Semester-wise EE Course Structure for B. Tech (Exit) and DD

(Based on the discussions with Director, Deans, Heads and DUGC Conveners in the meeting held on 13.02.2020 and 03.07.2020 in the conference room following the BoG approved course structure)

HSS subject in the 7th Semester B.Tech course

First Semester

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/week	Marks
			L	T	P			
1.	Mathematics – I		3	1	0	4	4	100
2.	Chemistry/Physics		3/4	0	0	3/4	3/4	100
3.	Basic Electrical Engineering		3	1	0	4	4	100
4.	Mechanics/Ecology & Environment		4/3	0	0	4/3	4/3	100
5.	English/Sociology & Professional Ethics		3	0	0	3	3	100
	Theory Sub-total		**16/17**	**2**	**0**	**18/17**	**18/17**	**500**
6.	Chemistry Lab/Physics Lab		0	0	3	2	3	50
7.	Basic Electrical Engineering Laboratory		0	0	3	2	3	50
8.	Drawing/Workshop		0	1/0	3	3/2	4/3	50
9.	NSS/NCC/PT/Yoga					R*		
	Practical Sub-total		**0**	**1/0**	**9**	**7/6**	**10/9**	**200**
	First Semester Total					**25**	**28**	**700**

*R: Required (Non-credit but with grade)

Second Semester

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/ week	Marks
			L	T	P			
1.	Mathematics – II		3	1	0	4	4	100
2.	Physics/Chemistry		4/3	0	0	4/3	4/3	100
3.	Intro to Computing		3	0	0	3	3	100
4.	Ecology & Environment/ Mechanics		3/4	0	0	3/4	3/4	100
5.	Sociology & Professional Ethics/ English		3	0	0	3	3	100

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	Theory Sub-total		**17/16**	**1**	**0**	**17/18**	**17/18**	**500**
6.	Physics Lab/Chemistry Lab		0	0	3	2	3	50
7.	Computer Lab		0	0	3	2	3	50
8.	Workshop/Drawing		0	0/1	3	2/3	3/4	50
9.	NSS/NCC/PT/Yoga					R*		
	Practical Sub-total		**0**	**0/1**	**9**	**6/7**	**9/10**	**200**
	Second Semester Total					**23**	**26**	**700**

*R: Required (Non-credit but with grade)

3rd Semester (4 years B. Tech (exit) and DD)

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load / week (Total)	Marks
			L	T	P			
1.	Mathematics III		3	0	0	3	3	100
2.	Electrical and Electronic Measurements (Core Theory-I)	EE2101	3	0	0	3	3	100
3.	Electrical Machines I (Core Theory-II)	EE2102	3	1	0	4	4	100
4.	Classical Electrodynamics (Core Theory-III)	EE2103	3	1	0	4	4	100
5.	Signals and Systems (Core Theory-IV)	EE2104	3	1	0	4	4	100
	Theory Sub-total		15	3	NIL	18	18	500
6.	Measurement Laboratory (Core Lab/Practical-I)	EE2171	0	0	3	2	3	50
7.	Electrical Machines Laboratory – I (Core Lab/Practical-II)	EE2172	0	0	3	2	3	50
8.	Numerical Simulation and Application Tools Laboratory (Core Lab/Practical-III)	EE2173	0	0	3	2	3	50
9.	Mini Project-I	EE2191	0	0	0	2	0	50
	Practical Sub-total		NIL	NIL	9	8	9	200
	3rd Semester Total					26	27	700

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4Th Semester (4 years B. Tech (exit) and DD)

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load / week	Marks
			L	T	P			
1.	**Electrical Machines –II (Core Theory – V)**	**EE2201**	**3**	**1**	**0**	**4**	**4**	**100**
2.	**Network Theory (Core Theory – VI)**	**EE2202**	**3**	**1**	**0**	**4**	**4**	**100**
3.	**Analog Electronics (Core Theory – VII)**	**EE2203**	**3**	**0**	**0**	**3**	**3**	**100**
4.	**Control Systems I (Core Theory – VIII)**	**EE2204**	**3**	**1**	**0**	**4**	**4**	**100**
5.	**Digital Electronics**	**EE2205**	**3**	**0**	**0**	**3**	**3**	**100**
	Theory Sub-total		**15**	**3**	**NIL**	**18**	**18**	**500**
6.	**Electrical Machines Laboratory-II (Core Lab-IV)**	**EE2271**	**0**	**0**	**3**	**2**	**3**	**50**
7.	**Digital Electronics and Analog Electronics Laboratory (Core Lab-V)**	**EE2272**	**0**	**0**	**3**	**2**	**3**	**50**
8.	**Laboratory on Network Theory(Core lab-VI)**	**EE2273**	**0**	**0**	**3**	**2**	**3**	**50**
9.	**Mini Project -II**	**EE2291**	**0**	**0**	**0**	**2**	**0**	**50**
	Practical Sub-total		**NIL**	**NIL**	**9**	**8**	**9**	**200**
	4th Semester Total					**26**	**27**	**700**

