GMRIT

Curriculum
2019

B. Tech.
Electrical & Electronics Engineering

(Duration of Study : 4 years)

GMRIT
Training Tomorrow's Engineers Today

Department of Electrical & Electronics Engineering
GMR Institute of Technology
Rajam, Andhra Pradesh
(An Autonomous Institute Affiliated to JNTU Kakinada, AP)
NBA Accredited and NAAC Accredited

The Vision of GMRIT

- To be among the most preferred institutions for engineering and technological education in the country
- An institution that will bring out the best from its students, faculty and staff – to learn, to achieve, to compete and to grow – among the very best
- An institution where ethics, excellence and excitement will be the work religion, while research, innovation and impact, the work culture

The Mission of GMRIT

- To turnout disciplined and competent engineers with sound work and life ethics
- To implement outcome based education in an IT-enabled environment
- To encourage all-round rigor and instill a spirit of enquiry and critical thinking among students, faculty and staff
- To develop teaching, research and consulting environment in collaboration with industry and other institutions

Department Vision

To be a most preferred Electrical & Electronics Engineering department of learning for students and teachers alike, with dual commitment to research and serving students in an atmosphere of innovation and critical thinking.

Department Mission

- To provide high-quality education in Electrical & Electronics Engineering, to prepare the graduates for a rewarding career in Electrical & Electronics Engineering and related industries, in tune with evolving needs of the industry.
- To prepare the students to become thinking professional and good citizens who would apply their knowledge critically and innovatively to solve professional and societal problems.

Program Educational Objectives (PEOs)

- PEO1: Graduates with ability to solve core engineering problems through continuous self-paced learning in tune with changing technologies
- PEO2: Reinforce engineering skills, critical thinking and problem-solving skills in professional engineering practices and deal with socio-economical, technical and business challenges
- PEO3: Nurture professionalism with soft skills, managerial & leadership skills and ethical values.

Program Outcomes (POs):

Engineering graduate will be able to:

PO 1: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. (Engineering knowledge)

PO 2: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences. (Problem analysis)

PO 3: 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. (Design/development of solutions)

PO 4: 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. (Conduct investigations of complex problems)

PO 5: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations. (Modern tool usage)

PO 6: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. (The engineer and society)

PO 7: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. (Environment and sustainability)

PO 8: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. (Ethics)

PO 9: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. (Individual and team work)

PO 10: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. (Communication)

PO 11: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. (Project management and finance)

PO 12: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change. (Life-long learning)

Program Specific Outcomes (PSOs):

Engineering graduate will be able to:

PSO#1: Utilize statistics, transformation methods, discrete mathematics and application of differential equations in analysing and design of electrical/electronic systems. (Program Specific)

PSO#2: Analyze, design and implement control of electrical systems in any problem/application of electrical/electronic (s) engineering. (Program Specific)

Department of Electrical & Electronics Engineering

Minimum Credits to be earned: 164 (for Regular Students)
131 (for Lateral Entry Students)

No	Course Code	Course	POs	Contact Hours			
				L	T	P	C
First Semester							
1	19HSX01	Communicative English	10,12	3	1	-	3
2	19MAX01	Engineering Mathematics I	1,12	3	1	-	3
3	19PYX01 19CYX01	Engineering Physics / Engineering Chemistry	1,12/ 1,12	3	1	-	3
4	19BEX01 19BEX02	Basics of Engineering / Problem Solving and Programming Skills	1,12/ 1,12	3	1	-	3
5	19BEX03 19HSX02	Problem Solving and Programming Skills Laboratory/ Communicative English Laboratory	4/ 10,12	-	-	3	1.5
6	19BEX04 19BEX05	Engineering Drawing / Engineering Workshop	1,5,10/ 1,9,10	-	-	3	1.5
7	19PYX02 19CYX02	Engineering Physics Laboratory / Engineering Chemistry Laboratory	4/ 4	-	-	3	1.5
			Total	**12**	**4**	**9**	**16.5**
Second Semester							
1		Language Elective	10,12	3	1	-	3
2	19MAX02	Engineering Mathematics II	1,12	3	1	-	3
3	19PYX01 19CYX01	Engineering Physics / Engineering Chemistry	1,12/ 1,12	3	1	-	3
4	19BEX01 19BEX02	Basics of Engineering / Problem Solving and Programming Skills	1,12/ 1,12	3	1	-	3
5	19BEX03 19HSX02	Problem Solving and Programming Skills Laboratory/ Communicative English Laboratory	4/ 10,12	-	-	3	1.5
6	19BEX04 19BEX05	Engineering Drawing / Engineering Workshop	1,5,10/ 1,9,10	-	-	3	1.5
7	19PYX02 19CYX02	Engineering Physics Laboratory / Engineering Chemistry Laboratory	4/ 4	-	-	3	1.5
			Total	**12**	**4**	**9**	**16.5**
Third Semester							
1	19MA302	Engineering Mathematics III	1,4,5	3	-	2	4
2	19EE302	DC Machines and Transformers	1,2	3	1	-	3
3	19EE303	Electrical Circuits I	1,2,4,5	3	-	2	4
4	19EE304	Electromagnetic Field Theory	1,2	3	1	-	3
5	19EE305	Measurements and Instrumentation	1,2,3	3	1	-	3
6	19EE306	Semiconductor Devices and Circuits	1,2,3	3	1	-	3
7	19EE307	DC Machines Lab	4	-	-	3	1.5
8	19EE308	Semiconductor Devices and Circuits Lab	4	-	-	3	1.5
9	19BEA01	Environmental Studies	1,6,7,12	-	-	-	-
10	19EE409	Employability Skills I	1,2,5,8,10,12	1	1	1	-
11	19HSX11	CC & EC Activities I	6,7,9,10	-	-	1	-
			Total	**19**	**5**	**12**	**23**
Fourth Semester							
1	19EE401	AC Machines	1,2	3	1	-	3
2	19EE402	Electrical Circuits II	1,2	3	1	-	3
3	19EE403	Linear and Digital Integrated Circuits	1,2,4	3	-	2	4
4	19EE404	Power Generation, Transmission and Distribution	1, 2,6	3	1	-	3
5	19EE405	Signals and Systems Theory	3,5,PSO1	3	1	-	3
6	19EE406	AC Machines Lab	4	-	-	3	1.5

7	19EE407	Measurements and Instrumentation Lab	4	-	-	3	1.5
8	19EE409	Employability Skills I	1,2,5,8,10,12	1	1	1	3
9	19HSX11	CC & EC Activities I	6,7,9,10	-	-	1	1
10	19EE408	Comprehensive Quiz I (Sem. 3 & 4)	-	-	-	-	2
			Total	**16**	**5**	**10**	**25**
Fifth Semester							
1	19IT306	Object Oriented Programming through Java	1,2,3,4,5	3	-	2	4
2	19EE502	Control Systems	2,3,4,5,PSO1,PSO2	3	-	2	4
3	19EE503	Power Electronics	2,3, PSO1,PSO2	3	1	-	3
4	19EE504	Power System Protection	2,3,PSO2	3	1	-	3
5		Elective I (Professional Elective)		3	1	-	3
6		Elective II (Open Elective I)		3	1	-	3
7	19EE507	Power Systems Lab	4,5	-	-	3	1.5
8	19EE508	Term Paper	1,4,10,12	-	-	3	1.5
9	19EE609	Employability Skills II	1,2,5,8,10,12	1	1	1	-
10	19HSX12	CC & EC Activities II	6,7,9,10	-	-	1	-
11	19EE511	Summer Internship I	1,2,8,10,12				1.5
			Total	**19**	**5**	**12**	**24.5**
Sixth Semester							
1	19HSX10	Engineering Economics and Project Management	11,12	3	1	-	3
2	19EE602	Electrical Drives	2,3, PSO2	3	1	-	3
3	19EE603	Power System Analysis and Control	2,3, PSO1,PSO2	3	1	-	3
4		Elective III (Professional Elective)		3	-	2	4
5		Elective IV (Open Elective II)		3	1	-	3
6	19EE606	Power Electronics and Drives Lab	4,5	-	-	3	1.5
7	19EE607	Mini Project	1 to12,PSO1,PSO2	-	-	3	1.5
8	19EE608	Comprehensive Quiz II (Sem. 5 & 6)	-	-	-	-	2
9	19EE609	Employability Skills II	1,2,5,8,10,12	1	1	1	3
10	19HSX12	CC & EC Activities II	6,7,9,10	-	-	1	1
11		Audit Course	12	-	-	-	-
			Total	**16**	**5**	**10**	**25**
Seventh Semester							
1		Elective V (Professional Elective)		3	1	-	3
2		Elective VI (Professional Elective)		3	1	-	3
3		Elective VII (Open Elective III)		3	1	-	3
4	19EE701	Summer Internship II	1,2,5,6,10,12	-	-	-	1.5
5	19EE702	Project	1 to12,PSO1,PSO2	-	-	16	8
			Total	**9**	**3**	**16**	**18.5**
Eighth Semester							
1		Elective VIII (Professional Elective)		-	-	-	3
2		Elective IX (Open Elective IV)		-	-	-	3
3	19EE801	Full Semester Internship (FSI)	1,2,5,8,9,10,PSO1, PSO2	-	-	-	9
			Total	**-**	**-**	**-**	**15**

List of Electives

Language Electives							
No.	**Course Code**	**Course**	**POs**	**Contact Hours**			
				L	**T**	**P**	**C**
1	19HSX03	Advanced Communicative English	10,12	3	1	-	3
2	19HSX04	Communicative German		3	1	-	3
3	19HSX05	Communicative French		3	1	-	3
4	19HSX06	Communicative Japanese		3	1	-	3
5	19HSX07	Communicative Spanish		3	1	-	3
6	19HSX08	Communicative Korean		3	1	-	3
7	19HSX09	Communicative Hindi		3	1	-	3

Elective I							
Career Path I, II, III and Other Core Electives							
1	19EEC11	Electrical Vehicle Technologies	2,3,12, PSO2	3	1	-	3
2	19EEC21	Green Energy Technologies	2,3,12	3	1	-	3
3	19EEC31	Micro and Smart Grid Technologies	2,3,12, PSO2	3	1	-	3
4	19EE004	Electrical Machine Design	2,3	3	1	-	3
5	19EE005	High Voltage DC Transmission	2,3, PSO2	3	1	-	3
6	19EE006	Special Electrical Machines	2,3, PSO2	3	1	-	3
7		MOOCs		-	-	-	3
Elective II:Open Elective I							
1	19CE001	Disaster Management	2,7	3	1	-	3
2	19EE001	Electrical Installation, Safety and Auditing	2,3,6,8	3	1	-	3
3	19ME001	Fundamentals of Optimization Techniques	1,2	3	1	-	3
4	19EC001	Sensors for Engineering Applications	1	3	1	-	3
5	19CS001	Fundamentals of Artificail Intellegence	1,2,3	3	1	-	3
6	19CH001	Energy Conversion and Storage Devices	1,3,6,7	3	1	-	3
7	19IT001	Fundamentals of Multimedia	1,5,7	3	1	-	3
8	19BS001	Nano Materials and Technology	1,12	3	1	-	3
Elective III							
Career Path I, II, III and Other Core Electives							
1	19EEC12	Electric Vehicle Drive Train Systems	2,3,12,PSO2	3	-	2	4
2	19EEC22	Power Electronic Applications to Green Energy Systems	2,3,5,12,PSO2	3	-	2	4
3	19EEC32	Control and Instrumentation of Smart Grid Systems	3,4,5,12,PSO2	3	-	2	4
4	19EE007	Advanced Control Systems	2,3,4,5,PSO1,PSO2	3	-	2	4
5	19EE008	Discrete Signal Processing	2,3,4,5,PSO1,PSO2	3	-	2	4
6	19EE009	Machine Modelling and Steady State Analysis	2,3,4,5	3	-	2	4
7		MOOCs		-	-	-	4
Elective IV : Open Eletive II							
1	19CE002	Air Pollution and Environmental Impact Assessment	6,7,12	3	1	-	3
2	19EE002	Renewable Energy Sources	2,7	3	1	-	3
3	19ME002	Principles of Entrepreneurship	1,11	3	1	-	3
4	19EC002	Electronics for Agriculture	1,2	3	1	-	3
5	19CS002	Fundamental of Machine Learning	2,5	3	1	-	3
6	19CH002	Industrial Safety and Hazard Management	1,2,3,6,8	3	1	-	3
7	19IT002	Fundamentals of Cloud Computing	1,7	3	1	-	3
8	19BS002	Advanced Numerical Techniques	1,2	3	1	-	3
9	19BS003	Functional Materials and Applications	1,4	3	1	-	3
Elective V							
Career Path I, II, III and Other Core Electives							
1	19EEC13	Battery Management Systems	2,12, PSO1, PSO2	3	1	-	3
2	19EEC23	Hybrid Renewable Energy Systems Design	2,12, PSO1, PSO2	3	1	-	3
3	19EEC33	Communication and Security in Smart Grid	2,12, PSO1, PSO2	3	1	-	3
4	19EE010	Electrical Distribution Systems	2,3,PSO2	3	1	-	3
5	19EC401	Analog and Digital Communications	1,2	3	1	-	3
6	19IT304	Database Management Systems	1,2,3,12	3	1	-	3
7		MOOCs		-	-	-	3
Elective VI							
1	19EE011	Utilization of Electrical Energy	3,6,7,8	3	1	-	3
2	19EE012	Microprocessors and Microcontroller interfacing	2,3,10,PSO2	3	1	-	3
3	19EE013	Programmable Logic Controllers	2,3,PSO2	3	1	-	3
		MOOCs		-	-	-	3

Elective VII:Open Elective III							
1	19CE003	Solid Waste Management	3,7,12	3	1	-	3
2	19EE003	Fundamentals of Electrical Vehicle Technology	2,3,12	3	1	-	3
3	19ME003	Industrial Engineering and Management	1,11	3	1	-	3
4	19EC003	Interfacing and Programming with Arduino	1,2	3	1	-	3
5	19CS003	Data Science for Engineering Applications	2,3,4	3	1	-	3
6	19CH003	Industrial Ecology for Sustainable Development	2,6,7	3	1	-	3
7	19IT003	Fundamentals of Mobile Computing	1,7	3	1	-	3
8	19BS004	Advanced Materials of Renewable Energy	1,7	3	1	-	3
9	19BS005	Applied Linear Algebra for Engineers	1,12	3	1	-	3
Elective VIII (Professional Elective)							
1	19EE014	Power system Deregulation	2,3,PSO2	-	-	-	3
2	19EE015	Energy Audit, Conservartion & Management	2,3,12,PSO2	-	-	-	3
3	19EE016	High Voltage Engineering	2,3,PSO2	-	-	-	3
Elective IX (Open Elective IV)							
1	19CE019	Green Buildings	1,7,12	-	-	-	3
2	19EE017	Sustainable Energy	1,2,12	-	-	-	3
3	19ME019	Total Quality Management	1,11	-	-	-	3
4	19EC011	Communication Technologies	1,2	-	-	-	3
5	19CS020	Applications of Artificial Intelligence	2,3,6,7	-	-	-	3
6	19CH016	Green Technologies	1,6,7	-	-	-	3
7	19IT015	Human Computer Interaction	1,7	-	-	-	3
8	19BS006	Handling of Industrial waste and waste water	1,7	-	-	-	3
Audit Course							
1	19AT001	Communication Etiquette in Workplaces	-	-	-	-	-
2	19AT002	Contemporary India: Economy, Policy and Society	-	-	-	-	-
3	19AT003	Design The Thinking	-	-	-	-	-
4	19AT004	Ethics and Integrity	-	-	-	-	-
5	19AT005	Indian Heritage and Culture	-	-	-	-	-
6	19AT006	Human Values and Professional Etheics	-	-	-	-	-
7	19AT007	Intellectual Property Rights and Patents	-	-	-	-	-
8	19AT008	Introduction to Journalism	-	-	-	-	-
9	19AT009	Mass Media Communication	-	-	-	-	-
10	19AT010	Science, Technology and Development	-	-	-	-	-
11	19AT011	Social Responsibility	-	-	-	-	-
12	19AT012	The Art of Photography and Film Making	-	-	-	-	-
13	19AT013	Gender Equality for Sustainbility	-	-	-	-	-
14	19AT014	Women in Leadership	-	-	-	-	-
15	19AT015	Introduction to Research Methodology	-	-	-	-	-
16	19AT016	Climate Changes and Circular Economy					
B. Tech. (Honors)							
Domain I: AI in Electrical and Electronics Engineering							
01	19EEH11	Computational Intellegence in Electrical Engineering	2,12, PSO2	4	-	-	4
02	19EEH12	Data analytics in Electrical Engineering	2,12	4	-	-	4
03	19EEH13	Internet of Things in Electrical Engineering	2,12,PSO1	4	-	-	4
04	19EEH14	Introduction to Smart Cities	2,12,PSO2	4	-	-	4
Domain II: Power Systems							
01	19EEH21	Design and Layout of Power Systems	2,3,8	4	-	-	4
02	19EEH22	Distributed Generation Technologies	2,6,7,8,PSO2	4	-	-	4
03	19EEH23	Distribution System Planning and Automation	2,3,6,PSO2	4	-	-	4
04	19EEH24	Power Quality	2,3,8,PSO2	4	-	-	4
Domain III: Control Systems							
01	19EEH31	Adaptive Control Systems	2,3,PSO1,PSO2	4	-	-	4
02	19EEH32	Introduction to Autonomous Vehicles	2,3,PSO2	4	-	-	4

03	19EEH33	Introduction to Robust Control Systems	2,3,PSO1,PSO2	4	-	-	4
04	19EEH34	Optimal Control Systems	2,3,PSO1,PSO2	4	-	-	4
Domain IV: Power Electronics and Drives							
01	19EEH41	Advanced Power Electronics	2,3,PSO1,PSO2	4	-	-	4
02	19EEH42	Flexible AC Transimission Systems	2,3,PSO1	4	-	-	4
03	19EEH43	Power Electronic Control of DC Drives	2,3,PSO2	4	-	-	4
04	19EEH44	Power Electronic Control of AC Drives	2,3,PSO2	4	-	-	4
B. Tech. (Minors)							
Energy Science & Technology							
01	19CHM11	Foundation of Energy Science and Technology	1,2,3,5,7,12	4	-	-	4
02	19CHM12	Energy Generation from Waste	1,2,3,4,5	4	-	-	4
03	19CHM13	Energy Storage Systems	1,2,3,6,7	4	-	-	4
04	19CHM14	Hydrogen Energy and Fuel Cells	1,2,3,7	4	-	-	4
Nano Science & Technology							
01	19CHM21	Introduction and Characterization of Nano Materials	1,2,3,7	4	-	-	4
02	19CHM22	Carbon Nanostructures and Applications	1,3,4,5	4	-	-	4
03	19CHM23	Energy, Environment & Biomedical Nanotechnology	1,2,3,7	4	-	-	4
04	19CHM24	Industrial Applications of Nano Technology	2,3,5,7	4	-	-	4
Environmental Engineering							
01	19CEM11	Watershed Management	6,7	4	-	-	4
02	19CEM12	Industrial Pollution Control and Engineering	3,6,7	4	-	-	4
03	19CEM13	Solid and Hazardous Waste Management	1,3,6,7	4	-	-	4
04	19CEM14	Ecology and Environmental Assessment	1,3,6,7	4	-	-	4
Artificial Intelligence & Machine Learning							
01	19CSM11	Fundamentals of AI & Machine Learning	1,12	4	-	-	4
02	19CSM12	Feature Engineering for Machine Learning	1,2,3	4	-	-	4
03	19CSM13	Exploratory Data Analytics	1,4	4	-	-	4
04	19CSM14	Deep Learning	1,2,4	4	-	-	4
Cyber Security							
01	19CSM21	Fundamentals of Security	1,2	4	-	-	4
02	19CSM22	Management of Information Security	3,6,7	4	-	-	4
03	19CSM23	Cyber Security	1,3,4	4	-	-	4
04	19CSM24	Cloud Security	2,3	4	-	-	4
Data Science & Analytics							
01	19CSM31	Data Cleaning	2,3,4	4	-	-	4
02	19CSM32	Data Engineering	1,2,3,4	4	-	-	4
03	19CSM33	Text Analytics	1,2,4	4	-	-	4
04	19CSM34	Social Network and Semantic Analysis	2,4	4	-	-	4
Computer Systems Programming							
01	19CSM41	Programming Fundamentals	1,2,3	4	-	-	4
02	19CSM41	Data Structures & Algorithms	1,2,3,4	4	-	-	4
03	19CSM41	Fundamentals of Databases	1,4	4	-	-	4
04	19CSM41	Fundamentals of Computer Networks & Operating Systems	1,2,3	4	-	-	4
Digital IC Design							
01	19ECM11	Fundamentals of VLSI Design	1,2,3	4	-	-	4
02	19ECM12	Digital Design using HDL	1,2,3	4	-	-	4
03	19ECM13	FPGA Technology	1,2	4	-	-	4
04	19ECM14	Analog and Mixed Signal Design	1,2	4	-	-	4
Industrial Automation							
01	19ECM21	Microcontrollers and Interfacing	1,2,3	4	-	-	4
02	19ECM22	Sensors and Data Acquisition System	1,2	4	-	-	4
03	19ECM23	Fundamentals of Labview	1,2	4	-	-	4
04	19ECM24	Medical Robotics	1,2,3	4	-	-	4

Communications and Networking							
01	19ECM31	Principles of Communications	1,2	4	-	-	4
02	19ECM32	Coding Theory and Practice	1,2	4	-	-	4
03	19ECM33	Ad-hoc and Wireless Sensor Networks	1,2,3	4	-	-	4
04	19ECM34	Fundamentals of Multimedia Networking	1,2,3	4	-	-	4
Avionics							
01	19ECM41	Principles of Aerodynamics	1,2	4	-	-	4
02	19ECM42	Aircraft Electrical Systems	1,2	4	-	-	4
03	19ECM43	Aircraft Instrument Systems	1,2	4	-	-	4
04	19ECM44	Aircraft Communication and Navigational Systems	1,2	4	-	-	4
Geographic Information System							
01	19ECM51	Sensors and Sensing Technology	1,2	4	-	-	4
02	19ECM52	Geographic Information Systems	1,2	4	-	-	4
03	19ECM53	Digital Image Processing	1,2	4	-	-	4
04	19ECM54	Lidar Systems	1,2	4	-	-	4
Cloud Application Development							
01	19ITM11	Introduction to Cloud Computing	6,7,12	4	-	-	4
02	19ITM12	Introduction to Web Development with HTML, CSS, JavaScript	1,2,3,9,12	4	-	-	4
03	19ITM13	Developing Cloud Native Applications	5,8,10	4	-	-	4
04	19ITM14	Developing Cloud Apps with Node.js and React	5,8,10	4	-	-	4
Robotics and Automation							
01	19MEM11	Introduction to Robotics	1,2,3	4	-	-	4
02	19MEM12	Drives and Sensors	1,2,3,4	4	-	-	4
03	19MEM13	Control Systems for Robotics	1,2,3,4	4	-	-	4
04	19MEM14	Machine Learning for Robotics	2,5	4	-	-	4
Industrial Systems Engineering							
01	19MEM21	Industrial Management	1,10,11,12	4	-	-	4
02	19MEM22	Fundamentals of Operations Research	1,2,3,5	4	-	-	4
03	19MEM23	Enterprise Resource Planning	1,2,3,5,11,12	4	-	-	4
04	19MEM24	Production Planning and Control	1,2,3,5,11,12	4	-	-	4

19MA302 Engineering Mathematics III

(Programmes: EEE, MECH, CHEM)

3 0 2 4

Course Outcomes

1. Utilize numerical methods to find approximate solutions of equations and to find the best fit curve for given data
2. Make use of the concepts of interpolation to estimate the unknown functional values
3. Find approximate values of finite integrals and solution of ODE using numerical techniques
4. Interpret Baye's theorem and probability distribution functions to solve engineering problems
5. Identify the suitable distribution among Binomial, Poisson and Normal in engineering applications
6. Apply the concept of correlation between the variables and also construct the regression lines

COs – POs Mapping

COs	PO_1	PO_4	PO_5
1	3	1	2
2	3	1	2
3	3	1	2
4	3	1	2
5	3	1	2
6	3	1	2

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

Unit I

Solution of Algebraic and Transcendental Equations

Introduction, Bisection Method, Method of False Position, Newton-Raphson Method

Curve fitting-Fitting a straight line, Second degree curve, exponential curve, power curve by method of least squares

Geometrical interpretation - Bisection Method, Method of False Position, Newton-Raphson Method

Practical components

1. The Bisection method
2. Newton-Raphson Method
3. Linear Regression (Fitting of a straight line)

11 +10 Hours

Unit II

Interpolation, Numerical Integration and Numerical solution of Ordinary differential equations

Introduction, Finite differences, Newton's- forward and backward differences, Symbolic relations

Numerical Integration-Trapezoidal rule, Simpson's 1/3 Rule

Numerical Solution of Ordinary Differential equations: Solution by Taylor's series, Euler's, Modified Euler's Method, Runge-Kutta Methods

Milne's Predictor-Corrector Method

Practical components

1. Trapezoidal rule
2. Simpson's 1/3 Rule
3. Solution of Initial Value Problem using Taylor's series method
4. Solution of Initial Value Problem using Runge-Kutta Method of order four

12 +10 Hours

Unit III

Probability and Random variables

Probability, axioms of probability, Conditional probability, Baye's theorem

Random variables-Discrete and continuous Distributions and properties, Mathematical expectation, MGFs

Addition, Multiplication theorems of probability

Practical components

1. Baye's Rule

11 + 4 Hours

Unit IV

Probability Distributions, Correlation and Regression

Binomial, Poisson and Normal distribution – related properties

Correlation- Pearson's correlation coefficient and Spearman's Rank correlation coefficient, linear Regression (construction of Regression lines)

Correlation of grouped data, curvilinear regression

Practical components

1. Normal Distribution
2. Correlation related problems

11 + 6 Hours

Total: 45+30 Hours

Textbook (s)

1. B. S. Grewal, Higher Engineering Mathematics, 44th ed., Khanna Publishers, New Delhi, 2017
2. B. V. Ramana, Engineering Mathematics, 4th ed., Tata Mc Graw Hill, 2018
3. Engineering Mathematics-III lab manual-Mathematics Department (BS&H) - GMRIT, Rajam

Reference (s)

1. T. K.V. Iyengar, S.Ranganatham, B.Krishna Gandhi, Mathematical Methods, 2nd ed., S.Chand Co., New Delhi, 2006
2. T. K. V. Iyengar, K.B. Gandhi, Probability and Statistics, S. Chand Co., New Delhi, 2012
3. Ervin Kreyszig, Advanced Engineering Mathematics, 9th ed., Wiley India Pvt. Ltd., 2012
4. S. S. Sastry, Introductory methods of Numerical Analysis, 4th ed., Prentice Hall of India Pvt. Ltd., 2006
5. .Engineering Mathematics-III Lab Manual - Mathematics Department (BS&H) - GMRIT, Rajam.
6. https://www.scilab.org/tutorials

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)
Remember	10	10
Understand	30	30
Apply	60	60
Analyze	-	-
Evaluate	-	-
Create	-	-
Total (%)	100	100

Sample question (s)

Remember

1. Identify the root lies between which values for $x^3 - 5x + 1 = 0$.
2. State the Axioms of probability.

Understand

1. Prove that $\mu = \frac{1}{2}(E^{\frac{1}{2}} + E^{-\frac{1}{2}})$.
2. Show that the mean and variance are equal for Poisson distribution.

Apply

1. Given $y' = x^2 - y$, $y(0) = 1$, find $y(0.1)$, by using Euler's method.
2. In a bolt factory machines A, B, C manufacture 20%, 30% and 50% of the total of their output and 6%, 3% and 2% are defective. A bolt is drawn at random and found to be defective. Calculate the probabilities that it is manufactured from (i) machine A (ii) machine B.

Analyze

1. Analyze the roots of the equation $x^2 - 2x + 3 = 0$ by drawing its curve.
2. Assume wireless sets are manufactured with 25 soldered joints each on the average one joint in 500 is defective. How many sets can be expected to be free from defective joints in a consignment of 10,000 sets.

Evaluate

1. Compare the procedures of N-R method and R-F method.
2. Determine the probability of getting at least i) 7 heads ii) 6 heads, when 10 coins are tossed simultaneously.

19EE302 DC Machines and Transformers

3 1 0 3

Course Outcomes

1. Illustrate the constructional features and working of DC machine
2. Outline the various starting, speed control and testing methods of DC motors
3. Analyze the performance of DC machine
4. Illustrate the constructional features and working of transformer
5. Outline the testing methods of transformer
6. Analyze the performance of transformer

COs – POs Mapping

COs	PO_1	PO_2
1	3	2
2	3	2
3	3	3
4	3	2
5	3	2
6	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

DC Generators

DC Machine-constructional features - principle of operation, EMF equation, methods of excitation – circuit model, armature reaction - effects of armature reaction - cross magnetizing and de-magnetizing AT/pole, commutation, power flow equation - losses - constant & variable losses, build-up of EMF - OCC and load characteristics of shunt, series and compound generators, parallel operation of DC shunt generators, applications of DC generators

Purpose of equalizer rings and dummy coils

12+4 Hours

Unit II

DC Motors

DC Motors - principle of operation, types of DC Motors, torque equation, characteristics and application of shunt, series and compound motors, speed control of DC Motors - armature voltage and field flux control methods, three-point starter, Brake test, Swinburne's test, Hopkinson's test

Four-point starters and Retardation test

11+4 Hours

Unit III

Single Phase Transformers

Single phase transformers – types, constructional details, Ideal Transformer, EMF equation, operation at no-load and load, practical Transformer, phasor diagrams, equivalent circuit, losses and efficiency, regulation, OC and SC tests, all day efficiency, applications, parallel operation of transformers with equal voltage ratios.

Parallel operation of transformers with unequal voltage ratios

12+4 Hours

Unit IV

Auto-Transformers and Three Phase Transformers

Auto-transformers: Constructional details, copper saving, VA rating, conversion of two winding transformer to an autotransformer, applications.

Three phase transformers: Construction, principle of operation, three phase transformer connections - Y/Y, Y/Δ, Δ /Y, Δ/Δ, Open Δ and Scott connections.

Tap changing transformers

10+3 Hours

Total: 45+15=60 Hours

Textbook (s)

1. P. S. Bimbra, “Electrical Machinery”, Khanna Publishers, 7th Edition, Color Reprint 2014.
2. I.J. Nagrath& D.P. Kothari, “Electric Machines”, Tata McGraw Hill, 5th Edition, 2017.
3. A.E. Fitzgerald, Charles Kingsley, JR., Stephen D. Umans, “Electric Machinery”, Tata McGraw Hill, 6th Edition, 2017.

Reference (s)

1. Samarjit Ghosh, “Electric Machines”, Pearson Publications, 2nd Edition, 2012.
2. J. B. Gupta, “Theory and Performance of Electrical Machines”, S. K. Kataria & Sons Publishers, New Delhi, 14th Edition, Reprint 2013.
3. S. K. Sahdev, “Electrical Machines”, Cambridge University Press; 1st Edition, 2017
4. P. S. Bimbra, “Generalized Theory of Electrical Machinery”, Khanna Publishers, 6th Edition, 2015.
5. B.L. Theraja & A.K. Theraja “A Textbook of Electrical Technology: Volume-2, AC and DC Machines”, 23rd edition, 2019.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	25	25	---
Analyze	---	---	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. State Faraday's laws of electromagnetic induction
2. Label any 4 parts of a DC machine
3. List the different types of three phase transformer connections.
4. Define armature reaction
5. List any 4 applications of transformer

Understand

1. Compare dc generator and dc motor
2. Explain the principle of operation of DC motor
3. Justify the condition for maximum efficiency for a DC machine
4. Represent e.m.f. equation of a transformer
5. Explain why transformer rating will be given in kVA but not in kW

Analyze

1. Analyze the effect of load sharing due to impedance variations between transformers during parallel operation.
2. There is an old Tram Vehicle which was not used for more than 10 years. However, due to some requirement its working is to be restored. Up on preliminary inspection by an engineer it was diagnosed that the tram employed a DC series motor for operation with mechanical gear wheel arrangement for speed control. Further, it was also found that the entire systems in the tram are intact i.e. no physical damages were identified and ideally the tram should start working. But when the engineer tried to start the tram the motor could not start.
   (i) Identify the proper reasons for the motor not starting.
   (ii) Having known the reasons why the motor is not starting, how would you bring it back to working condition.

(iii) Since, the mechanical speed control systems are inefficient, suggest a modern control system for the motor with illustrations. Justify your selection.

3. The design specification of Transformer was provided by a foreign collaborator to reputed and experienced Indian manufacturer. The subject transformer manufacturing was going on well with all quality checks and records till the Vapour Phase Drying (VPD) process. After VPD at the stage of servicing before tanking, as per scheduled check an isolation test at 10 kV between Core laminations and Core clamping structure was performed. On application of high voltage, voltage couldn't reach beyond the level of 8 KV and collapsed. On second attempt voltage collapsed only at 800 Volts. It was a rare failure, least expected by the manufacturer. Suggest the corrective actions by reviewing the above problem statement. The Construction and transformer detail are given below.

Transformer	Generator Transformer
Power	315 MVA
Voltage	24 (LV) / 420/√3 KV (HV)
Current	11666.67 A / 1299.04 A
Vector Group	YNd11
Phase	Single
Class	420 KV

(For Open Book Examination and not for semester end examination)

4. A steel plant is constructed to be operated on a DC supply. The main functional units in the plants are depicted below.
   a. Blast furnace (BF)
   b. Steel melt shop (SMS)
   c. Rolling mill

I. To transport coal/ raw materials over conveyor belt to blast furnace (BF). The molten steel is then transferred to steel melt shop (SMS) in wagons. The conveyor belt operates at a variable load at constant speed. Suggest a suitable motor for conveyor belt system and justify your answer.

II. The molten metal from BF which is received by wagon is lifted by electrically operated trolley (EOT) crane for superheating the molten metal to 6000^{o}C to remove impurities and moisture. The entire working of the SMS plant is based on the operation of the EOT crane which is used to lift and tilt the ladle (bucket) containing molten metal into the heating furnace. The weight of the molten metals will be in tons and the operation must be carried out very slowly in order to avoid casualties. Suggest a suitable motor for EOT crane and justify your answer.

III. The molten metal from SMS is then sent to continuous casting department (CCD) where it is cooled down, solidified and cut into rectangular blooms of uniform length. The blooms are then transferred to mills where they are made into different shapes for consumer use. The output products from mills are circular wires, L and I angles, rectangular sheets etc.
   a. A motor is required to compress the bloom such that the above shapes can be obtained.
   b. Another motor is required to roll the compressed bloom into required final product.
   c. Finally, a motor is used to transfer the product to the warehouse using a conveyer belt.

   Suggest suitable motors for the operations mentioned in a,b,c in the above question and justify the same. **(For Open Book Examination and not for semester end examination)**

19EE303 Electrical Circuits I

3 0 2 4

Course Outcomes

1. Outline various network reduction techniques
2. Interpret the response of RLC circuits for sinusoidal excitation
3. Apply the concept of RLC circuits for various applications
4. Summarize the concepts of three phase circuits
5. Illustrate the concepts of coupled magnetic circuits
6. Apply network theorems for various applications

COs – POs Mapping

COs	PO_1	PO_2	PO_4	PO_5
1	3	3	3	3
2	3	2	3	3
3	3	3	3	3
4	3	2	3	3
5	3	2	2	2
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I
DC Circuits
Circuit concept – R, L, C parameters, voltage and current sources – independent and dependent sources, source transformation, Kirchhoff's laws, network reduction techniques – series, parallel, series parallel, star-to-delta or delta-to-star transformation, nodal analysis, mesh analysis, super node analysis and super mesh analysis for DC excitations
Voltage and current division rules
Practical Component
1. Verification of KVL and KCL through Simulation
2. Simulation of RLC circuits
3. Verification of mesh analysis for DC circuit through Simulation
4. Verification of nodal analysis for DC circuit through Simulation

11+8 Hours

Unit II
Single Phase AC Circuits
R.M.S value, average value and form factor for different periodic wave forms, AC though pure R, L and C, concept of reactance, impedance, susceptance and admittance, j-notation, concept of phase and phase difference, concept of real, reactive and complex powers, power factor, sinusoidal excitation to RL, RC and RLC series and parallel circuits, Resonance – series, parallel circuits, concept of resonant frequency, band width and quality factor.
Complex and Polar forms of representation, selectivity
Practical Component
1. Simulation of series RLC circuits.
2. Simulation of parallel RLC circuits.
3. Determination resonant frequency and band width of series RLC circuit.
4. Determination resonant frequency and band width of parallel RLC circuit

10+8 Hours

Unit III
Three Phase and Magnetic Circuits
Three Phase Circuits: Advantages of 3-phase system over 1-phase systems, 3-phase balanced system connections-star connection, delta connection and their comparison, Unbalanced 3-phase connections-delta connection, 3-wire star connection, 4-wire star connection, measurement of power in 3-phase circuits using 2-wattmeter method for balanced load
Magnetic Circuits: Basic terminology, Concept of self and mutual inductance, dot convention, co-efficient of coupling, analysis of series and parallel magnetic circuits

Measurement of power in 3-phase circuits using three-wattmeter and one wattmeter methods, analysis of coupled circuits.

Practical Component

1. Measurement of active power for star and delta connected balanced loads
2. Measurement of reactive power for star and delta connected balanced loads

14+8 Hours

Unit IV

Network Theorems

Superposition, Thevenin's, Norton's, Maximum Power Transfer, Reciprocity, Millman's and compensation theorems for both DC and AC excitations.

Tellegen's theorem

Practical Component

1. Verification of superposition theorem through simulation.
2. Verification of Thevenin's/Norton's theorem through simulation.
3. Verification of maximum power transfer theorem through simulation.
4. Verification of compensation theorem through simulation
5. Verification of reciprocity theorem through simulation

10+6 Hours

Total: 45 + 30=75 Hours

Textbook (s)

1. W.H.Hayt, J.E.Kimmerly, and S.M.Durbin, "Engineering Circuit Analysis", Tata McGraw Hill, 8th Edition, 2015.
2. Charles K Alexander and Mathew N.O Sadiku, "Fundamentals of Electric Circuits", Tata McGraw Hill, 5th Edition, 2013.
3. M.E Van Valkenburg, "Network Analysis", Prentice Hall of India, 4th Edition, 2018.

Reference (s)

1. Ramana Pilla, "Network Analysis and Synthesis", Universities Press India Pvt. Ltd, 1st Edition, 2018.
2. Abhijit Chakrabarti, "Circuit Theory Analysis and Synthesis", Dhanpat Rai & Co., 6th Edition, 2014.
3. A Sudhakar, and Shyammohan S. Palli, "Circuits and Networks: Analysis and Synthesis", McGraw Hill Higher Education, 5th Edition, 2015.
4. M Nahvi, Joseph Edminister, K Uma Rao, "Electric Circuits, (Schaum's Outline Series)", McGraw Hill Higher Education, 7th Edition, 2017.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)
Remember	25	25
Understand	50	50
Apply	25	25
Analyze	---	---
Evaluate	---	---
Create	---	---
Total (%)	100	100

Sample Question (s)

Remember

1. Define the terms RMS value, average value and form factor.
2. State Superposition and Millman's theorems.
3. Define resonant frequency
4. List the applications of resonant circuits
5. Define real and reactive power

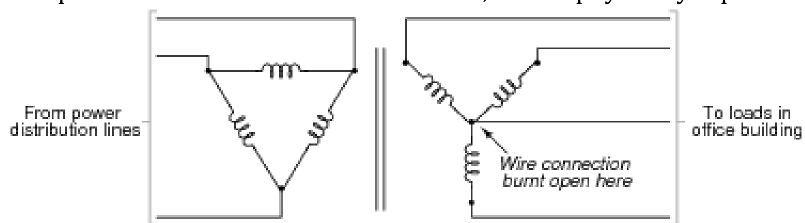
Understand

1. Represent transient response of RC circuit for DC excitation

2. Explain interrelation between Z and ABCD parameters.
3. Explain the significance of power factor
4. Two bulbs of 100W and 40W respectively connected in series across a 230Vsupply, which bulb will glow bright and why?
5. If one lamp connects between two phases it will glow or not?

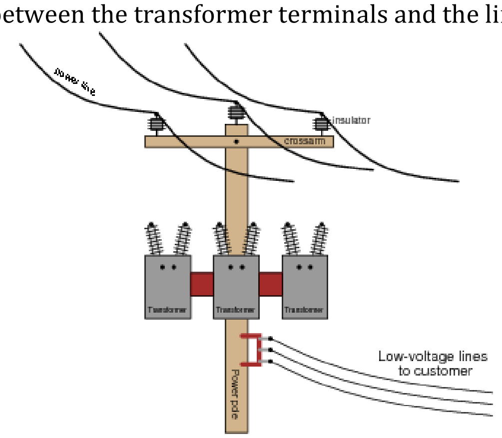
Apply

1. Find the equivalent voltage with internal impedance when four generators with internal impedance connected in parallel. If one of the generators is fail to generate the voltage then find change in the equivalent voltage with internal impedance.
2. One of the conductors connecting the secondary of a three-phase power distribution transformer to a large office building fails open. Upon inspection, the source of the failure is obvious: the wire overheated at a point of contact with a terminal block, until it physically separated from the terminal.



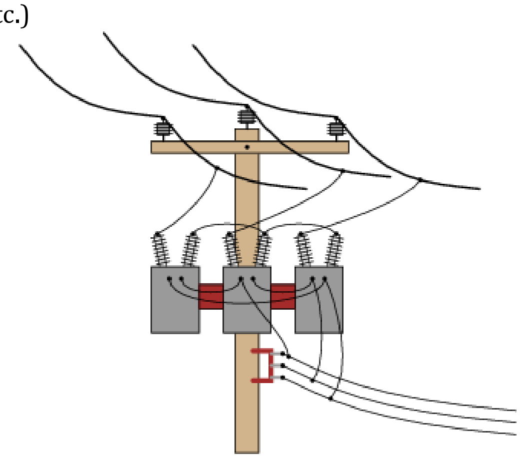
What is strange, though, is that the overheated wire is the neutral conductor, not any one of the "line" conductors. Based on this observation, what do you think caused the failure?
After repairing the wire, what would you do to verify the cause of the failure?

3. An electrical lineman is connecting three single-phase transformers in a Y(primary)-Y(secondary) configuration, for power service to a business. Draw the connecting wires necessary between the transformer windings, and between the transformer terminals and the lines

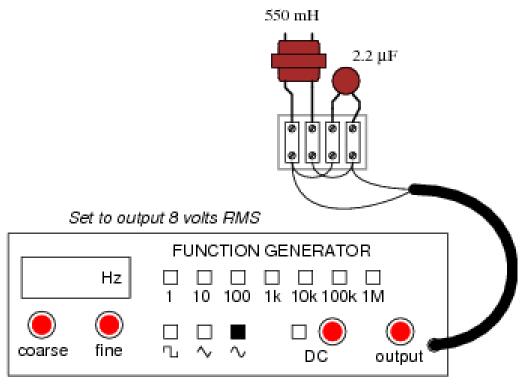


Note: fuses have been omitted from this illustration, for simplicity.

4. Identify the primary-secondary connection configuration of these pole-mounted power transformers (i.e. Y-Y, Y-Delta, Delta-Y, etc.)

