	PO 2	Design (formulate) dc-dc converter for power electronics systems to meet given objectives (problem statement & formulation). Designs are tested (validation) through numerical simulation or hardware implementation (experimental design), and modifications are implemented as needed (interpretation of results) **using first principles of science and mathematics**	6
	PO 4	**Identify the Various switching techniques** to apply the different control stratagies and understand the corresponding **context of engineering knowledge related** to the performance indicators and measures in the switched mode regulators	6
CO 5	PO 2	Analyze AC voltage controller circuits using **fundamentals of engineering and science** including the application of **first order differential equations** in the roles of capacitance and inductance in power electronics circuits.	3
	PO 5	Identify the problems associated with conversion of fixed AC supply into variable output and apply suitable control to achieve desired output. The developed models and control strategies are validated through numerical simulation or hardware implementation and modifications are implemented as needed (interpretation of results) **using first principles of science and mathematics**	5
CO 6	PO 2	Explain the concepts and working principle involved in inverter circuits with **the knowledge of mathematics, science and engineering fundamentals related basic electrical and electronics**.	3
	PO 5	Select a suitable switching technique for inverter to obtain **desired** output voltage. The techniques and corresponding models are **validated** through numerical simulation or hardware implementation and results are **interpreted using first principles of mathematics and engineering fundamentals**.	5
	PO 6	The **design** of inverter systems includes interfacing with alternate energy sources and improvement of **energy efficiency**, both of which are tied into the **global, economic, environmental and societal context**.	4

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	-	-	-
CO 2	4	4	2	-	-	-
CO 3	4	3	-	-	-	-
CO 4	3	6	-	2	-	-
CO 5	2	2	-	2		-
CO 6	1	2	-	4	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	75	56	-	-	-	-
CO 2	75	56	56	-	-	-
CO 3	75	56	-	-	-	-
CO 4	75	56	-		-	-
CO 5	75	56	-	28	-	20
CO 6	75	56	-	28	-	20

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -$5 < C \leq 40\%$ – Low/ Slight

2 - $40\% < C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	-	-	-	-
CO 2	3	2	2	-	-	-
CO 3	3	2	-	-	-	-
CO 4	3	2	-	1	-	-
CO 5	3	2	-	1	-	-
CO 6	3	2	-	1	-	1
TOTAL	18	12	2	3	-	1
AVERAGE	3	2	1	1	-	1

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**MATHEMATICAL BACKGROUND TO DIGITAL PROTECTION**
	Overview of static relays, transmission line protection, transformer protection, need for digital protection; performance and operational characteristics of digital protection, basic structure of digital relays, finite difference techniques, interpolation formulas, numerical differentiation, curve fitting and smoothing, Fourier analysis, Walsh function analysis, relationship between Fourier and Walsh coefficients
MODULE II	**BASIC ELEMENTS OF DIGITAL PROTECTION**
	Basic components of a digital relay, signal conditioning subsystems, conversion subsystem, digital relay subsystem, the digital relay as a unit
MODULE III	**DIGITAL RELAYING ALGORITHMS-I**
	Sinusoidal wave-based algorithms: Sample and first derivative methods, first and second derivative methods, two sample technique, three sample technique, an early relaying scheme. Fourier analysisbased algorithms: Full cycle window algorithm, fractional-cycle window algorithms, Fouriertransform based algorithm. Walsh-function-based algorithms. Unbalanced faults: Introduction to symmetrical components, sequence impedances, sequence circuits of synchronous machine, transformer and transmission lines, sequence networks analysis of single line to ground, line to line and double line to ground faults using Thevenin's theorem and Z-bus matrix.
MODULE IV	**DIGITAL RELAYING ALGORITHMS-II**
	Least squares based methods: Integral LSQ fit, power series LSQ fit, multi-variable series LSQ technique, determination of measured impedance estimates; differential equation based techniques: representation of transmission lines with capacitance neglected, differential equation protection with selected limits, simultaneous differential equation techniques; travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's-equation based protection scheme, ultra-high-speed polarity comparison scheme, ultra-high-speed wave differential scheme, discrimination function based scheme, superimposed component trajectory based scheme.

MODULE V	**DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES**
	Principles of transformer protection, digital protection of Transformer using FIR filter-based algorithm, least squares curve fitting based algorithms, Fourier-based algorithm, flux-restrained current differential relay; Digital Line differential protection: Current-based differential schemes, Composite voltage- and current- based scheme.

TEXTBOOKS

1. AG Phadke and J S Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 1st Edition, 2009.
2. AT Johns and S K Salman, "Digital Protection of Power Systems", IEEE Press, 1st Edition, 1999

REFERENCE BOOKS:

1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Public Corporate Publishing, 1st Edition, 2006.
2. SRB hide "Digital Power System Protection" PHI Learning Pvt.Ltd. 3rd Edition, 2014

WEB REFERENCES:

1. . https://www.sciencedireect.com
2. https://www.spinger.com
3. https://www.ieeexplore.ieee.org/Xplore/home.jsp

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Overview of static relays, transmission line protection	CO1	T1: 1.1
2	Basic Concept of transformer protection	CO1	T1: 1.2
3	Need for digital protection; performance and operational characteristics of digital protection,	CO1	T2: 1.1.1
4	basic structure of digital relay	CO1	T2: 1.3.1
5	finite difference techniques, interpolation formulas, numerical differentiation,	CO1	T2: 1.3.3
6	Discuss the Concept of curve fitting and smoothing	CO1	T1: 1.3.2
7	Discuss the Concept of curve fitting and smoothing	CO1	T1: 1.3.2
8	Discuss about Fourier Analysis	CO2	T2: 1.3.8
9	Walsh function analysis, relationship between Fourier and Walsh coefficients	CO2	T1: 2.1
10	Walsh function analysis, relationship between Fourier and Walsh coefficients	CO2	T1: 2.1

11	Basic components of a digital relay	CO3	T3: 5.2
12	Discuss about signal conditioning subsystems	CO3	T1: 5.7
13	Discuss about conversion subsystem	CO3	T3: 5.7
14	Discuss about digital relay subsystem	CO3	T2: 5.7
15	Discuss about the digital relay as a module	CO3	T3: 5.7
16	Discuss about Sinusoidal wave-based algorithms	CO4	T1: 9.1
17	Discuss about Sample and first derivative methods,	CO4	T1: 9.1
18	Discuss about first and second derivative methods	CO4	T1: 9.1
19	Discuss about two sample technique, three sample technique, an early relaying scheme.	CO4	T1: 9.1
20	Discuss about Fourier analysis-based algorithms	CO4	T1: 9.1
21	Discuss about Full cycle window algorithm	CO4	T1: 6.2
22	Discus about fractional-cycle window algorithms	CO4	T1: 7.1
23	Discus about Fourier- transform based algorithm	CO4	T3: 5.7
24	Discus about Walsh-function-based algorithms.	CO4	T2: 5.7
25	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7
26	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7
27	Discuss about determination of measured impedance estimates and differential equation-based techniques	CO5	T1: 2.2
28	Discuss about representation of transmission lines with capacitance neglected	CO5	T1: 2.3
29	Discuss about differential equation protection with selected limits, simultaneous differential equation techniques	CO5	T1: 5.7
30	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
31	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
32	Discuss about Ultra-high-speed wave differential scheme	CO5	T1: 5.7
33	Discuss about discrimination function-based scheme	CO6	T1: 2.2
34	Discuss about Sample and first derivative methods,	CO4	T1: 9.1
35	Discuss about first and second derivative methods	CO4	T1: 9.1
36	Discuss about two sample technique, three sample technique, an early relaying scheme.	CO4	T1: 9.1
37	Discuss about Fourier analysis-based algorithms	CO4	T1: 9.1
38	Discuss about Full cycle window algorithm	CO4	T1: 6.2
39	Discus about fractional-cycle window algorithms	CO4	T1: 7.1
40	Discus about Fourier- transform based algorithm	CO4	T3: 5.7
41	Discus about Walsh-function-based algorithms.	CO4	T2: 5.7
42	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7

43	Least Squares Based Methods: Integral LSQ fit, power series lsq fit, multi-variable series lsq technique	CO5	T1: 5.7
44	Discuss about determination of measured impedance estimates and differential equation-based techniques	CO5	T1: 2.2
45	Discuss about representation of transmission lines with capacitance neglected	CO5	T1: 2.3
46	Discuss about differential equation protection with selected limits, simultaneous differential equation techniques	CO5	T1: 5.7
47	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
48	travelling-wave based protection: fundamentals of travelling-wave based protection, Bergeron's- equation based protection Scheme, Ultra-high-speed polarity Comparison scheme,	CO5	T2: 2.1
49	Discuss about Ultra-high-speed wave differential scheme	CO5	T1: 5.7
50	Discuss about discrimination function-based scheme	CO6	T1: 2.2
51	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
52	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
53	Discuss about Principles of transformer protection	CO6	T1: 2.3
54	Discuss about Principles of transformer protection	CO6	T1: 2.3
55	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
56	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
57	Discuss about Principles of transformer protection	CO6	T1: 2.3
58	Discuss about Principles of transformer protection	CO6	T1: 2.3
59	Discuss about digital protection of Transformer using FIR filter-based algorithm	CO6	T1: 9.1
60	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
DISCUSSION OF QUESTION BANK			
1	Mathematical Background To Digital Protection	CO1 CO2	-
2	Basic Elements Of Digital Protection	CO3	-
3	Digital Relaying Algorithms-I	CO4	-
4	Digital Relaying Algorithms-II	CO5	-
5	Digital Protection Of Transformers And Transmission Lines	CO6	-

Signature of Course Coordinator **HOD,EEE**
Mr.P. Shiva kumar , Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**AI Techniques in Power System**				
Course Code	BPSB16				
Program	M.Tech				
Semester	II				
Course Type	Professional Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. T Ravi Babu,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB59	VII	Artificial Neural Networks

II COURSE OVERVIEW:

The modern power system operates close to the limits due to the ever increasing energy consumption and the extension of currently existing electrical transmission networks and lines.Sophisticated computer tools are now the primary tools in solving the difficult problems that arise in the areas of power system planning, operation, diagnosis and design. Among these computer tools, Artificial Intelligence has grown predominantly in recent years and has been applied to various areas of power systems.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Industrial Load Modelling and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. 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):

For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

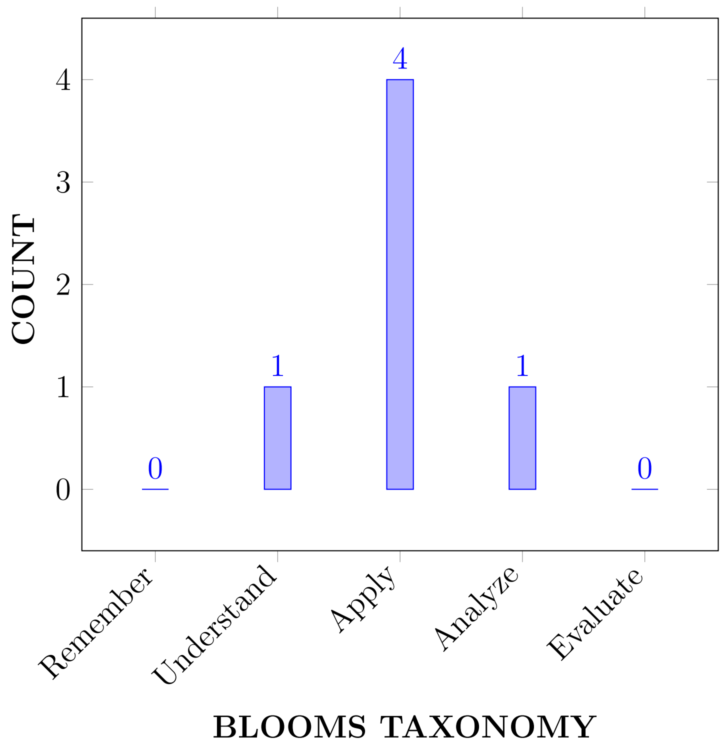
I	The basic knowledge regarding activation function, learning rules and various neural networks.
II	The conceptual knowledge of crisp set, fuzzy set and fuzzy logic controllers.
III	The application of genetic algorithms in the tuning of controllers.
IV	The fundamentals of controllers using simulation software fuzzy logic toolbox and NN toolbox.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** the concepts of biological foundation of artificial neural network . in modern power system analysis.	Apply
CO 2	**Demonstrate** the associative models and control schemes in neural network.	Understand
CO 3	**Identify** the structure of fuzzy logic controllers to apply in real time applications.	Apply
CO 4	**Acquire** the knowledge of genetic algorithm operator, mutation etc., for analyzing advanced power system.	Analyze
CO 5	**Develop** applications of AI techniques in electrical engineering, to carry out the research in the emerging areas in power system.	Apply
CO 6	**Develop** applications of AI techniques in electrical engineering, to carry out the research in the emerging areas in power electronic systems and controller design.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.

