RAISONI GROUP

a vision beyond

G H RAISONI INSTITUTE OF ENGINEERING & BUSINESSMANAGEMENT JALGAON

An AUTONOMOUS Institution affiliated to KBCNMU, JalgaonNAAC Accredited "A" Grade

Department of

ELECTRICAL ENGINEERING

SYLLABUS STRUCTURE

SEMESTER – 7TH & 8

W. E. F. 2023-24

G H RAISONI INSTITUTE OF ENGINEERING & BUSINESS MANAEGEMENT JALGAON

INSTITUTE VISION

To achieve excellent standards of quality education by keeping pace with rapidly changing technologies and create technical manpower of global standards with capabilities of accepting new challenges.

INSTITUTE MISSION

- Our efforts are dedicated to impart quality and value based education to raise satisfaction level of all stakeholders
- Our strength is directed to create competent professionals.
- Our endeavour is to provide all possible support to promote research and development activities

DEPARTMENT OF ELECTRICAL ENGINEERING

DEPARMENT VISION

To achieve excellent standards of quality education by keeping pace with rapidly changing technologies and to create technical manpower of global standards in electrical engineering with capabilities of accepting new challenges.

DEPARMENT MISSION

- To educate next generation of Engineers with, strong knowledge base of electrical engineering.
- To produce technical manpower capable of addressing industry problems.
- To pursue scholarly research in broad areas of electrical engineering

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B. Tech. in Electrical Engineering

Program Educational Objectives

PEO1	Practice electrical engineering in power system, drives & control
PEO2	Contribute to technical and economic development of society.
PEO3	Pursue higher education and work for research and development of society.

Program Specific Outcomes

PSO1	Demonstrate industrial practices learned through internship and solve the live-problems of industries.
PSO2	Utilize skills in transforming ideas into hardware project and to protectintellectual property rights
PSO3	Propose innovative solutions in the area of Power Systems and Electric Drives.

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Program Outcome:

PO1	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis, and interpretation of data, and synthesis of the information to provide valid conclusions
PO5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	The engineer and society: Apply reasoning informed by the contextualknowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstratethe knowledge of, and a need for sustainable development.
PO8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
PO11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in Multidisciplinary environments
PO12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context oftechnological change

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Department of Electrical Engineering Scheme of B. Tech. Electrical Engineering

Scheme Summary

Semester	Credits	Hours	Marks	No. of Theory Heads	No. of Practical Heads	Total Heads
I	19	27	575	5	7	12
II	18	25	550	5	6	11
III	20	24	550	6	4	10
IV	22	26	550	6	3	9
V	22	27	575	6	5	11
VI	22	31	675	6	7	12
VII	22	29	550	5	4	9
VIII	15	27	450	1	1	2
Total	**160**	**217**	**4500**	**40**	**38**	**78**

Course Category Credits Summary

Semester	No. of Credits for Course Category						TOTAL
	Core (C)	Basic Science and Humanities (BS &H)	Skills (A)	Electives (EL)	Open Electives (OE)	PROJECT/ INTRNSHIP (P)	
I	12	5	2	0	0	0	**19**
II	6	9	3	0	0	0	**18**
III	16	4	0	0	0	0	**20**
IV	14	4	2	0	2	0	**22**
V	16	2	1	3	0	0	**22**
VI	9	5	5	0	2	1	**22**
VII	0	0	0	18	0	4	**22**
VIII	0	0	0	0	3	12	**15**
TOTAL	**73**	**29**	**13**	**21**	**7**	**17**	**160**

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Scheme and Curriculum of B. Tech. Electrical Engineering

Scheme Summary

Semester	Credits	Hours	Marks	No. of Theory Heads	No. of Practical Heads	Total Heads
I	19	27	575	5	7	12
II	18	25	550	5	6	11
III	20	24	550	6	4	10
IV	22	26	550	6	3	9
V	22	28	600	6	6	12
VI	22	31	675	6	7	13
VII	22	29	550	5	4	9
VIII	15	27	450	1	1	2
Total	**160**	**217**	**4500**	**40**	**38**	**78**

Course Category Credits Summary

Semester	No. of Credits for Course Category						TOTAL
	Core (C)	Basic Science and Humanities (BS &H)	Skills (A)	Electives (EL)	Open Electives (OE)	Project/ Internship (P)	
I	12	5	2	0	0	0	**19**
II	6	9	3	0	0	0	**18**
III	16	4		0	0	0	**20**
IV	14	4	2	0	2	0	**22**
V	16	2	1	3	0	0	**22**
VI	9	5	5	0	2	1	**22**
VII	0	0	0	18	0	4	**22**
VIII	0	0	0	0	3	12	**15**
TOTAL	**73**	**29**	**13**	**21**	**7**	**17**	**160**

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Scheme of B. Tech. in Electrical Engineering

Semester-VIIth

Course Code	Name of Course	Course Category	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			L	T	P	Total Hrs		TAE	CAE	ESE	INT	EXT	
SEMESTER- VII													
UEELXXX	Elective-II	EL	3	-	-	3	**3**	10	15	50	-	-	75
UEELXXX	Elective-III	EL	3	-	-	3	**3**	10	15	50	-	-	75
UEELXXX	Elective-IV	EL	3	-	2	5	**4**	10	15	50	25	-	100
UEELXXX	Elective-V	EL	3	-	2	5	**4**	10	15	50	25	-	100
UEELXXX	Elective-VI	EL	3	-	2	5	**4**	10	15	50	25	-	100
UEEP401	Project	P	-	-	8	8	**4**	-	-	-	75	50	125
TOTAL			**15**	**0**	**14**	**29**	**22**						**575**

Semester VIIIth

Course Code	Name of Course	Course Category	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			L	T	P	Total Hrs		TAE	CAE	ESE	INT	EXT	
SEMESTER- VIII													
UISL4XX	MOOCS based open Electives	OE	3	-	-	3	**3**	10	15	50	-	-	75
UEEP402	Internship	P	-	-	24	24	**12**	-	-	-	175	200	375
TOTAL			**3**		**24**	**27**	**15**						**450**

Pool of Track wise Electives

Elective	**Power System**	**Renewable Energy**	**Power Electronics**	**Drives**	**Control**	**Instrumentation**
Track	**Track-I**	**Track-II**	**Track-III**	**Track-IV**	**Track -V**	**Track-VI**
Elective-II (Credits : 3) (Semester-VII)	Substation Engineering(UEEL403)	Electrical Power Distribution System(UEE L404)	Generalized theory of Electrical Machines(UE EL405)	Industrial Drives(UEEL40 6)	Nonlinear Control System(UEE L407)	Advanced Industrial Sensor(UEEL408)
Elective-III (Credits : 3) (Semester-VII)	Advanced Power System Stability(UEE L409)	Renewable and Distributed Energy Systems(UEE L410)	Power Electronics for Renewable Energy Systems(UEE L411)	Electrical Installation Design(UEEL4 12)	Modern Control System(UEE L413)	Robotics(UECL42 1)
Electives with Laboratory						
Elective-IV (Credits : 4) (Semester-VII)	Computer Methods in Power System(UEE L415 /UEEP415)	Smart Grid and Its Applications(UEEL416/UE EP416)	Advanced Power Electronics(U EEL417/UEEP 417)	Power Semiconductor Based Drives (UEEL420/UE EP420)	Sampled Data Digital Control(UEE L419/UEEP4 19)	Industrial Automation (UEEL418/UEEP 418)
Elective-V (Credits : 4) (Semester-VII)	Flexible AC Transmission System(UEE L421/UEEP4 21)	Power System Restructuring and Deregulation(UEEL422/UE EP422)	DSP and Its Applications(UEEL423/UE EP423)	Electric Vehicles(UEEL 424/UEEP424)	Optimal Control System(UEE L425/UEEP4 25)	PLC SCADA(UEEL42 6/UEEP426)
Elective-VI (Credits : 4) (Semester-VII)	AI Applications to Power System(UCS L428/UCSP4 28)	Power Quality Assessment and Mitigation(U EEL428/UEE P428)	Optimization Methods(UISL 406/UISP406)	Electrical Machine Design(UEEL4 30/UEEP430)	Advanced Control Theory(UEE L431/UEEP4 31)	Digital Protection(UEEL4 32/UEEP432)

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Skill Category Courses

SEM	DETAILS	NAME	CREDITS
I	A1	Foreign Language	1
I	A2	Biomedical Engineering	1
II	A3-A4	Introduction to Machine Learning	2
II	A5	Introduction to Drones	1
IV	A6-A7	Energy Audit and Solar photo Voltaic	2
V	A8	Aptitude	1
VI	A9	Campus Recruitment Training	1
VI	A10	Employability skills	1
VI	A11-A12-A13	Internet of Things	3

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Course Title: Elective-II: Substation Engineering										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	--	03	10	15	50	--	
Course Code	UEEL403									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	Explain various substation basics and switching configurations
	2	Interpret the different types of bus bar configurations
	3	Understand the calculations of substation design
	4	To know the various substation equipment &accessories
Course Outcomes	After completion of the course, students will be able to	
	CO1	Design a layout of different voltage substations.
	CO2	Justify the concept of grid, its importance and need for one grid concept.
	CO3	Understand level of substation automation, its architecture and various inputs.
	CO4	Understand GIS system and GIS in distribution management
	CO5	Understand the IEGC structure and role of various power utilities.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	--	2	1	2	--	--	--	--	1	1	--
CO2	3	2	2	--	3	1	2	1	--	--	--	1	2	--
CO3	2	2	2	--	3	2	2	1	--	--	--	2	2	--
CO4	2	1	1	--	2	1	2	--	--	--	--	1	1	--
CO5	2	1	1	--	2	1	2	--	--	--	--	1	1	--

Course Contents:

Unit	Contents	Hours
I	**Introduction:** Classification of substation, layout of substation, function of substation, types of bus bar used in the substation , design and construction of bus bar and earth wire in substation, jumping of conductors, jumping between equipment, stringing of shield/earth wire (Guarding and grounding of HT lines), factors affecting layout of substation. Testing of substation equipment, on load tap changer, commissioning of power transformer, list of material for construction of 132kv, 220kv, 400kv, and 765kv grid sub station	8
II	**Indian power sector and grid management:** introduction, benefits of synchronization of grids, formation of national grid, problems associated with the development of all India grid, Grid characteristics, controlling of transmission line loading, power system security	8
III	**Substation automation system:** Introduction, system architecture, levels of substation automation, list of equipment, list of analogue and digital inputs basic monitoring requirements, IEC 61850 Protocols	6
IV	**Management of Distribution and transmission network using GIS:** Introduction, GIS based system in distribution management. GIS based consumer indexing. Management of sub – Transmission and distribution system in power utilities. Mapping sciences in power sector, data sources in GIS	8
V	**Introduction of IEGC:** Introduction, scope, objective, role of various power utilities, planning criteria, scheduling and dispatch code	6

Text Books	1	Electric Power Substations Engineering, Second Edition (The Electric Power Engineering Hbk, Second Edition)by John D. McDonald
	2	Sub Station Engineering Design, Concepts & Computer Applications 2/E Pb 1st Edition, B.S. Dahiya
E--Books	1.	Electrical Substation Engineering & Practice: EHV-HVDC & SF-GIS

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Course Title: : Elective-II: Electrical Power Distribution System										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.		03	10	15	50		
Course Code	UEEL404									
Teaching Mode	Conventional	3Hrs			Total	75				
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To understand different types of power distributions systems and their usage in days life.
	2	To familiar with protection and coordination of protective devices in distribution systems.
	3	To familiar with short circuit analysis
	4	To understand how power factor can be improved and need for its improvement.
	5	To know the optimal location of substation.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Understand different loads and their characteristics and design the distribution feeders.
	CO2	Design substations and their optimal location
	CO3	Apply various protective devices and its coordination techniques to distribution system.
	CO4	Recognize the necessity of power factor correction and voltage drop compensation
	CO5	Analyze the characteristics of Voltage regulating Equipment

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes Cos	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	--	--	--	--	--	--	--	--	--	1	1
CO2	3	2	2	--	--	--	--	--	--	--	--	--	2	2
CO3	2	2	--	--	--	--	--	--	--	--	--	--	1	--
CO4	3	2	--	--	--	--	--	--	--	--	--	--	2	--
CO5	2	2	--	--	--	--	--	--	--	--	--	--	1	--

Course Contents:

Unit	Contents	Hours
I	**General Concepts:** Introduction on distribution systems, Load modeling and their characteristics, Load factor, Coincidence factor, Contribution factor and Loss factor and their relationships, Residential, Commercial, Agricultural and Industrial types of loads and their characteristics. **Distribution Feeders:** Primary and Secondary Feeders; Types of Primary Feeders (Radial and Loop)	8
II	**Distribution Substations:** Location of Substations: Distribution substation rating, area of substation with n- primary feeders, Benefits and finding of optimal location of substations. Calculation for voltage drop and Power loss in lines, Methods of solution for radial networks, three phase balanced primary lines, Analysis of non-three phase systems.	7
III	**Protection of Distribution System:** Objectives of distribution system protection; Classification of faults and their calculation procedure; Types of Protective devices and their principle of operations (Fuses, Circuit Reclosures, Circuit Breakers) Coordination of Protective Devices: Objectives and the procedure of protection coordination	7
IV	**Power Factor Improvement:** Importance of Power factor and its need, Application of Capacitor for power factor improvement, Types of power capacitors (Series and shunt capacitors) and their effect, synchronous condenser correction in power factor, optimal location determination process and its economic justification.	6
V	**Voltage Control:** Voltage regulators in distribution systems, Voltage control strategy,	6

	Distribution Planning, Automation, and Optimization.	

Textbooks	1	Anthony J. Pansini "*Electrical Distribution Engineering*", CRC Press, 2005.
	2	Electric Power Distribution Engineering, Turan Gonen, CRC Press, 3rd Edition, 2014.
	3	H Lee Willis, "*Distributed Power Generation Planning and Evaluation*", CRC Press, 2000.
	4	James A Momoh, "Electric Power Distribution Automation Protection and Control" CRC Press, 2007.
Reference Books	1	James J. Burke "Power distribution engineering: fundamentals and applications", CRC Press, 2004
	2	A. Pabla, *"Electric Power Distribution",* McGraw-Hill, 2005.