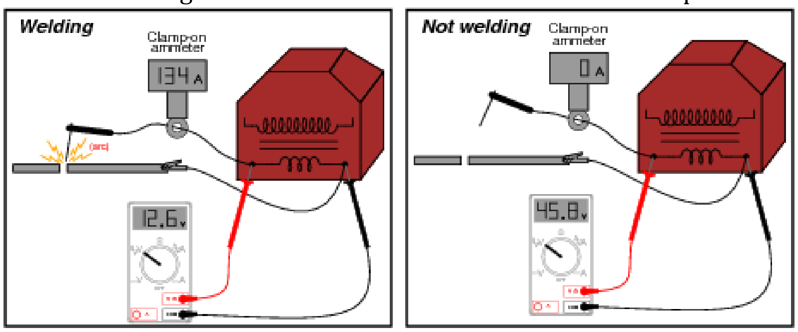


5. Calculate all voltages and currents in this circuit, at a power supply frequency near resonance



Based on your calculations, what general predictions can you make about parallel-resonant circuits, in terms of their total impedance, their total current, and their individual component currents?

6. An electric arc welder is a low-voltage, high-current power source used to generate hot arcs capable of melting metal. Note the voltage and current measurements taken for this particular welder?



Determine two Thevenin's equivalent circuits for the arc welder. The first circuit will simply be an AC voltage source and an internal impedance. The second circuit will be a voltage source and internal impedance connected through an ideal transformer with a step-down ratio of 8 to 1

19EE304 Electromagnetic Field Theory

3 1 0 3

Course Outcomes

1. Outline the concepts of vector calculus and coordinate systems
2. Summarize the laws of static electric fields
3. Examine the variations in field quantities for a given scenario in static electric fields
4. Summarize the field quantities in steady magnetic field
5. Examine the variations in field quantities for a given scenario in magnetic field
6. Summarize the Maxwell's equations in static and time varying fields

COs – POs Mapping

COs	PO_1	PO_2
1	3	2
2	3	2
3	3	2
4	3	2
5	3	2
6	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Introduction to coordinate systems and fields

Cartesian coordinates, Cylindrical coordinates, Spherical coordinates and their relationship, Electrostatic fields, Coulomb's law and field intensity, Differential length, area and volume, line, surface and volume integrals, Electric field due to charge distribution, Electric flux density, Electric Potential.

Electric field due to discrete charge distribution

12+4 Hours

Unit II

Electrostatics

Gauss' Law and it's applications, del operator, gradient of a scalar, Electric dipole and flux lines, Behavior of conductors, convection and conduction currents, polarization in dielectrics, dielectric constants, continuity equation and relaxation time, Ohm's law in point form, Electrostatic boundary conditions, capacitance, energy stored in capacitors, energy density in electrostatic fields, Poisson's and Laplace's equations, general procedures for solving Poisson's or Laplace's equations, Maxwell's equation in static electric field.

Properties of materials in electric field

12+4Hours

Unit III

Magnetostatics

Magneto-static fields, Biot-Savart's Law and it's applications, Curl of a vector, Ampere's circuit law, application of Ampere's law, Stoke's theorem, magnetic flux density, scalar and vector magnetic potentials, Forces due to magnetic field, Lorentz's force equation, magnetic dipole, magnetic torque and moment, magnetization in materials, magnetic boundary conditions, inductors and inductances, magnetic energy. Maxwell's equation in steady magnetic field

Properties of materials in magnetic field

11+3 Hours

Unit IV

Time-Varying Electromagnetic Fields

Magnetic Circuits-Basic terminology, Faraday's Law, Concept of self and mutual inductance, dot convention, co-efficient of coupling, analysis of series and parallel magnetic circuits, transformer and motional electromotive forces, displacement current, Maxwell's equation in point and integral forms for time varying fields, Introduction to finite element methods.

Modified Maxwell's equation.

10+4 Hours

Total: 45+15=60 Hours

Textbook (s)

1. Matthew N. O. Sadiku, “Elements of Electromagnetics”, Oxford University Press, 7th Edition, 2018.
2. W. H. Hayt and J. A. Buck, “Electromagnetic Field Theory”, Tata McGraw Hill, 8th Edition, 2011.
3. K A Gangadhar, “Electromagnetic Field Theory”, Khanna Publishers, 16th Edition, 2015.

Reference (s)

1. J.D.Krauss and Daniel Fleisch, “Electromagnetics with applications”, Tata McGraw Hill, 5th Edition, 2017.
2. Joseph A. Edminister, “Theory and Problems of Electromagnetics”, Schaum’s outline series, 4th Edition, 2013.
3. Roald K. Wangsness, “Electromagnetic Fields”, John Wiley & Sons, 2nd Edition, 1986.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	---	---	---
Analyze	25	25	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

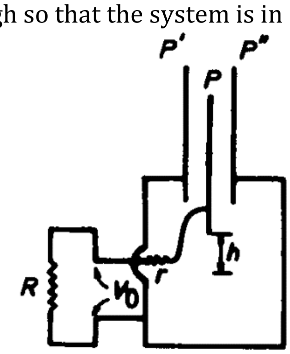
1. Reproduce the equivalent of a point in cylindrical form
2. Reproduce the equivalent of a point in spherical form
3. Label a vector in spherical form
4. Define Divergence, Gradient and Curl

Understand

1. Explain Coulomb's Law
2. Interpret Gauss' Law
3. Explain Biot-Savart's Law
4. Formulate magnetic field intensity due to long solenoid

Analyze

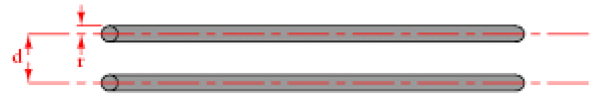
1. A long wire of radius R has static electric charge λ C/m placed inside a smoke precipitator. Identify the force of attraction between this wire and an uncharged spherical dielectric smoke particle of dielectric constant Є and radius a just before the particle touches the wire (a < R).
2. Flat metallic plates P, P^{I}, P^{II} are vertical and the plate P of mass M is free to move vertically between P^{I} and P^{II} as shown in figure below. The three plates from a double parallel plate capacitor. Let the charge on this capacitor to be Q. Ignore all the fringing filed effects. Assume that this capacitor is discharging through an external load resistor R, and neglect the small internal resistance. Assume that the discharge is slow enough so that the system is in static equilibrium at all times.



i. Assess the gravitational energy of the system that depends on the height of P.
ii. Assess the electro static energy of the system that depends on h and on the charge Q.

iii. Identify the value of h as a function of Q
iv. Analyze the output voltage whether it increase, decrease or stay the same as the given capacitor discharges.

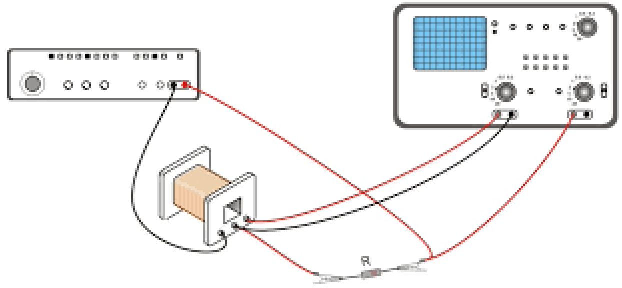
3. A long transmission line with radius R and separation between the lines d. The potential difference V across the lines varies as V= V_0 Sin wt. Assume that the electric field between the plates is uniform and neglect the edge effects and radiation.



i. Analyze the direction and magnitude of the magnetic induction B at point P which is at a distance r from the axis of the capacitor.
ii. Identify the magnetic field at the point P using a piece of wire and sensitive high impedance oscilloscope. Make a sketch of your experimental arrangement and estimate the signal detected by the oscilloscope.

(For Open Book Examination and not for semester end examination)

4. The experimental set up in a transmitter station is described as follows



The various components that are used to develop the experimental set up are
a. Frequency counter.
b. Function generator.
c. Digital multimeter.
d. Analog multimeter.
e. Voltage transformers 125/220 (two).
f. Field coil 485 turns/meter, 750 mm long.
g. Induction coil, 300 turns, 41 mm diameter.

i. Analyse the experimental and the theoretical relations between the induced voltage and current, number of turns, coil diameter and frequency.
ii. From your experimental curves, Identify the induced voltage for the case where N=350, a= 15 mm, I1= 10mA and f=10 kHz.

(For Open Book Examination and not for semester end examination)

19EE305 Measurements and Instrumentation

3 1 0 3

Course Outcomes

1. Outline the construction and working of instruments used for voltage/current measurement
2. Summarize the construction and working of instruments used for power and energy measurement
3. Analyze the performance of measuring instruments
4. Illustrate the working of AC and DC bridges
5. Explain the operation of sensors and transducers
6. Apply sensors and transducers for various applications

COs – POs Mapping

COs	PO_1	PO_2	PO_3
1	3	1	2
2	3	2	1
3	2	3	2
4	2	3	2
5	3	2	1
6	2	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Measuring Instruments

Classification of measuring instruments, different torques in an instrument, ammeters and voltmeters – PMMC, moving iron type instruments – expression for the deflecting torque and control torque – errors and compensations, extension of instrument range using shunts and multipliers, CT and PT – ratio and phase angle errors, digital voltmeters- successive approximation, ramp, dual slope integration continuous balance type, digital frequency meter

Electrostatic voltmeter

13+5 Hours

Unit II

Measurement of Power and Energy

Single phase dynamometer wattmeter, LPF wattmeter, expression for deflecting and control torques, measurement of 3-phase power, single phase induction type energy meter – driving and braking torques – errors and compensations, testing by phantom loading, three phase energy meter.

Extension of range of wattmeter using Instrument transformers.

9+3 Hours

Unit III

DC and AC Bridges

Principle and operation of DC Crompton's potentiometer – standardization – measurement of unknown resistance, current, voltage – applications, methods of measuring low, medium and high resistance –Wheat stone's bridge, Kelvin's double bridge, Loss of charge method, Measurement of inductance - Maxwell's bridge, Hay's bridge, Anderson's bridge, Measurement of capacitance – Desauty bridge – Schering Bridge.

Sensitivity of Wheat stone's bridge, Megger

11+4 Hours

Unit IV

Sensors and Transducers

Sensors and their classifications – Hall effect – Ultrasonic – Heat Flux – Fluid level measurement, Modern sensors-bio-sensors, glucose electrodes.

Classification of transducers – Resistive, Capacitive and Inductive transducers- active and passive transducers- Piezoelectric transducers – strain gauges, Phototransistor, LVDT, Photovoltaic Cell– thermocouple.

RVDT, RTD, Calibration of CRO

12+3 Hours

Total: 45+15=60 Hours

Textbook (s)

1. E.W. Golding, and F.C. Widdis, "Electrical Measurements and Measuring Instruments", Reem Publications Pvt. Ltd.,6th Edition, 2019.
2. A.K. Sawhney, "Electrical & Electronic Measurements & Instrumentation", Dhanpat Rai& Co. Pvt. Ltd., 19th Edition, 2015.
3. D.V.S. Murthy, "Transducers and Instrumentation", Prentice Hall of India, 2nd edition, 2008.
4. D.Patranabis, "Sensors and Transducers", Prentice Hall of India Learning, 2nd Edition, 2009.

Reference (s)

1. A. D. Helfrick and W. D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall of India, 5th Edition, 2002.
2. H. S. Kalsi, "Electronic Instrumentation", Tata McGraw Hill, 4th Edition, 2009.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	---	25	50
Analyze	25	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. List the different torques in measuring instruments.
2. Label the parts of a PMMC instrument.
3. Spell down the balancing equation for AC bridge.
4. List the application of DC Crompton's potentiometer.

Understand

1. Explain the construction and operation of PMMC and moving iron instruments.
2. Justify how CT is used for current measurement.
3. Explain the concept of Schering bridge to measure unknown capacitance with neat sketch.
4. Infer the conversion of linear displacement into electrical signal in LVDT.

Apply

1. Compute the ciruit of Kelvin double bridge used for measurement of low resistance and derive the conditions for balance.
2. Demonstrate the applications of various types of strain gauges.
3. Develop the torque equation for a PMMC instrument and show its scale is linear.
4. Design a hybrid digital measuring device to measure AC/DC electrical parameters to display magnitude and type (AC/DC) on the screen of the instrument. **(For Open Book Examination and not for semester end examination)**
5. Design an automation system for a water tank using appropriate measuring and sensing instruments such that,

   a) When the tank is 75% full, an alarm should beep.

   b) When the tank is 90% full, power supply to the motor should be cut-off.

   c) When the water level is below 25%, the power supply should be on.

   Assume that the motor rating is 1.5 HP, 230 V, single phase induction motor, and other required data's may be assumed on your own. **(For Open Book Examination and not for semester end examination)**

Analyze

1. Analyze the effect of temperature on the performance of PMMC meter with and without swamping resistance.

2. Compare the PMMC and MI instruments and analyze their performance with swapping of their input supply.
3. Analyze the constructional differences between LPF and UPF wattmeter, and examine the performance of UPF wattmeter when is connected in inductive load circuit.
4. Four students had taken a house for rent. After completion of 4th semester they went for summer internship. Before leaving the house they have noted down the energy meter reading as 181 units. After completion of summer internship, they have come back to their rented house. Now they have again noted down the reading, the energy meter was showing 20 units of energy consumption, literally they have not consumed any power during the period in that house. Now explain the reason behind the 20 units of energy consumption and state the remedies for this cause.
5. A group house consists of 2 floors each having 4 flats. The loads in the each flat are as follows.

S. No	Electrical load	Power (W)	Time Duration (Hrs)/Day
1	Incandescent Lamp	60	6
2	Night Bulb	10	4
3	Fan	100	8
4	A/C	1500	4
5	Washing Machine	1000	2
6	Fridge	250	8
7	Geyser	4000	1

Find the total energy consumed by each flat for the above load and time duration specified if the tariff is Rs.2.50/kWh. Also suggest few measures to be taken up for energy saving. **(For Open Book Examination and not for semester end examination)**

6. Assume that 21 SWG copper conductor of 1.5 m length is provided for the testing. What will be the resistance of the copper conductor, and what will be the measuring method to find the unknown resistance of the conductor? If the conductor is wounded on,
   a) Ferro magnetic material (Assume the material is steel)
   b) Ferrite material

   What will be the inductance of the coil? And, also find the capacitance between the turns of the coil. Assume the required data for the calculations. **(For Open Book Examination and not for semester end examination)**

19EE306 Semiconductor Devices and Circuits

3 1 0 3

Course Outcomes

1. Explain the construction and operation of semiconductor diode
2. Summarize the construction and operation of BJT
3. Make use of diodes and transistors in various applications
4. Summarize the construction and operation of FET
5. Illustrate h-parameter representation of transistor
6. Analyze low frequency single stage amplifiers

COs – POs Mapping

COs	PO_1	PO_2	PO_3
1	3	1	2
2	3	1	1
3	3	1	2
4	3	1	2
5	3	1	1
6	3	1	2

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit I

PN Junction Devices

PN junction diode –structure, operation and V-I characteristics, diffusion and transition capacitance - Tunnel Diode characteristics - Energy band diagrams, Rectifiers – Half Wave and Full Wave Rectifier, Capacitor filter – Zener diode characteristics- Zener Reverse characteristics – Zener as regulator

LED and Photo diodes

10+3 hours

Unit II

Bipolar Junction Transistor

BJT- construction, types, operation, current components, CE, CB and CC configurations, BJT as an amplifier, BJT biasing - Criteria for fixing operating point, Fixed bias, Collector to base bias, self-bias, stabilization techniques, Compensation techniques- compensation against variation in V_{BE} and I_{co}, thermal run away, thermal stability.

Unijunction transistor

13+4 hours

Unit III

Field Effect Transistor

FET – types, construction, operation and characteristics – JFET parameters, FET as an amplifier, FET biasing – Fixed bias circuit, voltage divider bias circuit, self-bias circuit, MOSFET- types, construction operation and characteristics – MOSFET biasing

FET as a Voltage Variable Resistor, Zener barrier

12+4 hours

Unit IV

Amplifiers

Generalized analysis of transistor amplifier model using h-parameters, Approximate analysis of CE, CC and CB configuration, Single stage amplifiers – CE, CC and CB amplifiers, small signal analysis of single stage BJT amplifiers – CE amplifier with fixed bias, CE amplifier - emitter resistor, Un-bypassed emitter resistor, voltage divider bus – CB and CC amplifier, Generalized analysis of FET small signal model.

Analysis of CS and CD amplifiers

10+4 hours

Total: 45+15 hours

Textbook (s)

1. A.Salivahanan and N.Suresh Kumar, Electronic Devices and Circuits, McGraw-Hill Education (India) Private Limited, 1st Edition, 2018.
2. J.Millman, C.C.Halkias and Chetan D Parikh, Integrated Electronics, 2ndEdition, Tata McGraw Hill, 2017
3. Robert L. Boylestad and Louis Nashelsky, Electronic Devices and Circuits Theory, Pearson/Prentice Hall, 11th Edition, 2015.

Reference (s)

1. Visvesvara Rao, K. Bhaskara Rama Murty, K. Raja Rajeswari, P.Chalam Raju Pantulu, Electronic Devices and Circuits, Pearson Education, 2nd Edition, 2007.
2. S.G.Burns and P.R.Bond, Principles of Electronic Circuits, Galgotia Publications, 2nd Edition, 2008.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	--
Understand	55	55	--
Apply	25	--	50
Analyze	--	25	50
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (s)

Remember

1. List any two advantages of JFET over BJT.
2. Define Rectifiers. List any two types of Rectifiers.
3. Define stability factor, S.
4. Reproduce the symbol of p type JFET
5. Arrange emitter, base and collector in increasing order of doping concentration.

Understand

1. Explain the consequences due to applied reverse voltage at Collector junction in CB configuration.
2. Represent the structure of JFET and explain the operation of n channel JFET.
3. Interpret FET as a Voltage Controlled Device.
4. Compare compensation techniques for the variations in I_{CO} due to temperature.
5. Explain the working principle of Tunnel diode with its V-I characteristics.

Apply

1. A full wave rectifier is designed with a 50 μF capacitor in parallel with a 500Ω resistor. The transformer secondary voltage to centre-tap is 40 V rms and 50 Hz. The diode and transformer resistances may be neglected. Compute the following:
   (i) Ripple factor of the rectifier-filter output
   (ii) % of load regulation
   (iii) Repeat (i) and (ii) if 100 μF capacitor in parallel with a 500 Ω resistor.
2. In a fixed bias circuit, a supply of 6 volts and a collector resistance (R_C)of 1kΩ is used. Determine the value of base resistor (R_B) so that a germanium transistor with β=25 and I_{CBO}=2μA draws a collector current 2mA. What will be the error if we neglect I_{CBO} and V_{BE}? Also determine the value of Ic if transistor parameters changed to β=40 and I_{CBO}=10μA due to rise in temperature.
3. Design a rectifier for the output requirements 300 V at 60 mA (18 Watts) with regulation of 15 % permissible, and 6.3 V AC at 3 A. Comment on suitability of transformer size, rectifier operating conditions and filter capacitor requirements. Also give the alternative solution for getting the required output. **(For Open Book Examination and not for semester end examination)**
4. A radio frequency (RF) signal refers to a wireless electromagnetic signal used as a form of communication. Radio waves are a form of electromagnetic radiation with identified radio frequencies that range from 3kHz to 300 GHz. The FM transmitter is a single transistor circuit. In the telecommunication, the frequency modulation (FM) transfers the information by varying the frequency of carrier wave according to the message signal. Design a simple single stage common emitter amplifier as the pre-amplifier for FM Transmitter application which uses RF communication

to transmit the medium or low power FM signal. The maximum range of transmission is around 2 km. Select the NPN Bipolar Junction Transistor, BC109. Since V_{CEO} for this transistor is around 40V and choose a much lesser Vcc, of about 9V. Assume the quiescent collector current as 1 mA. **(For Open Book Examination and not for semester end examination)**

Analyze

1. Design a low power circuit (0 V – 5 V Digital) for controlling a high Power Circuit (30 V – 240 V) using FET and BJT. Justify the right choice of semiconductor device.
2. Construct the circuit that can be used to transmit audio signals using FM transmission. Analyze the procedure of pre amplifier design, oscillator circuit design, power amplifier circuit design, selection of antenna and how to operate the FM transmitter circuit.
3. The method of selecting power semiconductor devices for group parallel connection on the basis of models developed on the basis of the measured electrical and thermal parameters and characteristics of certain devices are considered. In designing a low power circuit (0 V – 5 V Digital) for controlling a high Power Circuit (30 V – 240 V) using FET and BJT, Justify the right choice of semiconductor device at normal operating temperatures. **(For Open Book Examination and not for semester end examination)**
4. Construct the circuit that can be used to transmit audio signals using FM transmission. Analyze the procedure of pre amplifier design, oscillator circuit design, power amplifier circuit design, selection of antenna and how to operate the FM transmitter circuit. **(For Open Book Examination and not for semester end examination)**

19EE307 DC Machines Lab

0 0 3 1.5

Course Outcomes

1. Illustrate the procedure for representing magnetization characteristics of DC shunt generator.
2. Interpret the efficiency of DC machine using various tests.
3. Demonstrate suitable method to find the performance characteristics of DC machine
4. Interpret various losses of DC machine by performing indirect tests.
5. Demonstrate suitable method to find the stray losses of a DC machine
6. Illustrate the procedure for implementing speed control methods for DC motors

COs –POs Mapping

COs	PO_4
1	3
2	3
3	3
4	3
5	3
6	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

List of Experiments

1. Magnetization characteristics of DC shunt generator
2. Load characteristics of DC shunt generator
3. Load test on DC series generator
4. Load test on DC compound generator
5. Hopkinson's test on DC shunt machines
6. Swinburne's test
7. Speed control of DC shunt motor
8. Brake test on DC shunt motor
9. Separation of losses in DC shunt motor
10. Brake test on DC compound motor
11. Brake test on DC series motor
12. Field test on DC Series Machines
13. Retardation test on DC Shunt Motor

List of Augmented Experiments[1]

1. Simulation of brake Test on a DC shunt motor
2. Simulation of Swinburne's test
3. Simulation of separation of losses in A DC shunt motor
4. Simulation of open circuit characteristics of a DC shunt generator
5. Simulation of speed control of a DC shunt motor

Reading Material (s)

1. P. S. Bimbra, "Electrical Machinery", Khanna Publishers, 7th Edition, Color Reprint 2014.
2. I.J. Nagrath& D.P. Kothari, "Electric Machines", Tata McGraw Hill, 5th Edition, 2017.
3. S. K. Sahdev, "Electrical Machines", Cambridge University Press, 1st Edition, 2017

[1] Students shall opt any one of the augmented experiments in addition to the regular experiments

19EE308 Semiconductor Devices and Circuits Lab

0 0 3 1.5

Course Outcomes

1. Assess the characteristics of semiconductor devices
2. Determine the load and line regulation of rectifiers
3. Implement DC Regulated power supply
4. Assess the characteristics of BJT and FET
5. Construct the characteristics of CE and CS amplifiers
6. Assess the frequency response of CE and CS amplifiers

COs – POs Mapping

COs	PO_4
1	3
2	3
3	3
4	3
5	3
6	3

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

List of Experiments
(For Laboratory examination–Minimum of 10 experiments)

1. PN Junction diode characteristics
2. Zener diode characteristics
3. Full wave center tapped rectifier with and without filter.
4. Bridge type Full wave rectifier
5. Design of Zener regulator.
6. Characteristics of SCR
7. Characteristics of UJT
8. Transistor CE characteristics (Input and Output)
9. Transistor CB characteristics (Input and Output)
10. JFET characteristics
11. Characteristics of CE Amplifier
12. Characteristics of CS Amplifier
13. Frequency response of CE amplifier
14. Frequency response of CS amplifier

List of Augmented Experiments[2]

1. Design of Regulated DC Power Supply
2. Applications based on FET
3. Applications based on BJT
4. Applications based on SCR
5. Burglar Alarm

Reading Material (s)

1. N.N.Bhargava, D.C.kulshreshthaS.C.Gupta, Basic electronics and linear circuits Tata MC Graw Hill company Ltd., New Delhi, 2nd Edition, 2003.
2. R.L. Boylestad and Louis Nashelsky, Electronic Devices and Circuits, Pearson/Prentice Hall, 9thEdition, 2006.

[2] Students shall opt any one of the augmented experiments in addition to the regular experiments

19BEA01 Environmental Studies

0 0 0 0

Course Outcomes

1. Translate the learner's attitude to think globally and act locally
2. Motivate environmental organizations to create a concern about our present state of Environment.
3. Find solutions for conservation of natural resources
4. Identify the benefits of ecosystem conservation, biodiversity protection, implement pollution prevention and control measures
5. Illustrate social issues of environmental protection and adopt sustainable developmental practices
6. Perceives the basic structure of environmental policy and law pertaining to specific environmental issues (water quality, air quality, biodiversity protection, Forest, etc.)

COs – POs Mapping

COs	PO_1	PO_6	PO_7	PO_{12}
1	1	2	3	1
2	2	-	3	2
3	3	3	-	2
4	-	2	3	2
5	-	-	3	1
6	-	3	2	1

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit I

Multidisciplinary nature of Environmental Studies & Natural Resources

Definition, Scope and Importance, Multidisciplinary nature of Environmental Studies, Value of Nature - Productive, Aesthetic/Recreation, Option, Need for Public Awareness, Institutions (BNHS, BVIEER, ZSI, BSI) and People in Environment (Medha Patkar, Sundarlal Bahuguna, Indira Gandhi, Rachael Carson).

Natural Resources: Renewable and Non-renewable resources – Importance, uses, overexploitation/threats, and conservation of (i) forest (ii) water (iii) mineral (iv)food and (v) energy resources. (The topics include benefits and problems associated with dams, mining and case studies), role of an individual in conservation of natural resources.

Unit II

Ecosystem & Biodiversity

Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Bio geological cycles (Energy flow, Carbon and Nitrogen Cycles), Ecological succession, Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structures and functions of the following ecosystems:

a. Forest Ecosystem b. Aquatic Ecosystem

Biodiversity and its Conservation: Definition and levels of biodiversity, Bio-geographical classification of India, hot spots of biodiversity - India as a mega diversity nation, Threats to biodiversity, Endangered and endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation.

Unit III

Environmental Pollution & Social Issues

Environmental Pollution: Definition, Cause, effects, control measures and case studies of: Air pollution b. Water pollution c. Soil pollution

Solid waste Management: Causes, effects and control measures of urban and industrial wastes. Food and Household waste management, Disaster management (floods and cyclones)

Social Issues and the Environment: Sustainability, Urban problems related to energy, Water conservation and watershed management, Resettlement and rehabilitation of people; Environmental ethics: Issues and possible solutions, global warming, ozone layer depletion, Consumerism and waste products

Unit IV

Human Population and the Environmental Acts

Human Population and the Environment: Population growth, Affluence, Technology and Environmental Impact (Master Equation), Population explosion and Family Welfare Programme, Value Education, HIV/AIDS, Women and Child Welfare, Role of information Technology in Environment and human health.

Environment Protection Acts: Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act and Forest Conservation Act. Issues involved in enforcement of environmental legislation.

Textbook(s) and Reading Material (s)

1. E. Bharucha, Textbook of Environmental Studies, 1st Ed., University Press (India) Pvt. Ltd., 2013.
2. W. P. Cunningham, M.A. Cunningham, Principles of Environmental Science, 6th Ed., Tata McGraw Hill, 2008.
3. A. Kaushik, C. P. Kaushik, Perspectives in Environmental Studies, 4th Ed., New Age International Publishers, 2008.
4. H. S. Peavy, D. R. Rowe, G. Tchobanoglous, Environmental Engineering, 1st Ed., McGraw Hill Int. ed., 1984.
5. T. E. Graedel, B. R. Allenby, Industrial Ecology and Sustainable Engineering, 1st Ed., Pearson Publications, 2009.
6. http://172.30.1.222/wbc/it/schedule.aspx.
7. http://172.30.1.8/wbc/it/coursepage.aspx.
8. https://www.edx.org/course/environmental-protection-and-sustainability.

19EE409 Employability Skills I

1 1 1 0

Course Outcomes

1. Demonstrate oral communication and writing skills as an individual to present ideas coherently
2. Develop life skills with behavioral etiquettes and personal grooming
3. Assess analytical and aptitude skills
4. Develop algorithms for engineering applications
5. Solve engineering problems using software
6. Utilize simulation tools for testing

COs – POs Mapping

COs	PO_1	PO_2	PO_5	PO_8	PO_{10}	PO_{12}
CO1	-	-	-	-	3	2
CO2	-	-	-	1	2	2
CO3	2	1	-	2	-	-
CO4	2	-	2	-	-	-
CO5	2	-	2	-	-	-
CO6	2	-	2	-	-	-

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

PART-A

Soft Skills

Communication Skills & Confidence: How Communication Skills affect Confidence? How to communicate Effectively. (with Examples)

Listening: Listening? , Listening Vs Hearing, Possible reasons for why people do not Listen at times, Active Listening Vs Passive Listening, How Listening can affect our relationships? How Listening helps in Campus Placements also? (with Examples)

Goal Setting: SMART Technique to Goal Setting, Putting First things First, SWOT Analysis and Time Management

Attitude & Gratitude: Attitude Vs Skills Vs Knowledge, Attitude Vs Behavior, How to develop Positive Attitude? Developing the attitude of Gratitude.

Public Speaking: JAM, J2M, Presentations by Students on General Topics.

7 Hours

PART-B

Aptitude Skills

Quantitative Aptitude:

Number system, L.C.M and H.C.F, Problems on Ages, Averages, Time and work, Pipes and cisterns

8 Hours

PART-C

Domain Specific Knowledge

Programmable logic controllers -1

i. Implementation of basic logic gates
ii. Implementation of simple relay
iii. Implementation of direct on-line starter
iv. Implementation of on and off delay timer
v. Implementation of series and parallel switches

15 Hours

Total: 30 Hours

Text Books:

1. Frederick D. Hackworth and John R. Hackworth, Programmable Logic Controllers: Programming Methods and Applications, Pearson India; 1st edition, 2003.
2. Frank Petruzella, Programmable Logic Controllers, Tata McGrawhill, 3rd Edition, 2011.

Reference (s)

1. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.
2. W. Bolton, "Programmable Logic Controllers", Newnes – Elsevier, 2015.

19HSX11 CC&EC Activities I

0 0 1 0

Course Outcomes

1. Interpret and present the abstractive technical information through an activity
2. Think critically in providing solutions to the generic and common problems
3. Demonstrate the creative thinking in dealing with liberal arts
4. Instill team sprit through active engagement with the peer
5. Develop programs of common interest having social impact
6. Empower the under privileged through motivational activities

COs –POs Mapping

COs	PO_6	PO_7	PO_9	PO_{10}
1	-	-	-	3
2	3	2	-	-
3	3	-	-	-
4	-	-	3	-
5	3	-	-	-
6	3	-	-	-

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

19EE401 AC Machines

3 1 0 3

Course Outcomes

1. Illustrate the constructional features and working of induction motor
2. Analyze the performance of induction motor
3. Outline the various starting, speed control and testing methods of induction motors
4. Illustrate the constructional features and working of synchronous machine
5. Outline the regulation methods of an alternator
6. Analyze the performance of synchronous machine

COs – POs Mapping

COs	PO_1	PO_2
1	3	2
2	3	3
3	3	2
4	3	2
5	3	3
6	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Three-phase Induction Machines

Three-phase induction motors-constructional details of cage and wound rotor machines-production of rotating magnetic field - principle of operation, rotor e.m.f and rotor frequency, rotor reactance, rotor current and p.f at standstill and during operation, torque equation- expressions for maximum torque and starting torque, torque-slip characteristics, equivalent circuit, power stages, circle diagram, Applications

Crawling and cogging

12+4 Hours

Unit II

Speed Control and Starting Methods

Speed control-change of frequency, pole changing methods, rotor resistance control and cascade connection, voltage injection into rotor circuit, starting methods.

Single phase Induction motors: principle of operation, Double revolving field theory, equivalent circuit, Starting methods and applications.

Universal motor and BLDC motor.

9+4 Hours

Unit III

Synchronous Generators

Constructional features of wound rotor and salient pole machines – Armature windings –Distribution, pitch and winding factors, E.M.F equation, harmonics in generated e.m.f. – suppression of harmonics, armature reaction, phasor diagram, Regulation by synchronous impedance method, M.M.F.method, Z.P.F. method- two reaction theory-determination of X_d and X_q (slip test), phasor diagram, regulation of salient pole alternator.

Synchronization of alternators with infinite bus, Parallel operation - Effect of change in excitation and mechanical power input

Synchronizing power and torque, Applications of Synchronous Generators

15+4 Hours

Unit IV

Synchronous Motors

Principle of operation, Phasor diagram, methods of starting, variation of current and power factor with excitation, losses and efficiency, synchronous condenser, power factor improvement, hunting and its suppression, Applications

Excitation circle and power circle, comparison of synchronous and induction motors.

9+3 Hours

Total: 45+15=60 Hours

Textbook(s)

1. P. S. Bimbra, "Electrical Machinery", Khanna Publishers, 7th Edition, Color Reprint 2014.
2. I.J. Nagrath& D.P. Kothari, "Electric Machines", Tata McGraw Hill, 5th Edition, 2017.
3. A.E. Fitzgerald, Charles Kingsley, JR., Stephen D. Umans, "Electric Machinery", Tata McGraw Hill, 6th Edition, 2017.

Reference (s)

1. M. G. Say, "The Performance and Design of Alternating Current Machines", CBS Publishers and Distributers Pvt. Ltd., 3rd edition, 2005.
2. Samarjit Ghosh, "Electric Machines", Pearson Publications, 2nd Edition, 2012.
3. J. B. Gupta, "Theory and Performance of Electrical Machines", S. K. Kataria & Sons Publishers, New Delhi, 14th Edition, Reprint 2013.
4. S. K. Sahdev, "Electrical Machines", Cambridge University Press; 1st Edition, 2017
5. P. S. Bimbra, "Generalized Theory of Electrical Machinery", Khanna Publishers, 6th Edition, 2015.
6. B.L. Theraja & A.K. Theraja "A Textbook of Electrical Technology: Volume-2, AC and DC Machines", 23rd edition, 2019.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	25	25	---
Analyze	---	---	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember
1. Define cogging and crawling
2. Find difference between ac and dc generator?
3. Define Potier reactance
4. List the starting methods of synchronous motor

Understand
1. Explain why the rotor of induction motor can never attain synchronous speed.
2. Prove the condition P2:Pm: Pc=1:(1-s):s for an induction motor.
3. Show the generalized expression for an induced emf per phase in three phase alternator when coils are not full pitch and concentrated in one slot.
4. Identify the equivalent circuit parameters of 3-phase induction motor from the no-load and blocked rotor tests

Analyze
1. Three alternators having its voltages and impedances E_1& Z_1, E_2 & Z_2, E_3 & Z_3 respectively are connected in parallel to share a load. Derive the expressions I_1, I_2 and I_3 for load sharing of alternators.
2. Draw the circle diagram for a 5.6kw, 400V, 3-Φ, 4-pole, 50Hz, slip ring u=induction motor from the following data.

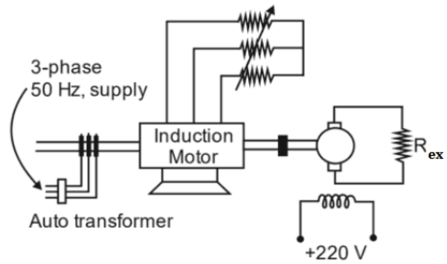
   No- load readings: 400V, 6A, $\cos\Phi_0$=0.087, Short circuit test data: 100V,12A,720W.

   The ratio of primary to secondary turns=2.62, Stator resistance per phase is 0.67Ω and of the rotor is 0.185Ω. Calculate
3. An Industry has the following loads and are connected to supply of three phase 400V,50Hz.
   Induction motor 1: 2.5kW, Z= 2.5+3j Ω

Induction motor 2: 3.6kW, Z= 1.6+2.5j Ω
Induction motor 3: 4.5kW, Z= 1.8+4.3j Ω
Induction motor 4: 5.3kW, Z= 2.1+1.8j Ω
Lighting load : 10kW, Z=6+4jΩ.

Design the suitable synchronous condenser to raise the industry power factor to 0.9 p.f lagging.
(For Open Book Examination and not for semester end examination)

4. A 3-phase, 440 V, 50 Hz, 4-pole slip ring induction motor is feed from the rotor side through an auto-transformer and the stator is connected to a variable resistance as shown in the figure



The motor is coupled to a 220 V, separately excited d.c generator feeding power to fixed resistance of 10 W. Two-wattmeter method is used to measure the input power to induction motor. The variable resistance is adjusted such that the motor runs at 1410 rpm and the following readings were recorded W1 = 1800 W, W2 =- 200 W.
(i) Find the speed of rotation of stator magnetic field with respect to rotor structure
(ii) Neglecting all losses of both the machines, the dc generator power output and the current through resistance R_{ex} **(For Open Book Examination and not for semester end examination)**

5. A colony having 25 houses and each house has a load of 5kw, and an average p.f is 0.85lag. All the loads has connected to a transformer of 150 VA, 440/230V. An additional apartment was constructed newly and it has the load of 50kW. Estimate the necessity of upgrading the existing transformer or a new transformer is required separately to the apartment. If so, what is the new rating of the transformer, and comment on efficiency of the transformer. **(For Open Book Examination and not for semester end examination)**

19EE402 Electrical Circuits II

3 1 0 3

Course Outcomes

1. Illustrate transient response of RLC circuits for DC and AC excitations in time and frequency domain
2. Illustrate the concepts of network topology
3. Apply the concept of transients for various applications
4. Interpret various parameters for a given two port network
5. Translate the given electrical system into network function
6. Implement network functions to design electric circuits

COs – POs Mapping

COs	PO_1	PO_2
1	2	3
2	3	2
3	3	3
4	2	3
5	2	3
6	2	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I
Transient Analysis

Initial conditions of R, L, C elements, transient response of RL, RC, RLC circuits, solution using differential equation and Laplace transform approach

Transient response of RC circuit for impulse input

11+4 Hours

Unit II
Two-port networks

Open circuit, short circuit, transmission, hybrid parameters and their inter relations, interconnection of two port networks, T and Π representation of two-port networks

Inverse transmission and inverse hybrid parameters

10+4 Hours

Unit III
Network Functions and Network Topology

Network Functions: Driving point impedance and admittance, Transfer impedance and admittance, current and voltage transfer ratio, Network functions of ladder and non-ladder networks

Network Topology: Terminology used in network topology, network graph and tree, basic cut-set and basic tie-set matrices for planar networks, concept of duality and dual networks.

Poles and zeros of a network function

9+3 Hours

Unit- V
Network Synthesis

Hurwitz criterion, Positive real function, Elementary synthesis procedure, Synthesis of LC immittance, RC impedance and RL impedance functions, Foster and Cauer Forms.

Realization of RLC networks.

10+4 Hours

Total: 45 + 15=60 Hours

Textbook (s)

1. W.H.Hayt, J.E.Kimmerly, and S.M.Durbin, “Engineering Circuit Analysis”, Tata McGraw Hill, 8th Edition, 2012.
2. Charles K Alexander and Mathew N.O Sadiku, “Fundamentals of Electric Circuits”, Tata McGraw Hill, 5th Edition, 2013.
3. M.E Van Valkenburg, “Network Analysis”, Prentice Hall of India, 3rd Edition, 2005.

Reference (s)

1. Ramana Pilla, “Network Analysis and Synthesis”, Universities Press India Pvt. Ltd, 1st Edition, 2018.
2. Abhijit Chakrabarti, “Circuit Theory Analysis and Synthesis”, Dhanpat Rai & Co., 6th Edition, 2014.
3. G.GopalBhise, R.Prem Chadha, and C.DurgeshKulshreshtha, “Engineering Network Analysis & Filter Design”, Umesh Publication, 3rd Edition, 2011.
4. M Nahvi, Joseph Edminister, K Uma Rao, “Electric Circuits, (Schaum's Outline Series)”, McGraw Hill Higher Education, 7th Edition, 2017.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	55	25	---
Apply	25	55	100
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define graph and tree of a network.
2. List the properties of L-C immittance function.
3. Why the Z-parameters are known as open circuit parameters?
4. Define time constant of RL series circuit

Understand

1. Represent transient response of RL circuit for DC excitation
2. Explain the Interrelation of Z-parameters in terms of Y, ABCD, h parameters.
3. Explain the procedure to test the polynomial is Hurwitz or not
4. Explain why the current in a pure inductance cannot change in zero time?

Apply

1. Develop the circuit to have underdamped response with DC excitation to the RLC series circuit.

2. Develop the network in the first Foster form for the LC impedance function
$$Z(s)=\frac{2(s^2+1)(s^2+9)}{s(s^2+4)}$$

6. A 12 V battery is sitting in a hut on a deserted island somewhere in the pacific. The positive terminal of the battery is connected to one end of a 314.2 pF capacitor in series with a 869.1 μH inductor. An earthquake in the bonin Islands of japan triggers a tsunami that crashes into the hut, spilling salt water onto a rag that connects the other end of the inductor/capacitor combination to the negative terminal of the battery. Determine the resistance of the damp rag so that the above circuit produces oscillations at a frequency of 290.5 kHz. **(For Open Book Examination and not for semester end examination)**
7. Design a circuit that will produce a damped sinusoidal pulse with a peak voltage of 5V, and at least three additional peaks with voltage magnitude greater than 1V. **(For Open Book Examination and not for semester end examination)**

19EE403 Linear and Digital Integrated Circuits

3 0 2 4

Course Outcomes

1. Infer the DC and AC characteristics of operational amplifiers and its effect on output
2. Elucidate and Design the linear applications of an Op-Amp
3. Elucidate and Design the non-linear applications of an Op-Amp
4. Identify a suitable tool (Boolean theorems, K-maps, Tabular etc.) to minimize Boolean expressions
5. Design and implement the combinational logic circuits
6. Design and implement the sequential logic circuits

COs – POs Mapping

COs	PO_1	PO_2	PO_4
1	2	1	1
2	3	2	3
3	3	2	3
4	2	2	1
5	3	2	3
6	3	2	2

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit-I

Op-Amp and characteristics

Introduction to Op-Amp, Ideal Op-Amp characteristics, DC characteristics, AC characteristics, Voltage -series feedback and voltage -shunt feedback, Frequency response of Op-Amp - Basic applications: inverting, noninverting and differential amplifier circuits, Adder-subtractor circuits, Differentiation and integrator circuits

Precision rectifiers

Practical Component

1. Voltage gain of non-inverting and inverting amplifier with feedback
2. OP AMP Applications–Adder and Subtractor.
3. Differentiator
4. Integrator

12+8 Hours

Unit II

Application of Op-Amps

Instrumentation amplifiers, First-order and Second order active filters, V to I and I to V converters, Comparators and multi-vibrators, Waveform generators, Clippers and Clampers, Peak detector, D/A converters (Weighted resistance type and R-2R ladder type), A/D converters (Flash type, Dual slope type and Successive Approximation types)

Schmitt Trigger

Practical Component

1. Active Filters–LPF, HPF (first order only)
2. Triangular wave Generator using 741OP AMP
3. Analog to Digital Converter using OP AMP
4. Digital to Analog Converter using OP AMP

11+7 Hours

Unit III

Boolean function minimization and combinational logic circuits

Review of Number System, Minimization of Boolean functions up to four variables using Karnaugh Map - PoS and SoP, with don't care conditions, Minimization of Boolean functions using tabular method, Combinational logic circuits - half adder, full adder, half-subtractor, full-subtractor, comparator, encoder, priority encoder, decoder, multiplexer, de-multiplexer, realization of switching functions using combinational logic circuits.

