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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING (EPS)**				
Course Title	**MODERN POWER SYSTEM ANALYSIS**				
Course Code	BPSD01				
Program	M.Tech				
Semester	I				
Course Type	Professional Core				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Dr. Shaik Ruksana Begam, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEED22	VI	Power System Analysis
B.Tech	AEED34	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	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 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 60 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 40 marks, with 30 marks for Continuous Internal Examination (CIE), 10 marks for Assignment and 10 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 40 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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:

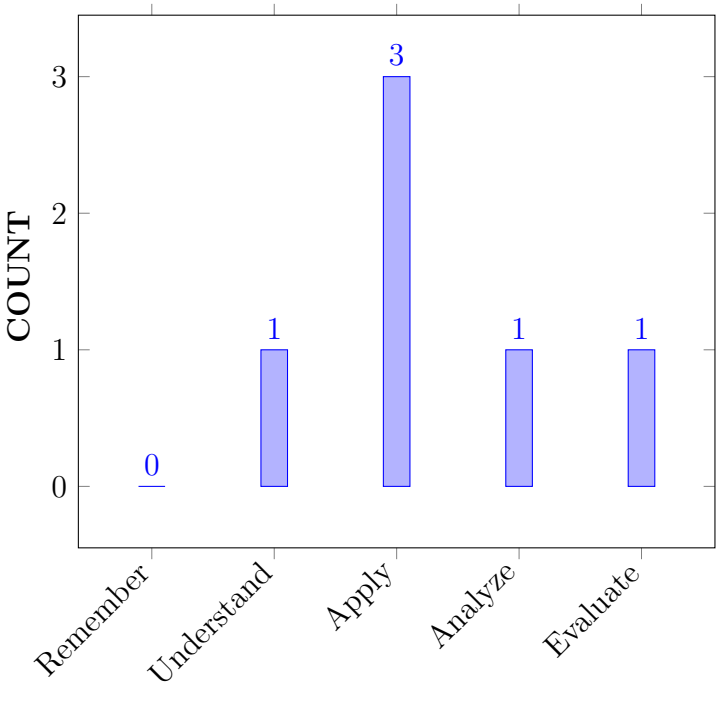
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

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



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	AAT
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
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
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	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	✓	✓	✓	✓	-	-

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
	PO 5	**Demonstrate the graph theory** for Bus clculation .	2
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 3	**Apply Power flow analysis** to get mastery .	7
	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 3	**Derive the expression for sequence network** for fault calculation.	4
	PO 4	**Illustrate** the use of PSCAD and MATLAB for faultanalysis.	3
	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
	PO 3	**Derive the expression for sequence network** for fault calculation.	4
	PO 4	**Illustrate** the use of PSCAD and MATLAB for faultanalysis.	3
	PO 5	**Demonstrate the computer programming** for fault clculation .	2
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
	PO 3	**Derive the expression for sequence network** for contigency calculation.	6

	PO 4	**Illustrate** the use of PSCAD and MATLAB for matrix calculation.	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
	PO 3	Illustrate the different protection and state estimation which helps to solve complex engineering problems	7
	PO 4	**Illustrate** the use of PSCAD and MATLAB for matrix calculation.	3
	PO 5	**Demonstrate the computer programming** for state eatimatiion .	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	7	4	2	-
CO 2	1	4	7	4	3	-
CO 3	1	4	6	3	-	2
CO 4	1	4	5	3	2	-
CO 5	2	3	6	4	-	-
CO 6	2	4	7	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	-	43	100	100	40	-
CO 2	25	57	100	100	50	-
CO 3	25	57	85	75	-	50
CO 4	25	57	72	75	40	-
CO 5	50	43	85	100	-	-
CO 6	50	57	100	75	50	-

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	2	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 2	1	2	3	3	3	-
CO 3	1	2	3	3	2	2
CO 4	1	2	3	3	-	-
CO 5	2	2	3	3	2	-
CO 6	2	2	3	3	-	-
TOTAL	7	12	18	18	4	2
AVERAGE	1.4	2	3	3	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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII 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	**SHORT CIRCUIT ANALYSIS**

	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

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 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
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COURSE TEMPLATE

Department	**ELECTRICAL POWER SYSTEMS**				
Course Title	**ECONOMIC OPERATION OF POWER SYSTEMS**				
Course Code	BPSD02				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. G.SESHADRI , Associate Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEED07	III	DC Machines and Transformers
B.Tech	AEED11	IV	AC Machines
B.Tech	AEED35	VII	Power System Operation and Control

II COURSE OVERVIEW:

The purpose of this course is to make the students understand about load compensation and how to select various types of reactive power compensation devices in transmission systems both during steady state and transient state operation. The course also enables the students about the management of reactive power on demand side, distribution side, and utility side of the power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
ECONOMIC OPERATION OF POWER SYSTEMS	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

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Total	-	-	**100 Marks**	

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VI COURSE OBJECTIVES:

The students will try to learn:

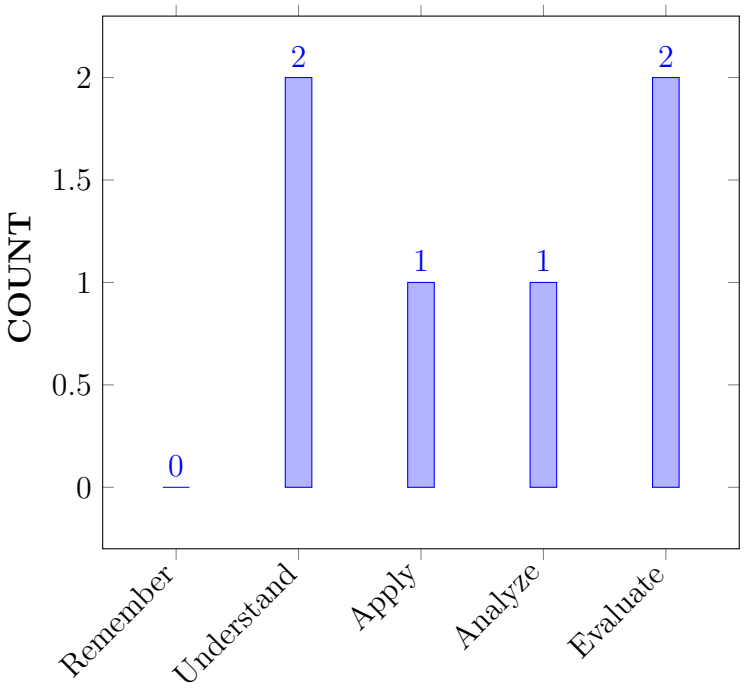
I	Necessary conditions for economical load scheduling problem.
II	Various constraints, problem formulation and methods to solve the unit commitment problem.
III	Constraints related to hydel power plants, problem formulation and solution techniques for hydro-thermal scheduling problem.
IV	Necessity, factors governing the frequency control and analyze the uncontrolled and controlled LFC system.
V	Basic difference between ELS and OPF problem, formulation of the OPF problem and solution techniques.

VII COURSE OUTCOMES:

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

CO 1	**Solve** the unit Commitment problem with various constraints using conventional optimization techniques and general transmission line loss formula..	Apply
CO 2	**Identify** an optimal operation setup of power system for minimizes operation costs and meet desired needs.	Understand
CO 3	**Categorize** single area load frequency control and two area load frequency control to minimize the transient deviations and steady state error to zero.	Evaluate
CO 4	**Analyze** the importance of Reactive power control and Power Factor in power systems for efficient and reliable operation of power systems	Analyze
CO 5	**Develop** the appropriate control scheme for compensating reactive power.	Evaluate
CO 6	**Identify** the different types of compensating equipment for reactive power to improve system's efficiency.	Understand

COURSE KNOWLEDGE COMPETENCY LEVEL



BLOOMS TAXONOMY

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	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Discussion and Seminars
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Seminars

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Laboratory Practice
PO 4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Assignments, Mock tests
PO 5	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.	2	Seminars

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	Recall the operation renewable energy systems using **science and engineering fundamentals.**.	2
	PO 6	Relate the environmental aspects of renewable energy systems with **engineering solutions in societal and environmental contexts.**	1
CO 2	PO 1	**Identify** Explain the operating principles of renewable energy sources using **science and engineering fundamentals**.	2
CO 3	PO 1	Provide the renewable energy conversion systems using the **knowledge of mathematics, science and engineering fundamentals**	2
	PO 2	Understand the several conversion systems used in energy conversion in renewable power plant with using **engineering sciences.**.	4
	PO 3	energy conversion with **system components or processes that meet the specified needs with appropriate consideration for the public health and safety.**.	6
CO 4	PO 1	Demonstrate the grid connected renewable energy systems using **science and engineering fundamentals**.	2
	PO 2	Illustrate the power quality issues in grid connected renewable energy systems using **using first principles of mathematics and engineering sciences.**	4
	PO 3	Demonstrate the power quality issues and mitigation techniques used in grid connected systems using **system components that meet the specified needs with appropriate consideration**	6
CO 5	PO 1	Choose the power converters used in solar photovoltaic systems with **science and engineering fundamentals**.	2
	PO 2	Understand the various inverters used in solar power plants using **first principles of mathematics and engineering sciences.**	4
	PO 3	Describe the converters and inverters used in solar photovoltaic systems using **system components that meet the specified needs with appropriate consideration**	6
CO 6	PO 1	Identify reliable inverter used in PV systems with the **knowledge of science and engineering fundamentals**.	2
	PO 2	Select the suitable inverter used in solar photovoltaic systems with**knowledge of science and engineering fundamentals**	4

	PO 3	Select the inverter suitable for grid synchronization of renewable energy systems using **system components that meet the specified needs with appropriate consideration**	6
	PO 4	Power Systems using advanced technologies with a global perspective **envisage advanced research in thrust areas.**	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	✓	-	-	-	-	✓
CO 2	✓	-	-	-	-	-
CO 3	✓	✓	✓	-	-	-
CO 4	✓	✓	✓	-	-	-
CO 5	✓	✓	✓	-	-	-
CO 6	✓	✓	✓	✓	-	-

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	66.67	-	-	-	-	33.4
CO 2	66.67	-	-	-	-	-
CO 3	66.67	40	60	-	-	-
CO 4	66.67	40	60	-	-	-
CO 5	66.67	40	60	-	-	-
CO 6	66.67	40	60	36.4	-	-

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	-	-	-	-	1
CO 2	3	-	-	-	-	-
CO 3	3	2	3	-	-	-
CO 4	3	2	3	-	-	-
CO 5	3	2	3	-	-	-
CO 6	3	2	3	1	-	-
TOTAL	18	8	12	1	-	1
AVERAGE	3	2	3	1	-	1

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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

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 D Stevenson, "Power system analysis", McGraw Hill, 1st edition, 2003.
2. Allen JWood, Bruce F Wollenberg, Gerald B Sheblé, "Power Generation, Operation and Control", Wiley Interscience, 2nd edition, 2013.

REFERENCE BOOKS:

1. Olle, Elgerd, "Electric Energy Systems Theory an Introduction", TMH, 3rd edition 2006.

WEB REFERENCES:

1. NPTEL Economic Operation of Power Systems - NOC: Planning and Operational Studies of Power Systems.
2. NPTEL Economic Operation of Power Systems - NOC: Introduction to symmetrical components.
3. NPTEL Modern Power system analysis - NOC: Power Flow Analysis.

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	Characteristics of steam turbine	CO1	T1: 1.1
2	variations in steam unit characteristics	CO1	T1: 1.2
3	economic dispatch with piecewise linear cost functions	CO1	T2: 1.1.1
4	Lambda iterative method	CO1	T2: 1.3.1
5	LP method, economic dispatch under composite generation production cost function examples.	CO1	T2: 1.3.3
6	base point and participation factors	CO2	T2: 1.3.8
7	thermal system dispatching with network losses considered	CO1	T1: 2.1
8	economic dispatch with piecewise linear cost functions	CO1	T1: 2.1
9	Characteristics of steam turbine	CO1	T3: 5.2
10	Characteristic time periods	CO1	T1: 5.7
11	Lambda iterative method	CO1	T3: 5.7
12	Unit Commitment	CO2	T2: 5.7

13	Unit Commitment	CO2	T3: 5.7
14	definition	CO2	T1: 9.1
15	constraints in unit commitment,	CO2	T1: 9.1
16	constraints in unit commitment	CO2	T1: 9.1
17	unit commitment solution methods	CO2	T1: 9.1
18	unit commitment solution methods	CO2	T1: 9.1
19	priority	CO3	T1: 6.2
20	list methods	CO2	T1: 7.1
21	list methods	CO2	T3: 5.7
22	dynamic programming solution	CO2	T2: 5.7
23	dynamic programming solution	CO2	T1: 5.7
24	radio frequency and electromagnetic interference	CO3	T1: 5.7
25	generation control with PID controllers	CO4	T1: 2.2
26	implementation of Automatic Generation control (AGC)	CO4	T1: 2.3
27	Characteristics of Hydroelectric units	CO4	T1: 5.7
28	introduction to hydrothermal coordination	CO4	T2: 2.1
29	System losses	CO4	T2: 2.1
30	models of power system elements	CO4	T1: 5.7
31	objectives	CO4	T1: 2.2
32	single area and two area block diagrams placement	CO4	T1: 2.2
33	AGC features.	CO4	T1: 2.2
34	Requirements for domestic appliances	CO5	T1: 2.3
35	purpose of using capacitors, selection of capacitors	CO6	T1: 2.3
36	deciding factors of capacitors	CO6	T1: 9.1
37	types of available capacitor	CO6	T1: 6.2
38	Load patterns	CO6	T1: 6.3
39	basic methods load shaping	CO6	T1: 6.3
40	Control of generation	CO6	T1: 6.4
PROBLEM SOLVING/ CASE STUDIES			
41	Define economic dispatch problem?	CO1	T1: 7.1
42	Define hydrothermal scheduling problem?	CO2	T3: 5.7
43	Devise protection schemes required for the system to safeguard against transients	CO5	T3: 5.7
44	Discuss about Characteristic time periods	CO3	T2: 5.7
45	Why DC supply is not used in home?	CO6	T1: 9.1
46	Discuss about Composite voltage- and current- based scheme.	CO6	T1: 6.35
47	Explain supply and Demand.	CO6	T1: 6.36
48	What is optimal power flow analysis?	CO6	T1: 6.33
49	purpose of using capacitors	CO6	T1: 6.39
50	reactive power control requirements	CO6	T1: 6.1
51	What is optimal power flow?	CO6	T1: 6.42
52	Why DC power flow is required?	CO6	T1: 6.41
53	What is an algorithm and an example?	CO6	T1: 6.41

54	transmission benefits	CO6	T1: 6.47
55	How does a governor work?	CO6	T1: 6.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	What is meant by load frequency?	CO1, CO2	T1: 2.1
57	What is DC current used for?	CO3	T1: 3.2
58	basic concepts of quality of power supply	CO4	T1: 4.2
59	Characteristics of Hydroelectric units	CO5	T1: 5.2
60	Control of generation	CO6	T1: 6.2
DISCUSSION OF QUESTION BANK			
61	Discuss the selection of power plant equipments. What are the selection criterion for selection them	CO1,CO2	-
62	Explain the optimal load allocation for a system having large of generating units.	CO3	-
63	When do hydrothermal resources arise?	CO4	-
64	EOPF calculations combining economic dispatch .	CO5	-
65	Describe financial efficiencies of electrical goods and services in brief.	CO6	-

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Branch	**Electrical and Electronics Engineering(EPS)**				
Course Title	**Research Methodology and IPR**				
Course Code	BHSD01				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	IARE - MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	2	-	-
Course Coordinator	Dr. Shobha Rani, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	-	-	-

II COURSE OVERVIEW:

This course imparts research methodology and philosophy of intellectual property rights, including basic concepts employed in quantitative and qualitative research methods, Patents, Copyrights, and Trademarks. It provides the research framework, research methodology research design, and formulation hypothesis, sampling techniques, data analysis and report writing. It implies on research skills and intellectual property rights to encourage new creations, including technology, artwork, and inventions, that might increase economic growth.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Research Methodology and IPR	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

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 40 marks, with 30 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 and 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.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Assignment / Quiz	05 Marks	05 Marks		10 Marks
Alternative Assessment Tool (AAT)	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the respectively 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. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by 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.

Quiz
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

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 include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

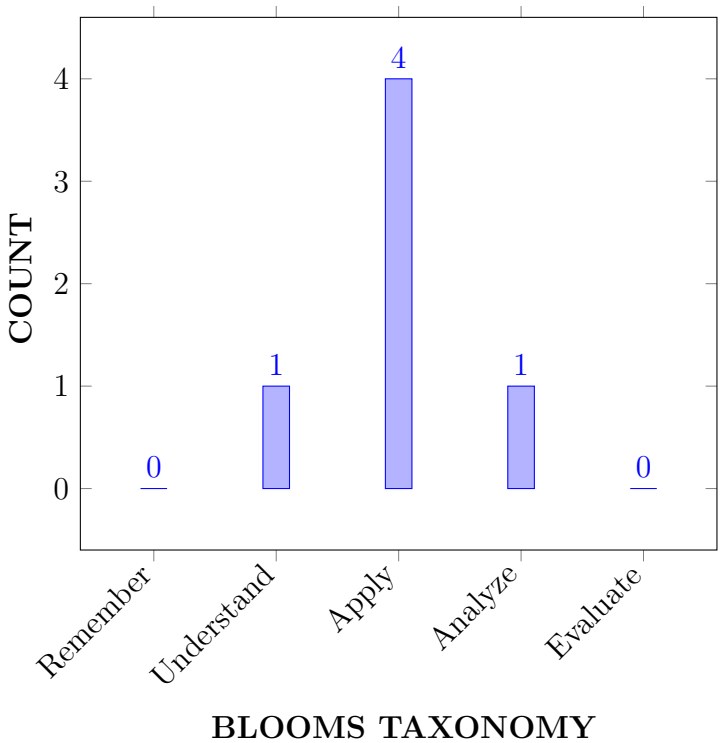
I	The Knowledge on formulate the research problem, characteristics of a good research and interpretation of collected data.
II	The importance of research ethics while preparing literature survey and writing thesis to achieve plagiarism free report..
III	The intellectual property rights such as patent, trademark, geographical indications and copyright for the protection of their invention done.