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Course Title: : Elective –II : Generalized Theory of Electrical Machines										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	-	--	03	10	15	50	--	--
Course Code	UEEL405									
Teaching Mode	Conventional	3Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To develop the basic elements of generalized theory
	2	To derive the general equations for voltage and torque of all type of rotating machines
	3	To deal with the steady state and transient analysis of rotating machines
Course Outcomes	After completion of the course, students will be able to	
	CO1	Analyze machine behavior based on the voltage and torque equations of the machine.
	CO2	Analyze the transient behavior of machines
	CO3	Analyze the steady state and transient analysis of rotating machines

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2	2	1	1	--	--	--	--	--	--	2	2
CO2	3	3	2	2	1	1	1	--	--	--	--	1	2	2
CO3	3	2	2	2	1	1	1	--	--	--	--	1	2	2

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Unit	Contents	Hours
I	**Introduction**: Electrical machine performance analysis- An unified approach; per unit system consideration; two pole modeling of rotating machines; primitive and non-primitive machine; rotational voltages; torque equations; resistance, inductance and torque matrix.	9
II	**Transformations**: Transformation from three phase to two phase; transformation from rotating axes to stationary axes; Passive linear transformation in electrical machines; transformation from a displaced brush axis; Restrictions of the Generalized theory of machines.	6
III	**DC Machines**: Application of generalized theory to various types of DC machines and analyses its steady and transient state; Separately excited dc generator-Sudden short circuit analysis, Separately excited dc motor- sudden inertia load incorporation analysis.	8
IV	**Synchronous Machines**: Reactance and time constants; Primitive machine model with damper windings on both axes; Steady state analysis; Transient analysis- sudden three phase short circuit at generator terminals – armature currents and torque; power angle curve.	8
V	**Induction Machines**: Primitive machine model representation; Steady state analysis; Equivalent circuit; Torque-slip characteristics.	7

Text Books	1.	P. S. Bhimbra, 'Generalized Theory Of Electrical Machines', Khanna Publishers, 2002.
	2.	Charles V. Johnes, 'Unified Theory Of Electrical Machines
Reference Books	1.	Adkins, Harley, 'General theory of ac machines'
	2.	M. G. Say, 'Introduction to Unified Theory of Electrical Machines
on line TL Material	1.	

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Course Title: Elective –II : Industrial Drives										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	--	03	10	15	50	--	--
Course Code	UEEL406									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To expose students to the operation, application and control of power conversion systems employing electric drive to cater to industrial needs.
	2	To introduce the concept of selection, Justification and Utilization of Electric drives
	3	To familiarize the operation principles, and design of starting, braking, and speed control arrangements for electric motors and their applications.
	4	To provide strong foundation to asses performance of different industrial drives considering issues such as, energy efficiency, power quality, economic justification, environmental issues, and practical viabilities.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Understand basics of electric drives
	CO2	Maintain the functioning of DC drives
	CO3	Maintain the functioning of AC drives
	CO4	Identify the relevant of electric drive
	CO5	To design and analyze different advanced control schemes of induction machines.

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	1	2	1	3	2	--	--	--	--	2	2	-
CO2	3	2	1	2	2	2	2	--	--	--	--	2	1	1
CO3	3	2	1	2	2	2	2	--	--	--	--	2	1	-
CO4	3	3	2	1	1	2	3	--	--	--	--	3	2	1
CO5	3	3	3	2	2	3	3	--	--	--	--	2	3	3

Course Contents:

Unit	Contents	Hours
I	**An Introduction to Electrical Drives:** AC and DC Electrical drives, elements of electrical drives, Advantages and disadvantages of electrical drives, selection of electrical drives, Electrical drives dynamics, multi-quadrant operation, speed torque convention and torque equation, equivalent drive parameter values, load torque component, type and categories the load torques, time and energy loss computation in transient operation, steady state stability, load equalization.	08
II	**Introduction of industrial drives :**DC Motor Drives ,Induction Motor (Cage) Drives, Induction Motor (Wound Rotor) Drives, Synchronous Motor Drives, Control Systems	09
III	**Rolling Mill Drives:** Reversing Mill Drives, Screw-down Mechanism, Continuous Mills, Cold Rolling Mills and Automatic Gauge Control **Cement Mill:**Weighfeeder, Mill Drive, Separator, Blower Drive, Cyclone **Coal Mines:** Precautions, Drum Winder, Modern Winder Drives, Shearer, Conveyors in Long-wall Systems, Auxiliary Motors	08
IV	**Paper Mill:** Pulp Manufacture, Paper Manufacture, Paper Mill Drives and Control **Machine Tool Drives:** Lathe, Drilling Machine, Milling Machine, Shaping Machine, Planer, Grinding Machine, Hydraulic Drives **Textile Mill:** Spinning Mill, Weaving, Loom Motors	06
V	**Electric Traction:** Tractive Effort, Requirements of Electric Traction, Suitability of Series Motors, Coefficient of Adhesion, Supply Systems and Traction Motors, Train Movement, Layout of Electric Drives, Speed Control	05

Textbooks	1	G.K.Dubey, "Fundamentals of Electrical Drives", Narosa Publishers,2001
	2	A first course on Electrical Drives, S.K. Pillai, , New Age International Publication.
	3	Vedam Subramanyam, "Electric Drives", Tata McGraw Hill Publishing Company.
E books	1	"Control of Electrical Drives" by W Leonhard
	2	"Electric Drives" by De Nisit K and Sen Prasanta K
	3	"Electric Drives" by D P Kothari and Rakesh Singh Lodhi
Reference Books	1	Ion Boldera, S.A.Nasar, "Electric Drives", Taylor and Francis Publishing company
	2	Electric motor drives, R. Krishnan, PHI
	3	Modern Power Electronics & Ac drives, B.K. Bose, Pearson Education
	4	Electric Motor & Drives. Austin Hughes, Newnes.

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Course Title: Elective –II : Non linear Control System										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	--	03	10	15	50	--	
Course Code	UEEL407									
Teaching Mode	Conventional	3Hrs			Total	75			---	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	Classify different types of nonlinearity and it's characteristics
	2	Make use of study of various methods to analyze and design of nonlinear system
	3	Study various methods of linearization
	4	Study of Fundamentals of Lyapunov Theory for advanced stability
Course Outcomes	After completion of the course, students will be able to	
	CO1	Derive and describe the methods for Phase Plane Analysis and Describing function
	CO2	apply the Phase Plane Analysis and Describing function method to specific systems.
	CO3	derive and describe the feedback linearization
	CO4	apply the method of feedback linearization to specific systems

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	2	3	----	----	----	----	---	---	----	1	2
CO2	3	2	1	2	3	----	----	----	----	---	---	----	1	--
CO3	3	2	2	3	3	----	----	----	----	---	---	----	1	2
CO4	3	3	1	2	3	----	----	----	----	---	---	----	1	2

Course Contents:

Unit	Contents	Hours
I	**Introduction:** Introduction to nonlinearities and nonlinear phenomenon, Nonlinear system behavior, Needs of nonlinear control system and its examples.	**06**
II	**Phase Plane Analysis:** Concepts of Phase Plane Analysis: Phase Portraits; Singular Points; Symmetry in Phase Plane Portraits, Methods of Constructing Phase Portraits: Analytical method, the method of Isoclines, Delta Method Determining time form Phase Portraits, Phase Plane Analysis of linear systems, and Phase Plane Analysis of nonlinear systems, limit cycles .	**10**
III	**Describing Function Method:** Describing function fundamentals: An example of describing functions; Computing describing functions, Derivations of describing functions of common nonlinearities, Describing function analysis of nonlinear systems	**06**
IV	**Fundamentals of Lyapunov Theory**: Introduction, Nonlinear Systems and Equilibrium Points. Autonomous and Non-autonomous systems, Concept of Stability, Asymptotic stability and exponential stability, Local and global stability, Linearization and Local stability, Lyapunov's linearization method, Lyapunov's direct method, Positive definite functions, and Lyapunov's functions, Equilibrium Point theorems; Lyapunov theorem for local and global stability.	10
V	**Feedback Linearization:** Intuitive concepts: Feedback linearization and canonical form; Input-state; Input-output linearization, Mathematical tools, Input-state linearization of SISO systems; Generating a linear input-output relation.	**08**

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Simulate the various nonlinearities using Op. Amps.
2	Construct Phase Plane Trajectory by any method and compare it with MATLAB simulation for a nonlinear system
3	Determination of stability of nonlinear systems using Lyapunov function.
4	Construct trajectories of Vander Pol's equation.
Open Ended Experiments / New Experiments	
1	
2	
Details of on line Laboratory Resource Material Instruction / Operating Manuals	
1.	
2.	

Textbooks	1	J. E. Slotine and w. Li, Applied Nonlinear Control., Prentice Hall Inc. Englewood cliffs, New Jersey 1995.
	2	M. Vidyasagar, Nonlinear System Analysis, Prentice-Hall Inc. Englewood cliffs, New Jersey 1978.
	3	Gibson, Nonlinear Automatic Control, Tata Ma-Graw Hill, 1963.
	4	Nonlinear Systems: Hasan A. Khalil, Prentice Hall of India
	5	Principle and Design of Control Systems, M. Gopal. Tata McGraw-Hill Education,2002
Reference Books	1	Gelb A. and Vander Velde W. E., Multiple Input describing Function and Nonlinear System Design, Machrao-Hill (1968).
	2	
	3	A. Isidori, Nonlinear Control System: An Introduction, Springer Yerlag, 1989.
	4	Nonlinear Systems: Analysis, Stability & Control, S.S. Sastry, Springer Verlag, New York, 1999

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Course Title: Elective –II : Advanced Industrial Sensors										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	-	-	03	10	15	50	--	--
Course Code	UEEL408									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To study fusion of multi sensors make them understand their applications.
	2	To train the students selection of sensors for specific application using Artificial intelligent techniques.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Identify, define, names various types of smart sensors, biosensors, fiber optic sensor MEMS, robotics sensors.
	CO2	Describe, draw, and explain the working principle and its possible application of various Intelligent sensors.
	CO3	Analyse problem and develop projects by using various types of intelligent sensors in Agriculture, Environmental, and Automotive industries and Wellness.
	CO4	Evaluate asses and compare various types of intelligent sensors and decide the test selection for particular application like biosensors, environmental sensors.

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	2	2	-	1	-	-	-	-	-	-	2	3	-
CO2	3	3	-	2	1	-	2	-	-	-	-	2	2	-
CO3	3	2	2	2	2	3	2	-	1	-	-	2	2	-
CO4	3	2	3	2	3	3	2	-	1	-	-	2	2	-

Course Contents:

Unit	Contents	Hours
I	**Smart Sensors:** Introduction, Primary sensors, Excitation, Amplification, Filters, Converters Compensation, Nonlinearity, Approximation and regression, Noise and interference, response time, drift, cross-sensitivity, Information Coding/Processing, Data communication, standards for smart sensor interface, the Automation. Introduction, Primary sensors, Excitation, Amplification, Filters, Converters,	**10**
II	**Recent trends in sensor technology** :Introduction, film sensors, thick film sensors, thin film sensors, semiconductor IC technology-standard methods. **MEMS/NANO**: Micro electromechanical systems (MEMS), Micromachining, Biomedical Applications, Nano-sensors, Carbon Nanotubes.	**06**
III	**Chemical Sensors** :Introduction, semiconductor gas detectors, Ion Selective electrodes, Conductometric sensors, Mass sensors.	13
IV	**Robotics sensors:** Introduction, characteristics, types of sensors, touch or tactile sensors, binary and analog sensors, proximity sensors, types of proximity sensors, contact and non- contact proximity sensors, robotic vision. Fiber optic sensors: Fiber optic sensors for the measurement of temperature, Pressure, turbidity, pollution. Biosensors: Enzyme sensors, Cell based biosensors using Microelectrodes, Biosensors in Food Analysis.	**05**

V	**Instrumentation** : Design of RTD, T/C, Thermister based Temperature Instrumentation,Design of Pressure Gauge, Bellows, Bourdon Tube, and Diaphragm based Pressure,Instrumentation. Design of Orifice, Rotameter, Venturi meter flow Instrumentation	**06**

Textbooks	1	Principles of Measurement systems John P. Bentley, Third edition 2000, Pearson.
	2	D. Patranabis, "Sensors and Transducers", Second Edition Prentice Hall of India Pvt. Ltd. New Delhi, 2006.
	3	Middlehook S. and Audet S. A., "Silicon Sensors", Academic Press, London 1999.
	4	Richard C. Dorf, "Sensors, Nanoscience, Biomedical engineering and instruments", CRC Press, Taylor and Francis group USA, third edition, 2006.
	5	Henry Zanger, Cynthia Zanger, "Fiber optics Communication and other applications", Macmillan publishing company, New York, 1991.
Reference Books	1	Raj Mohan Joshi, "Biosensors", First Edition, ISHA Books, Delhi, 2006.
	2	R. K. Rajput, "Robotics and Industrial Automation", S. Chand & company Ltd., First edition, 2008.
	3	D. V. S. Murty, "Transducers and Instrumentation", Second edition, PHI publication, Second edition, 2010.

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Course Title: Elective-III : Advanced Power System Stability										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.		03	10	15	50	-	-
Course Code	UEEL409									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To study the model of synchronous machines.
	2	To study the stability studies of synchronous machines.
	3	To study the solution method of transient stability.
	4	To study the effect of different excitation systems.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Determine the model of synchronous machines.
	CO2	Know the stability studies of synchronous machines.
	CO3	Get the knowledge of solution methods of transient stability.
	CO4	Know the effect of different excitation systems in power systems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	1	1	1	1	1	-	-	-	1	-	2
CO2	2	2	1	2	2	2	1	1	-	-	-	1	-	2
CO3	2	2	3	2	2	1	1	1	-	-	-	1	2	-
CO4	1	2	1	1	1	2	2	2	-	-	-	1	-	2

Course Contents:

Unit	Contents	Hours
I	**System Dynamics:** State space Synchronous machine model from computer representation, excitation and governor system, modelling of induction machines and loads.	8
II	**Steady state stability** : steady state and dynamic stability limit, Dynamic stability analysis, State space representation of infinite bus connected synchronous machine, time response Stability analysis using eigen value method	8
III	**Digital Simulation of Transient Stability:** Swing equation, Representation of loads, Alternate cycle solution method, Direct method of solution, Modified Euler method, Runge Kutta method, Concept of multi machine stability.	6
IV	**Improvement of transient stability** Governor action and exciter effect on power system stability, effect of saturation and automatic voltage regulators on power system stability, effect of saliency on stability.	6
V	**Excitation Systems :** Rotating Main Exciter, Rotating Self-excited Exciter with direct acting Rheostatic type voltage regulator, Rotating main and Pilot Exciters with Indirect Acting Rheostatic Type Voltage Regulator, Rotating Amplifier and Static Voltage Regulator, Static and Brushless excitation system. Power system stabilizer	8

Text Books	1	Power System Stability by Kimbark Vol. I&II, III, Willey.
	2	Power System control and stability by Anderson and Fund, IEEE Press
	3	Power systems stability and control by PRABHA KUNDUR, TMH.
Reference Books	1.	Computer Applications to Power Systems–Glenn.W.Stagg& Ahmed. H.El.Abiad, TMH.
	2	Computer Applications to Power Systems – M.A.Pai, TMH.
	3	Power Systems Analysis & Stability – S.S.VadheraKhanna Publishers

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Course Title: Elective-III: Renewable and Distributed Energy Systems										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	.	03	10	15	50	--	--
Course Code	UEEL410									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To develop fundamental understanding about Solar Thermal and Solar Photovoltaic systems.
	2	To provide knowledge about development of Wind Power plant and various operational as well as performance parameter/characteristics.
	3	To study concept of distributed generation and installation
	4	To describe different Storage systems, Integration and Economics of Renewable Energy System.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Describe various renewable energy sources such as Solar Photovoltaic, Biomass, Wind, Fuel cell.
	CO2	Explain different renewable energy sources as an alternate for conventional power sources in any application of energy.
	CO3	Analyze the concept of distributed generation and installation