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5th Semester(4 years B. Tech (exit) and DD)

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load / Week (Total)	Marks
			L	T	P			
1.	**Electrical Machines III (Core Theory-IX)**	**EE3101**	**3**	**1**	**0**	**4**	**4**	**100**
2.	**Power System – I(Core Theory-X)**	**EE3102**	**3**	**0**	**0**	**3**	**3**	**100**
3.	**Heat Power(Core Theory-XI)**	From ME	**3**	**0**	**0**	**3**	**3**	**100**
4.	**Control Systems II (Core Theory-XII)**	**EE3103**	**3**	**1**	**0**	**4**	**4**	**100**
5.	**Power Electronics(Core Theory-XIII)**	**EE3104**	**3**	**0**	**0**	**3**	**3**	**100**
	Theory Sub-total		**15**	**2**	**NIL**	**17**	**17**	**500**
6.	**Electrical Machines Laboratory- III (Core Lab/Practical-VIII)**	**EE3171**	**0**	**0**	**3**	**2**	**3**	**50**
7.	**"Power System Design and Estimation" and "Electrical Machine Design" (Core Lab/Practical-IX)**	**EE3172**	**0**	**0**	**3**	**2**	**3**	**50**
8.	**Heat Power Laboratory (Core Lab/Practical-X)**	From ME	**0**	**0**	**3**	**2**	**3**	**50**
	Practical Sub-total		**NIL**	**NIL**	**9**	**6**	**9**	**150**
	5th Semester Total					**22**	**25**	**650**

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6Th Semester (4 years B. Tech (exit) and DD)

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load / Week (Total)	Marks
			L	T	P			
1.	Electric Drives (Core Theory-XIV)	EE3201	3	0	0	3	3	100
2.	Power System II (Core Theory-XV)	EE3202	3	0	0	3	3	100
3.	Switchgear and Power System Protection (Core Theory-XVI)	EE3203	3	1	0	4	4	100
4.	Microprocessor and Microcontroller (Core Theory-XVII)	EE3204	3	0	0	3	3	100
5.	Transducers and Instrumentation (Core Theory-XVIII)	EE3205	3	0	0	3	3	100
	Theory Sub-total		15	3	NIL	16	16	500
6.	Power Systems and Drives Laboratory (Core Lab/Practical-XI)	EE3271	0	0	3	2	3	50
7.	"Microprocessors and Microcontrollers" and "Transducers and Instrumentation" Laboratory (Core Lab/Practical-XII)	EE3272	0	0	3	2	3	50
8.	Power Electronics and Control Systems Laboratory (Core Lab/Practical-XIII)	EE3273	0	0	3	2	3	50
	Practical Sub-total		NIL	NIL	9	6	9	150
	6th Semester Total					22	25	650

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7th Semester(4 years B. Tech (exit))

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load /Week (Total)	Marks
			L	T	P			
1.	Digital Signal Processing and Embedded System (Core Theory-XIX)	EE4101	3	0	0	3	3	100
2.	Electrical Energy Utilization and Grid Interactive Control (Core Theory -XX)	EE4102	3	0	0	3	3	100
3.	Core Elective – I	EE4121 /22/23	3	0	0	3	3	100
4.	Open Elective (HSS)		3	0	0	3	3	100
	Theory Sub-total		12	0	0	12	12	400
5.	Laboratory on "Digital Signal Processing and Embedded System" and Core Elective papers (Core Lab/Practical-XIV)	EE4171	0	0	3	2	3	50
6.	Switchgear and Power System Protection Laboratory (Core Lab/Practical-XV)	EE4172	0	0	3	2	3	50
7.	B. Tech Project/Part-1	EE4191	0	0	2	4	2	100
8.	Internship (Evaluation)	EE4192	0	0	0	2	0	50
	Practical Sub-total		NIL	NIL	8	10	8	250
	7th Semester Total					22	20	650

Core Elective-I : 1. High Voltage Engineering (EE4121) 2. New and Renewable Energy (EE4122) 3. Illumination Engineering(EE4123)

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8Th semester (4 years B. Tech (exit))

