PROPOSED COURSE STRUCTURE AND SYLLABI (NEP 2020) B.TECH (FOUR YEARS COURSE)



DEPARMENT OF ELECTRICAL ENGINEERING (EE),
INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY (IIEST),
SHIBPUR, HOWRAH

JUNE 2025

COURSE STRUCTURE FOR B. TECH. IN ELECTRICAL ENGINEERING

Sl.	Type Course Name Course Load/W		Class ad/W		Credit	Class load/	Marks				
No.	Type	Course I value	code	L	Т	P		week			
1	BSC	Engineering Mathematics – I	MA1101N	3	1	0	4	4	100		
2	BSC	Engineering Chemistry	CH1101N	3	0	0	3	3	100		
3	ESC1	Basic Electrical Engg	EE1101N	3	0	0	3	3	100		
4	ESC2	Basic Electronics	ET1101N	3	0	0	3	3	100		
5	VAC	Well-being and happiness	HU1101N	2	0	0	2	2	50		
6	HSC	Professional communication in English	HU1102N	2	1	0	3	3	100		
		Theory Sub-total		16	2	0	18	18	550		
7	ESC	Workshop	WS1171N	0	0	3	2	3	50		
8	ESClab1	Basic Electrical Engg Lab	EE1171N	0	0	3	2	3	50		
9	ESClab2	Computer Programming Practices Lab	CS1171N	0	0	3	2	3	50		
10		NSS/NCC/PT/Yoga					R*				
		Practical Sub-total		0	0	9	6	9	150		
		First Semester Total		16	2	9	24	27	700		
*R: R	Lequired (No	on-credit but with grade)									
Secon	id Semester										
Sl.	Туре	Course Name	Course	107160000000	Class Load/Week		Lond/Wook		Credit	Class load/	Mark
No	-3P-		code	L	T	P		Week			
1	BSC	Engineering Mathematics – II	MA1201N	3	1	0	4	4	100		
2	BSC	Engineering Physics	PH1201N	3	0	0	3	3	100		
3	ESC3	Basic Electrical Engg	EE1201N	3	0	0	3	3	100		
4	ESC4	Engineering Mechanics	AM1201N	3	0	0	3	3	100		
5	ESC5	Signals and Systems (for ET)	EE1202N	3	0	0	3	3	100		
6	ESC	Introduction to AI and ML	CS1201N	3	0	0	3	3	100		
7	VAC	Energy, Environment and Climate Change	CE1101N	2	0	0	2	2	50		



8	PC1	Digital and Analog Electronics	EE1203N	3	0	0	3	3	100
		Theory Sub-total		23	1	0	18	24	750
9	ESC	Engineering Graphics	AM1271N	0	0	3	2	3	50
10	ESClab3	Basic Electrical Engg Lab	EE1271N	0	0	3	2	3	50
11	ESClab4	Physics Lab	PH1271N	0	0	3	2	3	50
12	PC	Introduction to labs of the department	EE1272N	0	0	3	2	3	50
13		NSS/NCC/PT/Yoga					R*		
		Practical Sub-total		0	0	12	6	12	200
		Second Semester Total		23	1	12	24	36	950
*R: R	equired (No	on-credit but with grade)							

Third Semester

Sl.	Туре	Course Name	Course	Cla	ass Lo	S Load Credit		Class	Marks
110				L	L T P				
1	ESC6	Maths III	MA2101N	3	0	0	3	3	100
2	ESC7	Signals and Systems	EE2101N	3	0	0	3	3	100
3	PC2	Engineering Electrodynamics	EE2102N	3	0	0	3	3	100
4	PC3	Electrical Machines I	EE2103N	3	1	0	4	4	100
5	PC4	Network Theory	EE2104N	3	0	0	3	3	100
		Theory Sub-total		15	1	0	16	16	500
6	PC	Digital and Analog Electronics Lab and projects	EE2171N	0	0	3	2	3	50
7	PC	Electrical Machines I Lab	EE2172N	0	0	3	2	3	50
8	PC	Networks and Circuit Theory Lab and Projects	EE2173N	0	0	3	2	3	50
		Practical Sub-total		0	0	9	6	9	150
		Third Semester Total		15	1	9	22	25	650

Fourth Semester

Sl. No	Туре	Course Name	Course			Class Load/Week		Class Load/Week												Class load/	Marks
140			Code	L	T	P		week													
1	PC5	Electrical Machines II	EE2201N	3	1	0	4	4	100												
2	PC6	Power Systems I	EE2202N	3	0	0	3	3	100												
3	PC7	Control Systems I	EE2203N	3	0	0	3	3	100												



		Electrical and			(Felicians				
4	PC8	Electrical and Electronic	EE2204N	3	0	0	3	3	100
	100	Measurements	DDZZOTIV	3					100
5	OE	OE1		3	1	0	3	3	100
		Theory Sub-total		15	2	0	16	16	500
6	PC	Electrical Machines II Lab	EE2271N	0	0	3	2	3	50
7	PC	Measurements Lab and projects	EE2272N	0	0	3	2	3	50
8	PC	Programming and Numerical Computing in Electrical Engineering	EE2273N	0	0	3	2	3	50
9	PC	Power Systems Design and Machine Design	EE2274N	0	0	3	2	3	50
		Practical Sub-total		0	0	12	8	12	200
		Fourth Semester Total		15	2	12	24	28	700
Fifth	Semester								
Sl. No	Туре	Course Name	Course	Class Load/Week		Credit	Class load/	Marks	
	7.00		Code	L	T	P		week	4.00
1	PC9	Power Systems II	EE3101N	3	0	0	3	3	100
2	PC10	Control Systems II	EE3102N	3	0	0	3	3	100
3	PC11	Power Electronics	EE3103N	3	0	0	3	3	100
4	PC12	Power Systems Protection	EE3104N	3	0	0	3	3	100
5	OE	OE2		3	0	0	3	3	100
		Theory Sub-total		15	0	0	15	15	500
6	PC	Power Systems Lab	EE3171N	0	0	3	2	3	50
7	PC	Control Systems Lab and design	EE3172N	0	0	3	2	3	50
8	PC	Power System Protection Lab and Renewable Energy Lab	EE3173N	0	0	3	2	3	50
									1 = 0
		Practical Sub-total		0	0	9	6	9	150
		Fifth Semester Total		15	0	9	21	24	650
				1	1	I	I	1	
Civth	Comester								
	Semester				Class			Class	
Sixth Sl. No	Semester Type	Course Name	Course		Class		Credit	Class load/	Marks



1	PC13	Microcontrollers and Embedded Systems	EE3201N	3	0	0	3	3	100
2	PC14	Transducers and Instrumentation	EE3202N	3	0	0	3	3	100
3	PSE1	Elective 1		3	0	0	3	3	100
		i) High Voltage Engineering	EE3221N						
		ii) New and Renewable Energy	EE3222N						
		iii) Soft Computing and Intelligent Systems	EE3223N						
		iv) Electrical estimation and costing	EE3224N						
		v) Advanced Topics in Control and Estimation	EE3225N						
4	VAC	Sociology & Professional Ethics		3	0	0	3	3	100
5	OE	OE3		3	0	0	3	3	100
		Theory Sub-total		15	0	0	15	17	500
6	PC	Microcontroller and Embedded Systems Lab	EE3271N	0	0	3	2	3	50
7	PC	Transducers and Instrumentation Lab and Design	EE3272N	0	0	3	2	3	50
8	PC	Power Electronics Lab and design	EE3273N	0	0	3	2	3	50
9	PSE	Elective 1 Sessional	EE3274N	0	0	3	2	3	50
		Practical Sub-total		0	0	12	8	12	200
		Sixth Semester Total		15	0	12	23	29	700
Cougan	th Semeste	**							
Seven	in Semeste.				Class			Class	
Sl.	Type	Course Name	Course		ad/W		Credit	load/	Marks
No	-31		Code	L	T	P		week	
1	PC15	Industrial Drives and Automation	EE4101N	3	0	0	3	3	100
3	PSE2	Elective 2		3	0	0	3	3	100
		i) Digital Communication in Electrical Systems	EE4121N						
		ii) Power Generation Economics and Reliability Analysis	EE4122N						
		iii) Electronic System Design	EE4123N						



		Total		3	0	0	13	3	450
		Eighth Semester							
		Practical Sub-total		0	0	0	10	0	350
3	0	Grand viva	EE4272N				2		50
2	I/P	One Semester Internship / Project	EE4271N				8		300
		Theory Sub-total		3	0	0	3	3	100
		from Institute)							
1	OE	OE5 (from NPTEL for the students opting Internship/ for others	EE4201N	3	0	0	3	3	100
No	-31		Code	L	T	P		week	
Sl.	Туре	Course Name	Course		Class ad/W		Credit	Class load /	Mark
Eighi	th Semeste	<u>r</u>				The second second second			
		Total		12	U	0	10	10	300
		Seventh Semester		12	0	6	16	18	500
7	I	Internship Practical Sub-total		0	0	6	4	6	100
6	PSE	Elective 2 Sessional	EE4172N	0	0	3	2	3	50
5	PC	Drives and Automation Lab and Projects	EE4171N	0	0	3	2	3	50
		Theory Sub-total		12	0	0	12	12	400
4	OE	OE4		3	0	0	3	3	100
3	HSC	Finance Economics and Management for Engineers		3	0	0	3	3	100
		vi) Autonomous Navigation for Unmanned Vehicle	EE4126N						
		v) Electric Vehicle	EE4125N						4 1 5 7
		iv) Computer Networking and Programming Techniques for Electrical Applications	EE4124N						



A. NOMENCLATURE:

- 1. BSC-Basic Science Course
- 2. ESC-Engineering Science Course
- 3. PC-Programme Core
- 4. PSE-Programme Specific Elective
- 5. OE -Open Elective

B. DESCRIPTION:

- 1. This document contains syllabus of all EE courses (excepting Electrical Machines -1) appearing in the other pdf the EE course structure.
- 2. Total 8 semesters are there out of which the 8th sem has no departmental papers.
- 3. The syllabi of ESC, PC and PSE papers are arranged here semester wise, matching with course structure.
- 4. In the 6th sem **5** PSE are offered.
- 5. In the 7th sem 5 PSE are offered.



First Semester

Sl. No.	Туре	Course Name	Course code	STARTED ST	Clas	s Veek	Credit	Class load/	Marks
			code	L	Т	P		week	
1	BSC	Engineering Mathematics – I	MA1101N	3	1	0	4	4	100
2	BSC	Engineering Chemistry	CH1101N	3	0	0	3	3	100
3	ESC1	Basic Electrical Engg	EE1101N	3	0	0	3	3	100
4	ESC2	Basic Electronics	ET1101N	3	0	0	3	3	100
5	VAC	Well-being and happiness	HU1101N	2	0	0	2	2	50
6	HSC	Professional communication in English	HU1102N	2	1	0	3	3	100
		Theory Sub-total		16	2	0	18	18	550
7	ESC	Workshop	WS1171N	0	0	3	2	3	50
8	ESClab1	Basic Electrical Engg Lab	EE1171N	0	0	3	2	3	50
9	ESClab2	Computer Programming Practices Lab	CS1171N	0	0	3	2	3	50
10		NSS/NCC/PT/Yoga	B. C.				R*		
		Practical Sub-total		0	0	9	6	9	150
		First Semester Total		16	2	9	24	27	700
	1	*R:	Required (N	on- c	red	it bu	t with gra	ade)	1



Course	EE1101N	Course	Basic Electrical	Course	ESC	L	T	P
Code	EE1101N	Name	Engineering	Category	ESC	3	0	0

Pre-requisite Courses	Fundamentals of Physics	Co- requisite Courses	Nil	Progressive Courses	Electrical Machines
Course Offeri	ng Department	Electrical E	ngineering	Data Book / Codes/Standards	Nil

Course	1. To study fundamentals of D C circuits and circuit theorems.
Objectives	2. To learn about the fundamentals of A.C. circuits.
	3. To get acquainted with the working principle of measuring instruments.
	4. To study the basics of Magnetic circuits.
	5. To be familiarised with the generation, transmission and distribution of
	electricity.
	6. To learn the fundamentals of Transformers, D. C. Machines and Induction
	Motors.

Module	Syllabus	Duration	Module Outcome
	*	(class-hour)	
I.	DC Circuits: Introduction (Node, branch, active & passive elements, linear and non-linear circuits, unilateral and bilateral network), Kirchhoff's laws, Maxwell's loop current method, Nodal method, stardelta transformation, Network theorems:—Superposition theorem, Thevenin's theorem, Maximum power transfer theorem.	10	• Apply network theorems to solve problems in D.C circuits.
II.	MeasuringInstruments:CommonElectricalLaboratoryInstruments(Ammeter,Voltmeter,Wattmeter)-Classifications of measuringinstruments,mention of Digital meters	3	• Learn the fundamentals of measuring instruments.
III.	Magnetics: Magnetic quantities, B-H curve, calculation on magnetic circuits, analogy with electric circuit, iron losses.	3	• Analyse Magnetic Circuits, compute losses.
IV.	DC Machines: Construction, types, operating principles (motoring and generating modes), ratings, speed control methods, applications.	3	• Learn the fundamentals of D. C. Machines.
V.	Transformers: Construction, types, ratings, operating principle, EMF equation,	3	• Learn the fundamentals of Transformers.

	concept of losses, efficiency, mention of three-phase transformers.		
VI.	AC Fundamentals: Introduction, Sinusoidal and non-sinusoidal quantities, phase and phase difference, average and RMS values, form factor and peak factor, concept of phasor diagram, impedance and admittance, power and power factor.	6	 Learn fundamentals of AC signals Calculate average and R.M.S. quantities in an A.C. network.
VII.	AC Circuits: Single-Phase: V-I relationship in R-L-C circuit, series and parallel R-L-C circuit, phasor diagrams, apparent, active and reactive power, resonance in electrical circuit. Three-Phase-Balanced system, star and delta connections, phase and line quantities and their relationships.	8	• Analyse R-L, R-C and R-L-C series and parallel circuits
VIII.	Generation, Transmission and Distribution of Electricity: General structure of an Electrical Power System, domestic Supply System, Switch Fuse Unit, MCB, and Earthing.	3	• Know the structure of an electrical power system and domestic supply systems.
IX.	Three-phase Induction Machines: Construction, types, ratings, operating principle, slip, slip frequency, torque-slip characteristics.	3	• Learn fundamentals of Induction Motors.
	Total:	42L	

Course Outcome	 The students shall be able to, Apply network theorems to solve problems in D.C circuits. Calculate average and R.M.S. quantities in an A.C. network. Analyse R-L, R-C and R-L-C series and parallel circuits Analyse Magnetic Circuits, compute losses Learn the fundamentals of measuring instruments. Explain the structure of an electrical power system and domestic supply systems. Learn the fundamentals of Transformers, D. C. Machines and Induction Motors.
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Learning Resources	A course in Electrical Engineering: Volume I-Direct Currents; Volume II-Alternating Current by Chester L. Dawes, McGraw-Hill
	2. Basic Electrical Engineering by V. N. Mittal and Arvind Mittal, Second Edition, 2005, Tata McGraw-Hill Education

- 3. Electrical Engineering Fundamentals by Del Toro, 1972, Prentice-Hall
- 4. Advanced Electrical Technology by H. Cotton, 1990, Reem Publications (P) Ltd
- 5. Electrical and Electronic Technology by Hughes, 2005, Pearson Prentice Hall
- 6. Electric Circuits by J. Edminister and M. Nahvi, 2005, McGraw-Hill
- 7. Web resource:

http://ntpl.iitm.ac.in/course/Webcourse-contents/IIT%20kharagpur/Basic%20Technology/New index1.html.

Basic Electrical Engineering Laboratory (EE1171N)

Weekly Contact: 0-0-3(L-T-P) Full Marks -50

Credits:2

Laboratory experiments based on the subject "Basic Electrical Engineering (EE1101N)".

Second Semester

Sl. No	Туре	Type Course Name		Class Load/Week			Credit	Class load/	Marks
			code	L	Т	P		Week	
1	BSC	Engineering Mathematics – II	MA1201N	3	1	0	4	4	100
2	BSC	Engineering Physics	PH1201N	3	0	0	3	3	100
3	ESC3	Basic Electrical Engg	EE1201N	3	0	0	3	3	100
4	ESC4	Engineering Mechanics	AM1201N	3	0	0	3	3	100
5	ESC5	Signals and Systems	EE1202N	3	0	0	3	3	100
6	ESC	Introduction to AI and ML	CS1201N	3	0	0	3	3	100
7	VAC	Energy, Environment and Climate Change	CE1101N	2	0	0	2	2	50
8	PC1	Digital and Analog Electronics	EE1203N	3	0	0	3	3	100
		Theory Sub-total		23	1	0	24	24	750
9	ESC	Engineering Graphics	AM1271N	0	0	3	2	3	50
10	ESClab3	Basic Electrical Engg Lab	EE1271N	0	0	3	2	3	50
11	ESClab4	Physics Lab	PH1271N	0	0	3	2	3	50
12	PC	Introduction to labs of the	EE1272N	0	0	3	2	3	50
12	rc	department	EE12/2N	U	U	3	2	3	30
13		NSS/NCC/PT/Yoga					R*		
		Practical Sub-total		0	0	12	6	12	200
		Second Semester Total		23	1	12	24	36	950
		*R: Required (Non-cr	edit but with	grad	le)				



Course	EE1201N	Course	Basic Electrical	Course	ESC	L	Т	P
Code	EEIZUIN	Name	Engineering	Category	ESC	3	0	0

Pre-requisite Courses	Fundamentals of Physics	Co- requisite Courses	Nil	Progressive Courses	Electrical Machines
Course Offerin	Offering Department Electrical Engineering Codes/Standards		Nil		

Course	7. To study fundamentals of D C circuits and circuit theorems.				
Objectives	8. To learn about the fundamentals of A.C. circuits.				
	9. To get acquainted with the working principle of measuring instruments.				
	10. To study the basics of Magnetic circuits.				
	11. To be familiarised with the generation, transmission and distribution of				
	electricity.				
	12. To learn the fundamentals of Transformers, D. C. Machines and Induction				
	Motors.				

Module	Syllabus	Duration	Module Outcome
	· ·	(class-hour)	
I.	DC Circuits: Introduction (Node, branch, active & passive elements, linear and non-linear circuits, unilateral and bilateral network), Kirchhoff's laws, Maxwell's loop current method, Nodal method, stardelta transformation, Network theorems:—Superposition theorem, Thevenin's theorem, Maximum power transfer theorem.	10	Apply network theorems to solve problems in D.C circuits.
II.	MeasuringInstruments:CommonElectricalLaboratoryInstruments(Ammeter,Voltmeter,Wattmeter)-Classificationsof measuringinstruments,mention of Digital meters	3	Learn the fundamentals of measuring instruments.
III.	Magnetics: Magnetic quantities, B-H curve, calculation on magnetic circuits, analogy with electric circuit, iron losses.	3	Analyse Magnetic Circuits, compute losses.
IV.	DC Machines: Construction, types, operating principles (motoring and generating modes), ratings, speed control methods, applications.	3	Learn the fundamentals of D. C. Machines.
V.	Transformers: Construction, types, ratings, operating principle, EMF equation,	3	Learn the fundamentals of Transformers.

	concept of losses, efficiency, mention of three-phase transformers.		
VI.	AC Fundamentals: Introduction, Sinusoidal and non-sinusoidal quantities, phase and phase difference, average and RMS values, form factor and peak factor, concept of phasor diagram, impedance and admittance, power and power factor.	6	 Learn fundamentals of AC signals Calculate average and R.M.S. quantities in an A.C. network.
VII.	AC Circuits: Single-Phase: V-I relationship in R-L-C circuit, series and parallel R-L-C circuit, phasor diagrams, apparent, active and reactive power, resonance in electrical circuit. Three-Phase-Balanced system, star and delta connections, phase and line quantities and their relationships.	8	Analyse R-L, R-C and R-L-C series and parallel circuits
VIII.	Generation, Transmission and Distribution of Electricity: General structure of an Electrical Power System, domestic Supply System, Switch Fuse Unit, MCB, and Earthing.	3	Know the structure of an electrical power system and domestic supply systems.
IX.	Three-phase Induction Machines: Construction, types, ratings, operating principle, slip, slip frequency, torque-slip characteristics.	3	Learn fundamentals of Induction Motors.
	Total:	42L	

Course Outcome The students shall be able to, 8. Apply network theorems to solve problems in D.C circuits. 9. Calculate average and R.M.S. quantities in an A.C. network. 10. Analyse R-L, R-C and R-L-C series and parallel circuits 11. Analyse Magnetic Circuits, compute losses 12. Learn the fundamentals of measuring instruments. 13. Explain the structure of an electrical power system and domestic sup systems. 14. Learn the fundamentals of Transformers, D. C. Machines and Induct Motors.
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Learning Resources	8. A course in Electrical Engineering: Volume I-Direct Currents; Volume II-Alternating Current by Chester L. Dawes, McGraw-Hill
	9. Basic Electrical Engineering by V. N. Mittal and Arvind Mittal, Second Edition, 2005, Tata McGraw-Hill Education

- 10. Electrical Engineering Fundamentals by Del Toro, 1972, Prentice-Hall
- 11. Advanced Electrical Technology by H. Cotton, 1990, Reem Publications (P) Ltd
- 12. Electrical and Electronic Technology by Hughes, 2005, Pearson Prentice Hall
- 13. Electric Circuits by J. Edminister and M. Nahvi, 2005, McGraw-Hill
- 14. Web resource:

http://ntpl.iitm.ac.in/course/Webcourse-contents/IIT%20kharagpur/Basic%20Technology/New index1.html.