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	--	-	1	2	2	1	-	-	-	1	2	-
CO2	3	2	2	-	1	2	2	2	-	-	-	1	2	-
CO3	2	1	2	-	3	2	1	1	-	-	-	1	2	-

Course Contents:

Unit	Contents	Hours
I	**Introduction** Review of world's and India's production and reserves of conventional energy sources, Role and potential of new renewable sources, Distributed generation, Future trends in power generation and distribution.	6
II	**Solar Energy:** Basics of solar PV, Solar PV cell model, emerging solar cell technologies; Solar PV modules from solar cells, Mismatch and hot spots in module, Bypass diode, PV module-power output, P-V and I-V curves, Design and structure modules; BOS of PV system, MPPT algorithms for MPPT, distributed MPPT, battery charging controllers, Types of PV systems; Solar PV Micro-inverters, standalone PV system, Power quality and protection issues.	8
III	**Wind Energy:** Wind energy system and its components, classification of wind turbines and its characteristics, Betz criteria; Control strategy of wind energy systems, Power generation, Performance calculations, Different topologies, WES with rectifier / inverter system, Doubly Fed Induction Generators (DFIG) in Wind Turbines. **Bio-Mass:** Principle of operation of Biomass energy, Types of Bio-gas digesters, combustion characteristics of Bio-gas, I.C. Engine operation and cooking purposes utilization, economic aspects	10
IV	**Renewable sources in distributed generation** - Current scenario in distributed generation – Planning, Optimal location and sizing of DGs—Optimal location selection of DGs. **Grid Integration of DGs-** Types of interfaces (Inverter based and rotating machine based) – cluster of DG units – Different Energy storage elements - Batteries, ultra capacitors, flywheels.	7
v	**Energy Storage systems**: Hydrogen storage: methods of Hydrogen storage. Batteries: Introduction to Batteries, Battery classification, Battery Parameters, Factors affecting battery performance. Grid scale storage, various options available (pumped storage, SMES, compressed air storage, fly wheels, ultra capacitor etc.), Principle operation of fuel cell, Types of fuel cell, performance comparison of fuel cell, applications of fuel cell in power systems.	7

Text Books	1	S.P. Sukhatme, "Solar Energy," Tata McGraw Hill
	2	Chetan Singh Solanki , Solar Photo Voltaics , PHI Learning Pvt Ltd., New Delhi,2009
	3	HashemNehrir and Caisheng Wang, Modeling and control of fuel cells: Distributed Generation Applications, IEEE Press, 2009
Reference Books	1	H. P. Garg, J. Prakash, "Solar Energy-Fundamentals and Applications", Tata McGraw hill Publishing Co.ltd., First Revised Edition
	2	D. P. Kothari, K. C. Singal, RakeshRajan, "Renewable Energy Sources and Emerging Technologies", PHI Second Edition
	4	Thomas Ackermann, "Wind Power in Power Systems", Wiley Publications
	5	Donald L.Klass, "Biomass for Renewable Energy, Fuels, and Chemicals, Elsevier, Academic Press
On line TL Material	1	https://onlinecourses.nptel.ac.in/noc21_ch11/preview
	2	https://nptel.ac.in/courses/108/102/108102047/
	3	https://www.ijert.org/smart-grid-the-future-of-the-electric-energy-system
	4	https://nptel.ac.in/courses/108/108/108108034/
e-Books	1	S. Chakraborty, M. G. Simões and W. E. Kramer, Power Electronics for Renewable and Distributed Energy System, Springer 2013

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Course Title: Elective –III: Power Electronics for Renewable Energy Systems										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	-	03	10	15	50	--	--
Course Code	UEEL411									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	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
CO1	3	1	2	1	2	1	1	--	--	--	--	1	1	1
CO2	2	2	1	1	2	--	--	--	--	--	--	--	1	1
CO3	2	1	2	2	2	2	2	--	--	--	--	1	2	1
CO4	3	2	2	2	3	2	2	--	--	--	--	2	2	2
CO5	2	2	1	1	3	1	2	--	--	--	--	2	2	2

Course Contents:

Unit	Contents	Hours
I	**Introduction :** Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems	**09**
II	**Electrical Machines For Renewable energy Conversion**: Reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG	**9**

III	**Power Converters: Solar:** Block diagram of solar photo voltaic system - Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing **Wind:** Three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters	**09**
IV	**Analysis of Wind And PV Systems:** Stand alone operation of fixed and variable speed wind energy conversion systems and solar system- Grid connection Issues -Grid integrated PMSG, SCIG Based WECS, grid Integrated solar system	13
V	**Hybrid Renewable Energy Systems :** Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).	**05**

Textbooks	1	S. N. Bhadra, D.Kastha, S.Banerjee, "Wind Electrical Systems", Oxford University Press, 2005.
	2	B.H. Khan Non-conventional Energy sources Tata McGraw-hill Publishing Company, New Delhi,2009.
Reference Books	1	Rashid .M. H "power electronics Hand book", Academic press, 2001.
	2	Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
	3	Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
	4	Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
	5	Andrzej M. Trzynnadlowski, 'Introduction to Modern Power Electronics', Second edition, wiley India Pvt. Ltd, 2012

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Course Title: Elective –III: Modern Control System										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.		03	10	15	50	--	---
Course Code	UEEL413									
Teaching Mode	Conventional	3 Hrs			Total	75			---	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To study analysis of multi variable systems using concept of controllability, observability and stability.
	2	To analyze dynamics of a linear system by solving system model/equation or applying domain transformation.
	3	To analyze and design multivariable control system using state feedback and state observers.
	4	To understand relationship between state space and matrix fraction description of multivariable systems
	5	To carry out analysis of multi variable systems using concept of controllability, observability and stability.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Modeling of linear control systems using state space representation.
	CO2	To carry out analysis of multi variable systems using concept of controllability, observability and stability.
	CO3	Analyze dynamics of a linear system by solving system model/equation or applying domain transformation.
	CO4	Analyze and design multivariable control system using state feedback and state observers.
	CO5	To understand relationship between state space and matrix fraction description of multivariable systems

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	1	2	1	2	1	1	--	--	--	--	1	1	1
CO2	2	2	1	1	2	--	--	--	--	--	--	--	1	1
CO3	2	1	2	2	2	2	2	--	--	--	--	1	2	1
CO4	3	2	2	2	3	2	2	--	--	--	--	2	2	2
CO5	2	2	1	1	3	1	2	--	--	--	--	2	2	2

Course Contents:

Unit	Contents	Hours
I	**State Space Description for MIMO Control Systems:** The concept of state and state models, State equations for dynamic systems, State equations using phase, physical and canonical variables, Plant models of some illustrative control systems, State space representation and realization of transfer matrices,Solution of state equation.	**10**
II	**MIMO Control Systems Analysis:** Concept of Controllability and Reachability, Observability and Constructibility, Controllable and Uncontrollable subspace, Observable and unobservable subspace, Controllability and Observability tests: Kalman's test matrix, Gilbert's test, Popov-Belevitch-Hautus test, Controllability and observability canonical forms, Stability and stabilizability theory.	**06**
III	**MIMO Control Systems Design:** Linear state variable feedback: The effect of state feedback on controllability and observability, Necessary and Sufficient condition for arbitrary pole placement, Ackermann's formula for pole placement, State observers: Full order state observers and minimum order observers, Study of some physical plant like inverted pendulum for analysis and design.	13
IV	**State Space and Matrix-Fraction Descriptions of MIMO systems:** State observability, controllability and matrix-fraction descriptions, Some	**05**

	properties of polynomial matrices, Some basic state space realization, The Smith-McMillan form of a transfer function matrix, Poles and Zeros of a transfer function matrix, Matrix-fraction description (MFD) of a transfer function, State space realization from a transfer function matrix, Internal stability.	
V	**Advanced Control Technique** Introduction to Fuzzy, Neural and sliding mode control with application	

Textbooks	1	Modern control Engineering, Katsuhiko Ogata, Pearson Education India, 2015, 5th Edition.
	2	Modern Control Systems Theory, M. Gopal, New Age International Private Limited, 2014,
Reference Books	1	Modern Control Theory, Z. Bubnicki, Springer, 2010, 1st Edition.
	2	State functions & linear control systems, Schultz & Melsa, McGraw Hill Book Co. New
	3	.C. T. Chen, Linear System Theory and Design, Holt, Rinehart and Winston, New York, 1984.
	4	T. Kailath, Linear Systems, Prentice-Hall, Englewood Cliff's, NJ, 1980.
	5	M. Gopal, Modern Control System Theory, Second Edition, New Age International (P) Limited, New Delhi, 1996.
	6	W. A. Wolovich, Linear Multivariable Systems, Springer-Verlag, and Berlin, 1974.
	7	P. J. Antsaklis and A. N. Michel, Linear Systems, McGraw-Hill International Editions, 1998.

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Course Title: Elective –III: Electrical Installation Design										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.		03	10	15	50	--	---
Course Code	UEEL412									
Teaching Mode	Conventional	3 Hrs			Total	75			---	
Duration of ESE	02					75				

Course Objectives	The subject aims at basic components
	1.to design the distribution system for residential, commercial, industrial applications and utility distribution networks
	2. to understand methods of installation, testing and commissioning of electrical apparatus and conductors
	3. to understand statutory requirements related to electrical design, safety and protection.
Course Outcomes	Upon successful completion of this course, student will be able to:
	1. To apply procedures for testing & commissioning of transformers and to design substations for utility and industrial installations
	2. To understand the electric supply to induction motors in industries.
	3. To understand the industrial electrical installation.
	4. To get the knowledge of protection devices used in installation process
	5. understand the relevant provisions of IE rules for low medium and high voltage installations

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Course Outcomes	Program Outcomes and Program Specific Outcomes														
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO12	PSO 1	PSO 2	PSO3
CO1	3	-	3	-	-	2	-	-	-	-	-	2	3	2	-
CO2	3	-	3	-	-	2	-	-	-	-	-	2	3	2	-
CO3	3	-	3	-	-	1	-	-	-	-	-	2	3	2	-
CO4	3	-	3	-	-	2	-	-	-	-	-	2	3	2	-
CO5	3	-	3	-	-	2	-	2	-	-	-	2	3	2	

Course Contents:

Unit	Contents	Hours
I	Transformers: Specifications, ratings, selection, installation, testing & commissioning Substations: 11kV & 33 kV, indoor/ outdoor substations, plan/ elevations, Earthing Arrangement	6Hrs
II	**Electric supply to Induction Motors in industries:** Types of motors, SLD and working of DOL/ Star-Delta/ Autotransformer starters; types, specifications, selection of power contactors, Overload relays, short circuit protective devices.	8Hrs
III	**Design of Industrial Electrical Installations:** Preparing load list, assessing various factors associated with loads, selection of transformer, design of PCC & MCC, selection of all the associated electrical apparatus, busbars, cables, switchgear, protective devices, earthing system, testing, commissioning.	8Hrs
IV	**Switching & protection devices:** Types, specifications; selections of isolators, switches, switch fuse units, MCB, ELCB, MCCB,ACB, VCB, SF6 breakers, dropout/ horn gap fuses, AB switches, contactors for voltages upto 33 kV.	6Hrs
V	**Earthing (IS 3043):** Necessity of earthing, concept of system & equipment earthing, definitions of various terms, types of earthing, earth tester and measurement of earth resistance. IE Rules: Important IE Rules applicable to residential, commercial & industrial installations.	8Hrs

Text Books	1	Course in Electrical Power P. V. Gupta, M. L. Soni, U. S. Bhatnagar Dhampat Rai and Sons., 1987
	2	Electric Power Distribution system, A.S.Pabla, Tata McGraw-Hill
	3	Electrical Substation Engineering & Practice S. Rao Kanna Tech. Publ., 1992
Reference Books	1	Design of Electrical Installations V. K. Jain, Er. V.K. Jain & Er. Amitabh Bajaj Laxmi Publications Pvt Limited, 01-Jan-1993
	2	Electrical Engineering Handbook C. L. Wadhwa

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Course Title: Elective –IV: Computer Methods in Power System										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	
Course Code	UEEL415/UEEP415									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To introduce computer applications in the analysis of power systems
	2	To understand the solution methods and techniques used in power system studies
	3	Develop the student's simulation skills in power system to calculate and analyse parameters
	4	To get an overview of different software of Power System Applications
Course Outcomes	After completion of the course, students will be able to	
	CO1	Adopt the ability to critically analyse the solution methods used in power system studies.
	CO2	Analyze the given power system and solve problems related to Load Flow studies by using Gauss –Seidel method
	CO3	Analyze the given power system and solve problems related to Load Flow studies by using Newton-Raphson method, Fast Decoupled method.
	CO4	Understand the concept of steady state and transient stability and basics of power system
	CO5	Understand the solution of swing equation by different numerical techniques

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Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	2	1	1	--	--	--	--	1	1	1
CO2	2	2	1	1	2	--	--	--	--	--	--	--	1	1
CO3	2	1	2	2	2	2	2	--	--	--	--	1	2	1
CO4	3	2	2	2	3	2	2	--	--	--	--	2	2	2
CO5	2	2	1	1	3	1	2	--	--	--	--	2	2	2

Course Contents	**Hrs.**
Unit 1. Incidence and Network Matrices: Graphs, Incidence Matrices, Primitive Network, Formation of network matrices by singular transformation, Algorithm for formation of bus impedance matrix, modification of the bus impedance matrix for changes in the network. Numericals without mutual coupling. Three Phase Networks Three-phase network elements, three-phase balanced network elements, transformation matrices, three-phase unbalanced network elements, Incidence and network matrices for three-phase networks, Algorithm for formation of three-phase bus impedance matrix, Modification of three-phase bus impedance matrix for changes in the network. Numericals without mutual coupling	07
Unit II: Load Flow Studies-I: Introduction, Power flow equations, Classification of buses, Operating constraints, Data for load flow, Gauss- Seidal Method – Algorithm and flow chart for PQ and PV buses - Acceleration of convergence; (numerical for one iteration only)	06
Unit III: Load Flow Studies-II: Newton Raphson Method – Algorithm and flow chart for NR method in polar coordinates (numerical for one iteration only) - Load Flow Studies Algorithm for Fast Decoupled load flow method. Representation of Transformer tap setting Comparison of Load Flow Methods	06
Unit IV: Power System Stability: Classification of power system stability-Steady state and transient stability limits-Rotor dynamics and the swing equation, Power angle equation. Equal area criterion of stability evaluation and its application- methods of improving stability.	06
Unit V: Numerical solution of Swing equation: Numerical solution of Swing Equation – Point-by point method, Modified Euler's method, Runge-Kutta method, Milne's predictor corrector method Introduction to Power System Stabilizers-Block diagram representation, types and working	06