Sl. No	Course Name	Course code	Class Load/Week			Credit	Class load/ Week (Total)	Marks
			L	T	P			
1.	**Power System Planning and Reliability(Core Theory-XX)**	**EE4201**	**3**	**1**	**0**	**4**	**4**	**100**
2.	**Core Elective – II**	**EE4221 /22/23**	**3**	**0**	**0**	**3**	**3**	**100**
3.	**Open –Elective II ***		**3**	**0**	**0**	**3**	**3**	**100**
	Theory Sub-total		**9**	**1**	**0**	**10**	**10**	**300**
4.	**B. Tech Project Part- -2**	**EE4291**	**0**	**0**	**2**	**8**	**2**	**200**
5.	**Seminar**	**EE4292**	**0**	**0**	**0**	**2**	**0**	**50**
5.	**Comprehensive Viva**	**EE4293**	**0**	**0**	**0**	**2**	**0**	**100**
	Practical Sub-total		**9**	**0**	**2**	**12**	**2**	**350**
	8th Semester Total					**22**	**12**	**650**

Core Elective-II : 1. Advanced Programming in Electrical Engineering (EE4221) 2. Soft Computing and Intelligent System (EE4222) 3. Digital Communication in Electrical Systems(EE4223)

Open –Elective II: Electricity Conservation and Environmental Management (EE 4261)

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Dual Degree B.Tech-M.Tech (EE) Course Structure

Three specialisations will be offered to the DD students

1. **Control System and Instrumentation (CSI) 2. Power and Energy Systems (PES) 3. Power Electronics, Machines and Drives (PEMD)**

7th Semester(DD)

Sl. No	Course Name	Course code	Class Load/Week			Class Load/ Week (Total)	Credit	Marks
			L	T	P			
1.	Digital Signal Processing and Embedded System (Core Theory –XVIII)	EE4101	3	0	0	3	3	100
2.	DD Core-I		3	0	0	3	3	100
3.	DD Core-II		3	0	0	3	3	100
4.	DD Core-III		3	0	0	3	3	100
5.	HSS III		3	0	0	3	3	100
	Theory Subtotal		**15**	**0**	**0**	**15**	**15**	**500**
6.	Core Lab - XIV (Lab-I)		0	0	3	3	2	50
7.	Core LabXV (Lab-II)		0	0	3	3	2	50
8.	Internship evaluation	EE4192	0	0	0	0	2	50
	Practical Subtotal		**0**	**0**	**6**	**6**	**6**	**150**
	Seventh Semester Total					**21**	**21**	**650**

Proposed Courses for Core-I, II and III in the 7th Semester

Course	Control System & Instrumentation (CSI)	Power and Energy Systems (PES)	Power Electronics, Machines and Drives (PEMD)
Core-I	5101: Modelling and Control of Physical Systems	5104: Advanced Power System Analysis	5107: Advanced Power Electronics
Core-II	5102: Theory of Discrete and Digital Systems	5105: Power System Operation and Control	5108: Generalized Theory of Electrical Machines
Core -III	5103: Advanced Process Control & Instrumentation	5106: Power Transmission & Power Quality	5101: Modelling and Control of Physical Systems

Proposed Labs/Mini Projects for Core-I, II and III in the 7th Semester

Course	Control System & Instrumentation (CSI)	Power & Energy Systems (PES)	Power Electronics & Machine Drives (PEMD)
Lab-I	5171: Lab on Modelling and Control of Physical Systems	5174: Lab on Advanced Power System Analysis	5177: Lab on Advanced Power Electronics
Lab-II	5173: Lab on Advanced Process Control & Instrumentation	5175: Mini Project on Power System Operation and Control***	5171: Lab on Modelling and Control of Physical Systems

*** Mini Project in place of Lab, following PG guidelines

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8th Semester(DD)

Sl. No	Subject code	Course Name	Class Load/Week			Class Load/ Week	Credit	Marks
			L	T	P			
1.		DD Core-IV	3	0	0	3	3	100
2.		DD Core-V	3	0	0	3	3	100
3.		DD Core-VI	3	0	0	3	3	100
4.		DD Core VII	3	0	0	3	3	100
5.		Open Elective II*	3	0	0	3	3	100
		Theory Subtotal	15	0	0	15	15	500
6.	EE5291	M. Tech. Project Part I – (Term Paper)	0	0	2	2	4	200
7.	EE5292	Term Paper Seminar and Viva voce	0	0	0	0	2	100
8.	EE4293	Comprehensive Viva	0	0	0	0	2	100
		Practical Subtotal	0	0	2	2	8	400
		8TH SEMESTER TOTAL	15	0	2	17	23	900

***1. Electricity Conservation & Environmental Management(EE 4271)**

Proposed Courses for Core-IV, V, VI and VII in 8th Semester

Dual Degree	Control System & Instrumentation (CSI)	Power & Energy System (PES)	Power Electronics, Machines and Drives (PEMD)
CORE-IV	5201 : Optimal & Robust Control Theory	5204 : Advanced Power System protection	5207 : Advanced Electrical Drives
CORE-V	5202 : Signal and Image Processing for Instrumentation and Control	5205 : Power System Stability, Security and High Voltage Engineering	5208: Special Topics in Power Electronics
CORE-VI	5203: Optimal Filtering and Stochastic Processes	5206 : Smart Grid Technologies and Energy Informatics	5209: Selected Machines for Electric Vehicle and Wind Power Applications
CORE-VII	5222: Nonlinear Control Theory	5224 : Power System Reliability and Load Forecasting Techniques	5225 : Special Electrical Machines