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	Under-stand
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** 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/SEE/AAT
PO 2	An ability to write and present a substantial technical report / document.	2	CIE/SEE/AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	CIE/SEE/AAT

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 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**	**Describe** the steps involved in **problem identification for the research process** with **quality of work** and **demonstrate the solutions**	4
	PO 2	**Demonstrate and communicate** effectively in writing the **research problem** with **clarity** and **subject the knowledge while preparing report**	4
	PO 6	**Describe** the importance of **continuing education efforts through literature, personal development, meeting deadlines** and **producing solutions** in research study	4
CO 2	**PO 1**	**Explain** the methods for avoiding plagiarism in research work for improving the **quality of work, self driven** and **Independence** in research process	3
	PO 6	**Describe** the methods for avoiding plagiarism in research work by **continuing education efforts through literature, manage risk, meeting deadlines** and **producing solutions**	3
CO 3	**PO 1**	**Describe** the steps of **problem identification and implementation** in development of **independence, quality of work** by using research methodology	3
	PO 2	**Demonstrate and communicate effectively in writing** a proposed project with **clarity** and avoid the mistakes in terms of **grammar (writing)** to **subject knowledge while preparing report**	4
CO 4	**PO 1**	**Demonstrate the solutions** and **self driven, independence** in work for copyright and **quality of work** in document	4
	PO 2	**Demonstrate and communicate** effectively in Process of applying **presenting** Patent with clarity and **subject knowledge** of intellectual property management for claiming patent of invention	3
CO 5	**PO 1**	**Demonstrate the solutions** to attain the right of ownership and **independence and self driven** for scope of protection	3
	PO 6	**Continuing education efforts through literature, demonstrated ability to work well with a team, meeting deadlines and producing solutions** for licensing and transfer of technology in patent rights	4
CO 6	**PO 2**	**Demonstrate and communicate effectively** of the new Developments in IPR with considering **references** and **clarity** in **presentation**	4

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	4	4	-	-	-	4
CO 2	3	-	-	-	-	3
CO 3	3	4	-	-	-	-
CO 4	4	3	-	-	-	-
CO 5	3	-	-	-	-	4
CO 6	-	4	-	-	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	6	6	9	10	7	8
CO 1	66.6	66.6	-	-	-	50
CO 2	50	-	-	-	-	37.5
CO 3	50	66.6	-	-	-	-
CO 4	66.6	50	-	-	-	-
CO 5	50	-	-	-	-	50
CO 6	-	66.6	-	-	-	-

XIV COURSE ARTICULATION MATRIX (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.

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	3	-	-	-	2
CO 2	2	-	-	-	-	1
CO 3	2	3	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	2	-	-	-	-	2
CO 6	-	3	-	-	-	-
Total	12	11	-	-	-	5
Average	2.4	2.75	-	-	-	1.7

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
AAT	✓	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-				

XVI ASSESSMENT METHODOLOGY INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
-	Assessment of activities / Modeling and Experimental Tools in Engineering by Experts		

XVII 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:

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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

COURSE WEB PAGE:

`https://lms.iare.ac.in/index?route=course/details&course_id=367`

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		
0	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**
Dr. Shobha Rani , Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING (EPS)**				
Course Title	**HVDC Transmission and FACTS**				
Course Code	BPSD03				
Program	M.Tech				
Semester	I				
Course Type	Program Core Elective				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	0	3	-	-
Course Coordinator	Ms. T Saritha Kumari, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC16	V	Power Electronics
B.Tech	AEEC22	VI	Power system Analysis
B.Tech	AEEC47	VII	High Voltage Engineering

II COURSE OVERVIEW:

This course deals with the importance of FACTS controllers and 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:

Subject	SEE Examination	CIA Examination	Total Marks
HVDC Transmission and FACTS	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.
The expected percentage of cognitive level of the questions is broadly based on the criteria given in below Table.

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 40 marks, with 30 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 and 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.

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8^{th} and 16^{th} week of the respectively 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. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by 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.

Quiz
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

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 include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

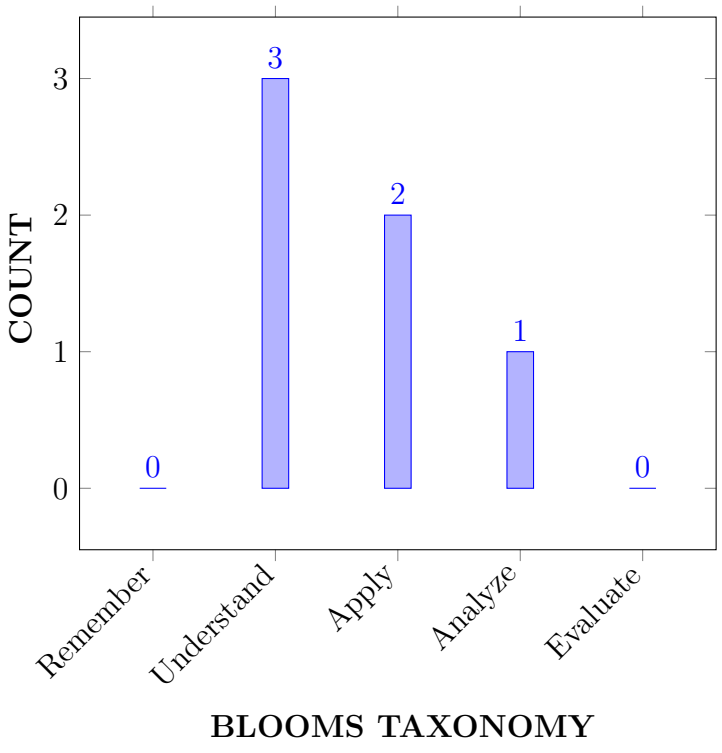
I	The fundamentals of FACTS Controllers.
II	The importance of controllable parameters and types of FACTS controllers and their benefits.
III	The basic concepts of HVDC system, components used in HVDC system and advantages of DC over AC transmission systems.
IV	The functioning of components of HVDC system 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	**Explain** the basic fundamentals of FACTS controllers.	Understand
CO 2	**Interpret** the enhancement of stability using static shunt and series compensation.	Understand
CO 3	**Model and Design** of coordinating multiple FACTS controllers UPFC and IPFC using control techniques.	Apply
CO 4	**Develop** the knowledge of HVDC transmission and HVDC converters and the applicability and advantage of HVDC transmission over conventional AC transmission.	Apply
CO 5	**Interpret** the modelling and analysis of HVDC system for inter-area power flow regulation.	Understand
CO 6	**Simplify and Solve** mathematical problems related to rectifier and inverter control methods and learn about different control schemes as well as starting and stopping of DC links.	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	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.	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.	3	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.	2	SEE/CIE/AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	2	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	✓	✓	✓	✓	-	✓

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 1	Demonstrate the importance of FACTS controllers and understand control characteristics of FACTS 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.	2
	PO 2	Apply the concepts (knowledge) of FACTS 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 FACTS transmission and understand control characteristics of FACTS 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.	5
	PO 6	Demonstrate the importance of FACTS transmission and understand control characteristics of FACTS system in life-long learning for continuing education in doctoral level studies and professional development.	2
CO 2	PO 1	Demonstrate the working of series and shunt compensation 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.	1
	PO 2	Apply the concepts (knowledge) of series and shunt compensation in stability enhancement 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. science and engineering fundamentals.	4

	PO 3	Demonstrate the working of series and shunt compensation in stability enhancement 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 and communicate effectively in writing / orally societal problems. science and engineering fundamentals.	5
	PO 4	Demonstrate the working of series and shunt compensation in stability enhancement for applying knowledge, understanding and demonstrations of power system applications in real time complex problems 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 effectively in writing / orally societal problems. science and engineering fundamentals.	3
	PO 6	Demonstrate the working of series and shunt compensation in stability enhancement in life-long learning for continuing education in doctoral level studies and professional development.	3
CO 3	PO 1	Demonstrate the importance of multiple FACTS controllers UPFC and IPFC 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.	1
	PO 2	Apply the concepts (knowledge) of multiple FACTS controllers UPFC and IPFC 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. science and engineering fundamentals.	4
	PO 3	Demonstrate the importance of multiple FACTS controllers UPFC and IPFC 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.	5
	PO 4	Apply the concepts (knowledge) of multiple FACTS controllers UPFC and IPFC 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 multiple FACTS controllers UPFC and IPFC in life-long learning for continuing education in doctoral level studies and professional development.	2
CO 4	PO 1	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 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.	5
	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.	2
	PO 6	Demonstrate the importance of AC and DC transmission and understand control characteristics of HVDC system in life-long learning for continuing education in doctoral level studies and professional development.	3
CO 5	PO 1	Demonstrate the importance of HVDC system for inter-area power flow regulation 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.	1
	PO 2	Apply the concepts (knowledge) of HVDC system for inter-area power flow regulation 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 science and engineering fundamentals.	4

	PO 3	Demonstrate the modelling 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 and manage the design process and evaluate outcomes using modern tools to get the solution development.	5
	PO 4	Apply the concepts (knowledge) of HVDC system in terms of modelling and analysis 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 HVDC system for inter-area power flow regulation in life-long learning for continuing education in doctoral level studies and professional development.	2
CO 6	PO 1	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.	1
	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.	5
	PO 4	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 complex problems and use creativity to establish innovative solutions and manage the design process and evaluate outcomes using modern tools to get the solution development.	3

	PO 6	Demonstrate the working of HVDC converter and design new innovative products in 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 OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2	4	5	-	-	2
CO 2	1	4	5	3	-	3
CO 3	1	4	5	3	-	2
CO 4	1	4	5	2	-	3
CO 5	1	4	5	3	-	2
CO 6	1	4	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	57.14	71.43	-	-	40.0
CO 2	25.0	57.14	71.43	75.0	-	60.0
CO 3	25.0	57.14	71.43	75.0	-	40.0
CO 4	25.0	57.14	71.43	50.0	-	60.0
CO 5	25.0	57.14	71.43	75.0	-	40.0
CO 6	25.0	57.14	71.43	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	2	3	-	-	1
CO 2	1	2	3	3	-	3
CO 3	1	2	3	3	-	1
CO 4	1	2	3	2	-	3
CO 5	1	2	3	3	-	1
CO 6	1	2	3	3	-	1
TOTAL	7	12	18	14	-	10
AVERAGE	1.2	2.0	3.0	2.3	-	1.7

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	-
Laboratory Practices	-	Student Viva	-	Certification	-
AAT	✓	5 Minutes Video	-	Open Ended Experiments	-
Assignments	-				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Early Semester Feedback	✓	End Semester OBE Feedback
✓	Assessment of mini projects by experts		

XVII SYLLABUS:

MODULE I	**FACTS CONCEPTS**
	Reactive power control in electrical power transmission, principles of conventional reactive power compensators. Introduction to FACTS, flow of power in AC parallel paths, meshed systems, basic types of FACTS controllers, definitions of FACTS controllers, brief description of FACTS controllers.
MODULE II	**STATIC SHUNT AND SERIES COMPENSATORS**
	Shunt compensation – objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators – SVC, STATCOM, SVC and STATCOM comparison. Series compensation – objectives of series compensation, thyristor switched series capacitors (TCSC), static series synchronous compensator (SSSC), power angle characteristics, and basic operating control schemes.
MODULE III	**COMBINED COMPENSATORS**
	Unified power flow controller (UPFC) – Introduction, operating principle, independent real and reactive power flow controller and control structure. Interline power flow controller (IPFC), Introduction to Active power filtering, Concepts relating to Reactive power compensation and harmonic current compensation using Active power filters.

MODULE IV	**HVDC TRANSMISSION**
	HVDC Transmission system: Introduction, comparison of AC and DC systems, applications of DC transmission, types of DC links, Layout of HVDC Converter station and various equipments. HVDC Converters, analysis of bridge converters with and without overlap, inverter operation, equivalent circuit representation of rectifier and inverter configurations.
MODULE V	**CONTROL OF HVDC SYSTEM**
	Principles of control, desired features of control, converter control characteristics, power reversal, Ignition angle control, current and extinction angle control. Harmonics introduction, generation, ac filters and dc filters. Introduction to multiterminal DC systems and applications, comparison of series and parallel MTDC systems, Voltage Source Converter based HVDC system.

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.

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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.

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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
PROBLEM SOLVING/ CASE STUDIES			
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			
51	Mathematical Background To Digital Protection	CO1 CO2	-
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 TEMPLATE

Department	**ELECTRICAL POWER SYSTEMS**				
Course Title	**Reactive Power Compensation and Management**				
Course Code	BPSD07				
Program	M.Tech				
Semester	I				
Course Type	Core				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. SK.Abdul Pasha , 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:

The purpose of this course is to make the students understand about load compensation and how to select various types of reactive power compensation devices in transmission systems both during steady state and transient state operation. The course also enables the students about the management of reactive power on demand side, distribution side, and utility side of the power system.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Reactive Power Compensation and Management	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 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 60 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 40 marks, with 30 marks for Continuous Internal Examination (CIE), 10 marks for Assignment and 10 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 40 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Technical Seminar and Term Paper

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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:

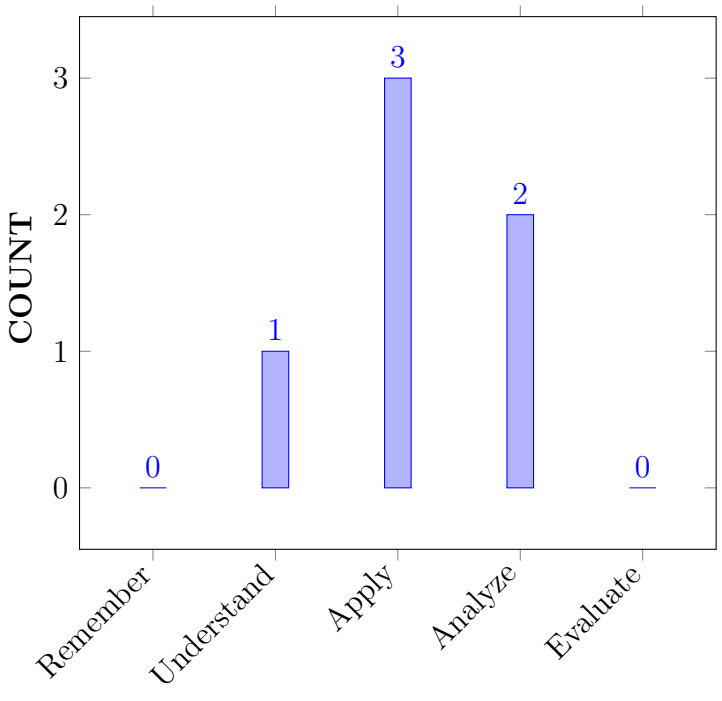
I	The objectives, specifications of reactive power compensation and the characteristics of compensation equipment used in power transmission system.
II	The use of series, shunt, passive, static and dynamic compensation equipment to maintain the reactive power under steady state operation of power system.
III	The reactive power coordination and management in demand side, distribution side and user side of power systems.

VII COURSE OUTCOMES:

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

CO 1	**Discuss** the objectives and specifications of reactive compensation for designing the compensating equipment.	Understand
CO 2	**Describe** the characteristics of an uncompensated line and a compensated line which are used for evaluating the performance of lines.	Apply
CO 3	**Examine** the mathematical modeling, operation planning and transmission benefits in reactive power coordination.	Apply
CO 4	**Describe** the load patterns, power tariffs, flicker and harmonic voltage levels used in billing the power consumers.	Apply
CO 5	**Explain** the use of different types of capacitors, their characteristics which are used in user side reactive power management.	Analyze
CO 6	**Discuss** the impact of electric traction systems and furnaces on the reactive power and suggest the user side reactive power management techniques.	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.	2	CIE/AAT
PO 2	An ability to write and present a substantial technical report / document.	3	AAT
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
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
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	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	-	✓	-	-	✓	-

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 1	Compensation methods 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 of compensation methods.	3
CO 2	PO 2	**Identify** the suitable compensation methods, 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 compensation strategies 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	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) all the converters 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**.	3
CO 4	PO 1	Identify (Knowledge) suitable switching techniques and control strategies to operate the converters with the **Knowledge of mathematics, science and engineering fundamentals related to electrical engineering**.	3

	PO 2	Design (formulate) converters 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 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**	1
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 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	✓	✓	-		✓	✓

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	100	60	-	-	-	-
CO 2	100	60	60	30	-	-
CO 3	100	60	-	30	-	-
CO 4	100	60	-	40	-	-
CO 5	100	60	-	-	100	-
CO 6	100	60	-	-	100	80

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	-	-	-	-
CO 2	3	2	2	1	-	-
CO 3	3	2	-	1	-	-
CO 4	3	2	-	1	-	-
CO 5	3	2	-	-	3	-
CO 6	3	2	-	-	3	3
TOTAL	18	12	2	3	6	3
AVERAGE	3	2	1	1	1	1

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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

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 interference

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 MTagare, "Reactive power Management", by Tata McGraw Hill, 1st Edition, 2004.Science Press, New Delhi, 2ndEdition, 2010.