Course	EE1202N	Course	Signals &	Course	ESC	L	T	P
Course Code	EE1202N	Name	Systems	Category	ESC	3	0	0

Pre-requisite Courses	Engineering Mathematics	Co-requisite Courses	Basic E Engin	lectrical eering	Progressiv Courses	
Course Offering Department		etrical Engineerin	Data Book / Codes/Standards		Nil	

Course	1.	To study the different types of sources and classification of signals,
Objectives	2.	To introduce an overview of different type of systems & their stability,
	3.	To apply differential equation method to analyse switching transients in electrical circuits with input excitation,
	4.	To study the dynamics and electrical circuit model of different electrical and non-electrical systems,
	5.	To introduce analysis of the signals & systems in Complex domain applying Laplace Transform
	6.	To explore Fourier decomposition to analyse and manipulate signals in frequency domain

Mod- ule	Syllabus	Duration (Class-Hours)	Module Outcome
I.	Source & Signals: Different types of Sources – deterministic and stochastic, dependent and independent sources; Source Transformation – VCVS, VCCS, CCVS, and CCCS; Continuous-time and discrete-time signals, even and odd signals, periodic and aperiodic signals, gate functions, standard signals and other basic signals, Energy and power signals.	5	To identify different types of sources and signals, classify and mathematical expression of signals and systems.
II.	Systems: Types of systems—continuous- time, discrete-time, linear, nonlinear, time-invariant, time-variant, causal, non- causal systems, Stability, Interconnection of systems.	3	To demonstrate an overview on the different types of systems & their stability.
III.	Transient Responses of Passive Circuits: Differential equation approach – RL, RC, RLC circuits with dc and sinusoidal excitation. Application to transient solution for different simple	10	To compute mathematically the switching transients in different electrical

	networks, switching transients and impulses in networks.		circuits with input excitations.
IV.	System Dynamics: System modelling concepts, Transfer function, block diagram representation of systems; Electrical Analogous networks for Mechanical, Thermal and Hydraulic systems.	5	To represent the dynamics and modelling of different electrical and non-electrical systems.
V.	Signal Analysis in Laplace Domain: Complex Frequency and the Laplace Transform – definitions, Transform of common forcing functions. Derivatives and integrals, shifted functions, shifting and scaling of signals, Initial and Final Value theorems, Inverse Laplace Transform, Convolution integral, Heaviside Theorem. Transient responses of Passive circuits using Laplace transform method.	10	To mathematically analyse the signals & in complex frequency domain and find transient response.
VI.	Fourier Analysis: Fourier series (continuous and discrete), evaluation of Fourier coefficients, reference of waveform symmetry, Frequency spectrum, convergence in truncated series, Properties of Fourier analysis, shifting function, Exponential form and Trigonometric form of Fourier series, Line spectrum, steady state responses to periodic signals, aperiodic functions, Fourier Integral and continuous spectra: Spectrum envelope for a recurring Pulse, Fourier Integral and Fourier Transform(continuous and discrete).	9	Fourier decomposition to analyze and manipulate signals in frequency domain
	TOTAL:	42L	

	Course	The students shall be able to,			
	Outcome	1. Identify different types of sources and classify the signals,			
	2. Demonstrate an overview on the different type of systems & its stab				
3. Mathematically compute the switching transients in different electrical with input excitations,4. Represent the dynamics of different electrical and mechanical systems,		3. Mathematically compute the switching transients in different electrical circuits with input excitations,			
		4. Represent the dynamics of different electrical and mechanical systems,			
		5. Apply the analysis of the signals & systems in complex frequency domain,			

6. Extend Fourier decomposition to analyse and manipulate signals in the frequency domain.

Learning Resources

- 1. Signals and Systems, Alan V. Oppenheim, A. S. Willsky and S. H. Nawab, 2nd edition, Pearson India, 2015.
- 2. Circuits and Systems, K. M. Soni, S. K. Kataria & Sons, New Delhi, 2010.
- 3. Fundamentals of Signals and Systems, M. J. Roberts and G. Sharma, $,2^{nd}$ edition, Mc Graw-Hill Education, 2017.
- 4. Networks and Systems, D. Roy Choudhury, 2nd edition, New Age International (P) Ltd., 2014.
- 5. Circuit Theory: Analysis and Synthesis, A. Chakrabarti, 7th revised edition, Dhanpat Rai & Co, 2018.
- 6. Network Analysis and Synthesis, C. L. Wadhwa, 3rd edition, New Age International (P) Ltd., 2014.

Course	EE1203N	Course	Digital and	Course	PC	L	Т	P
Code		Name	Analog	Category				
			Electronics			3	1	0

Pre-requisite Courses	Basic Electronics Engineering	Co- requisite Courses	Networks and Circuit Theory	Progressive Courses	Electrical and Electronics Measurement
Course Offering Department		Electrical E	Engineering	Data Book / Codes/Standards	-

	This course will enable students to			
Course	1. understand basic functional blocks constituting an OPAMP			
Objective	2. analyze and design various Operational Amplifier circuits used in			
	various linear and non-linear applications			
	3. understand the operation of IC555 timer IC and PLLIC565			
	4. understand the principles of Boolean Combinational Logic based			
	circuits and deduce their minimized forms			
	5. understand the principle of operation of various latches and flip-flops,			
	analyze sequential logic circuits and design counters			
	6. analyze the operation of various digital integrated circuits			
	7. acquire basic ideas behind the working of D/A and A/D converters			
	and know their limitations			
	8. learn about the basic building blocks of an elementary digital computer			
	and the principle functions of such blocks			

Module	Syllabus	Duration (class-hour)	Module outcomes
1.	Difference Amplifier: Common mode and differential mode gains, CMRR, Realization of DIFF amplifier using BJT and their difference mode and common mode gain, input common mode range, input difference mode range, introduction to FET difference amplifier	4	• To gain sufficient knowledge about initial building block of an OPAMP

2.	OPAMP: Internal circuit of a typical dual differential stage OPAMP (functional blocks only), ideal input and output characteristics, non-idealities in an op-amp (Output offset voltage, input bias current, input offset current, slew rate, gain bandwidth product), important specifications, frequency response	4	• To gain sufficient knowledge about the fundamental building blocks of an OPAMP and the limitations they invite The module will help to read the specification and selection of an OPAMP for particular contextual use.
3.	Feedback amplifiers and Oscillators: Different feedback configurations. Analysis of OPAMP amplifier circuit (non-inverting and inverting) using feedback concept, Use of positive feedback: Theory of sinusoidal oscillator — The Barkhausen criteria. Realization of sinusoidal oscillators (Wein bridge and phase shift)	4	• To gain knowledge about analysis of the OPAMP circuits with different feedback and to know how to design a sinusoidal oscillator.
4.	Linear application of OPAMPs: Realization of adder, subtractor, differentiator and integrators, constant gain multiplier, active filters (second order Butterworth low pass filter, high pass filter and bandpass filter), linear voltage regulator	3	• To gain knowledge about the important uses of OPAMP in linear circuit design like adder, subtractor, gain multipliers, filters, voltage regulators etc.
5.	Non-linear application of OPAMPs: Hysteresis Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators. Precision rectifier, multi-vibrators, logarithmic multiplier		• To gain knowledge about the important uses of OPAMP in non- linear circuit design like ZCD, Waveform generators, precision rectifiers, multivibrators, multipliers
6.	Other important applications of OPAMPs: Timer IC 555, PLL IC 565	2	• To gain knowledge about the important uses of timer IC 555 and PLL IC 565

7.	Combinational Logic Circuits: Short recapitulation on Karnaugh Mapping; SOP, POS; realization; Code Converter, Arithmetic Operations; MUX and DMUX, Encoder/Decoder—ROM &PLA, concept of Schmitt-trigger, Tristate Buffer etc.	4	• To have a thorough knowledge regarding the analysis and synthesis of combinational logic based circuits.
8.	Latches and Flip-Flops: R-S,D,T,J-K Flip-Flops, state-tables; flip-flops as units of memory and application as contact de-bouncer; Edge and Level Triggered architectures—etc.	3	• To gain knowledge about the functioning of various flip-flops and latches
9.	Sequential Logic Circuits: Registers and buffers using flip-flops; Shift-registers and Ring-counters using flip-flops; Serial to Parallel and Parallel to Serial data conversion: Principle and Block diagram; Counters: Up and Down; synchronous and ripple counters; Modulo-N counter — a few examples; design of counters and memory registers, basic binary cell, SRAM and DRAM cells	5	• To have a thorough understanding of working of some commonly used sequential logic circuits, which may also help the students in designing such circuits
10.	Digital Integrated Circuits BJT characteristics (recap), RTL, and DTL circuits; TTL circuits—conventional and open-collector architectures, tri-state TTL architecture, ECL and CMOScircuits	4	• To gain knowledge regarding the various architectures of digital integrated circuits
11.	Data Acquisition Systems: AtoDandDtoAconversion,Sample/Holdcir cuit,Acquisitiontime,Aperturetime,Holdti me, Conversiontime, Differenttypesof ADCsandDACs	3	To gain thorough knowledge on data conversion circuits and systems

12.	Digital Micro-Computer System: BasicBuildingBlocksofaDigitalMicro-Computer System—abriefintroduction	2	• To have a preliminary understanding regarding the building blocks of an elementary digital micro-computer — their working and significance
Total:		42L +14T	

Course Outcome	After Studying this course, students
	1. gain sufficient knowledge to realize various linear and non—linear circuits using OPAMPs,
	2. should be able to apply IC555 to realize various timing circuits
	3. should be able to utilize IC 565 for synchronization purpose
	4. should be able to understand and analyze elementary digital circuits based on combination and sequential logic,
	5. should be able to understand and analyze A/D and D/A circuits
	6. should be able to understand and analyze the operation of major types of digital integrated circuits
	7. should be able to identify the basic building blocks of a digital computer and their major functions

Learning Resources

Text Books:

- Microelectronic Circuits –Theory and Applications A. S. Sedra and K. C. Smith, Oxford University Press, 7th Edition, South Asia Edition, ISBN:9780199476299
- 2. Electronic Devices and Circuits (Discrete and integrated)— Y. N. Bappat, 2nd Edition, Tata McGraw-Hill
- 3. Fundamentals of Microelectronics, B. Razavi, 2nd Edition
- 4. OPAMP and Linear Integrated Circuits- Ramakant A Gaykward, 4th Edition, Prentice Hall, 2000, 0132808684, 9780132808682
- 5. Electronics Principles Albert Malvino and David Bates, Eighth Edition, McGraw-HillISBN13: 9780073373881
- 6. Digital Logic and Computer Design— M. Morris Mano,1st Edition, Pearson Education; ISBN No.: 9789332542525, 2016
- 7. Digital Principles and Applications Donald P. Leach, Albert Paul Malvino and GautamSaha, McGraw Hill Education, 8th Edition, ISBN No.: 978-9339203405, 2014

Web resources: https://archive.nptel.ac.in/courses/108/105/108105158/https://archive.nptel.ac.in/courses/117/106/117106086/

Reference Books:

- 1. **Integrated Electronics: Analog and Digital Circuits and Systems**. Millman and Halkias, Tata McGraw-Hill, ISBN 0-07-462245-5
- 2. **Operational Amplifiers** G B Clayton Steve Winder, Newnes, 5thEdition, ISBN-13: 978-0750659147
- 3. Design With Operational Amplifiers and Analog Integrated Circuits Sergio Franco, Tata McGraw-Hill, ISBN: 9780070530447, 0070530440
- 4. **Digital Integrated Electronics -** Herbert Taub and Donald Schilling, McGraw Hill Education, 1st Edition, ISBN No.: 978-0070265080, 2017.

Basic Electrical Engineering Laboratory (EE1271N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments based on the subject "Basic Electrical Engineering (EE1201N)".

Introduction to Labs of the Electrical Engineering Department (EE1272N)

Weekly Contact: 0-0-3 (L-T-P)

Full Marks -50

Credits:2

Fundamental experiments related to different core courses of Electrical Engineering (for example, Electrical Machines, Power Systems, Control Systems, Power Electronics, Instrumentation, etc.)

Experiments in newly introduced second semester sessional paper: "Introduction to Labs of the Electrical Engineering Department"

Serial No.	Name of the Labs	Experiment				
·1	Electrical Machines	Starting and Reversing of a D. C. shunt motor				
2	Power System	Simulation of Power Measurement of an A.C. system				
3	Control System	i) Square wave and ii) Sinusoidal Input Responses of an R-L-C series circuit				
4	Analog/Digital Electronics	Introduction to Combinatorial Digital Circuits using NAND/NOR gates				
5	Microprocessor	Stepper Motor Control using Microprocessor				
6	Instrumentation	Familiarisation with Temperature Transducer				
7	Simulation (Programming)	Finding the roots of the equation using GNU Plot, Maxima and Bisection Method				
8	Drives	Study of Characteristics of a Ceiling Fan				

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Third Semester

Sl. No	Туре	Course Name	Course	Class Load			Credit	Class load	Marks	
				L	T	P				
1	ESC6	Maths III	MA2101N	MA2101N 3 0		0	3	3	100	
2	ESC7	Signals and Systems	EE2101N	EE2101N 3 0 0		3	3	100		
3	PC2	Engineering Electrodynamics	EE2102N	E2102N 3 0 0		3	3	100		
4	PC3	Electrical Machines I	EE2103N 3 1 (0	4	4	100		
5	PC4	Network Theory	EE2104N	3	0	0	3	3	100	
		Theory Sub-total		15	1	0	16	16	500	
6	PC	Digital and Analog Electronics Lab and projects	EE2171N	0	0	3	2	3	50	
7	PC	Electrical Machines I Lab	EE2172N	0	0	3	2	3	50	
8	PC	Networks and Circuit Theory Lab and Projects	EE2173N	0	0	3	2	3	50	
		Practical Sub-total	0		0	9	6	9	150	
		Third Semester Total		15 1 9		22	25	650		



Course	EE2101N	Course	Signals &	Course	ESC	L	T	P	
Code	EE2101N	Name	Systems	Category	ESC	3	0	0	

Pre-requisite	Engineering	Co-requisite	Basic Electrical		Progressiv	
Courses	Mathematics	Courses	Engineering		Courses	
Course Offering Department	Elect	trical Engineerin	ng Data Book / Codes/Standards			Nil

Course	7. To study the different types of sources and classification of signals,
Objectives	8. To introduce an overview of different type of systems & their stability,
	9. To apply differential equation method to analyse switching transients in electrical circuits with input excitation,
10. To study the dynamics and electrical circuit model of different elenation non-electrical systems,	
	11. To introduce analysis of the signals & systems in Complex domain applying Laplace Transform
	12.To explore Fourier decomposition to analyse and manipulate signals in frequency domain

Mod- ule	Syllabus	Duration (Class-Hours)	Module Outcome
I.	Source & Signals: Different types of Sources – deterministic and stochastic, dependent and independent sources; Source Transformation – VCVS, VCCS, CCVS, and CCCS; Continuous-time and discrete-time signals, even and odd signals, periodic and aperiodic signals, gate functions, standard signals and other basic signals, Energy and power signals.	5	To identify different types of sources and signals, classify and mathematical expression of signals and systems.
II.	Systems: Types of systems—continuous- time, discrete-time, linear, nonlinear, time-invariant, time-variant, causal, non- causal systems, Stability, Interconnection of systems.	3	To demonstrate an overview on the different types of systems & their stability.
III.	Transient Responses of Passive Circuits: Differential equation approach – RL, RC, RLC circuits with dc and sinusoidal excitation. Application to transient solution for different simple	10	To compute mathematically the switching transients in different electrical

,	networks, switching transients and impulses in networks.		circuits with input excitations.
IV.	System Dynamics: System modelling concepts, Transfer function, block diagram representation of systems; Electrical Analogous networks for Mechanical, Thermal and Hydraulic systems.	5	To represent the dynamics and modelling of different electrical and non-electrical systems.
V.	Signal Analysis in Laplace Domain: Complex Frequency and the Laplace Transform – definitions, Transform of common forcing functions. Derivatives and integrals, shifted functions, shifting and scaling of signals, Initial and Final Value theorems, Inverse Laplace Transform, Convolution integral, Heaviside Theorem. Transient responses of Passive circuits using Laplace transform method.	10	To mathematically analyse the signals & in complex frequency domain and find transient response.
VI.	Fourier Analysis: Fourier series (continuous and discrete), evaluation of Fourier coefficients, reference of waveform symmetry, Frequency spectrum, convergence in truncated series, Properties of Fourier analysis, shifting function, Exponential form and Trigonometric form of Fourier series, Line spectrum, steady state responses to periodic signals, aperiodic functions, Fourier Integral and continuous spectra: Spectrum envelope for a recurring Pulse, Fourier Integral and Fourier Transform(continuous and discrete).	9	Fourier decomposition to analyze and manipulate signals in frequency domain
	TOTAL:	42L	

Course	The students shall be able to,
Outcome	7. Identify different types of sources and classify the signals,
	8. Demonstrate an overview on the different type of systems & its stability,
	9. Mathematically compute the switching transients in different electrical circuits with input excitations,
	10. Represent the dynamics of different electrical and mechanical systems,
	11. Apply the analysis of the signals & systems in complex frequency domain,

12. Extend Fourier decomposition to analyse and manipulate signals in the frequency domain.

- 7. Signals and Systems, Alan V. Oppenheim, A. S. Willsky and S. H. Nawab, 2nd edition, Pearson India, 2015.
- 8. Circuits and Systems, K. M. Soni, S. K. Kataria & Sons, New Delhi, 2010.
- 9. Fundamentals of Signals and Systems, M. J. Roberts and G. Sharma, ,2nd edition, Mc Graw-Hill Education, 2017.
- 10. Networks and Systems, D. Roy Choudhury, 2nd edition, New Age International (P) Ltd., 2014.
- 11. Circuit Theory: Analysis and Synthesis, A. Chakrabarti, 7th revised edition, Dhanpat Rai & Co, 2018.
- 12. Network Analysis and Synthesis, C. L. Wadhwa, 3rd edition, New Age International (P) Ltd., 2014.

Course	EE2102N		Engineering	Course	PC	L	Т	P
Code		Name	Electrodynamics	Category		3	1	0

Pre-requisite Courses	Engineering Mathematics, Physics, and Basic Electrical Engineering	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical E	ngineering	Data Book / Codes/Standards	Nil

Course Objectives	 Develop proficiency in vector calculus, coordinate transformations, and integral theorems to analyze electromagnetic fields. Gain a thorough understanding of electrostatic and magnetostatic fields, Maxwell's equations, and their applications in electrical engineering.
	3. Explore real-world implications such as power transmission, superconductivity, and electromagnetic effects in machines and devices.

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Preliminaries: Physical interpretation of gradient, divergence and curl. The Laplacian operator, vector relationship in rectangular, cylindrical and spherical polar coordinate systems, divergence and curl equations., Integral forms, Stoke's Theorem, Green's Theorem, Dirac delta distribution, field as derivative of potential, Helmholtz theorems	8	• Apply vector calculus (gradient, divergence, curl) and integral theorems to solve electromagnetic problems in different coordinate systems.
II.	Electrostatic Field: Coulomb's Law, electrostatic field, Laplace and Poisson's equation, divergence and curl of electrostatic field, scalar potential, Field equations in different coordinate systems, boundary conditions, Continuity equation and relaxation time, Energy stored due to accumulation of charges	8	• Formulate and solve Laplace/Poisson's equations for electrostatic fields, and analyze boundary conditions and energy storage.

III.	Magnetostatic Field: Lorentz force, Biot Savart's law, Scalar and vector potentials. Divergence and curl of magnetic field, Ampere's law, Force and Torque equations, field equations in different coordinate systems. Boundary conditions, magnetic vector potential and flux, energy stored in a magnetostatic field Permanent Magnets: Use, second quadrant B-H curve, load line concept, minimum volume criterion, focusing factor, simple problems on PM design	3	• Compute magnetic fields using Biot-Savart's law and Ampere's law, and evaluate forces, torque, and energy in magnetostatic systems.
IV.	Dynamic electric and magnetic fields: Time varying fields and Faraday's law. Displacement current, Maxwell's correction to Ampere's law, relation between electric and magnetic fields Poynting's Theorem and flow of power: Poynting's theorem and its equivalence to energy conservation law, Poynting's vector, power flow and relevance to power transmission Wave equation: Maxwell's equations, Wave equations in free space and in conducting medium, Wave impedance	3 3	Derive time-varying field equations (Faraday's law, displacement current), and analyze power flow using Poynting's theorem and wave impedance.
V.	Direct implications in Electrical Engineering: Eddy currents, Skin effect, proximity effect, elements of Electromagnetic fields in Electrical Machines. grain-oriented and non- oriented laminations, Force on conductors in Transformer and machines. Electric discharge, Applications in heating, welding, implications in flow of electrical power through transmission lines and cables	5	• Explain eddy currents, skin effect, and electromagnetic forces in electrical machines, and their impact on power transmission.
VI.	Superconductivity: Elementary concepts, super conducting magnets, super conducting magnetic energy storage,	3	Describe superconductivity principles and applications in

superconducting fault current limiters, superconducting machines and other applications.		magnets, energy storage, and fault current limiters.
TOTAL	42L	

					APROX 60			
Course	1.	Analyze	electrostatic/magnetostatic	fields	and	time-varying		
Outcome		electromagnetic waves using differential and integral formulations.						
	2.	Relate Max	well's equations to practical so	enarios li	ke powe	r transmission,		
		machine design, and superconductivity.						
	3. Compute energy storage, power flow (Poynting vector), and losses (eddy							
			in effect) in electromagnetic s					

Learning	
Resources	

Textbooks

- 1. D. J. Griffiths, *Introduction to Electrodynamics*, 4th ed. Cambridge, U.K.: Cambridge University Press, 2017. [ISBN: 978-1108420419].
- 2. M. N. O. Sadiku, *Principles of Electromagnetics*, 4th ed. Oxford, U.K.: Oxford University Press, 2009. [ISBN: 978-0198099154].
- 3. M. N. Wilson, *Superconducting Magnets*. Oxford, U.K.: Clarendon Press, 1987. [ISBN: 978-0198548102].

Reference Books

- 4. J. A. Edminister, *Outlines of Electromagnetics*, 4th ed. New York, NY, USA: McGraw-Hill, 2013. [ISBN: 978-0071831475].
- 5. J. C. Slater and N. H. Frank, *Electromagnetism*. Mineola, NY, USA: Dover Publications, 2015. [ISBN: 978-0486622637].
- 6. J. D. Jackson, *Classical Electrodynamics*, 3rd ed. Hoboken, NJ, USA: Wiley, 2007. [ISBN: 978-8126510948].
- 7. J. D. Ryder, *Networks, Lines and Fields*, 2nd ed. Noida, India: Pearson Education, 2015. [ISBN: 978-9332559516].
- 8. K. V. Ratnam, *Special Electrical Machines*. Hyderabad, India: Universities Press, 2008. [ISBN: 978-8173716317].
- 9. R. G. Powell, *Electromagnetism*. London, U.K.: Macmillan, 1990. [ISBN: 0-333-48317-0].
- 10. J. R. Reitz, F. J. Milford, and R. W. Christy, *Foundations of Electromagnetic Theory*, 4th ed. Boston, MA, USA: Addison-Wesley, 2008. [ISBN: 978-0321581747].

- 11. E. C. Jordan and K. G. Balmain, *Electromagnetic Waves and Radiating Systems*, 2nd ed. New Delhi, India: Prentice-Hall, 1964. [ISBN: 978-8120300545].
- 12. R. M. Fano, L. J. Chu, and R. B. Adler, *Electromagnetic Fields, Energy, and Forces*. Cambridge, MA, USA: MIT Press, 2020. [ISBN: 978-0262561709].
- 13. R. M. Fano, L. J. Chu, and R. B. Adler, *Electromagnetic Energy Transmission and Radiation*. Cambridge, MA, USA: MIT Press, 2020. [ISBN: 978-0262511407].