Program Outcomes	
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	1	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	✓	✓	-	-
CO 2	-	✓	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	-
CO 4	-	-	✓	✓	-	-
CO 5	-	-	-	✓	-	-
CO 6	-	-	✓	✓	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 3	UUnderstand the concept of biological, artificial neural networks and analyze and design innovative models to establish innovative solution.	3

	PO 4	Make use of feed forward neural networks, feedback neural networks and learning techniques using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	3
CO 2	PO 2	Illustrate the conceptual knowledge of Auto and hetero associative memory models for real time power system applications and with effective communication skills.	2
	PO 3	Demonstrate Hopfield network models and forward, inverse model by analyzing and design innovative solutions and apply the complex engineering problems.	3
	PO 4	Understand the concept of different models modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective.	4
CO 3	PO 1	Demonstrate research/investigation to solve practical problems in power systems and build solutions	2
	PO 2	Illustrate the conceptual knowledge of fuzziness involved in various systems and fuzzy set theory for application in electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Contrast the design process of fuzzy logic controller for solution development or experimentation / implementation in interpretation of results and validation	4
	PO 4	Understand the concept of different models modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective	3
CO 4	PO 3	Demonstrate the working of genetic algorithm, genetic operations and genetic mutations and Apply the complex engineering problems and their system components by design for the development of solution.	3
	PO 4	Make use of genetic algorithm and genetic algorithm operators and the real coded genetic algorithms engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	4
CO 5	PO 4	Understand the concepts of neural network for applications in electrical engineering and their effect on power system for real time and design process and evaluate out-comes and interpreting of results and Validation	4
CO 6	PO 3	Demonstrate the applications of neural network for applications in electrical engineering and apply the complex engineering problems and their system components by design for the development of solution.	3

	PO4	Make use of fuzzy logic control in power systems and genetic algorithm using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation.	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	3	3	-	-
CO 2	-	2	3	4	-	-
CO 3	2	2	4	3	-	-
CO 4	-	-	3	4	-	-
CO 5	-	-	-	4	-	-
CO 6	-	-	3	3	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	42.8	42.8	-	-
CO 2	-	28.57	42.8	57.1	-	-
CO 3	50	28.57	57.1	42.8	-	-
CO 4	-	-	42.8	57.1	-	-
CO 5	-	-	-	57.1	-	-
CO 6	-	-	42.8	42.8	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 <C≤ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	2	2	-	-
CO 2	-	1	2	2	-	-
CO 3	2	1	2	2	-	-
CO 4	-	-	2	2	-	-
CO 5	-	-	-	2	-	-
CO 6	-	-	2	2	-	-
TOTAL	2	2	10	12	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
AVERAGE	2	1	2	2	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**NEURAL NETWORKS**
	Neural Networks: biological neurons, Artificial neurons, activation function, learning rules, feed forward networks, supervised and unsupervised learning, Perceptron network, linear separability, back propagation networks algorithms, radial basis function networks.
MODULE II	**ASSOCIATIVE MODELS AND CONTROL SCHEMES IN NN**
	Auto and hetero associative memory, bi-directional associative memory, self organizing feature maps, Hopfield networks, Neural networks for non -linear system, schemes of Neuro control, system identification, forward model and, inverse model, case studies
MODULE III	**FUZZY LOGIC AND ITS CONTROLLERS**
	Fuzzy set: Crisp set, vagueness, uncertainty and imprecision, fuzzy set, fuzzy operation, properties. Crisp versus fuzzy relations, fuzzy relations, fuzzy Cartesian product and composition, composition of fuzzy relations Fuzzy to crisp conversion, structure of fuzzy logic controller, database, rule base, inference engine.
MODULE IV	**GENETIC ALGORITHMS**
	Genetic Algorithms (GA): Working principles, terminology, importance of mutation, comparison with traditional methods, constraints and penalty function, GA operators, real coded GAs.
MODULE V	**APPLICATIONS OF AI TECHNIQUES**
	Applications of neural network, fuzzy system, genetic algorithms for power systems and power electronics systems- designing of controllers using simulation software, NN tool box and fuzzy logic toolbox.

TEXTBOOKS

1. Jack M.Zurada, "Introduction to Artificial Neural Systems", Jaico publishing house 1st Edition,2006

2. Simon Haykin, “Neural Networks – A comprehensive foundation”, Pearson Education Asia, 1st Edition,2002

REFERENCE BOOKS:

1. Y. Manichaikul and F.C. Schweppe, ”Physically based Industrial load”, IEEE Trans. on PAS, 2nd Edition, 1981.

2. H. G. Stoll, ”Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 2nd Edition, 1989

3. J.Nagarath and D P Kothari, .Modern Power System Engineering.,Tata McGraw Hill publishers, New Delhi, 1stEdition, 1995.

4. IEEE Bronze Book- “Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities”, IEEE Inc, USA.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
CONTENT DELIVERY (THEORY)			
1	Introduction-Models of Neural Network: Biological neurons, Artificial neurons	CO1	T1 : 18.1
2	Architectures ,Knowledge representation, Artificial Neural Networks	CO1	T1 : 13
3	Models of atmosphere, main parameters and hypotheses, the isothermal exponential model.	CO1	T1 : 18.2
4	Learning process-Supervised learning, Unsupervised learning, Reinforcement learning, learning tasks	CO1	T1 : 18.2.1, 18.2.2
5	Aerodynamic coefficientsError correction learning, Hebbian learning, competitive learning, Boltzman learning.	CO2	T1 : 18.3.1, 18.3.2
6	Error correction learning, Hebbian learning, competitive learning, Boltzman learning	CO2	T2: 4.1, 4.1.1
7	Feed forward networks, Perceptron network, Linear separability.	CO2	T2: 4.1.5, 4.1.3
8	Feed forward networks, Perceptron network, Linear separability	CO2	T2: 4.1.4
9	Back Propagation Algorithms.	CO3	T2:4.1.6, 4.1.8
10	Back Propagation Algorithms.	CO3	T2: 4.5, 4.5.8
11	Radial basis function networks.	CO3	T2:5.3, 5.3.2

12	Radial basis function networks.	CO4	T2:5.3.2, R4:4.4
13	Auto and hetero associative memory.	CO4	T2: 4.2.8
14	Auto and hetero associative memory.	CO5	R1: 8.1, 8.2
15	Auto and hetero associative memory.	CO5	R1: 8.3 - 8.6
16	Bi-directional associative memory.	CO5	R1: 8.7, 8.8
17	Bi-directional associative memory.	CO5	R2: 11.2,11.3
18	Self organizing feature maps.	CO6	R2: 11.4, 11.5
19	Self organizing feature maps.	CO6	R2: 11.7
20	Hopfield networks.	CO5	R2:11.8
21	Hopfield networks.	CO6	T2:9.1 - 9.3
22	Neural networks for non -linear system, schemes of Neuro control,	CO6	T2: 9.4 - 9.5
23	Neural networks for non -linear system, schemes of Neuro control,	CO6	T2: 9.6
24	Fuzzy Logic Introduction, Fuzzy set , Crisp set, vagueness, uncertainty and imprecision,	CO6	T1:9.7, 9.8
25	Fuzzy Logic Introduction, Fuzzy set , Crisp set, vagueness, uncertainty and imprecision,.	CO6	T1:9.9
25	Fuzzy set, fuzzy operation, properties.	CO 1	T1:60
26	Fuzzy set, fuzzy operation, properties.	CO 1	T1:488-499
27	Crisp versus fuzzy relations, fuzzy relations,	CO 1	T1:97-132
28	Crisp versus fuzzy relations, fuzzy relations,	CO 1	T1:58
29	Fuzzy Cartesian product and composition, composition of fuzzy relations Fuzzy to crisp conversion	CO 1	T1:560-564
30	Fuzzy Cartesian product and composition, composition of fuzzy relations Fuzzy to crisp conversion	CO 1	T1:499-501
31	Structure of fuzzy logic controller, database, rule base, inference engine.	CO 2	T1:602-606
32	Structure of fuzzy logic controller, database, rule base, inference engine.	CO 2	T1:515-557
33	Genetic Algorithms (GA): Working principles.	CO 2	T1:515-557
34	Genetic Algorithms (GA): Working principles.	CO 2	T1:580-581
35	Terminology, importance of mutation, comparison with traditional methods.	CO 2	T1:570-575
36	Terminology, importance of mutation, comparison with traditional methods.	CO 2	T1:570-575

37	constraints and penalty function,	CO 2	T1:566-570
38	constraints and penalty function,	CO 2	T1:590-596
39	GA operators, real coded GAs.	CO 2	T1:590-596
40	GA operators, real coded GAs.	CO 2	T1:870
41	Applications of neural network for power systems and power electronics	CO 3	T1:289
42	Applications of neural network for power systems and power electronics	CO 3	T1:626-630
43	Applications of neural network for power systems and power electronics.	CO 3	T1:631-638
44	Applications of fuzzy system for power systems and power electronics	CO 5	T1:691-693
45	Applications of fuzzy system for power systems and power electronics	CO 5	T1:691-693
46	Applications of fuzzy system for power systems and power electronics	CO 5	T1:729-736
47	Applications of genetic algorithms for power systems and power electronics systems	CO 5	T1:729-736
48	Applications of genetic algorithms for power systems and power electronics systemss	CO 6	T1:200-215
49	Applications of genetic algorithms for power systems and power electronics systems	CO 6	T1:200-215
50	Designing of controllers using simulation software	CO 6	T1:200-215
51	Designing of controllers using simulation software	CO 6	T1:200-215
52	Designing of controllers using simulation software	CO 6	T1:200-215
53	Neural Network tool box	CO 6	T1:486
54	Neural Network tool box.	CO 6	T1:486
55	Neural Network tool box	CO5	R2:11.8
56	Fuzzy Logic toolbox.	CO6	T2:9.1 - 9.3
57	Fuzzy Logic toolbox.	CO6	T2: 9.4 - 9.5
58	Case Study	CO6	T2: 9.6
59	Case Study	CO6	T1:9.7, 9.8
60	Case Study	CO6	T1:9.9

DISCUSSION OF QUESTION BANK			
1	UNIT:I- Neural Networks	CO1	-
2	UNIT:II- Associate Models and Controls in NN	CO2,CO3	-
3	UNIT:III-Fuzzy logic and its controllers	CO4	-
4	UNIT:IV-Genetic Algorithm	CO5	-
5	UNIT:V-Application of AI techniques	CO6	-

Signature of Course Coordinator **HOD,EEE**
Mr.T Ravi Babu,Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**INDUSTRIAL LOAD MODELLING AND CONTROL**				
Course Code	BPSB15				
Program	M.Tech				
Semester	II				
Course Type	Professional Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. G. Kranthi Kumar,Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB34	V	Electrical Energy Conservation and Auditing
B.Tech	AEEB52	VI	Industrial Electrical System

II COURSE OVERVIEW:

Industrial load modeling and control analysis deals with Electrical energy scenario of Demand and load side management, Optimization and control algorithms and reactive power management of direct and interruptible load control, load profiling of cooling and heating loads and cool storage and control strategies , problem formulation, Describe capacitive power units and power pooling, Illustrate optimal operating and control strategies of optimal operating condition and load management for industries.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Industrial Load Modelling and Control	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. 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):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:
The students will try to learn:

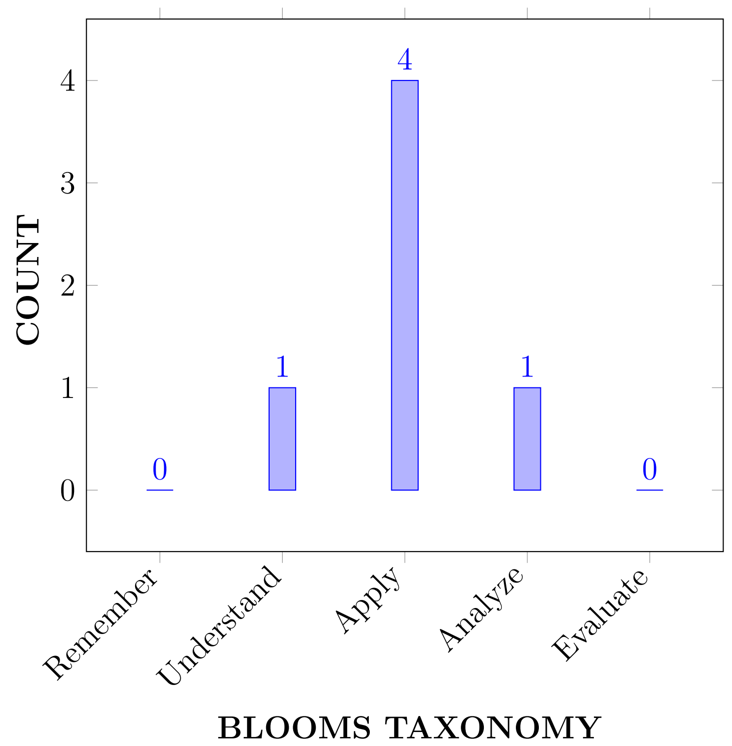
I	The Electric Energy Scenario - industrial load management and their implementation through various classical methods.
II	The necessity and power quality improvements of generation, transmission and distribution of electrical power for energy saving in industries.
III	The concepts of captive power units its operation, power pooling and industrial cogeneration with characteristics for real-world engineering problems and applications.
IV	The optimal operating strategies required on the system to meet the minute-tominute variation of system demand and its significance in power system operation and control by maintaining the frequency and voltage as constant.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Apply** knowledge of engineering science including electrical circuits, control systems and electrical machines in industrial load modelling and control.	Apply
CO 2	**Determine** the industrial load management in a power system supply specific amount of demand.	Understand
CO 3	**Outline** the interruptible load control, Direct load control, controls power quality impacts for minimising transmission line losses and energy saving in industries.	Apply
CO 4	**Analyze** the cooling and heating loads, cool storage, control strategies in an industrial power system.	Analyze
CO 5	**Design** a capacitive power unit in industrial load for imparting knowledge of various controllers with its evolution, principle of operation and applications.	Apply
CO 6	**Determine** the optimal operating strategies of power capacitors for integrated load management and industries with economic justification.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.