REFERENCE BOOKS:

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

WEB REFERENCES:

1. NPTEL Reactive Power Compensation and Management- NOC: Planning and Operational Studies Of Reactive Power Compensation And Management.
2. NPTEL Reactive Power Compensation and Management - NOC: Explain the basic fundamental of Reactive Power Compensation and Management.
3. NPTEL Reactive Power Compensation and Management - NOC: applicability and advantage of Reactive Power Compensation and Management.

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 Objectives and Specifications of reactive power compensation	CO1	T1: 1.1
2	Basic Concept of Reactive power characteristics	CO1	T1: 1.2
3	Inductive and capacitive approximate biasing	CO1	T2: 1.1.1
4	load compensator as a voltage regulator	CO1	T2: 1.3.1

5	Phase balancing and power factor correction of unsymmetrical loads examples.	CO1	T2: 1.3.3
6	Uncompensated line	CO2	T2: 1.3.8
7	Types of compensation	CO2	T1: 2.1
8	Passive shunt and series and dynamic shunt compensation	CO2	T1: 2.1
9	Examples of transient state reactive power compensation in transmission systems	CO2	T3: 5.2
10	Characteristic time periods	CO2	T1: 5.7
11	Passive shunt compensation	CO2	T3: 5.7
12	static compensations	CO2	T2: 5.7
13	series capacitor compensation	CO2	T3: 5.7
14	compensation using synchronous condensers, examples	CO2	T1: 9.1
15	Objectives of compensation,	CO3	T1: 9.1
16	mathematical modeling	CO3	T1: 9.1
17	operation planning.	CO3	T1: 9.1
18	transmission benefits	CO3	T1: 9.1
19	basic concepts of quality of power supply	CO3	T1: 6.2
20	disturbances steady, state variations	CO3	T1: 7.1
21	Discus about Fourier- transform based algorithm	CO3	T3: 5.7
22	Effects of under voltages	CO3	T2: 5.7
23	frequency, harmonics	CO3	T1: 5.7
24	radio frequency and electromagnetic interference	CO3	T1: 5.7
25	Load patterns	CO4	T1: 2.2
26	basic methods load shaping	CO4	T1: 2.3
27	power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels	CO4	T1: 5.7
28	Distribution side reactive power management	CO4	T2: 2.1
29	System losses	CO4	T2: 2.1
30	loss reduction methods	CO4	T1: 5.7
31	objectives	CO4	T1: 2.2
32	economics planning capacitor placement	CO4	T1: 2.2
33	retrofitting of capacitor banks	CO4	T1: 2.2
34	Requirements for domestic appliances	CO5	T1: 2.3
35	purpose of using capacitors, selection of capacitors	CO6	T1: 2.3
36	deciding factors of capacitors	CO6	T1: 9.1
37	types of available capacitor	CO6	T1: 6.2
38	Load patterns	CO6	T1: 6.3
39	basic methods load shaping	CO6	T1: 6.3
40	power tariffs	CO6	T1: 6.4
PROBLEM SOLVING/ CASE STUDIES			
41	Discuss about Reactive power compensation	CO1	T1: 7.1
42	Discuss about power factor correction	CO2	T3: 5.7
43	Discuss aboutpassive shunt and series and dynamic shunt compensation	CO5	T3: 5.7

44	Discuss about Characteristic time periods	CO3	T2: 5.7
45	Discuss about Current-based differential schemes	CO6	T1: 9.1
46	Discuss about Composite voltage- and current- based scheme.	CO6	T1: 6.35
47	Composite methods.	CO6	T1: 6.36
48	reactive power planning.	CO6	T1: 6.33
49	purpose of using capacitors	CO6	T1: 6.39
50	reactive power control requirements	CO6	T1: 6.41
51	furnaces transformer	CO6	T1: 6.42
52	filter requirements	CO6	T1: 6.41
53	power factor of an arc furnace	CO6	T1: 6.41
54	transmission benefits	CO6	T1: 6.47
55	transmission parameters	CO6	T1: 6.5
DISCUSSION OF DEFINITION AND TERMINOLOGY			
56	Mathematical Background to phase balancing and power factor correction	CO1, CO2	T1: 2.1
57	Basic Elements Of compensation	CO3	T1: 3.2
58	basic concepts of quality of power supply	CO4	T1: 4.2
59	state variations	CO5	T1: 5.2
60	electromagnetic interference	CO6	T1: 6.2
DISCUSSION OF QUESTION BANK			
61	Mathematical Background To compensation methods	CO1,CO2	-
62	Basic Elements Of compensation	CO3	-
63	KVAR based tariffs	CO4	-
64	Distribution side reactive power management	CO5	-
65	Reactive power management in electric traction systems and are furnaces	CO6	-

Signature of Course Coordinator **HOD,EEE**

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

ELECTRONICS AND COMMUNICATION ENGINEERING
COURSE DESCRIPTION

Course Title	**POWER SYSTEM COMPUTATIONAL LABORATORY**				
Course Code	BPSD11				
Program	M.Tech				
Semester	I				
Course Type	Laboratory				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Mr. K Lingaswamy, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AEEC22	III	Power System Analysis

II 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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power System Computational laboratory	60 Marks	40 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 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VI COURSE OBJECTIVES:

The students will try to learn:

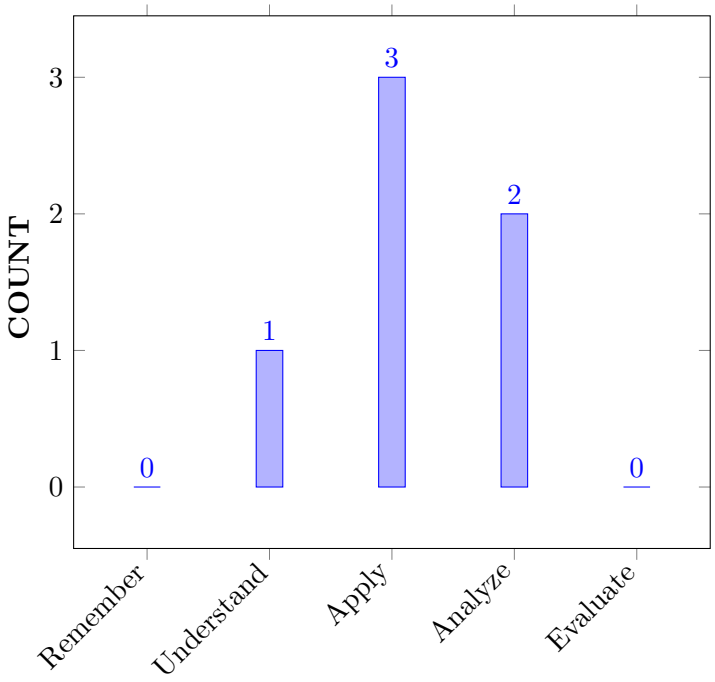
I	Construct Y bus, Z bus for a n bus system and analyze various load flow studies.
II	Understand the steady state, transient stability analysis and economic load dispatch problem.
III	State estimation of power system and unit commitment problem.

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 or state estimation of the power system.	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



BLOOMS TAXONOMY

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 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
PO1	Independently carry out research / investigation and development work to solve practical problems	2	Laboratory practices, student viva
PO2	An ability to write and present a substantial technical report / document.	1	Laboratory Practices, student viva
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	Laboratory Practices, student viva
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	Laboratory Practices, Mini-Project
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	3	Laboratory Practices, Mini-Project
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	3	Laboratory Practices, Mini-Project

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	PO4	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	-

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. 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.	CO4	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 6	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. K Lingaswamy, Assistant Professor

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

ELECTRICAL AND ELECTRONICS AND ENGINEERING
COURSE DESCRIPTION

Course Title	**Internet of Things Laboratory**				
Course Code	BPSD12				
Program	M.Tech				
Semester	I				
Course Type	Laboratory				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	3	2
Course Coordinator	Kumbha . Venkata Siva Rao, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
B.Tech	AECC14	IV	Embedded C

II COURSE OVERVIEW:

This laboratory course is designed to provide students with practical experience in designing and implementing ARM Cortex Architecture and Programming Laboratory. The following experiments are to be performed on ARM Cortex- M TM4C123 Microcontroller using Embedded C.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Cyber Security 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 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 10 marks for the final internal lab assessment and remaining 10 marks for The remaining 10 marks are for Laboratory Report/Project and Presentation, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 10 marks for final internal lab assessment and remaining 10 marks for Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Table 3: Programming based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VI COURSE OBJECTIVES:

The students will try to learn:

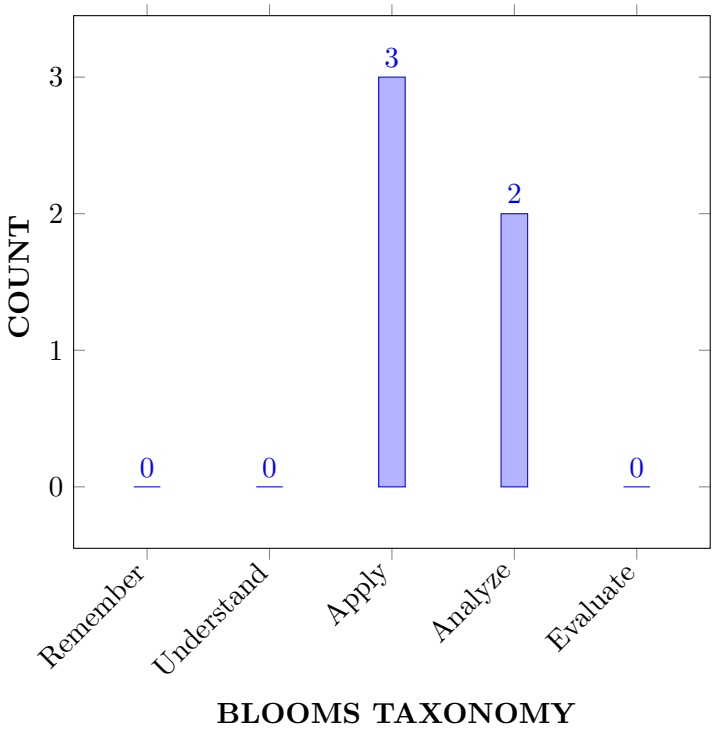
I	The IoT using Arduino programming
II	Interfacing of data, I/O devices with Arduino UNO.
III	Digital protection schemes in power system relays.

VII COURSE OUTCOMES:

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

CO 1	**Understand** the concept of Internet of Things for implementation of digital measuring devices.	Understand
CO 2	Develop the Arduino programming for controlling lightning appliances.	Apply
CO 3	**Analyze** the characteristics of Bluetooth modules for controlling the performance of appliances.	Apply
CO 4	**Apply** the features of various algorithms applicable for protection of Transformers and transmission lines.	Apply
CO 5	**Categorize** the digital relying algorithms for protection of three phase induction motor.	Analyze
CO 6	**Analyze** the various algorithms applicable for over current protection.	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 higher than the requirements in the appropriate bachelor program.
PO 4	Identify, formulate and solve real-time problems with advanced-level knowledge, techniques, skills, and modern tools in computer science thrust areas.
PO 5	Function effectively in multidisciplinary environments with the knowledge of frontier technologies by working cooperatively, creatively, and responsively as a member or leader in diverse teams.
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
PO1	Independently carry out research / investigation and development work to solve practical problems	2	Laboratory practices, student viva
PO2	Write and present a substantial technical report / document	1	Laboratory Practices, student viva
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.	2	Laboratory Practices, student viva
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at designing embedded systems for effective use in communications, IoT, medical electronics and signal processing applications	3	Laboratory Practices, Mini-Project
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	3	Laboratory Practices, Mini-Project
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	3	Laboratory Practices, Mini-Project

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	PO4	PO 5	PO 6
CO 1	2	1	2	3	3	3
CO 2	2	2	2	3	3	3
CO 3	2	2	2	3	3	3
CO 4	3	2	2	3	3	3
CO 5	3	2	2	3	3	3
CO 6	3	1	2	3	3	3

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	**ARDUINO BASED DIGITAL VOLTMETER, AMMETER**
	Design of digital voltmeter and ammeter using Arduino.
WEEK II	**ARDUINO BASED WATTMETER, ENERGY METER**
	Design of digital wattmeter and energy meter using Arduino.
WEEK III	**CONROLLING RGB LED**
	Programming for Controlling RGB LED using Arduino and Wi-Fi module.
WEEK IV	**IOT TO CONTROL REMOTE LED**
	Programming for Internet of things with Android and Arduino. Build an Arduino based IoT to control a remote LED.
WEEK V	**INTERFACING BLUETOOTH MODULE**
	Programming for how to interface HC-05 Bluetooth module with Arduino UNO for control of small dc motor. .
WEEK VI	**INTERFACING TO TEMPERATURE SENSOR**
	Programming to Interface temperature sensor and monitoring the room temperature using IoT with Arduino Uno and display the digital value on LCD screen.
WEEK VII	**INTERFCAING IR SENSOR**
	Programming to Interface IR sensors and Bluetooth for detecting obstacle using Arduino with android Application. .

WEEK VIII	**INTERFACE TO MOTION AND GAS SENSOR**
	Programming to interface a motion sensor to use GPIO pins with a Raspberry Pi Programming to interface Gas sensor for detection and monitoring of harmful gases using Arduino and IoT. .
WEEK IX	**SEND DATA FROM ARDUINO TO WEB PAGE**
	Programming for how to send data from Arduino to Webpage using Wi-Fi module.
WEEK X	**DIGITAL PROTECTION OF THREE PHASE INDUCTION MOTOR**
	Studying the ON / OFF control strategies of small dc motor using IoT
WEEK XI	**DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES**
	Study the protection schemes of three phase induction motor against over current and under voltage at remote location through IoT
WEEK XII	**OVER CURRENT RELAY**
	Design of over current relay in distribution system and displaying the tripping status of the relay through IoT .

TEXTBOOKS

1. **Internet of things and its applications** M.Anantha Guptha
2. **Inside the Internet of Things (IoT)** Jonathan Holdowsky, Monika Mahto, Michael E. Raynor and Mark Cotteleer.

REFERENCE BOOKS:

1. Mark Torvalds, "Arduino Programming: Step-by-step guide to mastering arduino hardware and software (Arduino, Arduino projects, Arduinouno, Arduino starter kit, Arduino ide, Arduinoyun, Arduino mega, Arduinonano) Kindle 2ndEdition, 2001.
2. Michael J Pont, "Embedded C", Pearson Education, 2ndEdition, 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	ARDUINO BASED DIGITAL VOLTMETER, AMMETER: Design of digital voltmeter and ammeter using Arduino. .	CO 1	T1:1.1,1.2
2	ARDUINO BASED WATTMETER, ENERGY METER : Design of digital wattmeter and energy meter using Arduino.	CO 2	T1:1.3,1.6
3	CONROLLING RGB LED : Programming for Controlling RGB LED using Arduino and Wi-Fi module.	CO 3	T1:9,1.12
4	IOT TO CONTROL REMOTE LED : Programming for Internet of things with Android and Arduino. Build an Arduino based IoT to control a remote LED	CO 4	T1:17.1,1.23
5	INTERFACING BLUETOOTH MODULE : Programming for how to interface HC-05 Bluetooth module with Arduino UNO for control of small dc motor.	CO 4	T2:11.1,1.8

6	INTERFACING TO TEMPERATURE SENSOR : Programming to Interface temperature sensor and monitoring the room temperature using IoT with Arduino Uno and display the digital value on LCD screen. .	CO4	T2:10.1,10.4
7	INTERFCAING IR SENSOR : Programming to Interface IR sensors and Bluetooth for detecting obstacle using Arduino with android Application.	CO 4	T2:11.2-11.4
8	INTERFACE TO MOTION AND GAS SENSOR : Programming to interface a motion sensor to use GPIO pins with a Raspberry Pi Programming to interface Gas sensor for detection and monitoring of harmful gases using Arduino and IoT. .	CO 5	T2:9.1,1.6
9	SEND DATA FROM ARDUINO TO WEB PAGE : Programming for how to send data from Arduino to Webpage using Wi-Fi module. .	CO 5	T2:10.2-11.4
10	DIGITAL PROTECTION OF THREE PHASE INDUCTION MOTOR : Studying the ON / OFF control strategies of small dc motor using IoT.	CO 5	T2:9.2-11.4
11	DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES : Study the protection schemes of three phase induction motor against over current and under voltage at remote location through IoT	CO 6	T1:12,1.9
12	OVER CURRENT RELAY : Design of over current relay in distribution system and displaying the tripping status of the relay through IoT .	CO 6	T2:1.1,1.5

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Describe how you could modify the circuit to measure higher voltages beyond the Arduino's ADC limits.
2	What is the principle behind the operation of a wattmeter and energy meter using Arduino?
3	Explain the role of a communication protocol (e.g., HTTP or MQTT) in IoT. Which protocol would you use for controlling a remote LED, and why? .
4	Describe a scenario where controlling an LED remotely via IoT could be practically useful.
5	Explain the role of the AT commands in configuring the HC-05 Bluetooth module. Provide an example of an AT command and its use. .