Course	EE2103N	Course	Electrical	Course	PC	L	Т	P
Code		Name	Machines - I	Category		3	1	0

Pre-requisite Courses	Basic Electrical Engineering	Co- requisite Courses	Network s and Circuit Theory	Progressive Courses	NIL
Course Offering Department		Electrical E	ngineering	Data Book / Codes/Standards	NIL

	1. To give the students a basic idea on the construction, field-excitation,
Course	operation and major characteristics of DC machines
Objective	2. To help the students develop the general concepts on electrical
	machinery, including those for for MMFs, flux, production of torque
	and EMF; generalized EMF and torque equation etc.
	3. To help the students have an idea on machine losses, cooling,
	efficiency, machine operational duty and its significance etc.
	4. To enable the students to have a basic idea regarding the
	constructional aspects of single-phase and three-phase transformers,
	equivalent circuit, phasor diagram etc.
	5. To give the students a basic idea on the operational aspects,
	advantages and disadvantages of auto-transformers

Module	Syllabus	Duration	Module outcomes
		(class-	
		hour)	
A.	Fundamental and Unified Concep	ts and Aspe	ects on Electrical Machinery
	(8L+2T):	_	-
	Fundamental Concepts:	1L	• Students should have
I.	Flux linkage, space time		concepts on flux-linkage,
	dependence, its dynamics and		its variation with time and
	embodiment in Faraday's law,		space and how such
	possibility of two distinct e.m.f		variations lead to different
	terms.		types of EMFs

II.	Machine Windings, MMF and Flux: Concept of concentrated and distributed windings, their m.m.f.s and relation with flux linkages. Concept of armature and field m.m.f in distributed winding electrical machines. Static field and armature m.m.f.s in DC machines, pseudostationary field coils in DC machines, pulsating m.m.f.s in transformers/ single phase AC windings, Rotating m.m.f.s / field (RMF) in polyphase (3-phase) AC distributed winding machines etc.	3L+1T	 Students should have a clear understanding on different types of windings, the MMFs and flux waveforms, set up by such windings upon being excited by different types of currents Students should have concepts on stationary, pulsating and rotating fields and how they are set-up
III.	Generation of EMF: Concept of pole pitch, coil pitch, (Short-pitched, full-pitched coils, pitch factor), EMF in full and short pitched coils; EMF polygon and distribution factor, concept of mechanical and electrical angles, flux per pole; harmonic cancellation etc.	2L+1 T	 Students should acquire concepts on the physical techniques of EMF generation and related deductions Students should have a clear understanding on the effect of harmonics in the flux wave and EMF and how such 'harmonic-effects' can be reduced to generate a 'sinusoidal' EMF Students should have a clear concept on coil-pitch and distribution, pitch-factor and distribution-factors.
IV.	Electromagnetic torque: General principles of electromechanical torque production in doubly excited machines; related deductions	2L	 Students should learn and understand the principles behind the generation of electro-magnetic torque in doubly excited machines and related deductions They should be able to apply the generalized torque equation to various specific case studies
В.	• DC Machines (14L+7T):		
V.	Constructional Features & OCC: Constructional features and parts, windings, methods of excitation, Open Circuit Characteristics, voltage building-up, critical field resistance and critical speed.	3L	• Familiarization with the principle, construction, and operational characteristics of DC machines

VI.	Armature Reaction: Demagnetizing and cross magnetizing ampere-turns, commutation process, role of interpoles and compensating winding.	3L+2T	• Understanding of the phenomena of armature reaction and its effects on DC generator and motor
VII.	DC Generator: Load characteristics of separately excited, series, shunt, cumulative and differentially compounded DC generators, control of terminal voltage, applications	3L+2T	• Understanding of the characteristics and applications of different types of DC generators
VIII.	DC Motor: Back emf, torque and speed equations, methods of speed control of series and shunt motors. Load characteristics of series, shunt, cumulative and differentially compounded motors. Applications based on characteristics.	3L+2T	• Understanding of the characteristics, speed control methods and applications of DC motors
IX.	Testing of DC Motors: Losses and efficiency of DC motors, no-load test, load tests and regenerative tests	2L+1T	• Understanding of the methods of determination of the losses and efficiency of DC motors.
C.	• Transformers (20L+ 5T):		
X.	Principle of operation, Construction of single-phase and three-phase transformers, Ideal transformer and practical transformer, Transformer accessories - Conservator, Breather, Buchholz relay, Bushings etc., Transformer oil, Tap changing basics	5+1T	• Students will be able to explain the working principle of single-phase and three-phase transformers, differentiate between ideal and practical transformers, and acquire knowledge on constructional features and accessories such as conservator, breather, Buchholz relay, bushings, and tap changers. They will also understand the functions and specifications of transformer oil.

zig-zag and so connection. They understand vector go classifications and			
operation, Comparison with two-winding transformer. Parallel operation of single and three-phase transformers. National/International Standards and codes of single-phase and three-phase transformers • Students will be fam with the relevant national standard and codes of single-phase and codes of singl	operation, Comparison with two winding transformer. Parall operation of single and three-pha transformers. National/International Standard and codes of single-phase and three	rison with two- mer. Parallel and three-phase nal Standards -phase and three-	the working of autotransformers, their advantages over two-winding transformers, also parallel operation of transformers. • Students will be familiar with the relevant national and international standards and codes of single-phase and three-phase
TOTAL: 42L+14T		TOTAL 421 +	

- 1. Students should have a basic idea on the constructional aspects of DC machines, their performance and major characteristics
- 2. Students should have concepts on general aspects of electrical machinery, such as various types of windings and field and flux generated by such windings, pulsating and rotating fields, the physics behind EMF and torque production and the governing equations etc.
- 3. Students should have concepts on heating and cooling of machines, losses and efficiency in machines etc.
- 4. Students should have a thorough idea on the constructional aspects, operation, phasor diagram and characteristics on single-phase and three-phase transformers and auto-transformers.

Learning Resources

Text Books:

- 1. Electrical Machinery, P.S. Bimbhra, 2011, Khanna Publishers, ISBN: 9788174091734,8174091734
- 2. Electrical Machinery, S. K. Sen, 1977, Khanna Publishers, India, ISBN-10:8174091521, ISBN-13:978-8174091529
- 3. Performance and design of AC Machines, M. G. Say, 2002, CBS Publishers and Distributors Pvt. Ltd., ISBN 10:8123910274 / ISBN 13:9788123910277

Reference Books:

- 1. Theory of AC Machines, Puchstein and Llyod –2nd Edition, 1942, John Wiley and Sons, New York
- Electric Machinery, Fitzgerald & Kingsley –6th Edition, 2017, McGraw Hill Education

Course	EE2104N	Course	Notaroul Theory	Course	DC.	L	Т	P	
Code	EE2104N	Name	Network Theory	Category	rc	3	0	0	

	Pre-requisite Courses	Basic EE		Co-requisite Courses	Signals & Systems		Progress	Nil
-	Course Offering Department		Electrical Engine	eering	Data I Codes/St	Book / tandards	Nil	

Course Objective	1. To learn all network theorems in generalized form to apply to all types of networks.
s	2. To describe all circuits as two port network and find the network parameters
	3. To find network elements in frequency domain and relate the input-output response in terms of pole-zero positions.
	4. To study the effects of magnetic coupling in a network and analyse the circuit.
	5. To develop proficiency in synthesizing passive filters, and understanding their applications in real-world systems.
	6. To provide a foundation in network topology, matrix representations, and the synthesis of passive networks using Foster and Cauer forms.

Mod- ule	Syllabus	Duration (Class- Hours)	Module Outcome
I.	Network Theorems in AC circuits and for dependent and independent sources: Review of basic Circuit Laws, Superposition theorem, Thevenin's theorem, Norton's theorem, Millman's theorem, Maximum Power Transfer theorem, Substitution theorem, Compensation theorem and Tellegen's theorem.	6	• Learning Network Theorems in generalized form for application to all types of networks with different sources.
II.	Two-port Network: Network elements - Concepts of ports and terminals; Classification of network, network configuration of network; <i>Z</i> -, <i>Y</i> -, <i>T</i> -, <i>h</i> - and <i>g</i> -parameters; Conditions of reciprocity and symmetry; Interrelationship of network parameters; Interconnections of 2-port networks; Input and output impedances, Short-circuit and Open-circuit impedances, image impedances, equivalent T- and p- network	7	Describing circuits as two port network in terms of network parameters, interconnected networks and relate with actual values of impedances.
III.	Network Functions: Driving point and Transfer functions and their properties, computing various driving point and transfer functions of standard networks,	5	• Finding network elements in frequency domain and relate the input-output response

IV.	Self and Mutual Inductance, Coefficient of coupling; Connections of coupled coils; Dot	3	• Computing the effects of magnetic coupling in a network and
	convention; Modelling of coupled circuits, Electrical equivalent of magnetically coupled circuits.	3	analyzing the circuits.
V.	Elements of Network Topology: Graph of network, concept of branch, node,	,	• Formulating network equations using graph
	mesh, tree, co-tree, Planar and non-planar graphs, incidence, tie-set and cut-set matrices, inter- relation between various matrices, KCL and KVL in topological form, network solution by node basis and loop basis, principle of duality, related problems	8	theory, incidence matrices, and solving via node/loop analysis.
VI.	Passive Filter Synthesis: Image and characteristic impedances of a two-port network, propagation constants, classification of filters, prototype T-section		• Designing of constant- k and m-derived passive filters (LPF, HPF, BPF, BSF) using
	and π -section filters, Low-Pass, High-Pass, Band-Pass, Band-Reject filters, Design of Constant-K filters, (low pass and high pass), m-derived filters (low pass and high pass); Composite filters.	8	image impedance concepts.
VII.	and π -section filters, Low-Pass, High-Pass, Band-Pass, Band-Reject filters, Design of Constant-K filters, (low pass and high pass), m-derived filters (low pass and high pass);	5	

Course	The students shall be able to,
Outcome	1. Solve and analyse different types of networks with different types of sources,
	2. Represent circuits as two-port networks and get variables in terms of parameters.
	3. Express the network elements in frequency domain and get the network functions to find the input-output response both in time and frequency domain.
	4. Solve the networks with magnetically coupled elements.
	5. Design filters, characterize two-port networks, and validate reciprocity/symmetry.

6. Implement passive network synthesis using stability criteria and Foster/Cauer methods.

- 1. Networks and Systems, D. Roy Choudhury, 2nd Edition, 2013, New Age International, ISBN 10: 8122427677/ ISBN 13: 9788122427677
- 2. Circuits and Systems, K. M. Soni, S K Kataria & Sons. ISBN-10: 8188438060, ISBN-13: 978-888438066.
- 3. Circuits and Networks, Sukhija and Nagsarkar 2nd Edition, 2010, Oxford University Press, ISBN-10: 019806870, ISBN-13: 978-019806878.
- 4. Network Analysis and Synthesis, C. L. Wadhwa 3rd Edition, 2018, New Age, ISBN-10: 978-8122420364, ISBN-13: 978-8122420364.
- 5. Circuit Theory Analysis and Synthesis, A. Chakrabarti 7th Edition, 2018, Dhanpat Rai & Co, ISBN-10: 8177000004, ISBN-13: 978-8177000009.
- 6. Network Analysis, M. E. Van Valkenburg, 3rd Edition, 2015, Pearson Education India, ISBN-10: 9789332550131.
- 7. Analysis and Synthesis of Electric Circuits, G. Zeveke, 1979, Mir Publishers

Digital and Analog Electronics Laboratory and Projects (EE2171N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and project works related to the subject "Digital and Analog Electronics (EE1203N)".

Electrical Machines I Laboratory (EE2172N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments related to the subject "Electrical Machines I (EE2103N)".

Networks and Circuit Theory Laboratory and Projects (EE2173N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and project works related to the subject "Network Theory (EE2104N)".

Fourth Semester

Sl. No Type		e Course Name	Course Class Load/Week			Credit	Class load/	Marks	
			Code	L	T	P		week	
1	PC5	Electrical Machines II	EE2201N	3	1	0	4	4	100
2	PC6	Power Systems I	EE2202N	3	0	0	3	3	100
3	PC7	Control Systems I	EE2203N	3	0	0	3	3	100
4	PC8	Electrical and Electronic Measurements	EE2204N	3	0	0	3	3	100
5	OE	OE1		3	1	0	3	3	100
		Theory Sub-total		15	2	0	16	16	500
6	PC	Electrical Machines II Lab	EE2271N	0	0	3	2	3	50
7	PC	Measurements Lab and projects	EE2272N	0	0	3	2	3	50
8	PC	Programming and Numerical Computing in Electrical Engineering	EE2273N	0	0	3	2	3	50
9	PC	Power Systems Design and Machine Design	EE2274N	0	0	3	2	3	50
		Practical Sub-total		0	0	12	8	12	200
		Fourth Semester Total		15	2	12	24	28	700



Course	FF2201N	Course	Electrical	Course	PC	L	Т	P
Code	EEZZUIN	Name	Machines - II	Category	FC	3	1	0

Pre-requisite Courses	Basic Electrical Engineering; Electrical Machines-I; Networks and Circuit Theory	Co-requisite Courses	-	Progressive Courses	-
Course Offering Department		Electrical Eng	gineering	Data Book / Codes/Standar ds	Relevant IS, IEC or IEEE standards

Сомия	1. To give the students a basic idea recording the constructional conects and
Course	1. To give the students a basic idea regarding the constructional aspects and
Objective	principle of operation of induction machines – both as a motor and generator
	2. To teach the students the basic methods of analyzing the performance of such induction machines
	3. To introduce a given standard on induction machines to students
	4. To give preliminary ideas regarding the construction and operation of single-phase induction motors
	5. To give the students a basic idea regarding the constructional aspects and principle of operation of synchronous machines
	6. To help the student develop concepts on power-flow, learn how to draw phasor diagrams and know about the various important steady state characteristics of synchronous machines.
	7. To give the students a thorough idea on regulation of alternators and how to estimate and measure the same
	8. To give the students a basic idea on various important operational aspects of synchronous machines.

Module	Syllabus	Duration	Module outcomes
		(class-	
		hour)	
Α.	Induction Machines (21 lectures):		
	Basics of IM operation:		• Students are expected to
I.	Principle of operation (as motor),	3	develop an understanding
	concept of slip (as motor), rotor		regarding the basic
	frequency, rotor, e.m.f, (w.r.t		operation of induction
	discussions in Machines-I), Varieties		machines, as motor first.
	(SCIM, WRIM), construction.		• Then they can appreciate
			the principle of operation of

II.	Implications of different ranges of slip values and glimpses of operation as generator and brake Analysis as motor: Derivation of per-phase equivalent circuit, measurement of parameters through tests and performance	4	 an induction machine as a generator and motor Students are then expected to learn a circuit theory based analytical approach (equivalent circuits)
	calculation. Operating characteristics of 3-phase induction motor, stable zone of operation etc. Effects of varying voltage and frequency on motor performance, Torque slip characteristics of IMs, Discussions and analysis, pointers to different ways of speed control arising out of torque-slip relation (to be taken up in more details in Machine Drives paper later on in the course); Issues related to starting and running.		towards parameter and performance of the machine. Thereafter they can also appreciate the way to derive the torque-speed characteristics and the method of locating the stable point of operation in the torque-speed plane. Students are expected to learn, how from the analytical torque expression, possible methods of slip and hence speed control emerge.
III.	Simplified approaches, spl. applications and generator/ brake operation: Analysis and performance calculation from approximate equivalent circuit, Circle diagram etc. Drawbacks and advantages of simplified approach. High torque, double cage/ deep bar construction etc. Generating and braking mode operation as continuation of circle diagram based approach; Grid connected and isolated induction generators, need for capacitive compensation at IG terminals etc. Applications of IG etc.	6	 Students are expected to learn, how simpler diagrammatic methods (in this case effectively based on phasors) are adopted in engineering towards performance evaluation exercise which may be appreciated/ understood at the user/ shop-floor/ technician level, without going into mathematical rigor even. Students are expected to appreciate how the generating and braking operation follow from the above.
IV.	Essentials based on fundamentals: Graphical approach to polyphase AC machine armature <i>mmf</i> and current distribution spatial plot derivation, geometrical approach to plot of current sheet, leading to winding factor and its component terms etc.	4	• Students are expected to learn, how graphical methods of spatial distribution of apparently complicated concepts of ampere-conductor/ flux and current distribution can take us to deeper

	Space harmonics - their effects, methods to reduce their drawbacks, slot skewing, skew factor, effect of/ on winding factors.		visualization and understanding of machine operating principle, performance evaluation and even advanced issues like effects of space harmonics. • Students are expected to develop an idea of how wrong design and combination of stator-rotor slots, saturation, slotting etc. adversely affect the machine performance, often in serious ways.
V.	Related important topics: Premium efficiency IMs: Cu-rotor IMs, NEMA classification, National/ International Standards and codes of Induction machines (discuss at least one). Single phase Induction Motors: Types, operation, performance, applications.	4	 Students are expected to get associated with a very important engineering topic of Standards and codes. The importance of standards is discussed. Students are expected to learn, about a very popular IM variety which is used in all homes, by small users etc
В.	• Synchronous Machines (21 lectures):		
VI.	Introduction: Basic constructional features of cylindrical and salient pole machines; operation as a generator and motor; field-excitation systems	2	 Students should have an idea regarding the basic constructional features of round rotor and salient pole type synchronous machines Students should understand the principle of operation of a synchronous machine as a generator and motor
VII.	Cylindrical Machines Phasor Diagram and Power Flow: Flux-MMF relationship & armature reaction; equivalent circuit & phasor diagram; Motor and generator action; Power flow and maximum power, power angle, torque angle etc.	4	 Students should be able to understand and draw the flux-mmf and voltage-current phasor diagrams for various modes of operation Students should have a clear understanding regarding the power flow and relevant equations as motor and generator

VIII.	Salient Pole Machines Phasor Diagram and Power Flow: Two reaction theory $-X_d$ and X_q ; phasor diagram, power flow and maximum power flow; P- δ and Q- δ characteristics	3	 Students should be able to understand the concept of d and q axis reactance and their significance in a salient pole machine Students should clearly understand the active and reactive power flow equations and phasor diagrams for various modes in salient pole machines
IX.	Various Operational Characteristics: P-δ and Q-δ characteristics; Terminal Voltage vs. Load Characteristics, OCC, SCC, Field-Compounding Characteristics & ZPFC; V-Curves and Inverted V-Curves	3	 Students should have a clear understanding regarding the nature of the major steady-state characteristics of synchronous machine and the physical phenomenon behind the same Students should understand how to apply some of these characteristics to predict the behavior of the machine
X.	Voltage Regulation of Alternators: Definition and steps in experimental determination; Short Circuit Ratio and its significance; Estimation of regulation by various methods	3	 Students should understand the significance of voltage regulation and its experimental determination procedure Students should have an idea regarding a few important methods to estimate regulation
XI.	Operational Aspects: Parallel operation of alternators; Starting of motors; methods of synchronization and excitation and power circle diagrams	6	 Students should understand some of the important operational aspects of synchronous machines as a motor and generator Students should be able to predict the change in current and power factor using circle diagrams
	TOTAL:	42L + 14T	

- 1. Students should have a basic idea on the constructional aspects and operation of Induction machines both as a motor and as a generator
- 2. Students should be able to analyze the operation and evaluate the steady state performance of three phase induction machines
- 3. Students should have preliminary ideas regarding standards on induction machines
- 4. Students should have the basic ideas regarding the construction and operation of single-phase induction motors
- 5. Students should have concepts on the operating principle, various phasor diagrams, power flow in synchronous machines
- 6. Students should have concepts on the various important steady state characteristics of synchronous machines and their utilities
- 7. Students should have a clear idea regarding regulation of an alternator and how to measure and estimate the same
- 8. Students should have a thorough idea on the operational aspects of synchronous machine, including their circle diagrams.

Learning Resources

Text Books:

- 1. Electrical Machinery, P.S. Bimbhra, 2011, Khanna Publishers, ISBN: 9788174091734,8174091734
- 2. Electrical Machinery, S. K. Sen, 1977, Khanna Publishers, India, ISBN-10:8174091521, ISBN-13:978-8174091529
- 3. Performance and design of AC Machines, M.G.Say, 2002, CBS Publishers and Distributors Pvt.Ltd., ISBN10: 8123910274 / ISBN13: 9788123910277

Reference Books:

- 1. Theory of AC Machines, Puchstein and Llyod –2nd Edition, 1942, John Wiley and Sons, New York
- 2. Electric Machinery, Fitzgerald & Kingsley –6th Edition, 2017, McGraw Hill Education

Course	EE2202N	Course	Power	Course	PC	L	Т	P
Code		Name	Systems I	Category		3	0	0

Pre-requisite	Basic Electrical	Co-requisite	Nil	Progressive	Nil
Courses	Engineering,	Courses		Courses	
	Electrical Machines I				
	and Circuit theory				
Course Offering Department		Electrical Eng	ineering	Data Book /	Nil
				Codes/Stand	
				ards	

	1. To provide a comprehensive understanding of the structure and
Course	functioning of electric power systems, including generation,
Objectives	transmission, and distribution, with both conventional and renewable
	sources.
	2. To equip students with analytical skills for evaluating electrical
	parameters, performance, and control mechanisms of transmission
	lines and power system components.
	3. To develop the ability to assess and apply techniques related to
	system design, fault analysis, insulation, grounding, and stability for
	reliable and efficient power system operation.

Module	Syllabus	Duration(c lass-hour)	Module Outcome
I.	Basic Concepts: Structure of Power Systems, Fundamental aspects of Thermal, Hydel, Nuclear and Gas-fired power generating stations, Renewable energy generation methods, Distributed generations, Introduction to transmission and distribution aspects of electrical power, Voltage levels, Mesh and Radial Systems, Concept of Grid and Micro-grid.	8	• To understand the fundamental structure and components of power systems, and various conventional and renewable power generation methods, transmission and distribution systems, voltage levels, and the concepts of grid and micro-grid configurations; mesh and radial system layouts and the role of distributed generation in modern power networks.