Code converters

Practical Component

1. Half adder and full adder
2. Half subtractor and full subtractor

3. 4X1 multiplexer and 1X4 demultiplexer
4. 8X3 encoder and 3X8 decoder

10+8 Hours

Unit IV

Sequential Logic circuits

Introduction to flip-flops, Registers - buffer register, controlled buffer register, shift registers, bi-directional shift register, universal shift register, Asynchronous & Synchronous counters - up, down, up down, ring counters, Johnson counters, Mealy and Moore state machines - conversion, reduction of state tables and state assignment.

Sequence Generator, Sequence detector

Practical Component

1. Shift registers
2. Synchronous counter
3. Asynchronous counter
4. Johnson / Ring counter

12+7 Hours

Total: 45 + 30=75 Hours

Textbook (s)

1. R.F. Coughlin and Fredrick Driscoll, "Operational Amplifiers & Linear Integrated Circuits", Pearson Education, 6th Edition, 2000.
2. Ramakanth A. Gayakwad, "Op-Amps & Linear ICs", Pearson Education, 4th Edition, 2015.
3. Morris Mano, "Digital Design", 3rd Edition, PHI, 2018.
4. A. Anand Kumar, "Switching theory and logic design", PHI, 3rd Edition 2016.

Reference (s)

1. D. Roy Chowdhury, "Linear Integrated Circuits", New Age International (p) Ltd., 4th Edition, 2011.
2. Sergio Franco, "Design with Operational Amplifiers & Analog Integrated Circuits", McGraw-Hill Higher Education, 2003.
3. Zvi Kohavi, "Switching & Finite Automata theory", 2nd Edition, TMH, 2010.
4. R P Jain, "Modern Digital Electronics", 3rd Edition, TMH, 2009.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)
Remember	25	25
Understand	50	25
Apply	25	50
Analyze	--	--
Evaluate	--	--
Create	--	--
Total (%)	100	100

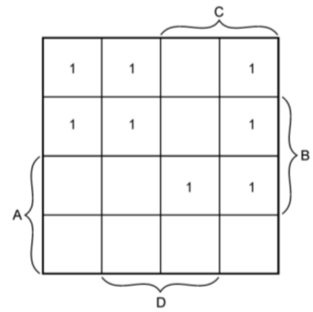
Sample Question (s)

Remember

1. List any four linear applications of op-amp.
2. List the ideal characteristics of operational amplifier
3. What is meant by the radix or base of a number system?
4. Define asynchronous sequential circuit.

Understand

1. Draw the circuit diagram of an instrumentation amplifier and explain its operation.
2. Explain the successive approximation type A/D converter.
3. What is an encoder? How does a priority encoder differ from a conventional encoder? With the help of a truth table, briefly describe the functioning of a 10-line to four-line priority encoder with active LOW inputs and outputs and priority assigned to the higher-order inputs.
4. Write the simplified Boolean expression given by the Karnaugh map shown in figure.



Apply

1. Design a practical differentiator that will eliminate the limitations of ordinary differentiator using op-amp
2. Design a 4bit binary adder using finite state machine.
3. Design a two-bit magnitude comparator. Also, write relevant Boolean expressions.
4. Implement the product-of-sums Boolean function expressed by ∏1,2,5 by a suitable multiplexer.

19EE404 Power Generation, Transmission and Distribution

3 1 0 3

Course Outcomes

1. Illustrate the working principles of various power generating stations
2. Interpret the parameters for various overhead conductor configurations.
3. Analyze the performance of short, medium and long transmission line models.
4. Develop the mechanical design parameters of transmission line.
5. Illustrate the construction and working of cables and insulators.
6. Compare the operation of AC and DC distribution systems.

COs – POs Mapping

COs	PO_1	PO_2	PO_6
1	3	1	3
2	3	3	1
3	3	3	1
4	3	3	2
5	3	3	2
6	1	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Power Generating Stations

Hydel Power Stations- classification-construction and working of hydroelectric power station, thermal power Stations-single line diagram highlighting major components and working, nuclear power stations- nuclear fission and chain reaction-working of nuclear reactors-BWR, PWR

Breeder reactors

8+2 Hours

Unit II

Transmission Line parameters and performance

Transmission Line Parameters: Transmission line components, GMR and GMD, Numerical problems on resistance, inductance and capacitance for single phase and three phase single circuit symmetrical and asymmetrical configurations (no derivation), Performance of Short, Medium and Long Transmission Lines: model description with phasor diagram for Short, Nominal-T, Nominal-π and long transmission lines respectively. ABCD parameter interpretation and calculation of transmission efficiency and voltage regulation, Corona loss and its effects

Ferrant, Skin and Proximity effects, surge impedance loading

14+6 Hours

Unit III

Underground cables and Mechanical design of overhead lines

Underground Cables: Construction, Types of Cables, Types of Insulating materials, Calculation of Insulation resistance and stress in insulation, Capacitance of Single and 3-Core belted cables, Grading of Cables - Capacitance grading and Inter-sheath grading.

Insulators-types-calculation of string efficiency

Sag and Tension calculations with equal & unequal heights of towers- effect of Wind & Ice loading,

Grading of Insulators

11+3 Hours

Unit IV

DC & AC distribution systems

Distribution System-Components, connection schemes, classification and comparison; Voltage Drop Calculations in DC Distribution System-Voltage Drop Calculations in DC Distributors for the following cases: Radial DC Distributor fed one end and at both the ends (equal/unequal Voltages) and Ring Main Distributor.

Voltage Drop Calculations in AC Distribution System- Distributors for the following cases: Power Factors referred to receiving end voltage and with respect to respective load voltages.

Economics-terminology and numericals, Tariff-Types and numericals

11kV Substation layout

12+4 Hours
Total: 45 + 15=60 Hours

Textbook (s)

1. C.L. Wadhawa, "Generation, Distribution and Utilization of Electric Energy", New Age International (P) Limited, 4th Edition, 2017.
2. C.L. Wadhawa, "Electric Power Systems", New Age International (P) Limited, 7th Edition, 2017.
3. TuranGonen, Electric Power Distribution system, Engineering, McGraw-hill Book Company, 4th edition,2016.

Reference (s)

1. A Chakrabarti, ML Soni, PV Gupta, US Bhatnagar, "A text book on Power System Engineering," Dhanpat Rai & Co., 2008.
2. Hadi Saadat, Power System Analysis, TMH, 3rd edition, 2010.
3. VK Mehta, R Mehta, "Principles of power system," S. Chand, New Delhi, 4th edition, 2005.
4. S.N.Singh, "Electric Power Generation, Transmission and Distribution", PHI, 2nd edition, 2008

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	---	25	50
Analyze	25	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Illustrate the single line diagram of a power system
2. Define GMD
3. List any two effects of corona
4. Define Skin effect in the long transmission line

Understand

1. Classify hydroelectric power plants based on water flow, head, power generated and load
2. Explain any four differences between short and medium transmission line models
3. Outline the construction of an underground cable
4. Summarize any four benefits of bundle Conductors over single conductor.

Apply

1. Develop the model of a Nominal-T transmission line to transfer a power of 100MW for a distance of 80km. Assume any other parameters required.
2. A certain amount of power has to be transmitted from the generating station to a load centre passing through a densely populated urban area extending a distance of 50km. The site engineer has the choice of selecting overhead or underground cables for transmission. Help the engineer choose the type of transmission based on economy, safety and technical superiority.
3. 1000 MW of power has to be transmitted for a distance of 500km over a 400kV double circuit long transmission line. Select a suitable spacing pattern between conductors and calculate the inductance. Justify your selection.
4. Suppose you are a maintenance engineer working at load end and observe the distribution side parameters. At some instant, you observe abnormalities due to light load condition. To solve that issue you have checked with the state load dispatch centre, and figured out that the voltage at the generating station is less as compared to the voltage at your end. Make use of this information and identify the possible impacts at your end with the help of a suitable phasor diagram. Suggest remedies to overcome this situation and obtain a voltage balance in a system.

(For Open Book Examination and not for semester end examination)

Analyze

1. Compare the AC and DC distribution systems for distribution of power in an urban area
2. A certain amount of power has to be transmitted over a distance of 100km at 66kV. Develop and compare
   the T and Pi models and suggest which is more preferable for transmitting the power keeping in view the complexity of solving the network for parameter analysis.
3. Compare the different compounding methods and suggest which is the best method for super thermal power plants employing two stage steam turbines.
4. A cyclone named Titili with wind gusts around 170 km/hr hit the north costal region of Andhra Pradesh. Your locality was within five kilo meters from the epicentre of the cyclone. As a result, transmission lines and towers got damaged. The load end requires 100MVA load at power factor of 0.8 lagging for daily smooth operation. As an electrical engineer, design the conductor configuration based on the following:
   - choice of voltage level
   - choice of conductors
   - Type of circuits
   - spacing of the conductor

(For Open Book Examination and not for semester end examination)

19EE405 Signals and Systems Theory

3 1 0 3

Course Outcomes

1. Outline the operations on various signals
2. Identify the response of linear time invariant systems
3. Solve various random signals using probability theory
4. Identify correlation, auto-correlation and power spectral density for various signals
5. Analyze the characteristics of noise signals
6. Identify the Weiner and Kalman filters for real time applications

COs – POs Mapping

COs	PO_3	PO_5	PSO_1
1	3	2	2
2	2	3	2
3	2	3	1
4	2	3	3
5	2	3	2
6	2	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Mathematical Description and Analysis of Signals

Introduction to signals, Continuous-Time Signal Functions, Discrete-Time Signal Functions, Signal Energy and Power, System characteristics, Convolution sum, Convolution integral and their evaluation, analysis of LTI Systems based on convolution and differential equations.

Solutions of differential equations with initial conditions using Laplace transform

9+3 Hours

Unit II

Probability theory

Probability, Random variables, Transformation of random variables, Multiple random variables, Stochastic processes, White noise and colored noise, simulating correlated noise.

Response of a linear system to random inputs

14+4 Hours

Unit III

Least Square Estimation

Gaussian random process, Correlations and power spectral densities – autocorrelation, cross-correlation, power spectral density or power spectrum, cross-power spectral densities, weighted least squares estimation, recursive least square estimation.

Minimum mean square error **10+4 Hours**

Unit IV

Linear filters

Introduction to Weiner filter; Discrete time Kalman filter- derivation of the discrete time Kalman filter, Kalman filter properties.

Condition number, square-root Kalman filter.

12+4 Hours

Total: 45+15=60 Hours

Textbook (s)

1. V. Oppenheim, A. S. Willsky and S. H. Nawab, Signals and Systems, PHI, 2nd Edition, 2015
2. Simon, D, Optimal state estimation: Kalman, H-infinity and nonlinear approaches, John Wiley & Sons, 1st Edition, 2018.
3. Hsu, H.P, Signals and Systems, Schaum's Outline Series, 1st Edition, 2019.

Reference (s)

1. Michel J. Robert, Fundamentals of Signals and Systems, MGH International, 2nd Edition, 2008.
2. L. Philips, J.M.Parr and Eve A.Riskin, Signals, Systems and Transforms, 4th Edition, Pearson education, 2014.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	---	---	---
Understand	50	25	---
Apply	50	50	50
Analyze	---	25	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define impulse function.
2. Define autocorrelation.
3. Define a random signal.
4. List out any types of state estimation methods.

Understand

1. Compare Autocorrelation and cross correlation function.
2. Show that the power spectral density of a bandlimited white noise is constant over a range of frequency.
3. Explain the process of state estimation using Kalman filter.

Apply

1. Find out the autocorrelation function of $e^{-at}u(t)$
2. Develop discrete time Kalman filter
3. Estimate a random constant using Weiner filter
4. Consider the below data which consists of a set of the third-year students of EEE GMRIT biometric punching time.

No. of students (X)	4+XX	12+XX	18+XX	24+XX	27+XX	19+XX	12+XX
Biometric Time (Y)	08.57	08.58	08.46	09.01	09.13	09.12	09.07

Where XX is last two digits of the student roll number.

i. Find the Mean of X and Y
ii. Identify the covariance and correlation
iii. Develop or fit the linear curve for the above data
iv. Develop a suitable software code after adding Gaussian noise to the above system

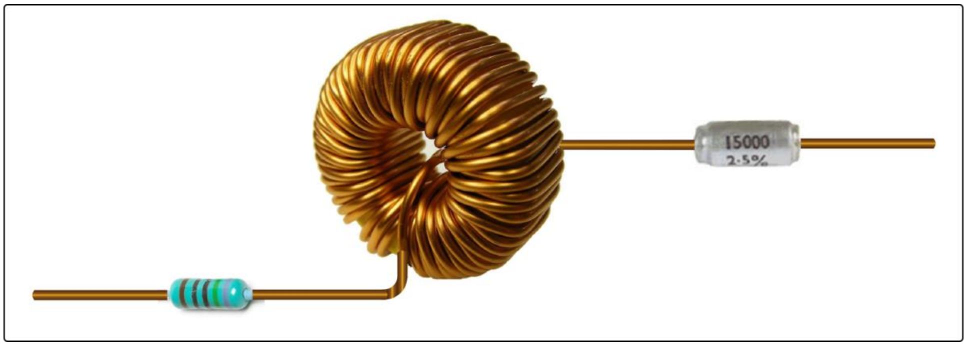
(For Open Book Examination and not for semester end examination)

Analyze

1. Examine the following signals for causality and time invariance
   (i) y(t) = tx(t)   (ii) y(t) = x(-t)
2. Justify whether the following signal is energy signal or power signal?

$$x(t) = \begin{cases} t, o \le t \le 1 \\ 2 - t, 1 \le t \le 2 \\ 0 \; otherwise \end{cases}$$

3. A radio receiver circuit with the following parameters as follows
   R=10 Ohms, L=0.1mH and C=15mF,



i. Simplify the transfer function of the above circuit, assuming zero initial conditions. assuming that the two states are voltage across the capacitor and current through the inductor, where the output is the voltage across the capacitor
ii. Simplify the state space model for the above derived transfer function; further derive the discrete model assuming the sampling time is 1msec.
iii. Discover the discrete Kalman filter of the above model assuming the measurement of the capacitor voltage is available.
iv. Develop a suitable software code and draw the output results.

(For Open Book Examination and not for semester end examination)

19EE406 AC Machines Lab

0 0 3 1.5

Course Outcomes

1. Examine performance of alternators using various methods
2. Examine the efficiencies of single-phase transformer
3. Inspect the parameters of single-phase transformer
4. Examine the efficiencies of induction motors
5. Analyze the performance of synchronous motors
6. Assess direct and quadrature axes' reactance for a given synchronous machine

COs – POs Mapping

COs	PO_4
1	3
2	3
3	3
4	3
5	3
6	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

List of Experiments

1. Regulation of a three -phase alternator by synchronous impedance method & m.m.f. method
2. No-load & Blocked rotor tests on three phase Induction motor
3. Brake test on three phase Induction Motor
4. O.C. & S.C. Tests on Single phase Transformer
5. Separation of core losses of a single-phase transformer
6. Sumpner's test on a pair of single-phase transformers
7. Equivalent Circuit of a single-phase induction motor
8. Regulation of three-phase alternator by Z.P.F. method
9. Synchronization of three phase alternator to the Bus bars
10. V and Inverted V curves of a three-phase synchronous motor
11. Determination of X_d and X_q of a salient pole synchronous machine
12. Parallel operation of single-phase transformers

List of Augmented Experiments[1]

1. Estimation of heat developed by primary and secondary windings of a transformer
2. Determination of regulation of synchronous machine by using ASA method
3. Determination of sequence impedances of salient pole synchronous machine
4. Fault analysis of Alternator
5. Synchronization of alternator by using dark & bright lamp method
6. Determination of All day efficiency of transformer
7. Design and development of equivalent circuit of an auto transformer
8. Comparison of volume of copper in two winding transformer and auto transformer
9. Design and development of equivalent circuit of an auto transformer by using MATLAB
10. Maintenance of power transformer
11. Variation in the active and reactive power of an alternator connected to an infinite bus by (a) Varying excitation, (b) varying Mechanical-power input
12. *Determine the insulation resistance of a transformer at no load and at full load condition*

Reading Material (s)

1. S.G.Tarnekar, P.K.Kharbanda, S.B.Bodkhe, S.D.Nayak,"laboratory courses in Electrical Engineering" S.Chand & company limited, 2009
2. Bimbhra P.S., "Electrical Machines", 7th edition, Khanna Publishers, 2006.

[1] Students shall opt any one of the augmented experiments in addition to the regular experiments

19EE407 Measurements and Instrumentation Lab

0 0 3 1.5

Course Outcomes

1. Demonstrate suitable methods for measuring R, L and C parameters
2. Interpret the dielectric strength of a given fluid
3. Demonstrate suitable method for calibration of meters
4. Summarize the procedure for measurement of various electrical parameters using sensors and transducers
5. Summarize the procedure for measurement of various non-electrical parameters using sensors and transducers
6. Interpret the characteristics of various sensors

COs – POs Mapping

COs	PO_4
1	3
2	3
3	3
4	3
5	3
6	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

List of Experiments

Any 10 experiments out of which at least 5 experiments from group-A and 5 experiments from group-B.

Group-A: Measurements

1. Measurement of resistance by Kelvin's Double Bridge
2. Measurement of inductance by Maxwell's Bridge
3. Measurement of capacitance by Schering Bridge
4. Measurement of choke coil parameters by using 3-ammeter and 3-Voltmeter method
5. Measurement of dielectric strength of transformer oil
6. Calibration of single-phase energy meter
7. Calibration of dynamo type wattmeter by using Phantom loading

Group B: Sensors & Transducers

1. Measure the Linear displacement into Electrical signal using LVDT.
2. Strain measurement and Calibration by using Resistance strain gauge
3. Characteristics of photo transistor and solar cell
4. Response of Thermocouple
5. Measurement of Pressure by using Transducers
6. Capacitive Level sensor for liquid level measurement
7. Measurement of moisture using Hygrometer

List of Augmented Experiments[2]

1. Development of level measurement system using proximity sensor
2. Development of automatic door opening system using sensors
3. Development of illumination control system using sensors
4. Development of soil resistance measurement system

Reading Material (s)

1. E.W. Golding, and F.C. Widdis, "Electrical Measurements and Measuring Instruments", Reem Publications Pvt. Ltd.,3^{rd} Edition, 2011.
2. A.K. Sawhney, "Electrical & Electronic Measurements & Instrumentation", Dhanpat Rai & Co. Pvt. Ltd., 19^{th} Edition, 2011.
3. D.V.S. Murthy, "Transducers and Instrumentation", Prentice Hall of India, 2^{nd} edition, 2008.

[1] Students shall opt any one of the augmented experiments in addition to the regular experiments

19EE409 Employability Skills I

1 1 1 3

Course Outcomes

1. Demonstrate oral communication and writing skills as an individual to present ideas coherently
2. Develop life skills with behavioral etiquettes and personal grooming
3. Assess analytical and aptitude skills
4. Develop algorithms for engineering applications
5. Solve engineering problems using software
6. Utilize simulation tools for testing

COs – POs Mapping

Cos	PO_1	PO_2	PO_5	PO_8	PO_{10}	PO_{12}
CO1	-	-	-	-	3	2
CO2	-	-	-	1	2	2
CO3	2	1	-	2	-	-
CO4	2	-	2	-	-	-
CO5	2	-	2	-	-	-
CO6	2	-	2	-	-	-

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

PART-A
Soft Skills
Building Confidence: Fear? Steps to Overcoming the Fear of Public Speaking?
Self Esteem: Definition? Types of Self Esteem, Causes of Low Self Esteem, Merits of Positive Self Esteem and Steps to build a positive Self Esteem.
Group Discussions (Practice): GD? GD Vs Debate, Overview of a GD , Skills assessed in a GD, Dos & Don'ts, & Conducting practice sessions (Simple Topics).
Motivational Talk: Team Work: Team Vs Group? Stages in Team Building, Mistakes to avoid and Lessons to Learn (Through Stories or Can be a Case Specific)

8 Hours

PART-B
Aptitude Skills
Quantitative Aptitude:
Percentages, Profit and loss, Mixtures and Allegations, Simple Interest, Compound Interest

7 Hours

PART-C
Domain Specific Knowledge
Programmable logic controllers -2

i. Implementation of binary to BCD converter
ii. Implementation of combinational circuits
iii. Implementation of sequential circuits
iv. Basic PLC design for dc motor control
v. Basic PLC design for induction motor control

15 Hours
Total: 30 Hours

Text Books:

1. Frederick D. Hackworth and John R. Hackworth, Programmable Logic Controllers: Programming Methods and Applications, Pearson India; 1st edition, 2003.
2. Frank Petruzella, Programmable Logic Controllers, Tata Mc-Grawhill, 3rd Edition, 2011.

Reference (s)

1. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.
2. W. Bolton, "Programmable Logic Controllers", Newnes – Elsevier, 2015.

19HSX11 CC&EC Activities I

0 0 1 1

Course Outcomes

1. Interpret and present the abstractive technical information through an activity
2. Think critically in providing solutions to the generic and common problems
3. Demonstrate the creative thinking in dealing with liberal arts
4. Instill team sprit through active engagement with the peer
5. Develop programs of common interest having social impact
6. Empower the under privileged through motivational activities

COs – POs Mapping

COs	PO_6	PO_7	PO_9	PO_{10}
1	-	-	-	3
2	3	2	-	-
3	3	-	-	-
4	-	-	3	-
5	3	-	-	-
6	3	-	-	-

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

19IT306 Object Oriented Programming through Java

3 0 2 4

Course Outcomes

1. Implement object-oriented concepts to the problems
2. Implement applications using different types of inheritances
3. Develop user defined packages
4. Identify and recover runtime exceptions arise in the applications
5. Demonstrate parallel processing applications using threads.
6. Design interactive applications using Hibernate and spring Framework.

CO–PO Mapping

COs	PO_1	PO_2	PO_3	PO_4	PO_5
1	1	3	2	3	2
2	1	3	3	3	2
3	1	2	3	3	2
4	1	2	3	3	2
5	1	3	3	3	2
6	1	3	3	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Introduction to Java

Overview of Object-Oriented Programming principles, Importance of Java to the Internet, Byte code, Data types, arrays, control statements, Classes and Objects– constructors, methods, access control, this keyword, overloading methods and constructors, garbage collection

Features of object-oriented programming–Java History–Computer Programming Hierarchy–Role of Java Programmer in Industry

Practical Components

1. Write a program that prints all real solutions to the quadratic equation ax2 + bx +c = 0.
2. Write a program that uses both recursive and non-recursive functions to print the nth value in the Fibonacci sequence.
3. Write a program to demonstrate String handling methods and tokenizing given string/text using String Tokenizer class
4. Write a program to implement matrix operations using multidimensional arrays.

10+9 Hours

Unit II

Inheritance, Packages & Interface

Inheritance: Hierarchical abstractions, Base class and subclass, Benefits of inheritance, super keyword, final keyword with inheritance, polymorphism, abstract classes

Packages: Defining, Creating and Accessing a Package, Understanding CLASSPATH, importing packages, Member access rules

Interface: Defining an interface, differences between classes and interfaces, implementing interface, variables in interface and extending interfaces

Nested–Inner Class & Anonymous Classes–Generic Class Types

Practical Component

1. Write a program for creating one base class for student personal details and inherit those details into the sub class of student educational details to display complete student information.
2. Write a program that illustrates runtime polymorphism.
3. Write a program to create a package which has classes and methods to read Student admission details.

12+6 Hours

Unit III

Exception Handling & Multithreading

Exception handling: Concepts and benefits of exception handling, exception hierarchy, usage of try, catch, throw, throws and finally, built-in and User Defined Exceptions

Multithreading: Definition thread, thread life cycle, creating threads, synchronizing threads
Control Flow in Exceptions– JVM reaction to Exceptions– Inter Communication of Threads– Critical Factor in Thread–Deadlock

Practical Component

1. Write a program to define and handle User Defined Exceptions (make use of throw - throws).
2. Introduction to Eclipse Environment

11+6 Hours

Unit- IV

Java JDBC, Hibernate & Spring Framework

Java JDBC: Introduction, JDBC Driver, JDBC Connectivity steps, Connectivity with MySQL/Oracle. Hibernate Framework: Introduction, Object Relational Mapping tool, Java Persistence API, Hibernate Architecture
Spring Framework: Introduction, Spring Framework
Spring Application, Spring Boot.

Practical Component

1. Implement Hibernate Example without IDE
2. Implement Hibernate Example with Eclipse

12+9 Hours

Total: 45+30=75 Hours

Textbook (s):

1. H. Schildt, "Java: The complete reference", Tata McGraw Hill Companies, 7th Edition, 2016
2. T. A. Budd, "An Introduction to Object–Oriented Programming", Addison Wesley Longman,3rd Edition, 2012

Reference (s):

1. Dietal & Dietal, "Java: How to Program", 8th Edition, PHI, 2010
2. E. Balaguruswamy, "Programming with Java A Primer", Tata McGraw Hill Companies, 4th Edition, 2009
3. C. S. Horstmann and G. Cornell, "Core Java, Vol 1. Fundamentals", Pearson Education, 7th Edition, 2014
4. C. Horstmann, "BIG JAVA Compatible with Java 5 & 6", Wiley Publishers, 3rd Edition, 2008

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	25	35	---
Understand	45	35	---
Apply	30	30	40
Analyze	---	---	20
Evaluate	---	---	40
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. List out 6 different java buzz words
2. List the three OOP principles
3. Define Inheritance
4. List the 5 keywords used in exception handling

Understand

1. Summarize the OOP principles
2. Illustrate the procedure for creating a user defined package
3. Interpret the Thread Life cycle
4. Interpret the Applet Life cycle
5. Define Encapsulation

Apply

1. Implement a java program that read an integer between 0 and 1000 and adds all the digits in the integer
2. Implement an abstract base class shape with two members base and height, a member function for initialization and a function to compute area ( ). Derive two specific classes Triangle and Rectangle which override the function area ( ). Use these classes in a main function and display the area of a triangle and a rectangle.
3. Demonstrate an applet that receives two numerical values as input from the user and then displays the sum of these numbers on the screen.
4. Given are two one dimensional arrays A and B which are sorted in ascending order. Develop a program to merge them into a single sorted array C that contains every item from arrays A and B, in ascending order.
5. Implement a Java program for creating one base class for student personal details and inherit those details into the sub class of student educational details to display complete student information.

Analyze

1. Compare and Contrast between procedure oriented and object-oriented programming.
2. Analyze the concurrent programming using threads.
3. Differentiate method overloading and method overriding.
4. Differentiate sleep and suspend.
5. Analyze platform independency of java with the help of JVM.

Evaluate

1. Judge whether hibernate and spring frameworks are better for java database connectivity.
2. Asses the performance of threads
3. Determine the importance of run time polymorphism
4. Defend why pointer were removed in JAVA
5. Judge why do you java to develop a web-based application

19EE502 Control Systems

3 0 2 4

Course Outcomes

1. Build mathematical models of control systems in continuous time
2. Outline the system using block diagram and signal flow graph techniques
3. Analyze the transient and steady state performances of a control system
4. Analyze the stability of a system using time domain and frequency domain techniques
5. Develop different controllers in time/frequency domain
6. Illustrate state space modeling and compute the controllability and Observability for the given system

COs – POs Mapping

COs	PO_2	PO_3	PO_4	PO_5	PSO_1	PSO_2
1	3	3	3	3	3	3
2	2	2	3	2	3	3
3	3	3	3	3	3	3
4	3	3	3	3	3	3
5	3	3	3	3	3	3
6	2	2	3	2	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Mathematical Models of Physical Systems

Concepts of Control Systems-Open Loop and closed loop control systems, Classification of control systems, Transfer function, Modeling of Electric systems, Translational and rotational mechanical systems, Block diagram reduction Technique, Signal flow graphs

Effects of feedback

Practical Component

1. Open loop and closed loop analysis of a double integrator.
2. Simulation and analysis of R-L-C circuit

12+6 Hours

Unit II

Time Domain Analysis

Standard test signals, Time response of first and second order systems, time domain specifications, characteristic Equation, Static error constants, Effects of P, PI, PD and PID controllers, Concept of stability, Routh-Hurwitz stability criterion, Difficulties and limitations in RH stability criterion, Root locus concept, construction of root loci

Effects of addition of poles and zeros on root locus plot

Practical Component

1. Analysis of an open-loop DC motor using root locus
2. PID controller design for a DC motor
3. Controller design in time domain and root-locus analysis

12+9 Hours

Unit III

Frequency Domain Analysis

Frequency response characteristics, Frequency domain specifications, Time and frequency domain parameters correlations, Bode plot, transfer function from the Bode plot, Stability Analysis using Bode plot, Polar plot and Nyquist's stability criterion.

M & N circles

Practical Component

1. PID controller design in frequency domain and analysis
2. Stability analysis using Nyquist plots

11+6 Hours

Unit IV

State Space Analysis

Concepts of state, state space modeling of physical systems, Representation of state space model in different canonical forms, Transfer function and state space model correlations, Solution of state equations, State Transition Matrix and it's Properties, Basic concept of Controllability and Observability.

Diagonalization

Practical Component

1. Construction of simulation diagram from differential equations and state space equations
2. Controllability and Observability analysis of complex systems
3. Controller design in the state space domain

10+9 Hours

Total: 45+30=75Hours

Textbook (s)

1. I.J. Nagrath and M. Gopal, "Control Systems Engineering" New Age International (P) Limited, 6th Edition, 2015.
2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd., 4th Edition, 2006.
3. Mario E. Salgado, Graham C. Goodwin, Stefan F. Graebe, "Control Systems Design", Pearson Education India; 1st Edition, 2015.

Reference (s)

1. K. Alice Mary and P. Ramana, "Control Systems", Universities Press (India) Pvt. Ltd., 1st Edition, 2016.
2. Smarajit Ghosh, "Control Systems", Pearson Education, 2nd Edition, 2012.
3. Benjamin C. Kuo, "Automatic Control Systems", John Wiley & Sons, 9th Edition, 2011.

Internal Assessment Pattern

Cognitive level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	20	10	---
Understand	20	30	---
Apply	30	30	40
Analyze	30	30	60
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define a closed loop control system
2. List any 4 applications of closed loop control system
3. Define transfer function
4. List 2 advantages of Signal flow graph over Block-diagram reduction technique
5. List any 3 properties of state transition matrix
6. Label different types of frequency domain analysis methods

Understand

1. Differentiate SISO and MIMO systems
2. Explain the traffic control system concepts using open loop as well as closed loop system
3. Derive f-v and f-i analysis
4. Explain different cases in R-H criteria
5. Derive state transition matrix
6. Explain Mason's gain formula

Apply

1. Apply Open Loop and closed loop control systems for the person walking on a road
2. Construct root locus for the open loop T.F function G(s) = (s+2)/(s+1)(s+3)
3. Evaluate transfer function for the state space equation give bellow

$\dot{x} = AX + BU \quad y = CX + DU$

4. Construct the Bode plot for given open loop transfer function
   G(s) = (s+2)/(s+1)(s+3)
5. Develop the Nyquist plot for the given open loop transfer function. G(s) = (s+2)/(s+1)(s+3)

Analyze

1. Compare the properties of time domain and frequency domain analysis
2. Analyze the effect of disturbance on the system performance due to feedback
3. Feedback will increase instability of the system. Justify
4. Distinguish the advantage and disadvantages of the root locus and Bode plot
5. Illustrate the variation of root locus with respect to variations in K
6. Formulate the state space model in different canonical forms

19EE503 Power Electronics

3 1 0 3

Course Outcomes

1. Summarize the operation of various power semiconductor devices
2. Outline the control and protection methods for power semiconductor devices
3. Analyze the performance of AC-DC for various loads
4. Examine the performance of AC-AC converters
5. Investigate the performance of DC-DC converters
6. Analyze the performance of DC-AC inverters

COs – POs Mapping

COs	PO_2	PO_3	PSO_1	PSO_2
1	2	2	1	1
2	2	2	1	1
3	3	3	3	3
4	3	3	3	3
5	3	3	3	3
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I
Power Semiconductor Devices
Introduction to power electronics devices - Construction, operation, and characteristics of thyristor family (SCR & GTO), BJT, MOSFET, IGBT - Turn on and turn off methods of SCR - Two transistor analogy of SCR - SCR firing and protection circuits - Series and parallel operations of SCR - Introduction to wide-bandgap semiconductor devices (SiC & GaN).
Role of Gate Drive Circuits in Power Electronics

11 + 3 Hours

Unit II
Phase Controlled Converters (AC-DC Converters)
Introduction to phase-controlled converter – Operation of 2-pulse, 3-pulse, and 6-pulse converter with R, RL, and RLE loads – Derivation of average load voltage and average load current – Effect of source inductance on single-phase controlled converter – Introduction to dual converter.
Improved Power Quality AC-DC Converters

12 + 5 Hours

Unit III
AC–AC Converters
Introduction to AC-AC converter - AC voltage controllers - Operation of single-phase AC voltage regulator - Derivation of RMS load voltage and RMS load current – Cyclo-converters – Operation of single-phase to single-phase.
Three phase AC voltage controller

10 + 3 Hours

Unit IV
Choppers & Inverters
Introduction to choppers – Operation of buck, boost, and buck-boost dc-dc converters - Derivation of average load voltage and average load current - Time ratio control and current limit control strategies – Introduction to high frequency isolated dc-dc converters.
Introduction to voltage source inverters – Operation of single-phase half and full bridge inverters – Operation of three-phase inverters with 180-degree and 120-degree conduction mode - Pulse width modulation techniques (Single, Multiple, and Sinusoidal) - Introduction to current source inverters.
Introduction to Space Vector Modulation

12 + 4 Hours
Total:45 + 15=60 Hours

Textbook (s)

1. M. H. Rashid, "Power Electronics: Circuits, Devices and Applications," PHI, 2nd Edition, 2009.
2. P.S. Bhimbra, "Power Electronics, Khanna Publishers", 4th Edition, 2012.
3. M.D. Singh and K.B. Kanchandhani, "Power Electronics", TMH, 2nd Edition, 2008.
4. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics - Converters, Applications, and Design", Wiley, 3rd Edition, 2002.

Reference(s)

1. Robert W. Erickson and Dragan Maksimović, "Fundamental of Power Electronics", Springer, 1st Edition, 1997.
2. Barry W. Williams, "Power Electronic, Devices, Applications, and Passive Components", McGraw Hill Higher Education, 2nd Edition, 1992.
3. Vedam Subramanyam, "Power Electronics", New Age International Pvt. Limited, 1st Edition, 2015.
4. L. Umanand, "Power Electronics: Essentials & Applications", Wiley, 1st Edition, 2009.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	60	50	---
Apply	---	---	---
Analyze	20	30	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define latching current & holding current
2. Define firing angle
3. List the advantages of dc-ac converters
4. What is an inverter?
5. Define duty cycle of the switch

Understand

1. Explain static V-I characteristics of an SCR
2. Explain the differences between series and parallel operation of SCRs
3. Compare the performance of the converter when it is connected with R, RL loads
4. Classify the different power converters based on input and output supply
5. Explain the operation of the single-phase ac voltage controller

Analyze

1. Analyze the performance of single-phase full converter and half–wave-controlled converters
2. Analyze the impact of source inductance on the performance of single-phase ac-dc converters
3. Assess the importance of various PWM technique in an inverter operation
4. Assume the situation that an isolated 5kW solar PV system needs to be established in agricultural field. The solar PV source of $60V_{DC}$ has to deliver the required power to drive the induction motor for the pumping application in agricultural field. In addition, it has to deliver the required power to some heating loads. Assume the heating load of 1 kW requires DC source of $300V_{DC}$, and the induction motor of 4 kW capacity requires 440 V_{AC} sources.
    i. How many power conversion stages required to attain the above-said objectives? Draw the optimal layout of the PV system and illustrate the function of each conversion stage. Justify your answer with proper reasons.
    ii. Compare and select a suitable power semiconductor switch with complete rating details for various power conversion stages.

iii. Select an optimal modulation technique to generate the gate pulse which suits for various switches in converter/inverter. Justify.

iv. During operation, assume the situation that induction motor speed increases more than synchronous speed. What are the necessary steps needs to be taken to overcome this issue? Justify with proper reasons.

(For Open Book Examination and not for semester end examination)

5. Identify a suitable power converter for a single-phase induction motor for variable speed application. Justify your answer with supportive design procedure.

(For Open Book Examination and not for semester end examination)

19EE504 Power System Protection

3 1 0 3

Course Outcomes

1. Outline the working of various circuit breakers
2. Summarize the construction and working of different types of relays
3. Identify suitable protective device for power system equipment
4. Identify protection schemes for relaying equipment
5. Outline the operation of electrostatic and digital relays
6. Apply digital logic in relay communications

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	2	2	1
3	3	3	2
4	3	3	2
5	2	2	1
6	3	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I
Circuit Breakers
Basics of Protection & its significance, Circuit Breakers: Elementary principles of arc interruption, Restriking and Recovery voltages - Restriking Phenomenon, Average and Max. RRRV- Current Chopping and Resistance Switching - CB ratings and Specifications, Auto-reclosures, Description and Operation of Oil Circuit breakers, Air Blast Circuit Breakers, Vacuum Circuit Breakers and SF6 circuit breakers, MCB and MCCBs, Isolators.
Difference between a Fuse, an Isolator and a Circuit breaker.

11+4 Hours

Unit II
Electromagnetic Relays
Principle of operation and construction of attracted armature, Balanced beam, induction disc and induction cup relays. Instantaneous, DMT and IDMT relays.
Over current/ Under-voltage relays, Directional relays, Differential and percentage differential relays, Translay relay, Universal torque equation,
Distance relays- Impedance, Reactance and Mho relays.
Fundamental requirements of protective relays, Types of protection.

11+4 Hours

Unit III
Power system components protection
Generator Protection-Protection of generators against stator faults, rotor faults, restricted earth fault and inter-turn fault.
Transformer protection - Percentage differential protection, Buchholz relay protection.
Line protection -Over current, carrier current and three-zone distance relay protection using impedance relays, ZnO and rod gap Lightning arresters, grounding wires, Peterson coil.
Bus bar protection – Differential protection.
Voltage surge, lightning.

12+3 Hours

Unit IV
Static & Digital Relays
Static Relays-Introduction, Static relay components, Comparators – Amplitude and phase, Static over current relay, Static distance relay and Static poly-phase relay.
Digital Relays- Introduction, Digital logic communication, Microprocessor based over current, impedance, reactance & Mho relays, relay testing, static relays versus electromagnetic relays
Static relays versus electromagnetic relays.

11+4 Hours

Total: 45+15=60 Hours

Textbook (s)

1. Badri Ram and D.R.Viswakarma, "Power System Protection and Switchgear", Tata McGraw Hill Education Private Limited, 2nd Edition, 2013
2. J. B. Gupta, "Switchgear and Protection", S. K.Kataria & Sons, 1st Edition, 2009.

Reference (s)

1. V.K. Mehta and Rohit Mehta, "Principles of Power Systems", S. Chand & Company Ltd., 2005.
2. Sunil S Rao, "Switchgear and Protection", Khanna Publishers, 13th Edition 2019
3. Paithankar and S. R. Bhide, "Fundamentals of Power System Protection", PHI publications, 2nd Edition 2013.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	40	20	---
Understand	40	40	---
Apply	20	40	60
Analyze	---	---	40
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Label the circuit diagram of relay
2. List the advantages of vacuum circuit breaker
3. Define arc voltage
4. List any three problems associated with differential relay

Understand

1. Formulate the expression for restriking voltage
2. Illustrate the SF6 circuit breaker with neat diagram
3. Explain any three types of lightning arresters
4. Classify voltage balance differential relay and translay relay
5. Explain the working principle of restricted earth fault relay for the protection of stator winding of alternator

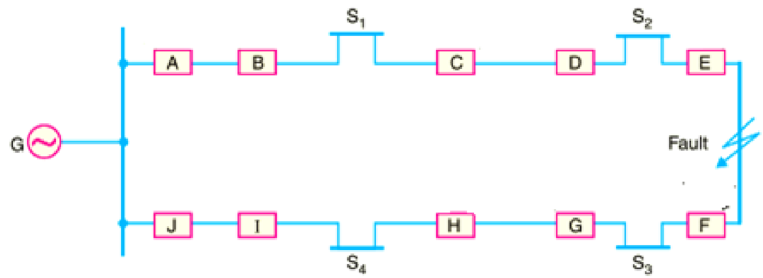
Apply

1. For 132kV system the reactance and capacitance up to location of circuit breaker is 3ohms, and 0.015μF, respectively. Find i) frequency of transient oscillation, ii) maximum value of restriking voltage iii) RRRV
2. A star connected 3-phase,10MVA,.7.5 kV alternator has a per phase reactance of 10%. it is protected by Merz-Price circulating current principle which is set to operate for fault currents not less than 200A. Find the value of earthling resistance to be protected in order to ensure that only 10% of the alternator winding remains unprotected.
3. Find the time of operation of a 5 amp 3 second over current relay having current setting of 125% and time setting multiplier of 0.6 connected to supply circuit through a 400/5 current transformer when the circuit carries a fault current of 4000A. Use the following table

Operating Time	2	4	6	8	10	12
PSM	2	2.5	3	3.5	4	4.5

4. Fig shows the single line diagram of a typical ring main system consisting of one generator supplying four sub-stations *S*1, *S*2, *S*3 and *S*4. In this arrangement, power can flow in both directions under fault conditions. In this system, various power stations or sub-stations are interconnected by

alternate routes, thus forming a closed ring. In case of damage to any section of the ring, that section may be disconnected for repairs, and power will be supplied from both ends of the ring, thereby maintaining continuity of supply Therefore, it is necessary to grade in both directions round the ring. Select optimal location for relays and identify their time settings so that only faulty section of the ring is isolated under fault conditions. Justify your answer. **(For Open Book Examination and not for semester end examination)**



Analyze

1. Distinguish between Electrostatic and Electromagnetic relays
2. Vacuum circuit breakers are mostly suitable for rural areas. Justify
3. An alternator is used in a generating station and it was observed that the following issues are being faced in alternator operation.
   (i) one-phase open circuits
   (ii) unbalanced loading
   (iii) motoring
   (iv) loss of synchronism.

   Can relays be used to protect an alternator against the above issues. Justify your answer with suitable protection schemes. **(For Open Book Examination and not for semester end examination)**

19EEC11 Electrical Vehicle Technologies

3 1 0 3

Course Outcomes

1. Outline various electric and hybrid vehicle architectures
2. Analyze the operations of vehicle dynamics
3. Select optimal vehicle technology based on architecture and dynamics for a particular application
4. Outline various power electronic converters for electric vehicles
5. Outline various motors for electric vehicles
6. Analyze the performance of power electronic converter based electric drives

COs – POs Mapping

COs	PO_2	PO_3	PO_{12}	PSO_2
1	2	2	3	1
2	3	3	3	3
3	3	3	3	2
4	2	2	3	1
5	2	2	3	1
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Introduction to Electric and Hybrid Electric Vehicles

Sustainable transportation, Brief history of electric vehicles (EV's), Hybrid electric vehicles, Fuel cell vehicles, Architectures of EV, Series HEV, Parallel HEVs, Diesel HEVs, PHEV & FCEV, Hybridization ratio, Interdisciplinary Nature of HEVs, Challenges and key technology of HEVs.