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9th Semester(DD)

Sl. No	Subject code	Course Name	Class Load/Week			Class Load/ Week (Total)	Credit	Marks
			L	T	P			
1.	**EE5123**	**Application of Soft Computing Technique in Electrical Engineering**	3	0	0	3	3	100
		Theory Subtotal	**3**	**0**	**0**	**3**	**3**	**100**
2.	**EE6191**	**M. Tech. Project Part II (Progress Report)**	0	0	0	0	12	300
3.	**EE6192**	**Progress Report Seminar and Viva voce**	0	0	0	0	6	100
		Practical Subtotal	**0**	**0**	**0**	**0**	**18**	**400**
		9TH SEMESTER TOTAL	3	0	0	**3**	**21**	**500**

10th Semester(DD)

Sl. No	Subject code	Course Name	Class Load/ Week			Class Load/ Week (Total)	Credit	Marks
			L	T	P			
1.	**EE6291**	**M. Tech. Project Part III (Thesis)**	0	0	0	0	**22**	**400**
3.	**EE6292**	**Thesis Seminar and Viva voce**	0	0	0	0	**8**	**200**
		Practical Subtotal	**0**	**0**	**0**	**0**	**30**	**600**
		10TH SEMESTER TOTAL	3	0	0	**0**	**30**	**600**

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Syllabi

Basic Electrical Engineering (EE 1101/1201)

Prerequisite: Fundamentals of Physics

Weekly contact: 3 – 1 – 0 (L – T – P) **Full Marks: 100** **Credits: 04**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**DC Circuits:** Node, branch, active& passive elements, linear and non linear circuits, bilateral network, Kirchoff's laws, Maxwell's loop current method, star-delta transformation. Network theorems – Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem.	6
2.	**Measuring Instruments:** Discussion on common Electrical Laboratory Instruments (Ammeter, Voltmeter, Wattmeter) -Classification, torques in the instruments; Mention of digital meters.	3
3.	**Magnetics:** Magnetic quantities, B-H curve, calculation on magnetic circuits, analogy with electric circuit, iron losses.	3
4.	**AC Fundamentals:** 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
5.	**AC Circuits:** Single-Phase – V-I relationship in R-L-C circuit, R-L,R-C, series and parallel combinations of R, L & C, phasor diagram, apparent, active and reactive power, series resonance, Three-Phase -Balanced system, star and delta connections, phase and line quantities and their relationships.	6
6.	**Distribution of Electricity:** Basic Distribution and Wiring System, Use of Switch Fuse Unit, MCB, earthing and protection;	2
7.	**Transformers:** Constructional parts, types, ratings and specifications, emf equation, concept of transformer emf, phasor diagrams, equivalent circuit, concepts of losses, temperature rise, cooling, efficiency, voltage regulation. Mention of three phase transformers.	6
8.	**DC Machines:** Construction, types, operating principles (motoring and generating modes), ratings and specifications, torque and emf equations (derivation not required), elementary principles of speed-control of DC motor, Applications of DC motor	4
9.	**Induction Motor:** Three-phase Induction Motors – operating principle, types, ratings and specifications, slip; torque-speed characteristic curve	3
	Total:	**39L+13T**

Text Books:

1. **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 II Cotton, 1990, Reem Publications (P) Limited
5. **Electrical and electronic Technology** by Hughes, 2005, Pearson Prentice Hall
6. **Electric Circuits** by J. Edministerand M. Nahvi, 2005, McGraw Hill

Web resource

1. http:ntpl.iitm.ac.in/course/Webcourse-contents/IIT%20kharagpur/Basic%20Technology/New_index1.html

Reference books;

1. **Applied Electricity for Engineers** by I. Bessonow, 1973,Izdat. Mir
2. **Introductory Electrical Engineering** by George F, Corcoran & Henry R.Reed, 1957, Wiley
3. **Alternating current circuits** 4th edition by Russel M, Kerchner& George F. Corcoran, 4th Edition, 1960, John Wiley & Son Inc
4. **Engineering Circuit Analysis** by Hayt&Kemmerly1971, McGraw-Hill

Book on electrical engineering problems with answers:

1. **Problems in Electrical Engineering** by Stanley Parker Smith, 9th Edition, CBS publishers and distributors

BASIC ELECTRICAL ENGINEERING LABORATORY (EE-1171/1271)

Weekly Contact: 0-0-3 (L-T-P) **Full Marks: 50** **Credits: 2**

Laboratory experiments based on the subject (Basic Electrical Engineering) (EE1101/E1201)