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II.	Per-unit method: Per unit system, Concept of base parameters and per unit parameters, Calculation of Per-unit impedance, change of base, Advantages of p.u. method.	3	• To gain the knowledge of selection of base values and calculation of per unit parameters of single phase and three phase systems.
III.	Transmission line Parameters: Overhead line inductance and capacitance, flux linkage due to internal flux, flux linkage due to flux between two external conductors, 1-φ and 3-φ inductance and capacitance calculation (symmetrical and unsymmetrical spacing), composite conductors, configuration of bundled conductors, Skin and Proximity effect, Transposition, Double circuit line, Interference.	6	 To calculate inductance due to both internal and external flux for single phase and three phase conductors. To learn the concept of transposition for unsymmetrically placed three phase conductors and calculate the inductance for the same. To calculate the capacitance of single phase and three phase lines (a) without considering the effect of earth and (b) considering the effect of earth.
IV.	Performance of Transmission lines: short, medium, and long line, ABCD constants, Voltage regulation, Ferranti effect, Power flow through line, Surge Impedance Loading, Power circle diagram, P-δ and Q-V coupling, Reactive power compensation, St. Clair's Curve (loadability).	4	• To analyze the performance of short, medium, and long transmission lines using ABCD constants, evaluate voltage regulation, understand Ferranti effect, and interpret power flow characteristics through concepts such as surge impedance loading, power circle diagrams, P-δ and Q-V coupling. They will also understand reactive power compensation techniques and assess line loadability.
V.	Mechanical Design of Overhead Line: Poles and towers, Calculation of sag, effect of ice and wind loading, Stringing chart, Sag template, Vibration damper, Arcing horn.	3	• To analyze the mechanical aspects of overhead line design, calculation of sag under various loading conditions; To learn the use of stringing charts, sag templates, and protective devices like vibration dampers and arcing horns.

VI.	Power cables: Types and classification, insulating materials, Conductor materials, Dielectric stress, intersheath and capacitance grading, Power factors of cables, Heating and causes of breakdown, Cable laying and Joining, Cable selection, Power factor of cables, Cable capacitance and Cable testing	4	• To understand the types, construction, and materials used in power cables, and analyze their electrical characteristics such as dielectric stress, capacitance, and power factor. To gain knowledge of cable testing methods and selection criteria for cables.
VII.	Overhead line insulators and Corona: Types, Voltage distribution, String efficiency, Methods of equalizing potential, Insulator failure, Coronaits formation, Critical voltage, Corona loss and its reduction.	3	• To learn to explain the types and performance characteristics of overhead line insulators, analyze voltage distribution and string efficiency, and evaluate the phenomena of corona formation, including critical voltage, associated losses, and mitigation methods.
VIII.	P-f and Q-V control: Concepts, Power-frequency (P-f) and Reactive Power-Voltage (Q-V)control mechanisms.	3	• They will understand the fundamental concepts of (P-f) and (Q-V) control mechanisms, and will be able to analyze how these controls maintain system stability and ensure reliable operation of power systems.
IX.	Symmetrical faults: Three phase short circuit on loaded and unloaded alternator, Calculation of short circuit kVA.	3	• They will learn to calculate the value of the short circuit current when a three phase symmetrical fault occurs and draw the profile of the short circuit current.
X.	Power system grounding: Objective of Neutral grounding, Difference between grounded and ungrounded system, Different methods of grounding, Grounding transformer, Equipment grounding.	5	 This module will enable the students to learn the disadvantages of running ungrounded system and necessity of grounding different types of grounding methods with their merits and demerits. the function of grounding transformer concept of equipment grounding
Total		42L	

- 1. Upon completion of this course, students will have a comprehensive understanding of the structure, components, and operational principles of electrical power systems, including both conventional and renewable generation, transmission lines, and distribution networks.
- 2. They will be able to analyze and apply fundamental concepts such as perunit calculations, transmission line performance, power cable and insulator characteristics, fault analysis, grounding methods, and system control mechanisms.
- 3. The course equips students with the analytical and technical skills required for designing, operating, and maintaining reliable and efficient power systems.

- 1. Power System Analysis, Grainger and Stevenson, 1st Edition, 2010, McGraw Hill Education, ISBN-10: 9780070585157
- 2. Power System Engineering, Kothari and Nagrath, 2008, Tata McGraw Hill Education, ISBN 0070647917, 9780070647916
- 3. Power System Analysis and Design, Glover, Sarma and Overbye, 5th edition, 2012, Cengage Learning India Private Limited, ISBN-10: 9788131516355, ISBN-13: 978-8131516355
- 4. Power System Analysis, Bergen and Vittal, 2nd edition, 2000, Prentice Hall, ISBN 0136919901, 9780136919902
- 5. Power System Analysis Operation and Control, Chakrabarti and Halder, 3rd edition, 2020, PHI Learning Pvt. Ltd, ISBN-10: 8120340159, ISBN-13: 978-812052

Course	EE2203N	Course	Control	Course	DC.	L	T	P
Code	EEZZUSIN	Name	Systems-I	Category	r C	3	0	0

Pre-requisite Courses	Engineering Mathematics	Co-requisite Courses	Signals and Systems, Mathematics	Progressive Courses	Control Systems-II
Course Offering Department		Electrical	Engineering	Data Book / Codes/ Standards	Nil

Course To inherit a basic knowledge on the classifications of different dynamic systems **Objectives** and their representations. 2. To obtain an input-output relationship of any physical system based on its mathematical modelling. 3. To examine the stability of the systems represented in the form of transfer functions. 4. To discuss concepts of state, state variables and state models for linear continuous time systems. 5. To introduce the time domain and frequency domain attributes of any plant considered. 6. To confirm the sensitivity and robust stability of a plant from the open loop frequency response of the compensated plant. 7. To have an elementary overview of different controllers/ compensators and its design to meet design specifications.

Module	Syllabus	Duration (class-hour)	Module Outcomes
I.	Introduction: (i)Classification of Dynamic Systems: Continuous/Discrete, Time- invariant/Time-varying, Linear/Nonlinear, Open-loop/ Closed- loop, Concept of negative feedback, Examples, Servomechanisms and regulators. (ii)Transfer Function: Definition, Relation with Impulse Response Function, Order and type of transfer functions, Example: R-L-C series circuit or equivalent.	4	Classify dynamic systems represented with transfer functions in different forms having certain order and type of the plant considered.
II.	Representation of Systems: Block diagram algebra, Mason's Gain Formula, Signal Flow graph (SFG).	4	• Represent any physical system with the help of block diagrams and its reduction with SFG.
III.	Stability: Definition of BIBO and Zero Input Stability, Routh Hurwitz's criterion	4	• Examine and determine the stability of the plant represented by the transfer function.

IV.	Time domain analysis: (i)State-Space Modelling of Physical Systems, Solution to State Equations, State Diagrams, State Space to Transfer Function, Linear Transformations. (ii)Transient analysis with Step Input, Time Domain Specifications, Transient and steady state errors—definitions, Error constants.	4	 Apply the state variable approach to obtain the state-space model of any linear- time variant system. Perform transient analysis with respect to different standard inputs and minimize the steady state errors.
	(iii)Construction of Root Locus	5	
V.	Frequency domain analysis: (i) Nyquist stability criterion, Relative stability; Time delay Systems/ Transportation lag.	5	Execute frequency domain analysis to confirm robust stability and sensitivity to any external perturbations.
	(ii) Steady state response due to periodic excitations, Bode plots, Elementary concept of sensitivity and robustness, Minimum/ Non-minimum phase systems	5	
VI.	Controllers: P,PI, PD and PID control, Lead and lag compensation (Mention only)	3	Formulate the different controllers and compensators to meet preferred design specifications.
VII.	Control system components: Encoders, Synchros, Tacho-generators, A.C. and D.C. Servo Motors, Sensors and Actuators.	2	Identify and describe the various control system components that can be utilized to realize any closed loop application.
	Total	42L	

Course	The students shall be able to,
Outcomes	
	1. Classify dynamic systems represented with transfer functions in different
	forms having certain order and type of the plant considered.
	2. Represent any physical system with the help of block diagrams and its
	reduction with SFG.
8	3. Examine and determine the stability of the plant represented by the transfer
	function.
	4. Apply the state variable approach to obtain the state-space model of any linear-
	time variant system.
	5. Perform transient analysis with respect to different standard inputs and
	minimize the steady state errors.

6.	Execute frequency domain analysis to confirm robust stability and sensitivity
	to any external perturbations.
7.	Formulate the different controllers and compensators to meet preferred design
	specifications.
8.	Identify and describe the various control system components that can be
	utilized to realize any closed loop application.

Learning	Text Books:
Resources	1. Control Systems Engineering—N.Nise,6th edition, 2010, Wiley India Edition.
	2. Control Systems Engineering-Nagrath and Gopal, 6th Edition, New Age
	International Publishers.
	Reference Books:
	1. Modern Control Engineering– K.Ogata, 5thEdition, Pearson.
	2. Automatic Control Systems –B.C.Kuo and F.Golnaraghi, 9thEdition, Wiley.
	3. Feedback Control of Dynamic Systems- Franklin, Powell and Naeimi,5 th
	Edition, Pearson.
	4. NPTEL lecture: https://nptel.ac.in/courses/108101037/

Course	EE2204DI	Course	Electrical and	Course	P.C	L	Т	P	
Code	EE2204N	Name	Electronic Measurements	Category	PC	3	0	0	

Pre-requisite Courses	Basic Electrical Engineering, Fundamentals of Electronics	Co-requisite Courses	Nil	Progressive Courses	Transducers and Instrumentati on
Course Offering Department		Electrical En	gineering	Data Book / Codes/Standards	Nil

Course Objectives

- 1. To understand the principles and applications of electrical and electronic measurement techniques.
- 2. To learn about different types of measuring instruments, their constructions, operating principles
- 3. To apply these instruments to measure various electrical and electronic parameters like voltage, current, frequency, power, energy, resistance, inductance, capacitance, power factor and other relevant quantities.

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Measurement Errors and Analysis: Definitions, accuracy, precision, resolution, sensitivity, dead zone, dead time, Limiting error, Probable error, Statistical analysis	3	 Familiarization with static and dynamic characteristics of measuring systems Statistical error analysis of measuring system
II.	Indicating Instruments: Review of Voltmeter, Ammeter, Range Extension—Shunt and Multipliers; Dynamometer type Wattmeter.	4	Dynamics of indicating instruments
III.	Measurement of Power: Active power: single wattmeter, two wattmeter method, balanced, unbalanced three phase system, Reactive Power: two wattmeter, single wattmeter methods.	6	 Active power measurement Reactive power measurement Balanced & Unbalanced load
IV.	Integrating Instruments : Energy meter, Smart Energy Meter.	3	Understanding of Energy meter & Smart meter
V.	Other Electrical Instruments: Phase angle and power factor meter, frequency meter, synchroscope, meters for kVAh,	4	Principle of Phase angle, Power factor, Maximum Demand Meter

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	kVARh, Maximum Demand		
	Indicator, Trivector meter.		
VI.	Measurement of Resistance: Low,		Kelvin Double Bridge
	medium, high and insulation	2	• Megger
	resistances.	_	TVIOSSEI
	Inductance and Capacitance		AC bridge measurement of
V 11.			
	measurement:	4	inductance and capacitance
	AC bridges for inductance and	80	
	capacitance measurement.		
VIII.	Instrument Transformers:		• Acquire an understanding of
	Current and Potential transformers,		the Instrument Transformers
	ratio and phase angle errors, design	4	. Importance of CT & PT in
	considerations, numerical problem.	-	measurement of Voltage,
	considerations, numerical problem.		Current and Power
IX.	Ossillaras CDO Starte		
IA.	Oscilloscopes: CRO, Storage		Operating principles of
	oscilloscope, Spectrum and Wave	6	Oscilloscopes
	analyzer.		
X.	Other Electronic Measurements:		• Understanding the operating
	Electronic voltmeter, multimeter,		principles of digital
	multi-function meter, wattmeter,	6	instruments
	energy meter, Frequency and Phase	U	mistraments
	Angle meters.		
	Total	42 L	

Course	After successful completion of the course, the students will be <i>able</i> to
Outcomes	1. Appreciate a system to determine appropriate instruments by type and range to
	measure different quantities in the system.
	2. Learn the operating principles of the ammeter, voltmeter, wattmeter, and energy
	meter.
	3. Gain knowledge about the Potentiometer and various resistance measurement
	techniques
	4. Balance various AC Bridges to find unknown values
	5. Acquire an understanding of the Instrument Transformers
	6. Be familiar with CRO and have an introduction to Digital Instrumentation.

Learning Resources	1. Modern Electronic Instrumentation and Measurement Techniques, Helfrick and Cooper, 1997, Prentice Hall of India, ISBN: 9788120307520, 9788120307520.
	2. Instrumentation Measurement and Feedback, Jones, B.E., 1995, Tata McGraw-Hill. ISBN 0993831.
	3. Electrical Measurement and Measuring Instruments, Golding, E.W., 3 rd Edition, Sir Issac Pitman and Sons.
	4. Principles of Electrical Measurements , Buckingham, H. and Price, E.M., 1959, English Universities.

Electrical Machines II Laboratory (EE2271N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments related to the subject "Electrical Machines II (EE2201N)".

Measurements Laboratory and Projects (EE2272N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and project works based on the theory subject "Electrical and Electronic Measurement (EE2204N)".

Programming and Numerical Computing in Electrical Engineering (EE2273N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and tutorials on Programming and Numerical Computing in Electrical Engineering.

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Course	EE2254N	Course	Power	Systems	Course		L	T	P	
Code	EE2274N	Name	Design Machine	and e Design	Category	PC	0	0	3	

Pre-requisite Courses	Basic Electrical Engineering, Power Systems I and Electrical Machines I	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical Engineering		Data Book / Codes/Standards	Relevant IS, IEC & IEEE standards

Course	1. To enable students to apply national and international standards in the electrical design of transformers, induction motors, overhead
Objectives	transmission lines, and AC substation grounding systems.
,	 To analyze key electrical performance parameters such as short-circuit impedance, voltage regulation, and overload capacity of transformers under various loading and contingency conditions. To design an overhead ACSR conductors considering the voltage
	 regulation, and corona loss, to determine voltage distribution in an insulator string and calculate string efficiency and compensation for p.f. improvement 4. To design core components of transformers and induction motors—including magnetic circuits, windings, tanks, shafts, and other accessories—with attention to performance, thermal behaviour, and protection requirements. 5. To validate electrical designs through the use of software programming.

Module	Syllabus	Duration (class-hour)	Module Outcome
Power Syste	ems Design	•	
Ι.	Determination of transformer capacity, determination of short circuit impedance and overload capacity of the transformer following national/international standards, determination of voltage regulation, validation of transformer sizing under various loading/contingency conditions, validation of the design using programming technique.	10	• Upon completion of this module, students will be able to determine the appropriate transformer capacity, short circuit impedance, and overload capacity in accordance with national/international standards. They will also be able to validate transformer sizing under different loading and contingency conditions using analytical

			and programming techniques.
II.	Electrical design of overhead ACSR conductor, voltage distribution in an insulator string, string efficiency and determination of compensating device rating for p.f. improvement.	11	 Upon completion of this module, students will be able to: Design of overhead ACSR conductors considering electrical performance requirements. Analyse voltage distribution across insulator strings and calculate string efficiency. Determine rating of compensating devices required for power factor improvement.
III.	AC substation grounding design.	o oongidaya	 Understand the principles and objectives of substation grounding, including safety requirements and fault current dissipation. Develop the ability to design a grounding grid by calculating step potential, touch potential, and ground resistance using relevant standards.
Note: Modu Machine De	le I and either module II and III will b	e considered	for a particular semester.

I.	Design of Transformer (1 phase and 3 phase): Construction, Main dimensions, Core design, Winding design, Magnetic circuit and leakage reactance calculations, Performance calculation, Design of tank, cooling tubes, radiators and conservators, Design considerations for protection against surge, Transformer accessories.	11	 Understand the constructional aspects and detailed design process of single-phase and three-phase transformers, including core, winding, and magnetic circuit design. Perform calculations related to leakage reactance, transformer performance, and the design of components such as the tank, cooling system, and accessories, with consideration for surge protection and operational reliability.
II.	Design of 3 Phase Induction Motor: Main Dimensions, Design of windings and slots, Squirrel cage motor bars and end rings, Selection of slot combination, Calculation of equivalent circuit parameters and performance characteristics, Calculation of temperature rise, Design of shaft.	10	 Gain ability to design a three-phase induction motor by determining main dimensions, selecting suitable slot and winding configurations, and designing rotor components such as squirrel cage bars and end rings. Calculate equivalent circuit parameters, analyze performance characteristics, estimate temperature rise, and design of motor shaft.
	Total	42P	

- 1. Students will acquire the ability to design electrical equipment such as transformers, overhead transmission lines, grounding grid and induction motors, following relevant national/international standards and performance criteria.
- 2. They will develop skills in calculating and analyzing transformer capacity, short circuit impedance, voltage regulation, and induction motor characteristics, as well as grounding systems for substations.
- 3. The course emphasizes application-oriented learning through programming-based design validation and equips students with knowledge of practical design elements like windings, cooling systems, and protective components.

- 1. **Power System Analysis**, Grainger and Stevenson, 1st Edition, 2010, Mc Graw Hill Education, ISBN-10:9780070585157
- 2. **Power System Engineering**, Kothari and Nagrath, 2008, Tata McGraw Hill Education, ISBN 0070647917, 9780070647916
- 3. **Power System Analysis and Design**, Glover, Sarma and Overbye, 5th edition, 2012, Cengage Learning India Private Limited, ISBN-10: 9788131516355, ISBN-13:978-8131516355
- 4. **Electrical Machines**, P.S. Bimbhra, 7th Edition, 2011, Khanna Publishers, New Delhi
- A Course in Electrical Machine Design, A.K. Sawhney, Dhanpat Rai
 Co. (P) Limited, ISBN- 10 8177001019, ISBN-13 978-8177001013



Fifth Semester

Sl. No	Туре	Type Course Name	Course	Class Load/Week			Credit	Class load/	Marks
			Code	L	Т	P		week	
1	PC9	Power Systems II	EE3101N	3	0	0	3	3	100
2	PC10	Control Systems II	EE3102N	3	0	0	3	3	100
3	PC11	Power Electronics	EE3103N	3	0	0	3	3	100
4	PC12	Power Systems Protection	EE3104N	3	0	0	3	3	100
5	OE	OE2		3	0	0	3	3	100
		Theory Sub-total		15	0	0	15	15	500
6	PC	Power Systems Lab	EE3171N	0	0	3	2	3	50
7	PC	Control Systems Lab and design	EE3172N	0	0	3	2	3	50
8	PC	Power System Protection Lab and Renewable Energy Lab	EE3173N	0	0	3	2	3	50
		Practical Sub-total		0	0	9	6	9	150
		Fifth Semester Total		15	0	9	21	24	650



Course	EE3101N	Course	Power System	Course	P.C.	L	Т	P	
Code	EESTOIN	Name	II	Category	PC	3	0	0	

Pre-requisite Courses	Power Systems I	Nil		Progressive Courses	Nil
Course O Depart	O	Electrical En	gineering	Data Book / Codes/Standards	Relevant IS, IEC, IEEE & CIGRE standards

Course	1. To provide fundamental and advanced knowledge on power transmission
Objective	systems, both AC and HVDC.
	2. To develop competency in power flow studies and numerical solution
	techniques for large power networks.
	3. To enable the learner to analyze faults and transients in power systems
	using symmetrical components and traveling wave methods.
	4. To impart understanding of system stability, protection, and control
	measures including insulation coordination and economic dispatch.
	5. To familiarize learners with the basics of deregulated power markets.
	6. To familiarize learners will be able to understand the characteristics and
	grid integration challenges of various renewable energy sources in the
	power system.

Module	Syllabus	Duration (Class - hour)	Module Outcome
I.	EHV AC and HVDC Transmission Systems— Introduction to AC and DC Power Transmission, Aspects of EHV AC Power transmission, Comparison of AC and DC Power transmission, HVDC systems—terminal equipment, power flow through DC links, control of power, HVDC protection system.	4	 After completing this module, learners will be able to compare AC and DC transmission systems, understand the operation of HVDC terminal equipment, control power through DC links, and evaluate HVDC protection schemes.
II.	Power Flow Analysis – Formation of bus admittance matrix, real and reactive power balance equations at a node, bus specifications, Gauss-Seidel, Newton-Raphson, First Decoupled and DC load flow methods, solutions of non-linear	5	• After completing this module, learners will be able to formulate power flow equations, apply Gauss-Seidel, Newton-Raphson, and Fast-

Module	Syllabus	Duration (Class - hour)	Module Outcome
	equations and application of numerical methods, Sparse matrix, computational issues in large power systems, basic aspects of Contingency analysis		Decoupled methods for load flow studies, and address computational challenges in large-scale systems including contingency analysis.
III.	Analysis of Faults in Power Systems—Symmetrical and unsymmetrical faults, Step bystep method of formation of ZBUS, symmetrical components—Fortescue's Theorem, Sequence impedance, Positive, negative and zero sequence networks, Un symmetrical faults—single line to ground, line to line, double line to ground.	6	• After completing this module, learners will be able to analyze symmetrical and unsymmetrical faults using sequence components, construct Z-bus matrices, and understand the effect of different fault types like SLG, LL, and DLG on system operation.
IV.	Power System Transients—Lightning and switching surges, Travelling wave, Bewley's Lattice diagram, Basic Insulation level, Protection of systems and equipment against over voltage, Insulation co-ordination	4	• After completing this module, learners will be able to describe the impact of lightning and switching surges, model traveling waves using Bewley's lattice diagram, and implement insulation coordination techniques for system protection.
V.	Fundamental Aspects of Power System, Stability-Steady State and Transient stability, Equal area criteria, Critical clearing time and angle, Swing equation and its solution, Factors affecting stability, Improvement of stability, Aspects of voltage stability.	5	• After completing this module, learners will be able to understand steady-state and transient stability, apply equal area criteria and swing equation, determine critical clearing time, and suggest methods for improving system stability and maintaining voltage profiles.
vI.	Power System Economics and Management—Interconnected system, Its advantages, Distribution of load between thermal units within a plant, Economic operation with and	5	• After completing this module, learners will be able to explain load distribution strategies, perform economic dispatch with and without transmission losses, and

Module	Syllabus	Duration (Class - hour)	Module Outcome
	without transmission losses considered, concept of power exchange and spot pricing, Deregulation and management.		understand concepts related to power markets, spot pricing, and deregulation.
VII.	Basics of Renewable Energy Sources-Overview of renewable energy sources: solar, wind, biomass, and small hydro, Solar-thermal energy conversion -Solar Collectors, Solar photo voltaic conversion - Solar cell-Characteristics, model, series parallel connection, PV module, PV array, PV system components, types of PV system, concept of Maximum Power Point Tracking, Elementary design of a solar PV installation, Wind- Wind Electric System, Fuel cell.	5	• After completion of this module, the students will learn about different types of renewable energy sources with a detailed understanding of solar thermal and solar PV system.
VIII.	Integration of Renewable Energy into Power Systems: Grid integration challenges and solutions for variable renewable energy (VRE), Voltage and frequency regulation issues in RE-integrated grids, Impact on power quality, system protection, and stability, Forecasting, scheduling, Role of energy storage and micro-grids in facilitating RE penetration, Case studies on hybrid power systems and smart grid frameworks.	6	• After completing this module, learners will be able to understand the characteristics and grid integration challenges of various renewable energy sources, evaluate their impact on system stability, protection, and operation, energy storage, and smart grids to enable efficient renewable energy utilization.
IX.	Concise overview of Grid Intelligence and Autonomous Power Networks using AI/ML	2	 After completion of this module the students will learn probable areas in Power System where AI/ML can be applied.
	TOTAL	42 L	

Course	1. Analyze and compare high voltage AC and DC transmission systems with
Outcome	control and protection strategies.
	2. Formulate and solve power flow problems using iterative numerical
	techniques suitable for large-scale networks.
	3. Perform symmetrical and unsymmetrical fault analysis using sequence
	networks and Z-bus formulation.
	4. Analyze power system transients and implement insulation coordination
	for equipment protection.