Program Outcomes	
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	2	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓	-	-
CO 2	✓	✓	✓	✓	-	-
CO 3	✓	✓	✓	✓	-	-
CO 4	✓	✓	✓	✓	-	-
CO 5	✓	✓	✓	✓	-	-
CO 6	✓	✓	✓	✓	-	-

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Make use of industrial load management techniques in power systems in solving practical problems in power system.	3
	PO 2	Able to communicate effectively in writing / orally.	3
	PO 3	Understand the concept of industrial load and analyze and design innovative models to establish innovative solution.	3

	PO 4	Make use of industrial load management techniques in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation .	3
CO 2	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	3
	PO 4	Understand the concept of industrial load on modern-day issues of Power Systems like industrial load management using advanced technologies with a global perspective.	4
CO 3	PO 1	Demonstrate research areas to solve practical problems in power systems and build solutions	2
	PO 2	Illustrate the conceptual knowledge of electrical power systems for real time power system applications and with effective communication skills.	2
	PO 3	Contrast the design process to minimize transmission line losses and energy saving in industries in electrical power systems for Solution development or experimentation / Implementation in Interpretation of results and Validation	4
	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management and the design process.	3
CO 4	PO 3	Demonstrate energy consumption of industrial loads by understanding and analyzing and design innovative solutions and Apply the complex engineering problems and their system components by design for the development of solution.	3
	PO 4	Make use of captive power plants in power systems using the concepts of engineering fundamentals to develop the solution of problem formulation and abstraction to establish innovative solutions for Interpretation of results and Validation	4
CO 5	PO 4	Understand the concepts of heating loads and their effect on power system for real time energy management.	4
CO 6	PO 3	Demonstrate operating strategies of power capacitors for integrated load management forapplication and solution of the complex engineering problems for the development of solution.	3
	PO4	Make use of power capacitors in power systems using the concepts of engineering fundamentals to develop the solution of problems and establish innovative solutions.	3

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	4	4	4	-	-
CO 2	3	4	4	4	-	-
CO 3	3	4	4	4	-	-
CO 4	2	2	4	4	-	-
CO 5	2	2	4	4	-	-
CO 6	1	2	2	4	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	75	57.12	57.12	57.12	-	-
CO 2	75	57.12	57.12	57.12	-	-
CO 3	75	57.12	57.12	57.12	-	-
CO 4	50	28.56	57.12	57.12	-	-
CO 5	50	28.56	57.12	57.12	-	-
CO 6	25	28.56	28.57	57.12	-	-

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation
1 -5 <C$\leq$ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	2	2	-	-
CO 2	3	2	2	2	-	-
CO 3	3	2	2	2	-	-
CO 4	2	1	2	2	-	-
CO 5	2	1	2	2	-	-
CO 6	1	1	1	1	-	-
TOTAL	14	9	11	12	-	-
AVERAGE	2.3	1.5	1.8	2	-	-

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**ELECTRIC ENERGY SCENARIO**
	Electric Energy Scenario, demand side management, industrial load management, load curves, load shaping objectives, methodologies, barriers, classification of industrial loads, continuous and batch processes, load modeling.
MODULE II	**DIRECT LOAD CONTROL INTERRUPTIBLE LOAD CONTROL**
	Direct load control, interruptible load control, bottom up approach, scheduling, formulation of load models, optimization and control algorithms, case studies, reactive power management in industries, controls power quality impacts, application of filters, energy saving in industries.
MODULE III	**COOLING AND HEATING LOADS LOAD PROFILING**
	Cooling and heating loads, load profiling, modeling, cool storage, types. Control strategies, optimal operation, problem formulation, case studies.
MODULE IV	**CAPTIVE POWER UNITS**
	Captive power UNITs, operating and control strategies, power pooling, operation models, energy banking, industrial cogeneration.
MODULE V	**OPTIMAL OPERATING STRATEGIES**
	Selection of schemes, optimal operating strategies, peak load saving, constraints problem formulation, case study, integrated load management for industries.

TEXTBOOKS

1. CO Bjork “Industrial Load Management - Theory, Practice and Simulations”, Elsevier, theNetherlands, 1st Edition, 1989.
2. CW Gellings and S NTalukdar, “Load management concepts,” IEEE Press, New York, 2nd Edition,1986.

REFERENCE BOOKS:

1. Y. Manichaikul and F.C. Schweppe, ”Physically based Industrial load”, IEEE Trans. on PAS, 2nd Edition, 1981.

2. H. G. Stoll, ”Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 2nd Edition, 1989
3. J.Nagarath and D P Kothari, .Modern Power System Engineering.,Tata McGraw Hill publishers, New Delhi, 1stEdition, 1995.
4. IEEE Bronze Book- “Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities”, IEEE Inc, USA.

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO’s	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE)		
CONTENT DELIVERY (THEORY)			
1	Need for Electric Energy Scenario.	CO 1	T2:1.1,1.2
2	Basic demand side management.	CO 1	T2:1.3,1.4
3	Introduction to industrial load management.	CO 1	T2:1.5,1.6
4	Lload shaping objectives.	CO 1	T2:3.1
5	Per phase load shaping objectives	CO 1	T1:4.3 T2:5.2
6	Generator, methodologies	CO 2	T2:2.1
7	Generator, methodologies	CO 3	T2:2.1.3
8	Barriers	CO 2	T1:9.3-9.5, R1:4.2
9	Construction classification of industrial loads.	CO 3	T2: 9.3-9.5
10	Construction classification of industrial loads.	CO 3	R1:4.3-4.4
11	Construction of continuous and batch processes.	CO 2	T1: 9.3-9.5, R1:4.3-4.4
12	Importance of power load modeling.	CO 2	T2:9.1, R1:8.1
13	Classification Direct load control.	CO 2	T2:9.8, R1:8.2
14	Development of power flow interruptible load control.	CO 2	T2:9.9.1, R1:9.2
15	Iterative solution bottom up approach.	CO 4	T2:9.8, R1:9.2
16	Scheduling, formulation of load models	CO 4	T2:9.10
17	Iterative optimization and control algorithms.	CO 4	T1:9.10
18	Decoupled and fast case studies.	CO 4	T1:9.11.2
19	Reactive power management in industries.	CO 4	T1:9.12
20	Power flow controls power quality impacts	CO 4	T1:9.4.12, R1:9.2

21	Application of filters.	CO 3	T2:10.3, R1:6.1-6.3
22	Importance of energy saving in industries.	CO 6	T2:10.4, R1:6.4
23	Cooling and heating loads	CO 4	T1:10.5, R1:6.4
24	Load profiling	CO 5	T1:10.6, R1:6.3
25	Computations of modeling	CO 6	T1:10.7, R1:6.3
26	Computations of modeling	CO 6	T1:10.7, R1:6.3
27	Introduction to cool storage.	CO 4	T1:10.5, R1:6.3
28	Types of cool storages.	CO 4	T2:10.13, R1:6.3
29	Control strategies	CO 4	T2:10.13, R1:6.3
30	Optimal operation	CO 4	T1:10.13, R1:6.3
31	Optimal operation	CO 4	T1:10.13, R1:6.3
32	Operating problem formulation	CO 4	T1:10.13
33	Case studies, Captive power UNITs.	CO 5	R1:6.3
34	Operating and control strategies, Power pooling	CO 5	T2:13.7
35	Operating and control strategies, Power pooling	CO 4	T2:13.7
36	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
37	Power system operation models, Energy banking	CO 5	T1:13.6, R1:10.5
38	Selection of schemes	CO 6	T1:13.6
39	Optimal operating strategies	CO 6	T2:13.7
40	Peak load saving.	CO 6	R1:11.5
41	Constraints problem formulation	CO 6	T1:13.7
42	Constraints problem formulation.	CO 6	T1:13.7
43	Case study.	CO 6	T1:13.7
44	Optimal operating strategies.	CO 6	T2:13.7
45	Optimal operating strategies.	CO 6	T2:13.7
46	Optimal operating strategies.	CO 6	T2:13.7
47	Peak load saving	CO 6	T2:13.7
48	Peak load saving	CO 6	T2:13.7
49	Peak load saving	CO 6	T2:13.7
50	Integrated load management for industries	CO 6	T2:13.7
51	Integrated load management for industries	CO 6	T2:13.7

52	Integrated load management	CO 6	T1:200-215
53	Problems	CO 6	T1:486
54	Problems	CO 6	T1:486
55	Problems	CO5	R2:11.8
56	Constraints problem formulation	CO6	T2:9.1 - 9.3
57	Case studies	CO6	T2: 9.4 - 9.5
58	Case studies	CO6	T2: 9.6
59	Problems	CO6	T1:9.7, 9.8
60	Problems	CO6	T1:9.9
DISCUSSION OF QUESTION BANK			
1	UNIT:I-Electric Energy Scenario	CO1	-
2	UNIT:II- Direct Load Control Interruptible Load Control	CO2,CO3	-
3	UNIT:III-Cooling And Heating Loads Load Profiling	CO4	-
4	UNIT:IV-Captive Power Units	CO5	-
5	UNIT:V-Optimal Operating Strategies	CO6	-

Signature of Course Coordinator **HOD,EEE**
Mr.G.Kranthi Kumar,Assistant Professor

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**POWER SYSTEM DYNAMICS**				
Course Code	BPSB12				
Program	M.Tech				
Semester	II				
Course Type	Professional Core				
Regulation	R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr VC Jagan Mohan, Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	VI	Power System Analysis
B.Tech	AEEC34	VII	Power system Protection

II COURSE OVERVIEW:

Power system analysis deals formation impedance and admittance matrices for power system network, finding different electrical parameters for various buses in power system, study fault analysis and represent power system using per unit system, understand steady state and transient stability of power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Modern Power System Analysis	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with ”either” or ”choice” will be drawn from each module. 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:

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20 %	To test the application skill of the concept

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For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

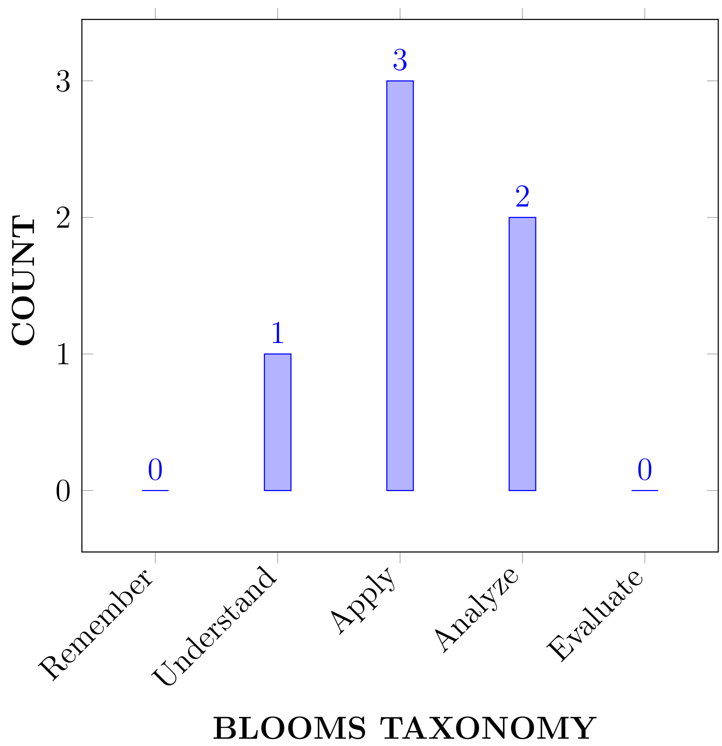
I	Mathematical models for synchronous machine, Exciter, Governor and Prime mover.
II	Power system dynamic phenomena and the effects of exciter and governor control.
III	The methods to improve dynamic stability.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the significance of power system stability and approach for analysis of multi machine system.	Understand
CO 2	**Develop** the state space equations, unit conversions, equivalent circuits for mathematical analysis of the synchronous machines.	Apply
CO 3	**Develop** the basic components of digital relay and signal conditioning subsystems for implementation of digital protection.	Apply
CO 4	**Identify** the types of excitation and voltage control configurations to address the effects of voltage changes and reactive power.	Apply
CO 5	**Illustrate** the significance of governing system for excitation and prime mover control.	Analyze
CO 6	**Explain** the methods to enhance the small signal stability of the power system.	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	Independently carry out research / investigation and development work to solve practical problems.
PO 2	Write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skillfulatdesigningembeddedsystemsforeffectiveuseincommunications, IoT, medical electronics and signal processing applications.
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	Independently carry out research / investigation and development work to solve practical problems.	2	AAT/SEE/CIE
PO 2	Write and present a substantial technical report / document.	2	AAT/SEE/CIE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2.5	AAT/SEE/CIE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	AAT/SEE/CIE
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	1	AAT/SEE/CIE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	AAT/SEE/CIE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	✓	-	-	-
CO 2	✓	-	✓	✓	-	-
CO 3	-	✓	✓	-	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 4	✓	-	✓	✓	-	✓
CO 5	-	-	✓	-	✓	-
CO 6	-	-	✓	✓	-	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate electively in writing / orally societal problems.	4
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
CO 2	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions to get the solution development and communicate electively in writing / orally societal problems.	6
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
CO 3	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5

	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
CO 4	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research for strengthen in embedded and advanced engineering areas.	1
CO 5	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research for strengthen in embedded and advanced engineering areas.	1