Signature of Course Coordinator **HOD,EEE**
Kumbha. Venkata Siva Rao, Assistant Professor

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

COURSE TEMPLATE

Department	**Electrical and Electronics Engineering**				
Course Title	**Digital Protection of Power System**				
Course Code	BPSD13				
Program	M.Tech				
Semester	II				
Course Type	Core				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr. S.Manohar , 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	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 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 60 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 40 marks, with 20 marks for Continuous Internal Examination (CIE), 10 marks for Assignment and 10 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 40 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	30	5	5	40

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:

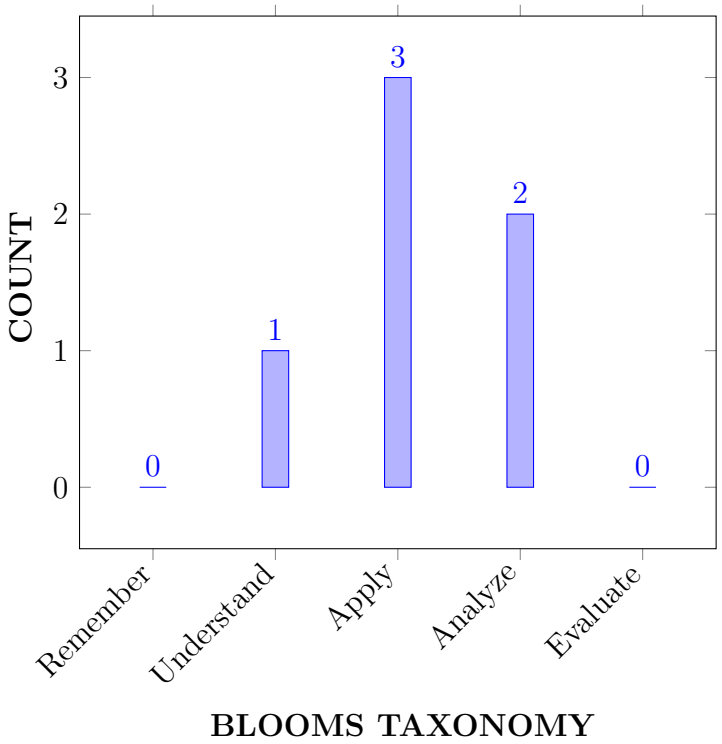
I	The need of numerical relays and their importance in digital protection of the power system.
II	The mathematical approach towards designing algorithms for the protection of power system.
III	The methods of protection employed for the transformers and transmission lines.

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.	2	CIE/AAT
PO 2	An ability to write and present a substantial technical report / document.	3	AAT
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
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
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	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	-	✓	-	-	✓	-
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

2-4	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 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	✓	✓	-	✓	-	-

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

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	-	-	-	-
CO 2	3	2	2	-	-	-
CO 3	3	2	-	-	-	-
CO 4	3	2	-	1	-	-
CO 5	3	2	-	1	-	-
CO 6	3	2	-	1	-	-
TOTAL	18	12	2	3	-	1
AVERAGE	3	2	1	1	-	1

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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

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 superimposed component trajectory-based Scheme	CO6	T1: 2.2

35	Discuss about superimposed component trajectory-based Scheme	CO6	T1: 2.2
36	Discuss about Principles of transformer protection	CO6	T1: 2.3
37	Discuss about Principles of transformer protection	CO6	T1: 2.3
38	Discuss about digital protection of Transformer using FIR filter-based algorithm	CO6	T1: 9.1
39	Discuss about least squares curve fitting based algorithms	CO5	T1: 6.2
PROBLEM SOLVING/ CASE STUDIES			
40	Discuss about Fourier-based algorithm	CO5	T1: 7.1
41	Discuss about flux-restrained current differential relay	CO5	T3: 5.7
42	Discuss about flux-restrained current differential relay	CO5	T3: 5.7
43	Discuss about Digital Line differential protection	CO6	T2: 5.7
44	Discuss about Current-based differential schemes	CO6	T1: 9.1
45	Discuss about Composite voltage- and current- based scheme.	CO6	T1: 6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
47	Mathematical Background To Digital Protection	CO1, CO2	T1: 2.1
48	Basic Elements Of Digital Protection	CO3	T1: 3.2
49	Digital Relaying Algorithms-I	CO4	T1: 4.2
50	Digital Relaying Algorithms-II	CO5	T1: 5.2
51	Digital Protection Of Transformers And Transmission Lines	CO6	T1: 6.2
DISCUSSION OF QUESTION BANK			
52	Mathematical Background To Digital Protection	CO1 CO2	-
53	Basic Elements Of Digital Protection	CO3	-
54	Digital Relaying Algorithms-I	CO4 -	
55	Digital Relaying Algorithms-II	CO5	-
56	Digital Protection Of Transformers And Transmission Lines	CO6	-

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS ENGINEERING (EPS)**				
Course Title	**POWER SYSTEM DYNAMICS AND STABILITY**				
Course Code	BPSD14				
Program	M.Tech				
Semester	I				
Course Type	Professional Core				
Regulation	MT23				
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	AEED22	VI	Power System Analysis
B.Tech	AEED34	VII	Power system Protection

II COURSE OVERVIEW:

This course will teach fundamentals on power system modeling, dynamics, stability and control, introduce the methods and tools for planning and operating a modern power grid to meet reliability criteria under disturbances. There will be moderate work on coding in MATLAB or using professional power system software for power system studies.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Modern Power System Analysis	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
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 40 marks, with 30 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 and 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

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

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:

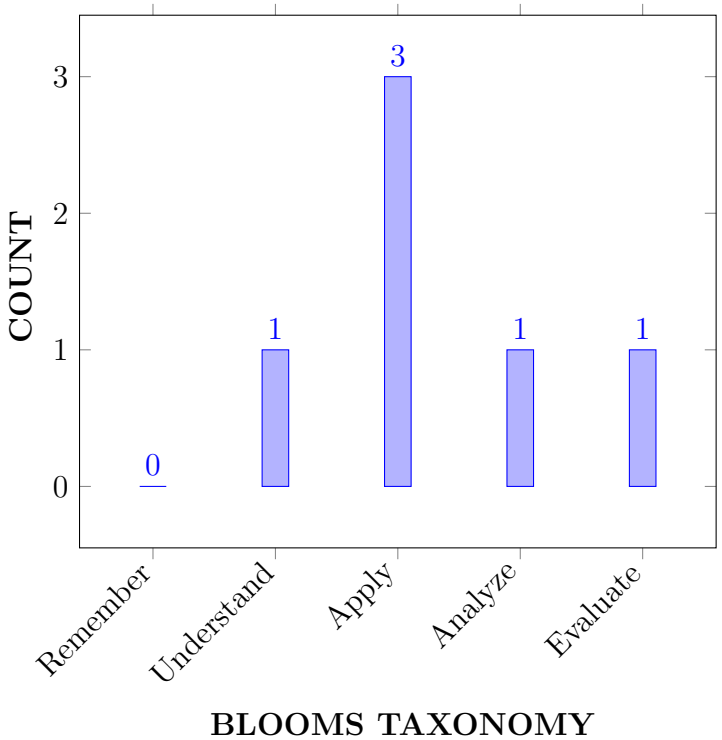
I	Mathematical models for synchronous machine, Exciter, Governor and Prime mover.
II	Power system dynamic phenomena and the effects of exciter and governor control.
III	The methods to improve dynamic stability.

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.	Appply
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	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 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
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
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	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	-	-	✓	✓	-	✓
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 OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	-	-	4	5	-	-
CO 2	-	-	6	5	-	-
CO 3	-	-	5	5	-	-
CO 4	-	-	5	5	-	2
CO 5	-	-	6	5	-	2
CO 6	-	-	6	5	-	-

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	-	-	40	50	-	-
CO 2	-	-	60	50	-	-
CO 3	-	-	50	50	-	-
CO 4	-	-	50	50	-	20
CO 5	-	-	60	50	-	20
CO 6	-	-	60	50	-	-

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	-	-	3	2	-	-
CO 3	-	-	2	2	-	
CO 4	-	-	2	2	-	1
CO 5	-	-	2	2	-	1
CO 6	-	-	3	2	-	-

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
TOTAL	-	-	14	12	-	2
AVERAGE	-	-	2.3	2	-	1

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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

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
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	CO 1	T4:9.41, R1:3.1-3.2
2	Requirements of a reliable electrical power service	CO 1	T4:9.41, R1:3.1-3.2
3	Swing equation	CO 1	T4:9.4.1, R1:3.1-3.2

4	Power-angle curve	CO 1	T4:9.4.1, R1:3.1-3.2
5	Stability analysis of SMIB system	CO 1	T4:9.4.3, R1:3.3-3.5
6	Equal area criteria,	CO 1	T4:9.4.3, R1:3.3-3.5
7	Classical model of a multi-machine system	CO1	T4:9.2, R1:3.3-3.5
	Shortcomings of the classical model	CO1	T4:9.2, R1:3.3-3.5
8	Block diagram of one machine	CO 1	T4:9.2, R1:3.3-3.5
9	System response to small disturbances	CO 1	T4:9.2, R1:3.3-3.5
10	Types of problems studied	CO 1	T4:9.2, R1:3.3-3.5
11	The unregulated synchronous machine	CO 1	T4:9.2, R1:3.3-3.5
12	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	Introduction	CO 2	T4:9.3-9.5, R1:4.2
14	Park's Transformation	CO 2	T4:9.3-9.5, R1:4.2
15	Flux linkage equations	CO 2	T4: 9.3-9.5, R1:4.3-4.4
15	Voltage equations	CO 2	T4: 9.3-9.5, R1:4.3-4.4
16	Formulation of state- space equations	CO 2	T4: 9.3-9.5, R1:4.3-4.4

17	Current formulation	CO 2	T4: 9.3-9.5, R1:4.3-4.4
18	Per unit conversion	CO 2	T4:9.1, R1:8.1
18	Normalizing the voltage and torque equations	CO 2	T4:9.1, R1:8.1
19	Equivalent circuit of a synchronous machine	CO 2	T4:9.8, R1:8.2
20	The flux linkage state-space model	CO 2	T4:9.8, R1:8.2
21	load equations	CO 2	T4:9.9.1, R1:9.2
21	Sub-transient and transient inductances and time constants	CO 2	T4:9.9.1, R1:9.2
22	Simplified models of the synchronous machine.	CO 2	T4:9.8, R1:9.2
22	Turbine generator dynamic models.	CO 2	T4:9.8, R1:9.2
23	Steady state equations and phasor diagrams	CO 3	T4:9.10, R1:9.2
24	Determining steady state conditions	CO 3	T4:9.10, R1:9.2
25	Evaluation of initial conditions	CO 3	T4:9.11.2, R1:9.2
26	Determining steady state conditions	CO 3	T4:9.10, R1:9.2
27	Simplified view of excitation control	CO 4	T4:9.12, R1:9.2
28	Control configurations,	CO 4	T4:9.12, R1:9.2
29	typical excitation configurations	CO 4	T4:9.4.12, R1:9.2
30	Excitation control system definitions	CO 4	T4:9.4.12, R1:9.2
31	voltage regulator	CO 3	T4:10.3, R1:6.1-6.3
32	Exciter buildup	CO 3	T4:10.3, R1:6.1-6.3
33	Excitation system response	CO 3	T4:10.3, R1:6.1-6.3
34	State-space description of the excitation system	CO 4	T4:10.4, R1:6.4

35	Computer representation of excitation systems	CO 4	T4:10.4, R1:6.4
36	Typical system constants	CO 4	T4:10.5, R1:6.4
36	The effects of excitation on generator power limits	CO 4	T4:10.5, R1:6.4
37	Transient stability	CO 4	T4:10.6, R1:6.3
38	Dynamic stability of the power system	CO 4	T4:10.6, R1:6.3
39	Prime mover contro	CO 4	T4:10.7, R1:6.3
40	Hydraulic turbines	CO 4	T4:10.7, R1:6.3
41	Governing systems	CO 4	T4:10.7, R1:6.3
42	Steam turbines and governing systems	CO 4	T4:10.7, R1:6.3
43	Short Circuit Analysis	CO 4	T4:10.7, R1:6.3
44	Short Circuit Current	CO 4	T4:10.7, R1:6.3
45	MVA CalculationsSolving numerical problems (Symmetrical fault Analysis).	CO 4	T4:10.7, R1:6.3
46	Fundamental concepts of stability of dynamic systems	CO 5	T4:10.5, R1:6.3
47	Eigen properties of the state matrix	CO 5	T4:10.5, R1:6.3
48	Small-signal stability of a single-machine infinite bus system	CO 5	T4:10.13, R1:6.3
49	Effects of excitation system	CO 5	T4:10.13, R1:6.3
50	Power system stabilizer	CO 5	T4:10.13, R1:6.1-6.3
51	System state matrix with amortizes characteristics of small-signal stability problems.	CO 5	T4:10.13, R1:6.1-6.3
52	Determine LLG fault with and without fault impedance	CO 5	T4:10.16, R1:6.1-6.3
53	Numerical problems.	CO 5	T4:10.16, R1:6.1-6.3
54	Compare LG, LL, LLG faults with and without fault impedance and numerical problems.	CO 5	T4:10.17, R1:6.1-6.3

55	Numerical problems	CO 5	T4:10.17, R1:6.1-6.3
56	Introduction to steady state, dynamic and transient stabilities.	CO 5	T4:13.1, R1:10.1
57	Description of steady state stability power limit, transfer reactance, synchronizing power coefficient.	CO 5	T4:13.2, R1:10.3
58	Transfer reactance synchronizing power coefficient.	CO 5	T4:13.2, R1:10.3
59	Synchronizing power coefficient.	CO 5	T4:13.2, R1:10.3
60	Plot Power Angle Curve	CO 5	T4:13.2, R1:6.4
60	determination of steady state stabilit	CO 5	T4:13.2, R1:6.4
61	Explain methods to improve steady state stability	CO 5	T4:13.2, R1:10.3
62	Derivation of swing equation.	CO 6	T4:13.3, R1:10.2
63	Determination of transient stability by equal area criterion.	CO 6	T4:13.6, R1:10.5
64	Application of equal area criterion to different cases.	CO 6	T4:13.7, R1:10.5
65	Discuss importance of critical clearing angle calculation.	CO 6	T4:13.6, R1:10.5
66	Solving numerical problems on equal area criteria.	CO 6	T4:13.7, R1:10.5
67	Solution of swing equation: point-by- point method.	CO 5	T4:13.7, R1:10.5
DISCUSSION OF QUESTION BANK			
68	UNIT I: Power System Stabilit and Classical Apporach	CO1, CO2	T1: 2.1
69	UNIT II: Synchronous machine modeling-I	CO3	T1: 3.2
70	UNIT III: Synchronous machine modeling-II	CO4	T1: 4.2
71	UNIT IV: Excitation and Prime Mover Control	CO5	T1: 5.2
72	UNIT V: Small Signal Stability Analysis	CO6	T1: 6.2

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Department	**ELECTRICAL AND ELECTRONICS AND ENGINEERING**				
Course Title	**INDUSTRIAL LOAD MODELLING AND CONTROL**				
Course Code	BPSD16				
Program	M.Tech				
Semester	II				
Course Type	Elective				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Mr.K.Venkata Siva Rao, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	BPSD16	II	Industrial Load Modelling and Control

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	CIE Examination	Total Marks
Embedded Systems for Machine Learning	60 Marks	40 Marks	100

IV DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 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 shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / 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. CIA is conducted for a total of 40 marks, with 30 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 and 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

Table 3: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	CIA - I	CIA - II	SEE	Total Marks
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. 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.

Assignment:

To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by 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.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

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 include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

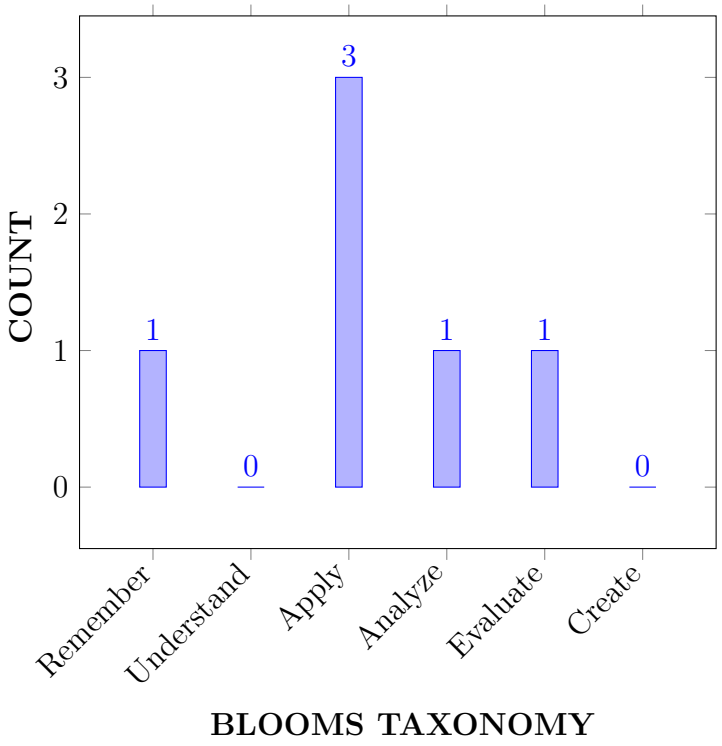
I	Understand the energy demand scenario..
II	Explain the modeling of load and its ease to study load demand industrially..
III	Describe electricity pricing models..
IV	Study reactive power management in industries.