- 5. Evaluate the dynamic performance of power systems through stability studies and propose enhancement techniques.
- 6. Understand the operation and coordination of protection devices such as fuses and circuit breakers.
- 7. Assess the economic operation of power systems and manage deregulated electricity markets.
- 8. Integrate renewable energy sources into conventional grids, analyze technical challenges, and propose solutions using modern power electronic and smart grid technologies.

Learning Resources

- 1. Grainger and Stevenson, Power System Analysis, 1st Ed., McGraw Hill Education, 2010.
- 2. Bergen and Vittal, Power System Analysis, 2nd Ed., Prentice Hall, 2000.
- 3. Kothari and Nagrath, Power System Engineering, Tata McGraw Hill Education, 2008.
- 4. Chakrabarti and Halder, Power System Analysis, Operation and Control, 3rd Ed., PHI Learning, 2020.
- 5. P. S. Kundur, Power System Stability and Control, McGraw Hill Education.
- 6. Weedy, Cory, Jenkins, Ekanayake, Electric Power Systems, 5th Ed., Wiley, 2012.
- 7. B.H. Khan, Non-Conventional Energy Resources, McGraw Hill Education.
- 8. S.N. Singh, Electric Power Generation, Transmission and Distribution, PHI Learning

Course	EE2102N	Course	Control	Course	PC	L	T	P
Code	EE3102N	Name	Systems-II	Category		3	0	0

Pre-requisite Courses	Engineering Mathematics	Co-requisite Courses	Control Systems-I	Progressive Courses	Advanced Topics in Control and Estimations
Course Offering Department		Electrical	Engineering	Data Book / Codes/ Standards	Nil

Course	1.	To examine State variable canonical forms representation of continuous-time			
Objectives		linear time invariant (LTI) systems.			
	2.	To explore the Controllability and design linear state variable feedback (LSVF)			
		controllers along-with the observer design.			
	3.	To analyze discrete-time systems in the time domain, sampling and hold			
		processes with their mathematical equations; stability in discrete-time.			
	4.	Frequency domain analysis of discrete-time systems for reconstruction			
		continuous-time signals obtained from the sampled data control system; design			
		control systems for discrete and real-time digital control implementations.			
	5.	Step by step design of Lead and Lag compensators and their implementation.			
	6.	Design of P, PI, PD and PID controllers and know their areas of application.			
	7.	To have a preliminary overview on non-linear systems and determination of its			
		stability.			
	8.	To learn about the design and theory of optimal control systems.			

Module	Syllabus	Duration		Module Outcomes
		(class-hour)		
I.	State Variable Control: Controllability, Linear State Variable Feedback Control, Observability, Observers, Case Studies and Design with Examples.	10	•	Identify the different canonical forms of state variable models. Design LSVF controllers for various systems to meet transient response specs. Implementation of LSVF controllers through observers
II.	Discrete Time Systems: Sampled-data systems; Overview of computer controlled systems; z- transform for discrete time signals and systems; Examples of z-domain transfer functions; Stability and response; Frequency spectrum and Sampling theorem; Aliasing effect and its remedy; Design of	11	•	Mathematical representation and time domain analysis of sampled data control systems. Stability of the discrete-time system.

	digital controllers with examples and problem solving.		 Frequency spectrum of discrete-time systems; sampling theorem for its reconstruction. Design real-time digital controllers and their implementations.
III.	Control Systems Design: Design of Lag, Lead and Lag/Lead compensators. Design of PI and PD controllers, Case studies with numerical examples.	11	Implement and verify mathematically the design methods/algorithms known for controllers and compensators on different case studies taken
IV.	Introduction to Nonlinear Control: Phase Plane Analysis, Lyapunov Stability, Examples and discussions on some Real-time Nonlinear Systems.	6	Distinguish between the linear and non- linear; linearization methods and stability of nonlinear system.
V.	Introduction to Optimal Control Systems: Performance Index, Examples, Linear Quadratic Regulator (LQR), Case Studies and Design with Examples.	4	• Introduction to LQR optimal control systems.
	Total	42 L	

Course	The students shall be able to,
Outcomes	
	1. Identify the different canonical form representations of LTI state variable models and controllability.
	2. Design linear state variable feedback controllers for pole placement and implementation through designed observers.
	3. Mathematical representation, time domain analysis and compute the condition of stability of a discrete-time of sampled data control systems.
	4. Describe the frequency spectrum of discrete-time systems and application of sampling theorem for its reconstruction; design control systems for some discrete and real-time digital control implementations
	5. Design of Lead and Lag compensators; learn their use and and implementation using passive elements.
	6. Learn applicability, structure and hands-on design of P, PI, PD and PID controllers.
	7. Distinguish between the linear and non-linear systems leading to the determination of the linearization methods and stability of any nonlinear control system.
	8. Create methodically LQR controllers to achieve optimal control systems.

Learning	Text Books:							
Resources	1. Control Systems Engineering, N.Nise,6th edition,2010,WileyIndiaEdition.							
	2. Modern Control Engineering, K.Ogata,5thEdition,Pearson.							
	3. Control Systems Engineering, Nagrath and Gopal,6thEdition,New Age							
	International Publishers.							
	4. Automatic Control Systems, B.C.Kuo and F. Golnaraghi, 9thEdition, Wiley.							
	5. Feedback Control of Dynamic Systems Franklin ,Powell and							
	Naeimi,5thEdition,Pearson.							
	6. Digital control and state variable methods- M. Gopal.							
	7. Discrete time control systems- K Ogata.							
	8. Nonlinear Systems - H. K. Khalil.							
	9. Applied Nonlinear Control - Jean-Jacques E Slotine, Weiping Li							

Course	EE3103N	Course	Power	Course	DC	L	Т	P
Code	EESTOSIN	Name	Electronics	Category	rc	3	0	0

Pre-requisite Courses	Analog Electronics	Co-requisite Courses	Nil	Progressive Courses	Nil
Course O Depart	0	Electrical En	gineering	Data Book / Codes/Standards	Relevant IS, IEC, IEEE & CIGRE standards

Course	1. To introduce various power semiconductor devices and their
Objective	characteristics relevant to power control.
	2. To develop understanding of converter circuits including rectifiers,
	inverters, and choppers used in power processing.
	3. To analyze and design power electronic converters for effective energy
	conversion.
	4. To explore the application of power electronic devices in industrial drives
	and power supplies like SMPS and UPS.
	5. To provide hands-on knowledge for selecting and designing power
	electronic circuits for real-world applications.

Module	Syllabus Solid State Devices for Power Control:	Duration (Class - hour)	Module Outcome • Students should be able to
I.	Power Diodes- construction and switching characteristics. Four-layer devices like – SCR, GTO, IGCT etc. – their operation and switching characteristics, Isolations and synchronization of driving pulses, Triggering and commutation scheme of SCR. BJT's, Power MOSFET's & IGBT's – their drive circuits, static and dynamic characteristics. Requirement and design of switching aid circuits. Introduction of modern solid state devices (GaN and SiC).		understand the construction, characteristics, and switching behavior of power semiconductor devices such as SCRs, GTOs, IGBTs, and MOSFETs, along with drive and protection requirements. • Students should acquire elementary ideas on modern solid state devices (GaN and SiC)
II.	Uncontrolled & Controlled Rectifier circuits (single phase and three phase): voltage output, power output, Transformer Utilization Factor, Ripple Factor, Power	7	• Students should be able to analyze the performance and compare various line-commutated rectifiers

Module	Syllabus	Duration (Class - hour)	Module Outcome
	Factor. Selection of rating of devices. Use of freewheeling Diodes. Effects of source and load inductances. Control strategies. Filter requirement.		• Students should be able to select ratings of power devices for such rectifiers
III.	AC Voltage Controller (single phase only): Integral cycle control, phase control, their applications- transformer tap changer	2	• Students should be able to analyze and understand the operation of a single-phase AC voltage controller
IV.	DC/DC Converters: Classifications, principles, design, analysis and uses	5	 Students should be able to analyze & compare the performance of various DC/DC Converters Should be able to select a DC/DC converter for a given application
V.	Inverters: Principles and different topologies of single-phase and three-phase bridge and PWM inverters. Commutation process for thyristorised inverters. Selection of circuit parameters, method of voltage and frequency control, reduction of harmonics, VSI & CSI.	5	 Students should be able to analyze the operation and performance of various square wave inverters (1-ph & 3-ph) Students should acquire elementary ideas on PWM VSI Students should gain elementary ideas on SCR-commutation in inverters – VSI and CSI
VI.	SCR Forced Commutation Techniques and Introduction to Soft-Switching: Various classes of SCR-commutation techniques — principles, circuit examples and major waveforms; a few applications; introduction to resonant converters, zero-voltage and zero-current switching	6	 Students should have a clear understanding regarding the various commutation techniques for SCR & the associated waveforms Students should have ideas regarding the principles of zero-voltage and zero-current switching and elementary ideas regarding resonant converters
VII.	Power Supplies: Principles, different topologies and uses of SMPS, UPS	3	Students should be able to understand the working of SMPS and UPS systems,

Module	Syllabus	Duration (Class - hour)	Module Outcome
			including their topologies, operating principles and application domains
VIII.	Battery Charger: Configuration of battery charger, methods of charging - boost, float and trickle charging, discharging of batteries	2	• Students should be able to understand the configuration of battery charger and the various methods of charging. Also, they will acquire ideas on discharging of batteries
IX.	Industrial Applications (AC Drives): Stator voltage control and PWM Control of three-phase induction motors. Closed-loop control principles and blocked schematics.	3	• Students should acquire ideas on the stator voltage control and PWM techniques for induction motor drives and understand their control through block schematics
	TOTAL:	42L	

Course	1. To understand the working principles, switching characteristics and drive
Outcome	requirements of various power semiconductor devices (e.g., SCR, IGBT,
	MOSFET).
	2. To analyze and design single-phase and three-phase controlled rectifier circuits.
	3. To gain knowledge on the application of AC voltage controllers and cycloconverters for variable voltage and frequency output.
	4. Design and analyze DC-DC converters and inverters for different industrial and utility applications.
	5. To understand the design and operation of SMPS and UPS systems.
	6. Model and simulate power electronic circuits for controlling DC and AC motor drives.
	7. Assess and mitigate power quality issues like harmonics in power converter systems.

Learning Resources

- 1. M. H. Rashid, Power Electronics: Circuits, Devices and Applications, 4th Edition, 2014, Prentice Hall.
- 2. G. K. Dubey et al., Thyristorised Power Converters, 1986, New Age International.
- 3. N. Mohan, T. M. Undeland, W. P. Robbins, Power Electronics: Converters, Applications and Design, 3rd Edition, 2002, John Wiley & Sons.
- 4. C. W. Lander, Power Electronics, 3rd Edition, 1993, McGraw-Hill.
- 5. P. S. Bhimra, Power Electronics, Khanna Publishers, 1990.
- 6. General Electric, "SCR Manual Including TRIACs and other Thyristors," General Electric Company, U.S.A, 1972.

Course	EE3104N	Course	Power System	Course	DC.	L	T	P
Code	EE3104N	Name	Protection	Category	PC	3	0	0

Pre-requisite Courses	Power System-I	Co-requisite Courses	Nil	Progressive Courses	Nil
Course O Depart	0	Electrical En	gineering	Data Book / Codes/Standards	Nil

Course Objectives

- 1. To provide students with a comprehensive understanding of the fundamentals of power system protection and protective relaying.
- 2. To familiarize students with electromechanical, static and numerical relays and to impart knowledge about the protection schemes for major power system equipment and components.
- 3. To Familiarize students with the operating principle and functioning of circuit breakers and equip them with the knowledge to select circuit breaker of proper rating and type for different applications.

Module	Syllabus	Duration (alass have)	Module Outcome
I.	Fundamentals of Protective Relaying: Function of protective relays, it's attributes and categorization. Elements in protection scheme - CT, PT, CVT and their functions. Types of relays - Electromechanical, Static and Numeric Relays. Over current(OCR) and Directional Over Current relays (DOCR), Differential relay, Impact of integration of Renewable Energy on the performance of protective relays.	(class-hour) 7	 Understanding of the functioning of protective relays and different elements of protection scheme Evolution of protective relays Characteristic and applications of OCR & DOCR
II.	Transmission Line protection: Distance Relaying and Pilot Relaying, Impedance and Modified Impedance, Angle Impedance, Mho, Quadrilateral Relay. Reach, Over-reach and Under-reach of an Impedance relay. Three step Time Lag Distance Rely. Wire pilot, Carrier pilot and Micro-wave pilot protection. Synchro Phasor, PMU, Phasor estimation.	8	 Thorough understanding of Distance protection and Pilot protection for overhead transmission lines. Understanding the fundamentals

III.	Alternator Protection: Stator Earth Fault and Phase Fault Protection, Restricted Earth Fault Relay, Rotor Earth Fault Protection, Protection against Loss of Excitation and Prime Mover Failure, Stator Overheating Protection, Protection against Negative	6	of phasor estimation • Understanding of the methods and schemes for protection of Alternators
IV.	Transformer Protection: Transformer Differential Relay, Harmonic Restraint feature, Protection against Incipient Faults, Protection against Overloading and Overheating, Restricted earth fault, Tankearth protection, Neutral displacement protection.	7	 Understanding of the different methods and schemes for protection of Transformers
V.	Protection of major Electrical Equipment: Motor Protection - Differential Protection for Large Motors, Short Circuit and Overload Protection, Under Voltage Protection, Earth Fault Protection. Protection of Busbar, Capacitor Bank and Shunt Reactor - Short Circuit, Over Current and Earth Fault Protection. Coordination of over current relays in Interconnected Power System	6	 Comprehensive understanding of the protection schemes for power system components like Motors, Bus bar, Capacitor Bank and Shunt Reactors. Coordination of OCRs in interconnected power system
VI.	Circuit-Breakers: Functions of a circuit breaker, its principle of operation and types. Arcing phenomenon and methods of Arc Quenching. Restriking voltage and Recovery voltage, Current Chopping, Capacitive Current Breaking, Resistance Switching. Ratings and Selection of Circuit Breakers, HVDC Circuit Breakers.	8	• Familiarization with the operating principle and functioning of Circuit Breakers, their types, ratings and characteristics.
	Total	42 L	

Course	1. Ability to comprehend the principles of power system protection and acquire
Outcome	knowledge to develop protection schemes for power system components and
	equipment.

- 2. Ability to apply the acquired knowledge and skills in power system protection to excel in the modern power industry/utility and power system research.
- 3. Ability to identify strategic solutions to provide effective protection to power system equipment and components in technically sound, economically feasible and socially acceptable manner

Learning Resources

- 1. Fundamentals of Power System Protection, Pathinkar, Y. G. and Bhide, S. R., (2008), PHI Learning Pvt. Limited.
- 2. Protective Relaying Theory and Applications, Elmore, W.A., (2003), ABB Power T and D Company Inc.
- 3. Power System Protection and Switchgear, Badri Ram and D. Vishwakarma, McGraw Hill Education; 2nd edition, 2017.
- 4. Protection and Switchgear, Bhavesh Bhalja, R. P. Maheshwari, Nilesh G. Chotani, 2011, Oxford University Press.

Power Systems Laboratory (EE3171N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments related to the theoretical subject "Power Systems II (EE3101N)".

Control Systems Laboratory and Design (EE3172N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and design aspects related to theoretical subjects "Control Systems I (EE2203N)" and "Control Systems II (EE3102N)".

Power Systems Protection and Renewable Energy Laboratory (EE3173N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments related to theoretical subject "Power Systems Protection (EE3104N)".

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Sixth Semester

Sl. No Type		Course Name	Course		Clas	s /eek	Credit	Class load/	Marks
			Code	L	Т	P		week	
1	PC13	Microcontrollers and Embedded Systems	EE3201N	3	0	0	3	3	100
2	PC14	Transducers and Instrumentation	EE3202N	3	0	0	3	3	100
3	PSE1	Elective 1		3	0	0	3	3	100
		i) High Voltage Engineering	EE3221N						
		ii) New and Renewable Energy	EE3222N						
		iii) Soft Computing and Intelligent Systems	EE3223N						
		iv) Electrical estimation and costing	EE3224N						
		v) Advanced Topics in Control and Estimation	EE3225N						
4	VAC	Sociology & Professional Ethics		3	0	0	3	3	100
5	OE	OE3		3	0	0	3	3	100
		Theory Sub-total		15	0	0	15	17	500
6	PC	Microcontroller and Embedded Systems Lab	EE3271N	0	0	3	2	3	50
7	PC	Transducers and Instrumentation Lab and Design	EE3272N	0	0	3	2	3	50
8	PC	Power Electronics Lab and design	EE3273N	0	0	3	2	3	50
9	PSE	Elective 1 Sessional	EE3274N	0	0	3	2	3	50
		Practical Sub-total		0	0	12	8	12	200
		Sixth Semester Total		15	0	12	23	29	700



Course	EE2204N	Course	se Microcontrollers	Course	DC.	L	T	P	
Code	EE3201N	Name	and Embedded Systems	Category	PC	3	0	0	

Pre-requisite Courses	Analog and Digital Electronics	Co-requisite Courses	Microcontrollers and Embedded Systems Lab	Progressive Courses	Nil
Course Offering Department		Electrica	l Engineering	Data Book / Codes/Standards	Nil

Course	1. Understanding of the architecture of microcontrollers like 8051, PIC, and							
Objectives	ARM Cortex.							
	2. To learn hardware interfacing and applications							
	3. To learn Programming in assembly level language.							
	4. To develop firmware for the microcontrollers.							
	5. Provide students with the knowledge and skills necessary to design,							
	implement, and maintain embedded systems.							
	6. To acquire basic knowledge about embedded system hardware and software components							
	7. To learn how to program microcontrollers and interface them with peripherals							
	8. To learn how to debug embedded systems.							

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Introduction: Basic concepts and historical development, difference between microprocessor and microcontroller, Von Neumann and Harvard architectures, RISC and CISC, Memory and I/O interfacing	4	 Learn preliminary concept of a microcontroller Learn about the basic components around the CPU
II.	Microcontroller Architecture: Architecture of a generic microcontroller - CPU organization and components, memory organization, I/O ports, concept of pipelining. Specific examples of 8-bit Intel 8051 Microcontroller / 16-bit PIC Microcontroller / 32-bit ARM Cortex Microcontroller	8	 Know the architecture of a microcontroller and its internal components Appreciate the methods to enhance the speed of operation of a microcontroller To get familiar with the architecture of 8-bit Intel 8051 Microcontroller / 16-bit PIC Microcontroller / 32-bit ARM Cortex Microcontroller

III.	Instruction Set Architecture: Instruction formats and addressing modes, Data Transfer and arithmetic/logic instructions, Control flow and branching instructions. Specific examples from 8-bit / 16-bit / 32-bit	8	• Apply the instruction set of a microcontroller (covering instruction formats, addressing modes, and control flow across 8051, PIC, and ARM Cortex
	microcontrollers. Introduction to programming in High Level Languages and software development tools (IDEs)		architectures) to write simple programs using Assembly level language.
IV.	Other features of microcontrollers: Interrupts (concept of stack and subroutine), I/O Ports, Timers/Counters, Serial Communication, DMA etc. Hardware interfacing examples (e.g DAC /ADC)	4	 Develop the ability to interface peripherals with the microcontroller Analyse the use of interrupts, timing functions and communication using a microcontroller
V.	Introduction to Embedded Systems: Components and applications, ASIC and SoC, Real time systems, Application examples from different areas like Mechatronics and Robotics	2	 Get familiarised with embedded system components Learn to appreciate the constraints in embedded system design
VI.	Memory Structure: Memory hierarchy, Virtual Memory and Paging, Memory Management Unit	3	 Analyse the importance of memory system design in embedded architecture Learn about memory size limitations and Virtual Memory
VII.	Embedded system software: Evolution of Embedded Software, Concept of RTOS, Multitasking, Scheduling	3	 Become aware of real time embedded system problems and their solutions Know about priority-based scheduling
VIII.	Embedded system communication: Bus structure, Serial and parallel bus standards	3	 Develop knowledge about the necessity of communication in interconnected embedded systems Learn about communication protocols
IX.	Programmable Logic Devices: Field Programmable Devices and	7	Know about FPGAs and their embedded applications

Applications, Introduction to Hardware Description Languages		Apply the knowledge of HDL to program FPGAs using VHDL/Verilog
Total	42L	

Course Outcome

- 1. Students will understand the architecture, components, and operation of microcontrollers.
- 2. Students will grasp the concept of embedded systems, their role in various applications, and the importance of hardware and software interaction/codesign.
- 3. Students will develop programming skills in assembly language or C for microcontrollers, enabling them to control and interact with hardware.
- 4. Students will be equipped with the knowledge to design embedded systems (real time or otherwise)
- 5. Students will have the ability to make a choice of microcontrollers for various applications industrial automation and consumer electronics, advanced computing, low power consumption, and high-speed processing etc.

Learning Resources

Text Books:

- 1. **The 8051 Microcontroller** (3rd ed.) by Kenneth J. Ayala, Delmar Cengage Learning, 2005
- 2. PIC Microcontroller and Embedded Systems Using Assembly and C for PIC18, Mazidi, 2008, Pearson Education
- 3. **ARM System Developer's Guide**, Sloss, Symes and Wright, 1st Edition, 2004, Elsevier
- 4. Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C by Yifeng Zhu, E-Man Press LLC, 2023
- 5. Embedded Systems Building Blocks, Labrosse, 2nd Edition, Elsevier
- 6. **FPGA-based system design**, Wayne Wolf, 1st Edition, 2004, Pearson Education
- 7. **A VHDL Primer,** J. Bhasker, 3rd Edition, 1995, Prentice Hall

Reference books:

- 8. **Programming and Customizing the ARM7 Microcontroller**, Predko, 2009, McGraw Hill
- 9. Modern Embedded Computing, Barry & Crowley, 2012, Morgan

Kaufmann						
10. Web resou	rces:					
• NPTEL https://npte	course el.ac.in/cour	on rses/117	Digital 102060/	Signal	Processing	-
NPTEL https://npte	course l.ac.in/cou	o rses/108		mbedded	Systems	-

Course	EE2202N	Course Transducers	Course	DC.	L	T	P		
Code	EE3202N	Name	and Instrumentation	Category	rc	3	0	0	

1	-requisite Courses	Electrical and Electronic Measurements, Analog Electronics.	Co-requisite Courses	Nil	Progressive Courses	Nil
Cor	urse Offeri	ng Department	Electrical E	ngineering	Data Book / Codes/Standards	Nil

Course	1. To impart knowledge of fundamental sensing principles and sensor							
Objectives	technologies.							
	2. To familiarize students with automation frameworks involving sensors and							
	transducers.							
	3. To understand sensor signal conditioning, integration, and their role							
	automated systems.							
	4. To acquire the knowledge about Ideal and Non-Ideal OpAmp.							
	5. To use OpAmp in Signal generation, conditioner and processor.							
	6. To demonstrate different types of signal transmission and line coding.							