Recent EV models

10+3 Hours

Unit II

Vehicle Dynamics

General description of vehicle movement, Vehicle Resistance - Rolling Resistance, Grading Resistance, Aerodynamic Drag, Tire–Ground Adhesion and Maximum Tractive Effort- Power Train Tractive Effort and Vehicle Speed, Vehicle performance -Maximum Speed of a Vehicle, Gradeability, Operating fuel economy-Fuel Economy Characteristics of Internal Combustion Engines, Braking performance.

Techniques to improve vehicle fuel economy

11+4 Hours

Unit III

Power Electronics in HEVs

Power electronics converters used in a series HEV, Schematics of a power converter, Rectifiers used in HEV - Ideal Rectifier, Practical Rectifier, Buck Converter Used in HEVs -operating principle, Voltage source inverter, Current source inverter, Isolated bidirectional DC–DC converter, EV and PHEV battery chargers-charger architecture, Emerging power electronics devices, Thermal management of HEV power electronics

Circuit Packaging

12+4 Hours

Unit IV

Electric Machines and Drives in HEVs

Introduction to induction motor drives and control

Principle of operation and analysis of BLDC motor Drive, PMSM drive and SRM drive.

Doubly salient permanent magnet machines

12+4 Hours

Total: 45+15=60 Hours

Textbook (s)

1. Chris Mi, Abul Masrur and David Wenzhong Gao, "Hybrid Electric Vehicles-Principles and Applications with Practical Perspectives", John Wiley & Sons, Ltd., 1st Edition, 2011.
2. James Larminie and John Lowry, "Electric Vehicle Technology Explained", Wiley, 1st Edition, 2003.

3. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", CRC Press, 2005.

Reference (s)

1. Tom Denton, "Electric and Hybrid Vehicles", Taylor & Francis, I[st] Edition, 2018.
2. Wei Liu, "Hybrid Electric Vehicle System Modeling and Control", General Motors USA, John Wiley & Sons, Inc., 2017.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	--
Understand	25	25	--
Apply	25	25	50
Analyze	25	25	50
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (s)

Remember

1. List various lighting systems and components
2. Label VI Characteristics of MOSFET & IGBT
3. List various PM motors used in EV technology
4. Define power train tractive effort

Understand

1. Explain in detail about layout of Electric vehicle
2. Explain the working principle of BLDC motor
3. Explain vehicle power transmission characteristics
4. Explain bi-directional DC-DC converter

Apply

1. Develop the layout of Series hybrid electric vehicle
2. Identify the techniques to improve the vehicle fuel economy
3. Develop the buck converters used in HEV's
4. Identify various losses in PM magnet machines used in EV's
5. Mr. Rahul, a businessman, needs to travel daily on an average covering 100km which consists of 70 km highway drive and 30 km city drive. He is currently using a diesel vehicle and wants to shift to non-polluting/less polluting vehicle. Help him identify which vehicle he can opt so that it would cater to his needs as well as reduce his vehicle carbon footprint. Justify your selection by giving a detailed layout of architecture of the proposed vehicle and by relating the driving requirements of Mr. Rahul with the operating characteristics of the vehicle. (make use of EV/HEV specifications available in the market)
   (For Open Book Examination and not for semester end examination)

Analyze

1. Analyze the factors leading to disappearance and resurgence of EV's
2. Analyze the Vehicle Power Plant and Transmission Characteristics
3. Analyze the EV and PHEV Battery Chargers
4. Analyze various charactistics of PM magnet motors
5. Analyze the reasons favoring the simultaneous emergence and existence of various electric vehicle architectures across the world. (Hint: Do all electric vehicle configurations have practical applications)
   (For Open Book Examination and not for semester end examination)

19EEC21 Green Energy Technologies

3 1 0 3

Course Outcomes

1. Illustrate the wind energy conversion systems
2. Recognize the impacts of temperature and insolation on PV electrical characteristics
3. Estimate the green energy dependent parameters
4. Design and explore the economic viability of the grid connected PV systems
5. Illustrate the Building integrated photovoltaics system
6. Identify the relevant standards related to the grid connection requirements of PV

COs – POs Mapping

COs	PO_2	PO_3	PO_{12}
1	2	2	2
2	2	2	2
3	3	3	3
4	3	3	3
5	2	2	2
6	2	2	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit-I Wind Energy

Introduction to wind energy - Potential of wind electricity generation in India and its current growth rate Types of wind turbines - Power in the wind, temperature and altitude correction for air density - Impact of tower height - maximum rotor efficiency - Wind turbine generators, synchronous generators and asynchronous induction generator - Speed control for maximum power, Idealized wind turbine power curve, cut in wind speed, cut out wind speed, Rated wind speed, wind farms for bulk power supply

Indirect grid connection systems

12+4 Hours

Unit-II Solar PV Energy

Introduction of solar energy - Solar spectrum - Altitude angle of the sun at Solar noon, tilt angle of a PV module, Solar position at any time of day. Direct Beam Radiation, Diffuse Radiation, Reflected Radiation and Tracking system. Solar Radiation Measurements

Photovoltaic electrical characteristics - A generic photovoltaic cell, the simplest equivalent circuit for a photovoltaic cell, PV cell - cells, modules and arrays, voltage and current from a PV module - the PV *i–v* curve under standard test conditions - Impacts of temperature and insolation on *i–v* curves - Shading impacts on i–v curves, Impact of shading on PV cell -, importance of maximum power point tracking and its methods

Introduction to crystalline silicon technologies **12+4 Hours**

Unit-III Grid-connected PV systems

Grid-connected systems, interfacing with the utility, dc and ac rated power, derating a PV array to a PTC, ac rating, the ''peak-hours'' approach to estimating PV performance, Grid-connected system sizing - system trade-offs, amortizing costs - stand-alone PV systems, Islanding and anti-islanding systems estimating the load, the inverter and the system voltage,

Batteries, Importance of storage capacity in Grid connected system, sizing the PV array, hybrid PV systems and stand-alone system design..

Introduction to PV powered water pumping

11+4 Hours

Unit-IV Building integrated photovoltaics & International Regulations

Introduction to Building integrated Advantages and challenges of building integrated photovoltaic PV – Design of building envelope integration, PV integration options - Shading system ,Rain scree system , Curtain wall systems, Stick system curtain wall, Unitized system, Double-skin façade,- Shading systems, Principles of construction, Integration of PV modules.

Grid Requirements for PV - International Regulations, Response to Abnormal Grid Conditions, Power Quality, Anti-islanding Requirements

Array wiring

10+3 Hours
Total: 45+15=60 Hours

Text Book(s)

1. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley & Sons, 1st Edition, 2013.
2. Remus Teodorescu, Marco Liserre and Pedro Rodriguez, "Grid Converters for Photovoltaic and Wind Power System", John Wiley & Sons, 1st Edition, 2011.

Reference Book(s)

1. Simon Roberts and Nicolò Guariento, "Building Integrated Photovoltaics: A Handbook", Springer Science & Business Media, 1st Edition, 2009.
2. Felix A. Farret, M. Godoy Simoes, "Integration of Alternative Sources of Energy", John Wiley & Sons, 1st Edition, 2013.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	50	50	---
Apply	30	30	100
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define photovoltaic.
2. What is air mass ratio?
3. Write the expression of Planck's law.
4. What is Capacity factor for PV Grid-Connected Systems?
5. State any two anti-islanding requirements.

Understand

1. Write short notes on (i) Altitude Correction for Air Density (ii) Impact of tower height
2. Find the air density (a), at 15◦ C (288.15 K), at an elevation of 2000 m (6562 ft). Then (b) find it assuming an air temperature of 5◦ C at 2000 m.
3. Derive the expression of fundamental relationship for the power delivered by the rotor and obtain Betz efficiency.
4. Describe in detail about rainscreen cladding and curtain wall systems.
5. With neat sketch explain the principal components in a grid-connected PV system using a single inverter.

Apply

1. A 40-m, three bladed wind turbine produces 600 kW at a windspeed of 14 m/s. Air density is the standard 1.225 kg/m3. Under these conditions,
   a) At what rpm does the rotor turn when it operates with a TSR of 4.0?
   b) What is the tip speed of the rotor?
   c) If the generator needs to turn at 1800 rpm, what gear ratio is needed to match the rotor speed to the generator speed?
   d) What is the efficiency of the complete wind turbine (blades, gear box, generator) under these conditions?
2. Consider a PV array rated at 1 kW under standard test conditions. Module nominal operating cell temperature (NOCT) is 47◦ C (see Section 8.6). DC power output at the MPP drops by 0.5%/◦ C above the STC temperature of 25◦ C. Estimate its ac output under PTC conditions if there is a 3% array loss due to mismatched modules, dirt loss is 4%, and the inverter has an efficiency of 90%.

3. A certain water heater is when operated from 120 V a.c will deliver a power of 2.88 kW. Now this heater (electrical resistance heating element) is directly connected to the PV system. Assume that you have 4 identical PV modules each with the I-V curve as shown in figure. Plot the I-V curves of different combinations of PV modules and decide which combination will give the most energy in a day time. Justify. **(For Open Book Examination and not for semester end examination)**
4. Identify the size of wind turbine power rating that is required to be installed to meet the annual energy requirement of an industry is 20000 kWh and also approximate cost of the wind turbine.
   Assume the following data for design of wind turbine:
   (i)Propeller type wind machine is used
   (ii)Wind speed at 15 m height is 5 m/sec (if the turbine hub is placed at the height other than 15 m, the wind speed should be estimated as shown in "vertical wind speed variation section".
   Assume any data required and justify your assumption
   (For Open Book Examination and not for semester end examination)

19EEC31 Micro and Smart Grid Technologies

3 1 0 3

Course Outcomes

1. Summarize the concepts of various operating modes in a microgrid
2. Outline the control strategies of a microgrid
3. Examine the dynamics in micro grid models
4. Outline the concepts related to design of smart grid
5. Summarize the regulations of smart grid
6. Identify various market models in smart grid

COs – POs Mapping

COs	PO_2	PO_3	PO_{12}	PSO_2
1	2	1	2	1
2	2	1	2	1
3	3	3	3	3
4	2	1	2	1
5	2	1	2	1
6	3	2	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Microgrids: Concept, Modes of Operation and Control

Introduction, Structure, Modes of operation, Overall representation of the grid-connected microgrid, Microgrid bus, Microgrid representation in the islanded operation, Model control mechanism for connected distributed generators in a microgrid, Speed control of classical distributed generators, Control of inverter-based distributed generators, Control structure in grid-connected mode, Control structure in islanded model.

Global architecture representation

11+4 Hours

Unit II

Microgrid Dynamics and Modeling

Introduction, Distribution network (Main Grid) and connection modeling, Distribution network modeling, Mechanical part and frequency regulation loop, Voltage regulation, Modeling of connection between the main grid and microgrid, Modeling of the medium voltage transmission lines

Adaptation between the per units and SI units

12+4 Hours

Unit III

Introduction to Smart Grid

Definition of smart grid, Justification for smart grid, History of smart grid evolution, Characteristics and benefits of smart grid, Vision and realization, Comparison between smart grid and existing electrical grid system in India, Advanced metering infrastructure.

Basic components of smart grid

11+3 Hours

Unit IV

Regulations of Smart Grid

Regulation and funding of smart grid, Regulation and economic models, Evolution of the value chain, Market regulation and standardization of smart grid

Market Models for Smart Grid

Demand response, Tariff design, Time of the day pricing (TOD), Time of use pricing (TOU), Consumer privacy and data protection, Cost benefit analysis of smart grid projects

Smart grid for smart cities **11+4 Hours**

Total:45+15=60 Hours

Textbook (s)

1. H. Bevrani, B. François and T. Ise, “Microgrid Dynamics and Control”, John Wiley & Sons, 1st Edition, 2017.
2. Jean Claude Sabonnadière and Nouredine Hadjsaïd, “Smart Grids”, Wiley-ISTE, IEEE Press, May 2012.

3. James Momoh, “Smart Grid: Fundamentals of Design and Analysis” – Wiley, IEEE Press, 2012

Reference (s)

1. N. D. Hatziargyriou, “Microgrids Architecture and control”, IEEE Press Series, John Wiley & Sons Inc, 1st Edition, 2013.
2. El-Shahat, Adel, Rami J. Haddad, YouakimKalaani. "Smart Grids Technology Fundamentals - New Course." Proceedings of the ASEE Southeastern Section Annual Conference Gainesville, FL: American Society for Engineering Education, 2015.
3. "Smart grid handbook for regulators and policy makers", Indian Smart Grid Forum (ISGF) Tech. Rep., Nov. 2017.
4. Kumar et al. 2013, Sanjeev Kumar, N.S. Sodha, and K. Wadhwa, "Dynamic tariff structures for demand side management and demand response: An approach paper from India", 2013 ISGAN issue brief Available for download from http://indiasmartgrid.org/en/knowledge-center/Reports/Dynamic \%20Tariffs \%20White \%20Paper.pdf

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	25	25	50
Analyze	---	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)
Remember

1. Define Microgrid.
2. What do you mean by main grid?
3. Define Smart grid
4. What do you mean by time of delay pricing?

Understand

1. Explain the operating modes in a microgrid.
2. Interpret the difference between existing grid and smart grid structure.
3. Summarize the concept evolution of value chain.
4. Outline the role of consumers and new players in the value chain?

Apply

1. Identify the type of control in a islanded microgrid?
2. Build the model of medium voltage transmission lines?
3. Identify the various components used in smart grid applications?
4. Identify a suitable business model for smart grid?
   There is a beautiful island known as Kona Seema Island near Kerala Backwaters, nearly 10 KM from the coast in Andhra Pradesh, In this island, in addition to the local renewable based power sources, a major portion of the island is powered from the main grid AP. One fine day due to some event, the grid is identified to have been disconnected with the main grid, with only a small amount of renewable energy power left to power the island. As a power engineer, identify the significant changes in the representation of the overall network, and sketch it in form of some neat diagrams. Further identify the possible reasons for the occurrence of such events and suggest some suitable control strategies to manage power under such circumstances to maintain life and tourism in the beautiful island. **(For Open Book Examination and not for semester end examination)**
5. Protection of the critical infrastructure is the primary objective of any nation and the power sector assumes top priority as all other sector depends directly and indirectly on the power sector. With the convergence of electrical technologies, information technologies and operational technologies in a smart grid, security of control systems and data protection is extremely important. Many attacks have been launched in Industrial and Control System. Identify the different types of attacks and

suggest proactive measures to address data protection and potential cyber security issues with necessary block diagram. Also, write the instruments need to be procured for monitor and control with justification. **(For Open Book Examination and not for semester end examination)**

Analyze

1. Compare the grid connected mode with islanded mode of operation in a microgrid.
2. Contrast the dynamics of frequency regulation loops in microgrids.
3. Analyze the characteristics of smart grids.
4. Examine the cost benefit analysis of a smart grid.
   As the cyclone is hitting to the costal belt in India every year, The Central Government has decided to upgrade the electrical communication system in the costal district of each state. As a technical engineer, the duty has assigned that, you have to inspect the locality and to finalize the smart communication methodology which will be collaborated with Gas Insulated Substation in your locality. As an expert in this area, inspect the details of some suitable instruments with justifications which need to be procured for unmanned work for grid scenario for the stability of the grid structure in your locality. Justify your answer with proper descriptions. **(For Open Book Examination and not for semester end examination)**
5. In Visakhapatnam assume a microgrid is in parallel with the main grid. Due to a severe cyclone the micro-grid is been isolated from remainder of the utility system- intentional islanding mode. In this mode, DG inverter system operates in voltage control mode to provide constant voltage to the local load. During grid connected mode, the Microgrid operates in constant current control mode to supply power to the main grid. Now in this scenario examine a scheme to minimize the voltage and frequency deviations at both local load level and at system level. **(For Open Book Examination and not for semester end examination)**

19EE004 Electrical Machine Design

3 1 0 3

Course Outcomes

1. Summarize electrical materials as per IS standards
2. Make use of various design concepts in construction of DC machines and transformers
3. Analyze the effect of design parameters on output of DC machines and transformers
4. Examine the effect of specific loadings in the design of AC rotating machines
5. Make use of various design concepts in construction of induction motor
6. Apply various design concepts in construction of synchronous machine

COs – POs Mapping

COs	PO_2	PO_3
1	2	2
2	3	3
3	3	3
4	3	3
5	3	3
6	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I
Introduction & DC Machines

Major considerations in Electrical Machine Design, Electrical Engineering Materials according to IS standards, Review of basic principles. DC Machines - Constructional details, output equation, choice of specific electric and magnetic loadings-separation of D and L for rotating machines, estimation of number of conductors/turns-coils-armature slots-conductor dimension-slot dimension, Choice of number of poles, length of air gap.

Choice of specific electric and magnetic loadings according to IS 1180-1989 & IS 2026-2011

12+4 Hours

Unit II
Transformers

Output equation, kVA output for single and three phase transformers, Window space factor, Overall dimensions, Transformer windings-coil design, determination of number of turns and length of mean turn of winding, leakage reactance of windings, design of Tank and cooling tubes, methods of cooling of transformers.

Various cooling techniques

11+4 Hours

Unit III
Induction Motors

Output equation of Induction motor, Main dimensions, design of stator winding and slots, Length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor.

Choice of specific electric and magnetic loadings according to IS 325-1996.

11+3 Hours

Unit IV
Synchronous Machines

Output equations, Main dimensions, Short circuit ratio, Length of air gap, shape of pole face, Armature design, length of mean turn, design of rotor, Design of damper winding, Design of field winding, Design of turbo alternators – Rotor design.

Choice of specific electric and magnetic loadings

11+3 Hours
Total: 45+15=60 Hours

Textbook (s)

1. Sawhney. A.K., A. Chakrabarti, "A Course in Electrical Machine Design", Dhanpat Rai & Sons, 6th edition, 2014.
2. Sen. S.K., "Principles of Electrical Machine Designs with Computer Programmes", Oxford and IBH Publishing Co. Pvt. Ltd., 2nd edition, 2011.
3. A. Nagoor Kani, "A Simplified Text in Electrical Machine Design", RBA Publications, 2nd edition, 2013.

Reference (s)

1. M.G. Say, "Alternating Current Machines", Pitman Publishing Ltd., 4th edition, 2012.
2. Mittle V.N. and Mittle A, "Design of Electrical Machines", Standard Publications and Distributors, New Delhi, 2012.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	20	20	---
Apply	40	20	50
Analyze	20	40	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define rating of Electrical machine
2. Define specific magnetic loading
3. List the parts of electromagnetic rotating machines
4. Define critical speed
5. List the types of synchronous machines.

Understand

1. Explain different types of magnetic materials
2. Illustrate total magnetic loading
3. Formulate the expression for output equation of a DC machines
4. Indicate different cooling methods used for dry type transformer
5. Represent the advantages of using open slots

Apply

1. Execute the applications of insulating materials
2. Demonstrate unbalanced magnetic pull
3. Develop the relationship between the number of commutator segments and number of armature coils in DC generator
4. Demonstrate the use of end rings
5. Use of damper winding in synchronous machine

Analyze

1. Classify the electrical engineering materials
2. Conclude why circular coils are preferred in transformers
3. Differentiate real and apparent flux density
4. Contrast shell type and core type transformer
5. There is an old Tram Vehicle which was not used for more than 10 years. However, due to some requirement its working is to be restored. Up on preliminary inspection by an engineer it was diagnosed that the tram employed a DC series motor for operation with mechanical gear wheel arrangement for speed control. Further, it was also found that the entire systems in the tram are intact i.e., no physical damages were identified and ideally the tram should start working. But, when the engineer tried to start the tram the motor could not start.
   I. Identify the proper reasons for the motor not starting.

II. Having known the reasons why the motor is not starting, how would you bring it back to working condition.

III. Since, the mechanical speed control systems are inefficient, suggest a modern control system for the motor with illustrations. Justify your selection.

(For Open Book Examination and not for semester end examination)

6. A steel plant is constructed to be operated on a DC supply. The main functional units in the plants are depicted below.
   a. Blast furnace (BF)
   b. Steel melt shop (SMS)
   c. Rolling mill

I. To transport coal/ raw materials over conveyor belt to blast furnace (BF). The molten steel is then transferred to steel melt shop (SMS) in wagons. The conveyor belt operates at a variable load at constant speed. Suggest a suitable motor for conveyor belt system and justify your answer.

II. The molten metal from BF which is received by wagon is lifted by electrically operated trolley (EOT) crane for superheating the molten metal to 6000^{o}C to remove impurities and moisture. The entire working of the SMS plant is based on the operation of the EOT crane which is used to lift and tilt the ladle (bucket) containing molten metal into the heating furnace. The weight of the molten metals will be in tons and the operation must be carried out very slowly in order to avoid casualties. Suggest a suitable motor for EOT crane and justify your answer.

III. The molten metal from SMS is then sent to continuous casting department (CCD) where it is cooled down, solidified and cut into rectangular blooms of uniform length. The blooms are then transferred to mills where they are made into different shapes for consumer use. The output products from mills are circular wires, L and I angles, rectangular sheets etc.
   a. A motor is required to compress the bloom such that the above shapes can be obtained.
   b. Another motor is required to roll the compressed bloom into required final product.
   c. Finally, a motor is used to transfer the product to the warehouse using a conveyer belt.

Suggest suitable motors for the operations mentioned in a,b,c in the above question and justify the same. **(For Open Book Examination and not for semester end examination)**

19EE005 High Voltage DC Transmission

3 1 0 3

Course Outcomes

1. Compare HVDC and HVAC Transmission systems
2. Analyze the operation of 6 and 12 pulse converters
3. Apply various control strategies to HVDC links
4. Develop power flow analysis in HVDC Transmission system
5. Identify protective schemes for different operating conditions
6. Analyze the effect of harmonics and elimination methods

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	3	3	3
2	3	3	3
3	3	3	2
4	3	3	2
5	3	3	2
6	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Basic Concepts & Analysis of HVDC Converters

Economics & Terminal equipment of HVDC transmission systems: Types of HVDC Links – Apparatus required for HVDC Systems – Comparison of AC &DC Transmission, Application of DC Transmission System – Planning & Modern trends in DC Transmission.

Choice of Converter configuration – analysis of Graetz circuit – characteristics of 6 pulse converters – Cases of two 3 phase converters in star –star mode – their performance.

Characteristics of 12-pulse converters, characteristics of n-pulse converter

11+4 Hours

Unit II

Converter & Reactive Power Control in HVDC

Principal of DC Link Control – Converters Control Characteristics – Firing angle control – Current and extinction angle control – Effect of source inductance on the system; Starting and stopping of DC link; Power Control.

Reactive Power Requirements in steady state-Conventional control strategies-Alternate control strategies, AC Filters.

Shunt capacitors-synchronous condensers, Static VARS

11+4 Hours

Unit III

Power Flow Analysis, Converter Fault & Protection

Modeling of DC Links-DC Network-DC Converter-Controller Equations-Solution of DC load flow – PU System for DC quantities-solution of AC-DC power flow-Simultaneous method-Sequential method.

Converter faults – protection against over current and over voltage in converter station – surge arresters – smoothing reactors – DC breakers.

corona effects on DC lines-Radio interference, Audible noise-space charge field

12+3 Hours

Unit IV

Harmonics & Filters

Generation of Harmonics –Characteristic harmonics, calculation of AC Harmonics, Non- Characteristic harmonics, adverse effects of harmonics – Calculation of voltage & Current harmonics – Effect of Pulse number on harmonics. Types of AC filters, Design of Single tuned filters.

Design of High pass filters.

11+4 Hours

Total=45+15=60 Hours

Textbook (s):

1. K. R. Padiyar, "HVDC Power Transmission Systems: Technology and system Interactions", New Academic Science publishers, 3rd Edition, 2017
2. S. Rao "EHVAC and HVDC Transmission & distribution Engineering", Khanna publisher, 3rd Edition (reprint), 1999

Reference (s):

1. J. Arrillaga, "High Voltage Direct Current Transmission", The Institution of Engineering and Technology, 1998.
2. Edward Wilson Kimbark, "Direct Current Transmission", John Wiley & Sons, 1st Edition, 1971.
3. E. Uhlmann, "Power Transmission by Direct Current" , B. S. Publications, 2nd edition, 2012

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	40	30	---
Apply	10	40	40
Analyze	30	10	60
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define firing angle and extinction angle
2. List the advantages of HVDC transmission
3. List the various modes of operation of 6 pulse converter

Understand

1. Explain the protection of converter against over voltages
2. Contrast HVDC and HVAC transmission systems
3. Illustrate the working principle of 12 pulse converter
4. Outline the effect of corona on DC lines
5. Explain the various control strategies of converter

Apply

1. Identify the applications of HVDC transmission system
2. Model a suitable filter for reduction of 3rd and 6th harmonic components
3. Develop an algorithm for DC power flow
4. In the erection and commissioning of a HVDC station, suggest a suitable HVDC link that is advantageous for DC transmission. Also facilitate the strategic planning using one of the modern trends in DC transmission. **(For Open Book Examination and not for semester end examination)**

Analyze

1. Analyze 12 pulse converter in detail
2. Compare AC and DC power flows
3. Design the high pass filter having cutoff frequency of 200MHz
4. Enumerate the suggested and most advantageous converter control strategies (alternate control strategies) in the HVDC transmission network by considering the probable effects of the source inductance on the system. Will there be any reactive power requirements in steady state that need to be addressed in the control strategy suggested by you – Justify. **(For Open Book Examination and not for semester end examination)**

19EE006 Special Electrical Machines

3 1 0 3

Course Outcomes

1. Outline the construction & working of stepper Motor.
2. Outline the construction & working of switched reluctance Motor.
3. Analyze the performance of switched reluctance Motor & stepper motor.
4. Outline the construction & working of different types of Permanent Magnet brushless D.C. Motors.
5. Examine the performance of square wave & sine wave Permanent Magnet brushless D.C. Motors.
6. Analyze the performance of different single phase Special Machine for a particular application.

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	2	2	1
3	3	3	3
4	2	2	1
5	3	3	3
6	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Stepper Motors

Classification of stepper motors – Hybrid and Variable Reluctance Motor (VRM) **-**Construction and principle of hybrid type synchronous stepper motor – Different configuration for switching the phase windings control circuits for stepper motors – Open loop and closed loop control of 2-phase hybrid stepping motor.
Construction and principle of operation of Variable Reluctance Motor (VRM) – Single stack and multiple stacks.
Open loop control of 3-phase VR Stepper Motor- Applications

11+4 Hours

Unit II

Switched Reluctance Motors

Construction – Comparison of conventional and switched reluctance motors – Design of stator and rotor pole arcs – Torque producing principle and torque expression – Different converter configurations for SRM – Drive and power circuits for SRM – Position sensing of rotor.
Applications of SRM

11+4 Hours

Unit III

Square wave Permanent Magnet Brushless DC Motor

Types of constructions – Surface mounted and interior type permanent magnet – Principle of operation of BLDC motor. Torque and EMF equations – Torque speed characteristics – Performance and efficiency**-** square wave brushless motors with 120^0 and 180^0 magnetic areas commutation.
Applications of BLDC motor

11+4 Hours

Unit IV

Sine wave Permanent Magnet Brushless DC Motor

Torque and EMF equations – Phasor Diagram – Circle diagram – Torque/speed characteristics – Comparison between square wave and sine wave permanent magnet motors

Other Special Machines

Construction–Principle of operation and Characteristics of universal motor, AC series motor, Hysteresis motor, Linear Induction motor, Reluctance motor- Applications.
Applications of PMSM

11+3 Hours

Total=45+15=60 Hours

Textbook (s)

1. E. G. Janardhanan, "Special Electrical Machines", PHI Learning Private Limited, 1st Edition, 2014.
2. K. Venkataratnam, "Special Electrical Machines", Universities Press (India) Private Limited, 1st Edition, 2009.
3. T. J. E. Miller, "Brushless Permanent magnet and reluctance motor drives", Oxford Science Publications 1st Edition, 1989.

Reference (s)

1. R. Srinivasan, "Special Electrical Machines", Lakshmi Publications, 1st Edition, 2018.
2. Theodore Wildi, 'Electric Machines, Drives and Power Systems', Pearson Education, 6th Edition, 2013
3. Cyril G. Veinott and Joseph E. Martin, "Fractional and Subfractional Horse-power Electric Motors", McGraw Hill Higher Education, 4th Edition, 1986

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	50	50	---
Apply	---	---	---
Analyze	30	30	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define detent torque.
2. What are the advantages of switched reluctance motor?
3. Why PMBLDC motor is called as electronically commutated motor?
4. What is the reluctance torque in reluctance motor?

Understand

1. Explain the modes of operation of variable reluctance stepper motor.
2. Explain with neat sketch construction & working of SRM.
3. Drive the expressions for the emf and torque of a PMBLDC motor.
4. Explain the construction & operation of universal motor.

Analyze

1. Analyze the closed loop control scheme of a permanent magnet brushless dc motor drive with a suitable schematic diagram.
2. Discuss the type of control strategy used for different regions of the SRM curves.
3. Describe the hysteresis type and PWM type current regulator for one phase of a SRM.
4. The main functional units in the steel plant are depicted below.
   Blast furnace (BF)
   Steel melt shop (SMS)
   Rolling mill
   (i) To transport coal/ raw materials over conveyor belt to blast furnace (BF). The molten steel is then transferred to steel melt shop (SMS) in wagons. The conveyor belt operates at a variable load at constant speed. Suggest a suitable special machine for conveyor belt system and justify your answer.

   (ii) The molten metal from BF which is received by wagon is lifted by electrically operated trolley EOT crane. The entire working of the SMS plant is based on the operation of the EOT crane which is used to lift and tilt the ladle (bucket) containing molten metal into the heating furnace. The weight of the molten metals will be in tons and the operation must be carried out very slowly to avoid casualties. Suggest a suitable special machine for EOT crane and justify your answer.
   (For Open Book Examination and not for semester end examination)

5. In hospital there is a ICU section and Laboratory section and general ward, in each section there are some conditions need to follow.

(i) In ICU section, for continuous monitoring of the patient there should be motor should be to record the continues pulse of the patient. A specific motor should not produce any noise and mechanical vibrations. Size of the motor should be small and need to consume less power. Suggest a suitable special machine for conveyor belt system and justify your answer.

(ii) In laboratory section medical imaging machinery need to be there, there is no condition for noise and mechanical vibrations. Speed of the machine can be low but need to have high precision. Suggest a suitable special machine for conveyor belt system and justify your answer.

(For Open Book Examination and not for semester end examination)

19EE507 Power Systems Lab

0 0 3 1.5

Course Outcomes

1. Interpret various characteristics of over current and voltage relays
2. Interpret various characteristics of distance relays
3. Inspect the breakdown strength of the oil
4. Assess the characteristics of a fuse
5. Evaluate the performance of long transmission lines
6. Summarize compensation techniques

COs – POs Mapping

COs	PO_4	PO_5
1	3	1
2	3	1
3	3	1
4	3	1
5	3	3
6	2	1

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

List of Experiments

Perform any 10 experiments from the given list

1) Simulation of performance characteristics of medium transmission lines
2) To study the characteristics of under voltage induction relay
3) To study the characteristics of attraction type relay
4) To study the characteristics of over current induction relay
5) To study the characteristics of directional over current relay
6) To study time vs. differential current characteristics of percentage biased differential relay
7) To study time vs. current characteristics of digital distance relay
8) To determination of breakdown strength of oil by variable distance Electrodes
9) To find the time vs. current characteristics of fuse
10) To study the characteristics of earth fault relay
11) To find the A, B, C, D parameters of the long transmission line
12) To find voltage regulation of the long transmission line under no-load and loaded condition
13) Application of compensation techniques to improve the performance of long transmission line

List of Augmented Experiments[1]

1. Development of over voltage protection
2. Development of under voltage protection
3. Development of over current relay
4. Development of a transmission line model

Text Books:

1. Ned Mohan "Electric Power System" John Wiley & Sons Inc, 2012
2. Badari Ram and D.N Vishwakarma, "Power System Protection and Switchgear", TMH Publications, 2nd Edition, 2011
3. I. J. Nagaraj and D. P. Kothari, "Modern Power System Analysis" Tata McGraw Hill, 3rd Edition, 2007
4. Sunil S Rao "Switchgear and Protection", Khanna Publishers, 13th edition, 2017

[1] Students shall opt any one of the Augmented Experiments in addition to the regular experiments

19EE508 Term Paper

0 0 3 1.5

Course Outcomes

1. Interpret the literature to link the earlier research with the contemporary technologies.
2. Communicate effectively as an individual to present ideas clearly and coherently
3. Review the research findings and its correlation to the latest applications
4. Prepare documents and present the concepts clearly and coherently
5. Inculcate the spirit of enquiry for self-learning
6. Identify interdisciplinary oriented topics

COs – POs Mapping

COs	PO_1	PO_4	PO_{10}	PO_{12}
1	-	2	-	-
2	-	-	3	3
3	3	-	-	-
4	-	-	3	-
5	-	-	-	3
6	1	-	-	-

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

19EE609 Employability Skills II

1 1 1 0

Course Outcomes

1. Demonstrate oral communication and writing skills as an individual to present ideas coherently
2. Develop life skills with behavioral etiquettes and personal grooming
3. Assess analytical and aptitude skills
4. Develop algorithms for engineering applications
5. Solve engineering problems using software
6. Utilize simulation tools for testing

COs – POs Mapping

COs	PO_1	PO_2	PO_5	PO_8	PO_{10}	PO_{12}
CO1	-	-	-	-	3	2
CO2	-	-	-	1	2	2
CO3	2	1	-	2	-	-
CO4	2	-	2	-	-	-
CO5	2	-	2	-	-	-
CO6	2	-	2	-	-	-

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

PART-A
Soft Skills
Communication Skills, Confidence and Quantitative Aptitude
Introduction to Campus Placements: Stages of Campus Placement, Skills assessed in Campus Placements & How to get ready?
Motivational Talk on Positive Thinking: Beliefs, Thoughts, Actions, Habits & Results (Success)
Resume Preparation: Resume? Templates? Mistakes to be avoided in a Resume, Steps to be followed in preparing it.(with examples)
Group Discussions (Recap): GD? Stages of a GD, Skills assessed in a GD, Blunders to be avoided, How to excel in a GD? (through Practice Sessions)
Psychometric Tests: Definition, Types of Psychometric Tests: Numerical Computation, Data Interpretation, Verbal Comprehension, Verbal Critical Reasoning and Personality Questionnaires
Exercises related to Communication: Story Writing, TAT etc .

7 Hours

PART-B
Aptitude Skills
Quantitative Aptitude
Square &Cube roots, Partnership, Logarithms, Progressions, Mensuration, Data Sufficiency

8 Hours

PART-C
Domain Specific Knowledge
Programmable logic controllers -3

1) Implementation of Arithmetic instructions
2) Implementation of X-NOR gate using basic logic gates in PLC
3) Implementation of on-delay timer
4) Implementation of off-delay timer
5) Implementation of direct on line (DOL) starter

15 Hours
Total: 30 Hours

Text Books:

1. Frederick D. Hackworth and John R. Hackworth, Programmable Logic Controllers: Programming Methods and Applications, Pearson India; 1st edition, 2003.
2. Frank Petruzella, Programmable Logic Controllers, Tata Mc-Grawhill, 3rd Edition, 2011.

Reference (s)

1. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.

2. W. Bolton, “Programmable Logic Controllers”, Newnes – Elsevier, 2015.

19HSX12 CC&EC Activities II

0 0 1 0

Course Outcomes

At the end of the CC&EC activities students will be able to

1. Interpret and present the abstractive technical information through an activity
2. Think critically in providing solutions to the generic and common problems
3. Demonstrate the creative thinking in dealing with liberal arts
4. Instill team sprit through active engagement with the peer
5. Develop programs of common interest having social impact
6. Empower the under privileged through motivational activities

COs – POs Mapping

COs	PO_6	PO_7	PO_9	PO_{10}
1	-	-	-	3
2	3	2	-	-
3	3	-	-	-
4	-	-	3	-
5	3	-	-	-
6	3	-	-	-

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

19EE511 Summer Internship I

0 0 0 1.5

Course Outcomes

1. Demonstrate communication skills to meet the requirement of industry
2. Develop logical thinking and analytical skills to thrive in competitive examinations
3. Use mathematical concepts to solve technical quizzes
4. Develop technical skills to work out real time problems
5. Develop algorithms for different applications
6. Solve industry defined problems using appropriate programming skills

COs – POs Mapping

COs	PO_1	PO_2	PO_8	PO_{10}	PO_{12}
1	3	-	-	-	-
2	3	-	-	-	-
3	-	-	-	-	3
4	-	-	-	3	-
5	-	2	-	-	-
6	-	-	3	-	-

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

19HSX10 Engineering Economics and Project Management

3 1 0 3

Course Outcomes

1. Illustrate the principles of engineering economics
2. Demonstrate Cost-Volume-Profit (CVP) analysis in business decision making
3. Implement the financial statements for measuring financial performance of a firm
4. Evaluate investment proposals through various capital budgeting methods
5. Summarize the key issues of organization, management and administration
6. Determine the project cost estimates and plan future activities

CO-PO Mapping

COs	PO_{11}	PO_{12}
1	1	2
2	2	1
3	3	2
4	2	1
5	2	1
6	3	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Introduction to Engineering Economics - Demand Forecasting & Cost Analysis

Concept of Engineering Economics – Types of efficiency – Managerial Economics Nature and Scope – Law of Demand – Types of Elasticity of demand.

Demand Forecasting & Cost Analysis: Demand Forecasting: Meaning, Factors Governing Demand Forecasting, Methods of Demand Forecasting (Survey and Statistical Methods) – Cost Analysis: Basic Cost Concepts, Break Even Analysis.

Factors affecting the elasticity of demand – Supply and law of Supply

10 + 3 Hours

Unit II

Market Structures - Financial Statements & Ratio Analysis

Different type of Markets Structures – Features – Price Out-put determination under Perfect Competition and Monopoly

Financial Statements & Ratio Analysis: Introduction to Financial Accounting – Double entry system – Journal – Ledger – Trail Balance – Final Accounts (with simple adjustments) – Financial Analysis through Ratios: Interpretation of Liquidity Ratios (Current Ratio and quick ratio), Activity Ratios (Inventory turnover ratio and Debtor Turnover ratio, Creditors Turnover Ratio, Capital Turnover Ratio), Solvency Ratios (Debt- Equity ratio, Interest Coverage ratio), and Profitability ratios (Gross Profit Ratio, Net Profit ratio, Operating Ratio, P/E Ratio and EPS).

Price output determination under Monopolistic markets, Accounting concepts and conventions

13 + 4 Hours

Unit III

Investment Decisions and Fundamentals of Management

Time Value of Money – Capital Budgeting: Meaning, Need and Techniques of Capital Budgeting

Introduction to Management: Nature – Importance – Classical Theories of Management: F.W.Taylor's and Henri Fayol's Theory – Functions and Levels of Management – Decision Making Process – Inventory Control, Objectives, Functions – Analysis of Inventory – EOQ.

Maslow & Douglas McGregor theories of Management, ABC Analysis

10 + 4 Hours

Unit IV

Project Management

Introduction – Project Life Cycle and its Phases – Project Selection Methods and Criteria – Technical Feasibility – Project Control and Scheduling through Networks – Probabilistic Models of Networks – Time-Cost Relationship (Crashing) – Human Aspects in Project Management: Form of Project Organization – Role & Traits of Project Manager.

Sources of Long-term and Short-term Project Finance

12 + 4 Hours

Total: 45+15=60 Hours

Textbook (s)

1. Pravin Kumar, “Fundamentals of Engineering Economics”, Wiley India Pvt. Ltd., 2nd Edition, 2015
2. Rajeev M Gupta, “Project Management”, Prentice Hall of India, 2nd Edition, 2014

Reference (s)

1. Panneer Selvam. R, “Engineering economics”, Prentice Hall of India, 2nd Edition, 2013
2. R.B.Khanna, “Project Management”, Prentice Hall of India, 1st Edition, 2011
3. R. Panneer Selvam & P.Senthil Kumar, “Project Management”, Prentice Hall of India, 1st Edition, 2010
4. A. Aryasri, “Management Science”, Tata McGraw Hill, 4th Edition, 2014
5. A. Aryasri, “Managerial Economics and Financial Analysis”, Tata McGraw Hill, 4th Edition, 2014
6. Koontz & Weihrich, “Essentials of Management”, Tata McGraw Hill, 6th Edition, 2010
7. Chuck Williams and Mukherjee, “Principle of Management”, Cengage Learning, 7th Edition, 2013

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	35	35	---
Apply	40	40	50
Analyze	---	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define Managerial Economics. Explain its nature and scope.
2. Define Production Function? List the various types of production functions
3. Define the meaning of productivity? Explain how productivity can be enhanced in the Indian industries.
4. Define management and its functions
5. List out short-term source of finance and explain briefly
6. Why is it essential to define project life cycle and divide it into various phases?

Understand

1. Summarize engineering economics with suitable examples.
2. Explain different elements of costs used in cost analysis
3. Illustrate the effect of price on demand and supply with the help of a diagram.
4. Explain the features of Perfect Competition
5. Describe the Top level Upper Middle level of management and its functions
6. Explain Price-Output determination under Perfect Competition under Market period

Apply

1. Consider the following data of company for the year 2015
   Sales = Rs.2,40.000/-
   Fixed cost = Rs.50,000/-
   Variable cost = Rs.75,000/-
   Find out the followings
   a) Profit b) BEP c) Margin of safety
2. The following trial balance of Mr. Ramesh, prepare trading, profit & loss A/c for the year ended 31.12.2018 and balance sheet as on that date.

Particulars	Debit (Rs.)	Credit (Rs.)
Capital		1,00,000
Drawing	18,000	
Furniture	32,500	

Machinery	15,000	
Bills payable		15,000
Interest paid	900	
Sales		1,00,000
Purchases	75,000	
Opening stock	25,000	
Advertisement	15,000	
Wages	2,000	
Insurance	1,000	
Commission received		4,500
Sundry debtors	28,100	
Cash in hand	20,000	
Sundry creditors		10,000
Interest received		3,000
Total	**2,32,500**	**2,32,500**

Adjustments:

Closing Stock Rs.60,000 b) Outstanding wages Rs.500

3. From the following balances as on the date March 31st, 2014.

Particulars	Amount (Rs.)	Particulars	Amount (Rs.)
10% Debentures	3,00,000	Cash in hand	30,000
6% Long term Loans	50,000	Debtors	15,000
Share capital	2,50,000	Opening stock	50,000
Creditors	1,00,000	Closing stock	40,000
Bill payable	45,000	Gross Profit	20,000
Sales	100000	Building	700000

Calculate: Current Ratio, Debt-equity ratio, Quick ratio, Inventory turnover ratio, Debtors turnover ratio

4. A company requires 40,000 kg of raw materials. The company incurs a handing cost of Rs.360/- plus freight of Rs.390 per order. The incremental carrying cost of inventory of raw material is Rs. 15 per kg. Calculate:
a) EOQ b) Number of orders per annum c) How frequently should orders be placed
5. The following table gives the activities in a construction project and other related information:

Activity	Immediate Predecessors	t_0	t_m	t_p
A	-	1	9	11
B	-	5	6	7
C	A	5	7	9
D	A,B	4	7	10
E	C,D	1	4	7
F	C,D	7	9	11

a) Draw PERT diagram
b) Calculate total project duration
c) Mark the critical path
d) Find out the S.D and Variance of each activity
6. ABC Ltd., a US based organization, is engaged in manufacturing television screens. It is planning to establish a subsidiary organization in India to manufacture picture tubes. Cost studies produced the following estimates for the Indian subsidiary based on the estimated annual sales of picture tube (Rs.400000/-):

Particulars	Total Annual Cost (Rs.)	Percent of total annual cost that is variable
Materials	1936000	100%

Labour	900000	70%
Overhead	800000	64%
Administration	300000	30%

The Indian production would be sold by manufacturer's representatives who would receive a commission of 8% of the sales. No portion of the parent organizations' expenses is to be allocated to the Indian subsidiary.