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	ABCD parameters: Formation for symmetric Π/T configuration. Verification of AD - BC=1 Determination of coefficient and regulation
2	To develop a program in MATLAB for information of Y-bus matrix for N bus system. a) Y Bus formation for P systems with and without mutual coupling, by singular transformation and inspection method. b) Determination of bus currents, bus power and line flows for a specified system voltage (Bus) Profile
3	Formation of 2-bus, using 2-bus build Algorithm without mutual.
4	Formation of Jacobian for a system not exceeding 4 buses (no PV buses) in polar coordinates.
5	Assessment of transient stability of a single machine system.
6	Write a program to perform load flow studies using Gauss- Seidel method (only p q bus)
7	Load flow analysis using Gauss Seidel method for both PQ and PV buses
8	Load flow analysis using NR method for both PQ and PV buses
Open Ended Experiments / New Experiments	
1	Load flow analysis using Fast decoupled flow method for both PQ and PV buses
2	Determination of power angle diagrams for salient and non-salient pole synchronous m/c s, reluctance power, excitation, emf and regulation.
3	Visit to nearby substation is mandatory
Details of on line Laboratory Resource Material Instruction / Operating Manuals	
1.	https://www.scribd.com/doc/76279590/Introduction-to-Power-System-Analysis
2.	https://www.scribd.com/document/443000604/PS5111-Power-System-Simulation-Lab-I

Text Books:	[1] Arthur R. Bergen, Vijay Vittal, Power Systems Analysis (English) 2nd Edition, Pearson Higher Education [2] G.L. Kusic, Computer Aided Power System Analysis, PHI, 1989 [3] John J. Grainger, William D. Stevenson, Jr., Power System Analysis, Tata McGraw-Hill Series in Electrical and Computer Engineering. [4] 4. M. A. Pai, Computer Techniques in Power Systems Analysis, Tata McGraw-Hill, Second edition 2005 [5] I.J. Nagrath and D.P. Kothari, "Modern Power System Analysis", Tata McGraw Hill, 1980 [6] J. Arriliga and N.R. Watson, Computer modelling of Electrical power systems, 2/e, John Wiley, 2001 [7] LP. Singh, "Advanced Power System Analysis and Dynamics", 3/e, New Age Intl, 1996. [8] Stagg and El Abiad, "Computer methods in Power system Analysis", McGraw Hill,1968.
E- Book	[1] Computer Modeling of Electrical Power Systems, Arrillaga J. Arnord C.P Harker B.J. John Wiley &Son [2] Computer Aided Power Systems Analysis Kusic G.L. Prentice Hall Publication. [3] Modern Power Systems Analysis Nagrath I.J. and Kothari D.P. Tata Mc Graw Hill. [4] Power System Analysis Grainger J.J. & Stevnson W.D. Mc Graw Hill.
Reference Books:	[1] Power Generation, Operation and Control by A.J. wood and B.F. Wollenberg John Wiley & Sons Inc.1984. [2] Computer methods in power systems analysis – by stage G.W. and E.L. Abiad A.H. Mc Graw Hill. [3] Computer Techniques in Power Systems Analysis- Pai M.A. Tata Mc Graw Hill. [4] P.S.R. Murthy, "Power System Operation and Control", Tata Mc-Graw Hill, New Delhi 1984. [5] Taylor C.W., "Power System Voltage Stability", Mc-Graw Hill Inc, New York, 1993. [6] Reactive power Control in Electric Systems-by T.J.E. Miller, John Wiley & Sons.

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Course Title: Elective – IV : Smart Grid and its Applications										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	2Hrs	04	10	15	50	25	
Course Code	UEEL416/UEEP416									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To make students aware the need and importance of smart grid system
	2	To impart knowledge about architecture and performance smart grid
	3	To differentiate and analyse the various algorithm for Smart grid and DER
	4	To understand the different smart city projects and their features
Course Outcomes	After completion of the course, students will be able to	
	CO1	Understand the features of Smart Grid
	CO2	Assess the role of automation and digitization in Transmission and Distribution
	CO3	Analyse Smart grids and Distributed energy resources (DER) with evolutionary algorithms
	CO4	Understand operation and importance of data acquisition devices and their location in Voltage and frequency control
	CO5	Describe & study various pilot projects used in smart cities

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Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	2	1	1	--	--	--	--	1	1	1
CO2	2	2	1	1	2	--	--	--	--	--	--	--	1	1
CO3	2	1	2	2	2	2	2	--	--	--	--	1	2	1
CO4	3	2	2	2	3	2	2	--	--	--	--	2	2	2
CO5	2	2	1	1	3	1	2	--	--	--	--	2	2	2

Unit	Contents	Hours
I	**Introduction to Smart Grid Architecture :** Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.	7
II	**Communication and performance computing in Smart Grid:** Introduction to Communication Technology, Two Way Digital Communications Paradigm, Synchro Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS)- Introduction to Internet of things (IoT), Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broad band over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.	6
III	**Distribution Generation Technologies:** Introduction to Distribution Energy Sources, Renewable Energy Technologies – Microgrids – Storage Technologies –Electric Vehicles and plug – in hybrids – Environmental impact and Climate Change – Economic Issues.	6
IV	**Smart Meters and Advanced Metering Infrastructure :** Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.	6
V	**Power Quality Management in Smart Grid** : Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. IEEE standards for Power Quality	6

Text Books:	[1] S. Borlase, "Smart Grids, Infrastructure, Technology and Solutions", CRC Press, 1st Edition, 2013 [2] G. Masters, "Renewable and Efficient Electric Power System", Wiley–IEEE Press, 2nd Edition, 2013.
E- Book	[1] T. Ackermann, "Wind Power in Power Systems", Hoboken, N J, USA, John Wiley, 2nd Edition, 2012. [2] P. Kundur, "Power System Stability and Control", McGraw-Hill, Inc., 2nd Edition, 1994.
Reference Books:	[1] C. S. Solanki, "Solar Photovoltaic: Fundamentals, technologies & Applications", PHI Publishers, 3rd Edition, 2019. [2] O. Anaya-Lara, N. Jenkins, J. Ekanayake, P. Cartwright, M. Hughes, "Wind Energy Generation Modelling and Control", John Wiley & Sons Publishers, Ltd, 1st Edition, 2009. [3] M. H. Nehrir, C. Wang, "Modeling and Control of Fuel Cells: Distributed Generation Applications", Wiley- IEEE Press, 1st Edition, 2009. [4] A.G. Phadke and J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer, 2nd Edition, 2017.

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Course Title: Elective –IV : Advanced Power Electronics										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL417/UEEP417									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To review basic concepts of power electronics in the field of power control and drives
	2	To address the underlying concepts and methods behind Advanced Power Electronics
	3	To impart knowledge of power semiconductor technologies and their advancement in the field of power conversion.
	4	
Course Outcomes	After completion of the course, students will be able to	
	CO1	Evaluate different dc-dc voltage regulators, Simulate and analyse resonant converters
	CO2	Select appropriate phase shifting converter for a multi-pulse converter
	CO3	Evaluate various multi-level inverter configurations & Compare various FACTS devices for VAR compensation
	CO4	Concept of multi-pulse, Configurations for m-pulse (m=12,18,24 ….) converters, Different phase shifting transformer

Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	3	3	--	--	--	--	--	--	--	--	--	1	2
CO2	2	--	--	--	1	--	--	--	--	--	--	--	--	--
CO3	1	3	3	1	--	--	--	--	--	--	--	--	--	2
CO4	2	3	3	--	--	--	--	--	--	--	--	--	--	--
CO5	2	--	--	--	1	1	1	--	--	--	--	--	--	--

Course Contents:

Unit	Contents	Hours
I	**Review of Power Semiconductor Devices:** Thyristor, IGBT, MOSFET, IGCT, GTO and their driver circuits, Role of SiC in Power Semiconductor Technology. **MULTIPULSE CONVERTERS**: Multi-pulse converters: 12,18 and 24 pulse converters, Power factor improvement techniques, PWM rectifiers Single Phase and Three phase boost rectifier circuits	8
II	**PWM techniques of voltage fed converters:** Selective Harmonic Elimination (SHE), sine modulation, Third harmonic injection, Hysteresis Current Control, Sigma-Delta Modulation, Space Vector Pulse Width Modulation: under modulation and overmodulation and their implementation Current Source Inverter: Current Source inverters and their role in high power drives: Auto sequential Current Fed inverter, Pulse Width Modulation of CSI Matrix converters: Three phase matrix converters and their control, basic input filter, protection of matrix converter	8
III	**Multilevel inverters:** Diode Clamped MLI, Flying Capacitor MLI, Cascaded H-Bridge topology: operation with equal and unequal DC voltages, Carrier modulation schemes of multilevel inverter, SVPWM of Multilevel inverter, Neutral Point Balancing schemes	8
IV	**Design of Switching Power Converters:** Controller Design: Introduction - mechanism of loop stabilization - Shaping E/A	8

	gains vs frequency characteristics - Conditional stability in feed-back loop - Stabilizing a continuous mode forward and fly-back converter - Feed-back loop stabilization with current mode control -right plane zero.	
V	**Design of Power Converters Components:** Design of magnetic components-design of transformer - Design of Inductor and current transformer - Selection of filter capacitors -Selection of ratings for devices - input filter design - Thermal design.	

Sr No	Name of Experiments / Mini Projects/ Case Studies
1	Evaluate the performance and operating modes of SLR/PLR dc-dc converter with the change in switching frequency.
2	Simulate/Design a circuit for a Buck Converter with ZVS/ZCS to regulate the output voltage Vo with a given input voltage Vin
3	Carrier based Sine PWM control of a CHB multilevel inverter and study of harmonic spectrum.
4	Study the operation and performance of second order converters like Buck-Boost, Flyback, Forward converters etc.
5	Study the operation and performance of fourth order converters like C'uk or Sepic converters
6	Evaluate the performance of STATCOM/SVC as a shunt compensator.
7	Study of harmonic spectrum for 12 and 18 pulse converters.

Textbooks	1	Ned Mohan, Tore M. Undeland and William P. Robbins, "Power Electronics – Converters,
	2	Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
	3	Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2009.
	4	Bin Wu, "High Power Converters and AC Drives", John Willey & sons, Inc., 2006.
	5	Derek A. Paice "Power Electronic Converter Harmonics – Multipulse Methods for Clean Power", IEEE Press, 1996
Reference Books	1	Muhammad H. Rashid , "Power Electronics Handbook", Elsevier, 3rd ed., 2011.
	2	P. C. Sen, "Modern Power Electronics ", S. Chand and Co. Ltd., New Delhi, 2000.
	3	Vijay K. Sood, "HVDC and FACTS Controllers Applications of Static Converters in Power
	4	Systems", Kluwer Academic Publishers, Boston, 2004.
	5	L. Umanand, "Power Electronics Essentials and Applications", Wiley India Ltd., 2009
E books	1	Advanced Power Electronics Converters: PWM Converters Processing AC Voltages (IEEE Press Series on Power and Energy Systems) 1st Edition, Kindle Edition, by Euzeli dos Santos (Author), Edison R. da Silva (Author) https://www.amazon.in/Advanced-Power-Electronics-Converters-Engineering-ebook/dp/B00N2W8LPE
	2	Advanced Power Electronics Book, Pradeep Kumar https://www.academia.edu/7873112/Advanced_Power_Electronics_Book
	3	Power Electronics (Kindle Edition), Dr. Hidaia Mahmood Alassouli https://www.amazon.in/Power-Electronics-Hidaia-Mahmood-Alassouli-ebook/dp/B07JR5Y2FL?ref=kindlecontentin50-21&tag=kindlecontentin50-21&gclid=CjwKCAjwuYWSBhByEiwAKd_n_myH7IodT4XgJXqQ2ZX6YaGoTA5YnreHzJ1lese_-6kMiYufCg6eehoCtt4QAvD_BwE

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Course Title: Elective –IV: Power Semiconductor Based Drives										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL420/UEEP420									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To understand motor load dynamics
	2	To analyze the operation of the converter fed and chopper fed dc drives.
	3	To explain vector control of induction motor.
	4	To identify classes and duty of motor & the modes of operation of drive-in various applications.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Explain motor load dynamics and multi quadrant operation of drives
	CO2	Analyze operation of converter fed and chopper fed DC drives & braking methods of D.C. and induction motor drive.
	CO3	Explain vector control for induction motor drives & synchronous motor drive.
	CO4	Identify classes and duty cycles of motor and applications of drives in industries.

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	--	--	--	--	--	--	--	--	--	1	2
CO2	2	--	--	--	1	--	--	--	--	--	--	--	--	--
CO3	1	3	3	1	--	--	--	--	--	--	--	--	--	2
CO4	2	3	3	--	--	--	--	--	--	--	--	--	--	--

Course Contents:

Unit	Contents	Hours
I	**Power Semiconductor Based control of drives** Dynamics of electric drives and control of electric drives, energy conservations in electric drives. **Braking methods:** Rheostatic, Plugging, and Regenerative. Closed loop control of drives: current limit control, torque control and speed control.	7
II	**Power Semiconductor Based Control of DC motor Drives** Controlled rectifier fed d.c. drives, single phase and three phase rectifier control of d.c. separately excited motor. Dual converter control of D.C separately excited motor. Power factor, supply harmonics and ripple in motor current. Chopper controlled dc drives of separately excited dc motor, chopper control of series motor, source current harmonics.	8
III	**Power Semiconductor Based Induction Motor Drives:** Stator voltage control, variable frequency control using voltage source inverters, current sources inverters and cyclo converter.	8
IV	**Power Semiconductor Based Synchronous Motor Drive;** Starting Braking of synchronous motor, variable frequency control self-controlled synchronous motor drive employing load commutated thyristor inverter of cycle converter, starting of large synchronous motors.	8
V	**Special Drives** Brushless dc motor, stepper motor, switched reluctance motor drives and eddy current drives, Introduction to solar and battery powered drives. Advanced topic on the subject	8

S. No.	Name of Experiments / Mini Projects/ Case Studies
1	Study of Electrical braking of D.C. Shunt motor (Rheostatic, Plugging).
2	Study speed control characteristics of single phase fully converter fed separately excited D.C. motor
3	Study speed control characteristics of 3-ph fully converter fed separately excited D.C. motor.
4	Study of Chopper fed D.C. series/separately motor speed control characteristics.
5	Study of electrical braking of 3 phases Induction Motor (DC Dynamic Braking, Plugging).
6	Study of VSI fed 3 phase Induction motor (using V/f control PWM inverter) speed control characteristics.
7	Study of Solid-state stator voltage control of 3 phase Induction motor (Using AC voltage Regulator).
8	Study of constant torque and constant power characteristic of induction motor.
9	Design of FIR filter (window (any one) method).
10	Simulation of starting characteristics of D.C. motor.
11	Simulation of starting characteristics of 3 phase Induction motor.
12	Study of Closed loop speed control of separately excited D.C. motor/ Induction Motor.
13	Simulation of an electric drive system for steady state and transient analysis.
14	Simulation of chopper-controlled DC series motor.