VII COURSE OUTCOMES:

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

CO 1	**Illustrate** Electrical Energy scenario of demand side and load side Management. for demand side management .	Remember
CO 2	**Understand** Describe the load Control models and algorithms. Understand the direct load and interruptible load control.	Apply
CO 3	**Understand** cooling and Heating loads and control Strategies. Summarize the modeling and cool storage of loads.	Evaluate
CO 4	**Apply** Explain control and operating strategies of capacitive power unity. Narrate power cooling and energy banking.	Apply
CO 5	**Analyze** optimal operating strategies Design integrated load management for industries.	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 skilful at load modelling for effective use in industrial.
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	SEE/CIE/AAT
PO 2	Write and present a substantial technical report / document.	2	SEE/CIE/AAT
PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	1	SEE/CIE/AAT

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	3	SEE/CIE/AAT
PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	3	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	✓	✓	-	✓	✓	✓
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	Independently carry out research / investigation and development work to solve practical problems.	3
	PO 2	Write and present a substantial technical report / document	5
	PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	2
	PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	2
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2
CO 2	PO 1	Independently carry out research / investigation and development work to solve practical problems.	3
	PO 2	Write and present a substantial technical report / document	5
	PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	2
	PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	2
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2

Course Outcomes	PO'S PSO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 3	PO 1	Independently carry out research / investigation and development work to solve practical problems.	3
	PO 2	Write and present a substantial technical report / document	5
	PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	2
	PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	2
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2
CO 4	PO 1	Independently carry out research / investigation and development work to solve practical problems.	3
	PO 2	Write and present a substantial technical report / document	5
	PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	2
	PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	2
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2
CO 5	PO 1	Independently carry out research / investigation and development work to solve practical problems.	3
	PO 2	Write and present a substantial technical report / document	5
	PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	2
	PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	2
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2
CO 6	PO 1	Independently carry out research / investigation and development work to solve practical problems.	3
	PO 2	Write and present a substantial technical report / document	5
	PO 4	Apply the skills and knowledge needed to serve as a professional engineer skilful at industrial load modelling.	2
	PO 5	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	2
	PO 6	Recognize the need to engage in lifelong learning through continuing education and research.	2

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
	3	10	9	10	5	8
CO 1	3	5	-	4	3	3
CO 2	3	5	-	4	3	3
CO 3	3	5	-	4	3	3
CO 4	3	5	-	4	3	3
CO 5	3	5	-	4	3	3
CO 6	3	5	-	4	3	3

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO:

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 10	PO 12
	3	10	9	10	5	8
CO 1	100	50	-	40	60	37.5
CO 2	100	50	-	40	60	37.5
CO 3	100	50	-	40	60	37.5
CO 4	100	50	-	40	60	37.5
CO 5	100	50	-	40	60	37.5
CO 6	100	50	-	40	60	37.5

XIV COURSE ARTICULATION MATRIX (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	2	-	1	2	1
CO 2	3	2	-	1	2	1
CO 3	3	2	-	1	2	1
CO 4	3	2	-	1	2	1
CO 5	3	2	-	1	2	1
CO 6	3	2	-	1	2	1
TOTAL	**18**	**12**	**-**	**6**	**12**	**6**
AVERAGE	**3**	**2**	**-**	**1**	**2**	**1**

XV ASSESSMENT METHODOLOGY DIRECT:

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

XVI 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**
	Combining Multiple Learners– Model Combination schemes, voting, Bagging, Boosting.

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. I.J.Nagarath and DPKothari, .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

XVII 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	-	https://lms.iare.ac.in/index?route=course/details
CONTENT DELIVERY (THEORY)			
2	Need for Electric Energy Scenario.	CO1	T1:1.1
3	Basic demand side management.	CO1	T1:2,3,4
4	Introduction to industrial load management	CO1	T4:9.4.3
5	Single line diagram load curves.	CO1	T1:1.13 R4:3.4
6	Per phase load shaping objectives	CO1	T1:1.10- 1.11
7	Tri Generation	CO1	T1:2.3,3.1
8	Generator, methodologies	CO1	R4:3.1-3.2
9	Barriers	CO1	T4:9.4
10	Construction classification of industrial loads.	CO2	T1:7.1-7.10
11	Construction classification of load modelling control.	CO2	T1:7.1-7.11
12	Construction of continuous and batch processes.	CO2	T1: 8.1-8.7
13	Importance of power load modeling.	CO2	T1: 9.1 R4:6.1,6.4

14	Classification Direct load control.	CO2	T1:8.1 R4:6.1
15	Development of power flow interruptible load control.	CO2	T1:9.1 R4:6.1
16	Iterative solution bottom up approach	CO2	T1:9.2 R4:6.2
17	Scheduling, formulation of load models	CO2	T4:9.1
18	Iterative optimization and control algorithms.	CO3	T1:9.3-9.4 R4:6.3
19	Decoupled and fast case studies.	CO3	T1:9.7 R4:6.9
20	Reactive power management in industries.	CO3	T4:9.7 R4:6.10
21	Power flow controls power quality impacts.	CO3	T4:9.4.12
22	Application of filters.	CO3	T4:10.3
23	Importance of energy saving in industries.	CO3	T1:10.1- 10.2
24	Cooling and heating loads.	CO3	T1:8.2 R1:6.1-6.3
25	Load profiling.	CO3	T1:8.3
26	Computations of modeling.	CO4	T4:10.5
27	Classification of load modeling.	CO4	T4:10.6
28	Introduction to cool storage.	CO4	T1:11.1- 11.2
29	Types of cool storages.	CO4	T1:11.7
30	Control strategies.	CO4	T1:11.6
31	Optimal operation.	CO4	T1-3.5
32	Estimation of external loads.	CO4	T1-3.5
33	Operating problem formulation.	CO4	T1:15.1
34	Case studies, Captive power UNITs.	CO5	T1:14.1
35	Operating and control strategies.	CO5	T1-7.10,11
36	Power pooling.	CO5	T1-7.10,12
37	Power system operation models,	CO5	T1:14.3
38	Energy banking	CO5	T1:14.4
39	Selection of schemes	CO5	T1:14.4
40	Optimal operating strategies.	CO5	T1-7.10.
41	Industrial co generation.	CO5	T1-7.10.
42	Co generation system design and analysis.	CO5	T1-7.11.
43	General Considerations and Definitions.	CO5	T1-7.12.
44	Basic Co generation Systems.	CO5	T1-8.1.
45	Steam Turbine Systems.	CO5	T1-8.2.
46	Peak load saving.	CO6	T1:8.3
47	Constraints problem formulation.	CO6	T1:15.1
48	Electric Load Management	CO6	T1:15.2
49	Case study	CO6	T1:15.3
50	Integrated load management for industries.	CO6	T1:15.4
51	Optimal operating strategies	CO6	T1:15.5
52	The Cost of Electricity Supply	CO6	T1:15.6
53	Impact of Load Management on the Total Electricity System	CO6	T1:15.7
54	Example of Industrial Load Management	CO6	T1:15.8
55	Load Management in Selected Industries	CO6	T1:15.9

56	Load Management in Selected Industries	CO6	T1:16.1
DISCUSSION OF QUESTION BANK			
57	Introduction to Types of cool storages	CO1	T1:4.6
58	Classification of industrial loads.	CO2	T1:5.11
59	Summarize Load profiling techniques in loads.	CO3	T1:7.1
60	Compare which power plant has lowest running cost?	CO4	T1: 7.10
61	Summarize the overview of load management?	CO5	T1:4.2

Course Coordinator: **HOD, EEE**
Mr.K.Venkata Siva Rao, Assistant Professor

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

COURSE DESCRIPTION

Department	**ELECTRICAL POWER SYSTEMS**				
Course Title	**POWER QUALITY**				
Course Code	BPSD20				
Program	M.Tech				
Semester	II	EPS			
Course Type	Elective				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr D. Shobha Rani, Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
M.Tech	BPSD03	I	HVDC Transmission and FACTS

II COURSE OVERVIEW:

This course deals with the basic concepts power quality problems, mitigation techniques used to improve power quality in distribution system. This course is designed to construct study of characterization of voltage sag magnitude and three phase unbalanced voltage sag. This course also concludes with the behavior of power electronics loads, induction motors and synchronous motors.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
POWER QUALITY	60 Marks	40 Marks	100

IV 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 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE). Out of 40 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 shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / 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. CIA is conducted for a total of 40 marks, with 30 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 and 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

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. 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.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by 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.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

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 include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

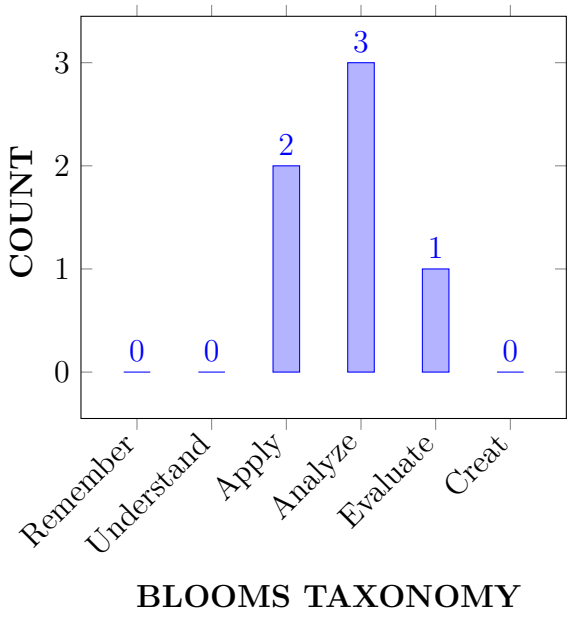
I	Power quality issues in distribution and transmission system.
II	The characterization of voltage unbalance in three phase system.
III	The power quality improvement in different load conditions.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the Power Quality problem by applying the techniques to mitigate them.	Apply
CO 2	**Analyze** the methodology to improve the power quality for sensitive loads by various custom power devices.	Analyze
CO 3	**Analyze** the difference between failure, outage and Interruptions for reliability evaluation to power quality	Analyze
CO 4	**Analyze** e the voltage sag and swell basedpower quality problem in Single phase and three phase system for deenergization of large load	Analyze
CO 5	**Identify** the Power Quality problems in Industry power systems for harmonic distortions in the nonlinear loads.	Apply
CO 6	**Evaluate** power quality monitoring and classification mitigating techniques for the quality of voltage and current produced by a power plant.	Evaluate

COURSE KNOWLEDGE COMPETENCY LEVEL



VIII 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	CIE/SEE/AAT
PO 2	**An ability** to write and present a substantial technical report / document.	2	CIE/SEE/AAT
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/SEE/AAT
PO 6	**Engage** in life-long learning for continuing education in doctoral level studies and professional development.	2	CIE/SEE/AAT

3 = High; 2 = Medium; 1 = Low

IX MAPPING OF EACH CO WITH PO(s),PSO(s):

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

X 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
CO 1	PO 1	**Apply** the knowledge of mathematics, science, engineering fundamentals for identify the sources of various **power quality problems in distribution system.**	3
	PO 3	research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics for Understand the factors that causes the harmonics and their effect	2
CO 2	PO 1	Explain the operating principles of renewable energy sources using science and engineering fundamentals	3
	PO 2	Analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics for Understand the factors that causes the harmonics and their effect on the power system	2

CO 3	PO 1	Recall power flow in transmission lines for stable operation of power systems for using principles of mathematics, science and engineering fundamentals.	3
CO 4	PO 1	Demonstrate the Static VAR Compensator, its configuration using basics engineering sciences.	3
	PO 2	Analyze the encompassing capabilities of voltage regulation, series compensation, and phase shifting in electrical components..	2
CO 5	PO 1	Recall the knowledge about the real and reactive power flow in the lines in order to maximize the power transmission using basics of mathematics and engineering sciences.	3
	PO 6	Analyze the Static Synchronous Compensator (STATCOM) and Thyristor Controlled Series Capacitor (TCSC) in life-long learning	2
CO 6	PO 1	Recall the importance of controllers according to the necessities	3
	PO 6	Mode l the SSSC involves power flow Studies which include the calculation of bulbar voltage, branch loadings, and real, reactive transmission losses in life-long learning	2

XI TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

COURSE OUTCOMES	**Program Outcomes/ No. of Key Competencies Matched**					
	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-
CO 2	3	2	-	-	-	-
CO 3	3	-	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	3	-	-	-	-	2
CO 6	3	-	-	-	-	2

XII PERCENTAGE OF KEY COMPETENCIES FOR CO – (PO, PSO):

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	100	0.0	0.0	0.0	0.0	0.0
CO 2	100	40	0.0	0.0	0.0	0.0
CO 3	100	0.0	0.0	0.0	0.0	0.0
CO 4	100	40	0.0	0.0	0.0	0.0
CO 5	100	0.0	0.0	0.0	0.0	100
CO 6	100	0.0	0.0	0.0	0.0	100

XIII 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≤ C≤ 5% – No correlation
1-5 <C≤ 40% – Low/ Slight
2 - 40 % <C < 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	3	-	-	-	-	-
CO 2	3	2	-	-	-	-
CO 3	3	-	-	-	-	-
CO 4	3	2	-	-	-	-
CO 5	3	-	-	-	-	2
CO 6	3	-	-	-	-	2
TOTAL	18	4	2	-	-	4
AVERAGE	3.0	2	2	-	-	2

XIV 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	-	-	-	-	

XV ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XVI SYLLABUS:

MODULE I	**INTRODUCTION**
	Introduction of the power quality (PQ): Problem, terms used in PQ voltage, sag, swell, surges, harmonics, over voltages, spikes, voltage fluctuations, transients, interruption, overview of power quality phenomenon, remedies to improve power quality, power quality monitoring.
MODULE II	**LONG AND SHORT INTERRUPTIONS**
	Interruptions: Definition, difference between failures, outage, interruptions, causes of long interruptions , origin of interruptions, limits for the interruption frequency, limits for the interruption duration, costs of interruption, overview of reliability evaluation to power quality, comparison of observations and reliability evaluation; Short Interruptions: Definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems, multiple events, single phase tripping, voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions
MODULE III	**SINGLE AND THREE-PHASE VOLTAGE SAG CHARACTERIZATION**
	Voltage sag: Definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults: Phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.
MODULE IV	**POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER**
	Voltage sag; Equipment behavior of power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation, mitigation of ac drives, adjustable speed dc drives and its operation, mitigation methods of dc drives
MODULE V	**MITIGATION OF INTERRUPTIONS AND VOLTAGE SAG**
	Overview of mitigation methods: From fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods; System equipment interface: Voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

TEXTBOOKS

1. Math H J Bollen,"Understanding Power Quality Problems", IEEE Press, 1st Edition, 2007.

2. Sastry Vedam Mulukutla S Sarma, "Power Quality VAR Compensation in Power Systems", R,CRC Press, 1st Edition, 2004.

REFERENCE BOOKS:

1. G T Heydt, "Electric Power Quality", (West Lafayette, IN, Stars in a circle Publications, 1 st Edition, 1994.

2. A Ghosh, G Ledwich, "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic, 1 st Edition, 2002.

XVII 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 Objectives, Course Outcomes, CO-PO Mapping, Blooms Taxonomy, CO Articulation Matrix		
CONTENT DELIVERY (THEORY)			
1	Introduction of the power quality (PQ)	CO1	T1: 1.1,
2	Problem, terms used in PQ voltage, sag, swell, surges	CO1	T1: 1.1,
3	terms used in PQ harmonics, over voltages	CO1	T1: 1.1,
4	transients, interruption,	CO1	T1: 1.1,
5	remedies to improve power quality	CO1	T1: 1.2
6	power quality monitoring	CO1	T1: 1.2
7	spikes, voltage fluctuations	CO1	T1: 1.3
8	overview of power quality phenomenon	CO1	T1: 3.6
9	Interruptions: Definition, difference between failures	CO2	T1: 1.1
10	outage, interruptions, causes of long interruptions	CO2	T1: 1.1,
11	origin of interruptions, limits for the interruption frequency	CO2	T1: 4.2,4.3
12	limits for the interruption duration, costs of interruption	CO2	T1: 4.2,4.3
13	overview of reliability evaluation to power quality,	CO2	T1: 4.4
14	comparison of observations and reliability evaluation	CO2	R2: 4.7
15	Short Interruptions: Definition, origin of short interruptions,	CO2	T1: 4.9
16	basic principle, fuse saving	CO2	T1: 4.9
17	voltage magnitude events due to re-closing	CO2	T1: 5.1,5.4
18	voltage during the interruption	CO2	T1: 5
19	difference between medium and low voltage systems,	CO2	T1: 5.1
20	multiple events, single phase tripping	CO2	T1: 5.1
21	voltage and current during fault period	CO2	T1: 5.1
22	stochastic prediction of short interruptions	CO2	T1: 6.1,6.4,6.5
23	voltage and current at post fault period	CO2	T1: 6.1,6.4,6.5
24	monitoring of short interruptions	CO2	T1: 6.1
25	Voltage sag: Definition, causes of voltage sag	CO3	T1: 6.1
26	voltage sag magnitude, and monitoring	CO3	T1: 6.1
27	theoretical calculation of voltage sag magnitude	CO3	T1: 6.1
28	voltage sag calculation in non-radial systems	CO3	T1: 6.13
29	meshed systems, and voltage sag duration	CO3	R1: 6.14
30	Three phase faults: Phase angle jumps	CO4	T1 : 9
31	magnitude jumps for three phase unbalanced sags	CO4	T1: 9.5