CO 6	PO 3	Demonstrate the importance of embedded technologies and design new innovative products for solving society relevant problems for applying knowledge, understanding and demonstrations of embedded applications in real time scenario and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development and communicate electively in writing / orally societal problems. science and engineering fundamentals.	5
	PO 4	Apply the concepts (knowledge) of embedded systems using their architectures by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations such as IoT and Robotics and use creativity to establish the solutions and make the experimental design.	5

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	4	4	-	-	-
CO 2	4		6	6	-	-
CO 3	-	5	5	-	-	-
CO 4	4	-	5	5	-	4
CO 5	-	-	6	-	4	-
CO 6	-	-	6	5	-	4

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	43	100	-	-	-
CO 2	50	-	80	80	-	-
CO 3	-	57	80	-	-	-
CO 4	50	-	75	80	-	60
CO 5	-	-	80	-	65	-
CO 6	-	-	80	73	-	60

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq C \leq 5\%$ – No correlation

1 -5 $< C \leq 40\%$ – Low/ Slight

2 - 40 % $< C < 60\%$ –Moderate

3 - $60\% \leq C < 100\%$ – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	2	-	-	-
CO 2	2	-	3	3	-	-
CO 3	-	2	2	-	-	
CO 4	2	-	2	3	-	2
CO 5	-	-	2	-	1	
CO 6	-	-	3	3	-	2
TOTAL	4	4	15	9	1	4
AVERAGE	2	2	2.5	3	1	2

XV ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**POWER SYSTEM STABILITY: A CLASSICAL APPROACH**
	Introduction, requirements of a reliable electrical power service, swing equation, power-angle curve, stability analysis of SMIB system, equal area criteria, classical model of a multi-machine system, shortcomings of the classical model, block diagram of one machine, system response to small disturbances: types of problems studied, the unregulated synchronous machine, modes of oscillation of an unregulated multi-machine system, regulated synchronous machine.
MODULE II	**SYNCHRONOUS MACHINE MODELING-I**
	Introduction, Park's Transformation, flux linkage equations, voltage equations, formulation of state- space equations, current formulation, per unit conversion, normalizing the voltage and torque equations, equivalent circuit of a synchronous machine, the flux linkage state-space model, load equations, sub-transient and transient inductances and time constants, simplified models of the synchronous machine, turbine generator dynamic models.
MODULE III	**SYNCHRONOUS MACHINE MODELING -III**
	Steady state equations and phasor diagrams, determining steady state conditions, evaluation of initial conditions, determination of machine parameters. Digital simulation of synchronous machines, linearization and simplified linear model and state-space representation of simplified model.

MODULE IV	EXCITATION AND PRIME MOVER CONTROL
	Simplified view of excitation control, control configurations, typical excitation configurations, excitation control system definitions, voltage regulator, exciter buildup, excitation system response, state-space description of the excitation system, computer representation of excitation systems, typical system constants, and the effects of excitation on generator power limits, transient stability and dynamic stability of the power system; Prime mover control: Hydraulic turbines and governing systems, steam turbines and governing systems.
MODULE V	SMALL SIGNAL STABLITY ANALYSIS
	Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, small-signal stability of a single-machine infinite bus system, effects of excitation system, power system stabilizer, system state matrix with amortizes, characteristics of small-signal stability problems.

TEXTBOOKS

1. 1. P M Anderson & A A Fouad "Power System Control and Stability", Galgotia, New Delhi, 1st Edition.
2. 2. J Machowski, J Bialek& J R W Bumby, "Power System Dynamics and Stability", John Wiley &Sons, 1st Edition.

REFERENCE BOOKS:

1. 1. P Kundur, "Power System Stability and Control", McGraw Hill Inc., 1st Edition.
2. 2. E WKimbark,"Powersystemstability",Vol.I&III,JohnWiley&Sons,NewYork1st Edition, 2002
3. 3. L Leonard Grigsby (Ed.); "Power System Stability and Control", Second edition, CRC Press, 1st Edition.

WEB REFERENCES:

1. .http://www.nptelvideos.in/2012/11/embedded-systems.html

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE)		
	CONTENT DELIVERY (THEORY)		
1	Introduction, requirements of a reliable electrical power service,	CO 1	T4:9.41, R1:3.1-3.2
2	Introduction, requirements of a reliable electrical power service,	CO 1	T4:9.41, R1:3.1-3.2
3	Swing equation, power-angle curve,	CO 1	T4:9.4.1, R1:3.1-3.2

4	Swing equation, power-angle curve,	CO 1	T4:9.4.1, R1:3.1-3.2
5	stability analysis of SMIB system, equal area criteria,	CO 1	T4:9.4.3, R1:3.3-3.5
6	stability analysis of SMIB system, equal area criteria,	CO 1	T4:9.4.3, R1:3.3-3.5
7	Classical model of a multi-machine system, shortcomings of the classical model,	CO1	T4:9.2, R1:3.3-3.5
8	Classical model of a multi-machine system, shortcomings of the classical model,	CO1	T4:9.2, R1:3.3-3.5
9	Block diagram of one machine, system response to small disturbances: types of problems studied,	CO 1	T4:9.2, R1:3.3-3.5
10	Block diagram of one machine, system response to small disturbances: types of problems studied,	CO 1	T4:9.2, R1:3.3-3.5
11	The unregulated synchronous machine, modes of oscillation of an unregulated multi-machine system,	CO 1	T4:9.2, R1:3.3-3.5
12	The unregulated synchronous machine, modes of oscillation of an unregulated multi-machine system,	CO 1	T4:9.2, R1:3.3-3.5
13	Regulated synchronous machine.	CO 1	T4:9.4, R1:4.1
14	Regulated synchronous machine.	CO 1	T4:9.4, R1:4.1
15	Introduction, Park's Transformation,	CO 2	T4:9.3-9.5, R1:4.2
16	Introduction, Park's Transformation,	CO 2	T4:9.3-9.5, R1:4.2
17	Flux linkage equations, voltage equations,	CO 2	T4: 9.3-9.5, R1:4.3-4.4
18	Flux linkage equations, voltage equations,	CO 2	T4: 9.3-9.5, R1:4.3-4.4
19	Formulation of state- space equations, current formulation,	CO 2	T4: 9.3-9.5, R1:4.3-4.4

20	Formulation of state- space equations, current formulation,	CO 2	T4: 9.3-9.5, R1:4.3-4.4
21	Per unit conversion, normalizing the voltage and torque equations,	CO 2	T4:9.1, R1:8.1
22	Per unit conversion, normalizing the voltage and torque equations,	CO 2	T4:9.1, R1:8.1
23	Equivalent circuit of a synchronous machine, the flux linkage state-space model,	CO 2	T4:9.8, R1:8.2
24	Equivalent circuit of a synchronous machine, the flux linkage state-space model,	CO 2	T4:9.8, R1:8.2
25	load equations, sub-transient and transient inductances and time constants,	CO 2	T4:9.9.1, R1:9.2
26	load equations, sub-transient and transient inductances and time constants,	CO 2	T4:9.9.1, R1:9.2
27	Simplified models of the synchronous machine, turbine generator dynamic models.	CO 2	T4:9.8, R1:9.2
28	Simplified models of the synchronous machine, turbine generator dynamic models.	CO 2	T4:9.8, R1:9.2
29	Steady state equations and phasor diagrams, determining steady state conditions,	CO 3	T4:9.10, R1:9.2
30	Steady state equations and phasor diagrams, determining steady state conditions,	CO 3	T4:9.10, R1:9.2
31	Evaluation of initial conditions, determination of machine parameters.	CO 3	T4:9.11.2, R1:9.2
32	Evaluation of initial conditions, determination of machine parameters.	CO 3	T4:9.11.2, R1:9.2
33	Simplified view of excitation control, control configurations,	CO 4	T4:9.12, R1:9.2
34	typical excitation configurations, excitation control system definitions,	CO 4	T4:9.4.12, R1:9.2
35	voltage regulator, exciter buildup, excitation system response,.	CO 3	T4:10.3, R1:6.1-6.3
36	state-space description of the excitation system, computer representation of excitation systems,	CO 4	T4:10.4, R1:6.4
37	state-space description of the excitation system, computer representation of excitation systems,	CO 4	T4:10.4, R1:6.4
38	typical system constants, and the effects of excitation on generator power limits,	CO 4	T4:10.5, R1:6.4
39	typical system constants, and the effects of excitation on generator power limits,	CO 4	T4:10.5, R1:6.4
40	transient stability and dynamic stability of the power system;	CO 4	T4:10.6, R1:6.3

41	Prime mover control: Hydraulic turbines and governing systems, steam turbines and governing systems.Short Circuit Analysis: Short Circuit Current and MVA CalculationsSolving numerical problems (Symmetrical fault Analysis).	CO 4	T4:10.7, R1:6.3
42	Prime mover control: Hydraulic turbines and governing systems, steam turbines and governing systems.Short Circuit Analysis: Short Circuit Current and MVA CalculationsSolving numerical problems (Symmetrical fault Analysis).	CO 4	T4:10.7, R1:6.3
43	Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix,	CO 5	T4:10.5, R1:6.3
44	Small-signal stability of a single-machine infinite bus system, effects of excitation system,	CO 5	T4:10.13, R1:6.3
45	Small-signal stability of a single-machine infinite bus system, effects of excitation system,	CO 5	T4:10.13, R1:6.3
46	Power system stabilizer, system state matrix with amortizes, characteristics of small-signal stability problems.	CO 5	T4:10.13, R1:6.1-6.3
47	Determine LLG fault with and without fault impedance and numerical problems.	CO 5	T4:10.16, R1:6.1-6.3
48	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 5	T4:10.17, R1:6.1-6.3
49	Introduction to steady state, dynamic and transient stabilities.	CO 5	T4:13.1, R1:10.1
50	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 5	T4:13.2, R1:10.3
51	Plot Power Angle Curve and determination of steady state,. stability.	CO 5	T4:13.2, R1:6.4
52	Explain methods to improve steady state stability.	CO 5	T4:13.2, R1:10.3
53	Derivation of swing equation.	CO 8	T4:13.3, R1:10.2
54	Determination of transient stability by equal area criterion.	CO 5	T4:13.6, R1:10.5
55	Application of equal area criterion to different cases.	CO 5	T4:13.7, R1:10.5
56	Discuss importance of critical clearing angle calculation.	CO 5	T4:13.6, R1:10.5
57	Solving numerical problems on equal area criteria.	CO 5	T4:13.7, R1:10.5
58	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5
59	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5
60	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5

DISCUSSION OF QUESTION BANK			
1	Power System Stabilit and Classical Apporach	CO1, CO2	T1: 2.1
2	Synchronous machine modeling-I	CO3	T1: 3.2
3	Synchronous machine modeling-II	CO4	T1: 4.2
4	Excitation and Prime Mover Control	CO5	T1: 5.2
5	Small Signal Stability Analysis	CO6	T1: 6.2

Signature of Course Coordinator **HOD,EEE**
Dr VC Jagan Mohan, Associate Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	ARTIFICIAL INTELLIGENCE LABORATORY				
Course Code	BPSB19				
Program	M.Tech				
Semester	II	EEE			
Course Type	Laboratory				
Regulation	IARE - PG 18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Dr. A Naresh Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC12	VI	Power System Analysis

II COURSE OVERVIEW:

The objective of artificial intelligence laboratory is to analyze electrical power system in load flow analysis, asses the different state estimation techniques, analyze the power system under fault conditions and evaluate the economic dispatch of coordinated thermal unit. Artificial intelligence including artificial neural networks, fuzzy logic and genetic algorithms. Provide the mathematical background for carrying out the optimization associated with neural network learning.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Artificial Intelligence Laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

x	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end lab examination for 70 marks shall be conducted by two examiners, one of them being Internal Examiner and the other being External Examiner, both nominated by the Principal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	Purpose
20 %	Analysis	Algorithm
20 %	Design	Programme
20 %	Conclusion	Conclusion
20 %	Viva	Viva

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component	**Laboratory**		**Total Marks**
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

VI COURSE OBJECTIVES:

The students will try to learn:

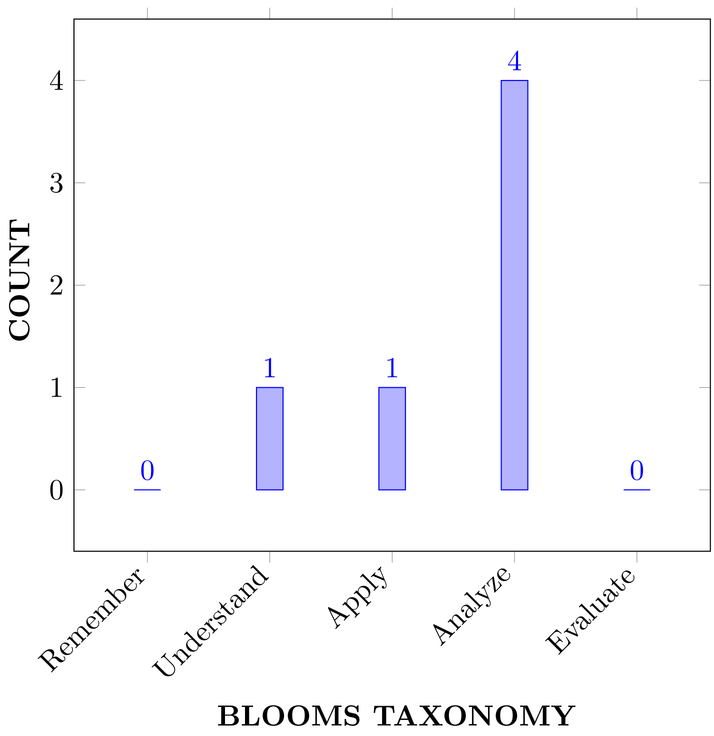
I	Explain the different state estimation techniques
II	Analyze and pick the best artificial intelligence technique for a given Power System problem.
III	Evaluate the economic dispatch of coordinated thermal unit
IV	Identify and use modern tools like fuzzy logic, artificial neural networks and ANFIS for power system problems

