



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE DESCRIPTOR

Course Title	REACTIVE POWER COMPENSATION AND MANAGEMENT				
Course Code	BPEB07				
Programme	M. Tech				
Semester	I	EEE			
Course Type	Elective				
Regulation	IARE - R18				
Course Structure	Theory			Practical	
	Lectures	Tutorials	Credits	Laboratory	Credits
	3	-	3	-	-
Chief Coordinator	Mr. P Shivakuymar Assistant Professor, EEE				
Course Faculty	Mr. P Shivakuymar Assistant Professor, EEE				

I. COURSE OVERVIEW:

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

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AEE010	V	Power electronics	4
UG	AEE012	VI	Power System Analysis	4

III. MARKSDISTRIBUTION:

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

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

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

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two session examinations. **Semester End Examination (SEE):** The SEE shall be conducted for 70 marks of 3 hours duration. The syllabus for the theory courses shall be divided into FIVE UNITS and each UNIT carries equal weight age in terms of marks distribution. The question paper pattern shall be as defined below. Two full questions with „either“ „or“ choice will be drawn from each UNIT. Each question carries 14 marks. There could be a maximum of three sub divisions in a question.

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

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

Continuous Internal Assessment (CIA):

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

Table 1: Assessment pattern for CIA

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

Continuous Internal Examination (CIE):

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

Technical Seminar and Term Paper:

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

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	Identify, formulate and solve power system related problems using advanced level computing techniques.	2	Discussion and Seminars
PO 2	Explore ideas to carry out research / investigation independently to solve practical problems through continuing education	2	Seminars

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 3	Demonstrate knowledge and execute projects on contemporary issues in multidisciplinary environment.	2	Seminars
PO 4	Ability to write and present a substantial technical report / document	2	Seminars
PO 5	Inculcate ethics, professionalism, multidisciplinary approach, entrepreneurial thinking and effective communication skills.	1	Discussion and Seminars
PO 6	Function effectively as an individual or a leader in a team to propagate ideas and promote teamwork.	2	Laboratory practice
PO 7	Develop confidence for self-study and to engage in lifelong learning.	2	Laboratory practice

3 = High; 2 = Medium; 1 = Low

VII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Explain the necessity of reactive power compensation
II	Describe load compensation
III	Understand the various types of reactive power compensation in transmission systems
IV	Illustrate reactive power coordination system
V	Discuss distribution side and utility side reactive power management.

VIII. COURSE OUTCOMES

COs	Course Outcomes	CLO's	Course Learning Outcomes
CO1	Understand objectives specifications of load compensation.	CLO 1	Understand objectives specifications of load compensation
		CLO 2	Examine how load compensator as a voltage regulator
		CLO 3	Analyze phase balancing and power factor correction of unsymmetrical loads examples.
CO2	Analyze steady state reactive power compensation in transmission system	CLO 4	Understand types of compensation
		CLO 5	Analyze examples transient state reactive power compensation in transmission systems
CO3	Understand reactive power coordination circuit analysis of balanced and unbalanced networks.	CLO 6	Understand objective, mathematical modeling, operation planning, transmission benefits
		CLO 7	Understand basic concepts of quality of power supply, disturbances steady, state variations.
		CLO 8	Examine Effects of under voltages, frequency, harmonics, radio frequency and electromagnetic interferences.
CO4	Understand demand side management.	CLO 9	Understand Load patterns, basic methods load shaping.
		CLO 10	Describe power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.
		CLO 11	Understand Distribution side reactive power management.
		CLO 12	Examine Economics planning capacitor placement, retrofitting of capacitor banks.

CO5	Understand user side reactive power management.	CLO 13	Purpose of using capacitors, selection of capacitors, deciding factors, types of available capacitor, characteristics and Limitations.
		CLO 14	Understand Reactive power management in electric traction systems and are furnaces.
		CLO 15	Illustrate typical layout of traction systems, reactive power control requirements.
		CLO 16	Understand electric arc furnaces, basic operations- furnaces transformer, filter requirements.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
BPEB07.01	CLO 1	Understand objectives specifications of load compensation	PO1	2
BPEB07.02	CLO 2	Examine how load compensator as a voltage regulator	PO1	2
BPEB07.03	CLO 3	Analyze phase balancing and power factor correction of unsymmetrical loads examples.	PO1,PO2	2
BPEB07.04	CLO 4	Understand types of compensation	PO1,PO2	2
BPEB07.05	CLO 5	Analyze examples transient state reactive power compensation in transmission systems	PO1,PO2,PO4	2
BPEB07.06	CLO 6	Understand objective, mathematical modeling, operation planning, transmission benefits	PO1,PO2	2
BPEB07.07	CLO 7	Understand basic concepts of quality of power supply, disturbances steady, state variations.	PO1,PO2,PO3, PO6,PO7	2
BPEB07.08	CLO 8	Examine Effects of under voltages, frequency, harmonics, radio frequency and electromagnetic interferences.	PO1,PO3	2
BPEB07.09	CLO 9	Understand Load patterns, basic methods load shaping.	PO1,PO3	2
BPEB07.10	CLO 10	Describe power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.	PO1,PO3	2
BPEB07.11	CLO 11	Understand Distribution side reactive power management.	PO1,PO3	2
BPEB07.12	CLO 12	Examine Economics planning capacitor placement, retrofitting of capacitor banks.	PO1,PO4,PO5	2
BPEB07.13	CLO 13	Purpose of using capacitors, selection of capacitors, deciding factors, types of available capacitor, characteristics and Limitations.	PO1,PO2,PO7	2
BPEB07.14	CLO 14	Understand Reactive power management in electric traction systems and are furnaces.	PO1,PO5 PO6,PO7	2
BPEB07.15	CLO 15	Illustrate typical layout of traction systems, reactive power control	PO1,PO3	2

		requirements.		
BPEB07.16	CLO 16	Understand electric arc furnaces, basic operations- furnaces transformer, filter requirements.	PO1,PO2,PO5,PO7	2