Module	Syllabus	Duration (class-hour)		Module Outcome
I.	Introduction to Transducers and Sensors: Definitions, classifications, measurement systems, sensor types, static characteristics.	3	•	Understand the need and architecture of automation in electric drive systems.
II.	Resistive and Potentiometric Sensors: Strain gauges, thermistors, RTDs, position sensing.	3	•	Analyze the working and characteristics of resistive sensors and applications.
III.	Inductive and Capacitive Transducers: LVDT, proximity sensors, capacitive displacement sensors, eddy current.	4	•	Explain electromagnetic principles and analyze inductive/capacitive transducer behavior.
IV.	Piezoelectric and Thermal Sensors Piezoelectric materials, applications in vibration/force; thermocouples.	3	•	Apply knowledge of dynamic measurement using piezo and thermal sensors.
V.	Optical and Magnetic Sensors: Photodiodes, LDRs, fiber-optic sensors, Hall-effect, magnetoresistive sensors.	4	•	Examine light-based and magnetic sensing methods and integration.

			T
VI.	Smart Sensors and Automation Interface: Microcontroller-based sensors, intelligent sensors, integration with PLC/DCS, digital protocols (4–20 mA, HART, I2C, SPI).	4	Understand architecture and application of smart sensors in automation.
VII.	Operational amplifiers: Basics, Instrumentation amplifiers.	4	Understand basics of OpAmp.
VIII.	Signal Generators: Sine wave generator (Wien Bridge oscillator), Comparator, Schmitt Trigger, Astable Multivibrator.	3	Apply OpAmp to generate different signal waveforms.
IX.	Signal conditioners: Voltage to current, current to voltage converter; Peak detectors, Sample/Hold circuit, Active Filters.	4	Able to design signal conditioners.
X.	Signal Processors: Window Comparators, Absolute value circuits, Precision rectifiers; Log- and Antilog-amplifiers, multiplier, divider, squarer, square rooter, Integrator, Differentiator, F to V and V to F converters.	4	Knowledge about different circuits used as signal processor.
XI.	Non-ideal OpAmp	3	• Able to differentiate Ideal and Non-ideal OpAmp.
XII.	Signal transmission : Analog and Digital data transmission, modulators and demodulators, Line Coding (RZ, NRZ signals etc.).	3	• Familiar with Signal transmission.
	Total	42L	

Course	1. Explain the principles, characteristics, and applications of various sensors					
Outcome	and transducers.					
	2. Design and analyze signal conditioning circuits and interfacing schemes.					
	3. Apply sensor technology in automation and control systems with					
	awareness of emerging technologies.					
	4. Knowledge about Ideal and Non-ideal OpAmp.					
	5. Able to apply OpAmp in Signal generation, conditioner and processor.					
	6. Learn to demonstrate different types of signal transmission and line					
	coding.					

Learning	1. Patranabis D., Sensors and Transducers, PHI Learning.
Resources	2. Doebelin E. O., Measurement Systems: Application and Design, McGraw-
	Hill.
	3. Neubert H. K. P., Instrument Transducers, Oxford University Press.

- 4. D. V. S. Murthy, Transducers & Instrumentation, 2nd Edition, ISBN: 9788120335691.
- 5. H. S. Kalsi, Electronic Measurements and Instrumentation, 3rd Edition, 2012, TataMcGrawHill.
- 6. Rangan, Sarma and Mani, Instrumentation: Devices and Systems,2nd Edition, 2017, TataMcGrawHill.
- 7. Mitra and Sengupta, Programmable Logic controllers and Industrial Automation-an Introduction, 2nd Edition, 2017.

Course	EE3221N	Course	High Voltage	Course	DCE	L	Т	P
Code	EE322IN	Name	Engineering	Category	FSE	3	0	0

Pre-requisite Courses	Power System-I	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical Engineering		Data Book / Codes/Standards	Nil

Course 1. Objectives

- 1. To provide students with a comprehensive understanding of the overvoltage phenomena in power system, its causes and mitigation and the concept of insulation coordination.
- 2. Familiarize students with different types of dielectric materials, their characteristics and applications in electrical apparatus and equipment.
- 3. To provide students with the understanding of different methods of high voltage generation for dielectric testing, techniques for measurement of high voltage and current and high voltage testing of power apparatus.

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Overvoltage in Power System: Overvoltage and its impact on electrical power system. Over-voltage due to lightning, switching and other causes. Protection against overvoltage - earthing screen, overhead ground wires, lightning arresters, surge diverters and surge absorbers.	6	Understanding of the overvoltage phenomena in power system, it's causes and mitigation
II.	Breakdown phenomena in Dielectrics: Gases as insulating medium: ionization processes, Townsend's theory, electronegative gases and vacuum as dielectric. Liquids as insulators: pure and commercial liquids, conduction, and breakdown in liquids. Breakdown in Solid Dielectrics: intrinsic, electromechanical, and thermal breakdown in solid dielectrics, breakdown in voids and partial discharges. Use of solid, liquid and	7	• Thorough understanding of the breakdown mechanisms in solid, liquid and gaseous dielectrics and applications of different dielectric materials in electrical apparatus and equipment.

	gasses as dielectric medium in high voltage power equipment.			
III.	Generation of High Voltages for Dielectric Testing: AC High Voltage: High voltage Testing Transformer, Cascaded High Voltage Transformer, Resonant Transformer. DC High Voltage: Voltage Doubler Circuits, voltage drop and regulation, Electrostatic Machines for High DC voltage generation — Van de Graaff Generator. Impulse Voltage: Standard Impulse Waveshapes, Circuits for Producing Impulse Waves, Waveshape Control, Multi-stage Impulse Generator — Triggering and Control mechanism.	8	•	Understanding of the methods for generation of high AC, DC and Impulse voltage for dielectric testing of power apparatus and equipment.
IV.	Measurement of High Voltages and Currents High DC Voltage: Ammeter with High Series Resistance, Resistive Potential Divider, Electrostatic Voltmeter. High AC and Impulse Voltage: Series Impedance Voltmeter, Capacitive Potential Divider, Capacitive Voltage Transformer (CVT). Peak Voltmeters: Series Capacitor Peak Voltmeter, Peak Voltmeter with Potential Dividers, Sphere Gap Measurements. High Currents: Resistive Shunts, Current Transformers	8		Thorough understanding of the different techniques for the measurement of high voltages and currents
V.	Wave Propagation Theory and Insulation Coordination: Standing and Travelling waves, reflection and refraction of travelling waves. Principles of insulation-coordination in high and extra high voltage power systems	6	•	Comprehensive understanding of the wave propagation theory and principles of insulation coordination in high voltage power system.
VI.	Non-destructive testing of Materials and Electrical Equipment: Measurement of D.C. Resistivity and Capacitance. Measurement of Dielectric Constant and loss factor, Partial discharge	7	•	Familiarization with the techniques for measurement of different electrical parameters and non-

Total	421.	equipment
measurements and radio Interference. Testing of Insulators, bushings, circuit breakers, cables, transformers and surge		destructive test methods for electrical apparatus and

Course Outcome

- 1. Ability to comprehend the high voltage phenomena in power system and acquire knowledge to solve practical problems in the domain of high voltage engineering.
- 2. Ability to apply the knowledge and skills in high voltage engineering to excel in various sectors in modern power industry/utility and power system research.
- 3. Ability to identify strategic solutions to real life problems in the areas of high voltage engineering that are technically sound, economically feasible and socially acceptable.

Learning Resources

- 1. High Voltage Engineering, M. S. Naidu and V. Kamaraju, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2015, ISBN: 9781259062896.
- 2. High Voltage Engineering, C. L. Wadhwa, New Age International Publishers, ISBN: 9788122430905
- 3. High Voltage Engineering Fundamentals, E. Kuffel and W. S. Zaengl and J. Kuffel, Second Edition, 2000, Newnes Publication, ISBN: 978-0750636346

		~	Renewable			L	T	P
Course Code	EE3222N	Course Name	and Sustainable Energy	Course Category	PSE	3	0	0

Pre-requisite Courses	Basic Electrical Engineering	Co-requisite Courses	Nil	Progressive Courses	Nil
Course C Depart	U	Electrical Eng	gineering	Data Book / Codes/Standards	Relevant IS, IEC, IEEE & CIGRE standards

Course Objective 1. To provide an overview of different types of non-conventional and renewable energy. 2. To familiarise the learners with basics of solar energy, instruments for

- 2. To familiarise the learners with basics of solar energy, instruments for measuring solar radiation, details of two routes to utilize solar power -solar-thermal route and solar PV route.
- 3. To impart knowledge of wind energy conversion, wind electric system.
- 4. To familiarize learners with different forms of micro-hydel energy like hydro, tidal, wave.
- 5. To impart knowledge of bio-energy conversion, bio-gas, gasifiers, bio-gas plant.
- 6. To familiarize the learners with nuclear energy, nuclear reactor, hazards of nuclear energy.
- 7. To impart knowledge of fuel cell, electric and hybrid vehicle, ocean thermal energy, geothermal energy.
- 8. To impart the knowledge of micro-girds, different issues arising out of connecting renewable energy sources to micro-grids.

Module	Syllabus	Duration (Class - hour)	Module Outcome
I.	Introduction: Concept of energy, energy scenario and conversion to electrical form, energy and society, energy and environment, necessity of non-conventional and renewable energy.	2	• After completion of the module, the students will get an overview of different types of different types of non-conventional and renewable energy sources and energy scenario.
II.	Solar energy : Solar radiation and its characteristics, Solar Geometry, Measuring solar radiation—Pyranometer,	7	Upon completion of the module the students will learn the characteristics

Module	Syllabus	Duration (Class - hour)	Module Outcome
	Pyhelio-meter, Sunshine recorder. Green house effects, Solar collector-flat plate, focusing, Solar water heating-natural circulation, forced circulation, Space heating-active and passive system, solar thermal energy storage, solar pond, Solar power plant.		of solar energy, different types of instruments for measuring the solar radiation, details of the solar thermal energy conversion using collectors, application of solar thermal energy conversion in solar water heating and space heating, solar thermal energy storage and solar power plants.
III.	Solar Photo voltaic Conversion: Solar cell-Characteristics, model, series parallel connection, PV module, PV array, PV system components, types of PV system, concept of Maximum Power Point Tracking (MPPT).	4	• After completion of the module, the students will learn the characteristics and types of Solar PV cell, interconnection of cells as modules and array, different types of Solar PV system.
IV.	Wind energy: Potential, development of wind turbines, wind electric system, wind pump, utilization and national scenario.	6	 Upon completion of the module the students will learn the methods of wind energy conversion, construction and control of wind turbines, description of wind electric systems.
V.	Micro-hydel energy: Potential, development of micro hydro-electric generators & auxiliaries. Non-conventional (tidal, wave) hydro-electric conversion system	5	• This module will enable the students to learn different forms of microhydel energy conversion like hydro-electric, tidal, wave etc.
VI.	Nuclear energy and environment: Review of conventional and nuclear power plant, Nuclear fusion reactor, description of existing models, safety and hazards of nuclear energy.	4	Upon completion of the module, the students will learn about nuclear energy, nuclear reactors and risks of nuclear energy.
VII.	Magneto hydrodynamic energy conversion: Concept, present and future concept, Economic and environmental aspects of MHD generator plant.	3	• This module will enable the students to learn the basics of magneto hydrodynamic energy conversion.

Module	Syllabus	Duration (Class - hour)	Module Outcome
VIII.	Bio-energy: Resources and conversion process—biogas conversion, biogas plant, present gasifiers and biogas plants used in India, Fuel cell, electric and hybrid vehicles.	4	 This module will enable the students to learn different routes of obtaining energy from biomass, biogas conversion, gasifiers, bio-gas plants. Basic ideas of fuel cell and electric and hybrid vehicles.
IX.	Thermal energy: Ocean thermal energy conversion, Geothermal Energy conversion	2	Upon completion of the module, the students will learn ocean thermal and geothermal energy conversion.
X.	Concept of micro grid: the inter facing of renewable energy micro sources into the micro-grid, the smart grid and its relevance while using renewable energy sources.	3	• This module will enable the students to understand the concept of micro-grid, integration of different renewable energy sources to the grid.
XI.	Rural energy security: Hybrid system of renewable energy sources – necessity, Implementation, national policy.	2	• This module will enable the students to learn rural energy scenario from the perspective of renewable energy, national policy.
	Total	42L	

Course	
Outcome	 Upon completion of this course, students will have an overview of the different types of renewable energy sources. They will develop a comprehensive understanding of solar energy, wind energy, bio-energy, nuclear energy, hydel energy. The course will equip the students with the knowledge of micro-grid and integration of different renewable energy sources to the grid.

Lea	rning
Res	ources

- 1. **Renewable Energy** ,Bent Sorensen,5thedition, AcademicPress, ISBN:9780128045671
- 2. Renewable Energy Sources and Energy Technology, Kothari, Singal and Ranjan, 2ndedition, Prentice Hall India, ISBN:9788120344709
- 3. **Solar Energy**, S.P. Sukhatme, J.K. Nayak, 4thedition, TataMcGraw-Hill, ISBN: 9789352607112
- **4. Renewable Energy Resources**, J. Twidelland T. Weir, 2nd Edition, 2005, Taylor and Francis
- 5. Renewable and efficient electric power systems ,G.M. Masters, 2nd edition, John Wiley and Sons, ISBN:9781118140628
- 6. Renewable energy engineering and Technology. VVN Kishore, 2010, TERI, ISBN 8179932214, 9788179932216
- 7. **Bio fuels Engineering Process Technology**, Caye M.Drapcheo, NP Nhuan, T.H Walkar, 1st edition, Mc Graw Hill ISBN: 9780071487498
- 8. Bio hydrogen production: Fundamentals and Technology Advantages , D. Das, N. Khanna , C. Nag, 1st edition, CRC Press, ISBN 9781138073203
- 9. **Solar Engineering of Thermal Processes**, J. A. Duffie and W. A. Beckman, 4th edition, John Wiley, New York,ISBN:978-0-470-87366-3
- 10. **Principles of Solar Engineering**, D.Y. Goswami, F. Kreithand, J. F.Kreider, 2nd edition, Taylor and Francis, Philadelphia ,ISBN: 978-1560327141
- 11. **Biomass Regenerable Energy**, D.D. Hall and R.P.Grover,1987,JohnWiley, NewYork
- 12. Solar Cells, M.A. Green, 1982, Prentice-Hall, Englewood Cliffs.

			Soft	_		L	Т	P
Course Code	EE3223N	Course Name	Computing and Intelligent	Course Category	PSE	3	0	0
			Systems					

Pre- requisite Courses	Engineering Mathematics and Statistics	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical En	gineering	Data Book / Codes/Standards	Nil

Course	1. To understand the of Soft Computing techniques and their applications	
Objectives	2. To design and implement intelligent systems for complex real world	
	problems, characterized by imprecision, uncertainty, and partial truth,	
	mimicking human-like decision-making.	
	3. To create systems that can learn from data, generalize from incomplete	
	information, and provide robust and cost-effective solutions to complex problems.	
	 To apply ANN, Fuzzy logic, and Evolutionary Algorithms in difference contexts of Electrical Engineering 	

Module	Syllabus	Durat ion (class	Module Outcome
I.	Introduction to Soft Computing and Intelligent Systems: Inspiration behind soft computing, difference between hard and soft computing, computational intelligence, need for intelligent systems and data driven approaches;	hour)	Acquaintance with soft Computing techniques and Intelligent Systems
II.	Machine Learning(ML) and Artificial Neural Network (ANN): Introduction to Regression: linear and nonlinear, Clustering, Classification, learning: supervised, unsupervised and Reinforcement learning, features: feature extraction, feature reduction, data mining, validation; Basics of Neural Computing & Artificial Neural Networks: Major variety of ANN architectures covering Perceptron, MLP, SOM, LVQ with supervised and unsupervised training algorithms;	8	 Clear Understanding of Classification, Clustering, and Regression Supervised & Unsupervised Learning Thorough concept of ANN

III.	Soft introduction to Convolution Neural Networks(CNN) and Recurrent Neural Networks(RNN) Applications of Artificial Intelligence(AI)		
	and ML: Case studies and algorithmic development of intelligent systems with typical examples in electrical engineering: clustering, classification, Regression, pattern recognition, signal processing	8	Typical applications of ANN and ML in Electrical Engineering domain
IV.	Fuzzy Systems and its Applications: Basic concepts of Fuzzy logic approaches, linguistic variables, membership functions, basic operation, Fuzzy relations, different de-Fuzzification techniques, Fuzzy rule based model, type-2 Fuzzy system, Intelligent Systems and fuzzy logic controllers	6	 Fuzzy logic based decision making Fuzzy logic based Controller
V.	Evolutionary Algorithms: Introduction to search optimization method, evolutionary algorithms (EA) Genetic algorithms (GA): biological inspiration behind GA, working principles, encoding, crossover and mutation, basic GA algorithm Particle Swam Optimization (PSO): Natural inspiration of Swarm intelligence, ring topology, star topology	6	 Clear concept of Evolutionary Algorithms Thorough understanding of GA Understanding of the operating principle of PSO
VI.	Applications of Evolutionary Optimization Techniques Development of GA and PSO-based algorithms in typical electrical engineering applications.	5	Ability to apply Evolutionary optimization techniques in the domain of Electrical Engineering
VII.	Hybrid Intelligent System: Neuro-fuzzy, ANN-EA, Fuzzy-EA based inference systems, advantages, and applications	5	• Fusion of Soft Computing techniques with improved performances
	Total	42L	

Course	After successful completion of the course, the students will be able to
Outcome	1. Learn fundamental
	2. Concept of Soft computing tools, techniques, and intelligent systems
	3. Innovative products design leading to unique AI/ML solutions to the
	complex real word problems including in the domain of Electrical
	Engineering

Learning	1. Simon Haykin, Neural Networks and Learning Machines, Pearson, 2019
Resources	2. A. Konar, Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of Human Brain, CRC press 2000
	3. Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis And Applications, By S. Rajasekaran and G. A. Vijayalakshmi Pai, PHI Learning Ltd, 2003
	4. Soft Computing: Techniques and is Applications in Electrical Engineering, By D. K. Chaturvedi, Springer, 2008
	5. K. Deb, Optimization for Engineering Design : Algorithms and Examples, PHI, 2012

Course		Course	Electrical	Course		L	Т	P	
Code	EE3224N	Name	estimation and costing	Category	PSE	3	0	0	

Pre-requisite Courses	Knowledge about Basic Electrical Engineering and Engineering Drawing	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical Engi	neering	Data Book / Codes/Standards	National Electrical Codes/ Building Rules

Course	1. To enable the students to understand the electrical installation, National
Objectives	Electrical Code, etc.
	2. To enable the students to understand the different illumination schemes
	for various applications
	3. To enable the students to prepare the schedule of materials with
	specifications and estimates for different types of electrical
	4. installations. Layouts and single-line diagrams of outdoor and indoor
	substations
	5. To enable the students to know about the safety and protection schemes
	related to the electrical system

Module	Syllabus	Duratio	Module Outcome
		n (class- hour)	
I.	Electrical Installations:- General requirements, design considerations, testing, estimating and costing -symbols, standards –National Electrical Code – design of panel boards –design and estimation of service connections –design and safety aspects of residential buildings, Energy Audit.	10	Knows about the electrical installation, National Electrical Code, etc.
II.	Illumination schemes:- Types of light sources and lighting arrangements —energy efficiency in lamps and illumination — design of lighting for various purposes.	8	Knows about the design illumination schemes for various applications
III.	Design, Estimation and Costing: Electrical system design, estimation and	12	• Knows about the design, estimate and estimated

	costing of commercial and residential buildings, Design of electrical installations of high-rise buildings: electrical aspects of lifts, escalators services, standby generators		cost of different electrical installations
IV.	Substation Design:-Design, estimation and costing of outdoor and indoor Substations -Layouts and single line diagrams of outdoor and indoor substations, design of earthing system, earth mat, plate and pipe earthing –Safety of electrical installations –Lightning protection	12	Knows about the selection and application of safety and protection schemes related to the electrical system
	Total	42L	

C	1 T. L. and L. Add. L. Add. Linds H. C. and Electrical Code at
Course	1. To learn about the electrical installation, National Electrical Code, etc.
Outcome	2. To learn about the design illumination schemes for various applications
	3. To learn about the design, estimate and estimated cost of different
	electrical installations
	4. To learn about the selection and application of safety and protection
	schemes related to the electrical system

Learning	1. Electrical Design Estimating and Costing, K.B. Raina, S.K. Bhattacharya,					
Resources	New Age International Publisher.					
	2.Electrical Installation Estimating & Costing, J.B.Gupta, VIII Edition S.K.					
	Katria & Sons New Delhi					
	3. Electrical Wiring Estimating and Costing, Uppal, Khanna Publishers Delhi					
	4. Design of Electrical Installations, Dr. V.K. Jain, Dr. Amitabh Bajaj,					
	University Science Press.					
	5. Electricity pricing Engineering Principles and Methodologies, Lawrence J.					
	Vogt, P.E., CRC Press.					
	6. Guide for Electrical Layout in residential buildings, Indian Standard					
	Institution, IS:4648-1968					
	7. Electrical Installation buildings Indian Standard Institution, IS:2032.					

Сония		Comman	Advanced	C		L	T	P	
Course Code	EE3225N	Course Name	Topics in Control and Estimation	Course Category	PSE	3	0	0	

Pre-requisite Courses	Signals and Systems, Control Systems-I	Co- requisite Courses	Control Systems-II	Progressive Courses	Nonlinear control, Nonlinear MPC, Nonlinear Observer design
Course Offerin	g Department	Electri	cal Engineering	Data Book / Codes/ Standards	Nil

Course Objectives

- 1. To develop a deep understanding of control performance objectives including loop shaping, stabilization, tracking, sensitivity analysis, and robustness using classical and modern techniques such as H-infinity control.
- 2. To introduce and analyze model-based control strategies including 1-DOF and 2-DOF controllers, Sylvester's equation-based formulations, Internal Model Principle (IMP), and Internal Model Control (IMC).
- 3. To design observer-based feedback controllers for real-time systems.
- 4. To provide foundational knowledge and practical formulation skills in Model Predictive Control (MPC) and Moving Horizon Estimation (MHE), emphasizing constrained optimization and finite-horizon control.
- 5. To introduce students to estimation theory, covering stochastic modeling, observer design, and optimal filtering techniques including the Kalman Filter and Extended Kalman Filter, with applications in dynamic system estimation and real-time control.