Electrical and Electronic Measurements (EE2101)

Prerequisite: Basic Electrical Engineering, Fundamentals of Electronics

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**Measurement Errors and Analysis**	2
2.	**Indicating Instruments:** Voltmeter, Ammeter, Range Extension–Shunt and Multipliers, Wattmeter.	4
3.	**Integrating Instruments**: Energy meter	2
4.	**Measurement of Power:** Active power: single wattmeter, two wattmeter method, balanced, unbalanced three phase system, Reactive Power: two wattmeter, single wattmeter methods.	5
5.	**Other Electrical Instruments:** Phase angle and power factor meter, frequency meter, synchroscope, meters for kVAh, kVARh, Maximum Demand Indicator, Trivector meter.	5
6.	**Measurement of Resistance:** Low, medium, high and insulation resistances.	2
7.	**Inductance and Capacitance measurement**: AC bridges for inductance and capacitance measurement.	4
8.	**Magnetic Measurements:** Magnetic measurement using Ballistic Galvanometer, Grassot Flux meter, BH curve of magnetic material, separation of losses.	2
9.	**Instrument Transformers:** Current and Potential transformers, ratio and phase angle errors, design considerations, numerical problem.	4
10.	**Electronic Measurements:** Electronic voltmeter, multimeter, wattmeter and energy meter. Time, Frequency and Phase Angle meters; CRO, Storage oscilloscope, Spectrum and Wave analyzer.	9
	TOTAL:	39

Text Books:

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., 3rd Edition, Sir Issac Pitman and Sons.
4. **Principles of Electrical Measurements**,Buckingham, H. and Price, E.M.,1959, English University

Electrical Machines-I (EE2102)

Prerequisites: **Basic Electrical Engineering**

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**General concepts:** Concept of mmf and flux density distribution in machines – pulsating and rotating type. Basics of electromagnetic torque production and concept of torque angle.	3
	DC Machines	
2.	**DC machines:** Principle of operation (motor and generator), Construction- geometry, materials used in different parts like yoke, poles, armature, commutator etc., commutation process , function of brush commutator assembly. armature winding (idea only).	3
	Armature reaction, demagnetising and cross-magnetising effects, interpoles and compensating windings,	2
	Generators: No-load operation, Magnetisation curve, OCC, build-up process in generators, critical field resistance and critical speed. Load characteristics of DC generators – sep. excited, shunt, series, compound.	2 2
	Motors: Load characteristics of DC motors – sep. excited, shunt, series motors*n*-T, *n*-I and *T-I* characteristics. Zones of torque-speed plane (voltage/ field control), speed control of DC motors.	2 2
	Losses and efficiency of DC machines: Swinburne's test, Hopkinson's test, Brake test, heat-run. Mention of type tests and routine tests	3
	International standards and codes of DC machines (discuss at least one)	2
	Transformers	
3.	**Principle of operation :**Construction of single and three-phase transformers (core and shell type), Transformer oil, Transformer accessories e.g. conservator, breather, Buchholz relay, bushings , Tap changing basics. Equivalent circuit (per phase), phasor diagrams, per unit system of representation, Voltage regulation for different types of load, maximum voltage regulation and its condition. .	2 1 1
	Losses and efficiency: Efficiency load curve and maximum efficiency condition, All day efficiency. **Tests:** Polarity test, OC and SC test, Separation of losses, Sumpner test, difference between type and routine tests.	2 2
	Three phase connections: star-star, delta-star, delta-delta, star-delta, open delta, zigzag). Vector groups,. **Auto transformer:** Principle of operation, Comparison with two-winding transformer. Parallel operation of single and three-phase transformers. Three winding transformer - Equivalent circuit, Role of tertiary winding.	2 2 2
	Phase conversion: 3 ph to 6 ph, 3 ph to 12 ph, 3-ph to 2-ph (Scott connection), Ferriote core transformers and sq. wave operation of transformers	2
	National/International Standards and codes of 1 & 3-phase trf. (discuss at least one)	2
	TOTAL:	**39L +13T**

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-

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3. **Performance and design of AC Machines,** M.G. Say, 2002, CBS Publishers and Distributors Pvt. Ltd., ISBN 10: 8123910274 / ISBN 13: 9788123910277.
4. **Electric Machines,** I J Nagrath and D P Kothari, 5th Edition McGraw Hill Education 2017, ISBN: 978-9352606405
5. **Electric Machinery**, P.K. Mukherjee and S. Chakravorti, 2nd Edition, 1993, Dhanpat Rai

Reference books:

1. **Electric Machinery,** A.E. Fitzgerald, Charles Kingsley, JR., Stephen D. Umans, 6th Edition, 2005, McGraw Hill;
2. **Electrical Machinery and Transformer**, Irving L. Kosow , 2nd Edition, 1991, Prentice Hall, ISBN0132487330, 9780132487337
3. **Performance and design of DC Machines**, Clayton and Hancock , CBS Publishers, ISBN: 9788123909271, 9788123909271
4. **A Course in Electrical Engineering, Volume II, Alternating Currents,** Chester L. Dawes, McGraw-Hill, 1922, ISBN10: 1330312228, ISBN13: 9781330312223
5. **J and P Transformer Book**, Ray Arnold and Martin Heathcote, 14th Edition Newnes Publication, ISBN: 978-0080966182

Classical Electrodynamics (EE2103)

Prerequisites: **Vector Calculus in Mathematics, Electromagnetic Field theory module in Physics and Basics of Electrical Engineering .**

Weekly Contact :3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module No.	Module Name and Topics	No. of lecture-hrs
1.	**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**
2.	**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	**7**
3.	**MagnetostaticField:**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, focussing factor, simple problems.on PM design	**5** **3**
4.	**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** **2** **3**
5.	**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**
6.	**Superconductivity**: Elementary concepts, super conducting magnets, super conducting magnetic energy storage, superconducting fault current limiters, superconducting machines and other applications.	**3**
	Total:	**39L+13T**

Suggested readings(as Text Books first 2 or 3 from the list and the rest for reference):

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1. **Introduction to Electrodynamics**: David J. Griffiths, Cambridge University Press, 2017, 4th Ed. ISBN-13: 978-1108420419 & ISBN-10: 1108420419
2. **Principles of Electromagnetics:** Matthew N.O. Sadiku, Oxford Intnatl. Student Edition, 2009, 4th Ed., ISBN-10: 019806229X &**ISBN-13:** 978-0198099154
3. Superconducting Magnets: Martin N. Wilson, Clarendon Press 1987, ISBN: 9780198548102
4. **Outlines of Electromagnetics:**Joseph A. Edminister**,**Schaum's Series, McGraw-Hill Education; 4 edition (16 December 2013)**ISBN-10:** 0071831479 &**ISBN-13:** 978-0071831475
5. **Electromagnetism** : John C. Slater and Nathaniel H. Frank , Dover Publications USA, 2015, ISBN-10: 0486622630 &ISBN-13: 978-0486622637
6. **Classical Electrodynamics:** John David Jackson, Wiley; 3rd Ed. (2007), ISBN-10: 9788126510948&ISBN-13: 978-8126510948
7. **Networks, lines and Fields:** John D. Ryder, Pearson Education India,2nd Ed. 2015, ISBN 10: 9789332559516&ISBN-13: 978-9332559516
8. **Special Electrical Machines:** K.V. Ratnam**,** Universities Press; 1st Ed. 2008, ISBN-10: 9788173716317 &ISBN-13: 978-817371631
9. **Electromagnetism** : R.G. Powell, MacMillan, 1990, ISBN 0-333-48317-0
10. **Foundations of Electromagnetic Theory**: John R. Reitz, Frederick J. Milford& Robert W. Christy, Addison-Wesley 4th Edition 2008, ISBN-10: 0321581741&ISBN-13: 978-0321581747
11. **Electromagnetic Waves and Radiating Systems:** Jordan and Balmain, Prentice Hall India Learning Private Limited, 2nd Ed. 1964, ISBN-10: 8120300548 & ISBN-13: 978-8120300545
12. **Electromagnetic Fields, Energy, and Forces:** Robert M. Fano, Lan Jen Chu and Richard B. Adler, MIT Press 2020, ISBN: 9780262561709
13. **Electromagnetic Energy Transmission and Radiation:** Robert M. Fano, Lan Jen Chu and Richard B. Adler, MIT Press 2020, ISBN: 9780262511407

Signals and Systems (EE2104)

Prerequisite: Basic electrical engineering, Mathematics

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**Signals:** 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.	4
2.	**Systems:** Interconnection of systems, Types of systems – continuous-time, discrete-time, linear, nonlinear, time-invariant, time-variant, causal, non-causal systems. Stability.	2
3.	**Signal Analysis:** Complex Frequency and The Laplace TransformDefinitions, Transform of common forcing functions. Derivatives and integrals, shifted functions, Initial and Final Value theorems, Inverse Laplace Transform, Convolution integral, Heaviside Theorem.	5
4.	**System dynamics:**System modelling concepts, Transfer function, block diagram representation;ElectricalAnalogous networks for Mechanical, Thermal, Hydraulic systems.	4
5.	**Transient responses of Passive circuits**: (Differential equation approach) – RL, RC, RLC circuits with dc and sinusoidal excitation. Application to transient solution for simple network, switching transients and impulses in networks.	5
6.	**Frequency Response of Systems:** steady state response due to periodic excitations, Bode plots	4
7.	**Fourier Analysis**: Fourier series, evaluation of Fourier co-efficients, 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.	10
8.	**z-Transform and its applications:** definition of z-transform, region of convergence, relationship between z-transform and Laplace transform, Inverse z-Transform	5
	TOTAL	**39L+13T**