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Develop** a neural network based model for Load flow analysis. .	Analyze
CO 2	**Analyze** the state estimations using neural network.	Analyze
CO 3	**Analyze** contingency technique to predict the effect of outages like failures of equipment , transmission line u sing ANN	Analyze
CO 4	**Apply** the power system security using neural network.	Apply
CO 5	**Determine** automatic Generation Control for single area system and two area systems using Fuzzy Logic Method.	Understand
CO 6	**Analyze** the transient and small signal stability analysis of Single-Machine-Infinite Bus (SMIB) system using Fuzzy Logic	Analyze

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document.	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	3	-	-	-	-
CO 2	2	-	2	-	-	-
CO 3	2	-	2	-	-	-
CO 4	3	-	1	-	-	-
CO 5	3	-	-	-	-	-
CO 6	3	-	1	-	-	-

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XII ASSESSMENT METHODOLOGY INDIRECT:

X	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIII SYLLABUS:

WEEK I	**LOAD FLOW ANALYSIS**
	Load flow analysis using neural network
WEEK II	**STATE ESTIMATIONS**
	State estimations using neural network.
WEEK III	**CONTINGENCY ANALYSIS**
	Power system security using neural network.
WEEK IV	**POWER SYSTEM SECURITY**
	Contingency analysis using neural network
WEEK V	**AGC - SINGLE AREA SYSTEM / TWO AREA SYSTEM**
	Fuzzy logic based AGC for single area system and two area systems.
WEEK VI	**SMALL SIGNAL STABILITY ANALYSIS**
	Fuzzy logic based small signal stability analysis.
WEEK VII	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal UNITs using conventional and GA logic.
WEEK VIII	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal UNITs using conventional and ANN logic.
WEEK IX	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal UNITs using conventional and Fuzzy logic.
WEEK X	**ECONOMIC DISPATCH OF THERMAL PLANTS**
	Economic dispatch of thermal plants using conventional and ANN algorithms.
WEEK XI	**ECONOMIC DISPATCH OF THERMAL PLANTS**
	Economic dispatch of thermal plants using conventional and GA algorithms.
WEEK XII	**ECONOMIC DISPATCH OF THERMAL PLANTS**
	Economic dispatch of thermal plants using conventional and Fuzzy logic.

TEXTBOOKS

1. Samuel Greengard, K B Kanchandhani, "The Artificial Intelligence", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Cuno Pfister, "Getting started with Artificial Intelligence", Khanna Publishers, 5th Edition, 2012.

REFERENCE BOOKS:

1. Vedam Subramanyam, "Learning Artificial Intelligence", New Age International Limited, 2nd Edition, 2006.
2. Klaus Schwab, "The Fourth Artificial IntelligenceRevolution", New Age International Limited, 2nd Edition, 2008.

XIV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Load flow analysis using neural network	CO 1	T1:3.1
2	State estimations using neural network.	CO 2	T1:3.11
3	Power system security using neural network.	CO 3	T1:4.8
4	Contingency analysis using neural network	CO 2	T1:4.8
5	Fuzzy logic based AGC for single area system and two area systems.	CO 3	T1.5.5
6	Fuzzy logic based small signal stability analysis.	CO 4	T1:5.6
7	Economic dispatch of thermal UNITs using conventional and GA logic.	CO 4	T1:8.3
8	Economic dispatch of thermal UNITs using conventional and ANN logic.	CO 5	T1:8.3
9	Economic dispatch of thermal UNITs using conventional and Fuzzy logic.	CO 3	T1:9.2
10	Economic dispatch of thermal plants using conventional and ANN algorithms.	CO 5	T1:9.3
11	Economic dispatch of thermal plants using conventional and GA algorithms.	CO 3	T1:10.6
12	Economic dispatch of thermal plants using conventional and Fuzzy logic.	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Determine the economic dispatch of thermal plants
2	Determine the state estimations .
3	Determine the single area system and two area systems
4	Determine the mamdani fuzzy inference system.
5	Determine the Back propegation algorithm

Signature of Course Coordinator **HOD, EEE**
Dr. A Naresh Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

ELECTRICAL AND ELECTRONICS ENGINEERING
COURSE DESCRIPTION

Course Title	**POWER SYSTEMS LABORATORY**				
Course Code	BPSB20				
Program	M.Tech				
Semester	II	EEE			
Course Type	Core				
Regulation	IARE - PG18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Mr. P. Shivakumar, Assistant Professor				

I COURSE OVERVIEW:

The objective of the course is to provide an overview of basic protection methods such as earthing, milli volt drop test, soil resistivity and determination of breakdown voltage of air using horn gap apparatus. It provides in depth knowledge on working of microprocessor based over current relay and electromechanical over current relay. In addition to this, merz price protection of single phase transformer is studied. It provides in depth knowledge on working of various types of relays in protection of alternator.

II COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECB09	III	Electronic Devices and Circuits Laboratory

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Computational laboratory	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Demo Video	✓	Lab Worksheets	✓	Viva Questions	✓	Probing further Questions

V EVALUATION METHODOLOGY:

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks forinternal assessment and 70 marks for semester end lab examination. Out of 30 marks ofinternal assessment, continuous lab assessment will be done for 20 marks for the day today performance and 10 marks for the final internal lab assessment.

Semester End Examination (SEE): The semester end labexamination for 70 marks shall be conducted by two examiners, one of them beingInternal Examiner and the other being External Examiner, both nominated by thePrincipal from the panel of experts recommended by Chairman, BOS. The emphasis on the experiments is broadly based on the following criteria given in Table: 1

	Experiment Based	Programming based
20 %	Objective	-
20 %	Analysis	-
20 %	Design	-
20 %	Conclusion	-
20 %	Viva	-

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 1), with 20 marks for continuous lab assessment during day to day performance, 10 marks for final internal lab assessment.

Component			Total Marks
Type of Assessment	**Day to day performance**	**Final internal lab assessment**	
CIA Marks	20	10	30

Continuous Internal Examination (CIE):

One CIE exams shall be conducted at the end of the 16th week of the semester. The CIE exam is conducted for 10 marks of 3 hours duration.

1. **Experiment Based**

Objective	Analysis	Design	Conclusion	Viva	Total
-	-	-	-	-	-

2. **Programming Based**

Objective	Analysis	Design	Conclusion	Viva	Total
2	2	2	2	2	10

VI COURSE OBJECTIVES:

The students will try to learn:

I	Determine the earth resistance and electrical integrity of connections using crank type earth tester and milli volt drop test.
II	Understand the concept of Merz price protection of single phase transformer.
III	Examine the performance of alternator under various fault conditions using suitable relays.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Determine** earth resistance by using crank type earth tester.	Understand
CO 2	**Develop** the programming for load flow algorithms.	Apply
CO 3	**Analyze** the characteristics of fast decoupled loaf flow methods for developing algorithm.	Analyze
CO 4	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Apply
CO 5	**Categorize** the transient and short circuit analysis for analysing the performance of the system.	Analyze
CO 6	**Analyze** the various iterative methods applicable for state estimation of the power system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL

VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	Lab Exercises
PO 2	An ability to write and present a substantial technical report / document..	3	Lab Exercises
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	3	Lab Exercises
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	3	Lab Exercises
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment..	2	Lab Exercises
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	Lab Exercises

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	-	2	-
CO 2	-	3	3	-	-	2

CO 3	-	3	3	3	-	-
CO 4	3	-	3	3	2	2
CO 5	3	-	3	3	2	2
CO 6	-	3	-	-	2	2

XI ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	✓	Student Viva	✓	Certification	-

XII ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
X	Assessment of Mini Projects by Experts		

XIII SYLLABUS:

WEEK I	**EARTH TESTER**
	Determination of earth resistance by using crank type earth tester.
WEEK II	**MILLI VOLT DROP TEST**
	Measurement of contact resistances of different combinations of test objects.
WEEK III	**SOIL RESISTIVITY**
	Measurement of soil resistivity as a function of salinity and time.
WEEK IV	**MICROPROCESSOR BASED OVER CURRENT RELAY**
	Determination of performance characteristics of microprocessor based over current relay.
WEEK V	**ELECTROMECHANICAL OVER CURRENT RELAY**
	Determination of performance characteristics of electromechanical over current relay.
WEEK VI	**BREAKDOWN STRENGTH OF AIR BY HORN GAP**
	Determination of breakdown voltage of air using horn gap apparatus at atmospheric conditions.
WEEK VII	**POWER ANGLE CHARACTERISTICS OF SYNCHRONOUS MACHINE**
	Study the power angle characteristics of synchronous machine by synchronizing to the grid.
WEEK VIII	**MERZ PRICE PROTECTION IN SINGLE PHASE TRANSFORMER**
	Study the Merz price protection of single phase transformer and determine the characteristics of percentage biased relay.
WEEK IX	**DIFFRENTIAL PROTECTION SCHEME IN SYNCHRONOUS GENERATOR**
	Study of differential protection in three phase ac generator.

WEEK X	**OVER CURRENT AND TEMPARATURE PROTECTION IN ALTERNATOR**
	Study the performance of over current relay and temperature relay to protect alternator.
WEEK XI	**NEGATIVE SEQUENCE PROTECTION IN ALTERNATOR**
	Study the numerical type negative sequence protection in a given alternator.
WEEK XII	**OVER VOLTAGE AND UNDER VOLTAGE PROTECTION**
	Examine the alternator during over voltage and under voltage by using respective relays.
WEEK XIII	**OVER FREQUENCY AND UNDER FREQUENCY PROTECTION**
	Study the generator protection during over and under frequency cases with suitable relays.
WEEK XIV	**PERFORMANCE OF ALTERNATOR AGAINST INTERNAL FAULTS**
	Study the performance of synchronous machine and its protection scheme during internal faults.

TEXTBOOKS

1. 1. DP Kothari, B S Umre, "Lab manual for Electrical Machines", IK International Publishing House Pvt. Ltd, 1st Edition, 1996.

REFERENCE BOOKS:

1. MariesaLCrow, "Computational Methods for Electric Power Systems (Electric Power Engineering Series)", CRC Press Publishers, 1st Edition, 1992.

XIV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
1	Determine earth resistance by using crank type earth tester.	CO 1	T1:3.1
2	Explain the concept of electrical integrity of connections and contacts in a circuit breaker using milli volt drop test.	CO 2	T1:3.11
3	Understand the concept of soil resistivity as function of salinity and time.	CO 3	T1:4.8
4	Understand the working principle of microprocessor based over current relay.	CO 2	T1:4.8
5	Understand the working principle of electromechanical over current relay.	CO 3	T1.5.5
6	Determine of breakdown voltage of air using horn gap apparatus.	CO 4	T1:5.6
7	Estimate the power angle characteristics of synchronous machine.	CO 4	T1:8.3
8	Analyze internal fault protection of single phase transformer using Merz price protection.	CO 5	T1:8.3
9	Understand the concept of differential protection in three phase ac generator.	CO 3	T1:9.2

10	Examine the performance of over current relay, temperature relay and numerical type negative sequence protection scheme for alternator.	CO 5	T1:9.3
11	Examine the alternator during over voltage, under voltage, over and under frequency by using respective relays.	CO 3	T1:10.6
12	Examine the performance of alternator during internal faults.	CO 6	T1:10.7
13	Understand the generator protection during over and under frequency cases with suitable relays.	CO 3	T1:10.6
14	Examine the performance of synchronous machine and its protection scheme during internal faults.	CO 6	T1:10.7

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Design analysis of Numerical Relays for protection in power system.
2	Determine cuases of internal and externavfault protection of transformer
3	Design analysis of generator protection during over and under frequency cases.
4	Design analysis of over voltage prortection schemes in power systems
5	Design analysis of microprocessor based relays for protection in power system .

Signature of Course Coordinator **HOD,EEE**
Mr. P Shiva Kumar, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**RESEARCH METHODOLOGY AND IPR**				
Course Code	BCSB31				
Program	M.Tech				
Semester	III	EEE			
Course Type	Core				
Regulation	IARE R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Mr. G. Kranthi Kumar, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	**Course Code**	**Semester**	**Prerequisites**
M.Tech	-	-	-

II COURSE OVERVIEW:

This course provides the basic concepts on research methodology and intellectual property rights. This course emphasis on sampling techniques, data collection, writing Reports, Projects, Dissertations, thesis and articles for publication in academic journals, avail the intellectual property rights of the inventors or owners for their assets like patents on innovative design, copy rights on literary and artistic works, trademark on goods & services and geographical indications on products famous for specific geographical areas.This course makes use of the potential future economic benefits to the intellectual property owner or authorized user.