Textbooks	1	G. K. Dubey, "Fundamentals of Electric Drives", 2nd Edition, Narosa Publishing House
	2	N. K. De, P. K. Sen, "Electric Drives", Prentice Hall of India Eastern Economy Edition
	3	S. K. Pillai, "Analysis of Thyristor Power Conditioned Motors", University Press
	4	R. Krishnan, "Electric Motor Drives – Modeling Analysis and Control", PHI India

	5	G.K. Dubey, "Power Semiconductor controlled drives", PHI publication
E books	1	Power Semiconductor Drives Kindle Edition, M. Balasubba Sivanagaraju, S. Prasad, A. Mallikarjun Reddy (Author) https://www.amazon.in/Semiconductor-Drives-Mallikarjuna-Balasubba-Sivanagaraju-ebook/dp/B00K7YGN32
	2	Power Semiconductor Drives Hardcover – Import, 1 February 2017, P V Rao (Author) https://www.amazon.in/Power-Semiconductor-Drives-P-Rao/dp/9352300270
	3	Power Electronics: Drive Technology and Motion Control, Jean Pollefliet https://www.scribd.com/book/359394514/Power-Electronics-Drive-Technology-and-Motion-Control
Reference Books	1	B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education
	2	Malcolm Barnes, "Practical Variable Speed Drives and Power Electronics", Elsevier Newnes Publications
	3	V. Subrahmanyam, "Electric Drives: Concepts and Application", Tata Mc-Graw Hill
	4	(An imprint of Elsevier)
	3	M.D. Singh and Khanchandani "Power Electronics", Tata Mc-Graw Hill
	4	Austin Huges, "Electrical motor and drives: Fundamental, types and applications", Heinemann Newnes, London
	5	Tyagi MATLAB for Engineers oxford (Indian Edition
	6	M.D. Singh and Khanchandani "Power Electronics", Tata Mc-Graw Hill

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Course Title: Elective –IV : Sampled data Digital Control										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL419/UEEP419									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To equip the students with the basic knowledge of A/D and D/A conversion.
	2	To understand the basics of Z- Transform.
	3	To study the stability analysis of digital control system.
	4	To equip the basic knowledge of digital process control design.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Understand the basic sampling theory and converter.
	CO2	Understand Z-transform and its properties.
	CO3	Analyze signals in both time domain and Z domain.
	CO4	Understand d transfer function, block diagram, and signal flow graphs.
	CO5	Understand the state variable technique.
	CO6	Understand the basic knowledge necessary for system stability.

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	-	-	-	-	-	-	-	2	-	-
CO2	3	2	2	2	3	-	-	-	-	-	-	1	1	-
CO3	3	3	2	3	2	-	-	-	-	-	-	2	2	-
CO4	3	3	-	2	2	-	-	-	-	-	-	2	-	-
CO5	3	3	2	3	1	-	-	-	-	-	-	2		
CO6	3	3	2	2	2	-	-	-	-	-	-	2		

Course Contents:

Unit	Contents	Hours
I	**Digital control Systems** Introduction, description of some physical systems, continuous versus digital control, Discrete-time signals, discrete time systems, sampling and reconstruction, digitizing analog controllers.	**06**
II	**The Z Transforms** Definition and evaluation of Z-Transform, mapping between the s-plane and the z- plane, the inverse z-transform, theorems of z-transform, imitation of z-transform method. The pulse transfer function, pulse, transfer function of zero order hold, responses between the sampling instants, signal flow graph method applied to digital systems, stability of digital control systems, jurystability criterion.	**10**
III	**State variable analysis of digital control systems:** Introduction, state description of digital processors, state description of sampled continuous- time plant, state description of systems with dead time and sample and hold discrete state models using phase physical and canonical variables. Relation between state equation and transfer function and solution of state difference equations, controllability and observability.	**06**
IV	**Pole-placement design and digital state observer:** Stability improvement by state feedback, digital control systems, with state feedback, dead beat control by state feedback, design of the full order and reduced-order state observers, linear digital regulator design (Finite time and infinite time problems).	13

V	**Design of Sampled Data Control systems**: Discretizing the differential equation of continuous PID controllers, Parameter optimized discrete control algorithms of low order, PID control algorithm through Z transformations, Deadbeat algorithm, Dahlin's algorithm, Digital Equivalent of convention controller, Smith Predictor algorithm, Internal Model control, Analytical Predictor Algorithm, Kalman algorithm, Algorithm of Gautam and Mutharasan, Treatment of noisy process signals	**05**

Textbooks	1	Ogata K -. Discrete time control system Englewood cliffs prentice-Hall 1987.
	2	Kuo B. C. – Digital control system 2nd edition Orlando florida saunders college publishing 1992.
	3	M.Gopal- Digital control and state variable methods, Second Edition, Tata McGraw Hill 2002.
	4	M. Gopal - Digital Control Engineering Wikey eastern 1988.
	5	
Reference Books	1	Houpls C. H. and G. B.Lamont – Digital control systems, McGraw Hill 1984.
	2	P. B. Deshpande and R. H. Ash – Computer Process control with advanced
	3	Control applications, Second Edition, Instrument Society of America (ISA) Publications, 1988.
	4	R. Iserman – Digital Control Systems, Vol.I; Fundamentals, Deterministic Control, Second Edition, springer- Verlag, Berlin, Heidelberg 1989.
	5	

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Course Title: Elective –IV : Industrial Automation										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	
Course Code	UEEL418/UEEP418									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To understand about automation systems
	2	To understand about hardware and software used in Automation systems
	3	To understand SCADA system
	4	To get an overview of different protocols used in SCADA system
Course Outcomes	After completion of the course, students will be able to	
	CO1	Understand the fundamentals of Industrial Automation, PLC & SCADA.
	CO2	Develop Ladder Program using basic & advanced PLC instructions for Sequential & continuous processes.
	CO3	Interface Analog & Digital I/O devices, Hydraulic & Pneumatic systems and VFD with PLC.
	CO4	Apply Analog PLC functions to given process control applications. .
	CO5	Develop SCADA system for given applications.

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Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	2	1	1	--	--	--	--	1	1	1
CO2	2	2	1	1	2	--	--	--	--	--	--	--	1	1
CO3	2	1	2	2	2	2	2	--	--	--	--	1	2	1
CO4	3	2	2	2	3	2	2	--	--	--	--	2	2	2
CO5	2	2	1	1	3	1	2	--	--	--	--	2	2	2

Course Contents	**Hrs**
Unit – I: Introduction to Automation	**7**
Automation: Fundamentals of Industrial Automation Need & Role of Automation, Types of Industrial Automation System, Evolution of Automation. Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations.	
Unit – II: Control Technologies in Automation	**6**
Industrial Control Systems, Process Industries Verses Discrete- Manufacturing Industries, Continuous Verses Discrete Control, Computer Process Control and its Forms. Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks of Automation System: LAN, Analog & Digital I/O Modules	
Unit – III : Detroit-Type Automation	**7**
Automated Flow lines, Methods of Work-part Transport, Transfer Mechanism, Buffer Storage, Control Functions, and Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Computer Simulation of Automated Flow Lines.	
Unit – IV: PLC Interfacing to HMI, Hydraulic, Pneumatic, VFD& Motion Control	**7**
Need of HMI, Advantages of using HMI, PLC Interfacing to Hydraulic & Pneumatic circuits. Need, Objective & Benefits of Drives, Types of Drives, Selection Criteria for Drives, Advantages & Disadvantages of Drives. Working & Construction of VFD, Different Methods of Speed Control, Applications of VFD, Different Modes of VFD Such As PU, External & Network Mode, Interfacing of VFD to PLC. Introduction of Motion Control, Block diagram, Different elements &	

Applications of Motion Control.	
Unit – V: PLC and SCADA System	**7**
Introduction to PLC: Definition of PLC, Architecture, Types of PLC, PLC Selection. Signal processing of DI-DO-AI-AO Modules, Interfacing of I/O devices to PLC, Sinking & Sourcing and Program Scan & Advantages and Disadvantages of PLC. Programming Languages: Introduction to PLC Programming Languages as per IEC 61131-3: Ladder Programming (LD), Function Block Diagram (FBD), Instruction List (IL), Structured Text (ST) & Sequential Function Chart (SFC). General definition & SCADA Components. Need of SCADA system, application & benefits, PLCs Vs RTUs, RTU Block diagram, MTU communication interface, Types of SCADA System, Future trends, Internet based SCADA display system, Comparison of different SCADA packages. Trending, Historical data storage & Reporting, Alarm management. Programming techniques for: Creation of pages, Sequencing of pages, creating graphics & Animation & development of application using SCADA System	

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Introduction to Ladder Programming, develop and simulate Logic gates and Boolean equations.
2	Develop and Simulate Ladder program for simple on-off applications.
3	Develop and Simulate Ladder program for timer applications.
4	Develop and Simulate Ladder program for counter applications.
5	Creating and Configuring a Project and tags in SCADA
6	Design and Develop SCADA System for application.
7	Develop and Simulate Ladder program for PID controller using PLC for Level/Flow/Temp Control Systems.
8	Interfacing PLC to hydraulic & Pneumatic circuits.
Open Ended Experiments / New Experiments	
1	Develop and Simulate Ladder program for cascading of timers & counters.
2	Develop and Simulate Ladder program for Comparison Instruction/ Logical Instruction.
3	Interfacing Motion Control systems to PLC.

Details of on line Laboratory Resource Material Instruction / Operating Manuals	
1.	https://www.scribd.com/document/558187740/lab-manual-industrial-automation
2.	https://www.scribd.com/document/522238506/ELE-2613-Industrial-Automation-LabManual by Higher College of Technology

Text Books:	[1] Programmable Logic Controllers: Principles & Applications by John W. Webb, Ronald A. Reis, Prentice Hall of India, 5th ed. [2] Introduction to Programmable Logic Controllers by Gary Dunning, Delmar Thomson Learning, 3rd ed. [3] Programmable Logic Controllers: Programming methods and applications by John R. Hackworth and Frederick D. Hackworth Jr., Pearson publication
E- Book	[1] Introduction to industrial automation: https://nptel.ac.in/courses/108105063/1 [2] The architecture of Industrial Automation Systems https://nptel.ac.in/courses/108105063/2
Reference Books:	[1] Programmable Logic Controller by Frank D Petruzella, McGraw-Hill Education, 5th ed. [2] Programmable Logic Controllers by W. Bolton, Elsevier Newness publication, 4th ed. [3] Programmable Controller by T. A. Huges, ISA publication, 2nd ed. 4. SCADA by Stuart A. Boyer,

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Course Title: Elective –V: Flexible AC Transmission System										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	2Hrs	04	10	15	50	25	--
Course Code	UEEL421/ UEEP421									
Teaching Mode	Conventional	5hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To Introduce various Power Electronics controllers used in the Power Systems for the fast real and reactive power control.
	2	To Understand the fundamentals of FACTS Controllers, Importance of controllable parameters and types of FACTS controllers & their benefits
Course Outcomes	After completion of the course, students will be able to	
	CO1	An ability to apply knowledge of FACTS Controllers.
	CO2	An ability to identify, formulate, and solve real network problems with FACTS controllers
	CO3	Understand various systems thoroughly and their requirements
	CO4	Interpret the control circuits of for various functions

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes Cos	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1		--	--	--	--	--	--	--	--	--	1	--
CO2	3	2	2	--	--	--	--	--	--	--	--	--	2	--
CO3	2	2	1	--	--	--	--	--	--	--	--	--	1	--
CO4	2	2	2	--	--	--	--	--	--	--	--	--	1	--

Unit	Contents	Hours
I	Basics of power flow in AC systems, Steady state and dynamic problems in AC systems, Reactive power control and voltage regulation in power systems, Dynamic power flow control, Transmission line loading Advantages of FACTS, Compensation of uncompensated transmission line, shunt and series compensation, phase angle control.	8
II	Reactive power compensation- transmission and distribution level, Converters for Static Compensation - Three Phase Converters and Standard Modulation Strategies. GTO Inverters. Transformer Connections for 12, 24 and 48 pulse operation. Multilevel inverters and their modulation.	7
III	**Static Shunt Compensator**: Objectives of shunt compensation, controllable methods for VAR generation - Variable impedance type VAR Generators and their configuration, principle of operation and control -TCR, TSR, FC-TCR, TSC TCPAR, TCVR.	8
IV	**Static Series Compensator**: Objectives of series compensation, controllable methods for VAR generation - Variable impedance type VAR Generators and their configuration, principle of operation and control TCSC, TSSC - Regulation slope calculation, Transfer function representation; dynamic performance and power oscillation damping.	6
V	**VSC based FACTS Devices:** STATCOM, SSSC, UPFC, and IPFC: Principles of operation with circuit arrangement, Real and reactive power flow control, Control scheme for P and Q control.	5

Text Books	1.	NG Hingorani and L Gyugyi, "Understanding FACTS", IEEE Press, 2000
	2.	K R Padiyar, "FACTS Controllers in Power Transmission and Distribution", New Age International Publishers, 2007
Reference Books	1.	T J E Miller, "Reactive Power Control in Power Systems'', John Wiley, 1982
	2.	Ned Mohan et. al ''Power Electronics", John Wiley and Sons.
on line TL Material	1.	

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Course Title: Elective –V: Power System Restructuring and Deregulation										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	2hrs	04	10	15	50	25	--
Course Code	UEEL422/ UEEP422									
Teaching Mode	Conventional	5hrs			Total	75			25	
Duration of ESE	02					100				

Prerequisites: Knowledge in Power System Analysis and Power System Generation, Transmission and Distribution.

Course Objectives	The objective of this course is	
	1	To educate students about the process and operation of Restructuring of Power System.
	2	To familiarize students about the various Power System Restructuring Models.
	3	To elaborate students Pricing of Electricity.
	4	To explain fundamental concept of Congestion, its Management and Transmission Pricing.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Recall the implications of various Policies and Acts on Restructuring and Deregulation.
	CO2	Illustrate the Regulatory Process in India along with various Methods of Regulations & different Power Sector Restructuring Models.
	CO3	Identify the components involved in tariff determination, different Power Sector Restructuring Models & different types of Electricity Markets.
	CO4	List different Transmission Pricing methods and discuss Congestion Management

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**3**	--	--	--	--	**2**	--	--	--	--	**1**	--	**1**	--
CO2	3	3	--	--	--	--	--	--	--	--	--	--	--	--
CO3	--	3	--	2	**1**	--	--	--	--	--	--	--	--	--
CO4	**3**	**3**	**2**	--	--	--	--	--	--	--	--	--	--	--

Course Contents:

Unit	Contents	Hours
I	**Power Sector Reforms in India:** Need of Regulation, Roles of various key entities like Ministry of Power, CEA, Planning Commission, CERC and SERC in India. Electricity Act 2003 and 2010 and its implications for Restructuring and Deregulation. National Energy policy. Challenges before the Indian power sector.	7
II	**Power Sector Regulation & Power Sector Economics** Principles of Tariff setting, Phases of Tariff determination, types and methods of Regulation, Introduction to various concepts such as capital cost, debt and equity, depreciation, fixed and variable costs, working capital. Typical cost components of utilities.	8
III	**Power Sector Restructuring Models and Introduction to energy Markets** Introduction, models based on energy trading or structural models – monopoly, single buyer, wholesale competition, retail competition. Models based on contractual arrangements – pool model, bilateral dispatch, pool and bilateral trades, multilateral trades. ISO models. Introduction to Energy Exchange	8
IV	**Electricity Markets** Electricity markets such as spot markets, forward contracts and forward markets, future contracts and future markets, day ahead market, reserve market, ancillary services market, market for differences, Options contracts. Market operation-settlement process, Market Clearing Price (MCP), Market efficiency	7
V	**Transmission Pricing and Transmission Congestion issues** Cost components of transmission system, Cost allocation of Transmission system, Transmission pricing methods, physical transmission rights, Open Access, Role of Load Dispatch canters, Congestion in power network, reasons for congestion, congestion management.	8

Text Books	1.	Know Your Power: A citizen Primer on the electricity Sector, Prayas Energy Group, Pune
	2.	Daniel S. Kirschen, Goran Strbac, "Power System Economics" John Wiely and Sons Publication Ltd. August 2006.
	3	Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured Electrical Power Systems: Operation Trading and Volatility" CRC Press, June-2001
Reference Books	1.	Steven Stoft, "Power System Economics: Designing Markets for Electricity", John Wiley and Sons, 2002
	2.	Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc
	3	Geoffrey Rothwell, Tomas Gomez, "Electricity Economics Regulation and Deregulation" A John Wiley and Sons Publication 2003
	4	Mohammad Shahidehpour, Hatim Yamin, Zuyi Li, "Market operations in Electric Power System" A John Wiley and Sons Publication.
	5	Deregulation in Power Industry – A course under continuing Education Program, Department of Electrical Engineering , IIT , Bombay
on line TL Material	1.	http://www.cercind.gov.in/Function.html
	2	www.cercind.gov.in/serc.html
	3	http://www.power.gov.ng/index.php/about-us/our-functions
	4	http://www.cea.nic.in/functions.html
	5	http://planningcommission.nic.in/reports/genrep/arep9920/ar9920role.htm
E-Books:	1	Power System Restructuring & Deregulation Trading, Performance And Information Technology: https://www.kopykitab.com/Power-System-Restructuring-And-Deregulation-Trading-Performance-And-Information-Technology-Eng-by-PUBLIC-DOMAIN
	2	Creating Competitive Power Markets: The PJM Model https://www.pennwellbooks.com/creating-competitive-power-markets-the-

		pjm-model/
	3	**Restructured Power System and Electricity Market Forecasting** https://www.amazon.in/dp/1512221449/ref=as_sl_pc_tf_til?tag=sanfoundry-21&linkCode=w00&linkId=d524ff140896a1a08e9495bd0e1c6ca8&creativeASIN=1512221449

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Course Title: Elective –V: Digital Signal Processing and its Applications										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	2hrs	04	10	15	50	25	--
Course Code	-------									
Teaching Mode	Conventional	5hrs			Total	75			25	
Duration of ESE	02					100				

Prerequisites: Knowledge in Power System Analysis and Power System Generation, Transmission and Distribution.