Module	Syllabus	Duration (class-hours)	Module Outcomes
I.	Introduction to Robust Control: Response and Loop Goals, Stabilization with Pole-placement, Trajectory Tracking, Loop Shaping Techniques, Sensitivity analysis, Utilities of Gain and Phase Margin determination, Robust Control, Sensitivity, S and H-infinity norm and H-infinity control, Case studies with Problem Solving and practical implementation.	7	 Set the performance objectives on response and loop goals for advanced controller design. Apply the different methods of control to confirm robustness and robust stability
II.	Internal Model Control (IMC): One degree-of-freedom (1-DOF) control, Two degree-of-freedom (2-DOF) control, Sylvester's matrix Formulation, Internal Model Principle (IMP), Internal Model Control (IMC), Problems and	8	 Extend one degree of freedom control to two degree of freedom control structure.

	solutions with case studies on any practical or industrial systems.		 Adopt and implement different model based control methods.
III	Observer-based Feedback Control design: Design of Full Order State observer and Reduced Order observer, Separation Principle, observer-based state and output feedback design for dynamical systems, Design examples, MATLAB tools and practical case studies and implementation on any real-time non-linear physical systems.	7	Design and implementation of observer-based feedback controllers for real-time systems.
IV.	Model Predictive Control (MPC) and Moving Horizon Estimation (MHE): Introduction to MPC; Finite horizon prediction, output prediction, formulation of optimization problem; Cost Function Formulation; Constraints in MPC; Moving Horizon Estimation (MHE):Optimization-based Estimation, constraints, Case studies and problem solving	10	 Fundamental concepts, mathematical formulation, and implementation strategies of Linear Model Predictive Control (MPC) Design, simulate, and analyze constrained control systems using state-space models and optimization techniques for real-time applications
V.	Introduction to Estimation Theory: Random processes, noise models, Bayes theorem; Luenberger observer, observer canonical form; Kalman Filter: Derivation, assumptions, Riccati equation, Discrete-time KF, convergence, numerical issues; Extended Kalman Filter (EKF) Linearization, Jacobians, applications, case studies and problem solving.	10	 Introduce the fundamentals of random processes and noise modeling relevant to estimation. Develop understanding of observer design using Luenberger observers and observer canonical forms. Derive and analyze the Kalman Filter and EKF, including assumptions, convergence, and the Riccati equation.
	Total	42L	

Course	The students shall be able to,
Outcomes	
	1. Analyze and design control systems to meet desired performance specifications
	using loop shaping, pole-placement, and sensitivity-based methods.
	2. Evaluate system robustness using gain and phase margins, and apply H-infinity
	control techniques for robust performance.

- Design and implement model-based control strategies, including 1-DOF and 2-DOF control, based on the Internal Model Principle and IMC structure.
 Implementation of observer-based feedback controllers for real-time systems.
 Design and implement Moving Horizon Estimation (MHE) and Model Predictive Controllers (MPC) for various systems.
 Design and implement estimation algorithms including Kalman Filter and
- Extended Kalman Filter for linear and nonlinear systems.7. Integrate theoretical control and estimation concepts through case studies and problem-solving relevant to real-world applications.

Learning	Text Books:					
Resources	1. Doyle, J., Francis, B., and Tannenbaum, A. Feedback Control Theory. New					
	York: Macmillan Publishing, 1992.					
	2. Grewal, M. S., and Andrews, A. P. Kalman Filtering: Theory and Practice Using					
	MATLAB, 4th ed. Hoboken: Wiley, 2015.					
	3. D'Azzo, J. J., Houpis, C. H., and Sheldon, S. N. Linear Control System Analysis					
	and Design with MATLAB, 6th ed. Boca Raton: CRC Press, 2013.					
	4. Green, M., and Limebeer, D. J. N. Linear Robust Control. Englewood Cliffs:					
	Prentice Hall, 1995.					
	5. Simon, D. Optimal State Estimation: Kalman, H Infinity, and Nonlinear					
	Approaches. Hoboken: Wiley, 2006.					
	6. Li, W., and Zhang, J. Model Predictive Control System Design and					
	Implementation Using MATLAB. Beijing: Tsinghua University Press and					
	Springer, 2019.					

Microcontroller and Embedded Systems Laboratory (EE3271N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments related to the theoretical subject "Microcontroller and Embedded Systems (EE3201N)".

Transducers and Instrumentation Laboratory and Design (EE3272N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and design aspects related to theoretical subjects "Transducers and Instrumentation (EE3202N)".

Power Electronics Laboratory and Design (EE3273N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments related to theoretical subject "Power Electronics (EE3103N)".

Elective 1 Sessional (EE3274N)

Weekly Contact: 0-0-3(L-T-P)

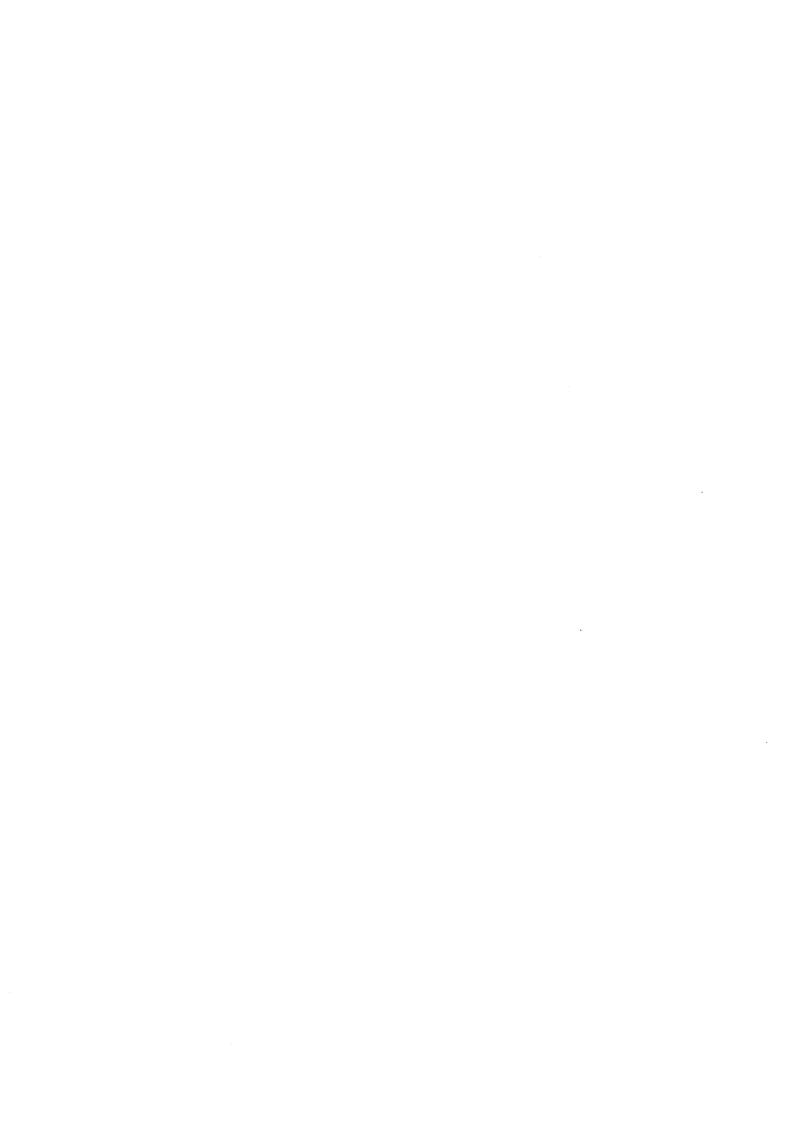
Full Marks -50

Credits:2



Seventh Semester

Sl. No	Туре	Course Name	Course Code	Class Load/Week			Credit	Class load/	Marks
			Couc	L	L T P			week	
1	PC15	Industrial Drives and Automation	EE4101N	3	0	0	3	3	100
2	PSE2	PSE2 Elective 2		3	0	0	3	3	100
		i) Digital Communication in Electrical Systems	EE4121N						
		ii) Power Generation Economics and Reliability Analysis	EE4122N						
		iii) Electronic System Design	EE4123N						
		iv) Computer Networking and Programming Techniques for Electrical Applications	EE4124N						
		v) Electric Vehicle	EE4125N						
		vi) Autonomous Navigation for Unmanned Vehicle	EE4126N						
3	HSC	Finance Economics and Management for Engineers		3	0	0	3	3	100
4	OE	OE4		3	0	0	3	3	100
		Theory Sub-total		12	0	0	12	12	400
5	PC	Drives and Automation Lab and Projects	EE4171N	0	0	3	2	3	50
6	PSE	Elective 2 Sessional	EE4172N	0	0	3	2	3	50
7	I	Internship							
		Practical Sub-total		0	0	6	4	6	100
		Seventh Semester Total		12	0	6	16	18	500



Course	EE 4404N	Course	Industrial	Course	DC.	L	T	P
Code	EE4101N	Name	Drives and Automation	Category	PC	3	0	0

Pre-requisite Courses	Electrical Machines I-II, Control System, power electronics, Transducers and Instrumentation	Co- requisite Courses	Nil	Progressive Courses	Advanced Control of Drives, Real-time Embedded Systems
Course Offering Department		Electrical I	Engineering	Data Book / Codes/Standards	Nil

Course	1. To learn about the concepts of Electric Drives					
Objectives	2. To learn different controls of DC and AC motors					
	3. To learn different types of electrical braking and the effects of heating and					
	cooling					
	4. To learn different types of applications in Drives					
	5. To provide knowledge of automation hardware and control algorithms					
	used in electric drives.					
	6. To impart the skills for integrating PLC, HMI, SCADA, and					
	communication protocols with drive systems.					
	7. To develop capability in simulation, real-time implementation, and fault-					
	tolerant control of industrial drives.					

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Concept of drives: Group drives, multimotor drives, direct drives. Drive specifications. Four-quadrant representations, dynamics of loading of motors with Different types of load. Constant torque drive and constant power drive. Motor Control components: DOL starters, contactors, limit switches, relays etc.	4	Understand the concept of drives and motor control component
II.	Solid state control of DC motors: Basic principles.	2	Understand the solid state control of DC motors
III.	Solid state control of AC motors: Basic principles. Drive schemes with stator voltage control. V/f control with constant flux and field weakening with and without	6	Understand the solid state control of AC motors

,			T
	tacho feed- back, slip compensation.		
	Concept of vector control of induction		
	machine, direct torque and flux control.	*	
IV.	Braking: Dynamic braking, regenerative		• Understand different
	braking, DC injection, plugging.		electrical braking
	Protection schemes for overall drive	4	
	systems. Transient time and energy loss		,
	during transient process.		
V.	Heating and cooling of motors: operating		• Effects of Heating and
	duty cycles. Enclosures of motors.	2	cooling of motors
	Selection of motor rating. Choice of	3	
	coupling and bearings.		
VI.	Drives for Specific Applications: Drive		• To know about the
٧1.	Considerations for Textile Mills, Steel		different application
	Rolling Mills, Cranes and Hoist Drives.	3	of Drives
	Cement Mills, Machine Tools, Paper	3	of Drives
X711	Mills, Coal Mines. Centrifugal Pumps etc.		- TT 1 / 1 /1 / 1
VII.	Introduction to Industrial Drive		• Understand the need
	Automation: Overview of automation	3	and architecture of
	architecture, control hierarchy		automation in electric
			drive systems
VIII.	Basics of Drives and Digital Control:		• Analyze control
	Closed-loop speed/torque control, PI/PID	4	strategies in modern
	control, discrete control techniques		drive systems
IX.	PLC and Drive Interfacing: PLC		• Program and
	hardware & programming, ladder	5	implement basic PLC-
	diagrams, analog/digital IOs, interfacing	5	based drive control
	with VFDs		
X.	Industrial Communication Protocols:		• Use industrial
	RS-485, Modbus, Profibus, CAN,		communication
	EtherCAT — data handling and timing,	3	interfaces with
	PROFINET		automation hardware
XI.	SCADA and HMI Systems: Architecture,		Apply SCADA and
7 M.E.	real-time monitoring, alarms, supervisory		HMI concepts for
	control	2	drive visualization and
	Control		
VII	Intenfering Congous and Death I		monitoring
XII.	Interfacing Sensors and Feedback	2	• Integrate sensing and
	Systems: Speed/position sensors,	3	feedback for high-
	encoders, sensorless estimation techniques	467	performance control
	Total	42 L	

Course	1. Understand the concept of drives and motor control components
Outcome	2. Understand the solid state control of DC motors and AC motors
	3. Understand different electrical braking and the effects of heating and
	cooling of motors
	4. To know about the different applications of Drives
	5. Apply concepts of automation in designing and controlling electric drives.

6.	. Interface	Drives	with	industrial	controllers	and	implement	real-time
	control us	ing PLC	C/SCA	DA.				

- 1. B. K. Bose, Modern Power Electronics and AC Drives, Pearson.
- 2. Petruzella F. D., Programmable Logic Controllers, McGraw-Hill.
- 3. Webb J. W., Reis R. A., Programmable Logic Controllers: Principles and Applications, Pearson.
- 4. Fundamentals of Electrical Drives, G.K.Dubey; 2003, Narosa Publishing House,
- 5. Electric Drives, N.K.De and P.K.Sen;2001, Prentice Hall of India Ltd.,
- 6. Power Electronics: Converters. Applications and Design N.Mohan. T.M. Undeland and W.P. Robbins: Eds., 2003, John Wiley & Sons.
- 7. Power Electronics-Circuits, Devices and Applications M.H. Rashid 3rd Ed., 2004, Prentice Hall

C		C	Digital			L	Т	P
Course Code	EE4121N	Course Name	Communication in Electrical Systems	Course Category	PSE	3	0	0

Pre-requisite Courses	Analog and Digital Electronics, Microcontrollers and Embedded systems	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offerin	ng Department	Electrical Engine	eering	Data Book / Codes/Standards	Nil

Course Objectives	To make students appreciate the relevance of digital communication in Electrical Engineering applications and to expose them to fundamental principles of digital communication
	2. To make students learn about the role of the medium in data transmission
	3. To make students aware of digital communication protocols and the suitability of each to various applications
	4. To make students learn about the use of digital communication in industrial environments and in electrical substations

Module	Syllabus	Duration (class- hour)	Module Outcome
I.	Introductory concepts of Digital Communication: Sampling theorem, Quantization, Serial / Parallel, Synchronous / Asynchronous, Wired / Wireless, Baud Rate, Time / Frequency division Multiplexing, Frequency Shift Keying, Digital Modulation techniques. (Amplitude, Frequency, Phase)	8	• Learn about fundamental principles of digital communication, including modulation and multiplexing techniques
II.	Cabling and Interference: Copper based cable, Coaxial cable, Twisted pair cable, Fiber optic cable, Definition of noise, Frequency analysis of noise,	4	• Learn about various media for digital transmission and their application areas

	Total	42L	
VI.	Applications in Power Engineering: IEC 61850, Power Line Communication, Smart metering, other recent developments	8	 To learn about the communication protocol IEC 61850 and how it has eased the control of electrical substations To learn about other applications of digital communication in electrical apparatus.
V.	Industrial Communication Interface: MODBUS, CANBUS, PROFIBUS, HART, Field bus and Device Net system.	7	 To learn about communication requirements in industrial environments To learn about the application areas of industrial buses
IV.	Computer Communication: Network Topologies, Basic concepts of LAN, Ethernet, Wireless LAN, Internet, TCP/IP, 7 layer OSI model, IoT.	7	Learn about interconnection of computers through wire / wireless means and data exchange through such interconnections
III.	Serial Communication: Different Protocols - RS 232C, RS 422, RS 485, 20 mA current loop, I2C, ZigBee, USB, Blue Tooth, Mobile Communication	8	• Learn about different digital communication protocols and the application areas of each
	Source of electrical noise, Electrical coupling of noise, Shielding, Cable ducting, Cable spacing, Earthing and grounding requirement, Suppression techniques.		 Learn about noise mitigation techniques Learn about proper earthing techniques for errorfree communication

Course	1. Students are equipped with the basic knowledge about digital
Outcome	communication enabling them to find employment in industries /
	research on sensor integration, electrical substations, automation of
	factories, EV etc.

2. Students will develop the ability to design and implement digital communication systems, including choice of medium, modulation technique and specific protocol etc.

Learni ng

Resour

ces

Text Book:

1. **Digital Communications: Fundamentals and Applications**, B. Sklar and P. K. Ray, 2nd edition, 2014. Prentice Hall

Reference Books:

- 1. **Digital Communication Systems**, Simon Haykin, 2013, Wiley
- 2. **Electronic Communications System: Fundamentals Through Advanced**, W. Tomasi, 5th edition, 2013, Pearson
- 3. Wireless Communications: Principles and Practice, T. S. Rappaport, 2nd edition, 2010, Pearson
- 4. Computer Networks, A. S. Tanenbaum, 5th edition, 2011, Pearson
- 5. **Data Communication and Networking, Forouzan,** 5th edition, 2017. Science Engineering & Math
- 6. **Industrial Communication Technology Handbook,** R. Zurawski (ed.), 2nd edition, 2017, CRC Press
- 7. IEC 61850-Based Smart Substations: Principles, Testing, Operation and Maintenance, Yuan and Yang (ed.), 1st Edition, 2019, Academic Press

Web resources:

- 1. https://pdhonline.com/courses/e497/e497content.pdf
- PDH online Course E497 (3 PDH), Industrial Communications and Control Protocols by Michael J. Hamill, P.E.
- 2. https://doi.org/10.1155/2017/9324035
- Internet of Things: Architectures, Protocols, and Applications, Pallavi Sethi and Smruti R. Sarangi
- 3. https://www.webopedia.com/quick_ref/OSI_Layers.asp
- 4. https://www.tutorialspoint.com/ data_communication_computer_network/ data_communication_computer_ network_tutorial.pdf
- 5. https://nptel.ac.in/content/storage2/courses/106105080/pdf/M2L2.pdf
- 6. https://nptel.ac.in/content/storage2/nptel data3/html/mhrd/ict/text/106105081/lec20.pdf
- 7. https://nptel.ac.in/content/storage2/courses/108105057/Pdf/Lesson-26.pdf
- 8. https://nptel.ac.in/content/storage2/courses/106105080/pdf/M5L8.pdf
- 9. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106105166/lec12.pdf
- 10. https://www.swarthmore.edu/NatSci/echeeve1/Class/e91/Lectures/E91(10)Serial.pdf.

			Power			L	Т	P
Course Code	EE4122N	Course Name	Generation Economics and Reliability Analysis	Course Category	PSE	3	0	0

Pre- requisite Courses	Power System I, Power System II, Fundamentals of Probability theory	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offeri	ng Department	Electrical E	ngineering	Data Book / Codes/Standards	Nil

Course	1. To understand various types of power generation technologies and their
Objectives	economic roles in base and peak load supply, analyse load characteristics
	and factors affecting the design and operation of generation systems.
	2. To gain insight into tariff structures and cost components of electrical
	energy, including Time-of-Day and Availability Based Tariffs (ABT).
	3. To apply forecasting techniques for short-, medium-, and long-term load
	predictions, optimize economic dispatch with and without losses, and
	evaluate system reliability using probabilistic and statistical methods
	including Markov modelling.

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Economics of Generation: Types of power generation – Thermal (fossil fuel, nuclear, gas turbine), Hydro and Wind Power, Base load and peak load plants, Types of consumers -Domestic, Commercial, Industrial, Agricultural etc. Load curve, concept of load factor, plant capacity factor, plant use factor, diversity factor, demand factor. Selection of size and number of generation units.	9	 To understand different types of power generation methods and their suitability for base load and peak load demands. To analyse load characteristics using load curves and related factors (load factor, plant capacity factor, etc.), and apply these concepts to select appropriate size and number of generation units for various types of consumers.
II.	Tariff: Classification of cost of Electrical Energy, Block rate, flat rate, two-part, maximum demand, Power	9	•To understand the classification of the cost components involved in

	factor and three-part tariffs. T.O.D and Availability based tariff (ABT).		electrical energy pricing and explanation of various tariff structures and their impact on energy consumption.
III.	Load Forecasting: Objectives of power system load forecasting, load forecasting categories — long term, medium term and short term, Characteristics of loads, forecasting methodology, extrapolation technique to fit trend curves to basic historical data, simple regression and least square estimation, Different types of regression curves, scatter diagram, correlation and correlation coefficient, statistical definitions, time series, exponential smoothing technique, ARIMA model.	9	 To understand the objectives and importance of power system load forecasting and differentiate between long-term, medium-term, and short-term forecasting categories. To apply various forecasting methodologies including extrapolation techniques, regression analysis, time series models, exponential smoothing, and ARIMA models using historical load data and statistical tools.
IV.	Economic Dispatch: Input/Output characteristics of unit, incremental cost curves, constraints in economic operation, lambda iteration method, analytical approach to determine economic operation criterion with and without network losses for thermal plants.	6	 To understand and analyse the input/output characteristics and incremental cost curves of generating units for optimal power dispatch. To apply the lambda iteration method and analytical techniques to determine the economic operation of thermal power plants, considering system constraints with and without transmission losses.
V.	Reliability Analysis: Definition of reliability, reliability indices, outage classification Reliability functions: Reliability functions and their relationships—exponential distribution—expected value and standard deviation of exponential distribution—	9	• To understand the key concepts and measures of system reliability, including reliability indices, outage classifications, and reliability functions.

exponential l distribution – reliability measures MTTF, MTTR, MTBF. Markov modelling: Continuous Markov processes, evaluation of time dependent and limiting state probabilities for one component repairable. Network modelling and reliability analysis: Analysis of Series, Parallel, Series-Parallel networks—decomposition method. Frequency and duration techniques: Frequency and duration concept — evaluation of frequency of encountering state, mean cycle time, for one, two component repairable models. Approximate system reliability evaluation for two component repairable series and parallel system.	42L	the reliability of systems using exponential distribution, Markov modelling, and network decomposition techniques for both series and parallel configurations. To apply frequency and duration methods to assess reliability in one- and two-component repairable systems, and perform approximate reliability evaluations for such systems.
series parallel networks using		the reliability of systems
1		
		distribution, Markov
S S		modelling, and network
Markov processes, evaluation of time		
dependent and limiting state		
		for both series and parallel
1 ^		configurations.
repairable. Network modelling and		
reliability analysis: Analysis of		
, , , , , , , , , , , , , , , , , , , ,		duration methods to assess
		reliability in one- and two-
		1
techniques: Frequency and duration		systems, and perform
concept – evaluation of frequency of		approximate reliability
		systems.
models. Approximate system		
reliability evaluation for two		
	427	
Total	42L	

Course Outcome

- 1. Understand the economics behind power generation, including various generation types, consumer categories, and key performance and design factors such as load curves, diversity, and capacity factors.
- 2. Analyse and apply appropriate tariff structures for electrical energy, including Time-of-Day (T.O.D) and Availability Based Tariff (ABT).
- 3. Gain proficiency in load forecasting techniques using statistical and timeseries models to support reliable and economic system operation.
- 4. Apply analytical and iterative methods for economic dispatch to optimize power generation costs under different constraints.
- 5. Evaluate system reliability using mathematical tools such as exponential distribution, Markov modelling, and frequency-duration techniques to ensure consistent and dependable power supply.