Text Books:

1. **Signals and Systems**, Alan V. Oppenheim, A.S. Willsky and S.H. Nawab, 2nd edition ,Pearson India, 2015, ISBN:-9332550239
2. **Circuits and Systems**, K.M.Soni, S.K Kataria& Sons, New Delhi, 2010, ISBN:-8188458066

Reference Books:

1. **Networks and Systems**, D. Roy Choudhury, 2nd edition,New Age International(p) Ltd., 2014, ISBN:-9788122427677
2. **Network Analysis and Synthesis**, Franklin.F.Kuo, Student edition, Wiley India Pvt. Ltd., 2013, ISBN:-9788126510016
3. **Network Analysis and Synthesis**, C.L.Wadhwa, 3rd edition, New Age International (p) Ltd. 2014, ISBN:- 8122420362
4. **Circuit Theory: Analysis and Synthesis**, A. Chakrabarti, 7th revised edition, DhanpatRai & Co, 2018, ISBN:-8177000004

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Measurement Laboratory

(EE2171)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments based on the theory subject "Electrical and Electronics Measurement (E2101) .

Electrical Machine Laboratory- I

(EE2172)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to the subject "Electrical Machine-I (EE2102)" .

Numerical Simulation and Application Tools Laboratory

(EE2173)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits:2**

Laboratory experiments and tutorials on numerical simulation and application tools.

Mini Project-I

(EE2191)

Class (0-0-0) (L-T-P) **Full Marks -50** **Credits:2**

General outline: Preferably, four to five students should form a group and each such group will have to undertake a 'Mini Project-I' in the 3rd semester which will continue in the 4th semester. A single student also

may undertake such a project. The aim of such a 'Mini project' is to make the students aware of the concept of a project as beginners. The group/student should select/identify a specific engineering problem out of a broad area of electrical engineering and plan for its execution, employing scientific methods. The methods should have components of analysis/ synthesis/ design/ simulation/ testing etc. towards the solution of the project problem with a focus to complete the project within two semesters. The project should have finite concrete deliverables and conclusions. A project report should be finally submitted at the end of each semester. Additionally, a seminar on the same must be presented by the group/individual at the end of each semester in front of a board of examiners where each student has to present at least a part of the project. On completion of the seminar, each student will have to answer questions asked by the board of examiners on the project undertaken. The evaluation of each student will depend on the work done, report submitted, seminar presentation and the viva-voce examination. The evaluation will test the capability of a student of working in an individual capacity as well as in a group to plan and execute a project.

Specific requirement for Mini project, 3rd Semester:

The entire planning for undertaking the total project should be finalized by the end of the 3rd semester. Staring from a broader topic initially chosen, efforts should be undertaken to narrow down and eventually pinpoint the project problem. As fast as possible, the project problem should be clearly identified, formulated and finalized. The objective behind the project must be clearly laid down with justification of the problem identified to be solved. Major activities/modules should be identified with timelines keeping in view contingency measures. Activities must be grouped clearly identifying activities/modules to be undertaken by each candidate. Work scheduling should be so planned that work should be undertaken in individual capacity for some activities/modules and/or in groups for some others. Financial planning should be made and presented. Existing laboratory support, if needed for any hardware development/testing etc. in future must be planned and presented. Concrete deliverables of the projects must be identified and mentioned. After this comprehensive planning is over, project execution should start as per the identified activity schedule and timeline. At the end of the 3rd semester, the project report submitted should include the above-mentioned points and present the work done and progress made with respect to the planned activities. Existing books, datasheets, website URL's, research papers etc., as and when consulted for the project work, should be referenced and cited properly in the project report and in the seminar presentation. The project report should end with specific conclusions as on date and the scope of future work for the 4th semester. The seminar presentation to be made should point-wise summarize the content written in the project report.

Electrical Machines-II (EE2201)

Prerequisites: (i) Basic Electrical Engineering and (ii) Electrical Machines-I at the second year level.