Course Objectives	The objective of this course is	
	1	To provide better understanding of discrete-time signals with representation in Time and Frequency domain.
	2	To provide knowledge for analysis and design of Linear and Time-Invariant (LTI) systems using mathematical tools like Fourier Transform and Z-transform.
	3	To provide knowledge for efficient realization of digital systems (FIR and IIR filters) using hardware and software.
	4	To demonstrate DSP Applications in Electrical Engineering.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Represent and analyze the discrete-time signals and LTI systems in the frequency domain using Discrete-Time Fourier Transform (DTFT), z-transform and Discrete Fourier transform (DFT) tools.
	CO2	Implement DFT efficiently using Fast Fourier Transform (FFT) algorithms and use in practical applications.
	CO3	Design an FIR or IIR filter for the specifications given in frequency domain.
	CO4	To propose and design a digital system for simple real application.

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e-mail: principal.ghribmjal@raisoni.net, Website: https://ghribmjal.raisoni.net

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	--	--	--	--	--	--	--	--	--	1	2
CO2	2	--	--	--	1	--	--	--	--	--	--	--	--	--
CO3	1	3	3	1	--	--	--	--	--	--	--	--	--	2
CO4	2	3	3	--	--	--	--	--	--	--	--	--	--	--
CO5	2	--	--	--	1	1	1	--	--	--	--	--	--	--

Course Contents:

Unit	Contents	Hours
I	**Review of Z transform:** Definition, basics, Properties, Inverse Z-transform using Power-Series and Partial Fraction, Solution of Difference Equation Sampling Theorem, Frequency Domain representation of sampling, reconstruction of a band limited Signal, A to D conversion Process: Sampling, quantization and encoding.	7
II	**Discrete Time Fourier Transform** The Discrete Fourier Transform, Relation with z transform Properties of DFT Effective computation of DFT and FFT, Fast Fourier Transform (FFT): Discrete Fourier Transform and its Properties, Divide and Conquer Approach, Decimation in Time and Decimation in Frequency FFT Algorithms (Radix 2 DIT and DIF algorithms).	8
III	**IIR Filter Design:** Concept of filtering, Advantages and disadvantages of Digital Filter over Analog Filters, classification of digital filters Specifications of Filter, IIR filter design from Continuous Time Filters: Characteristics of Butterworth and Chebyshev Low Pass Filter, Impulse Invariant and Bilinear transformation Techniques, Design examples, Basic structures for IIR Systems: Direct form, Cascade form.	8
IV	**FIR Filter Design using Windows:** Specifications & Properties of Commonly used Windows, Basic Structures for FIR Systems: direct form. Comparison of IIR and FIR Filters **Applications**: Measurement of Magnitude and Phase of Voltage, Current, Power, Frequency and Power Factor Correction, harmonic Analysis and Measurement, DSP based Protective Relaying.	8

V	**Multirate Digital Signal Processing:** Decimation by a factor D, Interpolation by a factor I, Sampling Rate Conversion by a Rational factor I/D, Filter Design & Implementation for Sampling Rate Conversion, Multi stage Implementation of sampling rate conversion.	7

	Name of Experiments / Mini Projects/ Case Studies
1	Plotting of discrete time waveforms (a) Sin, (b) Unit Step, (c) Exponential.
2	Find Linear convolution
3	Plot frequency response of given system function (Magnitude and Phase)
4	Verification of Z-transform properties (any two)
5	Find Circular convolution Using DFT IDFT method and linear convolution using Circular convolution.
6	Find DFT and IDFT of sequence
7	DIT- FFT or DIF-FFT algorithm
8	Design of IIR filter (Butterworth method).
9	Design of FIR filter (window (any one) method).
10	Harmonic analysis of any non-sinusoidal signal using DSP.

Text Books	1.	Mitra S., "Digital Signal Processing: A Computer Based Approach", Tata McGraw-Hill, 1998, ISBN 0-07-044705-5
	2.	Proakis J., Manolakis D., "Digital signal processing", 3rd Edition, Prentice Hall, ISBN 81- 203-0720-8
	3	P. Ramesh Babu "Digital Signal Processing" 4th Edition, Scitech Publication, Chennai
	4	Discrete-Time Signal Processing, 3rd Edition, A. V. Oppenheim and R. W. Schafer
	5	Foundations of Signal Processing, M. Vetterli, J. Kovacevic and V. K Goyal
Reference Books	1.	Oppenheim A., Schafer R., Buck J., "Discrete time signal processing", 2nd Edition, Prentice Hall, 2003, ISBN-81-7808-244-6
	2.	Rebizant, Waldemar, Szafran, Janusz, Wiszniewski, Andrzej, "Digital Signal Processing in Power System Protection and Control", 1st Edition. Springer, 2011,

		ISBN 0857298011, 9780857298010
	3	Understanding Digital Signal Processing, 3rd Edition, R. G. Lyons
E-Books:	1	Digital Signal Processing: A Practical Approach, 2nd Edition, E. Ifeachor and B. Jervis http://fourierandwavelets.org/FSP_v1.1_2014.pdf
	2	Hilbert Space Methods in Signal Processing, R. A. Kennedy and P. Sadeghi https://www.cambridge.org/core/books/hilbert-space-methods-in signalprocessing/BA54ECB490D53FF8CB176CFDCE34A962
	3	The Fourier Transform and its Applications, Lecture Notes for EE261, Stanford University. http://see.stanford.edu/materials/lsoftaee261/book-fall-07.pdf Lectures at: https://www.youtube.com/playlist?list=PLB24BC7956EE040CD
	4	MIT course: Discrete-Time Signal Processing https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-341 discretetime-signal-processing-fall-2005/index.htm

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Course Title: Elective V : Electric Vehicles										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL424									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	Understanding of basic principles, operation, performance of Electric vehicles
	2	Understanding and performing various measuring instruments through practical demonstrations
Course Outcomes	After completion of the course, students will be able to	
	CO1	Review history, Social and environmental importance of Hybrid and Electric vehicles.
	CO2	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals
	CO3	Analyze the use of different power electronics devices and electrical machines in hybrid electric vehicles.
	CO4	Interpret working of different configurations of electric vehicles and its components, hybrid vehicle configuration, performance analysis and Energy Management strategies in HEVs.

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes Cos	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	2	3	3	--	--	--	--	1	1	1
CO2	2	2	2	1	2	2	3	--	--	--	--	1	1	2
CO3	2	3	2	2	2	2	2	--	--	--	--	1	2	3
CO4	2	3	2	2	3	2	2	--	--	--	--	2	2	2

Course Contents:

Unit	Contents	Hours
I	**Electric Vehicles (EV)** Electric Vehicles History, Components of Electric Vehicle, General Layout of EV, EV classification Comparison with Internal combustion Engine: Technology, Advantages & Disadvantages of EV, Overview of Tesla car. Hybrid Electric Vehicles (HEV) History, Components of Hybrid Electric Vehicle, General Layout of Hybrid EV, Comparison with Electric Vehicles, Advantages & Disadvantages of Hybrid EV, Overview of Toyota prius	**06**
II	**Vehicle Fundamentals:** Vehicle resistance, Types: Rolling Resistance, grading resistance, Aerodynamic drag vehicle performance, Calculating The Acceleration Force, maximum speed, Finding The Total Tractive Effort, Torque Required On The Drive Wheel, Transmission: Differential, clutch &gear box, Braking performance	**06**
III	**Motors Used in EV & HEV:** Principle and working of DC motor, Characteristics and Types of DC Motors Overview (Speed torque characteristics) of Permanent Magnet motor, BLDC Motor, and Induction motor. Comparison of all motors.	**07**
IV	**Converters and Energy Storage Systems:** Introduction of DC-DC, AC-AC, AC-DC, DC-AC converters, four-quadrant operation, Driver circuits. Batteries, fuel cells, ultra capacitors and battery management system.	**06**
V	**INDIAN and GLOBAL Scenario:** Technology Scenario, Market Scenario, Policies and Regulations, Payback and commercial model, Payback and commercial model, Polices in India	**05**

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Experiment for conversion of DC to DC voltage using converter.
2	Simulation for AC to DC conversion
3	Simulation for DC to AC conversion
4	Study of 3-phase Induction motor.
5	Speed control of DC motor using IGBT.
6	To perform speed reversal of DC shunt motor
7	Study of various elements of transmission systems (clutch, differentials, gearbox etc.)
8	Calculate and compare the brake power, torque and mechanical efficiency of IC Engine and Electrical Motor of same configuration
9	Study of various types of braking systems
10	Case study of Tesla car.
11	Case study of Toyota prius
Open Ended Experiments / New Experiments	
1	Modelling and developing prototypes for EV application for better performance
2	Designing Electric drive powertrain for better performance and efficiency of EV's
3	Designing of charging station to overcome drawbacks of wired chargers
4	Developing architecture of V2G to improvise sustainable mobility
Details of on-line Laboratory Resource Material Instruction / Operating Manuals	
1.	https://www.iitg.ac.in/e_mobility/
2.	https://www.powerlab.dk/Facilities/Electric-Vehicle-Lab

Textbooks	1	Chris Mi, M. AbulMasrur, David WenzhongGao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2011, Wiley publication.
	2	Allen Fuhs, "Hybrid Vehicles and the future of personal transportation", 2009, CRC Press.
E books	1	Iqbal Husain, ELECTRIC and HYBRIDVEHICLES, Design Fundamentals, CRC Press,2003.
	2	2. M. Ehsani, Y. Gao, S. Gay and A. Emadi, Modern Electric, Hybrid Electric, and Fuel CellVehicles, CRC Press, 2005.

Reference Books	1	Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
	2	Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
	3	James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

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Course Title: Elective –V : Robotics										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.		03	10	15	50	--	--
Course Code	-----									
Teaching Mode	Conventional	3 Hrs			Total	75			--	
Duration of ESE	02					75				

Course Objectives	The objective of this course is	
	1	To introduce the functional elements of Robotics
	2	To introduce the power source and sensors
	3	To introduce the manipulator differential motion and control
	4	To educate on various path planning techniques
	5	To introduce the dynamics and control of manipulators
Course Outcomes	After completion of the course, students will be able to	
	CO1	Ability to understand basic concept of robotics
	CO2	To analyze Instrumentation systems and their applications to various
	CO3	To know about the differential motion add statics in robotics
	CO4	To know about the various path planning techniques
	CO5	To know about the dynamics and control in robotics industries

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Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	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
CO1	3	1	1	1	1	1	1	--	--	--	--	2	1	1
CO2	3	2	2	2	2	1	1	--	--	--	--	1	1	1
CO3	3	2	1	2	1	2	-	--	--	--	--	2	2	1
CO4	3	1	2	1	2	2	2	--	--	--	--	2	2	1
CO5	3	1	2	2	3	2	2	--	--	--	--	3	2	2

Course Contents:

Unit	Contents	Hours
I	**Basic Concepts of Robotics:** Origin and Definition of robotics, types and generation of robots, Degrees of freedom, Asimov's laws of robotics, Dynamic stabilization of robots	**08**
II	**Power Sources and Sensors:** Pneumatic, Hydraulic, and electric drives, Determine HP of motor and gearing ratio, arrangements of variable speed, path determination, machine vision and ranging, laser acoustic, fiber optic, magnetic and tactile sensors.	**06**
III	**Manipulator Differential Motion and Statics:** Angular and Linear velocities, Manipulator Jacobian, Prismatic and rotary joints, Inverse arm and Wrist singularity, Static analysis, Moment and Force Balance.	**08**
IV	**Path Planning:** Definition of Joint space technique, p-degree polynomial use, Cartesian space technique, Cubic polynomial technique, Parametric descriptions of circular path and Straight line, Orientation and Position planning.	**06**
V	**Dynamics and Control:** 2DOF Manipulator, Lagrangian mechanics, Lagrange Euler formulation, Dynamic model, Linear and PID control scheme, Manipulator control problem, Force control of robotic manipulator.	**08**

Textbooks	1	R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
	2	JohnJ.Craig ,Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 3. 2009.
	3	M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.
E books	1	Nicolas Mollet, **Remote and Telerobotics**, Published by: InTech, 2010
	2	Yoshihiko Takahashi, **Service Robot Applications**, Published by: InTech, 2008
Reference Books	1	Ashitava Ghoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press, Sixth impression, 2010.
	2	K. K.Appu Kuttan, Robotics, I K International, 2007.
	3	Edwin Wise, Applied Robotics, Cengage Learning, 2003.
	4	B.K.Ghosh, Control in Robotics and Automation: Sensor Based Integration, Allied Publishers,Chennai, 1998