- 1. **Reliability Evaluation of Power Systems**, Roy Billinton and Roland Allan,2nd Edition, Springer India Pvt. Ltd. New Delhi, 2008, ISBN:978-81-8128-321-4
- 2. **Introduction to Time series Analysis and Forecasting**, Douglas Montgomery, C.L. Jennings and M.Kulahci, 2nd Edition, John Wiley &Sons, ISBN: 978-1-118-74511-3
- 3.**Electrical Power Systems Planning**, A.S. Pabla, 1stEdition, Macmillan India Ltd,1998, ISBN:0333930673)
- 4. **Power System Engineering**, Kothari and Nagrath, 2008, Tata McGraw Hill Education, ISBN0070647917,9780070647916

5. Power Generation Operation and Control, Wood A.J., Wollenberg, John Wiley and Sons Inc, USA.

Course	EE4123N	Course	Electronic System	Course	PSE	L	T	P
Code		Name	Design	Category		3	0	0

Pre- requisite Courses	Digital and Analog Electronics; Power Electronics; UG Courses on Micro-controllers and Instrumentation	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical Eng	ineering	Data Book / Codes/ Standards	Relevant IS, IEC, IEEE & CIGRE, Standards; datasheets

Course Objective	To enable the students to have a basic idea regarding the structure and major components in an industrial electronic installation
	To develop understanding of PCB layout and component placement considerations
	3. To give the students an idea regarding cooling, protection and signal conditioning requirements for industrial electronic installations
	4. To explore the various types of wires, cables and their connectors, used for industrial electronic systems and to understand the basis of their selection
	5. To guide the students regarding how to study and extract important information from datasheets and how to use such information
	6. To give a basic idea regarding the various types of drivers for power semi-conductor devices and how to design such driver circuits

Module	Syllabus	Duration (Class - hour)	Module Outcome
I.	Introduction: Structure and major components of industrial electronic installations – preliminary ideas	1	Students should have a basic idea regarding the major components of an industrial electronic installation
II.	EMI/EMC Filters and PCB Design: General	7	• Students should able to
	concepts on PCBs – signal level and power-		understand the basic

Module	Syllabus	Duration (Class - hour)	Module Outcome
	boards; Concept of power and signal grounds, significance of digital and analogue grounds, general layout considerations on PCBs involving the above grounds; General placement strategies of power-circuits (magnetic and semi-conductor) and control circuits within an enclosure; Concepts on noise, EMI, EMC, discussion on general techniques to minimize such issues and / or their effects; Stray inductance and capacitance – their origin and minimization; insulation resistance to body and Megger test; DSP/microcontroller based systems vs. Analogue systems;		concepts behind PCB design and layout considerations Students should be able to understand and learn the concepts behind component placement
III.	Cooling and Ventilation: Introduction to Cooling and Ventilation— its purpose and importance; Some popular techniques for achieving ventilation in electronic installations—natural and forced ventilation, water-cooling etc.; Heat-Sinks—their importance, types, design methodology of natural and forced air cooled and forced water-cooled heat sinks; desirable attributes of heat sinks	5	 Students should be able to understand the importance and mechanism of cooling in electronic installations Students should be able to select and/or design heat sinks for electronic installations
IV.	Protection Requirement and Schemes: Discussion for protection requirements against various types of mal-functioning / maloperation etc.; Over-current protection types — catastrophic, cycle-by-cycle etc., design of such protection circuits; Over-voltage, single-phasing, regulation failure, inrush current and ripple-current limit protections — their designmethods; electro-magnetic vs. electronic protection schemes; importance of grounding	8	 Students should be able to analyze and understand the various major protection-schemes required for an electronic installation Students should be able to design such protection schemes
V.	Signal Conditioning Requirements and Techniques: Basic purpose of signal-conditioning; Conditioning of analogue signals with the help of analogue filters (active and passive) – Butterworth filters (OPAMP-based) – their design and applications;	8	• Students should be able to understand and analyze signal conditioning circuits using active and passive components

		Duration	Module Outcome
Module	Syllabus	(Class - hour)	
	Stepping down input signals and amplifying output signals		• Students should be able to design OPAMP based filters for signal conditioning purpose
VI.	Cables, Wires and Connectors: Different types of wires, used in electronic systems, single strand, multi-strand and shielded wires – types and applications; Different types of industrial connectors/couplers (Amphenol, Euro, Phoenix, Wago etc.) – some case studies;	4	 Students should have a basic understanding of different types of wires and cables, used in industrial electronic installations Students should have an idea regarding cable connectors and how to use them
VII.	Techniques to Study Datasheet of Semiconductor Devices: Significance of Datasheets; major information given by datasheets of semi-conductor components; case study with a few power semi-conductor and signal-level semi-conductor components—using the information in datasheet to implement circuit design	5	 Students should have a clear understanding regarding the information given by datasheets and their utilities Students should be able to study datasheets and extract useful information from the same to solve a practical design problem
VIII.	Voltage and/or Current Matching for Control Signals: Study of the various major types of drivers and their basic working principles; case study with a few major types of drivers, using manufacturer's datasheet;	4	 Students should be able to understand the working principle of the major types of drivers Students should be able to select drivers and design such driver circuits for industrial applications
	Total	42 L	

Course Outcome

- 1. To understand the basic structure and know the major components of an industrial electronic installation
- 2. To understand the basic concepts of an electronic printed circuit board (PCB) its layout and component placement considerations
- 3. To have a basic knowledge regarding cooling requirements of electronic components and study various popular ventilation schemes in an industrial electronic installation
- 4. To understand the major types of protection requirements and their design principles in an electronic installation
- 5. To understand the requirement of signal conditioning using active and passive components and to be able to design such conditioning circuits.
- 6. To have a basic idea on cables, wires and their connectors the basis of their selection etc.
- 7. To be able to efficiently study datasheet and extract useful information from the same and use this information to design a system
- 8. To have a knowledge on the working of basic types of industrial drivers and driver circuits for power-semiconductor devices

- 1. Ki-CAD User Manual
- 2. A Course in Electrical Machine Design A. K. Sawhney
- 3. Power Electronics Converters, Applications and Design N. Mohan, T. M. Undeland and W. P. Robbins
- 4. OPAMPs and Linear Integrated Circuits R. A. Gayakwad
- 5. Transistor Circuit Approximations A. P. Malvino
- 6. Phoenix, WAGO, Euro Connectors User Manuals

			Computer			L	Т	P
Course Code	EE4124N	Course Name	Networking and Programming Techniques for Electrical Applications	Course Categor y	PSE	3	0	0

Pre-requisite Courses	Introduction to C Programming and Programming Environment	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical Eng	ineering	Data Book / Codes/Standards	Nil

Course	1. To equip students with in-depth concepts and applications associated	with
Objective	different advanced programming and computation schemes.	This
	encompasses the study of various types of data sharing, advanced topi	cs in
	numerical computations, parallel computing, familiarization with	the
	Python language, basic network protocols of LAN and WAN, web-b	ased
	application development, and concepts of RDBMS.	
	2. To apply them across different domains of Electrical Engineering	

Module	Syllabus	Duration (Class - hour)		Module Outcome
I.	Types of Data sharing: Shared memory, Socket programming under UNIX/LINUX and C environment	7	•	This module focuses on inter-process communication (IPC) methods, specifically shared memory and socket programming, within the context of UNIX/Linux and C environments. Students will learn to implement and utilize these mechanisms for efficient data sharing between processes, understand their respective strengths and limitations, and gain practical experience with C programming techniques.
II.	Advanced topics in numerical computation: Eigenvalue computations, Sparse Matrix, Ordering, Partitioning, and relevant topics	7	•	Upon successful completion of the module, students will be able to understand and apply advanced techniques in numerical computation, including eigenvalue computations, sparse matrix

Module	Syllabus	Duration (Class - hour)	Module Outcome
			methods, and their associated ordering and partitioning strategies. This includes developing the ability to formulate, analyze, and solve problems using these techniques in various engineering and scientific applications.
III.	Basic of Parallel processing: Parallel Programming and Message Passing Interface(MPI)	4	 The module will enable students to understand the fundamental concepts of parallel computing, such as the benefits, types, and architectures. They should be able to identify bottlenecks in sequential algorithms, design basic parallel algorithms using appropriate methodologies, and implement these designs in a suitable programming environment.
IV.	Familiarization with Python Language: Python Data types, numbers, Python numbers and strings, index, slice. List, Dictionaries, tuples, set etc. Python object and DSA Running Python code on Jupiter.	7	• The module involves understanding the Python data types, structure, purpose, and how to use them in code. This leads to the ability to reuse code, organize projects, and leverage pre-built functionalities.
V.	Basic Network protocols for LAN & WAN: TCP/IP services - DHCP, DNS, HTTP, SSL, Telnet, ftp and ssh	3	 To understand the foundational protocols used in local area networks (LANs) and wide area networks (WANs). This includes identifying common protocols like TCP/IP, DHCP, etc. and understanding their roles in network communication. Students should be able to differentiate between LANs and WANs, recognize how they are connected, and grasp the importance of these

Module	Syllabus	Duration (Class - hour)	Module Outcome
			protocols for network operation and management
VI.	Web-based application development: using HTML/JAVA or some other advance Scripting languages, concepts of digital certificates, signature etc.	5	 Upon completing a module in Web-based application development, students should be able to design, develop, and deploy functional web applications. This includes understanding fundamental web technologies, building interactive front-ends, connecting to back-end databases, and utilizing various frameworks and libraries. Students should also be able to assess the usability and accessibility of their applications, ensuring they meet specific user needs and standards.
VII.	RDBMS-Concept: SQL—DDL, DML, DCL; concept of functions, triggers and PL/SQL	9	• Understanding the concepts, features, and applications of RDBMS. This includes grasping the principles of relational data modeling, learning to use SQL for data manipulation, and recognizing the advantages and limitations of RDBMS compared to other database systems.
	Total	42L	

Course Outcome

Upon completion of this course, students will be able

- 1. To implement and utilize different mechanisms for efficient data sharing between processes.
- 2. To understand and apply advanced techniques in numerical computation.
- 3. To understand the fundamental concepts of parallel computing.
- 4. To be familiar with Python data types, structure, and how to use them in real programs.
- 5. To gain knowledge of the foundational protocols used in local area networks (LANs) and wide area networks (WANs).
- 6. To design, develop, and deploy functional web applications
- 7. To understand the concepts, features, and applications of RDBMS

Learning Resources

- 1. Computational Methods for Electric Power Systems, M. L. Crow 2nd Edition, CRC Press
- 2. Numerical methods, J. H. Mathews 2nd Edition, Prentice Hall of India
- 3. **Web Technologies,** A.S.Godbole and A.Kahate, Tata McGraw Hill Education, ISBN1259083241, 9781259083242
- 4. **UNIX Network Programming,** W. R. Stevens, 2004, Addison-Wesley Professional, ISBN 0131411551,9780131411555
- 5. **SQL,PL/SQL the Programming Language of Oracle**, IvanBayross, 4th

revised edition, BPB Publications, ISBN: 9788176569644, 9788176569644

Course	EE4125N	Course	Electric	Course	PSE	L	T	P	
Code	EE4125N	Name	Vehicle	Category	PSE	3	0	0	

Pre-requisite Courses	Control Systems, Electrical Machines –I, Electrical Machines –II & Power Electronics.	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department		Electrical En	gineering	Data Book / Codes/Standards	Nil

Course	To understand working of Electric Vehicles and recent trends.	
Objectives	1. Ability to analyze different power converter topology used for electric	
	vehicle application.	
	2. Ability to develop the electric propulsion unit and its control for	
	application of electric vehicles.	
	3. Ability to design converters for battery charging and explain transformer	
	less topology.	

Module	Syllabus	Duratio	Module Outcome
		n (class- hour)	
I.	Electric and Hybrid Electric Vehicles: Configuration of Electric Vehicles, Performance of Electric Vehicles, Traction motor characteristics, Tractive effort and Transmission requirement, Vehicle performance, Tractive effort in normal driving, Energy consumption Concept of Hybrid Electric Drive Trains, Architecture of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel hybrid electric drive trains.	10	Explain the working of electric vehicles and recent trends.
II.	Energy storage for EV and HEV: Energy storage requirements, Battery parameters, Types of Batteries, Modelling of Battery, Fuel Cell basic principle and operation, Types of Fuel Cells, PEMFC and its operation, Modelling of PEMFC, Supercapacitors.	6	• Explain the different types of Batteries, Fuel cells and their applications
III.	Electric Propulsion: EV consideration, DC motor drives and speed control,	6	Develop the electric propulsion unit and its

IV.	Induction motor drives, Permanent Magnet Motor Drives, Switch Reluctance Motor Drive for Electric Vehicles, Configuration and control of Drives. Power Electronic Converter for Battery Charging: Charging methods for battery, Termination methods, charging from grid, The Z-converter, Isolated bidirectional DC-DC converter, Design of Z- converter for battery charging, High-frequency transformer based isolated charger topology, Transformer less topology. Design of Electric and Hybrid Electric Vehicles: Series Hybrid Electric Drive Train Design: Operating patterns, control strategies, Sizing of major components, power rating of traction motor, power rating of engine/generator, design of PPS Parallel Hybrid Electric Drive Train Design: Control strategies of parallel hybrid drive train, design of engine power capacity, design of electric motor drive capacity, transmission design, energy	10	 control for application of electric vehicles. Design converters for battery charging and explain transformer less topology Analyze different power converter topology used for electric vehicle application.
	storage design. Total	42L	

Course	At the end of the course, the student will be able to:					
Outcome	1. Explain the working of electric vehicles and recent trends.					
	2. Analyse different power converter topologies used for electric vehicle					
	applications.					
	3. Develop the electric propulsion unit and its control for the application of					
	electric vehicles.					
	4. Design converters for battery charging and explain transformerless					
	topology					

Learning	1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals,			
Resources	Theory, and Design, M. Ehsani, Y. Gao, S. Gay and Ali Emadi, CRC Press,			
	2005			
	2. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Husain, CRC			
	Press, 2003			
	3. Energy Management Strategies for Electric and Plug-in Hybrid Electric			
	Vehicles, Sheldon S. Williamson, Springer, 2013			
	4. Modern Electric Vehicle Technology, C.C. Chan and K.T. Chau, Oxford			
	University, 2001			
	5. Hybrid Electric Vehicles Principles And Applications With Practical			
	Perspectives, Chris Mi, M. Abul Masrur, David Wenzhong Gao, Wiley			

Publication, 2011

Course	DE 440 (N	Course	Autonomous	Course	DCE	L	T	P
Code	EE4126N	Name	Navigation for Unmanned Vehicle	Category	PSE	3	0	0

Pre-requisite Courses	Transducers & Instrumentation	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offer	ing Department	Electrical Engineering		Data Book / Codes/Standards	Nil

Course	1. To learn Mobile robots (UAV, UGV, etc.) kinematics and dynamics		
Objectives	2. To acquire knowledge about different sensors and actuators used in		
	robotics.		
	3. To be able to localize the mobile robot in the environment.		
	To navigate the mobile robot autonomously by avoiding obstacles.		
	5. To design the shortest path to reach the destination from the starting		
	location.		
	6. To learn the use of computer vision to perceive the environment.		

Module	Syllabus	Duration (class-hour)	Module Outcome
I.	Mobile robot kinematics and dynamics: Classification of Different mobile robots such as Unmanned Ground Vehicle (UGV), Unmanned Aerial Vehicle (UAV/Drone), etc., modelling of unmanned vehicles considering basic forces, forward and inverse kinematics, and dynamics.	7	• Students should learn how to model and analyze the motion and forces acting on a mobile robot. Key outcomes include understanding forward and inverse kinematics, analyzing robot motion constraints, and grasping the concepts of robot dynamics, including forces and torques that influence movement.
II.	Sensors and Actuators:		• The module should
	Sensors: Proximity, IMU,	7	enable students to
	magnetometers, LiDAR, GPS, RTK,		identify, analyze, and

State estimation methods: Bayes filter, Gaussian Filters (Kalman filter, Extended Kalman Filter, unscented Kalman filter), Particle Filter. Co-operative Localization & SLAM IV. Navigation and obstacle avoidance: Navigation: Sensor-based navigation, Dead reckoning, Beacon-based navigation, Landmark-based navigation, etc. Obstacle Avoidance Techniques: Potential field method, Virtual force field method, Artificial potential fields method, etc. V. Optimal Path Planning Techniques and Trajectory Planning: Sampling-based algorithms (A*, PRM, RRT), Trajectory planning for Mobile Robots. VI. Introduction to Computer Vision: Image representation, camera modelling and calibration, stereo vision, epipolar geometry, stereo matching algorithms, feature points, edge detection, SIFT, SURF. Total	III.	rotary encoders, touch and slip sensors, different types of cameras, and others, along with their characteristics; Sensor data aggregation, processing, and sensor fusion. Actuators: Motors, servos, harmonic drive, linear actuators, pneumatic and hydraulic actuators etc.		design robotic/ autonomous vehicular systems incorporating various sensors and actuators. This includes understanding the different classes of sensors and actuators, their operating principles, and how to select the right ones for specific robotic/autonomous vehicular applications. • Students will have the
Navigation: Sensor-based navigation, Dead reckoning, Beacon-based navigation, Landmark-based navigation, etc. Obstacle Avoidance Techniques: Potential field method, Virtual force field method, Artificial potential fields method, etc. V. Optimal Path Planning Techniques and Trajectory Planning: Sampling-based algorithms (A*, PRM, RRT), Trajectory planning for Mobile Robots. VI. Introduction to Computer Vision: Image representation, camera modelling and calibration, stereo vision, epipolar geometry, stereo matching algorithms, feature points, edge detection, SIFT, SURF. to enable a robot or autonomous system to successfully reach a designated goal while avoiding collisions with obstacles in its environment. • Students will be able to design different path planning algorithms to autonomously navigate the robot. • Students will learn how robots use computer vision to perceive their environment, including object recognition, depth perception, and scene understanding.	111.	State estimation methods: Bayes filter, Gaussian Filters (Kalman filter, Extended Kalman Filter, unscented Kalman filter), Particle Filter.	7	knowledge about the localization of the robot in the local and world coordinates of the
 V. Optimal Path Planning Techniques and Trajectory Planning: Sampling-based algorithms (A*, PRM, RRT), Trajectory planning for Mobile Robots. VI. Introduction to Computer Vision: Image representation, camera modelling and calibration, stereo vision, epipolar geometry, stereo matching algorithms, feature points, edge detection, SIFT, SURF. Students will be able to design different path planning algorithms to autonomously navigate the robot. Students will learn how robots use computer vision to perceive their environment, including object recognition, depth perception, and scene understanding. 	IV.	Navigation: Sensor-based navigation, Dead reckoning, Beacon-based navigation, Landmark-based navigation, etc. Obstacle Avoidance Techniques: Potential field method, Virtual force field method, Artificial potential fields	7	to enable a robot or autonomous system to successfully reach a designated goal while avoiding collisions with obstacles in its
Image representation, camera modelling and calibration, stereo vision, epipolar geometry, stereo matching algorithms, feature points, edge detection, SIFT, SURF. Tobots use computer vision to perceive their environment, including object recognition, depth perception, and scene understanding.	V.	Optimal Path Planning Techniques and Trajectory Planning: Sampling-based algorithms (A*, PRM, RRT), Trajectory planning for Mobile	7	design different path planning algorithms to autonomously navigate
	VI.	Image representation, camera modelling and calibration, stereo vision, epipolar geometry, stereo matching algorithms, feature points, edge detection, SIFT,	7	robots use computer vision to perceive their environment, including object recognition, depth perception, and
		Total	42L	

Course	At the end of the course students will be <i>able</i> to			
Outcome	Understand robot motion (kinematics) and the forces causing that motion (dynamics), enabling them to design, program, and simulate robots (UAV, UGV, etc.) for various tasks.			

- 2. Gain knowledge of dynamics and state estimation for various robotic systems, mainly focusing on the Kalman filter and its family.
- 3. Grasp the underlying mathematical concepts of SLAM, such as linear algebra, optimization, and graph theory, and understand the concepts of data association, loop closure, and error propagation.
- 4. Identify different types of sensors and actuators for robotic and autonomous vehicle applications, understand their working principles, and analyze their performance characteristics, evaluating their suitability for specific robotic tasks.
- 5. Learn how to use computer vision to enable autonomous vehicles to perceive their surroundings, understand spatial relationships, and navigate complex environments
- 6. Evaluate the effectiveness of different autonomous navigation and path planning algorithms in different situations

- 1. S. Thrun, W. Burgard, and D. Fox, *Probabilistic Robotics*, MIT Press, 2005.
- 2. S. M. LaValle, *Planning Algorithms*, Cambridge University Press, 2006. [Online]. Available: http://planning.cs.uiuc.edu/
- 3. K. M. Lynch and F. C. Park, *Modern Robotics: Mechanics, Planning, and Control*, Cambridge University Press, 2017. [Online]. Available: https://modernrobotics.org/
- 4. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, *Principles of Robot Motion: Theory, Algorithms, and Implementations*, MIT Press, 2005.
- 5. R. Siegwart, I. R. Nourbakhsh, and D. Scaramuzza, *Introduction to Autonomous Mobile Robots*, 2nd ed., MIT Press, 2011.

Drives and Automation Laboratory and Projects (EE4171N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Laboratory experiments and project works related to theoretical subject "Industrial Drives and Automation (EE4101N)".

Elective 2 Sessional (EE4172N)

Weekly Contact: 0-0-3(L-T-P)

Full Marks -50

Credits:2

Eighth Semester

Sl. No	Туре	Course Name	Course	Class Load/Week		Credit	Class load /	Marks	
			Code	L	Т	P		week	
1	OE	OE5 (from NPTEL for the students opting Internship/ for others from Institute)	EE4201N	3	0	0	3	3	100
		Theory Sub-total		3	0	0	3	3	100
2	I/P	One Semester Internship / Project	EE4271N				8		300
3	0	Grand viva	EE4272N				2		50
		Practical Sub-total		0	0	0	10	0	350
		Eighth Semester Total		3	0	0	13	3	450