III MARKS DISTRIBUTION:

Subject	**SEE Examination**	**CIE Examination**	**Total Marks**
Research Methodology and IPR	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Open Ended Experiments	✓	Seminars	x	Mini Project	x	Videos
✓	Others						

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. 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):

For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

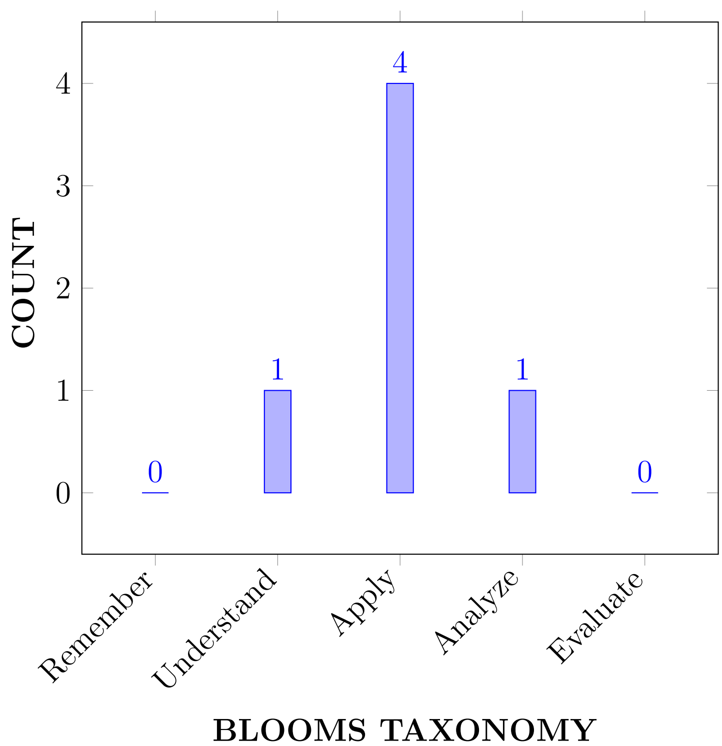
I	The knowledge on sources of research problem, data collection, analysis, and interpretation.
II	The importance of effective technical writing and analysis plagiarism.
III	The new developments in the law of intellectual property rights in order to bring progressive changes towards a free market society.

VII COURSE OUTCOMES:

After successful completion of the course, students will be able to:

CO 1	**Interpret** the technique of determining a research problem for a crucial part of the research study	Understand
CO 2	**Examine** the way of methods for avoiding plagiarism in research	Analyze
CO 3	**Apply** the feasibility and practicality of research methodology for a proposed project	Apply
CO 4	**Make use of** the legal procedure and document for claiming patent of invention.	Apply
CO 5	**Identify** different types of intellectual properties, the right of ownership, scope of protection to create and extract value from IP	Apply
CO 6	**Defend** Defend the intellectual property rights throughout the world with the involvement of World Intellectual Property Organization	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	3	CIE/AAT/SEE
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.	2	CIE/AAT/SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	-	-	-	✓
CO 2	✓	-	-	-	-	✓
CO 3	✓	✓	✓		-	-
CO 4	✓	✓	-		-	-
CO 5	✓	-	-	-		✓
CO 6	-	✓	-	-	-	-

XI COURSE ARTICULATION MATRIX (CO-PO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	-	-	-	2
CO 2	2	-	-	-	-	1
CO 3	2	3	2	-	-	-
CO 4	3	2	-	-	-	-
CO 5	2	-	-	-	-	2
CO 6	-	3	-	-	-	-
TOTAL	12	11	2	-	-	5
AVERAGE	2.4	2.75	2	-	-	1.7

XII ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XIII ASSESSMENT METHODOLOGY-INDIRECT:

✓	**End Semester OBE Feed Back**

XIV SYLLABUS:

MODULE I	**INTRODUCTION**
	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
MODULE II	**RESEARCH ETHICS**
	Effective literature studies approaches, analysis Plagiarism, Research ethics.
MODULE III	**RESEARCH PROPOSAL**
	Effective technical writing, how to write report, Paper Developing a Research Proposal. Format of research proposal, a presentation and assessment by a review committee
MODULE IV	**PATENTING**
	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT

MODULE V	**PATENT RIGHTS**
	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

TEXTBOOKS

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science and engineering students".
2. C R Kothari, "Research Methodology: Methods and techniques", New age international limited publishers, 1990 .
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"

REFERENCE BOOKS:

1. Halbert, "Resisting Intellectual Property", Taylor and Francis Ltd , 2007.
2. Mayall , "Industrial Design", McGraw Hill, 1992.
3. Niebel , "Product Design", McGraw Hill, 1974.

WEB REFERENCES:

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley Age", 2016 , " Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO" S. Chand 2008
3. Peter-Tobias stoll, Jan busche, Katrianarend- WTO- Trade –related aspects of IPR-Library of Congress

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping		
CONTENT DELIVERY (THEORY)			
1	Introduction, Definition, types of research	CO 1	T1:2.1
2	Meaning of research problem	CO 1	T1:2.1
3	Sources of research problem	CO 1	T1:2.3
4	Criteria characteristics of good research problem	CO 1	T1:2.3.1
5	Research process	CO 1	T1:7.2
6	Research design	CO 1	T1:7.3

7	Errors in selecting a research problem	CO 1	T1:7.4
8	Scope and objectives of research problem	CO 1	T1:2.3
9	Approaches of investigation of solutions for research problem	CO 1	T1:7.4
10	Data collection	CO 1	T1:8.1
11	Analysis and interpretation of data	CO 1	T1:8.1.1
12	Necessary instrumentation's	CO 1	T1:8.1.1
13	Effective literature studies approaches	CO 2	T1:8.2
14	Literature	CO 2	T1:8.2
15	Literature review	CO 2	T1:8.2
16	Literature review techniques	CO 2	T1:8.2
17	Literature studies	CO 2	T1:8.2
18	Introduction to ethics, Importance of ethics	CO 2	T1:8.2
19	Ethical issues in conducting research	CO 2	T1:8.3
20	Principles of research ethics	CO 2	T1:8.4
21	Analysis	CO 2	T1:8.5
22	Plagiarism- types of plagiarism	CO 2	T1:8.6
23	Tips to avoid plagiarism	CO 2	T1:9.1
24	Other ethical issues	CO 2	T1:9.2, 9.3
25	Interpretation, Interpretation Techniques and precautions	CO 2	T2:9.3.4
26	Writing of report and steps involved	CO 3	T2:7.1
27	Layout of research report	CO 3	T2:7.2
28	Types of reports	CO 3	T2:7.3
29	Paper developing a research proposal	CO 3	T2:7.4
30	Format of research proposal	CO 4	T2:8.3
31	Presentation of report	CO 4	T2:8.4
32	Summary of findings	CO 4	T3:8.5
33	Assessment by review committee	CO 4	T3:8.6
34	Technical appendixes	CO 4	T3:8.6
35	Logical analysis of the subject matter	CO 4	T3:8.6
36	Statement of findings and recommendations	CO 4	T3:8.6
37	Introduction, Nature of Intellectual Property	CO 5	T3:10.1-10.6
38	Types of intellectual Property rights	CO 5	T3:10.1-10.6
39	Patents	CO 5	T3:11.10
40	Designs	CO 5	T3:11.10
41	Trademarks and copyrights: Definition, classification of trademarks	CO 5	T3:11.10
42	Process of Patenting and Development	CO 5	T3:11.14
43	Technical research, innovation, patenting	CO 5	T3:11.15
44	Developments in patenting	CO 5	T3:11.17
45	Patent Trademark Organization	CO 5	T3:11.17
46	International Organization, Agencies and Treaties	CO 5	T3:11.17

47	International scenario, international cooperation on Intellectual property	CO 5	T3:11.19
48	Procedure for grant of patents	CO 5	T3:11.21
49	procedure of copyright	CO 5	T1:8.1-8.3; R2: 7.4-7.5
50	Patenting under PCT, Provisional patent application	CO 5	T1-8.1-8.1.7
51	Patent protection for the invention	CO 5	T1-8.1-8.1.7
52	Patent Rights	CO 6	T3:12.1
53	Scope of Patent Rights	CO 6	T3:12.1
54	Licensing and transfer of technology	CO 6	T3:12.1
55	Patent information and databases	CO 6	T3:12.4
56	Geographical Indications	CO 6	T3:12.4
57	New Developments in IPR: Administration of Patent System	CO 6	T3:12.7
58	New developments in IPR, IPR of Biological Systems and Computer Software etc	CO 6	T3:12.10
59	Traditional knowledge Case Studies	CO 6	T3:12.13
60	IPR and IITs.	CO 6	T3:12.15
DISCUSSION OF QUESTION BANK			
61	Module – I: Research problem	CO 1	T1:2.1-2.3
62	Module – II: Research ethics	CO 2	T1:8.2
63	Module – III: Research proposal	CO 3, CO 4	T3:8.3; R2: 7.4-7.5
64	Module – IV: Patenting	CO 5	T3:10.1-10.6
65	Module – V: Patent rights	CO 6	T3:12.1-12.15

Signature of Course Coordinator **HOD, EEE**
Mr. G. Kranthi Kumar, Assistant Professor

IARE — EDUCATION FOR LIBERATION

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**FLEXIBLE AC TRANSMISSION SYSTEMS**				
Course Code	BPSB23				
Program	M.Tech				
Semester	III				
Course Type	Program Elective				
Regulation	R-18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Mr. T. Ravi Babu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEB20	V	Power Electronics
B.Tech	AEEB22	VI	Power system Analysis

II COURSE OVERVIEW:

This course deals with the principle, operation and applications in power systems with respect to active/reactive power control. It also elaborates the issues with power quality on utility side and proposes the compensation/mitigation techniques in transmission systems. This course also concludes with multilevel switching coordination among FACTS controllers.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Flexible AC Transmission Systems	70 Marks	30 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOCs
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Semester End **Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. 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):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 COURSE OBJECTIVES:

The students will try to learn:

I	Understanding of uncompensated lines and their behavior under heavy loading conditions.
II	Explain the concept and importance controllable parameters of FACTS controllers.
III	Describe the objectives of Shunt compensation, and basic operation of SVC and STATCOM.
IV	Analyze the functioning of series controllers like GCSC, TSSC and TCSC.

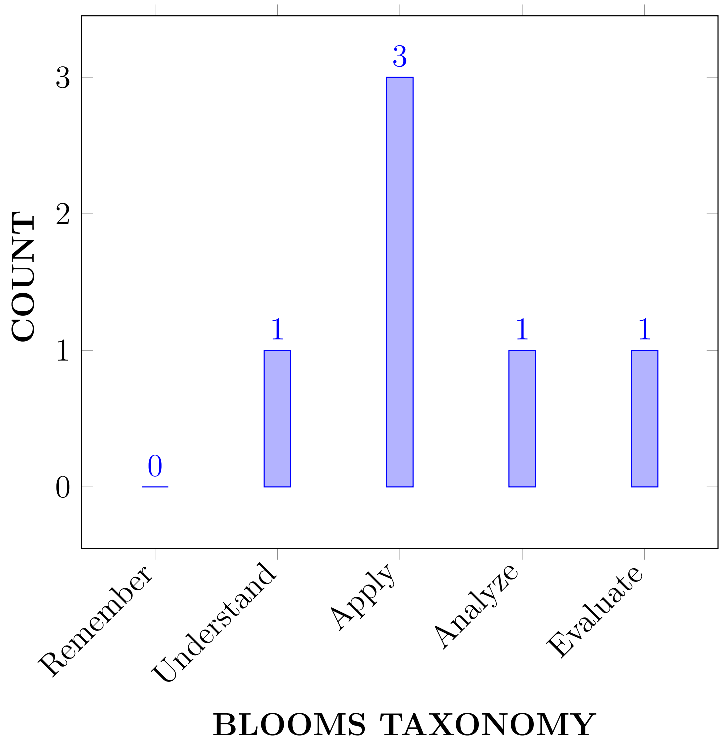
VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the power flow in AC system to describe the basics of FACTS controllers	Understand
CO 2	**Identify** the suitable VSC and CSC, for high pulse operation of FACTS controllers	Apply
CO 3	**Analyse** the need for series and shunt compensation inpower systems and role of facts controller for achieving it	Analyse

CO 4	**Apply** the concept of the controllable VAR generation for Hybrid mode	Apply
CO 5	**Evaluate** the performance of SVC and STATCOM to see how they are involved in enhancing the dynamic performance and transient stability	Evaluate
CO 6	**Examine** the impact of static series compensation to demonstrate voltagestability, transient stability and power oscillation damping.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	3	AAT/SEE/CIE
PO 3	Student should be able to demonstrate a degree of mastery over Electrical Power System in designing and analyzing real-life engineering problems and to provide strategic solutions ethically.	2	AAT/SEE/CIE
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.	2	AAT/SEE/CIE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	AAT/SEE/CIE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	-	✓	✓	-	✓
CO 2	✓	-	✓	✓	-	✓
CO 3	✓	-	✓	✓	-	✓
CO 4	✓	-	✓	✓	-	✓
CO 5	✓	-	✓	✓	-	✓
CO 6	✓	-	✓	✓	-	✓

XI JUSTIFICATIONS FOR CO – PO/ PSO MAPPING -DIRECT:

Course Outcomes	PO(s) PSO(s)	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO 1	Demonstrate the power flow in AC system to describe the basics of FACTS controllers for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions	2
	PO 3	Apply the basics of FACTS controllers for power flow by using Scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design .	5