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<table>
<tr><td colspan="11">Course Title: Elective V : PLC and SCADA</td></tr>
<tr><td rowspan="2">Semester</td><td rowspan="2">VII</td><td colspan="4" rowspan="2">Teaching Scheme</td><td colspan="5">Evaluation Scheme</td></tr>
<tr><td colspan="3">Theory</td><td colspan="2">Practical</td></tr>
<tr><td>Term</td><td>Odd</td><td>Th</td><td>Tu</td><td>Pr</td><td>Credits</td><td>TAE</td><td>CAE</td><td>ESE</td><td>INT</td><td>EXT</td></tr>
<tr><td>Course Category</td><td>EL</td><td rowspan="2">3Hrs.</td><td rowspan="2">.</td><td rowspan="2">02Hrs.</td><td rowspan="2">04</td><td rowspan="2">10</td><td rowspan="2">15</td><td rowspan="2">50</td><td rowspan="2">25</td><td rowspan="2">--</td></tr>
<tr><td>Course Code</td><td>UEEL426/UEEP426</td></tr>
<tr><td>Teaching Mode</td><td>Conventional</td><td colspan="3" rowspan="2">5 Hrs</td><td rowspan="2">Total</td><td colspan="3">75</td><td colspan="2">25</td></tr>
<tr><td>Duration of ESE</td><td>02</td><td colspan="5">100</td></tr>
</table>

Course Objectives	1. To know the importance and benefits of automation in an industrial process using PLC.
	2. To understand the instructions of PLC and program PLC using the Ladder diagrams.
	3. To learn applications of timers, counters and effective use of program flow control instructions to manage PLC operations.
	4. To understand need for DCS/ SCADA in Process Control Instrumentation
Course Outcomes	Upon successful completion of this course, student will be able to:
	CO1: Develop and explain the working of PLC with the help of a block diagram
	CO2: Develop ladder programming for different using different PLC instructions
	CO3: Execute, debug and test the programs developed for digital and analog operations
	CO4: Develop architecture of SCADA and explain the importance of SCADA in critical infrastructure
	CO5: Reproduce block diagram representation on industrial applications using PLC and SCADA and applications of protocols

Mapping of Course Outcomes with Program Outcomes:

Course Outcomes	Program Outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	0	0	0	0	1	0	0	1	1	0
CO2	2	2	1	1	0	0	0	0	1	0	0	1	1	0
CO3	2	2	2	1	1	0	0	0	1	0	0	1	1	0
CO4	2	2	1	1	1	0	0	0	1	0	0	1	1	0
CO5	2	2	1	1	0	0	0	0	1	0	0	1	1	0

Unit	Course Contents	Hrs.
I	**Introduction to PLC:** Definition & History of PLC, Overall PLC system, PLC Input & Output modules, central processing unit, CPUs & Programmer/monitors, Solid state memory, the processor, Input modules (Interfaces), Power supplies, PLC advantages & disadvantages. Selection criteria for PLC.	7
II	**Programming of PLC:** Programming equipments, proper construction of PLC ladder diagram, Basic components & their symbols in ladder diagram, Fundamentals of ladder diagram, Boolean logic & relay logic, and analysis of rungs. Input ON/OFF switching devices, Input analog devices, Output ON/OFF devices, output analog devices, programming ON/OFF Inputs to produce ON/OFF outputs.	6
III	**Advanced PLC Function:** Analog PLC operation, PID control of continuous processes, simple closed loop systems, problems with simple closed loop systems, closed loop system using Proportional, Integral & Derivative (PID), PLC interface, and Industrial process example. Motors Controls: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive	6
IV	**SCADA Systems:** Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, Communication requirements, Desirable Properties of SCADA system, features, advantages, disadvantages and applications of SCADA. SCADA Architectures (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, Power System Automation (Automatic substation control	6

	and power distribution), Petroleum Refining Process, Water Purification System, Chemical Plant.	
V	**SCADA Protocol:** Open systems interconnection (OSI) models, TCP/IP protocol, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Device Net, Control Net, Ether Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus). Interfacing of SCADA with PLC	**7**

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Introduction to Ladder Programming, develop and simulate Logic gates and Boolean equations.
2	Develop and Simulate Ladder program for simple on-off applications.
3	Develop and Simulate Ladder program for timer applications.
4	Develop and Simulate Ladder program for counter applications.
5	Creating and Configuring a Project and tags in SCADA
6	Design and Develop SCADA System for application.
7	Develop and Simulate Ladder program for cascading of timers & counters.
8	Develop and Simulate Ladder program for Comparison Instruction/ Logical Instruction.
Open Ended Experiments / New Experiments	
1	Study of VFD control using PLC.
2	Speed Control of DC Motor systems to PLC using SCADA
3	Interfacing Motion Control systems to PLC.
Details of on line Laboratory Resource Material Instruction / Operating Manuals	
1.	https://www.scribd.com/document/558187740/lab-manual-PLC and SCADA Applications
2.	https://www.scribd.com/document/522238506/ELE-2613-Industrial-Automation-LabManual by Higher College of Technology

Text Books:	[4] Programmable Logic Controllers: Principles & Applications by John W. Webb, Ronald A. Reis, Prentice Hall of India, 5th ed. [5] Introduction to Programmable Logic Controllers by Gary Dunning, Delmar Thomson Learning, 3rd ed. [6] Programmable Logic Controllers: Programming methods and applications by John R. Hackworth and Frederick D. Hackworth Jr., Pearson publication
E- Book	[1] Introduction to industrial automation: https://nptel.ac.in/courses/108105063/1 [2] The architecture of Industrial Automation Systems https://nptel.ac.in/courses/108105063/2
Reference Books:	[1] Programmable Logic Controller by Frank D Petruzella, McGraw-Hill Education, 5th ed. [2] Programmable Logic Controllers by W. Bolton, Elsevier Newness publication, 4th ed. [3] Programmable Controller by T. A. Huges, ISA publication, 2nd ed. 4. SCADA by Stuart A. Boyer,

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Course Title: Elective VI : AI Applications to Power Systems										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UCSL428/UCSP428									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To enhance knowledge of intelligence system to carry out power system problems.
	2	To impart knowledge about Artificial neural network and fuzzy logic programming for electrical engineering applications like load dispatch and load shedding
Course Outcomes	After completion of the course, students will be able to	
	CO1	Classify neural networks
	CO2	Compare various AI tools
	CO3	Develop algorithms for AI tools
	CO4	Apply AI tools for Applications in electrical power system

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	2	2	2	2	2	2	--	--	--	--	--	2	1	--
CO2	2	2	2	2	2	2	--	--	--	--	--	2	1	--
CO3	2	2	2	2	3	2	--	--	--	--	--	2	1	--
CO4	3	2	2	2	3	2	--	--	--	--	--	2	1	--

Course Contents:

Unit	Contents	Hours
I	**Introduction to Artificial Intelligence** Historical Developments. Essentials of Artificial Neural Networks: Artificial Neuron Model, operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Supervised, Unsupervised, Reinforcement Learning Rules.	**10**
II	**Introduction to Fuzzy logic and Expert system** Fuzzy versus crisp, fuzzy sets: membership function, Basic fuzzy set operations, properties of fuzzy sets, fuzzy relations. defuzzification methods, PSO, biological background, GA operators, selection, encoding, crossover, mutation, chromosome	**10**
III	AI application in Load Forecasting, load scheduling, and energy management system: Data identification processing and interpretation	**08**
IV	AI application in Load flow, stability studies, unit commitment, and state estimation of the power system: Data identification processing and interpretation	**08**
V	AI application in transmission and distribution line protection, fault detection, classification and location: Data identification processing and interpretation	**06**

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Write program to evaluate output of any given architecture of neural network with different transfer functions such as linear logsig tanh, threshold function.
2	Verify the fault tolerant nature of neural network by disconnecting few weight link for a given architecture
3	Write program for perceptron learning algorithm.
4	To study some basic neuron models and learning algorithms by using ANN tool
5	Power system failure analysis using ANN tool
6	Predict power factor of four bus system using neural network
7	Predict system analysis for measurements like rms voltage using ANN tool
8	Write supervised and unsupervised ANN program for Signal Frequency Separation using Perceptron

9	Temperature monitoring using fuzzy logic
10	Speed control of DC motor using fuzzy logic
11	Fuzzy logic based washing machine control
12	Fuzzy logic based air conditioner
13	Design of a Fuzzy Multi-Objective Power System Stabilizer via Linear Matrix Inequalities
Open Ended Experiments / New Experiments	
1	Wind Speed Forecasting Using ANN
2	Solar Irradiation prediction using ANN
Details of on line Laboratory Resource Material Instruction / Operating Manuals	
1.	https://cse22-iiith.vlabs.ac.in/List%20of%20experiments.html
2.	http://vlabs.iitb.ac.in/vlabs-dev/labs/machine_learning/labs/index.php

Textbooks	1	Simon Haykin, "Neural Networks: A Comprehensive Foundation", 2nd Edition, Pearson Education
	2	S. Rajsekaram, G. A. Vijayalaxmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms Synthesis and Applications", Practice Hall India
	3	Mohamed H. Hassoun, "Fundamentals of Artificial Neural Network", Practice Hall India
E books	1	Jacek Zurada, "Introduction to Artificial Neural Network", Jaico Publishing House India
	2	James A. Anderson, "An Introduction to Neural Networks", Practice Hall India Publication
Reference Books	1	Kelvin Waruicke, Arthur Ekwlle, Raj Agarwal, "AI Techniques in Power System", IEE London, U.K.
	2	S. N. Sivanandam, S. Sumathi, S. N. Deepa, "Introduction to Neural Network Using MATLAB 6.0", Tata McGraw Hill

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Course Title: Elective VI : Power Quality Assessment & Mitigation										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL428/UEEP428									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	Ability to identify various power quality issues
	2	Understanding of relevant IEEE standards
	3	Understand and learn to identify harmonics in systems
	4	Awareness about various PQ monitoring techniques and instruments
	5	Ability to characterize various PQ problems
	6	Ability to decide and deploy mitigation techniques
	7	Learn various equipment of monitoring and assessment
Course Outcomes	After completion of the course, students will be able to	
	CO1	Identify the presence of power quality attributes
	CO2	Evaluate and measure various power quality attributes
	CO3	Analyze the industrial systems for various power quality indices and voltage sag monitor and mitigation techniques
	CO4	Identify the sources of waveform distortion
	CO5	Monitor and assess various types of power quality issues and to use various power quality measuring tools, their settings according power systems and to do the power quality audit of the industry and provide solutions to overcome the power quality problems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	2	2	1	1	--	--	--	--	1	1	--
CO2	3	1	2	2	2	1	1	--	--	--	--	--	1	--
CO3	2	1	2	2	3	1	2	--	--	--	--	1	1	2
CO4	2	1	2	2	2	1	2	--	--	--	--	1	1	1
CO5	3	1	2	2	3	1	3	--	3	--	--	1	1	2

Course Contents:

Unit	Contents	Hours
I	**Introduction:** Importance of power quality, terms and definitions of power quality as per IEEE std. 1159.such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance, flickers. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding	**06**
II	**Flickers & Transient Voltages:** RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long-term flickers. Various means to reduce flickers. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages	**06**
III	**Interruptions:** Voltage sags versus interruptions. Sources of sags and interruptions, Economic impact of voltage sag. Voltage sag characteristics. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Voltage sag performance, areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag limits for computer equipment, CBEMA, ITIC, SEMI F - 42 curves. Voltage sag indices.	**07**
IV	**Waveform Distortion:** Definition of harmonics, inter-harmonics, subharmonics. Causes and effect of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices and other indices for assessing impacts of harmonics. A.C. quantities under non-sinusoidal conditions. Triplen harmonics, characteristics and non-characteristics harmonics. Power assessment under waveform distortion conditions. Harmonics resonances - series and parallel	**06**

	resonances. Consequences of harmonic resonance. Principles for controlling harmonics. Reducing harmonic currents in loads. K-rated transformer. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Modifying the system frequency response. Harmonic filtering, passive and active filters. IEEE Harmonic standard 519-1992.	
V	**Power Quality Monitoring and Assessment:** Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality instrumentation. Selection of power quality monitors, selection of monitoring location and period. Selection of transducers. Harmonic monitoring. Transient monitoring, event recording and flicker monitoring. Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion.	**05**

Sr. No.	**Name of Experiments / Mini Projects/ Case Studies**
1	Introduction to power quality analyzer.
2	Measurement of harmonic distortion of SMPS.
3	Design of passive harmonic filter – computer simulation for power electronic application
4	Design of active harmonic filter – computer simulation for power electronic application
5	Simulation studies of harmonic generation sources such as VFD, SVC, STATCOM and FACTS devices and harmonic measurement (THD) by using MATLAB
Open Ended Experiments / New Experiments	
1	Power quality audit of institute or department
2	Case study of grid connected system for power quality mitigation techniques and analysis
Details of on line Laboratory Resource Material Instruction / Operating Manuals	
1.	https://www.researchgate.net/publication/228092496_Power_Quality_Monitoring_and_Analysis_of_a_Laboratory_Building
2.	https://www.researchgate.net/publication/342104097_A_Case_Study_on_Power_Quality_Analysis_for_600_kW_Grid_Connected_Wind_Farm
3	https://onlinecourses.nptel.ac.in/noc21_ee103/preview

Textbooks	1	Understanding power quality problems, voltage sag and interruptions - M. H. J. Bollen IEEE press, 2000, series on power engineering.
	2	Electrical power system quality - Pogei C. Dugan, Mark F. McGranghan, Surya santoso, H. Wayne Beaty, second edition, McGraw Hill Pub
E books	1	Derek A. P., "Power Electronic Converter Harmonics", IEEE Press
	2	Arrillaga J., Smith B. C., Watson N. R. and Wood A. R., "Power System Harmonic Analysis", 2nd 2008 Ed., Wiley India.
	3	Dugan R. C., McGranaghan M. F. and Beaty H. W., Electrical Power System Quality", McGraw-Hill International Book Company
	4	https://onlinecourses.nptel.ac.in/noc21_ee56/preview
Reference Books	1	Power system quality assessment - J. Arrillaga, M.R. Watson, S. Chan, John Wiley and sons.
	2	Electric Power Quality - G. T. Heydt. Stars in a circle Publications

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Course Title: Elective-VI : Optimization Methods										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	
Course Code	UISL406/UISP406									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	Formulate a real-world problem as a mathematical programming model.
	2	Understand the mathematical tools that are needed to solve optimization problems.
	3	Use mathematical software to solve the proposed models.
	4	
Course Outcomes	After completion of the course, students will be able to	
	CO1	Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
	CO2	Apply optimization algorithms to solve Constrained and unconstrained optimization problem
	CO3	Solve different real life problems using linear programing method
	CO4	Understand the Modern methods of Optimization and their applications programming

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	-	-	-	-	-	1	-	-	-	-	-
CO2	1	3	3	2	2	1	1	1	-	-	-	-	2	-
CO3	1	2	2	2	2	3	2	1	1	-	-	-	2	-
CO4	3	1	2	1	3	1	-	-	-	-	-	2	1	-

Course Contents:

Unit	Contents	Hours
I	**Introduction to Optimization:** Engineering application of Optimization – Statement of an Optimization problem – Optimal Problem formulation – Classification of Optimization problem. Optimum design concepts: Definition of Global and Local optima – Optimality criteria – Review of basic calculus concepts – Global optimality	8
II	**Linear programming methods for optimum design:** Review of Linear programming methods for optimum design – Post optimality analysis – Application of LPP models in design and manufacturing.	6
III	Optimization algorithms for solving unconstrained optimization problems – Gradient based method: Cauchy's steepest descent method, Newton's method, Conjugate gradient method.	8
IV	**Optimization algorithms for solving constrained optimization problems** – direct methods – penalty function methods – steepest descent method – Engineering applications of constrained and unconstrained algorithms.	6
V	**Modern methods of Optimization:** Genetic Algorithms – Simulated Annealing – Ant colony optimization – Tabu search – Neural-Network based Optimization – Fuzzy optimization techniques – Applications. Use of Matlab to solve optimization problems.	8