32	magnitude jumps for three phase unbalanced sags	CO4	T1: 9.5
33	phase angle jumps for three phase unbalanced sags	CO4	T1: 9.5
34	load influence on voltage sags.	CO4	R2: 9.6
35	Voltage sag; Equipment behavior of power electronic loads	CO5	R3: 1.5,
36	Voltage sag; Equipment behavior of power electronic loads	CO5	R3: 1.5,
37	induction motors, synchronous motors	CO5	1.9
38	computers, consumer electronics	CO5	T1: 9.1
39	mitigation of ac drives	CO5	R3: 2.6
40	adjustable speed dc drives and its operation	CO5	T1: 9.1
41	adjustable speed dc drives and its operation	CO5	T1: 9.1
42	adjustable speed AC drives and its operation	CO5	R3: 4.3,
43	mitigation methods of dc drives.	CO5	4.8
44	mitigation methods of dc drives.	CO5	4.8
45	Overview of mitigation methods: From fault to trip	CO5	R1: 9.9 R3:5.8
46	Overview of mitigation methods: From fault to trip	CO5	R1: 9.9 R3:5.8
47	Overview of mitigation methods: From fault to trip	CO5	R1: 9.9 R3:5.8
48	reducing the number of faults	CO5	T1 : 9.1
49	reducing the number of faults	CO5	T1 : 9.1
50	reducing the number of faults	CO5	T1 : 9.1
51	reducing the fault clearing time changing the power system	CO5	T1 : 9.1
52	installing mitigation equipment	CO6	T1 : 9.1
53	improving equipment immunity	CO6	T1 : 9.1
54	different events and mitigation methods	CO6	T1 : 9.1
55	different events and mitigation methods	CO6	T1 : 9.1
56	System equipment interface: Voltage source converter	CO6	T1 : 9.1
57	System equipment interface: Voltage source converter	CO6	T1 : 9.1
58	series voltage controller	CO6	T1 : 9.1
59	shunt controller	CO6	T1 : 9.1
60	combined shunt and series controller	CO6	T1 : 9.1
DISCUSSION OF QUESTION BANK			
1	Problem, terms used in PQ voltage, sag, swell, surges	CO1	R4:2.1
2	Origin of interruptions	CO2	T4:7.3
3	Voltage sag, Three phase faults	CO3, CO4	R4:5.1
4	Equipment behavior of power electronic loads	CO4	T1:7.5
5	Overview of mitigation methods	CO5	T1: 4.1

Signature of Course Coordinator **HOD,EEE**
Dr. D. Shobha Rani, Professor

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

Branch	**ELECTRICAL POWER SYSTEMS**				
Course Title	**PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMEN**				
Course Code	BHSD09				
Program	M.Tech				
Semester	II	EPS			
Course Type	AUDIT				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	2	-	0	-	-
Course Coordinator	Ms. T Saritha Kumari, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	

II COURSE OVERVIEW:

In this course, students delve into various aspects of personal development and self-awareness. They learn techniques to improve self-confidence, self-esteem, and self-awareness, which are vital for thriving in their engineering careers. Students explore their strengths, weaknesses, values, and beliefs, enabling them to develop a clearer understanding of themselves and their goals.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Personality development through life enlightenments	60 Marks	40 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 40 marks for Continuous Internal Assessment (CIA) and 60 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. CIA is conducted for a total of 40 marks, with 30 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 and 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

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	05 Marks	05 Marks		10 Marks
Tech Talk / Assignment	05 Marks	05 Marks		10 Marks
Semester End Examination (SEE)	-	-	60 Marks	60 Marks
Total	-	-	**100 Marks**	

Continuous Internal Examination (CIE):
Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. 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.

Assignment:
To improve the writing skills in the course an assignment will be evaluated for 05 marks. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by 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.

Quiz:
It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

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 include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

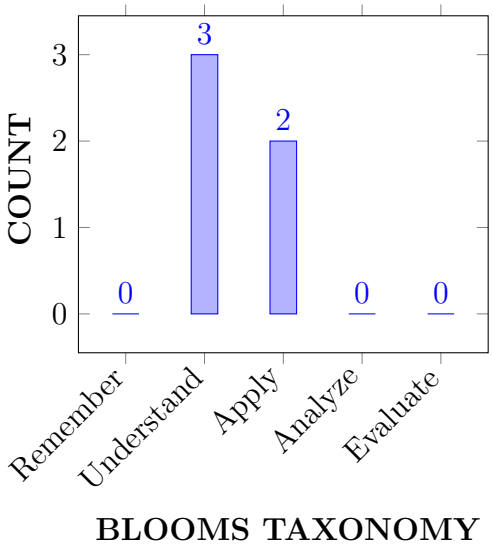
I	How to achieve the highest goal happily.
II	How a person become with stable mind, pleasing personality and determination.
III	Awaken wisdom in students.

VII COURSE OUTCOMES:

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

CO 1	**Summarize** steps to develop personality with stable mind, pleasing manners and determination.	Understand
CO 2	**Identify** day to day work and duties for developing peace and prosperity as depicted in Srimad Bhagwat Geeta.	Apply
CO 3	**Formulate** the daily life style by depicting the verses from Bhagavatgeetha.	Understand
CO 4	**Outline** the verses of Shrimad Bhagavad Geetha for holistic development.	Apply
CO5	**Demonstrates** personality development by verses of Bhagavatgeetha.	Understand

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 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	-	✓	-	-	-	-

X 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.

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

XI ASSESSMENT METHODOLOGY DIRECT:

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

XII ASSESSMENT METHODOLOGY INDIRECT:

✓	**End Semester OBE Feed Back**

XIII SYLLABUS:

MODULE I	**HOLISTIC DEVELOPMENT**
	Neetisatakam-Holistic development of personality, Verses- 19,20,21,22 (wisdom), Verses- 29,31,32 (pride , heroism), Verses- 26,28,63,65 (virtue),Verses- 52,53,59 (dont's),Verses- 71,73,75,78 (do's).
MODULE II	**BHAGWAD GEETA**
	Approach to day to day work and duties. Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48. Chapter 3- Verses 13, 21, 27, 35.
MODULE III	**BHAGWAD GEETA**
	Shrimad BhagwadGeeta: Chapter 6-Verses 5, 13, 17, 23, 35, Chapter 18-Verses 45, 46, 48.
MODULE IV	**BASIC KNOWLEDGE**
	Statements of basic knowledge. Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68. Chapter 12 -Verses 13, 14, 15, 16,17, 18.
MODULE V	**ROLE MODEL**

	Personality of Role model. Shrimad BhagwadGeeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42.

TEXTBOOKS

1. P.Gopinath, "Bhartrihari's Three Satakam (Niti-sringar-vairagya)", Rashtriya Sanskrit Sansthanam, New Delhi..

REFERENCE BOOKS:

1. Swami Swarupananda, "Srimad Bhagavad Gita", Advaita Ashram (Publication Department), Kolkata.

WEB REFERENCES:

1. https://ocw.mit.edu/16-687IAP19

COURSE WEB PAGE:

https://ocw.mit.edu/16-687IAP19

1.

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
	OBE DISCUSSION		
-	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
	CONTENT DELIVERY (THEORY)		
1	Holistic development - Introduction,	CO 1	T1 : v19
2	Need for holistic developments in real life	CO 1	T1 : v20
3	Verse number 19-21 related to wisdom of individual.	CO 1	T1: v21
4	Neetisatakam verse number 29-32 pride and heroism.	CO 1	T1: v22
5	Verses- 26,28,63,65 (virtue of human)	CO 1	T1:v23
6	Verses- 52,53,59 (dont's of life)	CO 1	T1:v24
7	Verses- 71,73,75,78 (do's)	CO 1	T1:v71
8	Verses 75,78 for human life and its functionality	CO 1	T1:v72
9	Approach to day to day work and duties Shrimad BhagwadGeeta Chapter 2-Verses 41,	CO 2	T1 :v73
10	Approach work and duties Geeta Chapter 2-Verses 47,48.	CO 2	T1 :v74
11	Approach to duties. Geeta Chapter 3- Verses 13, 21	CO 2	T1:v75
12	Approach to day to day work and duties. Shrimad BhagwadGeeta Chapter 3- Verses 27, 35.	CO 2	T1:3.1.1
13	Shrimad BhagwadGeeta: Chapter 6-Verses 5,and 13	CO 3	T1:3.1.5
14	Shrimad BhagwadGeeta: Chapter 6-Verses 17, 23, and 35,	CO 3	T1:4.1.5,
15	Shrimad BhagwadGeeta: Chapter 18-Verses 45, 46	CO 3	T1:3.1.4
16	Shrimad BhagwadGeeta: Chapter 6-Verses Chapter 18-Verses 48.	CO 3	T2:4.1.4

17	Statements of basic knowledge. Shrimad BhagwadGeeta: Chapter2-Verses 56	CO 4	T2:4.2.4
18	Statements of basic knowledge. Shrimad BhagwadGeeta: Chapter2-Verses 62, 68.	CO 4	T1:12
19	Shrimad BhagwadGeeta: Chapter 12 -Verses 13, 14	CO 4	T1:12
20	Shrimad BhagwadGeeta: Chapter2-Verses 56	CO 4	T1:12
21	Personality of Role model	CO 2	T2:4.5.8
22	Shrimad BhagwadGeeta: Chapter 3-Verses 36	CO 2	T1:2.5
23	Shrimad BhagwadGeeta: Chapter 3-Verses 37,42	CO 2	T1:3.5
24	Shrimad BhagwadGeeta: Chapter 3-Verses 42	CO 3	T1:3.3

Signature of Course Coordinator **HOD,EEE**
Ms. T Saritha Kumari, Assistant Professor

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

ELECTRICAL AND ELECTRONICS ENGINEERING(EPS)
COURSE DESCRIPTION

Course Title	**Artificial Intelligence in Power Systems Laboratory**				
Course Code	BPSD23				
Program	M.Tech				
Semester	II				
Course Type	Laboratory				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Dr. B Navothna, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites

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 in Power Systems Laboratory	60 Marks	40 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 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 20 marks for the final internal lab assessment and remaining and Laboratory Report/Project and Presentation, which consists of the Hardware Model Presentation (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 20 marks for final internal lab assessment and Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

COURSE OBJECTIVES:

The students will try to learn:

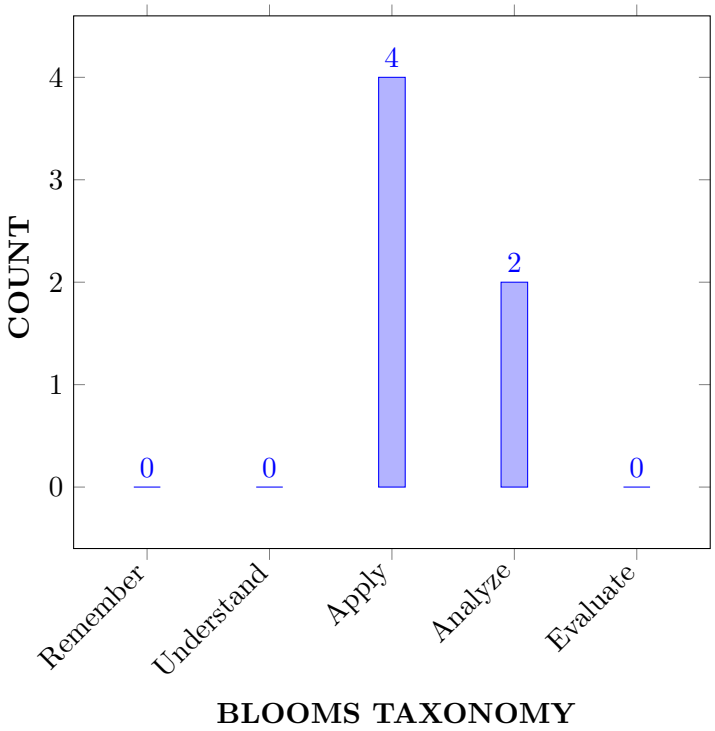
I	Apply the concepts of biological foundation of artificial neural network in modern power system analysis.
II	Demonstrate the associative models and control schemes in neural network.
III	Identify the structure of fuzzy logic controllers to apply in real time applications.
IV	Acquire the knowledge of genetic algorithm operator, mutation etc., for analysing advanced power system.
V	Develop applications of AI techniques in electrical engineering, to carry out the research in the emerging areas.

VI COURSE OUTCOMES:

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

CO 1	**Analyze** contingency techniques to predict the effect of outages like failures of equipment and transmission lines using ANN	Analyze
CO 2	**Determine** automatic generation control for single-area systems and two-area systems using Fuzzy Logic Method.	Apply
CO 3	**Analyze** the transient and small signal stability analysis of the Single-Machine-Infinite Bus (SMIB) system using Fuzzy Logic	Analyze
CO 4	**Implement** the Economic dispatch of thermal units using conventional and ANN Algorithm	Apply
CO 5	**Implement** Economic dispatch thermal units using conventional and GA algorithms	Apply

COURSE KNOWLEDGE COMPETENCY LEVEL



VII 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.

VIII HOW PROGRAM OUTCOMES ARE ASSESSED:

Program		Strength	Proficiency Assessed by
PO1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	Laboratory practices, student viva
PO2	An ability to write and present a substantial technical report / document.	1	Laboratory Practices, student viva
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	Laboratory Practices, student viva
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	Laboratory Practices, Mini-Project
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	3	Laboratory Practices, Mini-Project
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development..	3	Laboratory Practices, Mini-Project

3 = High; 2 = Medium; 1 = Low

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

COURSE OUTCOMES	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO4	PO 5	PO 6
CO 1	✓	✓		✓		✓
CO 2	✓	✓	✓		✓	
CO 3	✓	✓		✓		✓
CO 4	✓	✓			✓	
CO 5	✓				✓	
CO 6	✓	✓		✓		

X ASSESSMENT METHODOLOGY DIRECT:

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

XI ASSESSMENT METHODOLOGY INDIRECT:

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

XII 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**
	Contingency analysis using neural network.
WEEK IV	**POWER SYSTEM SECURITY**
	Power system security using neural network.
WEEK V	**AGC - SINGLE AREA SYSTEM / TWO AREA SYSTEM**
	Fuzzy logic-based AGC for single-area systems 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 ANN algorithms.
WEEK VIII	**ECONOMIC DISPATCH THERMAL UNITS**
	Economic dispatch of thermal units using conventional and GA algorithms.
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. **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. Power System Analysis And Design by Dr. B.R. GUPTA — 8 August 2005
2. ELEMENTS OF POWER SYSTEM ANALYSIS 4/ED by D. William Stevenson and STEVENSON W. — 1 January 1982.

XIII 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 :Load flow analysis using neural network.	CO 1	T1:1.1,1.2
2	STATE ESTIMATIONS : State estimations using neural network.	CO 2	T1:1.3,1.6
3	CONTINGENCY ANALYSIS : Contingency analysis using neural network.	CO 3	T1:9,1.12
4	POWER SYSTEM SECURITY : Power system security using neural network	CO 4	T1:17.1,1.23
5	AGC - SINGLE AREA SYSTEM / TWO AREA SYSTEM : Fuzzy logic-based AGC for single-area systems and two-area systems.	CO 4	T2:11.1,1.8
6	SMALL SIGNAL STABILITY ANALYSIS :Fuzzy logic-based small signal stability analysis.	CO4	T2:10.1,10.4
7	ECONOMIC DISPATCH THERMAL UNITS :Economic dispatch of thermal units using conventional and ANN algorithms.	CO 4	T2:11.2-11.4
8	ECONOMIC DISPATCH THERMAL UNITS : Economic dispatch of thermal units using conventional and GA algorithms. .	CO 5	T2:9.1,1.6
9	ECONOMIC DISPATCH THERMAL UNITS :Economic dispatch of thermal units using conventional and Fuzzy logic.	CO 5	T2:10.2-11.4

10	ECONOMIC DISPATCH OF THERMAL PLANTS: Economic dispatch of thermal plants using conventional and ANN algorithms.	CO 5	T2:9.2-11.4
11	ECONOMIC DISPATCH OF THERMAL PLANTS: Economic dispatch of thermal plants using conventional and GA algorithms.	CO 6	T1:12,1.9
12	ECONOMIC DISPATCH OF THERMAL PLANTS : Economic dispatch of thermal plants using conventional and Fuzzy logic .	CO 6	T2:1.1,1.5

XIV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Load Forecasting using Machine Learning Algorithms
2	Predictive Maintenance in Power Systems with AI
3	Energy Efficiency Optimization using AI in Microgrids
4	AI-Powered Voltage Stability Analysis in Power Systems
5	Analyze the performance of HVDC and Flexible AC Transmission Systems (FACTS) devices.