Questions:

1. Compute the sale price per picture tube to enable management to realize an estimated 10% profit on sale proceeds in India.
2. Is it feasible for ABC Ltd., to invest in the Indian market by studying the preceding calculation? **(For Open Book Examination and not for semester end examination)**

Analyze

1. From the following cases analysis the situation of price elasticity of product.

   Case 1:

Price of product (Rs.)	Quantity of Demand (Units)
100	1000
90	1500

   Case 2:

Price of product (Rs.)	Quantity of Demand (Units)
100	1000
70	1100

2. Analyze the attributes to be consider for selection project
3. Differentiate between Perfect Competition & Monopoly Competition
4. Compare significances and limitation of liquidity and solvency ratios.
5. You are given the following information about two companies in the year 2020.

Particular	Company – A	Company – B
Sales	Rs. 50,00,000	Rs. 50,00,000
Fixed Expenses	Rs. 12,00,000	Rs. 17,00,000
Variable Expenses	Rs. 35,00,000	Rs. 30,00,000

   A friend seeks your advices as to which company's shares be should purchase. Assuming the capital invested is equal for the two companies, state the advice that you will give.
6. A private school is considering the purchase a school bus to transport students to school. The initial cost of the bus is Rs.600,000. The life of bus is estimated to be five years, after the life time the vehicles would have to be scrapped with no salvage value. The school's management team has derived the following estimates for annual revenues and cost for the next five years.

Year	Annual Revenue	Diver Cost	Repairs & maintenance	Other costs	Annual depreciation
1	330000	33,000	8,000	130000	120000
2	330000	35,000	13,000	135000	120000
3	350000	36,000	15,000	140000	120000
4	380000	38,000	16,000	136000	120000
5	400000	40,000	18,000	142000	120000

   The buses would be purchased at the beginning of the project (i.e., in Year 0) and all revenues and expenditures shown in the table above would be incurred at the end of each relevant year. A business consultant has advised management that they should use a cost of capital of 10% to evaluate this project.

   Questions:

   1. Attributes to be involved to estimate the net cash flow for each year in this project.
   2. Justify the steps involved in the calculation process of net present cash flows above the project investment. **(For Open Book Examination and not for semester end examination)**

19EE602 Electrical Drives

3 1 0 3

Course Outcomes

1. Summarize the speed torque characteristics of different motors
2. Analyze speed control and braking methods of converter fed drives.
3. Examine the speed torque characteristics of chopper fed dc drives
4. Analyze the performance of converter fed induction motor from stator side.
5. Analyze the performance of induction motor from rotor side
6. Outline the operation of converter fed synchronous motor drives

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	2	2	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Control of DC motors by Single Phase & Three Phase Converters

Introduction to Thyristor controlled Drives, Single Phase semi and Fully controlled converters connected to dc separately excited and dc series motors – continuous current operation – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque Characteristics.

Three phase semi and fully controlled converters connected to dc separately excited and dc series motors – output voltage and current waveforms – Speed and Torque expressions – Speed – Torque characteristics.

Speed and Torque characteristics of dc motor, applications of converter fed dc motor.

11+4 Hours

Unit II

Electrical Braking and Chopper Fed Drives

Introduction to Four quadrant operation – Motoring operations, Electric Braking – Plugging, Dynamic and Regenerative braking operations. Four quadrant operation of DC motors by dual converters –Closed loop operation of DC motor, Single, Two and four quadrants chopper fed dc separately excited and series excited motors – Continuous current operation – Output voltage and current wave forms – Speed torque expressions – speed torque characteristics.

Four quadrant operation of DC motor by chopper, Closed Loop Operation of chopper dc drive.

11+4 Hours

Unit III

Control of Induction Motor from Stator Side

Variable voltage characteristics-Control of Induction Motor by AC Voltage Controllers-speed torque characteristics. Control of Induction Motor through Stator Frequency-Variable frequency characteristics-Variable frequency control of induction motor by Voltage source and current source inverters - PWM control – Comparison of VSI and CSI operations –Speed torque characteristics.

Closed loop operation of induction motor drives.

11+4 Hours

Unit IV

Control of Induction Motor from Rotor Side and Synchronous Motors

Static rotor resistance control, Slip power recovery – Static Scherbius drive – Static Kramer drive –their performance and speed torque characteristics, Separate control & self-control of synchronous motors.

Introduction to vector control

Advantages & applications of slip power recovery scheme.

12+3 Hours

Total: 45+15=60 Hours

Textbook (s)

1. G K Dubey, "Fundamentals of Electric Drives", Narosa Publications, 2nd edition, 2010.
2. Vedam Subramanyam, "Electrical Drives-Concepts and Applications", McGraw Hill Education, 2nd Edition, 2017.
3. R. Krishnan, "Electrical drives: Modeling, Analysis and Control", Prentice Hall of India., 1st Edition, 2015.

Reference (s)

1. B.K.Bose, "Modern Power Electronics and AC Drives", Prentice Hall of India, 1st Edition, 2015.
2. S K Pillai, "A First course on Electrical Drives", New Age International (P) Ltd, 2nd Editon, 2012.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	10	---
Understand	20	30	---
Apply	30	40	60
Analyze	30	20	40
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define Drive
2. Describe the block diagram of electric drive
3. List any four speed control methods of Induction motor

Understand

1. Explain the operation of fully controlled converter fed DC motor
2. Compare the performance of single phase full converter and half –wave converters
3. Explain the operation of chopper fed DC motor

Apply

1. Develop a single phase full converter for separately excited DC motor
2. Identify a suitable converter for an induction motor for variable speed applications
3. Compute the RMS value of the output voltage for a single phase full converter
4. Develop an equivalent circuit for static rotor resistance method
5. A compressors supplying high-pressure clean air to fill gas cylinders and this is controlled by a single-phase, full-wave ac voltage controller of 120-V, 60-Hz, operating with a conduction angler γ= l 30°.
   a) When compressor power factor varies from 0.5 at starting to 0.85 at full load, determine the corresponding range of the delay angle α.
   b) Determine the ratio of the output voltage to input voltage corresponding to the conditions of part (a.) **(For open book Examination not for semester end examination)**

Analyze

1. Compare the performance of the converter fed DC motor under motoring and braking conditions
2. Examine the regenerative braking of DC series motor
3. Compare the performance of synchronous motor by using self and separate control
4. The DC drives are widely used in applications requiring adjustable speed control, an electric vehicle is controlled by a basic chopper circuit consists of a series combination of R = 10 Ω, an L= 15×10^{-3}H and a back emf Eo = 18 V. The period of the chopper is T= 0. 20 ms. The de supply voltage is 220 V.
   a) Find the critical value of the on-time for which the minimum value of the load current is zero.
   b) Find the value of the maximum load current corresponding to the conditions of part (a)
   c) Assume that ton = 0.5 T, determine the minimum and maximum values of the instantaneous load current. **(For open book Examination not for semester end examination)**

19EE603 Power System Analysis and Control

3 1 0 3

Course Outcomes

1. Illustrate the per-unit representation for given power system network
2. Analyze power system behavior under short circuit conditions
3. Make use of load flow and stability studies in power system networks
4. Model load frequency control components
5. Analyze the various economic aspects of power plant operations
6. Examine the behavior of power system for change in load demand

COs – POs Mapping

COs	PO_2	PO_3	PSO_1	PSO_2
1	2	2	1	1
2	3	3	3	3
3	3	3	2	2
4	3	3	3	3
5	3	3	3	3
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit – I

Per-unit Representation and Short Circuit Analysis

Per-unit System representation of a given power system network, Per-unit equivalent reactance diagram Symmetrical fault Analysis: Short Circuit Current and MVA Calculations. Symmetrical Component Theory: Symmetrical Component Transformation, Sequence Networks. Unsymmetrical Fault Analysis: LG, LL, LLG faults without fault impedance

Unsymmetrical Fault Analysis: LG, LL, LLG faults with fault impedance

12+4 Hours

Unit –II

Power Flow studies and stability

Power flow problem – significance, classification of buses, Formation of Y_{bus} using direct inspection method, Derivation of Static load flow equations, Load flow solutions using Gauss Seidel Method, Acceleration Factor, Newton Raphson Method in Rectangular and Polar Co-ordinates, Comparison of different load flow methods. (Only derivative approach)

Stability: Classification of power system stability, Swing equation, equal area criterion and its applications, methods to improve stability

Decoupled and Fast decoupled load flow method

12+4 Hours

Unit – III

Economic operation of power system

Input-output characteristics, heat-rate curve, incremental fuel cost, incremental production cost, optimal generation allocation with and without transmission line losses, loss coefficients, hydro-thermal scheduling-long term and short term, unit commitment-priority list method

Dynamic programming method

11+4 Hours

Unit – IV

Load Frequency Control

Necessity of keeping voltage and frequency constant, Modeling of Speed governing system, Turbine, Generator and load systems, complete block diagram of an isolated power system, Control area, Single area control -Steady state analysis, Dynamic response -uncontrolled and controlled cases.

Load frequency and economic dispatch control- Load frequency control of two area system – Steady state analysis, Dynamic response -uncontrolled and controlled cases, tie-line bias control.

Performance Index and optimal load frequency control

10+3 Hours
Total: 45+15=60 Hours

Textbook (s)

1. I.J. Nagrath & D.P. Kothari, "Modern Power System Analysis", Tata McGraw-Hill, 4th Edition, 2013.
2. C.L. Wadhwa, "Electrical Power Systems", New Age International Publishers, 7th Edition, 2017.
3. P.Kundur, "Power System Stability and Control", McGraw Hill Inc, 2nd Edition**,** 2005
4. Allen J Wood, Bruce F Wollenberg, Gerald B Sheble, "Power Generation, Operation and Control", Wiley India, 3rd Edition, 2013.

Reference (s)

1. John J. Grainger, William D. Stevenson, Gary W. Chang, "Power System Analysis", McGraw Hill, 2016.
2. Hadi Saadat, "Power System Analysis", McGraw Hill, 3rd edition, 2011.
3. N V Ramana, "Power System Operation and Control", Pearson Education India, 2010.
4. M.A. Pai, "Computer Techniques in Power System Analysis", TMH Publications, 2nd Edition, 2000.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	15	15	---
Understand	20	25	---
Apply	35	30	---
Analyze	30	30	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)
Remember

1. Define per-unit value.
2. List the advantages of per-unit system.
3. Define acceleration factor
4. Define control area

Understand

1. Explain the necessity of slack bus.
2. Represent the equation for transformation base kV on LT side to HT side of a transformer and vice-versa.
3. Classify buses in the load flow study
4. Outline single area load frequency control

Apply

1. A 50Hz, 13.2kV, 30MVA alternator has X1=X2=30% and X0=18% and the neutral is grounded through a reactor of 0.5 ohm. Determine the initial symmetrical RMS current in the ground reactor when a double line o ground fault occurs at the generator terminals at the time when the generator voltage was 22kV.
2. Find the expression for fault current for line-to-line fault without fault impedance using symmetrical components method
3. Demonstrate operation of single area load frequency control
4. Describe the Economic dispatch control and Load frequency control

Analyze

1. Distinguish different load flow method for power system study.
2. Contrast with and without PI control operation of LFC
3. Analyze the concept of two area load frequency control
4. Figure 1 shows a load flow situation. There are two generators, one generating at unity power factor, the other under voltage control. The generator on bus 1 is producing two per-unit real power and

zero reactive power. The generator on bus 3 is providing one per-unit real power and is controlled to unity voltage. There are loads of two per-unit on bus 2 and one per-unit on bus 5. Bus 4 is the 'swing bus', with voltage magnitude of one and angle of zero.

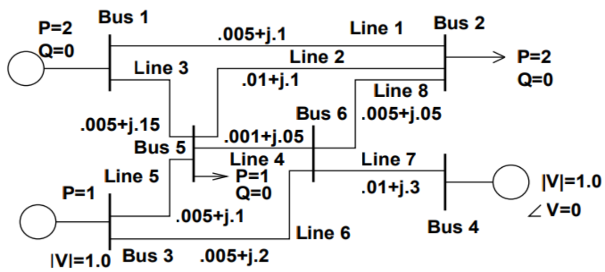


Figure 1: Load Flow Problem

a) For this problem, calculate the bus voltages and line currents. In your answer, generate a list of bus voltage magnitudes and angles and a list of line currents.

b) Also, estimate the reactive power supplied by the generator at Bus 3 and the real and reactive power supplied by the swing bus. To assist, you will need to fill in the bus incidence matrix.

c) You will note that the voltages at the various buses are actually not very good. It would be good if we could get the voltage magnitudes to be within ±5% of one per-unit. You should be able to accomplish this by injecting some reactive power into the system at selected points. Figure out where and how much reactive power to inject and show, with a run of the program, that this does correct the voltage profile to within the required tolerance.**(For Open Book Examination and not for semester end examination)**

5. Re-draw the system diagram (figure 2) with all impedances and loads translated to per-unit. Assume that the transformers between 69 and 161 kV, buses 15 and 16 at one substation and between buses 9 and 17 at another substation are rated at 150 MVA and that their voltage ratings correspond with the nominal system voltages. You may represent them as purely reactive with $x_t = 8\%$ on their own base. For your per-unit normalization use a system base of 100 MVA and the nominal system voltages (161 and 69 kV). Note, of course, that power called out at each bus is MW+jMVAR and that voltage are line-line, RMS. **(For Open Book Examination and not for semester end examination)**

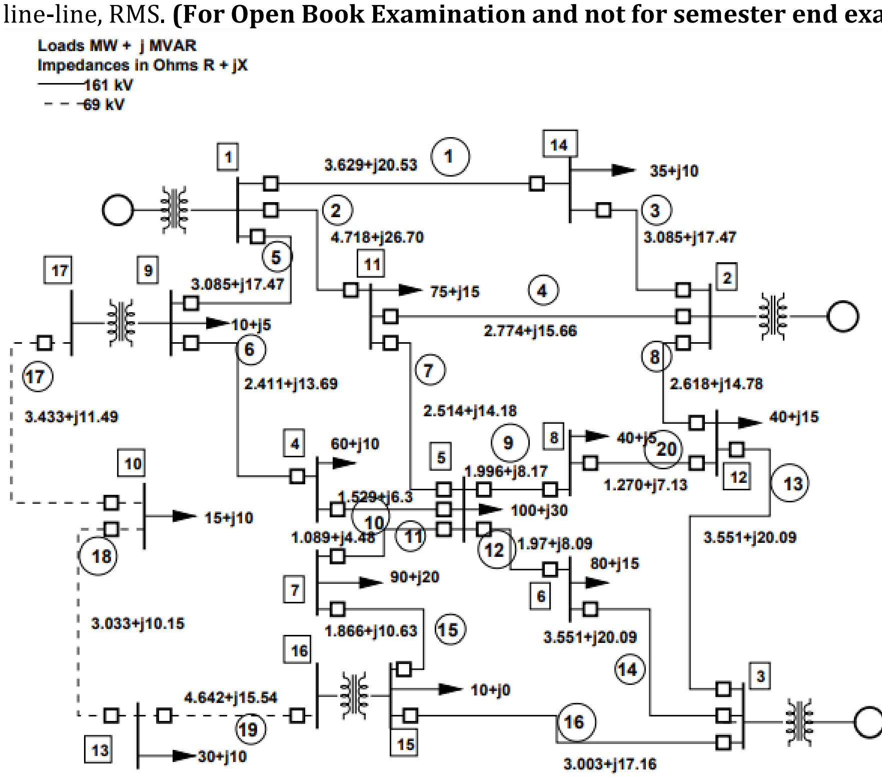


Figure 2: Example Power System

19EEC12 Electric Vehicle Drive Train Systems

3 0 2 4

Course Outcomes

1. Outline the performance of various EV drive train systems
2. Analyze the performance of various propulsion drives for Electric Vehicle
3. Contrast the performance of BLDC and PMSM motors in EV drive train systems
4. Analyze the performance of Series-Parallel Electric drive train system
5. Analyze the performance of Fuel cell EV drive train system
6. Contrast the Series-Parallel and Fuel cell drive train performance

COs – POs Mapping

COs	PO_2	PO_3	PO_{12}	PSO_2
1	2	2	3	1
2	3	3	3	3
3	2	2	3	1
4	3	3	3	3
5	3	3	3	3
6	2	2	3	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

EV Drive Train

Introduction to Configurations and Performance of Electric Vehicles, Traction Motor characteristics, Tractive effort and Transmission Requirement, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption.

Importance of Different Transportation Development Strategies to Future Oil Supply

Practical Component

1. To study the traction motor characteristics
2. Analysis of energy consumption in Electrical drives

8+7 Hours

Unit II

Propulsion System

Introduction to DC motor drives, Induction motor drives- V/F, Field Oriented Control, Permanent Magnetic Brush-Less DC Motor Drives and Permanent Magnetic Synchronous Motor Drives- Modeling, Analysis and Control.
Drive Train with Floating-Stator Motor

HEV to PHEV Conversions

Practical Component

1. Simulation of BLDC drive system
2. Simulation of PMSM drive system

12+8 Hours

Unit III

SHEV& PHEV Drive Train Design

SHEV & PHEV -operation Patterns, Control Strategies, Max. SOC of PPS & Engine Turn-On/Turn-Off, Drive Train Parameters.

Practical Component

1. Simulation of Electric Drive system for Electric Vehicle
2. Simulation of hybrid electric drive train

12+7 Hours

Unit IV

Fuel Cell HEV Drive Train Design

Operating Principles of Fuel Cells, Electrode Potential and Current–Voltage Curve, Fuel Cell System Characteristics, Fuel cell drive train Configuration, Control Strategy, Parametric Design.

Non-hydrogen Fuel Cells

Practical Component

1. Modelling and Simulation of Fuel cell

2. Controller design for Fuel Cell System

13+8 Hours
Total: 45+30=75 Hours

Textbook (s)

1. Chris Mi, Abul Masrur and David Wenzhong Gao, "Hybrid Electric Vehicles-Principles and Applications with Practical Perspectives", A John Wiley & Sons, Ltd., Publication, 1st edition, 2011.
5. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2003.
6. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles', CRC Press, 2005.

Reference (s)

1. Rolf Isermann, "Engine Modeling and Control - Modeling and Electronic Management of Internal Combustion Engines", Springer Verlag, 2014.
2. William, B. Ribbens, "Understanding Automotive electronics", Butterworth Heinemann, 2017.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	10	10	---
Understand	20	10	---
Apply	30	40	50
Analyze	40	40	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define tractive effort
2. List various electrical braking methods
3. List the various factors effecting fuel economy in PHEV's
4. List various fuel cell technologies

Understand

1. Outline the Performance of Electric Vehicles
2. Explain the Torque-Coupling Operating Mode in HEV's
3. Outline the Power Management of PHEVs
4. Illustrate the Fuel Cell System Characteristics

Apply

1. Identify the transmission requirement in EV's
2. Develop the Control Strategy in HEV's
3. Identify the Component Sizing of EREVs
4. Develop the Power Design of the Fuel Cell System

Analyze

1. Analyze the various traction motor characteristics
2. Analyze the performance of Series Hybrid Electric Drive Trains and Parallel Hybrid Electric Drive Trains
3. Examine the Power Management of PHEVs
4. Analyze the various Fuel Cell Technologies

19EEC22 Power Electronic Applications to Green Energy Systems

3 0 2 4

Course Outcomes

1. Analyze the performance of DC-DC converter
2. Demonstrate the working and performance of DC-DC converter
3. Design a suitable converter for solar PV system
4. Analyze the performance of the inverter
5. Demonstrate the working and performance of the inverter
6. Design a suitable converter for wind energy system

COs – POs Mapping

COs	PO_2	PO_3	PO_5	PO_{12}	PSO_2
1	3	3	3	2	3
2	2	2	3	2	1
3	3	3	3	2	2
4	3	3	3	2	3
5	2	2	3	2	1
6	3	3	3	2	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit-I

DC-DC Converters 1 for solar energy system

The Role of Power Electronics in Renewable Energy Systems, General Scheme for a Solar PV System, Utility-scale PV Power Plants & stand-alone PV systems, Topologies of DC-DC converters, Unidirectional DC-DC converter, Bidirectional DC-DC converter, non-isolated bidirectional DC-DC converters, Isolated bidirectional DC-DC converters.

Double-input pulse width modulation DC-DC converter

Practical Component

1. Simulation of Uni-directional DC-DC converter
2. Simulation of Bi-directional DC-DC converter

11+8 Hours

Unit-II

DC-DC Converters 2 for solar energy system

Half-bridge LLC resonant converter, Benefits of resonant converters, Emerging DC-DC converter topologies, SEPIC converter, Luo converter, Soft-switching converter, Series charge controller, Shunt charge controller.

Integrated SEPIC-Cuk converter

Practical Component

1. Simulation of SEPIC converter
2. Simulation of Luo converter

11+7 Hours

Unit-III

Multilevel converters and configurations for wind energy system

Multilevel converter topologies, Diode-clamped inverter, Capacitor-clamped inverter, Cascaded H-bridge inverter, Flying capacitor multilevel inverter.

Comparisons between the three-Level NPC and NPP Inverters

Practical Component

1. Simulation of Diode clamped inverter
2. Simulation of Flying capacitor multi-level inverter

11+8 Hours

Unit-IV

Modulation techniques for multilevel converters in wind energy system

Modulation Methods for Multilevel Power Converters, Carrier‐Based Modulation Techniques, Level‐shifted PWM Method, Phase‐shifted PWM Method, Hybrid PWM Methods, Space‐vector based modulation methods, Grid‐connected Multilevel Converters for the Integration of Renewable Energy Sources.

Converters for tidal energy systems

Practical Component

1. Simulation of five-level Modular Multi-level inverter
2. Simulation of SPM based inverter

12+7 Hours

Total: 45+30=75 Hours

Text Book(s)

1. Bimal K Bose, "Power Electronics in Renewable Energy Systems and Smart Grid", IEEE Press and John Wiley & Sons, 2019.
2. L. Ashok Kumar, S. Albert alexander, M. Rajendran, "Power Electronic Converters for Solar Photovoltaic Systems", Academic Press, 2021.

Reference Book(s)

1. Haitham Abu-Rub, Mariusz Malinowski and Kamal Al-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", IEEE Press and John Wiley & Sons, 2014.
2. Vahedi, Trabelsi, Mohamed, "Single-DC-Source Multilevel Inverters," Springer, 2019.
3. Ersan Kabalci, "Multilevel Inverters- Control Methods and Advanced Power Electronic Applications," Academic Press, 2021.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	20	20	---
Understand	50	50	---
Apply	30	30	50
Analyze	---	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. List any two advantages of Luo converter
2. List any two advantages of Resonant converter
3. Select a suitable DC-DC converter for a solar PV system

Understand

1. Explain the operation of Luo converter.
2. Explain the operation and working of Half-bridge LLC resonant converter.
3. Explain the operation and working of Flying capacitor multi-level inverter.

Apply

1. Build a Bi-directional DC-DC converter for islanded solar PV system.
2. Build Luo converter for islanded solar PV system.
3. Develop a Uni-directional converter for islanded solar PV system with.

Analyze

1. Analyze the impact of leakage current on the performance of Modular Multi-level converter.
2. A modular multi-converter is installed on grid integrated wind energy system. One of firing pulse of upper module of a Modular Multi-level converter is disconnected because of loose connection. Now analyze the performance of the converter under this fault condition. Suggest some suitable approaches to identify the fault.
3. Analyze the working of multilevel inverter under variable load conditions.

19EEC32 Control and Instrumentation of Smart Grid Systems

3 0 2 4

Course Outcomes

1. Summarize the control strategies for AC systems in smart grid
2. Analyze the control strategies for DC systems in smart grid
3. Identify voltage and frequency control schemes for smart grid.
4. Identify the importance of smart instruments and benefits of Smart Grid
5. Outline the smart management systems for Smart Grid
6. Classify smart sensors for PMU and WAMS

COs – POs Mapping

COs	PO_3	PO_4	PO_5	PO_{12}	PSO_2
1	2	3	2	2	1
2	3	3	3	3	3
3	3	3	3	3	2
4	3	3	3	3	2
5	2	3	2	2	1
6	2	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Concept Strategies for Smart Grid Systems

Control Strategies for AC and DC Systems - Microgrid Control Hierarchy, Local Control, Secondary Control, Central/Emergency Control, Global Control, Droop Control, Droop Characteristic in Conventional Power Systems, DC Microgrid for a Residential Area, System Configuration and Operation.

Resistive Grid

Practical component:

1. Study the control in an AC microgrid system.
2. Study the control in a DC microgrid system.

11+8 Hours

Unit II

Voltage and frequency control in smart grid

Load frequency control, Voltage Stability Assessment, Concepts on the design of smart grid stabilizers to improve voltage stability, frequency & voltage regulations, and volt-VAR support, Operational aspects of smart grid system, active and reactive power response.

Ancillary Services

Practical Component:

1. Eigen value analysis of single machine infinite bus system.
2. Synchronous generator no load short circuit analysis.
3. Study of voltage stability and obtain PV and QV curves for two bus system.

12+7 Hours

Unit III

Introduction to Instrumentation System in Grid Scenario

Smart devices, Smart Sensors, Data Cataloguing, Data Recording, Data Processing, Application of smart sensors, Grid Management system (block diagram), Battery modeling system (block diagram), Study of accurate prediction using AI techniques.

Need of Smart Instruments: Low Power devices, wired or wireless technology and its Advantages.

Need of High Bandwidth Storage devices in SG

Practical Components:

1. Study of renewable energy data profile and finding the mean.
2. Study of data normalization procedure.
3. Plotting of Renewable energy data and find the maximum and minimum value.

11+8 Hours

Unit IV

Sensors, PMUs and WAMS

Smart Substation: Advanced Magnetic Sensor, Fiber Optic Sensor and its application- phasor measurement units (PMU) - Wide area measurement systems (WAMS)-Concept, architecture, data collection, advanced data processing in smart grids.
Smart Meters
Practical component:
1. Analysis of data conversion and data acquisition
2. Voltage Sensor/ Current sensor in power system during fault analysis
3. Find the resolution and measurements of Digital meter/Digital Instruments for the given specifications

11+7 Hours
Total: 45+30=75 Hours

Textbook (s)
1. H. Bevrani, B. François, T. Ise, "Microgrid Dynamics and Control", John Wiley & Sons, 1st Edition, 2017.
2. J. Momoh, "Smart Grid: Fundamentals of Design and Analysis," Wiley-IEEE Press, 1st Edition, 2012.
3. Huang, Qi, et al. "Innovative testing and measurement solutions for smart grid". John Wiley & Sons, 2015.
4. R. Messina, "Wide Area Monitoring of Interconnected Power Systems", IET publisher, 1st Edition, 2018

Reference (s)
1. S. Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2013.
2. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, "Smart Grid: Technology and Applications," John Wiley & Sons, 1st Edition, 2015.
3. Yong Li, D. Yang, Fang Liu, Y. Cao, "Interconnected Power Systems Wide-Area Dynamic Monitoring and Control Applications", Springer-Verlag Berlin Heidelberg, 1st Edition, 2016.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	25	25	---
Understand	50	50	---
Apply	25	25	75
Analyze	---	---	25
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)
Remember
1. Define droop control.
2. Recall the role of real and reactive power in smart grid.
3. Mention the use of phasor measurement unit.

Understand
1. Classify local and secondary control.
2. Outline the bottlenecks in smart grid control.
3. Classify the various time frequency representations of signal in smart grids.

Apply
1. Develop the concept of voltage clamo control for dc components in smart grid.
2. Develop a controller for voltage control in smart grid
3. Develop the concept of WAMS in smart grid.
4. Apply the basic concepts how to transfer the normal grid to smart grid and its importance in daily life.

Analyze
1. Examine the characteristics of droop control in conventional power systems.
2. Analyze the controllers suitable for self-healing system.
3. Examine the important aspects of wide area measurement systems.

19EE007 Advanced Control Systems

3 0 2 4

Course Outcomes

1. Apply z-transforms to discrete time systems
2. Develop pulse transfer function for a given discrete time system
3. Examine the controllability, observability and stability of a given system
4. Design state feedback controller/observer for a given system
5. Identify different types of non-linearities
6. Analyze non-linear systems using describing function and phase plane analysis

COs – POs Mapping

COs	PO_2	PO_3	PO_4	PO_5	PSO_1	PSO_2
1	3	2	2	1	3	2
2	3	2	2	2	3	2
3	3	2	3	2	3	3
4	3	3	3	2	3	2
5	2	3	2	2	3	2
6	2	3	3	2	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit – I

Fundamentals of Digital control systems and Z-transforms

Fundamentals of Digital Control System: Block diagram of digital control system, Advantages, disadvantages and applications of digital control system, Sampling operations, sampling theorem, Aliasing effect, Zero order hold.

Z–Transforms: Introduction, Properties and theorems of Z-transforms, Inverse Z-transforms, Z-Transform method for solving difference equations, Pulse transfer function, block diagram analysis of sampled-data systems, Pulse transfer function of ZOH.

Examples of digital control systems

Practical Component

1. Determination of Pole-Zero Plot using MATLAB/Scilab
2. Determination of pulse transfer function using MATLAB/Scilab

12 + 8 Hours

Unit – II

Stability Analysis

Mapping between s-plane and the z-plane, Stability Analysis of closed loop systems in the z-plane- Bilinear Transformation, Jury stability test, Lyapunov Stability

Concepts of Controllability and Observability, Tests for controllability and Observability, Duality between controllability and observability, Effect of Pole-zero Cancellation in Transfer Function.

Steady state error analysis of digital control system

Practical Component

1. Analysis of Stability of a given discrete time systems using MATLAB/Scilab
2. Tests for controllability and observability a given discrete time systems using MATLAB/Scilab

10 + 8 Hours

Unit – III

State feedback Controllers and Observers

Design of state feedback controller through pole placement- Ackerman’s formula, Effect of dead-beat response

State Observers – Full order observer. Effect of dead-beat response

Reduced order observer

Practical Component

1. Design of full order and reduced order observers a given systems using MATLAB/Scilab
2. Design of state feedback controller through pole placement using MATLAB/Scilab

12 + 7 Hours

Unit – IV
Non-linear Systems
Features of linear and non-linear systems-Common physical non-linearities–Derivation of describing functions for common nonlinearities-Concept of phase portraits–Singular points–Limit cycles–Phase plane analysis of linear and non-linear systems–Isocline method.
Construction of phase portraits
Practical Component

1. Phase plane analysis of a given nonlinear system by analytical method using MATLAB/Scilab
2. Phase plane analysis of a given nonlinear system by Isocline method using MATLAB/Scilab

11 + 7 Hours

Total: 45+30=75 Hours

Text book (s)

1. K. Ogata, "Discrete-Time Control Systems" PHI Learning, 2nd Edition, 2008.
2. Katsuhiko Ogata "Modern Control Engineering" Prentice Hall of India Pvt. Ltd., 5th Edition, 2011.

Reference (s)

1. B.C. Kuo, "Digital Control Systems", Oxford University Press, 2nd Edition, 2007.
2. M. Gopal, "Modern control system theory", New Age International Publishers, 4th Edition, 2003.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	20	20	---
Understand	50	40	---
Apply	30	40	60
Analyze	---	---	40
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)
Remember

1. Define discrete time control system
2. List different types of discrete time systems
3. State Sampling theorem
4. List the properties of state transition matrix
5. Define stability in the sense of Lyapunov

Understand

1. Explain the properties of Z-transform.
2. Formulate the pulse transfer function for ZOH
3. Represent the necessary and sufficient conditions for pole placement
4. Represent the conditions for controllability and observability

Apply

1. Implement pole placement design of continuous time system with a suitable example
2. Demonstrate Jury's stability test for a given discrete time system
3. Compute the impulse response of sampled data system to step and ramp inputs.

Analyze

1. Examine whether the discrete data system

$$x(k+1) = Ax(k) + Bu(k),\ \ y(k) = Cx(k)$$

Where $A = \begin{bmatrix} 0 & -1 \\ 1 & -1 \end{bmatrix}, B = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \& B = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ Is (i) State controllable (iii) Observable

2. Consider the following pulse transfer function, $\frac{Y(z)}{U(z)} = \frac{z+0.2}{(z+0.8)(z+0.2)}$. Inspect this system is completely state controllable or not?
3. Contrast briefly about simple degeneracy and full degeneracy
4. A discrete system is described by the difference equation $y(k+2)+3y(k+1)+2y(k)=r(k), \quad y(0)=y(1)=0, T=1Sec.$ Identify a state variable model for the system?

19EE008 Discrete Signal Processing

3 0 2 4

Course Outcomes

1. Classify discrete time signals and systems
2. Apply Discrete Fourier transform and Fast Fourier transform for a given discrete time signal
3. Contrast the signals in time and frequency domain
4. Develop FIR and IIR digital filters for a given application
5. Examine the frequency response characteristics of FIR and IIR digital filters
6. Apply adaptive filters for various applications

COs – POs Mapping

COs	PO_2	PO_3	PO_4	PO_5	PSO_1	PSO_2
1	3	3	2	1	3	2
2	3	3	3	1	3	2
3	3	3	3	1	3	3
4	3	3	3	2	3	2
5	3	3	3	2	3	3
6	3	3	3	2	3	2

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

Unit I

Introduction to Discrete–Time signals and systems

Classification of discrete-time signals and sequences, properties of discrete time signals and systems, difference equations and their solutions – homogeneous and non-homogeneous equations, Linear and circular convolution, Sampling theorem and aliasing effect.

Concept of z-transforms, Region of Convergence, properties, Inverse z- transform and its application in solving the difference equations.

Analog-to-digital conversion and digital-to-analog conversion techniques

Practical Component

1. Determination of convolution of a given two discrete time signals using MATLAB/ Scilab
2. Determination of frequency response of a given discrete time system using MATLAB/ Scilab
3. Determination of Pole-Zero plot of a given discrete time system using MATLAB/ Scilab

12 +8 Hours

Unit II

Discrete–Time signals in Transform domain

Discrete Fourier Series (DFS), Discrete Fourier transform (DFT), Properties of DFT, Fast Fourier transform (FFT) – butterfly diagrams - Radix-2 decimation in time, Inverse FFT. Quantization effects in the computation of the DFT.

Short-time Fourier transform (s-transform)

Practical Component

1. Computation of DFT using DIT FFT algorithm for a given discrete time signals using MATLAB/ Scilab
2. Computation of IDFT using DIT FFT algorithm for a given discrete time signals using MATLAB/ Scilab

11 + 8 Hours

Unit III

IIR and FIR Digital Filters

IIR Filters: Properties of linear-phase IIR filters, Butterworth and Chebyshev filters, Impulse Invariant transformation, Bilinear transformation

FIR Filters: Characteristics of FIR Digital Filters, Gibbs phenomenon, windowing techniques – rectangular, Hamming, Hanning and Bartlett. Comparison of IIR & FIR filters.

Program to design FIR and IIR filters

Practical Component

1. Design of FIR filter from the given specifications for a particular using MATLAB/ Scilab
2. Design of IIR filter from the given specifications for a particular using MATLAB/ Scilab

11 + 7 Hours

Unit IV

Introduction to Multi-rate Signal Processing
Multi-rate signal processing: Decimation, Interpolation, Sampling rate conversion by a rational factor – Adaptive Filters: Introduction, Applications of adaptive filtering.
Program to design adaptive filters
Practical Component
1. Illustration of up-sampling for a given discrete time signal using MATLAB/ Scilab
2. Illustration of down-sampling for a given discrete time signal using MATLAB/ Scilab
3. Design of adaptive filter for a given application using MATLAB/ Scilab

11 + 7 Hours
Total: 45+30=75 Hours

Textbook (s)

1. John G. Proakis, Dimitris, G. Manolakis," Digital Signal Processing, Principles, Algorithms, and Applications", Pearson Education / PHI, 4th Edition, 2013.
2. Alan V. Oppenheim, Ronald W. Schafer, "Digital Signal Processing", PHI, 4th Edition, 2007

Reference (s)

1. Sanjit K.Mitra, "Digital Signal Processing", Tata Mc Graw Hill publishers, 4th Edition, 2013.
2. MH Hayes, "Digital Signal Processing, Schaum's Outlines", Tata Mc-Graw Hill, 2nd Edition,2009
3. S. Salivahanan, A. Vallavaraj, "Digital signal processing", Tata McGraw-Hill Education, 21st reprint, 2007.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	25	20	---
Understand	45	40	---
Apply	30	40	60
Analyze	---	---	40
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)
Remember
1. Define Signal and System
2. List any two advantages of DSP
3. Define Gibb's phenomena
4. Recall the need of Multi rate signal processing
5. List any four differences between FIR and IIR filters

Understand
1. Show that the following systems is time invariant
   (i) $y(n) = x(n) - x(n-1)$
   (ii) $y(n) = nx(n)$
   (iii) $y(n) = e^{x(n)}$
2. Show that the given systems are stable
   (i) $y(n) = \cos(\ x(n))$
   (ii) $y(n) = x(-n-2)$
   (iii) $y(n) = ax^2(n)$
3. Illustrate whether the signal x(n)=sin15πn+ sin√2_n is periodic or not
4. Illustrate windowing techniques to design FIR filters
5. Summarize the need of anti-aliasing filter prior to down sampling in multirate signal processing

Apply
1. Solve for the DFT of a sequence x[n] = {1, 2, 3, 4, 4, 3, 2, 1} using DIT algorithm
2. Solve for the IDFT of the sequence X[k] = {12, 0, 0, 0, 4, 0, 0, 0} using DIF Algorithm
3. Develop a digital butterworth filter to meet the following constraint
   3db ripple in pass band; $0 \le \omega \le 0.2\pi$

25db attenuation in stopband; $0.45\pi \le \omega \le \pi$
by using bilinear transformation and assume sampling period T= 1 sec

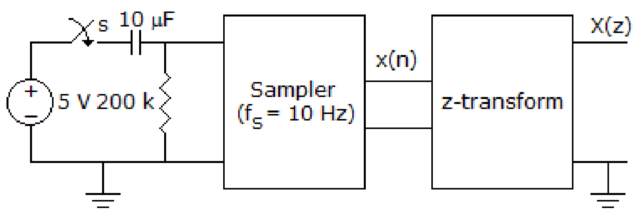
Analyze

1. Simplify the analog filter with transfer function $(s+0.1)/(s+0.1)^2+9$, into a digital IIR filter using bilinear transformation. The digital filter should have a resonant frequency of $\omega_r = \pi/4$
2. The specification of the desired LPF is

   $0.8 \le |H(\omega)| \le 0.1 \quad 0 \le \omega \le 0.2\pi$

   $|H(\omega)| \le 0.2 \quad 0.32\pi \le \omega \le \pi$

   Inspect the Butterworth IIR digital filter using Impulse invariant transformation technique and Bilinear Transformation technique
3. Compare the frequency response of Linear phase FIR filter
   Case (1) impulse response $h_{(n)}$ is symmetrical N is odd
   Case (2) impulse response $h_{(n)}$ is anti symmetrical N is even
   Case (3) impulse response $h_{(n)}$ is symmetrical N is even
   Case (4) impulse response $h_{(n)}$ is anti-symmetrical N is odd
4. In the following network, the switch is closed at t=0 − and the sampling starts from t=0. The sampling frequency is 10Hz.



Examine the region of convergence of Z-Transform of sampled signal.

19EE009 Machine Modelling and Steady State Analysis

3 0 2 4

Course Outcomes

1. Outline the basic principles of Electrical machines
2. Examine the working of a DC machine under static and dynamic conditions
3. Summarize the reference frame theory
4. Analyze the performance of synchronous machines under steady state and dynamic conditions
5. Analyze the performance of Induction machines under steady state and dynamic conditions
6. Demonstrate the working of an electrical machine under various dynamic conditions

COs – POs Mapping

COs	PO_2	PO_3	PO_4	PO_5
1	2	2	2	2
2	3	3	3	3
3	2	2	2	2
4	3	3	3	3
5	3	3	3	3
6	2	2	2	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit-I

Basic Principles for Electric Machines

Magnetically coupled circuits, Nonlinear magnetic system, Electro-mechanically energy conversion, Energy in coupling fields, steady state and dynamic performance of an electromechanical system, machine windings and air gap mmf, winding inductances and voltage equations.

Inductance machine mmf

Practical Component

1. Simulation of magnetic coupled circuit
2. Simulation of dynamic performance of an electromechanical system

11+8 Hours

Unit-II

Analysis of DC-machine

Elementary DC machine, voltage and torque equations, dynamic characteristics of DC motors, Dynamic performance during starting and load change conditions, state equations.

Reference frame theory: Equations of transformation, conversion of stationary variables to arbitrary reference frame, Transformation between reference frames

Commonly used reference frames

Practical Component

1. Simulation of the dynamic behavior of permanent DC motor
2. Simulation of the dynamic behavior of shunt DC motor
3. Simulation of transformation of variables between reference frames

11+7 Hours

Unit-III

Analysis of Synchronous machine

Voltage equations in machine variables, Torque equation, Stator voltage equations in arbitrary reference-frame variables, Voltage equations in rotor reference-frame variables, rotor angle and angle between rotors, Analysis of steady state operation, Dynamic operation during sudden change in torque

Practical Component

1. Simulation of hydro turbine generator under dynamic conditions
2. Simulation of dynamic behavior of steam turbine generator during a step increase of input torque
3. Simulation of dynamic performance of hydro turbine generator during three phase fault

Approximate Transient Torque versus Rotor Angle Characteristics

11+8 Hours

Unit-IV

Analysis of Induction machine

Voltage equations in machine variables, Torque equation, equations of transformation for rotor circuits, voltage equations in arbitrary reference-frame variables, Analysis of steady state operation, Dynamic operation during sudden change in torque.
Per unit system.

Practical Component

1. Simulation of Torque–speed characteristics during free acceleration
2. Simulation of free acceleration characteristics of a 10-hp induction motor in a reference frame fixed in rotor
3. Simulation of free acceleration characteristics of a 10-hp induction motor in the synchronously rotating reference frame

12+7 Hours

Total: 45+30=75 Hours

Text Book(s)

1. Krause, Paul C., Oleg Wasynczuk, Scott D. Sudhoff, and Steven Pekarek. "Analysis of electric machinery and drive systems," Vol. 3. New York: IEEE press, 2013.
2. Krishnan, Ramu. "Electric motor drives: modeling, analysis, and control," Pearson, 2001.