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

CLOs	Program Outcomes (POs)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CLO 1	2						
CLO 2	2						
CLO 3	2	2					
CLO 4	2	2					
CLO 5	2	2		2			
CLO 6	2	2					
CLO 7	2	2	2			2	2
CLO 8	2		2				
CLO 9	2		2				
CLO 10	2		2				
CLO 11	2		2				
CLO 12	2			2	1		
CLO 13	2	2			1		2
CLO 14	2	2		2	1	2	2
CLO 15	2		2				
CLO 16	2	2					2
CLO 17	2	2			1		2

3 = High; 2 = Medium; 1 = Low

XI. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO1, PO2, PO3,PO4,PO5, PO6,PO7	SEE Exams	PO1, PO2, PO3, PO5,	Assignments	PO2, PO3, PO5	Seminars	PO2, PO5
Laboratory Practices	PO3	Student Viva	PO2, PO3,	Mini Project	-	Certification	-
Term Paper	-						

XII. ASSESSMENT METHODOLOGIES - INDIRECT

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

XIII. SYLLABUS

UNIT-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	
UNIT-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.	
UNIT-III	REACTIVE POWER COORDINATION
Objective, mathematical modeling, operation planning, transmission benefits, basic concepts of quality of power supply, disturbances steady, state variations. Effects of under voltages, frequency, harmonics, radio frequency and electromagnetic interferences.	
UNIT-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.	
UNIT-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 arc 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.	
Text Books:	
1. TJE Miller, "Reactive power control in Electric power systems", Wiley Publication, 1 st Edition, 1982.	
2. D M Tagare, "Reactive power Management", by Tata McGraw Hill, 1 st Edition, 2004.	
Reference Books:	
1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just "Reactive Power Compensation: A practical Guide", Wiley publication, 4 th Edition, 2012.	

XIV. COURSE PLAN:

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

Lecture No.	Topics tobcovered	CLOs	Reference
1	Objectives and specification:	CLO1	T1:1.1
2,3	inductive approximate biasing	CLO1	T1:2,3,4
4	Capacitive approximate biasing.	CLO2	T4:9.4.3
5	Capacitive approximate biasing. load compensator as a voltage	CLO2	T1:1.13
6,7	phase balancing, power factor correction of unsymmetrical loads examples	CLO2	T1:1.10-1.11
8	power factor correction of unsymmetrical loads examples Problems	CLO3	T1:2.3,3.1 R4:3.1-3.2
9,10	Introduction of reactive power compensation, Types of compensation	CLO3	T1:7.1-7.10
11	passive shunt and series compensation	CLO4	T1: 8.1-8.7
12	dynamic shunt compensation	CLO4	T1: 9.1
13	examples of transient state reactive power compensation in	CLO4	T1:8.1
14	Characteristic time periods, Passive shunt compensation	CLO5	T1:9.1
15	static compensations, series capacitor compensation	CLO5	T1:9.2 R4:6.2
16	Compensation using synchronous condensers, Examples.	CLO5	T4:9.1
17	Introduction of reactive power coordination	CLO6	T1:9.3-9.4 R4:6.3
18	Objective of reactive power coordination	CLO6	T1:9.7
19	mathematical modeling	CLO7	T4:9.7
20	operation planning ,transmission benefits	CLO7	T4:9.4.12
21	basic concepts of quality of power supply	CLO8	T4:10.3
22	disturbances steady, Effects of under voltages	CLO8	T1:10.1-10.2
23	frequency, harmonics	CLO8	T1:8.2
24	Introduction of demand side management, Load patterns	CLO9	T1:8.3
25,26	basic methods load shaping, power tariffs KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels;	CLO9	T4:10.5
27	System losses, loss reduction methods	CLO10	T1:11.1-11.2
28	examples, reactive power planning	CLO11	T1:11.7
29	objectives, economics planning capacitor placement	CLO12	T1:11.6
30,31	retrofitting of capacitor banks.	CLO12	T1:12.3-12.4
32	Requirements for domestic appliances	CLO13	T1:15.1
33	purpose of using capacitors, selection of capacitors	CLO13	T1:14.1
34,35	deciding factors, types of available capacitor, characteristics and Limitations	CLO14	T1:14.2
36,37	Reactive power management in electric traction systems and are furnaces	CLO14	T1:14.3
38	Typical layout of traction systems, reactive power control requirements	CLO14	T1:14.4
39	distribution transformers	CLO15 CLO15	T1:15.1
40	Electric arc furnaces, basic operations- furnaces	CLO15	T1:15.2
41,42	filter requirements	CLO16	T1:15.4
43	remedial measures	CLO16	T1:15.3

Lecture No.	Topics to be covered	CLOs	Reference
44	power factor of an arc furnace.	CLO16	T1:15.4
45	problems	CLO16	T1:15.5

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

S No	Description	Proposed actions	Relevance with POs
1	Distribution side reactive power management	Organizing workshops, mini projects	PO1,PO3
2	Types of reactive power compensation	Organizing workshops	PO1,PO2

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