Signature of Course Coordinator **HOD,EEE**
Dr. B Navothna, Assistant Professor

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

ELECTRICAL AND ELECTRONICS ENGINEERING(EPS)
COURSE DESCRIPTION

Course Title	**Power Systems Laboratory**				
Course Code	BPSD24				
Program	M.Tech				
Semester	II				
Course Type	Laboratory				
Regulation	MT23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	-	-	-	4	2
Course Coordinator	Kumbha . Venkata Siva Rao, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites

II COURSE OVERVIEW:

The main objective of the course is to provide an overview of the principles of basic protection circuits such as earth tester, different type of relays, breakdown strength of air gap, soil resistivity, millivolt drop test. It will also help students to formulate different type of protection scheme.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
Power Systems Laboratory	60 Marks	40 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 40 marks for internal assessment and 60 marks for semester end lab examination. Out of 40 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance including viva voce, 20 marks for the final internal lab assessment and remaining and Laboratory Report/Project and Presentation, which consists of the Hardware Model Presentation (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 40 marks (Table 1), with 20 marks for continuous lab assessment during day-to-day performance including viva voce, 20 marks for final internal lab assessment and Laboratory Report / Project and Presentation.

Table 1: CIA marks distribution

Component				
Type of Assessment	Day to Day performance and viva voce examination	Final internal lab assessment	Laboratory Report / Project and Presentation	Total Marks
CIA marks	20	10	10	40

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.

Table 2: Experiment based

Objective	Analysis	Design	Conclusion	Viva voce	Total
4	4	4	4	4	20

Semester End Examination:

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the other colleges which will be decided by the Head of the institution.

In the Semester End Examination held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

VI COURSE OBJECTIVES:

The students will try to learn:

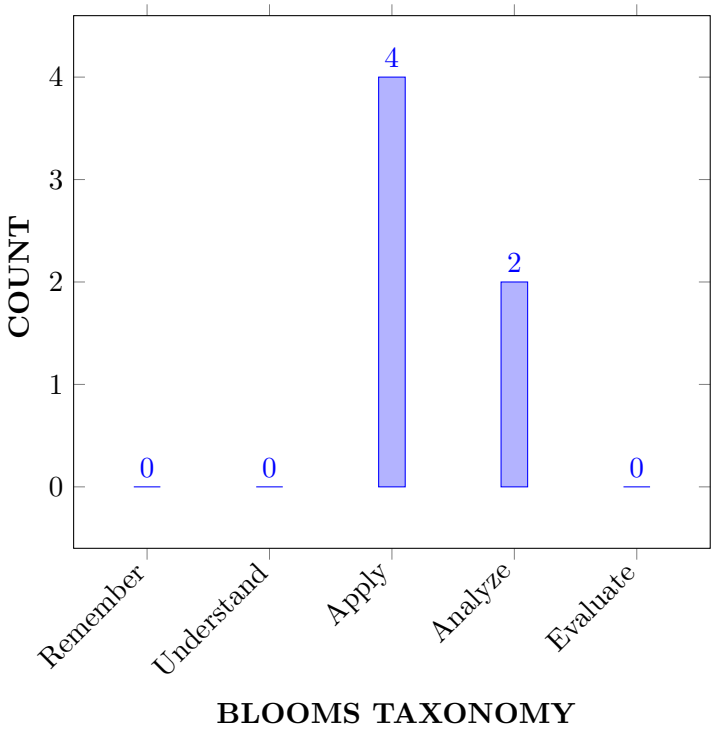
I	Parameters, surge impedance loading and reactive power compensation of transmission lines.
II	Concept of various transmission line protection schemes.
III	How Simulate and study feeder protection and generator protection circuits.

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.	Apply
CO 2	**Explain** the concept of electrical integrity of connections and contacts in a circuit breaker using milli-volt drop test.	Apply
CO 3	**Analyze** the concept of soil resistivity as function of salinity and time.	Analyze
CO 4	**Analyze** internal fault protection of single-phase transformer using merz price protection.	Apply
CO 5	**Examine** the alternator during over voltage under voltage.	Apply
CO 6	**Analyze** the various Voltage applicable over and under frequency by using respective relays.	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 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		Strength	Proficiency Assessed by
PO1	An ability to independently carry out research/investigation and development work to solve practical problems.	2	Laboratory practices, student viva
PO2	An ability to write and present a substantial technical report / document.	1	Laboratory Practices, student viva
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	Laboratory Practices, student viva
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	Laboratory Practices, Mini-Project
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	3	Laboratory Practices, Mini-Project
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development..	3	Laboratory Practices, Mini-Project

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	PO4	PO 5	PO 6
CO 1	✓	✓		✓		✓
CO 2	✓	✓	✓		✓	
CO 3	✓	✓		✓		✓
CO 4	✓	✓			✓	
CO 5	✓				✓	
CO 6	✓	✓		✓		

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	**NEGATIVE SEQUENCE PROTECTION IN ALTERNATOR**
	Study the numerical type negative sequence protection in a given alternator
WEEK XI	**OVER FREQUENCY AND UNDER FREQUENCY PROTECTION**
	Study the generator protection during over and under frequency cases with suitable relays.
WEEK XII	**PERFORMANCE OF ALTERNATOR AGAINST INTERNAL FAULTS**
	Study the performance of synchronous machine and its protection scheme during internal faults.

TEXTBOOKS

1. **Paithankar, S RBhide, "Fundamentals of Power System Protection", PHI, 1st Edition, 2003.**
2. **CLWadhwa, "Electrical Power Systems", New Age international (P) Limited, 6th Edition, 2010.** .

REFERENCE BOOKS:

1. Power System Analysis And Design by Dr. B.R. GUPTA — 8 August 2005
2. ELEMENTS OF POWER SYSTEM ANALYSIS 4/ED by D. William Stevenson and STEVENSON W. — 1 January 1982.

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	EARTH TESTER : Determination of earth resistance by using crank type earth tester.	CO 1	T1:1.1,1.2
2	MILLI VOLT DROP TEST : Measurement of contact resistances of different combinations of test objects.	CO 2	T1:1.3,1.6
3	SOIL RESISTIVITY : Measurement of soil resistivity as a function of salinity and time.	CO 3	T1:9,1.12
4	MICROPROCESSOR BASED OVER CURRENT RELAY : Determination of performance characteristics of microprocessor based over current relay.	CO 4	T1:17.1,1.23
5	ELECTROMECHANICAL OVER CURRENT RELAY : Determination of performance characteristics of electromechanical over current relay.	CO 4	T2:11.1,1.8

6	BREAKDOWN STRENGTH OF AIR BY HORN GAP :Determination of breakdown voltage of air using horn gap apparatus at atmospheric conditions.	CO4	T2:10.1,10.4
7	POWER ANGLE CHARACTERISTICS OF SYNCHRONOUS MACHINE : Study the power angle characteristics of synchronous machine by synchronizing to the grid.	CO 4	T2:11.2-11.4
8	MERZ PRICE PROTECTION IN SINGLE PHASE TRANSFORMER : Study the Merz price protection of single-phase transformer and determine the characteristics of percentage biased relay. .	CO 5	T2:9.1,1.6
9	DIFFRENTIAL PROTECTION SCHEME IN SYNCHRONOUS GENERATOR : Study of differential protection in three phase ac generator.	CO 5	T2:10.2-11.4
10	NEGATIVE SEQUENCE PROTECTION IN ALTERNATOR: Study the numerical type negative sequence protection in a given alternator.	CO 5	T2:9.2-11.4
11	OVER FREQUENCY AND UNDER FREQUENCY PROTECTION : Study the generator protection during over and under frequency cases with suitable relays.	CO 6	T1:12,1.9
12	PERFORMANCE OF ALTERNATOR AGAINST INTERNAL FAULTS :Study the performance of synchronous machine and its protection scheme during internal faults .	CO 6	T2:1.1,1.5

XV EXPERIMENTS FOR ENHANCED LEARNING (EEL):

S.No	Design Oriented Experiments
1	Analyze power flow in a transmission network under different loading conditions.
2	Determine fault currents under symmetrical and unsymmetrical faults?
3	Analyze transmission line parameters (resistance, inductance, capacitance) and study corona losses?
4	Improve power factor using capacitor banks and measure reactive power compensation.
5	Analyze the performance of HVDC and Flexible AC Transmission Systems (FACTS) devices.

Signature of Course Coordinator **HOD,EEE**
Kumbha. Venkata Siva Rao, Assistant Professor

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

COURSE TEMPLATE

Department	**Electrical and Electronics Engineering**				
Course Title	**SCADA SYSTEM AND APPLICATIONS**				
Course Code	BPSD26				
Program	M.Tech				
Semester	III				
Course Type	Core				
Regulation	MT-23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. D.Shobha Rani. Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites

II COURSE OVERVIEW:

This course provides an exposure to technology of automation and control as widely seen across a typical power system network. It contains a wide range of topics from typical SCADA system Architecture, Communication requirements, Desirable Properties of SCADA system, features and other devices used for interfacing with real time systems. The course also includes the applications of SCADA systems in monitoring, control and management of energy in transmission and distribution networks of a power system and other industries.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
SCADA SYSTEM AND APPLICATIONS	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✓	Power Point Presentations	✓	Chalk & Talk	x	Assignments	x	MOOC
x	Open Ended Experiments	x	Seminars	x	Mini Project	x	Videos
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 30 marks for Continuous Internal Examination (CIE), 10 marks for Assignment and 10 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 20 marks for Continuous Internal Examination (CIE),Definitions and 05 marks forTerminology / Quiz, 05 marks for Tech- nical Seminar and Term Paper

Table 2: Outline for Continuous Internal Assessments (CIA - I and CIA - II) and SEE

Activities	**CIA - I**	**CIA - II**	**SEE**	**Total Marks**
Continuous Internal Examination (CIE)	10 Marks	10 Marks		20 Marks
Definitions and Terminology / Quiz	00 Marks	05 Marks		05 Marks
Tech Talk / Assignment	00 Marks	05 Marks		05 Marks
Semester End Examination (SEE)	-	-	70 Marks	70 Marks
Total	-	-	**100 Marks**	

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:

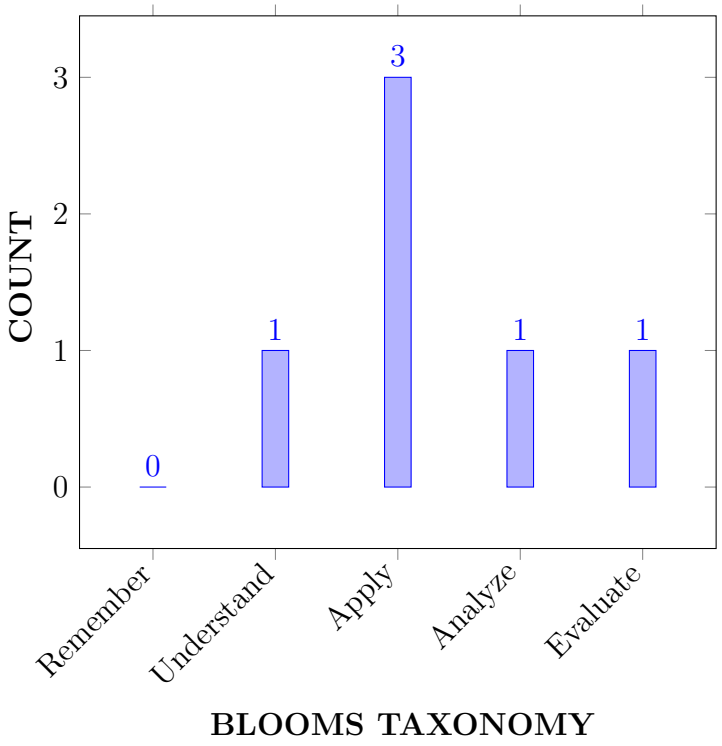
I	The fundamentals of SCADA systems including its architecture, components and communication protocols.
II	The control aspects of power system network and energy management using automation
III	The substantial applications of SCADA systems and analyze industrial problems from an automation perspective.

VII COURSE OUTCOMES:

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

CO 1	**Demonstrate** the basic functionality, merits and demerits of PLC and SCADA systems for supervisory control of an industrial system.	Understand
CO 2	**Develop** the ladder diagram and functional block diagrams for interfacing PLC with SCADA system.	Apply
CO 3	**Identify** the typical components of SCADA systems used for interfacing with real time systems	Apply
CO 4	**Analyze** the different types of architectures and communication technologies of a typical SCADA system	Analyze
CO 5	**Make use of** SCADA systems for controlling, security and energy management of a power system networks	Apply
CO 6	**Appraise** the superiority of SCADA systems in operation, controlling, and monitoring of oil, gas, water and power industries.	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 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.	2	CIE/AAT
PO 2	An ability to write and present a substantial technical report / document.	3	AAT
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
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
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	1	AAT
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	1	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	-	✓	-	-	✓	-

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 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**.	3
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**	1
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 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	✓	✓	-		✓	✓

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	100	60	-	-	-	-
CO 2	100	60	60	30	-	-
CO 3	100	60	-	30	-	-
CO 4	100	60	-	40	-	-
CO 5	100	60	-	-	100	-
CO 6	100	60	-	-	100	80

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	-	-	-	-
CO 2	3	2	2	1	-	-
CO 3	3	2	-	1	-	-
CO 4	3	2	-	1	-	-
CO 5	3	2	-	-	3	-
CO 6	3	2	-	-	3	3
TOTAL	18	12	2	3	6	3
AVERAGE	3	2	1	1	3	1

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:

	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII SYLLABUS:

MODULE I	**INTRODUCTION TO SCADA AND PLC**
	Data acquisition system, evaluation of SCADA, communication technologies, monitoring and supervisory functions; PLC: Block diagram, programming languages, ladder diagram, functional block diagram, applications, interfacing of PLC with SCADA
MODULE II	**SCADA SYSTEM COMPONENTS**
	Industries SCADA system components: Schemes, remote terminal unit (RTU), intelligent electronic devices (IED), communication network, SCADA server, SCADA / HMI systems.
MODULE III	**SCADA ARCHITECTURE AND COMMUNICATION**
	CADA architecture: Types, advantages and disadvantages of each system, single unified standard architecture-IEC 61850. SCADA Communication: Various industrial communication technologies, wired and wireless methods, fiber optics, open standard communication protocols.

MODULE IV	**OPERATION AND CONTROL**
	SCADA Operation and Control: Operation and control of interconnected power system, automatic substation control, SCADA configuration, energy management system, system operating states, system security, state estimation unit.
MODULE V	**:SCADA APPLICATIONS**
	SCADA Applications: Utility applications, transmission and distribution sector operations, monitoring, analysis and improvement, industries, oil, gas and water, case studies, implementation, simulation exercises. 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 feature

TEXTBOOKS

1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA,2004.
2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newness Publications, Oxford, UK,2004.

REFERENCE BOOKS:

1. William T. Shaw, "Cyber Security for SCADA systems", Penn Well Books,2006.
2. David Bailey, Edwin Wright, "Practical SCADA for industry", Newness,2003.
3. Sunil S Rao, "Switchgear and protections", Khanna Publications, 2nd Edition, 2000.
4. Michael Wiebe, "A guide to utility automation: AMR, SCADA, and IT systems for electric power", PennWell1999.

WEB REFERENCES:

1. https://www.as.wiley.com/WileyCDA/WileyTitle/productCd-1118634039.html.
2. https://www.springer.com/us/book/9788132221180.
3. https://www.springer.com/us/book/9781447151036.

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	Data Acquisition System (DAS)?	CO1	T1: 1.1
2	Evaluation of SCADA (Supervisory Control and Data Acquisition)	CO1	T1: 1.2
3	Communication Technologies in SCADA	CO1	T2: 1.1.1
4	Monitoring and Supervisory Functions in SCADA	CO1	T2: 1.3.1
5	PLC (Programmable Logic Controller)	CO1	T2: 1.3.3

6	Applications of PLC	CO1	T1: 1.3.2
7	Interfacing PLC with SCADA	CO1	T1: 1.3.2
8	SCADA System Overview	CO2	T2: 1.3.8
9	SCADA System Components	CO2	T1: 2.1
10	Schemes (SCADA System Architecture)	CO2	T1: 2.1
11	SCADA Architecture: Types, Advantages, and Disadvantage	CO3	T3: 5.2
12	Single Unified Standard Architecture: IEC 61850	CO3	T1: 5.7
13	SCADA Communication: Industrial Communication Technologies	CO3	T3: 5.7
14	Fiber Optics in SCADA Communication	CO3	T2: 5.7
15	Open Standard Communication Protocols in SCADA	CO3	T3: 5.7
16	Name one advantage and one disadvantage of a distributed SCADA system.	CO4	T1: 9.1
17	How does a networked SCADA architecture differ from a centralized one?	CO4	T1: 9.1
18	Dicuss the primary function of a centralized SCADA system?	CO4	T1: 9.1
19	Discuss aboutthe role of IEC 61850 in SCADA systems?	CO4	T1: 9.1
20	Discuss about IEC 61850 preferred for modern electrical substations?	CO4	T1: 9.1
21	Operation and Control of Interconnected Power System	CO4	T1: 6.2
22	Discus about Automatic Substation Control	CO4	T1: 7.1
23	Discus about SCADA Configuration	CO4	T3: 5.7
24	Discus about Energy Management System (EMS).	CO4	T2: 5.7
25	Discus about System Operating States	CO5	T1: 5.7
26	Discus about System Security	CO5	T1: 5.7
27	Discuss about State Estimation Unit	CO5	T1: 2.2
28	Discuss about the primary function of state estimation in a SCADA system?	CO5	T1: 2.3
29	How does automatic substation control enhance operational efficiency in power systems?	CO5	T1: 5.7
30	Describe the role of energy management systems (EMS) in optimizing power distribution.	CO5	T2: 2.1
31	What are the different system operating states in a SCADA-controlled power	CO5	T2: 2.1
32	How does SCADA configuration vary between centralized, distributed, and networked architectures?	CO5	T1: 5.7
33	Discuss about SCADA Applications in Utility Sectors	CO6	T1: 2.2
34	Discuss about SCADA in Transmission and Distribution Sector	CO6	T1: 2.2
35	Discuss about SCADA Applications in Industries	CO6	T1: 2.2
36	Discuss about Control of Generation and Automatic Generation Control (AGC)	CO6	T1: 2.3
37	Discuss about Simulation Exercises and Implementation	CO6	T1: 2.3
38	Describe the role of SCADA in load management within the transmission and distribution sector.	CO6	T1: 9.1

39	Explain how simulation exercises contribute to the implementation and training of SCADA systems.	CO5	T1: 6.2
PROBLEM SOLVING/ CASE STUDIES			
40	Discuss about Automatic Substation Control Failure	CO5	T1: 7.1
41	Discuss about Cybersecurity Breach	CO5	T3: 5.7
42	Discuss about Load Imbalance During Peak Demand	CO5	T3: 5.7
43	Discuss about SCADA Implementation in Water Utilities	CO6	T2: 5.7
44	Discuss about Transmission Line Monitoring Issues	CO6	T1: 9.1
45	Discuss about AGC Implementation in Power Generation	CO6	T1: 6.2
DISCUSSION OF DEFINITION AND TERMINOLOGY			
47	Data Acquisition System (DAS)	CO1, CO2	T1: 2.1
48	SCADA System Components	CO3	T1: 3.2
49	SCADA Architecture	CO4	T1: 4.2
50	Operation and Control	CO5	T1: 5.2
51	SCADA Applications	CO6	T1: 6.2
DISCUSSION OF QUESTION BANK			
52	What is SCADA, and what are its main components?	CO1 CO2	-
53	Describe the communication network used in SCADA systems.	CO3	-
54	Describe the role of field devices in a SCADA system.	CO4	-
55	Describe the data acquisition process in SCADA systems.	CO5	-
56	Describe how SCADA systems are utilized in electric power generation and distribution.	CO6	-

Signature of Course Coordinator **HOD,EEE**

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

COURSE DESCRIPTION

Department	**ELECTRICAL POWER SYSTEMS**				
Course Title	**Energy from Waste**				
Course Code	BCCD31				
Program	M. Tech				
Semester	III				
Course Type	ELECTIVE				
Regulation	MT - 23				
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Course Coordinator	Dr. G Hima Bindu, Assistant Professor				

I COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
-	-	-	-

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.