Text Books	1	Engineering optimization: Theory and practice"-by S. S. Rao, New Age International (P) Limited.
	2	Operations Research: An Introduction" by H A Taha, 5th Edition, Macmillan, New York.
	3	Operations Research by NVR Naidu, G Rajendra, T Krishna Rao, I K International Publishing house, New Delhi.
	4	K. Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.
E--Books	1.	"Optimization methods: from theory to design", January 2013,Edition: 1st, Publisher: Springer, ISBN: 9783642311864
	2.	"Handbook of Optimization", Ivan Zelinka, Vaclav Snasel, Ajith Abraham (Eds.) From Classical to Modern Approach
	3.	
Reference Books	1.	Optimization Methods in Operations Research and systems Analysis" – by K.V. Mittal and C. Mohan, New Age, International (P) Limited, Publishers
	2	Operations Research – by S. D. Sharma, Kedarnath Ramanath & Co
	3	Linear programming, G. Hadley, Narosa Publishing House, New Delhi.
	4	Industrial Engineering and Production Management, M. Mahajan, Dhanpat Rai & co
	5	

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Course Title: Elective VI : Electrical Machines Design										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3H rs.	.	02H rs.	04	10	15	50	25	--
Course Code	UEEL430/ UEEP430									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	Design of transformer based on specifications.
	2	Determine performance based on the parameters of transformer.
	3	Design of Induction motor based on specifications.
	4	Determine performance based on the parameters of Induction motor.
	5	Apply computer aided design techniques to transformer and induction motor design.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Summarize temperature rise, methods of cooling of transformer and consider IS 2026 in transformer design
	CO2	Design the overall dimensions of the transformer.
	CO3	Analyze the performance parameters of transformer
	CO4	Design overall dimensions of three phase Induction motor
	CO5	Analyze the performance parameters of three phase Induction motor
	CO6	Implement and develop computer aided design of transformer and induction motor

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes COs	Program Outcomes (POs)												Program Specific Outcomes	
	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
CO1	3	1	2	1	1	--	--	--	--	--	--	1	2	--
CO2	3	3	1	2	1	--	--	--	--	--	--	--	2	1
CO3	1	3	3	2	2	1	--	-	--	--	--	--	2	1
CO4	1	2	3	1	2	1	1	1	--	--	--	--	2	1
CO5	1	3	3	2	3	2	2	--	--	--	--	--	2	1
CO6	2	2	2	3	2	--	--	--	--	--	--	--	2	--

Course Contents:

Unit	Contents	Hours
I	**Transformer Design: Part I** Modes of heat dissipation. Heating and cooling curves. Calculations of heating and cooling time constants. Methods of cooling of transformer. Types and constructional features of core and windings used in transformer. Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. Specifications of three phase transformers as per IS 2026 (Part I). Introduction to computer aided design. Output equation with usual notations, optimum design of transformer for minimum cost and loss. Design of core, estimation of overall dimensions of frame and windings of transformer. Design of tank with cooling tubes	**08**
II	**Transformer Design: Part II** Estimation of resistance and leakage reactance of transformer. Estimation of no-load current, losses, efficiency and regulation of transformer. Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. Computer aided design of transformer, generalized flow chart for design of transformer	**08**
III	**Three phase Induction Motor Design: Part I** Specifications and constructional features. Types of ac windings. Specific electrical and magnetic loadings, ranges of specific loadings. Output equation	**08**

	with usual notations. Calculations for main dimensions, turns per phase and number of stator slots. Suitable combinations of stator and rotor slots. Selection of length of air gap, factors affecting length of air gap. Design of rotor slots, size of bars and end rings for cage rotor. Conductor size, turns and area of rotor slots for wound rotor	
IV	**Three phase Induction Motor Design: Part II** Leakage flux and leakage reactance: Slot, tooth top, zig - zag, overhang. Leakage reactance calculation for three phase machines. MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation, effects of ducts on calculations of magnetizing current, calculations of no-load current. Calculations of losses and efficiency. Computer aided design of induction motor, generalized flow chart for design of induction motor	**08**
V	**Computer Aided Design** Philosophy and economics of computer aided design, advantages limitations, analysis and synthesis methods, and selection of input data and design variables, flow charts for design of induction motor and synchronous machine. Optimization of design constrained and unconstrained optimization problem	**06**

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Details and assembly of three phase transformer with design report. (Sheet in CAD)
2	Details and layout of AC winding with design report. (Sheet in CAD)
3	Assembly of 3- phase induction motor. (Sheet optional CAD or Drawing)
4	Use of Finite Element Analysis (FEA) software for analysis of electrical machines, the report should include: a. Schematic diagram (Diagram/FEA model/Layout) b. Current/Flux/Force distribution. c. Analysis by variation of design parameters.
5	Report based on Industrial visit to a manufacturing unit. (Transformer or Induction motor).
Open Ended Experiments / New Experiments	
1	Industrial visit to a manufacturing unit of transformer and Induction motor.
Details of on line Laboratory Resource Material Instruction / Operating Manuals	

1.	https://www.youtube.com/watch?v=krNH7-wDnZk
2.	https://www.youtube.com/watch?v=2zpkI0Uzab4
3.	https://www.youtube.com/watch?v=WgpmOR5jcVQ

Textbooks	1	M.G. Say – Theory and Performance and Design of A.C. Machines, 3rd Edition, ELBS London.
	2	A.K.Sawhney – A Course in Electrical Machine Design, 10th Edition, - Dhanpat Rai and sons New Delhi.
	3	K. G. Upadhyay- Design of Electrical Machines, New age publication
	4	R. K. Agarwal – Principles of Electrical Machine Design, S. K.Katariya and sons.
	5	Indrajit Dasgupta – Design of Transformers – TMH
E books	1	http://www.sasurieengg.com/e-course-material/EEE/III-Year%20Sem%206/EE2355%20%20%20DEM.pdf
Reference Books	1	K.L. Narang , A Text Book of Electrical Engineering Drawings, Reprint Edition : 1993 / 94 – Satya Prakashan, New Delhi.
	2	A Shanmugasundaram, G. Gangadharan, R. Palani, - Electrical Machine Design Data Book, 3rd Edition, 3rd Reprint 1988 - Wiely Eastern Ltd., - New Delhi
	3	Vishnu Murti, "Computer Aided Design for Electrical Machines", B.S. Publications.
	4	Bharat Heavy Electricals Limited, Transformers - TMH.

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Course Title: : Elective-VI : Advanced Control Theory										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL431/ UEEP431									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	To study advanced knowledge and understanding of theory and application in optimal control, Nonlinear optimization and stochastic optimal control.
	2	To study digital control system design.
Course Outcomes	After completion of the course, students will be able to	
	CO1	Demonstrate advanced knowledge and understanding of theory and application in Control system engineering.
	CO2	Students will be equipped with stability analysis of linear andnonlinear systems.
	CO3	Demonstrate advanced knowledge and understanding of optimal system control, Nonlinear optimization and stochastic optimal control.
	CO4	Design, analyze and perform simulation of digital control system design and ensure desired performance and stability criteria are met.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	3	-	-	-	-	-	-	1		
CO2	3	3	2	3	2	-	-	-	-	-	-	2		
CO3	3	3	-	2	2	-	-	-	-	-	-	2		
CO4	3	3	2	3	1	-	-	-	-	-	-	2		

Course Contents:

Unit	Contents	Hours
I	Review of state variable learning, analysis,controllability and Observability. Discritization of continuous time state equations. Solution of state difference equation, controllability and Observability tests for Digital Control Systems.	6
II	Stability of discrete time Systems. Stability improvement by state feedback ,pole placement design and observers.	8
III	**Lyapunov stability Analysis.** Basic concepts, Lyapunov's first and second methods Stability definitions, Stability theorems, Lyapunov functions for linear and non-linear systems.	8
IV	Optimal Control, parameters optimization techniques, Lagrange parameter techniques, Calculus of variation, unconstrained and constrained minimization of functional. Two point boundary value problems.	6
V	**Introduction to Fuzzy control:** Fuzzy sets and linguistic variables, The fuzzy control scheme, Fuzzification and de fuzzufication methods, Examples, Comparison between conventional and fuzzy control. Introduction to adaptive control and variable structure control. Advanced topic on the subject: Co- ordination and integrated control of different systems in industry.	8

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Simulate the various nonlinearities using Op. Amps.
2	Construct Phase Plane Trajectory by any method and compare it with MATLAB simulation for a nonlinear system.
3	Determination of stability of nonlinear systems using Lyapunov function.
4	Construct trajectories of Vander Pol's equation.
5	Simulate the various methods for direct and indirect model reference adaptive control

6	Determine of stability MIT rule for continues time MRAC systems Lypunov approach and hyper stability approach for continuous time
7	Determine of stability MIT rule for continues time MRAC systems Lypunov approach and hyper stability approach for discrete time MRAC systems
8	Simulate the various methods for applications of adaptive control in Industrial applications.
9	Numerical solution of matrix Riccati equation.
10	State and explain any one of the method for unconstrained optimization (Dichotomous search, Fibonacci method and Golden section method)
11	Dynamic programming in continuous time/Discrete time system for optimal solution of control system

Text Books	1	Chalam, V.V., "Adaptive Control Systems", Techniques & Applications, Marcel Dekker, Inc. NY and Basel. 1987.
	2	Eveleigh, V.W., "Adaptive Control and Optimisation Techniques". McGraw-Hill, 1967.
	3	Narendra and Annasamy, "Stable Adaptive Control Systems", Prentice Hall, 1989.
	4	Astry, S. and Bodson, M., "Adaptive Control", Prentice Hall,1989.
	5	Graham C., Goodwill, S. F. Graebe and M. E. Salgado,"Control System Design" Pearson; US edition (26 September 2000).
Reference Books	1.	M. Vidyasagar, "Nonlinear Systems Analysis", 2nd Ed., Prentice Hall, 1993.
	2	Hassan K. Khalil, "Nonlinear Systems", Third Edition, Prentice Hall, 2002.
	3	William S. Levine (Editor), "The Control Handbook(Electrical Engineering Handbook Series)", CRC Press, March 1996.
	4	Kirk D.E., "Optimal control theory-an introduction", Prentice Hall, N.J. 1970.
	5	Gopal. M., "Modern control system Theory", Wiley Eastern Ltd., 2nd Edition Reprint 1995.

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Course Title: Elective-VI : Digital Protection										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	EL	3Hrs.	.	02Hrs.	04	10	15	50	25	--
Course Code	UEEL432/ UEEP432									
Teaching Mode	Conventional	5 Hrs			Total	75			25	
Duration of ESE	02					100				

Course Objectives	The objective of this course is	
	1	Understand philosophy of various relays used in power system protection.
	2	To know the basic principle of digital relaying
Course Outcomes	After completion of the course, students will be able to	
	CO1	Study of numerical relays
	CO2	Developing mathematical approach towards protection
	CO3	Study of algorithms for numerical protection

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	2	2	1	-	-	-	-	1	1	-
CO2	1	2	2	1	1	-	-	1	1	-	2	1	1	-
CO3	1	2	2	2	2	1	-	-	1	-	-	1	-	1

Course Contents:

Unit	Contents	Hours
I	**Introduction to Digital Relaying**: Evolution of digital relays from electromechanical relays, Types of Digital Relays, Performance and characteristics of digital relaying.	6
II	**Basic elements of digital protection:** Conversion subsystem: the sampling theorem, signal aliasing error, sample and hold circuits, analog to digital conversion Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers Digital filtering concepts, the digital relay as a unit consisting of hardware and software	8
III	**Interconnected System Protection:** Protection of an interconnected system Link net structure, Flowchart of Primary/Backup relay pairs, Examples based on existing power system network	8
IV	**Digital Protection Algorithm:** Sinusoidal wave based algorithms Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm. Least Squares based algorithms. Walsh function based algorithm. Differential equation based algorithms. Traveling Wave based Techniques	6
V	**Numerical Relays :** Digital protective relays – multistage frequency relay - measurement of power system signals through phase locked loop interface - protection of alternators against loss of excitation. over current relays- impedance relays- directional relay-reactance relay – distance relay – measurement of R and X – mho relay -quadrilateral relay – generalized interface for distance relays.	10

Sr. No.	Name of Experiments / Mini Projects/ Case Studies
1	Study of digital relays with detailed description of each component of the schematic diagram of digital
2	Relay
3	Setting up IDMT relays for a radial feeder
4	Setting up IDMT/DOC relays for a power system using link net structure
5	Simulation of various fault signals and fault calculations.
6	Study of frequency domain analysis of a fault generated signal.
7	Study of Curve fitting and smoothing techniques.
8	Study of digital differential protection of transformers.

Text Books	1	A. G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009 2. 34. 4. 5.
	2	A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press,1999
	3	Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006
		S. R. Bhide "Digital Power System Protection" PHI Learning Pvt. Ltd.2014
		P M. Anderson, Series Editor, IEEE Press Power Engineering Series, "POWER SYSTEM PROTECTION"
		S. R. Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014
Reference Books	1.	Singh L. P, "Digital Protection-Protective Relaying from electromechanical to microprocessors"
	2	Madhava Rao T.S, "Power System Protection-Static relays"
on line TL Material	1.	http://nptel.ac.in/downloads/108101039/

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Course Title: Project										
Semester	VII	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	P	--	.	08Hrs.	04	--	--	--	50	50
Course Code	------									
Teaching Mode	Conventional	5 Hrs			Total	--			100	
Duration of ESE	---					100				

Course Objectives	The objective of this course is	
	1	To understand Electrical Engineering applications
	2	To understand concepts of Electrical Engineering
	3	To review research literature and analyze complex engineering problem
	4	To design solutions for complex engineering problems
Course Outcomes	After completion of the course, students will be able to	
	CO1	Design and develop Electrical system/model/simulation/analysis to solve real life problem.
	CO2	Use and apply modern tool and techniques to investigate and solve complex engineering problems
	CO3	Work efficiently individually and team work
	CO4	Able to comprehend and write effective reports make presentation, give and receive instructions

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	1	3	1	--	--	---	--	--	--	2	2
CO2	2	2	3	1	3	1	2	--	---	--	--	--	2	2
CO3	3	2	3	3	3	1	--	--	3	--	--	1	2	2
CO4	3	2	3	2	3	1	--	--	---	--	3	---	2	2

Guidelines:

The student shall complete the project in VIIth Semester. The change of topic has to be approved by Internal Assessment Committee consisting of Guide, Project Coordinator and Head of Department.
Student should incorporate suggestions given by examiner.
The student shall complete the project which consists of design, simulation, fabrication of set up required for the project, analysis and validation of results and conclusions.
The student shall prepare duly certified final report of the project work in the standard format in MS Word / LaTex. Student should maintain Project Work Book.