	PO 4	Apply the concepts of FACTS controllers for power flow by using Scientific principles and methodology and complex problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design	3
	PO 6	Apply the concepts of FACTS controllers for power flow by using Scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development	2
CO 2	PO 1	Demonstrate about VSC and CSC for more pulse operation of FACTS controllers for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions	4
	PO 3	Apply the concepts (knowledge) of VSC and CSC for more pulse operation of FACTS controllers by using scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design	5
	PO 4	Apply the concepts (knowledge) of VSC and CSC for more pulse operation of FACTS controllers by using scientific principles and methodology and complex problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design	3
	PO 6	Apply the concepts (knowledge) of of VSC and CSC for more pulse operation of FACTS controllers by using scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development	3
CO 3	PO 1	Analyze the need of series and shunt compensation in power system and role of FACTS controller to achieve it, for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions	2
	PO 3	Demonstrate series and shunt compensation in power system and role of FACTS controller to achieve it for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions and make the experimental design with manage the design process and evaluate outcomes using modern tools to get the solution development.	6

	PO 4	Apply the concepts (knowledge) of series and shunt compensation in power system and role of FACTS controller to achieve it by using scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design	3
	PO 6	Apply the concepts (knowledge) of series and shunt compensation in power system and role of FACTS controller to achieve it by using scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development.	2
CO 4	PO 1	Apply the concept of the controllable VAR generation for hybrid mode for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions	4
	PO 3	Demonstrate the concept of the controllable VAR generation for hybrid mode for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development	5
	PO 4	Demonstrate the concept of the controllable VAR generation for hybrid mode for solving society relevant complex problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	3
	PO 6	Apply the concepts (knowledge) of controllable VAR generation for hybrid mode by using scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development.	2
CO 5	PO 1	Evaluate the performance of SVC and STATCOM to enhance the dynamic performance and transient stability for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions.	4
	PO 3	Demonstrate the performance of SVC and STATCOM to enhance the dynamic performance and transient stability for solving society relevant problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development	5

	PO 4	Demonstrate the performance of SVC and STATCOM to enhance the dynamic performance and transient stability for solving society relevant complex problems for applying knowledge, understanding and demonstrations of power system applications in real time scenario and use creativity to establish innovative solutions to get the solution development.	3
	PO 6	Apply the performance of SVC and STATCOM to enhance the dynamic performance and transient stability by using scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development.	2
CO 6	PO 1	Examine the impact of static series compensation to demonstrate voltage stability, transient stability and power oscillation damping for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions.	2
	PO 3	Estimate the impact of static series compensation to demonstrate voltage stability, transient stability and power oscillation damping for applying knowledge, understanding and demonstrations of power sytem applications in real time scenario and use creativity to establish innovative solutions and make the experimental design with manage the design process and evaluate outcomes using modern tools to get the solution development.	5
	PO 4	Estimate the impact of static series compensation to demonstrate voltage stability, transient stability and power oscillation damping by using scientific principles and methodology and problem formulation and abstraction for understand the need of users with the importance of considerations and use creativity to establish the solutions and make the experimental design	3
	PO 6	Examine the impact of static series compensation to demonstrate voltage stability, transient stability and power oscillation damping by using scientific principles and methodology for life-long learning for continuing education in doctoral level studies and professional development.	2

XII TOTAL COUNT OF KEY COMPETENCIES FOR CO – PO/ PSO MAPPING:

COURSE	PROGRAM OUTCOMES					
OUTCOMES	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	5	3	-	2
CO 2	4	-	5	3	-	3
CO 3	2	-	6	3	-	2
CO 4	4	-	5	3	-	2

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 5	4	-	5	3	-	2
CO 6	2	-	5	3	-	2

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO/ PSO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	50.0	-	71.42	75.0	-	40.0
CO 2	100	-	71.42	75.0	-	60.0
CO 3	50.0	-	85.71	75.0	-	40.0
CO 4	100	-	71.42	75.0	-	40.0
CO 5	100	-	71.42	75.0	-	40.0
CO 6	50	-	71.42	75.0	-	40.0

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - $0 \leq$ C$\leq$ 5% – No correlation

1 -5 <C$\leq$ 40% – Low/ Slight

2 - 40 % <C < 60% –Moderate

3 - 60% $\leq$ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	-	3	3	-	1
CO 2	3	-	3	3	-	2
CO 3	2	-	3	3	-	1
CO 4	3	-	3	3	-	2
CO 5	3	-	3	3	-	1
CO 6	2	-	3	3	-	1
TOTAL	15	-	18	18	-	9
AVERAGE	2.5	-	3	3	-	1.5

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Assignments	-
Quiz	-	Tech-Talk	-	Certification	-
Term Paper	✓	Seminars	-	Student Viva	-
Laboratory Practice	-	5 Minutes Video / Concept Video	-	Open Ended Experiments	-
Micro Projects	-	-	-	-	

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	**End Semester OBE Feed Back**

XVII SYLLABUS:

MODULE I	**FACTS CONCEPTS**
	Transmission interconnections power flow in an ac system, loading capability limits, dynamic stability considerations, importance of controllable parameters basic types of FACTS controllers, benefits from FACTS controllers.
MODULE II	**VOLTAGE SOURCE CONVERTERS**
	Single phase three phase full wave bridge converters transformer connections for 12 pulse 24 and 48 pulse operation, three level voltage source converter, pulse width modulation converter, basic concept of current source converters, and comparison of current source converters with voltage source converters.
MODULE III	**STATIC SHUNT COMPENSATION**
	Objectives of shunt compensation, mid-point voltage regulation voltage instability prevention, improvement of transient stability, Power oscillation damping. Methods of controllable VAR generation, variable impedance type static VAR generators switching converter type VAR generators hybrid VAR generators.
MODULE IV	**SVC AND STATCOM**
	Regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping operating point control and summary of compensator control.
MODULE V	**STATIC SERIES COMPENSATORS**
	Concept of series capacitive compensation, improvement of transient stability, power oscillation damping and functional requirements of GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC)Control schemes for GSC TSSC and TCSC.

TEXTBOOKS

1. Hingorani H G and Gyugyi. L "Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems" New York, IEEE Press, 1st Edition, 2000.

2. Padiyar K R, "FACTS Controllers in Power Transmission and Distribution" New Age Int. Publishers,2nd Edition, 2007.

REFERENCE BOOKS:

1. Zhang, Xiao-Ping, Rehtanz, Christian, Pal, Bikash "Flexible AC Transmission Systems: Modeling and Control", Springer, , 1stEdition, 2012.

2. Yong-Hua Song, Allan Johns, "Flexible AC Transmission Systems", IET, 1stEdition,1999.

WEB REFERENCES:

1. https://www.researchgate.net

2. https://www.aar.faculty.asu.edu/classes

3. https://www.facstaff.bucknell.edu/
4. https://www.electrical4u.com

XVIII COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference T1: 4.1
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
CONTENT DELIVERY (THEORY)			
1	Introduction to FACTS and Power Systems Distribution	CO 1	R1:1.1
2	Review Of Basics Of Power Transmission Networks	CO 1	T2:1.2
3	Control of power flow in AC Transmission line.	CO 1	R1:1.2
4	Analysis Of Uncompensated AC Transmission Line	CO1	T1:2.1-2.2
5	Passive Reactive Power Compensation	CO 2	T1:2.3
6	Effect Of Series Compensation At The Midpoint Of The Line On Power Transfer	CO 2	T2:2.3
7	Effect of shunt compensation at the midpoint of the line on power transfer	CO 2	T2:2.4
8	Types of facts controllers.	CO 3	R1:1.6-1.7
9	Static Var Compensator: configuration of Static Var Compensator	CO 4	T2:3.2
10	Voltage regulation by Static VAR Compensator	CO 5	T2:3.4
11	Modeling of Static Var Compensator.	CO 4	T1:4.7.1
12	Modeling of Static Var Compensator for load flow analysis.	CO 4	T2:4.7.1
13	Modeling of Static Var Compensator for stability studies	CO 4	T2:4.7.4
14	Design of Static Var Compensator.	CO 4	T2:5.2.5
15	Static Var Compensator designing to regulate the midpoint voltage of SMIB system	CO 5	T1:5.2.5
16	Transient stability enhancement	CO 4	T1:6.3
18	Applications SVC	CO 6	T2:3.8
19	Series Compensator	CO 6	T1:7.1
20	Concepts of Controlled Series Compensation	CO 6	T2:4.2
21	Operation of Thyristor Controlled Series Capacitor	CO 6	T2:4.3
22	Gate turn off Thyristor Controlled Series Capacitor	CO 6	T2:4.3
23	Analysis of TCSC	CO 4	T2:4.4
24	Analysis of GCSC	CO 5	T2:4.7
25	Modeling of TCSC and GCSC for load flow studies	CO 6	T2:4.8
26	Modeling TCSC and GCSC for stability studies	CO 4	T2:4.8
27	Applications of TCSC and GCSC	CO 4	T2:4.9

28	Static Synchronous Compensator (STATCOM)	CO 5	T2:6.1
29	Static Synchronous Series Compensator (SSSC)	CO 5	T2:7.1
30	Operation of STATCOM and SSSC power flow control	CO 5	T2: 7.2
31	Modeling of STATCOM and SSSC for power flow	CO 5	T2:7.3
32	Modeling of STATCOM and SSSC for transient stability studies	CO 5	T2:7.3
33	Introduction UPFC and IPFC	CO 6	T2:8.2
34	Operation of unified and interline power flow controllers	CO 6	T2:8.2
35	Single and three phase full wave converter	CO 6	T2:8.7
36	Transformer connections for high pulse operation	CO 6	T2:8.7
37	Current source converter and comparison with voltage source converter	CO 6	T2:8.9
38	FACTS controller	CO 5	T1:9.1
39	FACTS controller interactions	CO 5	T1:9.2
40	FACTS controller interactions SVC	CO 5	T1:9.2
41	SVC interaction	CO 5	T1:9.3
42	Coordination of multiple controllers	CO 5	T1:9.8
43	Coordination using linear control techniques	CO 5	T1:9.8
44	Quantitative treatment of control co-ordination	CO 5	T1:9.9
45	Loading capability limits	CO1	T1:1.3
46	Dynamic stability considerations	CO1	T2:1.4
43	Importance of controllable parameters	CO1	T1:1.5
47	Benefits from FACTS controllers	CO1	T2: 1.5
48	single phase three phase full wave bridge converters	CO2	R1: 2.2
49	Transformer connections for 12 pulse 24 and 48 pulse operation	CO2	T2: 2.3
50	Three level voltage source converter	CO2	T2: 3.3
51	Pulse width modulation converter	CO2	T2: 3.7
52	Basic concept of current source converter	CO2	T2: 4.2
53	Objectives of shunt compensation	CO3	R2: 2.8
54	Mid-point Voltage regulation	CO4	r2: 2.9
55	Regulation and slope transfer function	CO5	T1: 9.11
56	Dynamic Performance	CO5	T: 9.8
57	Modelling of TCSC and GCSC	CO4	T1: 5.8
58	functional requirements of GTO	CO6	R2: 3.2
59	Mathematical Problems on UPFC	CO6	T3: 9.8
60	Mathematical Problems on IPFC	CO6	T3: 9.8

DISCUSSION OF QUESTION BANK			
61	Facts Concepts	CO 1	T1
62	Voltage Source Converters	CO 2	T2, R1,
63	Static Shunt Compensation	CO3,4	R1
64	SVC and STATCOM	CO 5	R2
65	Static Series Compensator	CO 6	T2

Signature of Course Coordinator **HOD,EEE**
Mr. T. Ravi Babu, Assistant Professor

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043
COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING**				
Course Title	**WASTE TO ENERGY**				
Course Code	BCSB30				
Program	M.Tech				
Semester	III	EEE			
Course Type	Elective				
Regulation	IARE R18				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. Devender Reddy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AHS009	II	Environmental Studies

II COURSE OVERVIEW:

The course is designed to create environmental awareness and consciousness among the present generation to become environmental responsible citizens. The course will discuss on the municipal solid waste composition, characteristics and to improve the methods to minimize municipal solid waste generation. This course deals with methods of disposal of solid waste by thermal biochemical processes and production of energy from different types of waste sand to know the environmental impacts of all types of municipal waste. This course will discuss the overall scenario of E-Waste management in India in comparison with other countries around the globe. This course will deals with E-waste legislation and government regulations on E-waste management.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Waste to Energy	70 Marks	30 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	PPT	✓	Chalk & Talk	✓	Assignments	x	MOOC
x	Seminars	x	Others				

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). **Semester End Examination (SEE):** The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each module. 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):
For each theory course the CIA shall be conducted by the faculty/teacher handling the course as given in Table 4. 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 2: Assessment pattern for Theory Courses

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 9^{th} and 17^{th} 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 COURSE OBJECTIVES:

The students will try to learn:

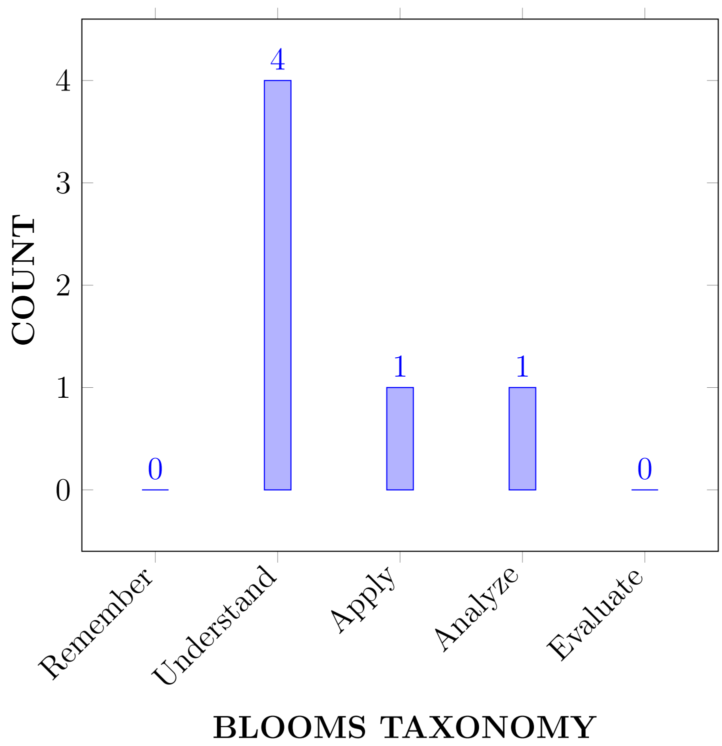
I	The principles of solid waste management in reducing and eliminating dangerous impacts of waste materials on human health and the environment to contribute economic development and superior quality of life.
II	The insight of the design and operations of a municipal solid waste landfill by collection, transfer and transportation of municipal solid waste for the final disposal.
III	The main operational challenges in operating thermal and biochemical energy from waste facilities and device processes involved in recovering energy from wastes.
IV	The scenario of E-Waste management in India and other countries around the globe and assess the impact of electronic waste on human, environment and society by informal recycling and management. The sustainable solution of E-Waste Management can be achieved by adopting modern techniques and Life-Cycle Analysis approach.