III MARKS DISTRIBUTION:

Subject	SEE Examination	CIE Examination	Total Marks
WASTE TO ENERGY	60 Marks	40 Marks	100

IV CONTENT DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V EVALUATION METHODOLOGY:

Each theory course will be evaluated for a total of 100 marks, out of which 40 marks for Continuous Internal Assessment (CIA) and 60 marks for Semester End Examination (SEE).

Semester End Examination (SEE): The SEE shall be conducted for 60 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE modules and each module carries equal weightage in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with 'either' 'or' choice will be drawn from each unit. Each question carries 12 marks. There could be a maximum of two / three sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria given in below Table.

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 40 marks, with 30 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 and 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.

Component		Marks	Total Marks
CIA - 1	Continuous Internal Examination	10	20
	Assignment or Quiz	5	
	Alternative Assessment Tool (AAT)	5	
CIA - 2	Continuous Internal Examination	10	20
	Assignment or Quiz	5	
	Alternative Assessment Tool (AAT)	5	
SEE	Semester End Examination (SEE)	60	60
Total Marks			100

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8 th and 16 th week of the semester respectively 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. Assignment has to submit either at the end of the CIE1 or CIE2 for the questions provided by 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.

Quiz: It is online proctor based online examination conducted either at the end of the CIE1 or CIE2. The choice of conduction of Assignment / Quiz in CIE1 or CIE2 is purely choice of course handling faculty.

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 include, Course related term paper, Technical seminar, Term paper, Case Study, Paper presentations conducted by reputed organizations relevant to the course etc.

VI COURSE OBJECTIVES:

The students will try to learn:

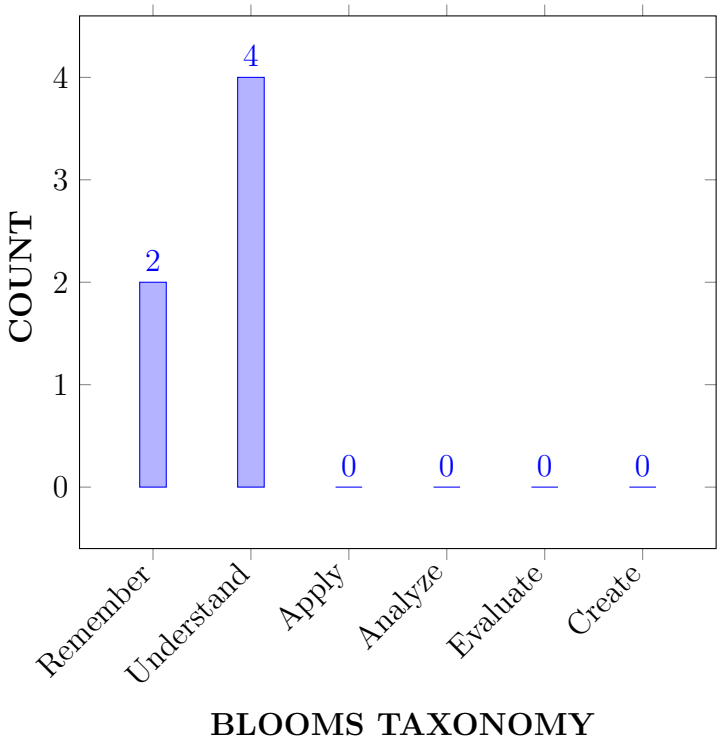
I	The principles of solid waste management in reducing and eliminating dangerous impacts of waste materials on human health and the environment to contribute economic development and superior quality of life
II	The insight of the design and operations of a municipal solid waste landfill by collection, transfer and transportation of municipal solid waste for the final disposal.
III	The 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.

VII COURSE OUTCOMES:

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

CO 1	**Identify** the different sources and types of solid waste by the properties of municipal solid waste for segregation and collection of waste.	Remember
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	**Illustrate** 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 gasesby 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	**Illustrate** the knowledge in planning and operations of waste to Energy plants by following legal legislation related to solid waste management.	Remember

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, SEE
PO 2	An ability to write and present a substantial technical report / document..	2	CIE, SEE

PROGRAM OUTCOMES		Strength	Proficiency Assessed by
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, 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, SEE
PO 5	Model and apply appropriate techniques and modern tools on contemporary issues in multidisciplinary environment.	3	CIE, SEE
PO 6	Engage in life-long learning for continuing education in doctoral level studies and professional development.	3	CIE, 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	Justification for mapping (Students will be able to)	No. of Key competencies matched.
CO 1	PO1	understanding the role of **Electrical power systems in controlling and monitoring waste-to-energy processes, investigate how embedded technologies can optimize energy recovery** development work to solve practical	4
	PO3	deep knowledge of electrical power systems and their **integration into waste-to-energy systems, going beyond general engineering concepts.**	2
CO2	PO4	focuses on **designing monitoring and control systems for waste-to-energy plants using embedded technologies, addressing real-world challenges like system reliability and energy optimization.**	6

Course Outcomes	PO'S	Justification for mapping (Students will be able to)	No. of Key competencies matched.
	PO5	Encourages to stay current with **evolving electrical power systems technologies and their applications in waste management, fostering continuous learning.**	3
CO3	PO 3	specialized knowledge in electrical control systems to manage **energy recovery processes efficiently, ensuring optimal performance of waste-to-energy plants.** Environmental Implications.	3
CO3	PO 4	Involves using modern tools and techniques to design embedded control systems **for automating waste-to-energy processes, from waste input to energy output.**	3
CO4	PO2	analyzing data collected from electrical power systems in **energy recovery processes and presenting findings in detailed technical reports.**	2
	PO 5	Stresses the importance of continuously learning about new methods for **data collection, processing, and analysis to improve energy recovery.** Environmental Issues.	3
CO5	PO4	Involves designing IoT-based smart systems for **waste-to-energy applications, utilizing advanced electrical power systems to monitor, control, and optimize energy recovery processes.** related to a Waste activities collection	4
	PO6	Collaborative development of **smart, interconnected systems, requiring teamwork across disciplines to implement IoT solutions for efficient waste-to-energy processes.**	5
CO6	PO3	strong understanding of energy-efficient electrical power systems specifically tailored for **waste management and energy recovery processes, ensuring systems are both reliable and sustainable.**	3
	PO4	Solving complex engineering problems by designing embedded systems that c **consume less energy while managing waste-to-energy plants.**	2

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

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	4	-	2	-	-	-
CO 2	-	-	-	6	3	-
CO 3	-	-	3	3	-	-
CO 4	-	2	-	-	3	-
CO 5	-	-	-	4	-	6
CO 6	-	-	3	2	-	-

XIII PERCENTAGE OF KEY COMPETENCIES FOR CO – PO

Course Outcomes	PROGRAM OUTCOMES					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	40.0	0.0	20.0	0.0	0.0	0.0
CO 2	0.0	0.0	0.0	60.0	30.0	0.0
CO 3	0.0	0.0	30.0	30.0	0.0	0.0
CO 4	0.0	20.0	0.0	0.0	30.0	0.0
CO 5	0.0	0.0	0.0	40.0	0.0	60.0
CO 6	0.0	0.0	30.0	20.0	0.0	0.0

XIV COURSE ARTICULATION MATRIX (PO / PSO MAPPING):

CO'S and PO'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	4.0	0.0	2.0	0.0	0.0	0.0
CO 2	0.0	0.0	0.0	6.0	3.0	0.0
CO 3	0.0	0.0	3.0	3.0	0.0	0.0
CO 4	0.0	2.0	0.0	0.0	3.0	0.0
CO 5	0.0	0.0	0.0	4.0	0.0	5.0
CO 6	0.0	0.0	3.0	2.0	0.0	0.0
Total	4.0	2.0	8.0	0.0	6.0	5.0
Average	4	1	2.5	3.75	3	5

XV ASSESSMENT METHODOLOGY-DIRECT:

CIE Exams	✓	SEE Exams	✓	Seminars	✓
Laboratory Practices	-	Student Viva	-	Certification	-
Term Paper	-	5 Minutes Video	-	Open Ended Experiments	-
Assignments	✓				

XVI ASSESSMENT METHODOLOGY-INDIRECT:

✓	Assessment of mini projects by experts	✓	End Semester OBE Feedback

XVII 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**
	Introduction types of damping, measurement of damping. Introduction to harmonic excitation, undamped harmonic excitation, damped harmonic excitation, characteristics curves, measurement of damping, vibration measuring instruments, vibration isolation.
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	**E-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, 1st Edition, 2003.
2. Paul Breeze, "Energy from Waste", An Imprint of Elsevier, New Delhi, 1st Edition, 2018.
3. P Aarne V esilind, William A Worrell and Debra R Reinhart, "Solid Waste Engineering", 2nd edition, 2002..

REFERENCE BOOKS:

1. Challal, D S, "Food, Feed and Fuel from Biomass", IBH Publishing Co. Pvt. Ltd., 1st edition, 2019.
2. C Y Were Ko-Brobby and E. B. Hagan, "Biomass Conversion and Technology", John Wiley and Sons, 1st edition, 2019.
3. C Parker and T Roberts (Ed), "Energy from Waste", An Evaluation of Conversion Technologies, elsevier Applied Science, London, 2018.

WEB REFERENCES:

1. https://www.e-waste Management: From waste to Resource Klaus Hieronymi, RamzyKahnat, Eric williams Tech. and Engg.-2013 (Publisher: Earthscan 2013)

2. https://www.What is the impact of E-waste: Tamara Thompson

COURSE WEB PAGE:

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: R1:
OBE DISCUSSION			
1	Discussion on OBE, POs and COs of Structural Dynamics		
CONTENT DELIVERY (THEORY)			
1	Summarize about solid waste sources and its importance.	CO1	T1,T2
2	Discuss solid waste properties and its composition	CO1	T1,T2
3	Provides the information regarding collection and transfer of solid waste.	CO1	T1,T2
4	Discuss the need of waste minimization and recycling	CO1	T1,T2
5	Discuss the need of segregating waste and managing solid waste	CO1	T1,T2
6	Acquire the knowledge about the technologies for generation of energy from solid waste	CO1	T1,T2
7	Acquire the knowledge about the technologies for generation of energy from biomedical waste.	CO1	T1,T2
8	Discuss the environmental impacts of incineration process	CO1	T1,T2
9	Illustrate the importance of landfill method of disposal.	CO1	T1,T2
10	Discuss the types of land fill disposal and classification of land fill sites.	CO1	T1,T2
11	Analyze the layout and preliminary design of landfills.	CO2	T1,T2
12	Summarize the properties and characteristics of landfills.	CO2	T1,T2
13	Acquire the knowledge of generating energy from landfills.	CO2	T1,T2
14	Discuss the emission of gasses and leach ate from landfills	CO2	T1,T2
15	Discuss the environmental monitoring system for land fill gases.	CO2	T1,T2
16	Discuss about the biochemical conversion and their advantages	CO2	T1,T2
17	Illustrate the sources of biochemical conversion process.	CO2	T1,T2
18	Analyze anaerobic digestion of sewage and municipal waste.	CO2	T1,T2
19	Analyze direct combustion of Municipal solid waste.	CO2	T1,T2
20	Discuss about refuse derived solid fuel and their importance in energy generation.	CO2	T1,T2
21	Discuss about industrial waste and agro residues.	CO3	T1,T2
22	Understand the concept of Thermo-chemical Conversion.	CO2	T1,T2
23	Discuss about Biogas production and generation of energy by Biogas.	CO3	T1,T2
24	Explain the land fill gas generation and utilization of landfill gas for various purposes.	CO3	T1,T2
25	Illustrate sources of thermo chemical energy generation	CO3	T1,T2

26	Explain gasification of waste using gasifies briquetting process.	CO3	T1,T2
27	Discuss utilization of various municipal solid wastes by recycling, refuse and reuse techniques	CO3	T1,T2
28	Discuss advantages and disadvantages of briquetting process.	CO3	T1,T2
29	Summarize environmental benefits of bio-chemical conversion	CO4	T1,T2
30	Summarize environmental benefits of thermo- chemical conversion	CO4	T1,T2
31	Outline the Growth of electrical and electronics industry in India.	CO4	T1,T2
32	Summarize the E-waste generation in India and in the global context.	CO4	T1,T2
33	Understand the Growth of E waste generated from electrical and electronics industry in India	CO4	T1,T2
34	Identify environmental concerns and health hazards	CO4	T1,T2
35	Determine recycling concept of E-Waste and advantages of E-waste.	CO5	T1,T2
36	Discuss A thriving economy of the unorganized sector of E-waste	CO5	T1,T2
37	Discuss the global trade in hazardous waste and their impact on the environment	CO5	T1,T2
38	Discuss impact of hazardous E-waste in India and effects on human health	CO5	T1,T2
39	Understand the management processes of E-waste and the importance of formal recycling of E-waste	CO5	T1,T2
40	Discuss the environmental impacts of incineration process	CO6	T1,T2
41	Analyze the layout and preliminary design of landfills.	CO6	T1,T2
42	Analyze the layout and preliminary design of landfills.	CO6	T1,T2
43	Discuss the emission of gasses and leach ate from landfills.	CO6	T1,T2
44	Discuss the environmental monitoring system for land fill gases.	CO6	T1,T2
45	Discuss the environmental monitoring system for land fill gases.	CO6	T1,T2
46	Case studies on Waste sources and characterization and collecting waste	CO1	T1,T2
47	Case studies on Energy production from organic waste	CO1	T1,T2
48	Case studies on E-Centralized and Decentralized Waste to Energy Plants.	CO2	T1,T2
49	Case studies on:Thermo-Chemical Conversion and biogas.	CO2	T1,T2
50	Case studies on non renewable fuel resources	CO2	T1,T2
51	Case studies Municipal solid waste(MSW)	CO2	T1,T2
52	Case studies on Land fill gas during the an aerobic decomposition of organic substances	CO3	T1,T2
53	Case study on Bio mass power technologies convert renewable bio mass fuels to heat and electricity	CO3	T1,T2
54	Case study Perforated tubes are drilled into the land fill body and interconnected by a pipe work system.	CO3	T1,T2

55	Case study E-waste comprises of waste electronics goods	CO3	T1,T2
56	Case study a well-designed gas collection system	CO4	T1,T2
57	Case study on Combustion systems for electricity and heat production	CO4	T1,T2
58	Case study on valuable renewable energy source for power generation	CO5	T1,T2
59	Case study on waste item consisting of everyday items that are discarded by public.	CO5	T1,T2
60	Case study on Location and Siting of 'Waste to Energy' plants.	CO5	T1,T2
DISCUSSION OF QUESTION BANK			
1	Module: I-Waste sources and characterization	CO1	T1,T2
2	Module: II- Technologies for waste to energy	CO2	T1,T2
3	Module: III- Waste to energy and implications	CO3, CO4,	T1,T2
4	Module: IV- Thermo chemical conversion	CO5	T1,T2
5	Module: V-Centralized and decentralized waste to energy	CO6	T1,T2

Signature of Course Coordinator
HOD,EEE
Dr. G Hima Bindu, Assistant Professor