Reference Book(s)

1. Chee, Mun Ong. "Dynamic Simulations of Electric Machinery: Using MATLAB/SIMULINK." (1997).

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Laboratory Test (%)
Remember	20	20	---
Understand	50	30	---
Apply	---	---	---
Analyze	30	50	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Understand

1. Derive torque equation of induction machine in terms of machine variables.
2. Obtain the transfer function of a separately excited DC motor by considering armature inductance, L_a and load torque, T_L in terms of undamped natural angular frequency and damping factor.
3. Obtain the mathematical model of DC series motor in state variable form.

Apply

1. A two-winding, iron-core transformer is shown in Figure 1P-1. N1=50 turns, N2=100 turns, and μR=4000. Calculate Lm1 and Lm2.
2. A three-phase, 64-pole, hydro turbine generator is rated at 325 MVA, with 20 kV line-to-line voltage and a power factor of 0.85 lagging. The machine parameters in ohms at 60 Hz are: r_s= 0.00234, X_q= 0.5911, and X d= 1.0467. For balanced, steady-state rated conditions, calculate T_e.
3. Show that for a two-phase set $f_{as}^2 + f_{bs}^2 = f_{qs}^2 + f_{ds}^2$

Analyze

1. Analyze the performance of synchronous machines under steady state and dynamic conditions
2. Analyze the performance of induction machine under steady state and dynamic conditions
3. Analyze the performance of a DC shunt motor with sudden change in load torque
4. The precise motor positioning of a salient-pole synchronous generator which has large number of poles is difficult to attain because the mechanical angle between adjacent d- and q-axes is very small. Even with the 1.4 MVA hydro generator with 10 poles, the rotor positioning proved to be very

difficult. More attention should be paid to the rotor positioning of a salient-pole synchronous machine. The estimated d-axis operational inductance at zero frequency Ld(0) of the hydro-generator showed a large difference from the value obtained from the conventional test whereas the estimated q-axis Lq(0) is within 15 % of the design value. Why inaccurate motor positioning has more effect on the d-axis? **(For Open Book Examination and not for semester end examination)**

5. The d-axis operational impedance shows a phase decreased in the high frequency range, while this is not so prominent for q-axis tests. What can be the reason for this? What is the possibility of eddy current loss on the operational inductance values? **(For Open Book Examination and not for semester end examination)**

19EE606 Power Electronics and Drives Lab

0 0 3 1.5

Course Outcomes

1. Demonstrate the characteristics of semiconductor switching devices.
2. Analyze the various firing schemes applied to SCR
3. Inspect the forced commutation methods used in Choppers
4. Demonstrate the performance of various types of power electronic converters with R and RL loads
5. Demonstrate the performance of AC-DC / DC-DC converters fed DC drives
6. Show the performance of DC-AC converter fed induction motor drive

COs – POs Mapping

COs	PO_4	PO_5
1	3	2
2	3	2
3	3	2
4	3	2
5	3	3
6	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

List of Experiments
(Any 10 Experiments)

1. Static V-I characteristics of SCR
2. Static characteristics of MOSFET & IGBT
3. Gate firing circuits for SCR
4. Single Phase AC Voltage Controller with R and RL Loads
5. Single Phase fully controlled bridge converter with R and RL loads
6. Forced Commutation circuits (Class A, Class B, Class C, Class D & Class E)
7. Single Phase Parallel inverter with R and RL loads
8. Single Phase cyclo-converter with R and RL loads
9. Single Phase Half controlled converter with R and RL load
10. Single Phase series inverter with R and RL loads.
11. Speed control of DC motor using Buck-Boost regulator
12. Design of Buck converter
13. Performance & speed control of DC shunt motor using 3-phase semi converter.
14. Performance & speed control of DC shunt motor using 3-phase full converter.
15. Four quadrant chopper fed DC drive.
16. dsPIC microcontroller-based speed control of three phase Induction Motor

List of Augmented Experiments[1]

1. Simulation of single-phase AC voltage controller for different loads using PSPICE/MATLAB
2. Simulation of a single phase fully controlled converter for RLE load using PSPICE/MATLAB
3. Simulation of converter fed DC Motor in closed loop speed control
4. Simulation of PWM inverter using MATLAB/Simulink
5. Simulation of Buck converter and its analysis using open loop and closed controllers
6. PWM pulse generation using low-cost PIC /Arduino controller for three phase inverters

Reading Material (s)

1. M. H. Rashid, "Power Electronics: Circuits, Devices and Applications", Prentice Hall of India, 4th Edition, 2017
2. P.S. Bhimbra, "Power Electronics", Khanna Publishers, 5th Edition, 2018.
3. M.D. Singh & K.B. Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 2017.

[1]Students shall opt any one of the Augmented Experiments in addition to the regular experiments

19EE607 Mini Project

0 0 3 1.5

Course Outcomes

1. Identify a contemporary engineering application to serve the society at large
2. Apply complex engineering concepts and use computational tools to get the desired solution
3. Analyze the assembled/fabricated/developed products intended.
4. Prepare documents and present the project report articulating the applications of the concepts and ideas coherently
5. Demonstrate ethical and professional attributes during the project implementation.
6. Evaluate & execute the project in a collaborative environment.

COs – POs Mapping

COs	PO_1	PO_2	PO_3	PO_4	PO_5	PO_6	PO_7	PO_8	PO_9	PO_{10}	PO_{11}	PO_{12}	PSO_1	PSO_2
1	3	2	-	-	-	3	2	-	-	-	-	-	-	-
2	3	3	-	-	3	-	-	-	-	-	-	-	3	3
3	3	3	3	2	-	-	-	-	-	-	2	-	-	-
4	-	-	-	-	-	-	-	-	-	3	-	2	-	-
5	-	-	-	-	-	-	-	3	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	3	-	-	-	-	-

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

19EE609 Employability Skills II **1 1 1 3**

Course Outcomes

1. Demonstrate oral communication and writing skills as an individual to present ideas coherently
2. Develop life skills with behavioral etiquettes and personal grooming
3. Assess analytical and aptitude skills
4. Develop algorithms for engineering applications
5. Solve engineering problems using software
6. Utilize simulation tools for testing

COs – POs Mapping

COs	PO_1	PO_2	PO_5	PO_8	PO_{10}	PO_{12}
CO1	-	-	-	-	3	2
CO2	-	-	-	1	2	2
CO3	2	1	-	2	-	-
CO4	2	-	2	-	-	-
CO5	2	-	2	-	-	-
CO6	2	-	2	-	-	-

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

PART-A

Soft Skills

Resume (Recap): Resume? Templates? Mistakes to be avoided in a Resume and Steps to be followed in preparing it.

Group Discussions (Recap) & Practice: GD? Stages of a GD, Skills assessed in a GD, Blunders to be avoided, How to excel in a GD? Practice sessions and sharing Feedback. (Screening sample Videos)

Interview Skills: Interview? Types of Interview, Dos & Don'ts, Skills assessed in an Interview, Mistakes to be avoided, How to equip oneself to excel? How to handle the Typical Interview Questions? (with Examples)

Mock Interviews: Practice sessions with Feedback.

Exercises related to Communication: Email Writing, Voice Versant., etc.

7 Hours

PART-B

Aptitude Skills

Time and Distance, Time and Distance, Problems on Trains, Problems on Trains, Blood relations, Ratio and Proportions, Calendars and Clocks

8 Hours

PART-C

Domain Specific Knowledge

Programmable logic controllers -4

i. Implementation of up-down counter
ii. DC motor direction control
iii. Implementation of PID controller
iv. Implementation of half wave rectifier using PLC
v. PLC implementation for an automation industry

15 Hours

Total: 30 Hours

Text Books:

1. Frederick D. Hackworth and John R. Hackworth, Programmable Logic Controllers: Programming Methods and Applications, Pearson India; 1st edition, 2003.
2. Frank Petruzella, Programmable Logic Controllers, Tata McGrawhill, 3rd Edition, 2011.

Reference (s)

1. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.
2. W. Bolton, "Programmable Logic Controllers", Newnes – Elsevier, 2015.

19HSX12 CC&EC Activities II

0 0 1 1

Course Outcomes

1. Interpret and present the abstractive technical information through an activity
2. Think critically in providing solutions to the generic and common problems
3. Demonstrate the creative thinking in dealing with liberal arts
4. Instill team sprit through active engagement with the peer
5. Develop programs of common interest having social impact
6. Empower the under privileged through motivational activities

COs – POs Mapping

COs	PO_6	PO_7	PO_9	PO_{10}
1	-	-	-	3
2	3	2	-	-
3	3	-	-	-
4	-	-	3	-
5	3	-	-	-
6	3	-	-	-

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Audit Course

0 0 0 0

Course Outcomes

1. Interpret the meaning of values and select their goals by self- Investigation based on personal values.
2. Interpret the major events and issues related to a period in Indian history.
3. Assess the benefits and limitations of science and its application in technological developments towards human welfare.
4. Check the awareness regarding basic human rights and to uphold the dignity of every individual.
5. Assess the individual and group behaviour, and understand the implications of organizational behaviour on the process of management.
6. Determine the appropriateness of various leadership styles and conflict management strategies used in organizations.

COs – POs Mapping

COs	PO_{12}
1	3
2	3
3	3
4	2
5	3
6	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

19EEC13 Battery Management Systems

3 1 0 3

Course Outcomes

1. Outline the battery management system in detail.
2. Summarize the requirements of battery management system.
3. Outline the State of Charge model in detail.
4. Illustrate Cell Balancing model in detail.
5. Demonstrate the battery charging algorithms.
6. Summarize Battery charging standards and safety Issues.

COs – POs Mapping

COs	PO_2	PO_{12}	PSO_1	PSO_2
1	2	3	1	1
2	3	3	1	1
3	3	3	1	1
4	3	3	1	1
5	2	3	1	1
6	3	3	1	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I
Introduction to Battery Management System

Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging.
Analysis of different battery technologies

12+4 Hours

Unit II
Battery Management System Requirement

Battery-pack topology, BMS design requirements, Battery-pack sensing: Voltage, Temperature, Current; State of charge estimation, Energy estimation, and Power estimation.
Importance of battery management

10+4 Hours

Unit III
Battery-State and Health Estimation

Battery State of Charge (SOC) estimation, some approaches to estimate SOC. Need for health estimates, Negative-electrode aging, Positive-electrode aging, Cell Balancing: Causes of imbalance, Not causes of imbalance, Balancer design choices, Circuits for balancing.
State of health analysis of different batteries

10+3 Hours

Unit IV
Battery charging standards and safety Issues

Battery charging standards and algorithms, Power limits, Cold temperature performance, Lithium-Ion battery safety issues, Battery aging, Energy balancing with multi-battery system.
Energy balancing with different battery technologies

13+4 Hours
Total: 45+15=60 Hours

Textbook (s)

1. Plett, Gregory L. Battery management systems, Volume I: Battery modelling. Artech House, 2015.

2. Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2020.

Reference (s)

1. Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.
2. Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	30	--
Understand	70	70	--
Apply	--	--	100
Analyze	--	--	--
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define Battery Management System
2. Recall the concept Battery pack technologies
3. List any twoBattery Management System design requirements
4. List any two battery charging standards
5. List any two Safety issues related to battery charging technologies

Understand

1. Explain the State of charge estimation.
2. Explain Cell balancing model in detail.
3. Outline the battery charging algorithms in detail.
4. Explain positive and negative electron gain.
5. Explain the Energy balancing mechanism with multi-battery system.

Apply:

1. Compare the batteries performance when the cells are connected n series and parallel.
2. Compare the energy and power estimation concepts.
3. Mr. Ram a businessman needs to travel daily on an average covering 100km which consists of 70 km highway drive and 30 km city drive. He is currently using a diesel vehicle and wants to shift to non-polluting/less polluting vehicle. Help him identify which vehicle he can opt with a suitable battery technology, so that it would cater to his needs as well as reduce his vehicle carbon footprint. Justify your selection make use of EV/HEV specifications available in the market.**(For Open Book Examination and not for semester end examination)**
4. An electric vehicle is designed using the hybrid model, and it is tested on a flat track in a high-speed manner to ensure the vehicle's performance. Select the appropriate battery technologies to match the characteristics of a high-powered electric vehicle, as well as the time of operation required to charge the chosen battery technologies, also recommend a suitable location for the charging station by selecting a suitable technology to charge the selected battery. **(For Open Book Examination and not for semester end examination)**

5. Mention the performance of the battery by operating the vehicle in different possible modes. **(For Open Book Examination and not for semester end examination)**

19EEC23 Hybrid Renewable Energy Systems Design

3 1 0 3

Course outcomes

1. Outline hybrid energy system
2. Identify the various converter topologies for hybrid energy systems.
3. Identify the various control strategies in the hybrid system
4. Outline the planning and modeling of solar and wind energy systems
5. Summarize the storage and control system for hybrid renewable energy systems
6. Examine the application of storage and control system for hybrid model

COs – POs Mapping

COs	PO_2	PO_{12}	PSO_1	PSO_2
1	2	3	1	1
2	3	3	2	2
3	3	3	2	2
4	2	3	1	1
5	2	3	1	1
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit:I
Fundamentals of Hybrid Energy Systems

Design and planning of hybrid system, Different Combinations of Hybrid Systems- PV System with Battery Storage, Hybrid Wind/Photovoltaic System, PV-diesel-battery system, Holistic planning approach.

Present Indian energy scenario of conventional and RE sources

11+4 Hours

Unit:II
Power Electronics Applications in Hybrid Energy Systems

AC and DC bus connected HES, DC-side integration of HES- Cascaded DC-connection, Series DC connection, Parallel DC connection, DC-side integrated hybrid energy storage systems, Three-port converters. AC side integration of HES.

Multi-level converter for hybrid energy systems.

11+4 Hours

Unit:III
Design of Hybrid Renewable Energy Systems

Photovoltaic plant planning for hybrid micro grids, Technical considerations for hybrid micro grids, Photovoltaic system design, Wind power plant planning and modeling, Design of wind System- Wind energy production estimate, Design of Hybrid Photovoltaic/Wind System/Fuel Cells (ADD SOME SUB TOPICS)

Environmental impacts of solar and wind energy system.

11+4 Hours

Unit:IV
Energy Storage System and Control

Need for ESS, Types of ESS configuration: passive configuration, semi active configuration, series active configuration, parallel active configuration, Control Strategies for hybrid energy storage system configurations, Control of microgrid configuration based on solar-photo voltaic-wind turbine and hybrid energy storage system.

Case studies of Wind-PV Maximum Power Point Tracking (MPPT)

12+3 Hours
Total: 45+15=60 Hours

Textbook (s)

1. Kabalci, Ersan, Ed. "Hybrid renewable energy systems and microgrids", Academic Press, 2020.

2. Djamila Rekioua, “Hybrid Renewable Energy Systems-Optimization and Power Management Control”, Springer 2020
3. Umakanta Sahoo, “Hybrid Renewable Energy Systems”, Scrivener Publishing LLC, 2021.

Reference (s)

1. Fu Y., Yang J. and Zuo T. (2011); Optimal sizing design for hybrid renewable energy systems in Rural Areas, Springer.
2. Tester J. W. (et al.) (2012); Sustainable Energy: Choosing among Options, Second Edition, MIT Press.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	30	10	---
Understand	30	40	---
Apply	30	30	60
Analyze	10	20	40
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define photovoltaic
2. List any two power electronic converters used in DC microgrid.
3. Select a suitable DC-DC converter for a solar PV system.
4. Draw the equivalent circuit of PV cell.
5. Classify different energy storage systems.

Understand

1. Derive the expression of fundamental relationship for the power delivered by the rotor and obtain Betz efficiency.
2. Illustrate series and parallel active configuration of energy storage system.
3. Illustrate different indexes used in hybrid photo voltaic system.
4. Illustrate Betz criteria in detail.

Apply

1. Build a suitable control strategy for hybrid solar PV system and wind turbine system.
2. Model a suitable DC-DC converter for the following data. Input Voltage 12 V, Output Voltage 48 V, Duty Cycle 75% , Switching frequency 50 KHz.
3. Identify different converters required for hybrid wind-PV system and discuss their significance.
4. Identify different parameters need to be considered in design of hybrid wind and solar system.

Analyze

1. Classify different energy storage systems and analyze their performance under static and dynamic working conditions.
2. Inspect the different challenges in wind energy system in hybridization of wind- solar system.
3. A certain water heater is when operated from 230 V a.c will deliver a power of 2.88 kW. Now this heater (electrical resistance heating element) is directly connected to the PV system. Assume that you have 4 identical PV modules. Make necessary assumptions and Plot the I-V curves of different combinations of PV modules and decide which combination will give the most energy in a day time. Justify. (**For Open Book Examination and not for semester end examination**).

19EEC33 Communication and Security in Smart Grid

3 1 0 3

Course Outcomes

1. Summarize wireless, wire line, and optical communication solutions to smart grid
2. Exemplify the different kind of networks of Wireless Communications in Smart Grids
3. Identify the various technologies of wire line communications in smart grids
4. Summarize the security models for SCADA, ICS, and Smart Grid
5. Identify the various security threats and standardization,
6. Outline the authentication and encryption key management in smart grid

COs – POs Mapping

COs	PO_2	PO_{12}	PSO_1	PSO_2
1	2	2	1	1
2	3	3	1	1
3	2	2	2	2
4	2	2	1	1
5	3	3	2	2
6	2	2	1	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Wireless Communications in Smart Grids

Introduction, Overview of Data link Control and Media access control, wireless personal area networks, wireless local area networks, wireless metropolitan area networks, cellular networks, satellite communications - frequency bands and propagation effects

Fixed Satellite Systems

11 + 4 Hours

Unit II

Wire line Communications in Smart Grids

Introduction - phone line technology, coaxial cable technologies, power line technology - plc scenarios, channel, and noise aspects, power line communication (PLC) electromagnetic compatibility regulations, narrowband PLC and broadband PLC.

Optical Communications in Smart Grids

12 + 3 Hours

Unit III

Security Models for supervisory control and data acquisition (SCADA) and Smart Grid

National Institute of Standards and Technology Framework - NISTIR 7628 Smart grid cyber security architecture, European Union Mandate - EU M/490 and the Smart Grid Coordination Group (SGCG) reference architecture for the smart grid, mapping security requirements to smart grid environments, applying the "3×3" cyber security model to smart grids.

Zone separation in a Smart Grid

10 + 4 Hours

Unit IV

Smart Grid Security Standardization

Smart Grid Security Requirements. Security Relevant Regulation and Standardization Activities - ISO/IEC, IEEE and CIGRE, Trends in Energy Automation Security. Smart Grid Authentication and Key Management - Authentication and Authorization Issues in the Smart Grid

Malware Protection

12 + 4 Hours

Total: 45+15=60 Hours

Textbook (s)

1. Lars T. Berger, Krzysztof Iniewski, “Smart Grid Applications, Communications, and Security”, Wiley, April 2012
2. Eric D. Knapp and Raj Samani, “Applied Cyber Security and the Smart Grid: Implementing Security Controls into the Modern Power Infrastructure”, Syngress (Elsevier), 2013.
3. Florian Skopik, Paul Smith, “Smart Grid Security Innovative Solutions for a Modernized Grid”, Syngress (Elsevier), 2015.

Reference (s)

1. Anuradha Tomar and Ritu Kandari, “Advances in Smart Grid Power System Network, Control and Security “, Academic Press, 2021.
2. J. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama, “Smart Grid: Technology and Applications,” John Wiley & Sons, 1st Edition, 2015.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	35	35	---
Apply	40	40	100
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)

Remember

1. What is wireless personal area network?
2. What is power line technology?
3. What are mapping security requirements to smart grid environments?
4. What are Smart Grid Security Requirements?

Understand

1. Explain the metropolitan area networks & cellular networks.
2. Explain NISTIR 7628 Smart grid cyber security architecture.
3. Explain Authorization Issues in the Smart Grid.

Apply

4. Identify which one is having more merits in narrowband plc and broadband PLC.
5. Utilize the Security Relevant Regulation and Standardization Activities - ISO/IEC, IEEE and CIGRE.
6. Identify the best architecture for the smart grid and explain it.
7. A smart grid's Supervisory Control and Data Acquisition (SCADA) system is a critical component. SCADA devices exchange data using a variety of different communication protocols, physical media, and security properties. Failures or attacks on such networks have the potential to result in data loss and false data injection, resulting in incorrect system estimations and control decisions, resulting in severe consequences such as power outages and equipment destruction. Develop an automated framework for SCADA security and resiliency analysis in smart grids. This framework should take smart grid configurations and organizational security and resiliency requirements as inputs, formalize configurations and various security constraints. (**For Open Book Examination and not for semester end examination**).
8. Smart Grids use both one-way and two-way communication to work, whereas traditional power grids mostly use one-way communication to work. The communication needs and best methods change depending on the environment and the situation. Survey all of the communication technologies used in

the SG, including the communication requirements, physical layer technologies and network architectures. This should be a complete and up-to-date survey. (**For Open Book Examination and not for semester end examination**).

19EE010 Electrical Distribution Systems

3 1 0 3

Course Outcomes

1. Interpret the concept of load modeling, characteristics and feeders
2. Outline the design of substations
3. Analyze voltage drop and line loss issues
4. Analyze the Coordination of Protective Devices.
5. Illustrate compensation methods for voltage control
6. Summarize the different pf improvement methods

COs – POs Mapping

COs	PO2	PO3	PSO2
1	3	2	1
2	2	3	1
3	2	3	3
4	2	3	3
5	3	2	1
6	2	3	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit – I

General Concepts & Distribution feeders

Introduction to distribution systems, Load modeling and characteristics. Coincidence factor, contribution factor, loss factor - Relationship between the load factor and loss factor. Classification of loads (Residential, commercial, Agricultural and Industrial) and their characteristics. Design Considerations of Distribution Feeders: Radial and loop types of primary feeders, voltage levels, Feeder loading; basic design practice of the secondary distribution system.

Load Forecasting

12+3 Hours

Unit – II

Substations & System Analysis

Location of Substations: Rating of distribution substation, service area with n primary feeders. Benefits Derived through optimal location of substations. Voltage drop and power-loss calculations: Derivation for voltage drop and power loss in lines, manual methods of solution for radial networks.

Three phase balanced primary lines.

11+4 Hours

Unit – III

Protection & Coordination

Objectives of distribution system protection, types of common faults and procedure for fault calculations. Protective Devices: Principle of operation of Fuses, Circuit Reclosures, line sectionalizes, and circuit Breakers. General coordination procedure, Coordination of Protective Devices.

Location of Sectionalizer

11+4 Hours

Unit – IV

Compensation for power factor Improvement & Voltage control

Shunt and series capacitors, effect of shunt capacitors (Fixed and switched), Power factor correction, capacitor allocation - Economic justification - Procedure to determine the best capacitor location. Voltage Control: Static Var compensator, Static Synchronous Compensator, Thyristor Controlled Series Compensator, Thyristor Controlled Reactor.
Effect of AVB/AVR, line drop compensation.

11+4 Hours
Total: 45+15=60 Hours

Textbook (s)

1. Turan Gonen, "Electric Power Distribution system, Engineering", Mc Graw-hill Book, 3rd edition,2014
2. A.S. Pabla, "Electric Power Distribution", Tata Mc Graw-hill Publishing Company, 7th edition,2019

Reference (s)

1. S.Sivanagaraju, V.Sankar, "Electrical Power Distribution and Automation", Dhanpat Rai & Co, 2015
2. V.Kamaraju, "Electrical Power Distribution Systems", Mc Graw-hill Publishing Company,2017

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Assignment Test[1](%)
Remember	40	20	---
Understand	40	40	---
Apply	20	40	70
Analyze	---	---	30
Evaluate	---	---	
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)
Remember

1. Define the term Load Diversity
2. Define Contribution factor
3. Define the Nominal voltage
4. Define Rated voltage
5. What is the function of circuit breaker

Understand

1. Explain different types of electric supply systems.
2. Explain the characteristics of residential, industrial and commercial loads
3. Explain the different factors to be considered to decide the ideal location for a substation.
4. Explain the practical procedure to determine the best capacitor location.
5. Explain the line drop compensation on voltage control.

Apply

1. Derive the expression for voltage drop for non-three phase system
2. A synchronous motor having a power consumption of 40 KW is connected with a load of 150KW, a lagging p.f of 0.8. If the combined load has a power factor of 0.9, Determine the leading reactive KVA supplied by the motor and at what p.f is it working.
3. In a radial feeder the load is connected at the receiving end. The impedance of the feeder is (0.11+j0.1) p.u, the sending end voltage is 1.0p.u, the real load and power factor at the receiving end are 1.0p.u and 0.8 lagging. Determine the receiving end voltage, load angle and find the corresponding values of the receiving end and sending end currents.
4. Develop the Fuse-circuit breaker coordination procedure.

Analyze

1. Compare the % voltage drop of the feeders with square type service area and hexagonal type service area
2. Classify different types of primary feeders and give their merits and demerits

3. A three radial feeder has a voltage of 10.5 kV at the receiving end, a total impedance of 5.25+j10.91 ohm/ph and the load of 5MW with a lagging power factor of 0.9. Then determine the three phase line and phase voltage at the sending end, load angle and the percentage voltage regulation.
4. Analyze the GMR Solar Power plant is Connected to grid with a primary distribution having 1MW generation in campus to meet the load demand. In the view of the substation associated to this power plant, justify your answers with suitable combinations.
   i.Analyze the protective relay, which we can use in the system for protection of line to ground fault ii. Compare over SF6 and airblast Circuit breaker which is more beneficial for this grid with normal operating conditions. iii. Build appropriate coordination between different protection schemes (**For Open Book Examination and not for semester end examination**).
5. Analyze the coordination among the Protective devices used in Distribution system. **(For Open Book Examination and not for semester end examination).**

19EC401 Analog and Digital Communications

3 1 0 3

Course Outcomes:

1. Explain Analog Modulation & Demodulation techniques
2. Summarise the noise level in Analog communication systems
3. Demonstrate the operations of Transmitters and Receivers
4. Explain different pulse modulation techniques
5. Illustrate different digital modulation and demodulation techniques
6. Outline the operations of digital communication receivers

COs-POs Mapping

COs	PO_1	PO_2
1	2	1
2	2	1
3	3	2
4	2	1
5	2	1
6	3	2

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit I

Amplitude Modulation and Frequency Modulation

Introduction to communication system, Need for modulation, Frequency Division Multiplexing, Amplitude Modulation, power relations in AM waves, Generation of AM waves: square law Modulator, Principle of Detection of AM Wave: Envelope detector. DSB Modulation: Double side band suppressed carrier modulators, Generation of DSBSC Waves, Coherent detection of DSB-SC Modulated waves.
SSB Modulated Wave, Vestigial side band modulation: Generation of VSB Modulated wave.
Frequency Modulation: FM Wave, Narrow band FM, Wide band FM, Generation of FM Waves, Direct FM, Detection of FM Waves: Balanced Frequency discriminator.
Switching modulator, COSTAS loop

12+4 hours

Unit II

Noise, Analog Transmitters and Receivers

Noise in DSB & SSB System Noise in AM System, Noise in Angle Modulation System, Threshold effect in Angle Modulation System, Pre-emphasis & de-emphasis AM Transmitter, FM Transmitter - Variable reactance FM Transmitter, Super heterodyne receiver, Comparison of FM and AM Receiver.
Phase modulated FM transmitter, Phase locked loop

11+3 hours

Unit III

Pulse modulation

PAM, PWM, PPM, Model of Digital Communication Systems, Digital Representation of Analog Signal, Certain issues in Digital Transmission, Advantages of Digital Communication Systems , Pulse Code Modulation: PCM Generation and Reconstruction, Quantization noise, Non uniform Quantization and Companding, Time Division Multiplexing, DPCM, DM and Adaptive DM.
Classification of line encoding techniques, TDM Frame Structures

11+4 hours

Unit IV

Digital Modulations

Introduction, ASK, FSK Modulator, Coherent ASK Detector, Non-Coherent ASK Detector, FSK, Bandwidth and Frequency Spectrum of FSK, Non coherent FSK Detector, Coherent FSK Detector, BPSK, Differential PSK DEPSK, QPSK, MPSK, MSK, Probability of Error, Correlation Receiver, Matched filter Receiver.
Telemetry, OQPSK

11+4 hours

Total: 45+15 hours

Textbook (s)

1. H.Taub and D. Schilling, Principles of Communication Systems, TMH,4th Edition, 2017
2. Simon Haykin , Digital communications, John Wiley, 4th Edition,2013
3. Simon Haykin , An Introduction to Analog& Digital Communications, John Wiley, 2nd Edition, 2012
4. George Kennedy and Bernard Davis , Electronic Communication Systems, TMH, 4th Edition, 2004

Reference (s)

1. R.P. Singh, SP Sapre, Communication Systems TMH, 3rd Edition, 2017
2. B.P.Lathi, Zhi Ding, Modern Digital and Analog Communication Systems, Oxford, 4th Edition, 2011
3. John G. Proakis, Masond, Salehi, Fundamentals of Communication Systems, Pearson Education, 3rd Edition, 2008
4. H Taub & D. Schilling, Gautam Sahe, Principles of Communication Systems , TMH, 3rd Edition. 2007
5. Sam Shanmugam, Digital and Analog Communication Systems, John Wiley, 2005
6. Bernard Sklar, Digital communications Fundamentals and applications, 2nd Edition, PHI, 2001

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Exam (%)
Remember	25	25	--
Understand	50	50	--
Apply	25	25	80
Analyse	--	--	20
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (S)

Remember

1. Define angle modulation.
2. Define modulation index.
3. List any two advantages of DSBSC.
4. List any two advantages of VSB.
5. Define quantization noise power.
6. Define QAM, and draw its constellation diagram.

Understand

1. Explain the need for modulation.
2. Illustrate the operation of square law modulator.
3. Compare SSB modulation with DSB-SC modulation.
4. Illustrate the operation of Frequency modulation.
5. Represent a neat block diagram of a typical digital communication system and explain the function of the key signal processing blocks.
6. Explain Binary PSK and QPSK with corresponding equations and constellation diagrams.

Apply

1. The antenna current of an AM transmitter is 8A when only the carrier is sent, but it increases to 8.93A when the carrier is modulated by a single sine wave. Calculate the percentage modulation. Find the antenna current when the percentage of modulation changes to 0.8.
2. An FM signal with single tone modulation has a frequency deviation of 15KHz and a bandwidth of 50KHz. Find the frequency of the modulating signal.
3. Execute the channel synchronization method in PCM systems.
4. A standard AM broad cast station is allowed to transmit 12 signals ,each band limited to 5KHz and are to be transmitted over a single channel by FDM. If AM –SSB modulation with guard band of minimum value is used, Find the band width of the multiplexed signal. Predict the number of

signals can be used if AM-DSBSC is used by the broad cast station instead of AM-SSB for the same bandwidth. **(For Open Book Examination and not for semester end examination).**

5. a) A QPSK signal is used to send data over a satellite transponder. The transponder has a bandwidth of 12MHz.A TV channel is planned to use two data rates of 18MHz and 28MHz.Find which data rate can be supported by the transponder and Justify the reason.

   b) For the same transponder, Find whether the TV channel can use the data rates of 15MHz and 30 MHz or not. **(For Open Book Examination and not for semester end examination).**

Analyse

1. Certain transmitter is radiating 132KW when a certain audio sinewave is modulating it to a depth of 80% and 150KW when a second sinusoidal audio wave also modulates it simultaneously. What is the depth of modulation for the second audio wave?
2. When the modulating frequencies in an FM system is 400Hz and the modulating voltage is 2.4v the modulation index is 60. What is the modulation index when the modulating frequency is reduced to 250 Hz and the modulating voltage is simultaneously raised to 3.2V Calculate the maximum deviation.
3. Outline the signal space diagram of quadrature amplitude modulation and its differences with respect to QPSK. Analyze different ways of increasing the efficiency of steam power plant by giving appropriate justification.
4. a) An All India radio station uses a carrier wave of 1MHz and whose amplitude is 3V is frequency modulated by a sinusoidal modulating signal frequency of 500Hz and of peak amplitude 1V.The peak deviation of the modulating wave form is 1KHz.The peak level of the modulating waveform is changed to 5V and the modulating frequency changed to 2KHz.Then find the expression for the new modulated wave and compare the parameters such as deviation ratio, Bandwidth and the number of side bands of FM waves.

   b) In the radio station if the carrier wave is changed to a square wave for the same specifications find the expression of the modulated wave and compare the parameters of the FM waves with sine and square modulating signals.**(For Open Book Examination and not for semester end examination).**
5. a) In a music competition, recording is done by sampling and storing the sample values .If the highest frequency tone to be recorded is 15800Hz, Examine the number of sample would be required to store three minutes performance. Conclude the number of binary digits would be required to store the three minutes performance if each sample is quantized in to 128 levels.

   b) Find the number of binary digits required to store 5 minutes performance if each sample is quantized in to 64 levels.**(For Open Book Examination and not for semester end examination).**

19IT304 Database Management Systems

3 1 0 3

Course Outcomes

1. Understand the fundamental concepts of data base and data models
2. Explain the use of Relational Algebra and integrity constraints in databases
3. Use SQL's Commands to handle the Database
4. Apply Normalization for schema refinement
5. Make use of the concept of transaction management and recovery system in databases
6. Outline Indexing concepts, different types of data

CO–PO Mapping

COs	PO_1	PO_2	PO_3	PO_{12}
1	3	3	2	1
2	3	3	3	2
3	3	3	2	2
4	2	3	3	1
5	3	3	3	2
6	3	3	2	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Introduction to DBMS and ER Model

DBMS Vs. File System, instance and schema, Data abstraction, Data independence, database users and database administrator, Database system structure, Introduction to Data Models (E-R Model, Relational Model, Hierarchical Model, Network Model, Object Oriented Data Model), Database Design Process, Entities, Attributes, Entity Sets, Relationships, Relationship Sets, Additional features of ER Model.

Applications of DBMS, Object Relational Data Model

11+4 Hours

Unit II

Introduction to Relational Model and Basic SQL Queries

Relational Algebra Operations: Selection, Projection, Rename, Set Operators, Joins, Division, Examples of Relational Algebra Queries, Relational Calculus: Tuple Relational Calculus.

Integrity Constraints over Relations, Introduction to Views.

SQL Queries: Basic Structure, Set Operations, Aggregate Functions, Null values, Sub Queries, Group By And Having Clauses, Outer Joins.

Domain Relational Calculus, Query Optimization

11+4 Hours

Unit III

Normalization and Transaction Management

Introduction To Schema Refinement - Problems Caused By Redundancy - Decomposition - Problems Related To Decomposition - Functional Dependency - Closure of a Set of Fds - Attribute Closure - First - Second - Third Normal Forms – BCNF - Multi Valued Dependencies – Fourth Normal Form, Join Dependency, Fifth Normal Form

Transactions: Acid Properties of Transaction - Transaction States - Schedule: Serial Schedule - Concurrent Schedules - Anomalies Associated with Concurrent Schedules (RW - WR - and WW Conflicts) -Serializability - Conflict Serializability - and View Serializability.

EF Codd Rules, Domain Dependency

11+4 Hours

Unit IV

Locking, Recovery Systems, Indexing, Different Types of Data

Introduction to Lock Management-Lock Based Concurrency Control: 2pl-Strict 2pl-Concurrency without Locking: Timestamp–Based Concurrency Control, Optimistic Concurrency Control.
Introduction to Aries - the Log - the Write-Ahead Log Protocol-Check Pointing Indexing: Types of Single-Level Ordered Indexes, Multilevel Indexes Different Types of Data: Structured, Semi-Structured and Unstructured Data
Heap File, Hash File Organizations

12 + 3 Hours

Total: 45+15 Hours

Textbook (s)

1. Elmasri & Navatha, Fundamentals of Database Systems, Pearson Education, 7th Edition, 2016
2. Silberschatz Korth, Database System Concepts, McGraw hill, 7th Edition, 2019

Reference (s)

1. Soraya Sedkaoui, Data Analytics and Big Data, Wiley, 1st Edition, 2018.
2. Peter Rob & Carlos Coronel, Database Systems design, Implementation and Management, 9th Edition, 2010.
3. Raghurama Krishnan & Johannes Gehrke, Database Management Systems, TATA McGraw-Hill, 3rd Edition, 2003
4. C.J.Date, An Introduction to Database Systems, Pearson Education, 8th Edition, 2006

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Exam (%)
Remember	40	40	--
Understand	30	40	--
Apply	30	20	50
Analyze	--	--	50
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (s)

Remember

1. List any four application of DBMS
2. Define data model
3. List any four applications for triggers
4. Define functional dependency
5. List the 4 properties of Transaction

Understand

1. Explain E-R Model with suitable example
2. Explain the role of integrity constraints in database design
3. Illustrate the working principle of 'write a head log' protocol
4. Differentiate 3NF and 4NF
5. Explain Two Phase Locking Protocol

Apply

1. When multiple transactions are being executed by the operating system in a multiprogramming environment, there are possibilities that instructions of one transaction are interleaved with some other transaction. Apply the suitable concept to overcome the problem
2. Classify various normal forms according to their applicability
3. Give some real-world applications of Normalization
4. Illustrate the Commit and Rollback operations of Transaction Control

5. Give some real-world applications for Database indexing techniques

Analyze

1. Compare File processing system with DBMS
2. Analyze different locking protocol for concurrency control and serializability
3. Normalization will increase the complexity of the database design. Justify
4. Compare DDL and DML of SQL
5. Compare and Contrast Serializability and Recoverability

Evaluate

1. Is database redesign being necessary? explain
2. How can you evaluate the performance of two data models?
3. Evaluate the performance of query processor and list the corresponding metrics
4. How can you assess the throughput and delay for any DBMS?
5. How can you evaluate the impact of data models on the query processing?
6. Anitha has a large CD collection. Her friends like to borrow her CD's, and she has to keep track of who has what. She maintains a list of friends, identified by unique FID's and a list of CD's, identified by CID's. With each friend are the name and telephone numbers which she can call to get the CD back. With each CD is actor name and title. Whenever a friend borrows a CD, She will enter that fact into her database along with the date borrowed. Whenever the CD gets returned, that fact, too, gets noted along with the date returned. Anitha wants to keep a complete history of her friends' borrowing habits so that she can ask favors of the heavy borrowers.
   Draw an ER diagram to figure out the above situation and identify types of attributes and cardinality. Represent this database as a collection of 3NF relational tables. **(For Open Book Examination and not for semester end examination).**
7. The relational scheme R(A,B,C,D,E,F) and set of functional dependencies AB -> D, E -> C, AF -> B. From this, find out all super keys for this relation, and which of these super keys form a key. **(For Open Book Examination and not for semester end examination).**

19EE011 Utilization of Electrical Energy

3 1 0 3

Course Outcomes

1. Identify suitable motor based on application
2. Summarize electric heating and welding methods
3. Design interior and exterior lighting systems
4. Apply electrolytic & electrolysis process in chemical manufacturing
5. Summarize the principles of refrigeration and air-conditioning
6. Analyze the performance of traction systems

COs – POs Mapping

COs	PO_3	PO_6	PO_7	PO_8
1	3	3	3	1
2	2	2	2	1
3	3	3	3	1
4	3	3	3	1
5	2	2	2	1
6	3	3	3	1

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

Unit I

Electric Drives, Heating and Welding

Type of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, Particular applications of electric drives, Types of industrial loads, continuous, Intermittent and variable loads, load Equalization.

Advantages and methods of electric heating-resistance heating, induction heating and dielectric heating

Electric welding-resistance and arc welding, comparison between A.C. and D.C. Welding

Electric braking-Plugging, Rheostat braking, Regenerative braking

10 + 3 Hours

Unit II

Illumination

Introduction, terms used in illumination, laws of illumination, polar curves, sources of light. Basic principles of light control, CFL & LED lighting-phenomena, construction and working, flood lighting, Types and design of lighting, measurement of illumination- photometry, integrating sphere.

tungsten filament lamps and fluorescent tubes, IS 6665, 3646, 2440 codes

12 + 4 Hours

Unit III

Electrolytic Processes, Refrigeration and Air Conditioning

Need of electro-deposition, Laws of electrolysis, process of electro-deposition - clearing, operation, deposition of metals, polishing, buffing, Equipment and accessories for electroplating, Factors affecting electro-deposition, Principle of galvanizing and its applications, Principles of anodising and its applications, Electroplating on non-conducting materials, Manufacture of chemicals by electrolytic & electrolysis process.

Principle of air conditioning, vapour pressure, refrigeration cycle, Description of Electrical circuit used in refrigerator, air-conditioner and water cooler

Eco-friendly refrigerants, BEE ratings, ISEER value

10 + 3 Hours

Unit IV

Electric Traction

System of Traction - Diesel & electric traction – Need for 25kV single phase AC traction in India, block diagrams of locomotives employing DC and AC drives, locomotive equipment – pantograph, transformer, rectifier, inverter, protective devices, Traction Mechanics: Mechanics of traction movement - speed-time curves for different services - trapezoidal and quadrilateral speed-time curves - tractive effort requirement at

driving wheels and for propulsion of train - power - specific energy consumption –factors effecting specific energy consumption–Dead, accelerating and adhesive weights, Coefficient of adhesion
Track electrification - DC, AC & Composite systems

13 + 5 Hours
Total: 45+15=60 Hours

Textbook (s)

1. Art and Science of Utilization of Electrical Energy by H Partap, Dhanpat Rai & Sons, 2nd edition, 2017
2. Utilization of Electrical Energy and Traction by J.B. Gupta, Rajeev Manglik, Rohit Manglik, Kataria Publications, 1st edition, 2013
3. A Text Book of Electrical Power by Dr. S.L Uppal, Khanna Publications, 1st edition, 2014

Reference (s)

1. Modern Electric Traction by H Partap, Dhanpat Rai & Sons, 2nd edition, 2017
2. Generation, Distribution and Utilization of Electrical Energy by CL Wadhwa, New Age International Publishers, 3rd edition, 2015.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open book examination (%)
Remember	25	25	---
Understand	50	50	---
Apply	25	25	50
Analyze	---	25	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)

Remember

1. Define adhesive weight
2. Give the expression for distance covered by a train for a specific run assuming quadrilateral speed time curve.

Understand

1. Derive an expression for the time-dependent temperature as the electrical apparatus cools, in terms of the cooling time constant.
2. Explain the Law of Inverse Squares w.r.t. illumination.

Apply

1. A hall of 30m×13m with ceiling height of 5m is to be provided with general illumination of 120lux. The coefficient of utilization is 0.5 and depreciation factor is 1.4. Determine the total wattage, number of fluorescent lamps required. Luminous efficiency of 80W lamp is 40lumen/watt. Show disposition of lamps with sketch. **(For Open Book Examination)**
2. An electric train accelerates uniformly from rest to a speed of 48 kmph in 24 seconds. It then coasts for 69 seconds against a constant resistance of 50 N/tonne and is braked to rest at 3.3 kmphps in 11 seconds. Calculate (i) coasting retardation (ii) V2 (iii) total distance (iv) schedule speed, if the station stops are 20 seconds duration. What would be the effect on schedule speed of reducing the station stop to 15 seconds duration, other conditions remaining same? Allow 10% for rotational inertia.