VII COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Analyze** the different sources and types of solid waste by the properties of municipal solid waste for segregation and collection of waste.	Analyze
CO 2	**Explain** the energy generation technologies from waste treatment plants and disposal of solid waste by aerobic composting and incineration process.	Understand
CO 3	**Explain** the classification, preliminary design considerations of landfill and methods of landfill disposal of solid to control greenhouse gases.	Understand
CO 4	**Understand** the Composition, characteristics of leachate to control the emission of gases by monitoring the movement of landfill leachate.	Understand
CO 5	**Outline** the Biochemical conversion of biomass for energy generation by anaerobic digestion of solid waste.	Understand
CO 6	**Apply** the knowledge in planning and operations of waste to Energy plants by following legal legislation related to solid waste management.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII PROGRAM OUTCOMES:

Program Outcomes	
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.
PO 2	An ability to write and present a substantial technical report / document.
PO 3	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level of higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve complex problems on modern-day issues of Power Systems using advanced technologies with a global perspective and envisage advanced research in thrust areas.
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.

IX HOW PROGRAM OUTCOMES ARE ASSESSED:

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	CIE/AAT/SEE
PO 2	An ability to write and present a substantial technical report / document.	2	CIE/AAT/SEE

3 = High; 2 = Medium; 1 = Low

X MAPPING OF EACH CO WITH PO(s):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	✓	-	-	-	-
CO 2	✓	✓	-	-	-	
CO 3	-	✓	-	-	-	-
CO 4	-	✓		-	-	-
CO 5	✓	-	-	-	-	-
CO 6	-	-	-	-	-	-

XI COURSE ARTICULATION MATRIX (CO – PO MAPPING):

CO'S and PO'S and CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	2	-	-	-	-
CO 2	1	2	-	-	-	-
CO 3	-	2	-	-	-	-
CO 4	-	2	-	-	-	-
CO 5	3	-	-	-	-	-
CO 6	-	-	-	-	-	-
TOTAL	4	4	-	-	-	-
AVERAGE	2	2	-	-	-	-

XII ASSESSMENT METHODOLOGY DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminar and term paper	-
Laboratory Practices	-	Student Viva	-	Mini Project	-

XIII ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XIV SYLLABUS:

MODULE I	**WASTE SOURCES AND CHARACTERIZATION**
	Waste production in different sectors such as domestic, industrial, agriculture, postconsumer, waste etc. Classification of waste – agro based, forest residues, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization. Waste Selection criteria
MODULE II	**TECHNOLOGIES FOR WASTE TO ENERGY**
	Biochemical Conversion – Energy production from organic waste through anaerobic digestion and fermentation. Thermo-chemical Conversion – Combustion, Incineration and heat recovery, Pyrolysis, Gasification; Plasma Arc Technology and other newer technologies..
MODULE III	**WASTE TO ENERGY AND ENVIRONMENTAL IMPLICATIONS**
	Environmental standards for Waste to Energy Plant operations and gas clean-up. Savings on nonrenewable fuel resources. Carbon Credits: Carbon foot calculations and carbon credits transfer mechanisms.
MODULE IV	**THERMO-CHEMICAL CONVERSION**
	Biogas production, land fill gas generation and utilization, thermo-chemical conversion: Sources of energy generation, gasification of waste using gasifies briquetting, utilization and advantages of briquetting, environmental benefits of bio-chemical and thermo-chemical conversion, comparison of various thermo-chemical conversion.
MODULE V	**CENTRALIZED AND DECENTRALIZED WASTE TO ENERGY PLANTS**
	Waste activities – collection, segregation, transportation and storage requirements. Location and Siting of Waste to Energy plants. Industry Specific Applications – In-house use – sugar, distillery, pharmaceuticals, Pulp and paper, refinery and petrochemical industry and any other industry. Centralized and Decentralized Energy production, distribution and use. Comparison of Centralized and decentralized systems and its operations.

TEXTBOOKS

1. Nicholas P Cheremisinoff, ―Handbook of Solid Waste Management and Waste Minimization Technologies‖, An Imprint of Elsevier, New Delhi, 2003.

2. P AarneVesilind, William A Worrell and Debra R Reinhart, ―Solid Waste Engineering‖, 2 nd edition 2002.

3. M Dutta , B P Parida, B K Guha and T R Surkrishnan, ―Industrial Solid Waste Management and Landfilling practice‖, Reprint Edition New Delhi, 1999.

4. RajyaSabha Secretariat, ―E-waste in India: Research unit‖, Reprint Edition, June, 2011.

REFERENCE BOOKS:

1. C Parker and T Roberts (Ed), ―Energy from Waste‖, An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.

2. KL Shah,"Basics of Solid and Hazardous Waste Management Technology", Prentice Hall, Reprint Edition, 2000.

3. M Datta, —"Waste Disposal in Engineered Landfill", Narosa Publishing House, 1997.

XV COURSE PLAN:

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

S.No	Topics to be covered	CO's	Reference
	OBE DISCUSSION		
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
	CONTENT DELIVERY (THEORY)		
1	Summarize about solid waste sources and its importance.	CO 1	T1:3.3, T2:1.2, R2: 2.2
2	Discuss solid waste properties and its composition.	CO 1	T1:3.4, T2:1.4
3	Provides the information regarding collection and transfer of solid waste.	CO 1	T1:3.5, R2:1.5
4	Discuss the need of waste minimization and recycling	CO 1	T1:3.7, R2:1.8
5	Discuss the need of segregating waste and managing solid waste.	CO 1	T1: 3.9, R3: 1.10
6	Acquire the knowledge about the technologies for generation of energy from solid waste.	CO 1	T1:5.5, T2:6.2, R3:4.8
7	Acquire the knowledge about the technologies for generation of energy from biomedical waste.	CO 1	T1:5.6, T2:6.3, R3:7.5
8	Discuss the environmental impacts of incineration process.	CO 1	T1:4.3, T2:5.2, R2: 5.7
9	Illustrate the importance of landfill method of disposal.	CO 1	T1: 4.4, R1:3.3
10	Discuss the types of land fill disposal and classification of land fill sites.	CO 1	T1:4.5, T2: 5.4, R3: 7.3
11	Analyze the layout and preliminary design of landfills.	CO 2	T1:4.6, T2:5.5
12	Summarize the properties and characteristics of landfills.	CO 2	T1: 4.5.2., T2: 5.6
13	Acquire the knowledge of generating energy from landfills.	CO 2	T1:4.6, T2:5.5

14	Discuss the emission of gasses and leach ate from landfills.	CO 2	T1:4.6.2, T2:5.5.2
15	Discuss the environmental monitoring system for land fill gases.	CO 2	T1:4.7, T2:5.6
16	Discuss about the biochemical conversion and their advantages.	CO 2	T1:4.7, T2:5.8
17	Illustrate the sources of biochemical conversion process.	CO 2	T1:4.7.2, T2:5.8.2
18	Analyze anaerobic digestion of sewage and municipal waste.	CO 2	T1:4.8, T2:5.9
19	Analyze direct combustion of Municipal solid waste.	CO 2	T1:4.9, T2:5.7
20	Discuss about refuse derived solid fuel and their importance in energy generation.	CO 3	T1:6.2, T2:5.6
21	Discuss about industrial waste and agro residues.	CO 3	T1:6.3, T2:5.7
22	Understand the concept of Thermo-chemical Conversion.	CO 3	T1:6.4, T2:5.8
23	Discuss about Biogas production and generation of energy by Biogas.	CO 3	T1:6.5, T2:5.3
24	Explain the land fill gas generation and utilization of landfill gas for various purposes.	CO 3	T1:6..6, T2:5.2
25	Illustrate sources of thermo chemical energy generation	CO 3	T1:6.7, T2:5.3
26	Explain gasification of waste using gasifies briquetting process.	CO 3	T1:6.5, T2:7.5
27	Discuss utilization of various municipal solid wastes by recycling, refuse and reuse techniques.	CO 3	T1: 6.2, 6.3, R2: 7.9
28	Discuss advantages and disadvantages of briquetting process.	CO 3	T1: 6.2
29	Summarize environmental benefits of bio-chemical conversion	CO 4	T1:6.2, T2:7.2
30	Summarize environmental benefits of thermo- chemical conversion	CO 4	T1:6.3, T2:7.3
31	Outline the Growth of electrical and electronics industry in India.	CO 4	T1:6.4, T2:7.5
32	Summarize the E-waste generation in India and in the global context.	CO 4	T1: 6.2, T2: 5.6
33	Understand the Growth of E waste generated from electrical and electronics industry in India	CO 4	T1:6.3, T2: 5.7
34	Identify environmental concerns and health hazards	CO 4	T1:6.4, T2:5.8
35	Determine recycling concept of E-Waste and advantages of E-waste.	CO 5	T1:2.1, T2:9.1

36	Discuss A thriving economy of the unorganized sector of E-waste	CO 5	T1:2.2, T2:9.2
37	Discuss the global trade in hazardous waste and their impact on the environment	CO 5	T1: 2.1, R2: 9.1
38	Discuss impact of hazardous E-waste in India and effects on human health	CO 5	T1:2.6, R1:5.1
39	Understand the management processes of E-waste and the importance of formal recycling of E-waste	CO 5	T1:2.7, R1:5.2
40	Outline E-waste legislation for the recycling and disposal	CO 5	T1:2.8, R1:5.5
41	Summarize government regulations on E-waste management	CO 5	T1:2.1, R1:5.6
42	Outline international E-waste management and the guidelines imposed for formal disposal	CO 5	T1:2.2, R1:5.4
43	Explain the need for stringent health safeguards of human health and their effects	CO 5	T1:2.4,R1:5
44	Discuss the need for environmental protection laws and	CO 5	T1:2.4, R1:5.5
45	Outline environmental protection laws of India with respect to E-waste management.	CO 5	T1:2.4, R1:5.5
46	Summarize about solid waste sources and its importance.	CO 6	T1:3.3, T2:1.2, R2: 2.2
47	Discuss solid waste properties and its composition.	CO 6	T1:3.4, T2:1.4
48	Provides the information regarding collection and transfer of solid waste.	CO 6	T1:3.5, R2:1.5
49	Discuss the need of waste minimization and recycling	CO 6	T1:3.7, R2:1.8
50	Discuss the need of segregating waste and managing solid waste.	CO 6	T1: 3.9, R3: 1.10
51	Acquire the knowledge about the technologies for generation of energy from solid waste.	CO 6	T1:5.5, T2:6.2, R3:4.8
52	Acquire the knowledge about the technologies for generation of energy from biomedical waste.	CO 6	T1:5.6, T2:6.3, R3:7.5
53	Discuss the environmental impacts of incineration process.	CO 6	T1:4.3, T2:5.2, R2: 5.7
54	Illustrate the importance of landfill method of disposal.	CO 6	T1: 4.4, R1:3.3
55	Discuss the types of land fill disposal and classification of land fill sites.	CO 6	T1:4.5, T2: 5.4, R3: 7.3

55	Analyze the layout and preliminary design of landfills.	CO 6	T1:4.6, T2:5.5
56	Summarize the properties and characteristics of landfills.	CO 6	T1: 4.5.2., T2: 5.6
57	Acquire the knowledge of generating energy from landfills.	CO 6	T1:4.6, T2:5.5
58	Discuss the emission of gasses and leach ate from landfills.	CO 6	T1:4.6.2, T2:5.5.2
59	Discuss the environmental monitoring system for land fill gases.	CO 6	T1:4.7, T2:5.6
60	Summarize the properties and characteristics of landfills.	CO 6	T1: 4.5.2., T2: 5.6
DISCUSSION OF QUESTION BANK			
61	Module: I-Waste sources and characterization	CO 1	T1
62	Module: II- Technologies for waste to energy	CO 2	T2, R1
63	Module: III- Waste to energy and implications	CO3,4	R1
64	Module: IV- Thermo chemical conversion	CO 5	R2
65	Module: V-Centralized and decentralized waste to energy	CO 6	T2

Signature of Course Coordinator **HOD, EEE**
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