Analyze

1. Identify a suitable motor for suburban system. Justify the selection.
2. Analyze the need for adopting 25kV single phase traction system in India
3. Visakhapatnam, an upcoming smart city in India, proposes to introduce a mass rapid rail transport system keeping in view its future transportation needs. The administrative body decides upon to adopt a 25kV single phase overhead AC suburban service system for the city. Analyze the reasons for this mode of traction over other alternatives available. Also, list the pros and cons of this selection. **(For Open Book Examination)**

19EE012 Microprocessors and Microcontroller Interfacing

3 1 0 3

Course Outcomes

1. Illustrate the architecture of 8086 microprocessor
2. Outline assembly language programs of 8086 microprocessor
3. Select the interfacing peripherals with 8086 microprocessor
4. Summarize the architecture of 8051 microcontroller
5. Model assembly language programs of 8051 microcontroller
6. Select the interfacing of peripherals with 8051 microcontroller

CO-PO Mapping

COs	PO_2	PO_3	PO_{10}	PSO_2
1	2	2	3	1
2	2	2	3	1
3	3	3	3	2
4	2	2	3	1
5	2	2	3	1
6	3	3	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

8086 Microprocessors and Assembly Language Programming

Introduction to microcomputer, evolution of processors and semiconductor memories (RAM, ROM, EPROM, EEPROM), Architecture of 8086 microprocessor, Register organization of 8086, Pipelining concept, Memory segmentation, Addressing Modes.

Instruction Set and Programming: Instruction set of 8086 microprocessor: Data transfer instructions, Arithmetic instructions, Logical Instructions, String instructions, Stack related instructions, Branching instructions, Assembler directives.

Data transfer instructions of 8085 microprocessor, Architecture of 8085 microprocessor

11+ 4 Hours

Unit II

8086 Operational Modes and Memory Interfacing

Minimum and Maximum mode operations of 8086 with timing diagrams, Procedures and macros, Stack Structure of 8086, Static RAM Interfacing, Interfacing of 8255 Programmable Peripheral Interface with 8086 microprocessor.

Dynamic RAM, Direct memory access

11 + 4 Hours

Unit III

8051 Microcontroller

Comparison between microprocessor and microcontroller, 8051 family microcontroller, RAM architecture of 8051, Integrated Development Environment (IDE), Pin description of 8051 microcontroller, Machine cycle. Addressing Modes, Instruction set of 8051: Data transfer instructions, Arithmetic instructions, Logical Instructions, Stack related instructions, Branching instructions. Programing and Applications of Timers, Interrupts, Universal Asynchronous Receiver Transmitter (UART).

External memory interfacing with 8051 microcontroller, various constituents of hex file

11 + 4 Hours

Unit IV

Interfacing with 8051 microcontroller with External Peripherals

Interfacing with 8051 microcontroller with: Keypad matrix, LCD, Seven segment displays, L293D Motor driver, Stepper motor, Analog to Digital Converter (804), Digital to Analog Converter (808), introduction to CISC architecture, RISC architecture and Features of ARM processor.

Interfacing of temperature sensor (LM 35) with 8051, interfacing of relay with 8051

12+ 3 Hours

Total: 45+15=60 Hours

Textbook (s)

1. A.K. Ray & K. M Bhurchandi, Advanced Microprocessors & peripherals, Tata McGraw-Hill, 3rd Edition, 2012
2. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D. McKinlay, The 8051 Micro controller and Embedded systems: using assembles and C, Pearson, 2nd Edition,2007.
3. Furber, Arm System-On-Chip Architecture, Pearson Education, 2001.

Reference (s)

1. D.V.Hall, Microprocessor and Interfacing, Tata McGraw Hill Publishing Company, 2nd Edition 2006
2. N. Sentil Kumar, M Sarvanan, S Jeevananthan, Microprocessors and Microcontrollers, Oxford University Press, 1st Edition, 2010
3. Kenneth J Ayala, The 8051 Microcontroller Architecture, Programming and Applications, Thomson Publishers, 3rd Edition, 2004

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	35	35	---
Apply	40	40	---
Analyze	---	---	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. List any four sixteen bit registers of 8086 microprocessor which can't split into two eight bit registers.
2. State the advantages of memory segmentation.
3. State the significance of Reset pin of 8051 microcontroller.
4. List four differences between 8051 family of microcontroller.

Understand

1. Explain the function of BIU and EU of 8086 microprocessor.
2. Explain the consequences of execution of MOV IP, #14H instruction of 8051 microcontroller.
3. Explain the structure of internal RAM of 8051 microcontroller.
4. Explain the significance of each bit of TMOD register of 8051 microcontroller.

Apply

1. Execute an ALP to perform sorting operation in ascending order on 16 bit numbers
2. Find the approximate time required to execute an ALP with the help of hardware timers
3. Execute an ALP to generate +4V (P-P) of square wave using 8086
4. Execute an ALP to blink the LED'S using 8051
5. Execute an ALP to find largest number

Analyse

1. Compare the register organization of 8086 and 80386 microprocessors
2. Outline the features of 80386 advanced microprocessor
3. Differentiate the features of 8086 microprocessors
4. Organize the instruction set for implementing stepper motor application
5. Differentiate the modes of operation of 8255

19EE013 Programmable Logic Controllers

3 1 0 3

Course Outcomes

1. Recall the basic structure and working of PLC
2. Illustrate the PLC programming formats and ladder logic fundamental concepts
3. Utilize different levels of ladder logic functions and addressing formats of File structures
4. Interpret the operation and significance of basic instruction sets like bit, timer and counter instructions
5. Classify the operation, symbols and control words of data-handling, comparison and sequencer instructions
6. Make use of PLCs for different real time applications using ladder diagrams and static application panels

COs – POs Mapping

COs	PO2	PO3	PSO2
1	3	2	3
2	2	3	3
3	2	3	3
4	2	3	3
5	3	2	3
6	2	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit – I

Introduction to PLC & Working of PLC

The concept of PLC, Building blocks of PLC, I/O module structure, Memory structures, Functions of various blocks, Advantages of PLCs over electromagnetic relays, list of top PLC manufacturers, Basic operation and principles of PLC.

PLC Programming: programming equipment, programming languages, Input instructions, outputs, operational procedures.

Drill press operation.

10 + 4 Hours

Unit – II

Ladder Logic & File Structure

Ladder Logic: Introduction, Basic Components & Their Symbols, Fundamentals of Ladder Diagrams – A PLC illustrated with relays, programming concepts, ladder logic inputs, ladder logic outputs. Ladder Logic Functions – Data handling functions, logical functions, List functions, input and output functions.

File Structure & Addressing Formats: Introduction, Output & Input Data Files, Status File, Bit Data File, Timer Data File, Counter Data File Elements, Control Data File, Integer Data File & Float Data File.

Boolean Logic & Relay Logic functions

12 +4 Hours

Unit – III

Instruction Sets

Introduction, bit instructions, timer instructions, counter instructions, reset instructions, data handling instructions, comparison instructions, sequencer instructions

Reset (RES) Instruction & Sequencer Compare Instruction

12 + 4 Hours

Unit – IV

PLC Applications

Introduction, Switching ON-OFF Light, Liquid Level Control, Process Control, Main Door Control, Vehicle Parking Control, Bottling Plant, Drink Dispenser, Motor in forward and reverse direction

Traffic Light Control

11 + 3 Hours

Total: 45+15=60 Hours

Textbook (s)

1. Rajesh Mehra, Vikrant Vij, "PLCs & SCADA: Theory & Practice", Laxmi Publications, 2nd Edition, 2012.
2. Kelvin T Erickson, "Programmable Logic Controllers: An Emphasis on Design and Application", Dogwood Valley Press, 2nd Edition, 2016.

Reference (s)

1. Gary Dunning, Thomson Delmar, "Programmable Logic Controller", Cengage Learning, 3rd Edition, 2005.
2. W. Bolton, "Programmable Logic Controllers", Newnes – Elsevier, 2015.
3. Mini S Thomas, John D McDonald, "Power System SCADA & Smart Grids", CRC Press, Dogwood Valley Press, 2017.

Internal Assessment Pattern

Cognitive Level	**Int. Test 1 (%)**	**Int. Test 2 (%)**	**Open book [2](%)**
Remember	25	20	---
Understand	50	40	---
Apply	25	40	50
Analyze	---	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define PLC
2. List out PLC input devices
3. List the characteristics of PLC registers

Understand

1. Explain advantages and disadvantages of PLC in detail.
2. Illustrate the input module for PLC.
3. Explain advantages and disadvantages of PLC over electromagnetic relays.

Apply

1. Develop the rules for constructing the ladder diagram.
2. Make use of SUBTRACT function for conveyor count application with neat schematic.
3. Develop PLC ladder diagram for vehicle parking control.
4. i. Recall the basic structure and working of PLC
   ii.Illustrate the PLC programming formats
   iii.How do you identify different levels of ladder logic functions and addressing formats of File structures? **(For Open Book Examination and not for semester end examination).**
5. i. Interpret the operation and significance of timer instruction set
   ii.Classify the operation, symbols and control words of data-handling instructions
   iii.Make use of PLCs for different real time applications using ladder diagrams and static application panels.**(For Open Book Examination and not for semester end examination).**

19EE701 Summer Internship II

0 0 0 1.5

Course Outcomes

1. Demonstrate communication skills to meet the requirement of industry
2. Develop logical thinking and analytical skills to thrive in competitive examinations
3. Use mathematical concepts to solve technical quizzes
4. Develop technical skills to work out real time problems
5. Develop algorithms for different applications
6. Solve industry defined problems using appropriate programming skills

COs – POs Mapping

COs	PO_1	PO_2	PO_5	PO_6	PO_{10}	PO_{12}
1	-	-	-	-	3	-
2	3	1	-	-	-	-
3	3	-	-	-	-	-
4	3	1	3	-	-	2
5	3	1	3	3	-	1
6	3	1	3	-	-	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

19EE702 Project

0 0 16 8

Course Outcomes

1. Identify a contemporary engineering application to serve the society at large
2. Use engineering concepts and computational tools to get the desired solution
3. Justify the assembled/fabricated/developed products intended
4. Organize documents and present the project report articulating the applications of the concepts and ideas coherently
5. Demonstrate ethical and professional attributes during the project implementation
6. Execute the project in a collaborative environment

COs – POs Mapping

Cos	PO_1	PO_2	PO_3	PO_4	PO_5	PO_6	PO_7	PO_8	PO_9	PO_{10}	PO_{11}	PO_{12}	PSO_1	PSO_2
1	3	2	-	-	-	3	2	-	-	-	-	-	3	3
2	3	3	-	-	3	-	-	-	-	-	-	-	3	3
3	3	3	3	2	-	-	-	-	-	-	2	-	3	3
4	-	-	-	-	-	-	-	-	-	3	-	2	3	3
5	-	-	-	-	-	-	-	3	-	-	-	-	3	3
6	-	-	-	-	-	-	-	-	3	-	-	-	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

19EE014 Power System Deregulation

0 0 0 3

Course Outcomes

1. Outline the components of deregulated systems.
2. Summarize deregulated model in detail.
3. Identify the need of power system restructuring in deregulation.
4. Compute the market power mitigation techniques.
5. Summarize the total transfer capability in detail.
6. Identify the various transmission open access issues in competitive market

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	2	2	1
3	3	3	2
4	2	2	1
5	2	2	1
6	3	3	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

UNIT- I

Introduction to Power System Deregulation

Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system

Regulation VS deregulation

12+3 Hours

UNIT- II

Power System Restructuring

Difference between integrated power system and restructured power system. Explanation with suitable practical examples. Deregulation of Power Sector: Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model.

Day ahead and hour ahead markets

11+4 Hours

UNIT- III

Competitive Electricity Market

Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services, Transmission Pricing-postage stamp, MW-mile.

Location based Marginal Pricing LMPs

11+4 Hours

UNIT- IV

Transmission Open Access Issues

Open Access Same Time Information System-structure, functionality, implementation, posting of information, uses, Congestion Management-Congestion management in normal operation, total transfer capability, Available transfer capability, Transmission Reliability Margin, Capacity Benefit Margin, Existing Transmission Commitments.

Tracing of power

11+4 Hours

Total: 45+15 = 60 Hours

Textbook (s)

1. Power System Restructuring and Deregulation by Loi Lei Lai, John Wiley & Sons Ltd

2. P Understanding Electric Utilities and Deregulation by Lorrin Philipson and H. Lee Willis, Marcel Dekker Inc, New York, CRC Press.

Reference (s)

1. Electric Utility Planning and regulation – Edward Kahn , University of California- 2005
2. M. Shahidehpour and M. Alomoush, "Restructured Electric Power Systems – Operations, Trading and Volatility", CRC Press, 2001.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	35	35	---
Apply	40	40	100
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)

Remember

1. Define optimal power flow?
2. List factors affecting power system security?
3. Label State estimation in power system?
4. List the benefits of deregulation?

Understand

1. Explain interior point algorithm?
2. Explain concentric relaxation?
3. Explain state estimation by orthogonal decomposition?
4. Explain the operation of deregulated power markets?

Apply

1. Identify the best linear programming method?
2. Identify the various problems in network?
3. Utilize state estimation for detection and identification of Bad measurements Estimation?
4. Identify the various electrical market entities?

19EE015 Energy Audit, Conservation and Management

0 0 0 3

Course Outcomes

1. Summarize the energy economic analysis methods
2. Outline energy auditing and management techniques.
3. Make use of energy auditing and economic analysis procedures for energy management.
4. Outline the concept of operating power factor.
5. Summarize the need for demand side management.
6. Select PF correction and DSM techniques for energy conservation.

COs – POs Mapping

COs	PO2	PO3	PO12	PSO2
1	2	2	3	1
2	3	3	3	1
3	3	3	3	2
4	3	2	3	1
5	2	1	3	1
6	3	2	3	2

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

UNIT-I

Introduction

Energy situation – world and India, energy consumption, conservation-need in thermal utility, Codes, standards and Legislation.

Energy economic analysis: The time value of money concept, developing cash flow models, payback analysis, depreciation, taxes and tax credit – numerical problems

Energy Policy based on management

12+4 Hours

UNIT-II

Energy auditing

Introduction, Elements of energy audits, energy use profiles, measurements in energy audits, presentation of energy audit results, case study.

Electrical system optimization: The power triangle, motor horse power, power flow concept.

Concept of electric machines-AC& DC

10+4 Hours

UNIT-III

Electrical equipment and power factor

Electrical equipment and power factor correction and location of capacitors, energy efficient motors, lighting basics, electrical tariff, Concept of ABT.

Flexibilization in thermal power plant.

10+3 Hours

UNIT – IV

Demand side management

Introduction to DSM, concept of DSM, benefits of DSM, different techniques of DSM – time of day pricing, multi-utility power exchange model, time of day models for planning, load management, load priority technique, peak clipping, peak shifting, valley filling, strategic conservation, energy efficient equipment. *Management and Organization of Energy Conservation awareness Programs*

13+4 Hours

Total: 45+15 Hours

Textbook (s)

1. Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher Gautam, Energy Management Conservation and Audits, CRC Press, 2020
2. Barun Kumar De, “Energy Management, Audit and Conservation”, Vrinda Publications, 2007.

Reference (s)

1. Chakrabarti, Amlan, Energy Engineering and Management, PHI Learning Pvt. Ltd., 2nd Edition, 2018.
2. S C Tripathy , Electric Energy Utilization and Conservation, Tata McGraw hill publishing company Ltd.,New Delhi, 1991.

Internal Assessment Pattern

Cognitive level	Int. Test 1 (%)	Int. Test 2 (%)	Open book examination (%)
Remember	25	25	---
Understand	50	50	
Apply	25	25	100
Analyze	---	---	
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define Energy
2. List out various types of energy resources present in Globe
3. Define principle of energy audit
4. Define energy management and auditing
5. Define load profiles
6. Define power factor

Understand

1. Summarise the duties of energy auditor and manager
2. Explain the types of energy audit
3. Explain energy policies and IETS
4. Explain break even chart
5. Explain about depreciation with all methods
6. Explain power factor methods and controlling
7. Illustrate Load management
8. Formulate energy auditing report in tabular form

Apply

1. Show how role of IT is important in EA&M
2. Demonstrate the star delta method of power factor improvement
3. Implement efficient lighting systems with Lux meter
4. Find SHR & MF and ratios of lighting with equations
5. GMRIT wants to understand the energy consumption patterns and look for scope of reducing unnecessary energy consumption and minimize wastage. In this regard, the institute sets up a team to perform an energy audit. As a member of the team, assigned the duty of identifying the auditing method which is suitable to GMRIT. Justify your selection. **(For Open Book Examination and not for semester end examination).**
6. It was noticed that GMRIT's electricity bill is consisting a heavy amount in the kVAr category. In this regard, the management has taken a decision to identify the various causes for increased kVAr usage in the campus and take counter measures to reduce it. You are entrusted with the duty of identifying the loads consuming high kVAr and suggesting the methods to improve the same. Elaborate the methodology adopted along with suitable counter measures. **(For Open Book Examination and not for semester end examination).**

19EE016 High Voltage Engineering

0 0 0 3

Course Outcomes

1. Outline the behavior of gas, solids and liquids when they are used as insulating medium
2. Outline the gas, solids and liquid insulating materials
3. Identify the applications and breakdown phenomenon in insulating materials
4. Illustrate the concepts used for high voltages and currents the generation
5. Identify the suitable high voltage testing methods.
6. Outline over Voltage measurement and Insulation Co-Ordination.

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	3	3	3
3	3	3	3
4	3	3	3
5	3	3	3
6	2	2	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

UNIT I

Introduction to High Voltage Technology and Applications

Electric Field Stresses, Gas / Vacuum as Insulator, Liquid Dielectrics, Solids and Composites, Surge voltages, their distribution and control, Applications of insulating materials in transformers, rotating machines, cable power capacitors and bushings.

Applications of circuit breakers

12+3 Hours

UNIT-II

Break Down In Gaseous, Liquids and Solid Dielectrics

Breakdown in Gases: Gases as insulating media, collision process, Ionization process, Townsend's criteria of Breakdown in gases, Paschen's law. Breakdown in Liquids: Liquid as Insulator, pure and commercial liquids, breakdown in pure and commercial liquids. Breakdown in Solids: Intrinsic breakdown, electromechanical breakdown, thermal breakdown, breakdown of solid dielectrics in practice.

Solid dielectrics used in practice

11+4 Hours

UNIT-III

Generation, Measurement and Testing of High Voltages and Currents

Generation of High Direct Current Voltages, Generation of High alternating voltages, Tripping and control of impulse generators. Measurement: Measurement of High Direct Current voltages, Measurement of High alternating Voltages, Measurement of High DC Currents, alternating Measurement of Dielectric.

Measurement of loss factor

11+4 Hour

UNIT – IV

Testing, Over Voltage Phenomenon and Insulation Co-Ordination

Testing: Testing of Insulators and bushings, Testing of Isolators and circuit breakers, testing of cables, Testing of Transformers. Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switching surges, system faults and other abnormal conditions, Principles of Insulation Coordination on High voltage.

Testing of Surge Arresters

11+4 Hours

Total: 45+15 Hours

Textbook (s)

1. High Voltage Engineering by M.S.Naidu and V. Kamaraju – TMH Publications, 5th Edition, 2013.
2. High Voltage Engineering by C.L.Wadhwa, New Age Internationals (P) Limited, 4th edition, 2020.

Reference (s)

1. High Voltage Engineering: Fundamentals by E.Kuffel, W.S.Zaengl, J.Kuffel by Elsevier, 2nd Edition, 2000.
2. High Voltage Insulation Engineering by Ravindra Arora, Wolfgang Mosch, New Age International (P) Limited, 1st edition, 2016.

Internal Assessment Pattern

Cognitive Level	**Int. Test 1 (%)**	**Int. Test 2 (%)**	**Open Book Examination (%)**
Remember	20	20	---
Understand	50	50	---
Apply	30	30	100
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define Field enhancement factor.
2. Define the mean free path (λ).
3. Define "Complex permittivity.

Understand

1. Illustrate the numerical methods used for electric field computation? Explain briefly about Finite difference method (FDM).
2. What is ionization process? Explain about all types in ionization process.
3. Derive the current growth equation for Townsend's criteria for breakdown with neat sketch.

Apply

1. Apply the partial discharge tests on high voltage cables. How a fault in the cable insulation can be located by using partial discharge technique
2. Identify different controlling methods of over voltages due to switching operations? Explain them briefly
3. Identify different testing methods suitable for testing of isolators and circuit breakers.
4. Make use of the given data and give solution. The line voltage of a 2-wire direct current increased from 100 v to 200v if the same amount of the same electrical power is transmitted over the same distance, what will be the percentage of saving in copper. **(For open book Examination not for semester end examination)**
5. Develop a surge arrester that can withstand high range current that can takes place at rainy season. Assume the required data.**(For open book Examination not for semester end examination)**

19EE801 Full Semester Internship

0 0 0 9

Course Outcomes

1. Use the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
2. Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
3. Select appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
4. Use ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
5. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
6. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

COs – POs Mapping

COs	PO_1	PO_2	PO_5	PO_8	PO_9	PO_{10}	PSO_1	PSO_2
1	3	-	-	-	-	-	3	3
2	-	3	-	-	-	-	3	3
3	-	-	3	-	-	-	3	3
4	-	-	-	3	-	-	3	3
5	-	-	-	-	3	-	3	3
6	-	-	-	-	-	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

HONOR COURSES

Domain I: AI in Electrical and Electronics Engineering

19EEH11 Computation Intelligence in Electrical Engineering

4 0 0 4

Course Outcomes

1. Outline the basic structural layout of a neural network architecture
2. Apply the basic concepts of Artificial Intelligence and its importance in real life scenario.
3. Summarize the SLFN and methods of learning.
4. Analyze the various optimization algorithms
5. Identify the various faults with its location.
6. Apply the various types of forecasting in Electrical Engineering

COs – POs Mapping

COs	PO_2	PO_{12}	PSO_2
1	2	3	1
2	3	3	2
3	2	3	1
4	3	3	3
5	3	3	2
6	3	3	2

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit-I

Introduction and Basic Knowledge

Introduction to Intelligence Technique, Difference between Human and Machine Intelligence, Basic concept about Machine Learning, Basic concept about Artificial Intelligence. Pros and Cons of AI. Introduction to Fuzzy logic, operations on fuzzy sets, Basic application of AI in Electrical Engineering

(15 Hours)

Unit II

Artificial Neural Network and its model

Fundamental concepts, Basic models (Input layer, hidden layer and output layer), learning rules, Single layer (SLFN) and multi-layer feed-forward and feedback networks, Supervised and unsupervised methods of training, Application of ANN in Electrical AC/DC motor application for fault finding concept.

(15 Hours)

Unit III

Evolutionary Algorithms

Introduction to Evolutionary algorithms, Genetic Algorithms, hierarchical concepts and steps to obtain GA, Particle Swarm Optimization, Hierarchical strategy to obtain PSO. Application of Evolutionary algorithms in Electrical Engineering for classification of various faults in Transmission lines.

(15 Hours)

Unit IV

Application in Electrical Engineering in various forecasting

Data pre-processing, Short term, medium term and long-term forecasting Techniques (i.e. Utility load demand, energy market, solar irradiance, solar power, wind speed and power forecasting).

(15 Hours)

(Total: 60 Hours)

Textbook (s)

1. Dan W. Patterson, "Introduction to Artificial Intelligence and Expert Systems", Pearson India Educational Services Pvt. Ltd., ISBN-978-93-325-5194-7, 6th edition 2018.
2. S. Rajasekaran and G. A. V. Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms" PHI, New Delhi, 2003.
3. Artificial Intelligence: Elaine Rich, Kevin Knight, Mc-GrawHill
4. Mohamed E. El-hawary, "Advances in Electric Power and Energy: forecasting In Electric Power Systems", ISBN: 13: 9781118171349. ISBN 10: 1118171349
5. Dr. Ing. Ajoy K. Palit, "Computational Intelligence in Time series Forecasting, Theory and Engineering Application", Springer, ISBN: 1852339489.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	--
Understand	50	25	50
Apply	25	25	50
Analyze	--	25	--
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Remember

1. Define the Single layer feed forward neural network (SLFN).
2. List the various layer in the ANN Architecture and its importance.

Understand

1. Explain the benefits of evolutionary algorithm in Artificial Intelligence
2. Classify the various faults created in power system, which can be detected by AI applications.
3. Classify the difference between Single layer and Multi-layer neural network

Apply

1. Apply the knowledge of Machine learning in the types of forecasting and its effectiveness.
2. Demonstrate the Pros and Cons, in Artificial Intelligence system.

Analyze

1. Compare the basic difference between supervised and unsupervised learning.
2. Analyze the forecasting approach depending on their duration and accuracy.

19EEH12 Data Analytics in Electrical Engineering

4 0 0 4

Course Outcomes

1. Elucidate the fundamental steps in conducting a data-analytics and data manipulation
2. Summarize the characteristics and purposes of visualizing univariate, bivariate and multivariate data
3. Summarize the concepts that underlie the foundations of statistical informatics
4. Illustrate the data for modeling, controlling and reliability assessment of renewable energy system.
5. Illustrate the wind energy forecasting model
6. Apply mathematical and statistical tools with modern technologies to obtain optimal solution

COs – POs Mapping

COs	PO_2	PO_{12}
1	1	3
2	2	3
3	2	3
4	2	3
5	2	3
6	2	3

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit-I

Introduction to Data Analytics & Data manipulation

Data analytics - finding structure in data, data quality versus data quantity, statistical modeling versus statistical description. basic probability and statistical distributions, random sampling, data types, data summarization - means, medians, and central tendency, summarizing variation and correlation, data diagnostics and data transformation- outlier analysis, entropy and data transformation, simple smoothing techniques – binning, moving averages and exponential smoothing.

(15 Hours)

Unit II

Data visualization and statistical graphics

Univariate visualization - Strip charts and dot plots, Boxplots, Stem-and-leaf plots Histograms and density estimators and Quantile plots, Bivariate and multivariate visualization - Pie charts and bar charts, Multiple boxplots and QQ plots, Scatterplots and bubble plots, Heatmaps and Time series plots.

(15 Hours)

Unit III

Solar-Wind Energy Assessment

Introduction - Pre-feasibility assessment of solar-wind energy system, Energy aware cluster node management of solar-wind energy system, Partitioning method, Hierarchical method, Basic big data measures for solar and wind data, Application of Map Reduces in solar and wind energy system, Market basket model in solar and wind energy system.

(15 Hours)

Unit IV

Wind Energy Forecasting

Introduction to Wind energy, Single time series model, Time scaling in short-term forecasting, simple forecasting model – Persistence model and Weibull distribution, data transformation and standardization, Autoregressive moving average model - Model diagnostics, Forecasting based on ARMA model.

(15 Hours)
(Total: 60 Hours)

Textbook (s)

1. Walter W. Piegorsch, “*Statistical Data Analytics: Foundations for Data Mining, Informatics, and Knowledge Discovery*”, First edition, John Wiley & Sons, Ltd, 2015.
2. Kris Jamsa, “*Introduction to Data Mining and Analytics*”, Jones & Bartlett Learning, 2020
3. Taha Selim Ustun, *“Innovation in Energy Systems New Technologies for Changing Paradigms”,* Intechopen, 2019.
4. Yu Ding, *“Data Science for Wind Energy”,* First edition, CRC Press, 2019.

Reference (s)

1. HOSSEIN PISHRO-NIK, "*INTRODUCTION TO PROBABILITY, STATISTICS, AND RANDOM PROCESSES*", KAPPA RESEARCH, LLC, 2014.
2. Jim Frost, "Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries", Statistics by Jim Publishing, 2020.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	--
Understand	50	25	--
Apply	25	50	100
Analyze	--	--	--
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (s)

Remember

1. What is interval data?
2. What is mean and median?
3. What is data mining?
4. What is data transformation?
5. List any four data visualization methods.

Understand

1. Distinguish between data quality and data quantity.
2. Show that if X and Y are two independent random variables, then Cov $[X, Y] = 0$.
3. Explain about bivariate and multivariate visualization.

Apply

1. A financial firm builds a large database of its customers to study their credit card usage. In a given month, customers who had submitted at least their minimum monthly payment but less than the total amount due on that month's statement were included. By how much, if at all, the monthly payment exceeded the minimum payment level was recorded. These values were then mined for patterns using the customers' ages, lengths of patronage, etc. Is there any selection bias evident in this approach? Why or why not?

2. For the following data sets, calculate the 10% trimmed mean. Comment on how it compares to the corresponding sample mean. A selection (smallest and largest values) of average daily net carbohydrate consumption (in grams) from a larger data set of n = 778 observations.

43	64	75	75 · · · 402	407	437	738

3. Find the probability distribution function for a three parameter Weibull distribution. Derive the corresponding log-likelihood function.

19EEH13 Internet of Things in Electrical Engineering

4 0 0 4

Course Outcomes

1. Outline the basics of Internet of things
2. Summarize the concepts of IoT Protocols
3. Analyze the Architecture of IoT
4. Outline the applications of Internet of Things in smart home
5. Apply Internet of Things in smart city
6. Apply Internet of Things in smart grid

COs – POs Mapping

COs	PO_2	PO_{12}	PSO_1
1	2	3	1
2	2	3	1
3	3	3	3
4	2	3	1
5	3	3	2
6	3	3	2

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit I

Internet of things and Protocols

Internet of things –Definition and its importance, Elements of an IoT ecosystem, Technology Drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security issues.

Protocol Standardization for IoT Efforts M2M and WSN, Protocols SCADA and RFID Protocols Issues with IoT Standardization, Unified Data Standards Protocols IEEE802.15.4 BACNet Protocol Modbus KNX Zigbee and Network layer APS layer Security.

(15 Hours)

Unit II

IOT Architecture

IoT Open-source architecture (OIC)- OIC Architecture & Design principles- IoT Devices and deployment models- IoTivity: An Open source IoT stack -Overview- IoTivity stack architecture- Resource model, Abstraction and Smart Home IoT Devices.

(15 Hours)

Unit III

IOT for smart cities

Introduction on Smart City Environmental Monitoring Applications using IoT, IoT Smart City Environment Monitoring Applications and methodologies, Arduino Uno, Xbee, and DHT22 Power Saving Schemes and testing, Direct and Indirect Application of IoT in Smart City

(15 Hours)

Unit IV

IOT for smart grids

Communication Protocols for the IoT-Based Smart Grid, IoT Applications Types, IoT Based Smart Grid Overview, Current IoT Based Smart Grid Technology Enablers, Future and Enabling Technologies for IoT Based Smart Grid **(15 Hours)**

Total:60 Hours

Textbook (s)

1. Serpanos D, Wolf M. Internet-of-things (IoT) systems: architectures, algorithms, methodologies. Springer; 2017 Nov 24.
2. Bhawani Shankar Chowdhry, Faisal Karim Shaikh, Naeem Ahmed Mahoto, IoT Architectures, Models, and Platforms for Smart City Applications, A volume in the Advances in Computer and Electrical Engineering (ACEE) Book Series, IGI Global, 2019.
3. Siozios K, Anagnostos D, Soudris D, Kosmatopoulos E. IoT for Smart Grids. Springer; 2019.

Reference (s)

1. Khan JY, Yuce MR, editors. Internet of Things (IoT): Systems and Applications. CRC Press; 2019 Sep 17.
2. Buyya R, Dastjerdi AV, editors. Internet of Things: Principles and paradigms. Elsevier; 2016 May 11.
3. Holler J, Tsiatsis V, Mulligan C, Karnouskos S, Avesand S, Boyle D. Internet of Things. Academic Press; 2014 Apr 8.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open book Exam (%)
Remember	25	25	---
Understand	25	25	---
Apply	50	50	50
Analyze	---	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. What is internet of things?
2. Define open source IoT stack.
3. Define data rate.
4. List any four direct applications of IOT for smart city.

Understand

1. Explain the different components of IOT?
2. Demonstrate the influence of IoT for the development of smart cities.
3. Outline IOT based Secure Encoder.
4. Explain IoT Based Smart Security and Home Automation System.

Apply

1. Develop the architecture for IoTivity stack.
2. Organize the Architecture & Design principles for OIC.
3. Model the Xbee power saving scheme.
4. Make use of Network layer technologies for smart grids.

Analyze

1. Categorize SCADA and RFID Protocols.
2. Contrast the various deployment models for IOT devices.
3. Inspect Massive and critical IOT.
4. Analyze IoT Based Smart Grid Technology Enablers.

19EEH14 Introduction to Smart Cities

4 0 0 4

Course Outcomes

1. Outline the basic concepts and various approaches for smart city design, components and requisites
2. Illustrate the various challenges, environmental impacts and framework for smart cities
3. Analyze the smart mobility concept and automation.
4. Apply the smart energy concept in smart cities for betterment of society.
5. Illustrate a smart cities project in a community using a range of tools and techniques.
6. Outline the concept of smart waste management and designs of smart buildings.

COs – POs Mapping

COs	PO_2	PO_{12}	PSO_2
1	2	3	1
2	2	3	1
3	3	3	3
4	3	3	2
5	2	3	1
6	2	3	1

3–Strongly linked | 2–Moderately linked| 1–Weakly linked

Unit-I

Smart cities: State of the art and smart environment

Definition of smart city, Evolution of smart cities, General prerequisites to be smart, smart city components and categories, Policy framework for smart cities, Deteriorating quality of basic resources, climate change and pollution control, measures, ICT framework for environmental management

(15 Hours)

Unit II

Smart urban mobility

Need of smart urban mobility, components of urban mobility, ICT support of smart mobility system, intelligent signalling system, real time traffic monitoring system, parking information system, automated vehicle location system, interactive journey planning for multiple modes, Infrastructure and policies.

(15 Hours)

Unit III

Smart Energy

Definition of smart energy, strategies in making a city energy smart, use of renewable energy, making of a smart grid-RE and smart grid, demand management, smart metering, use of electric vehicles-reducing reliance on fossil fuels, long term solution to climate change. **(15 Hours)**

Unit IV

Smart buildings and waste management

Intelligent buildings, smart buildings major sub systems- lighting, heating, ventilation and air conditioning, energy monitoring and management system, fire safety and emergency warning systems.

Waste management changing approaches- 3Rs and beyond, life cycle approach, waste collection and handling, IoT and ICT based systems for waste collection and management, indicators of solid waste management performance.

(15 Hours)

(Total: 60 Hours)

Textbook (s)

1. P. P. Anil Kumar, "Introduction to Smart Cities", First Edition, By Pearson India publication, ISBN: 978-9353439576
2. Dr N Mani, "Smart Cities & Urban Development in India", New Century Publications. ISBN: 978-8177084320
3. Yoshiki Yamagata, Perry P. J. Yang," Urban Systems Design, Creating Sustainable Smart Cities in the Internet of Things Era", Elsevier publication, ISBN-13: 978-0128160558.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	--
Understand	50	25	--
Apply	--	25	25
Analyze	25	25	75
Evaluate	--	--	--
Create	--	--	--
Total (%)	100	100	100

Sample Question (s)

Remember

1. What is a smart city as per BSI?
2. What are the four dimensions of smart city resilience?
3. What are the prerequisites for the city to be smart?

Understand

1. Distinguish in detail the difference between normal building and energy efficient building?
2. Explain how demand side management be helpful in making the grid smart?
3. Demonstrate the usage of IOT and ICT for smart waste management?

Apply

1. Develop a model for smart energy building by considering the air condition load as priority load.
2. Identify the key factors from the case study of the city Paris- a city of modernity?
3. A locality having 100 houses with well-connected roads. Every day on an average the collected garbage is about 500Kg. It is dumped at place 5Km away from the locality. However, it has been identified that over a time the stinking garbage causing health issues to the locals. Plan how the garbage should be handled in this scenario using the technologies you studied in this course?

Analyze

1. A community having smart buildings and interconnected with smart grid. At one of the houses in the community occurred fire accident. None of the sensors in that particular building worked. Analyze the reasons for this.
2. A community having smart buildings and interconnected with smart grid. At one of the houses in the community occurred fire accident. None of the sensors in that particular building worked. Develop a method such that even if sensors not working but the problem should be reported to the data center without human intervention.

Domain II: Power Systems

19EEH21 Design and layout of Power Systems

4 0 0 4

Course Outcomes

1. Outline the equipment used in transmission and distribution networks
2. Identify appropriate rating and locations for installing power equipment
3. Develop substation layout with appropriate design considerations
4. Identify the parameters effecting transmission line design
5. Identify the parameters effecting distribution line design
6. Design transmission and distribution lines for particular applications

COs – POs Mapping

COs	PO_2	PO_3	PO_8
1	2	2	1
2	3	3	1
3	3	3	1
4	3	3	1
5	3	3	1
6	3	3	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit – I

Layout and Installation of Power Equipment's

Introduction to transmission and distribution network power equipment, Installation of power transformers – Reactors – Installation of Insulators – Erection of earthing systems and secondary circuits – Installation of CT's and PT's and CVT's – Installation of fuses and their rating – Installation of Isolators and Circuit breakers – Installation of Capacitor banks –IEE rules.

Working and applications of CVT's

(15 Hours)

Unit – II

Design and Layout of Substations

Classification and comparison of substations, Substation equipment, operation and symbols, Busbar arrangements, materials for busbar, Substations earthing, Layout diagram of single and two stage substations – 66/11kV, 220/132/33kV, 11kV/440V indoor substation.

Selection of site for substation construction

(15 Hours)

Unit III

Design and Layout of Transmission Lines

Requirements of transmission Lines - Selection of voltage levels for HT transmission lines - Choice of conductors – transmission line clearances, right of way width, loadings on transmission towers, Stringing of transmission line conductors, factor of safety, types of towers – mono pole and lattice towers –earth wires, maintenance of transmission lines.

IS 816

(15 Hours)

Unit – IV

Design and Layout of Distribution Systems

Primary and secondary distribution system design – selection of conductors and insulator - Kelvin's law for economical choice of conductor – voltage regulation – Route survey and profiling of distribution lines; Mechanical design of low-tension distribution lines, selection of poles/supports; Electrical design of low-tension distribution lines

IS 5613

(15 Hours)

Text Books:

1. M.V. Deshpande, "*Elements of Power Station Design*", Tata McGraw-Hill, 2006
2. P. K. Nag, "*Power Plant Engineering-Steam and Nuclear*", Tata McGraw Hill, 4th edition, 2008

3. Sunil S Rao *"Switchgear and Protection"*, Khanna Publishers, 13th edition, 2017
4. Sriram Kalaga and Prasad Yenumula, *"Design of Electrical Transmission Lines Structures and Foundations"*, Taylor and Francis, 2021
5. Kamaraju. V, "Electric Power Distribution System", Tata McGraw Hill, 2nd edition, 2010.

Reference Books:

1. Mahesh Verma, "*Power Plant Engineering*", Metropolitan Book Co, Pvt. Ltd. 2005
2. George W. Sutton (Editor), "*Direct Energy Conversion*", Inter University Electronics Series Vol-3, McGraw-Hill, New York.
3. Jangwala, N.K., "Modern Trends and Practices in Power Subtransmission and Distribution Systems", Vol.-I and II, CBIP Publication.
4. Harker, K., "Power System Commissioning and Maintenance Practice", The Institution of Electrical Engineers.
5. Raina, K.B. and Bhattacharya, S.K., "Electrical Design Estimating and Costing", New Age International, 2nd edition, 2017.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	30	30	---
Understand	30	30	50
Apply	40	40	50
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. List different types of transmission towers.
2. Define voltage regulation in a distribution system.
3. State the purpose of earthing of electrical power apparatus.
4. List different types of substations.

Understand

1. Explain the steps involved in selection of voltage level for a HT transmission line.
2. Illustrate the layout scheme for rural and industrial distribution system.
3. Outline the procedure for installing a power transformer.
4. Compare and contrast indoor and outdoor substations.

Apply

1. Select the electrical and mechanical design parameters for constructing a 132 kV transmission line.
2. Design a scheme for distribution of power for an industry.
3. Develop a layout for 220/11 kV substation.
4. Distinguish between rural and industrial distribution design schemes.
5. Evaluate the design parameters for a 132kV transmission line.
6. Develop a layout for town electrification and justify the answer.
7. A thermal power station is planned to be installed in the remote village far from the city. Design a suitable substation in the vicinity of thermal power station for transmitting the generated power through three different transmission lines with a transmission voltage of 440kV. Draw a neat layout of the substation specifying the parameters of various equipment's to be used in the substation.
   (For Open Book Examination and not for semester end examination)
8. To meet the additional demand for electric power in a particular place, a new transmission line has to be laid from to this place from the transmitting substation which is 600 km away. Design a transmission line with suitable voltage level, insulators and proper towers for carrying the transmission lines. Also design an appropriate distribution system for distributing the electrical power within the city, keeping the voltage drops within the limit according to the IEEE rules for distribution. **(For Open Book Examination and not for semester end examination)**

19EEH22 Distributed Generation Technologies

4 0 0 4

Course Outcomes

1. Outline the importance of Distributed Generations (DGs)
2. Summarize the various storage techniques for DGs
3. Analyse the load curves and planning in Distributed generation systems
4. Develop suitable interface for grid integration of a DG system
5. Outline the reliability and Interconnection methodology in a DG System
6. Summarize economic aspects of DG system

COs – POs Mapping

COs	PO_2	PO_6	PO_7	PO_8	PSO_2
1	2	2	3	2	1
2	2	2	3	2	1
3	3	3	3	3	3
4	2	2	3	2	2
5	2	2	3	2	1
6	2	2	3	2	1

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Need for distributed generation

Introduction to Distributed Generation, Need, Importance and Advantages of DGs, Distributed vs, Central station Generation, Traditional power system, Load Curve Analysis and Measuring Load curve data accurately, Distributed Generation Systems: Planning and Comparison

Daily load curve

(15 Hours)

Unit II

Energy Storage with distributed generation

Planning Process: Finding best alternative with short term and long-term planning, Energy storage elements –Batteries, capacitors storage, Mechanical Storage: (flywheels, pumped and Compressed Fluid), Fuel cell powered distributed generators.

Superconducting Magnetic Energy Storage (SMES)

(15 Hours)

Unit III

Renewable Resource Generations with Grid Interconnections Options

Study of DG unit and storage sizes, Screening, Statistical or Simulation Studies, Power Grid, Pros and Cons of DG Grid Interconnection, Types of Interconnections, Comparing different types of DG Options

Power Quality issues or challenges

(15 Hours)

Unit IV

Economic aspects of DGs

Economic and financial aspects of distributed generation, Cost, Time value of Money, Decision based cost effectiveness evaluation Market facts, issues and challenges, Reliability evaluation of DG based systems

Cost Analysis of DG

(15 Hours)
(Total: 60 Hours)

Textbook (s)

1. H. Lee Willis, Walter G. Scott, 'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.

2. M.Godoy Simoes, Felix A. Farret, 'Renewable Energy Systems – Design and Analysis with Induction Generators', CRC press.

Reference (s)

1. Robert Lasseter, Paolo Piagi, 'Micro-grid: A Conceptual Solution', PESC 2004, June 2004.
2. F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	55	55	---
Apply	25	---	50
Analyze	---	25	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define the Importance of Interconnected Distributed generation system in power system networks
2. Define the economic aspects in distributed generation

Understand

1. Classify various types of Energy storage elements in Distributed Generation Context
2. Compare the basic difference between battery and supercapacitors in distributed generation system

Apply

1. Identify the challenges in Integration of Renewable energy in Distributed Generations
2. Determine the challenges in Integrating PV based microgrid in distributed generation
3. As an Electrical Engineer, you are posted in a village area, where the people are suffering with power quality problem for two decades. As per the area survey and load calculations, you found that renewable energy generating system or local grid connection with central grid will be efficient to supply the loads of that villages, but the challenging part is uninterrupted power supply. As per the funding amount its very costly to purchase battery or to construct the grid architecture for whole village. Define the best way possible for the Distribute generation plant and compare its benefits, challenges and drawbacks in future aspects. **(For Open Book Examination and not for semester end examination)**

Analyze

1. Analyze the grid integration system, its need and advantages.
2. Estimate the effectiveness of super capacitor in Distributed generation system
3. Due to generator blast inside the wind turbine nacelle, whole structure has been demolished of around 1MW. As an alternative resource in immediate effect, you have to plan for 1 MW generation to full fill the demand in both short time management and long run management. As an Engineer, you have to propose two working mechanisms for short term basis and long-term run, Justify your answer properly according to the need. **(For Open Book Examination and not for semester end examination)**

19EEH23 Distribution System Planning and Automation

4 0 0 4

Course Outcomes

1. Outline the load forecasting methods
2. Identify appropriate substation location and its rating
3. Compare and contrast different supply systems
4. Identify optimal location for capacitor bank placement
5. Summarize power sector reforms in India
6. Illustrate the need for distribution automation

COs – POs Mapping

COs	PO_2	PO_3	PO_6	PSO_2
1	2	2	2	1
2	3	3	3	2
3	2	2	2	1
4	3	3	3	2
5	2	2	2	1
6	2	2	2	1

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

Unit I

Distribution System Planning

Load characteristics- basic definitions, relation between load and loss factors, maximum diversified demand, Load forecasting techniques-Box Jenkins methodology, small area load forecasting and spatial load forecasting, Load management, Consumer billing, metering of energy.

Distribution substations

Distribution substations, Bus schemes, comparison of switching schemes, substation location and rating.

Distribution transformers

(15 Hours)

Unit II

Voltage Drop and Power Loss Calculations

Supply systems- Comparison of Conductor Material in Overhead System, Comparison of Conductor Material in Underground System, Economic Choice of Conductor size, Types of feeders- voltage levels, Copper loss, Distribution feeder costs, economic analysis and equipment losses

Loss reduction and Voltage improvement in rural networks

(15 Hours)

Unit III

Power factor improvement in Distribution System

Different types of power capacitors, shunt and series capacitors, effect of shunt capacitors, effect of series capacitors, power factor correction, capacitor allocation, economic justification, optimal capacitor allocation

Dynamic behavior of distribution systems

(15 Hours)

Unit IV

Distribution System Automation

Reforms in power sector, Methods of improvement, Reconfiguration, Automation, Communication systems, Sensors, Basic architecture of Distribution automation system, RTU and Data communication – SCADA requirement and application functions, Communication media for distribution system automation.

Communication protocols for Distribution systems - IEC 61850 and IEEE 802.3 standards.

(15 Hours)

(Total: 60 Hours)

Textbook (s)

1. Turan Gonen, *"Electric Power Distribution Engineering",* CRC Press, 3rd Edition, 2014.
2. James A Momoh, *"Electric Power Distribution, Automation, Protection and Control"*, CRC press, 1st Edition, 2007.
3. V. K. Mehta and Rohit Mehta, *"Principles of Power System"*, S, Chand Publications, 4th Edition, 2008.

Reference (s)

1. A.S. Pabla, *"Electric Power Distribution"*, Mc Graw Hill, 7th Edition, 2019.
2. M. K. Khedkar and G. M. Dhole, *"A Text book of Electric Power Distribution Automation"*, University Science Press, 1st Edition, 2011.
3. S. Sivanagaraju and V. Sankar, "*Electrical Power Distribution and Automation"*, Dhanpat Rai & Co, 1st Edition, 2015.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	30	30	
Understand	40	40	
Apply	30	30	100
Analyze	-	-	
Evaluate	-	-	
Create	-	-	
Total (%)	100	100	100

Sample question (s)

Remember

1. List the factors affecting the load forecast.
2. Define load factor and diversity factor.
3. Recall the rules to be observed while selecting ideal location for substation.

Understand

1. Compare power loss between single phase laterals and an equivalent three phase lateral.
2. Summarize expression for k factor in primary feeder main.

Apply

1. A three-phase express feeder has an impedance of (6+j20) Ω/ph. At the load end the line-to-line voltage is 13.8kV and the total three phase power is 1200kW at a lagging power factor of 0.8. Determine the
   (a) line to line voltage at the sending end of the feeder
   (b) Power factor at the sending end
   (c) the copper loss
   (d) the power at the sending end.
2. Develop expression for percentage voltage drop formulae considering geographic extensions, load growth and addition of new feeders.
3. A city in India having a square shaped distribution substation. This substation is located in a fast-growing area in terms of population and load demand. The feeders are made of copper conductors. Load is assumed to be lagging power factor load. A sudden increase in load demand on the substation causing voltage depressions and frequent tripping resulted in power outage. Municipal authorities contemplated on this problem and find building a new substation can solve the problem. If you are given a chance to provide a solution for this problem identify a solution using the known principles and that solution should support all the standards. Some of the standards like feeder thermal limits, voltage drop considerations etc. **(For Open Book Examination and not for semester end examination)**

19EEH24 Power Quality

4 0 0 4

Course Outcomes

1. Classify the power quality issues in power system
2. Outline the power quality issues with respect to voltage
3. Select suitable device/mechanism for mitigation of voltage issues
4. Interpret the harmonic distortion caused by various loads
5. Analyze the effects of harmonics on system parameters
6. Examine power quality bench marking and monitoring

COs – POs Mapping

COs	PO_2	PO_3	PO_8	PSO_2
1	3	3	3	2
2	2	2	2	1
3	3	3	3	2
4	2	2	2	1
5	3	3	3	3
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Power Quality Evaluation

Power quality–voltage quality, concerned about power quality, the power quality Evaluation procedure, Terms and Definitions, Transients, Long-duration voltage variations, short-voltage variations, voltage imbalance, wave form distortion, voltage fluctuation, power frequency variations, power quality terms CBEMA and ITI curves.

Remedies to improve power quality

(16 Hours)

Unit II

Transient Over Voltages and Voltage Sag

Sources of over voltages, principles of over voltage protection, devices for over voltage protection, utility capacitor-switching transients and utility system lightning protection. Voltage Sag: Sources of sags and interruptions, Estimating voltage sag performance, fundamental principles of protection, solutions at the end-use level, Motor-starting sags, utility system fault-clearing issues, mitigation of voltage sag.

Mitigation of over voltages

(15 Hours)

Unit III

Harmonics

Harmonic Distortion, Voltage versus current distortion, Harmonics versus Transients, power system qualities under non-sinusoidal conditions, Harmonic indices, Harmonic sources from commercial loads, Harmonic sources from Industrial loads.

Effects of Harmonics, Harmonic distortion evaluations, Principles of Controlling Harmonics, Devices for Controlling Harmonic Distortion

Techniques for harmonic mitigation

(16 Hours)

Unit IV

Power Quality Bench Marking and Monitoring

Benchmarking process, RMS Voltage variation Indices, Harmonics indices Power Quality Contracts 2009-10177. Monitoring considerations, power quality measurement equipment, Power quality Monitoring standards, Power quality analyzer -Application of Intelligent Systems.

Assessment of Power Quality Measurement Data **(13 Hours)**

(Total: 60 Hours)

Textbook (s)

1. Roger C. Dugan, Mark F. Mc Granaghan, Surya Santoso, H. Wayne Beaty, "*Electrical Power Systems Quality*", TMH Education Pvt. Ltd. 2nd Edition, 2008

2. C. Sankaran, "*Power quality*", CRC Press. 2nd reprint 2017

Reference (s)

1. Alexander Kusko, "Power *Quality in Electrical Systems*" McGraw-Hill Company, 2007
2. J. Arrillaga, N.R. Watson, S. Chen, "*Electrical systems quality Assessment*", John Wiley & Sons 2000
3. Math H. J. Bollen, "*Understanding Power quality problems*", 2001

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	40	30	---
Understand	40	30	---
Apply	20	40	50
Analyze	---	---	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)
Remember

1. Define Power quality
2. Define Harmonics
3. State the voltage sag and swell
4. List out the protection voltage devices
5. What are the sources of Power Quality problems?

Understand

1. Illustrate the CBEMA Curve
2. Explain the procedure for the Power quality Evaluation
3. Interpret the effect of harmonic distortion on capacitors, transformers and motors
4. Explain different devices for improving power system voltage regulation
5. Summarize power quality Monitoring standards

Apply

1. Choose the proper devices for the protection against over currents and explain
2. Identify the different power quality problems occurred in a power system
3. Utilizing the filters how harmonics are eliminated
4. Select an industry such as paper mill, rice mill, textile industry etc., and in the observation over a period of one year, what kind of power quality issues you have noticed. Explain each of the issue and its effect on the system. Describe how to mitigate all the issues with advanced equipment and necessary mitigation techniques. **(For Open Book Examination and not for semester end examination)**

Analyze

1. Compare CBEMA and ITI curves
2. Analyze the wave forms of the different power quality issues
3. Categorize the devices for Controlling Harmonic Distortion
4. For an electrical substation analyze the power flow from input of the substation to output of substation through each of the equipment used and outline the block diagram of power quality monitoring systems which makes to improve the power quality of your selected substation and explain each of the parameter you have chosen. List out All the ratings of equipment as per standards. **(For Open Book Examination and not for semester end examination)**

Domain III: Control Systems

19EEH31 Adaptive Control Systems

4 0 0 4

Course Outcomes

1. Outline various parameter estimation techniques
2. Develop continuous time self-tuning regulator
3. Outline pole placement design for a given system
4. Apply model reference adaptive control to a particular application
5. Examine the Lyapunov theory for a given system
6. Apply adaptive control for various systems

COs – POs Mapping

COs	PO_2	PO_3	PSO_1	PSO_2
1	2	2	1	1
2	3	3	2	2
3	3	3	1	1
4	3	3	2	2
5	3	3	3	3
6	3	3	2	2

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

Unit I

Introduction to Adaptive Control

Introduction to adaptive control, Real time parameter estimation- Least Square Models, Regression Models.
Recursive parameter estimation

(15 Hours)

Unit II

Self-Tuning Regulator

Pole Placement Design, Indirect Self-tuning Regulators, Continuous time self-tuning Regulators, Discrete time self-tuning Regulators
Disturbances with known characteristics

(15 Hours)

Unit III

Model reference Adaptive Control

MIT rule, Lyapunov theory – Direct and Indirect Methods, MRAC design
Relations between MRAS and STR

(15 Hours)

Unit IV

Applications of Adaptive Control

Applications of adaptive control in aerospace engineering, Applications of adaptive control in electrical engineering, challenges in adaptive control.
Adaptive Control in the Presence of Input Constraints **(15 Hours)**

(Total: 60 Hours)

Textbook (s)

1. K. J. Astrom and B. Wittenmark, *“Adaptive Control*”, 2^{nd} Edition, Addison-Wesley, 1995
2. Chalam, V.V., *“Adaptive Control Systems*”, Techniques & Applications, Marcel Dekker, Inc. NY and Basel, 1987.

Reference (s)

1. K. S. Narendra and A. M. Annaswamy, *“Stable Adaptive Systems”*, Prentice-Hall, 1989
2. M. Krstic, I. Kanellakopoulos, and P. Kokotovic, *“Nonlinear and Adaptive Control Design*”, Wiley-Interscience, 1995

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	10	---
Understand	30	20	---
Apply	50	30	50
Analyze	---	30	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample question (s)
Remember
1. Define least square error
2. Define continuous time system
3. Define stability in the sense of Lypanov
4. List any four applications of adaptive control

Understand
1. Outline the regression model in detail.
2. Explain about self-tuning regulator in detail.
3. Outline MIT rule in detail.
4. Outline the challenges in adaptive control

Apply
1. Identify the Least Square Models for a given application
2. Develop the Discrete time self-tuning Regulator for a given application
3. Develop the MRAC for a given application
4. Model adaptive control in aerospace applications

Analyze
1. Examine various regression models
2. Analyze the Indirect Self-tuning Regulators in detail
3. Contrast MRAS and STR
4. Analyze the behavior of adaptive control in the presence of non-linarites
5. Design an adaptive filter for active noise control in the system with the following conditions.
   i. Perform the cancelation of acoustic noise using destructive interference
   ii. Perform the cancellation in the acoustic environment

   (For Open Book Examination and not for semester end examination)

19EEH32 Introduction to Autonomous Vehicles

4 0 0 4

Course Outcomes

1. Summarize the concepts of autonomous vehicle.
2. Identify the framework of intelligent vehicles.
3. Examine the various algorithms for autonomous driving
4. Outline the models for detection of roads.
5. Select a suitable model for road tracking.
6. Classify the localization techniques for autonomous vehicle

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	3	3	2
3	3	3	3
4	2	2	1
5	3	3	2
6	3	3	3

3-Strongly linked | 2-Moderately linked | 1-Weakly linked

Unit I

Introduction to Autonomous Vehicles

Introduction, Key technologies of intelligent vehicles, multi-sensor fusion based environment perception and modelling, path planning and decision-making, low-level motion control, Framework of intelligent vehicles: Interactive safety analysis framework.

State of art autonomous vehicle models in USA **(15 Hours)**

Unit II

Introduction to Autonomous Driving

Overview of autonomous driving technologies, autonomous driving algorithms: sensing, perception, object recognition and tracking, action, autonomous driving client system: robot operating system (ROS), Autonomous Driving Cloud Platform

Deep learning based model training **(15 Hours)**

Unit III

Road Detection and Tracking

Introduction, related approaches for lane detection, lane shape model, adaptive random Hough transform, lane tracking: lane model, dynamic system model, road recognition: basic mean shift algorithm, road recognition algorithm.

Imaging Model **(15 Hours)**

Unit IV

Localization Techniques for Autonomous Vehicle

Localization with GNSS, GNSS Overview, GNSS Error Analysis, Satellite-Based Augmentation Systems, Real-Time Kinematic and Differential GPS, Precise Point Positioning, GNSS INS Integration, Overview of LiDAR technology.

Review of recent electric autonomous vehicles **(15 Hours)**

(Total: 60 Hours)

Textbook(s)

1. Hong Cheng, "*Autonomous intelligent vehicles: theory, algorithms, and implementation*," Springer Science & Business Media, 2011
2. S Liu, L Li, J Tang, S Wu, JL Gaudiot, "*Creating Autonomous Vehicle Systems*," Synthesis Lectures on Computer Science, Morgan & Claypool Publishers. 2nd Edition, 2020.

Reference (s)

1. Berns Karsten , Ewald von Puttkamer, "*Autonomous Land Vehicles*," Vieweg and Teubner Publications, 1st Edition, 2009

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	---	---	---
Understand	20	50	---
Apply	60	20	---
Analyze	20	30	100
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define autonomous vehicle.
2. Define autonomous driving
3. List any four types of techniques for lane detection.
4. Recall GNSS

Understand

1. Explain low level motion control
2. contrast the importance of perception.
3. Justify the need of road recognition algorithm.
4. Illustrate differential GPS with a neat diagram.

Apply

1. Identify the frameworks for intelligent vehicles.
2. Identify the approaches for lane detection,
3. Make us of basic mean shift algorithm for road recognition
4. Develop the Real-Time Kinematic for GPS

Analyze

1. Analyze robot operating system (ROS)
2. Examine the interactive safety framework
3. Contrast Satellite-Based Augmentation Systems.
4. Inspect LiDAR technology
5. CMU Navlab, a premier autonomous vehicle manufacture company, designs a new hardware computation platform for autonomous driving. It consists of two compute boxes, each equipped with an Intel Xeon E5 processor and four to eight Nvidia K80 GPU accelerators. The second compute box performs exactly the same tasks and is used for reliability: in case the first box fails, the second box can immediately take over. It is being observed that in the worst-case scenario, when both boxes run at their peak, they account for 5000 W of power consumption which would consequently generate enormous amount of heat. Also, each box costs $20,000–$30,000, making the whole solution unaffordable to average consumers. It is also observed that the power, heat dissipation, and cost requirements of this design prevents autonomous driving to reach the general public. As an engineer, examine the edges of the envelope and inspect some suitable alternatives so as the autonomous driving system could perform better and will be affordable to average consumers. **(For Open Book Examination and not for semester end examination)**

19EEH33 Introduction to Robust Control Systems

4 0 0 4

Course Outcomes

1. Illustrate various control system representations
2. Classify the norms of signals and systems
3. Develop feedback loop to determine stability and other characteristics
4. Outline the modeling of standard M-Δ configuration
5. Illustrate the robust stabilization under the presence of uncertainty
6. Develop the linear fractional transformation for a SISO system using uncertainty

COs – POs Mapping

COs	PO_2	PO_3	PSO_1	PSO_2
1	2	2	1	1
2	2	2	1	1
3	3	3	2	2
4	2	2	1	1
5	2	2	1	1
6	3	3	2	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit 1

Preliminary concepts on robust control

Introduction to Basic Concepts – control system representations, linear subspaces, eigen values and eigen vectors, matrix inversion formulas, invariant subspaces, norms for signals and systems

State-space realizations for transfer matrices

(15 Hours)

Unit II

Stability

Stability of LTI systems, basic feedback loop, internal stability and stable inverses, singular value decomposition (SVD), semi-definite matrices.

MIMO input-output controllability

(15 Hours)

Unit III

Modeling of Uncertainty

Unstructured uncertainties – additive & inverse additive perturbation, input multiplicative & output multiplicative perturbation, inverse input & inverse output multiplicative perturbation, left and right coprime factor perturbations.

Fundamental concept of robustness and the relationship between physical systems and mathematical models.

(15 Hours)

Unit IV

Robust Stabilization

Parametric uncertainty, Linear Fractional Transformations. Structured uncertainties and the standard M-Δ configuration. Small-Gain Theorem and Robust Stabilization - robust stability under stable unstructured uncertainties.

Case study of a classical SISO plant

(15 Hours)
(Total: 60 Hours)

Textbook (s)

1. Da-Wei Gu, Petko H. Petkov, Mihail M. Konstantinov, "*Robust Control Design with MATLAB*", Springer 2nd Edition, 2013.
2. Sigurd Skogestad, Ian Postlethwaite, *"Multivariable Feedback Control Analysis and Design"*, 2nd Edition, 2001

Reference (s)

1. Kemin Zhou, John C, Doyle, *"Essentials of Robust Control*", Prentice-Hall, Upper Saddle River, New Jersey, 1st Edition, 1998.
2. Michael Green, David J. N. Limebeer, *"Linear Robust Control*", Pearson Education, 2nd Edition, 2001
3. U. Mackenroth, "*Robust Control Systems – Theory and Case Studies*", Springer-Verlag Berlin Heidelberg, 1st Edition, 2004.
4. John Doyle, Bruce Francis, Allen Tannenbaum, "*Feedback Control Theory*", Macmillan Publishing Co., 1st Edition, 1990.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	30	30	---
Understand	30	30	---
Apply	40	40	100
Analyze	---	---	---
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Define Norm of a system
2. Recall stability
3. Recall internal stability
4. List the types of perturbations
5. What is additive perturbation

Understand

1. What is the difference between various norms of a signal?
2. Explain internal stability
3. Explain stable inverses
4. Explain unstructured uncertainty
5. Explain linear fractional transformation

Apply

1. Consider the family of plant transfer functions given below

   $\frac{1}{s^2 + as + 1}, \quad 0.4 \leq a \leq 0.8.$ Thus, $a = 0.6 + 0.2\Delta, \quad -1 \leq \Delta \leq 1,$

   How can you express the family of plant transfer functions?
2. Consider the unity-feedback system with
   $G(s) = \frac{p}{(s+1)(s+\alpha)}; C(s) = \frac{1}{s}$
   For what range of α (a real number) is the feedback system internally stable? Find the upper and lower gain margins as functions of α.
3. Consider a "true" plant $G'(s) = \frac{3e^{-0.1s}}{(2s+1)(0.1s+1)^2}$.
   (a) Derive and sketch the additive uncertainty weight when the nominal model is $G(s) = \frac{3}{(2s+1)}$
   (b) Derive the corresponding robust stability condition.
   (c) Apply this test for the controller K(s) = k/s and find the values of k that yield stability. Is this condition tight? **(For Open Book Examination and not for semester end examination)**
4. Consider the following alternative form of parametric zero uncertainty

$$G_p(s) = (s + z_p)G_0(s); \; z_{min} \leqslant z_p \leqslant z_{max}$$

which caters for zeros crossing from the LHP to the RHP through the origin (corresponding to a sign change in the steady-state gain). Show that the resulting multiplicative weight is $w_I(s) = \frac{r_z \bar{z}}{s+\bar{z}}$ and explain why the set of plants given by $G_p(s)$ is entirely different from that with the zero uncertainty in "time constant" form in equation $G_p(s) = \left(1+\tau_p s\right)G_0(s); \tau_{min} \leqslant \tau_p \leqslant \tau_{max}$. Explain what the implications are for control if $r_z > 1$. **(For Open Book Examination and not for semester end examination)**

19EEH34 Optimal Control Systems

4 0 0 4

Course Outcomes

1. Outline the concepts of optimal control.
2. Summarize calculus of variations, pontryagin minimum principle and dynamic programming methods
3. Analyze various optimal control methods
4. Develop linear quadratic regulator for a given application
5. Develop linear quadratic tracking system for a given application
6. Analyze the stability of optimal linear quadratic tracking system

COs – POs Mapping

COs	PO_2	PO_3	PSO_1	PSO_2
1	2	2	2	1
2	2	2	2	1
3	3	3	3	3
4	3	3	3	2
5	3	3	3	2
6	3	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Introduction to optimal control & Calculus of variations

Introduction- Optimization- Optimal Control- Plant, Performance Index, Constraints, Formal Statement of Optimal Control System

Calculus of variations: Fundamental concepts, Functional of a single function, Functional involving several independent functions, Constrained Extrema, Necessary conditions for optimal control.

Hamiltonian formalism and mechanics

(15 Hours)

Unit II

Dynamic programming

Pontryagin Minimum Principle-Constrained System, Necessary condition, Minimum time problem, Minimum control effort problem.

Optimal control law, Principle of optimality, Dynamic programming concept, Optimal Control of Continuous-Time Systems, Hamilton-Jacobi-Bellman equation.

Continuous linear regulator problem

(15 Hours)

Unit III

Linear Quadratic Optimal Control Systems

Problem formulation – Finite time Linear Quadratic regulator, Analytical Solution to the Matrix Differential Riccati Equation-Infinite time LQR system-Time Varying case, Time-invariant case.

Stability issues of Time invariant regulator

(15 Hours)

Unit IV

Linear Quadratic Tracking System

Linear Quadratic Tracking System- Finite-Time Case, Infinite-Time Case, Fixed-End-Point Regulator System, LQR with a Specified Degree of Stability, Frequency-Domain Interpretation

Variational Calculus for Discrete-Time Systems

(15 Hours)

(Total: 60 Hours)

Textbook (s)

1. D.E.Kirk, *"Optimal Control Theory- An Introduction"*, Dover Publications, New York, 2004.

2. Frank L. Lewis, DragunaVrabie, Vassilis L. Syrmos, *"Optimal Control",* Wiley Publication, 3rd Edition, 2012.
3. D. Subbaram Naidu, *"Optimal Control Systems",* CRC Press, New York, 1st Edition, 2003.

Reference (s)

1. B.D.O. Anderson and J.B.Moore, *"Optimal Control – Linear Quadratic Methods"*, Prentice-Hall of India, 1st Edition, 1991.
2. S.H.Zak, *"Systems and Control"*, Oxford University Press, 1st Edition, 2006.
3. R.T.Stefani, B.Shahian, C.J.Savant, J.G.H.Hosletter, *"Design of Feedback Control Systems",* Oxford University Press, 1st Edition, 2009.

Internal Assessment Pattern

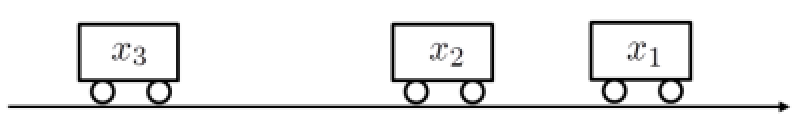
Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	25	25	---
Understand	50	25	---
Apply	---	25	50
Analyze	25	25	50
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)
Remember
1. Define an optimal control problem
2. Recall the two basic principles of 'Dynamic Programming'
3. Define the riccati equation and its importance

Understand
1. Explain how to formulate the optimal control problem?
2. Explain the principle of optimality and principle of causality of Dynamic programming
3. Explain tracking system in finite and infinite case

Apply
1. Solve for the optimal control law $U^x(t)$ for the system
$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -10 & 0 \end{bmatrix} x + \begin{bmatrix} 0 \\ 10 \end{bmatrix} U$$
which minimizes the performance index, $J = \frac{1}{2}\int_0^2 U^2 dt$
2. Develop the formulation of continuous linear regulator problem using state variable approach
3. A first order system is described by differential equation
$$x(\dot{t}) = u(t) + x(t)$$
Solve the control law using Hamilton-Jacobi Bellman equation such that performance index and final time T is specified
$$J(x) = \frac{1}{4}x^2(T) + \int_0^T \frac{1}{4}U^2(t)dt$$

Analyze
1. Analyze how linear state regulator is used for accommodation of external disturbances acting on the process
2. Consider three cars moving on the same lane, whose initial locations at time t = 0 are $X_1(0) = X_2(0) = X_3(0) = 0$. The above figure exemplifies the movement of cars in 1-D. Suppose the goal is for all three cars to meet at the same location (it does not matter where this meet-up location is). To achieve this goal, the following system dynamics can be designed, where $u(t)$ is an input control for the leading car:

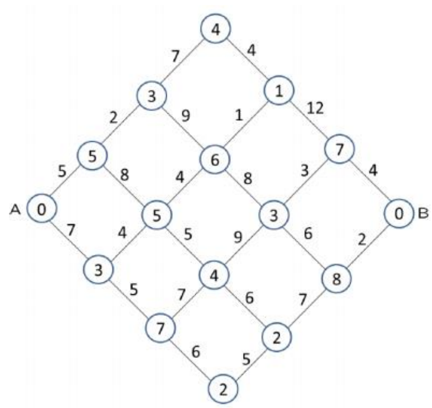


$$\dot{x_1}(t) = x_2(t) - x_1(t) + u(t) \quad (1)$$
$$\dot{x_2}(t) = \frac{x_1(t)+x_3(t)}{2} - x_2(t) \quad (2)$$
$$\dot{x_3}(t) = x_2(t) - x_3(t) \quad (3)$$

In other words, the leading and trailing cars will both move toward the middle car instantaneously; while the middle car will move towards the center of the leading and the trailing cars.

Assess the following CT-LTI system properties: stability, controllability, stabilizability, observability, and detectability, given that the outputs for the system are the first two states, i.e., X_1 (t) and X_2 (t). You'll have to obtain the C-matrix. **(For Open Book Examination and not for semester end examination)**

3. Suppose in the above graph, one starts from node A on the left and tries to reach node B on the right by only moving to the right at each step. The cost of any path is the sum of the following: • the cost of all the edges it passes through as indicated by the numbers above the edges • the cost of all the intermediate nodes it visits as indicated by the numbers inside the circles.



(a) Use the dynamic programming method to find the path from A to B with the smallest cost. You should only use dynamic programming to solve the above problem. You receive no credit if you don't show how you applied DP. Once you're done, draw a diagram/map that shows the DP-solution that exemplifies your numerical solution **(For Open Book Examination and not for semester end examination)**

Domain IV: Power Electronics and Drives

19EEH41 Advanced Power Electronics

4 0 0 4

Course Outcomes

1. Explain the operation of switch-mode power electronic converters
2. Analyze the performance parameters of resonant converters
3. Examine the benefits of soft-switching in power electronic converters
4. Contrast multilevel and modular power electronic converters
5. Select appropriate phase shifting converter for a multi-pulse converter
6. Design power electronic converter for a given application

COs – POs Mapping

CO	PO_2	PO_3	PSO_1	PSO_2
1	2	2	1	1
2	3	3	3	3
3	3	3	3	3
4	2	2	1	1
5	3	3	2	2
6	3	3	2	2

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Switching Voltage Regulators

Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, Push-pull converter, Sepic Converter

Multi-output switch mode regulator.

(15 Hours)

Unit II

Resonant Converters

Introduction, Need of resonant converters, Classification of resonant converters, Load resonant converters, Resonant switch converters, zero-voltage switching dc-dc converters, zero current switching dc-dc converters

Clamped voltage topologies.

(15 Hours)

Unit III

Multi-level Converters

Need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, Flying capacitor and Cascaded H-bridge multilevel converters configurations; Features and relative comparison of these configurations applications.

Carrier based PWM technique for multi-level converters.

(15 Hours)

Unit IV

Multi-pulse Converters

Concept of multi-pulse, Configurations for m-pulse (m=12,18,24 ….) converters, Different phase shifting transformer (Y-Δ1, Y- Δ2, Y-Z1 and Y-Z2) configurations for multi-pulse converters.

Advantages & applications of Multi-pulse Converter.

(15 Hours)

(Total: 60 Hours)

Textbook (s)

1. Ned Mohan, Tore M. Undeland and William P. Robbins, "*Power Electronics –Converters, Applications and Design*", John Willey & sons, Inc., 3rd edition. 2003.
2. Muhammad H. Rashid, "*Power Electronics -Circuits, Devices and Applications*", Prentice Hall of India, 3rd edition., 2009.
3. P. C. Sen, "*Modern Power Electronics*", S. Chand and Co. Ltd., New Delhi, 2000.

Reference (s)

1. Muhammad H. Rashid , "*Power Electronics Handbook*", Elsevier, 3rd edition., 2011.
2. L. Umanand, "*Power Electronics Essentials and Applications*", Tata Mc-Graw Hill, 2009.

Sample Question (s)
Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	10	10	---
Understand	30	30	---
Apply	40	40	20
Analyze	20	20	40
Evaluate	---	---	40
Create	---	---	---
Total (%)	100	100	100

Remember
1. Mention Advantages and disadvantages of switch mode power supplies.
2. What are the advantages of resonant converters?
3. Mention the applications of Multi level converters.

Understand
1. Explain the operation of Push-Pull converter.
2. Explain working of Series resonant converter.
3. Explain the concept of multi-level in converter.

Apply
1. Develop a Boost converter for separately excited DC motor
2. Identify a suitable DC-DC converter for low power applications
3. Develop a multi-level converter for high power applications with less harmonics

Analyze
1. Analyze M-type ZCS resonant converter
2. Compare the performance of Flying capacitor and Cascaded H-bridge multilevel Converters configurations
3. Compare the performance of different phase shifting transformer configurations for multi-pulse converters
4. Evaluate
   (i) Operating mode (CCM or DCM)
   (ii) Operating duty ratio and
   (iii) The primary current wave shape and its peak value of the following 10 W Flyback converter shown in Fig. 1

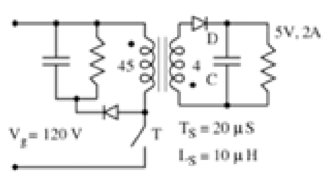


Fig. 1 Flyback converter

(For open book Examination not for semester end examination)

5. Analyze 5th and 7th harmonic elimination in 12- pulse converter With the help of circuit diagram and output voltage phasor diagram of 12-pulse converter.
   (For open book Examination not for semester end examination)

19EEH42 Flexible AC Transmission Systems

4 0 0 4

Course Outcomes

1. Outline the importance and scope of FACTS controllers
2. Classify FACTS controllers
3. Analyze the performance of shunt controllers and reactive power injection
4. Analyze the performance of series controllers and current injection.
5. Analyze combined series and shunt controllers for the given power system network
6. Analyze the performance of UPFC and Interline Power Flow Controller

COs – POs Mapping

COs	PO_2	PO_3	PSO_1
1	2	2	1
2	2	2	1
3	3	3	3
4	3	3	3
5	3	3	3
6	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

General System Considerations **(15 Hours)**

Transmission Interconnections, flow of power in AC systems, Loading capability, power flow and Dynamic Stability considerations of a transmission interconnections, Relative importance of controllable parameters.

Basic types of FACTS Controllers, Benefits from FACTS technology, HVDC versus FACTS. Voltage and current rating – Losses and speed of switching.

Parameter trade–off devices.

UnitII

Shunt Compensation **(15 Hours)**

Static shunt compensators-Objectives of Shunt compensation, Methods of controllable VAR generation-TCR, Mid–point voltage regulation for line segmentation – End of line voltage support to prevent voltage instability –,TSC, FC-TCR, TSC-TCR, STATCOM,

Improvement of transient stability

Unit III

Series Compensation **(15 Hours)**

Objectives of series compensation, Variable impedance type series compensators -GCSC, TSSC, TCSC and SSSC, Switching converter type series compensators. Three–phase full wave bridge converter– Three–phase current source converter

Comparison of current source converter with voltage source converter.

Unit IV

Combined Series and Shunt controllers **(15 Hours)**

Static Voltage Regulators, Objectives of voltage and Phase Angle Regulators, Thyristor Controlled Phase Angle Regulators, Switching converter based Phase Angle Regulators, Unified Power Flow Controller (UPFC) and Interline Power Flow Controller.

Application of these controllers on transmission lines.

(Total: 60 Hours)

Textbooks:

1. Narain G. Hingorani and Laszlo Gyugyi, "*Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems*" IEEPress, Wiley, 2001.
2. K. R. Padiyar, "*FACTS Controllers in Power Transmission & Distribution* ", New Age International (P) Ltd., 2^{nd} edistion,2009.

3. R. Mohan Mathur and Rajiv K. Varma, "*Thyristor Based FACTS Controller for Electrical Transmission Systems",* JohnWiley& sons,2011.

Reference books:

1. E. Acha, V. G. Agelidis, O. Anaya-Lara, T. J. E. Miller,"*Power Electronic Control in Electrical Systems"* Newnes Power Engineering Series, Oxford, 2002.

Sample Question (s)

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	10	10	---
Understand	50	40	---
Apply	---	---	40
Analyze	40	50	60
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Remember

1. List varioustypes of FACTS controllers
2. Define controllable VAR generation
3. Name the technical benefits of FACTS technology
4. List out the requirements of shunt compensation
5. List any three applications of UPFC

Understand

1. Explain the power flow considerations of a transmission interconnected systems
2. Illustrate the improvement of voltage stability using shunt compensation
3. Explain various loading capability limits in power flow systems
4. Summarize features of thyristor controlled reactor

Apply

1. Model thyristor controlled reactor.
2. Identify a suitable FACTS controller that improves voltage for a radial line.
3. Identify a suitable FACTS controller that controls both active and reactive power in a transmission line.
4. Model STATCOM for reactive power control.

Analyze

1. Compare series and shunt compensation.
2. Distinguish STATCOM and SVC in the following(i) V-I characteristics (ii) transient stability.
3. Examine the operation of UPFC.
4. Analyze the performance of GCSC.
5. Analyze the active power and reactive power profiles of a Windfarm connected to infinite bus using SSSC. Discuss the impacts of a STATCOM and SSSC on a power system with wind energy penetration under normal operating conditions, changing load conditions and in post-fault voltage recovery conditions**. (For open book Examination not for semester end examination)**
6. Analyze the performance of Wind Farm Connected to Distribution Network using SC and TCSC, and also discuss the position of the FACT devices to enhance transmission and stability of the system. Discuss with necessary block diagrams with locating the FACT devices.
   (For open book Examination not for semester end examination)

19EEH43 Power Electronic Control of DC Drives

4 0 0 4

Course Outcomes

1. Outline the speed control and braking methods of rectifier fed DC drives
2. Illustrate the performance characteristics of rectifier fed DC drives
3. Design the suitable AC to DC converter to control the DC motor
4. Design the suitable DC to DC converter to control the DC motor
5. Illustrate the closed loop control of chopper fed DC motor Drives
6. Develop the simulation model of DC drives

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	1
2	2	2	1
3	3	3	2
4	3	3	2
5	2	2	1
6	2	2	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I Single phase-controlled rectifier fed DC Motor Drive

Separately excited DC motors, Shunt motor, series motor and compound motor, Controlled Bridge Rectifier (1-ϕ) with DC Motor Load, separately excited DC motors with rectified single-phase supply-single phase semi converter and single-phase full converter for continuous and discontinuous modes of operation–power and power factor.

Harmonic Analysis in converter **(15 Hours)**

Unit II Three phase-controlled rectifier fed DC Motor Drive

Controlled Bridge Rectifier (3- ϕ) with DC Motor Load, Three phase semi converter and three phase full converter for continuous and discontinuous modes of operation–power and power factor –Addition of Freewheeling diode. Three phase naturally commutated bridge circuit as a rectifier or as an inverter, three phases Controlled bridge rectifier with passive load impedance, resistive load and ideal supply–Highly inductive load and ideal supply for load side and supply side quantities, shunt capacitor compensation, three phase-controlled bridge rectifier inverters.

Harmonic Analysis in inverter **(15 Hours)**

Unit III

Chopper controlled DC motor Drives

Open loop Transfer functions of DC Motor drive - Closed loop Transfer function of DC Motor drive, Chopper controlled DC motor drives-Principle of operation of the chopper–Four quadrant chopper circuit–Chopper for inversion–Chopper with other power devices–model of the chopper–input to the chopper–Steady state analysis of chopper-controlled DC motor drives –rating of the devices.

Phase-Locked loop control **(15 Hours)**

Unit IV

Closed loop control of chopper fed DC motor Drives

Speed controlled drive system–current control loop–pulse width modulated current controller–hysteresis current controller –modeling of current controller –design of current controller, Simulation of DC motor Drives-Dynamic simulations of the speed-controlled DC motor drives –Speed feedback speed controller–command current generator –current controller.

Simulation of the speed controlled DC drive using **(15 Hours)**

(Total: 60 Hours)

Textbook(s)

1. Gopal K. Dubey, Fundamentals of Electric Drives, Narosa Publications, 2nd Ed., 2001.

2. R. Krishnan, Electrical drives: Modelling, Analysis and Control, Prentice Hall of India., 1st Ed., 2007.

Reference book(s)

1. Shepherd, Hulley and Liang, Power Electronics and Motor Control, Cambridge University Press, 1995.
2. M. H. Rashid, Power Electronic Circuits, Devices and Applications, 3rd Ed, Prentice Hall of India, 2004.

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	50	50	---
Apply	30	30	100
Analyze	--	--	--
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. Draw the speed-torque characteristics of separately excited DC motor.
2. What is the difference between continuous & discontinuous conduction modes?
3. How the ratings of semiconductor switch will decide?
4. What is pulse width modulation?

Understand

1. Explain the operation of single phase fully controlled rectifier fed separately excited DC Motor.
2. Explain the four-quadrant operation of chopper fed separately excited DC Motor.
3. Explain the operation of three phase fully controlled rectifier fed separately excited DC Motor.
4. Explain hysteresis current control operation in Dc motor drive.

Apply

1. Deduce the closed loop transfer function for DC motor drive.
2. Derive the instantaneous current & critical speed expression for single phase fully controlled rectifier fed separately excited DC Motor.
3. Derive the instantaneous current & critical speed expression for three phase fully controlled rectifier fed separately excited DC Motor.
4. Identify the machine with conveyor application and the machine which is having constant flux in the field system. It is fed with one quadrant converter. The machine is required to run at 1450 rpm. The AC input voltage is 230 V and the machine is having a back emf of 75 V. The thyristors are fired symmetrically at $\alpha = \pi / 4$ in every half cycle, and the armature resistance is 5 Ω. Neglecting the armature inductance, calculate the average armature current and load torque. Identify the design implications of the AC to DC converter. Also construct the conduction table and thereby draw the waveforms of different system variables in the continuous conduction mode of operation of the converter. **(For open book Examination not for semester end examination)**
5. The electric vehicle application requires a DC-DC Converter. The required converter should have a bidirectional power flow. The converter may have four semiconductor switches and four diodes arranged in antiparallel. Identify the design implications of the DC-to-DC converter. Also explain the different modes of operation of the converter. **(For open book Examination not for semester end examination)**

19EEH43 Power Electronic Control of AC Drives

4 0 0 4

Course Outcomes

1. Illustrate the principle of operation and performance characteristics of induction motor drive.
2. Analyze the operation of VSI & CSI fed induction motor speed control.
3. Analyze the speed control of induction motor drive from the rotor side.
4. Explain the field oriented control of induction machine.
5. Illustrate the principle of Vector Control and DTC of induction motor drive.
6. Analyze the performance characteristics and its control strategies of synchronous motor drive.

COs – POs Mapping

COs	PO_2	PO_3	PSO_2
1	2	2	2
2	3	3	3
3	3	3	3
4	3	3	3
5	2	2	2
6	3	3	3

3–Strongly linked | 2–Moderately linked | 1–Weakly linked

Unit I

Stator Controlled Induction Motor Drives

Variable voltage constant frequency operation - Conventional method - Variable voltage characteristics – Control of induction motor by AC voltage controllers - Waveforms - speed torque characteristics - Four quadrant operation – Closed loop speed control - different braking methods.

Constant voltage variable frequency operation - constant Volt/Hz operation - speed torque characteristics, Analysis -Drive operating regions, variable stator current operation and analysis, six step inverter voltage and frequency control - PWM inverter fed induction motor drives - CSI fed IM variable frequency drives - comparison.

Closed loop speed control

(15 Hours)

Unit II

Rotor Controlled Induction Motor Drives

Review of rotor resistance control – Static rotor resistance control – Performance Analysis, Speed torque characteristics –Slip power recovery scheme - Conventional method, Static Kramer drives, Static Scherbius drives, analysis.

Modified Static Kramer Drive

(15 Hours)

Unit III

Field Oriented Control

Field oriented control of induction machines – Theory – DC drive analogy – Direct and Indirect methods – Flux vector estimation - Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes, DTC control strategy.

Advantages and disadvantages of DTC control

(15 Hours)

Unit IV

Synchronous Motor Drives

Introduction, Sinusoidal SPM Machine Drives Sinusoidal IPM machine drives, Trapezoidal SPM machines drives, wound field machine drives, switched reluctance motor drives.

Control Strategies Of Synchronous Motor Drives:
Constant angle control , UPF control , Flux weakening operation, Maximum speed, Direct flux weakening algorithem , Constant Torque mode controller ,Flux Weakening controller , Indirect flux weakening , Maximum permissible torque, speed control scheme , Implementation strategy – Speed controller design.
Cycloconverter fed drive

(15 Hours)
(Total: 60 Hours)

Textbook (s)

1. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education, 1st Edition 2002.
2. R.Krishnan, "Electric Motor Drives – Modeling, Analysis and Control", Prentice-Hall of India Pvt. Ltd., 1st Edition 2003.

Reference (s)

3. Vedam Subramanyam, "Electric Drives – Concepts and Applications", McGraw Hill, 2nd Edition, 2010.
4. Gobal K.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, 2nd Edition,2009

Internal Assessment Pattern

Cognitive Level	Int. Test 1 (%)	Int. Test 2 (%)	Open Book Examination (%)
Remember	20	20	---
Understand	20	20	---
Apply	40	40	100
Analyze	20	20	
Evaluate	---	---	---
Create	---	---	---
Total (%)	100	100	100

Sample Question (s)

Remember

1. What are the different speed control methods of Induction motor from stator side?
2. What are the different speed control methods of Induction motor from rotor side?

Understand

1. Explain the operation three phase AC voltage controller.
2. Explain Self-control of synchronous motor
3. Explain DTC control method.

Apply

1. Select suitable braking method of Induction motor for railway applications
2. Identify the suitable control method of synchronous motor.

Analyze

1. Compare the performance of VSI and CSI to control the Induction motor.
2. Compare the performance of Vector and Scalar control the Induction motor