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**Armature excitation in electrical machines:** Concept of uniform and sinusoidal current sheet, MMF waveforms and their amplitude for DC, AC single phase and polyphase winding; Pitch, Distribution and Winding factors	**7**
2.	**Electromagnetic torque:** General principles of electromechanical torque production in doubly excited machines	**2**
3.	**Introduction to Induction Machines (IM):** Types, Construction in details, Principle of operation (as motor, generator and brake), concept of slip, rotor frequency, rotor e.m.f during motion	**4**
4.	**Flux-mmf relationship and phasor diagram in IMs**: Derivation of per-phase equivalent circuit, measurement of parameters and performance calculation. Operating characteristics of 3-phase induction motor. Effects of varying voltage and frequency on motor performance	**4**
5.	**Torque–slip characteristics of IMs:** Discussions and analysis	**2**
6.	**Circle diagram of IMs**: Prediction of the machine performance from circle diagram, limitations of circle diagram	**2**
7.	**High torque squirrel cage induction motors**: Discussions on deep bar and double cage motors and analysis	**2**
8.	**Generating mode of IMs:** Working principle of Induction Generators, performance and applications	**2**
9.	**Starting of IMs:** Problems associated with induction motor starting, starting methods for squirrel cage and slip ring motors	**2**
10.	**Speed control of IMs:** Resistance and reactance variation, V/f control, variation of no. of poles, pole amplitude modulation, slip power recovery and exchanges for doubly fed induction machines	**3**
11.	**Space harmonics in IMs:** Effects of space harmonics, methods to reduce their disadvantageous effects, slot skewing, skew factor, effect on winding factor	**3**
12.	**Premium efficiency IMs:** Cu-rotor IMs, NEMA classification, National/International Standards and codes of Induction machines (discuss at least one)	**2**
13.	**Single phase Induction Motors:** Types, operation, performance, applications.	**4**
	Total:	**39L+ 13T**

Text Books:

1. **The Performance and design of Alternating Current Machines,** M.G. Say, CBS Publishers & Distributors Pvt. Ltd., 2002, ISBN 10: 8123910274 / ISBN 13: 9788123910277.
2. **Electrical Machinery,** P.S. Bimbhra, Khanna Publishers, 2011, ISBN: 9788174091734, 8174091734.

Reference Books:

1. **The Performance and design of AC Commutator motors – including the single-phase induction motor,** E Openshaw Taylor, New Delhi: Wheeler Publishing, 1971 (repr. 2000)
2. **Theory of Alternating Current Machinery,** A. S. Langsdorf, Tata McGraw Hill Education, 2001, ISBN-10: 0070994234 ISBN-13: 978-0070994232
3. **Electrical Machinery,** S.K. Sen, Khanna Publishers, India, 1977, ISBN-10: 8174091521, ISBN-13: 978-8174091529

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4. **A Course in Electrical Engineering, Volume II, Alternating Currents,** Chester L. Dawes, McGraw-Hill, 1922, ISBN10: 1330312228, ISBN13: 9781330312223
5. **Design and analysis of Electric Machines;** Kostenko and Piotrovsky
6. **Alternating-Current Machines.** Third Edition, A.F. Puchstein ,T.C. Lloyd and A.G. Conrad, New York; Chapman & Hall: London, 1954
7. **Electric Machinery,** A.E. Fitzgerald, Charles Kingsley, JR., Stephen D. Umans, 6th Edition, McGraw Hill; 2005

Network Theory (EE2202)

Prerequisites: Basic electrical engineering, Signals and systems, Maths-III

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module No.	Module Name and Topics	No. of Lecture-Hrs
1.	**Network Theorems in AC circuits and for dependent and independent sources**: Review of basic Circuit Laws, Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem, Substitution theorem, Compensation theorem, Millman's theorem and Tellegen's theorem.	5
2.	**Two-port Network:** Network elements – Concepts of ports and terminals; Classification of network, network configuration of network; Z-, Y-, T-, h- and g- parameters; Conditions of reciprocity and symmetry; Interrelationship of network parameters; Input and output impedances. Interconnections of 2-port networks; Short-circuit and Open-circuit impedances, image impedances, equivalent T- and π- network.	8
3.	**Network Functions:** Driving point and Transfer functions and their properties, computing various driving point and transfer functions of standard networks, concept of poles and zeros, time-domain responses for pole locations in complex s-plane.	3
4.	**Coupled Networks:** Self and Mutual Inductance, Coefficient of coupling; Connections of coupled coils; Dot convention; Modelling of coupled circuits, Electrical equivalent of magnetically coupled circuits.	3
5.	**Elements of Network Topology**: Graph of network, concept of branch, node, 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
6.	**Passive Filter Synthesis**:Image and characteristic impedances of a two-port network, propagation constants , classification of filters, prototype T-section 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.	7
7.	**Elements of Passive Network Synthesis:** Routh-Hurwitz stability criteria, Hurwitz polynomial, its properties , positive real function (p.r.f), properties and testing of p.r.f , synthesis of driving point and transfer functions of passive networks in Foster and Cauer forms.	5
	TOTAL	**39L+13T**

Text Books:

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, 2010, S K KATARIA & SONS, **ISBN-10:** 8188458066, **ISBN-13:** 978 - 8188458066
3. **Circuits and Networks**, Sukhija and Nagsarkar – 2nd Edition, 2010, Oxford University Press, **ISBN-10:** 0198061870 **ISBN-13:** 978-0198061878
4. **Network Analysis and Synthesis**, C.L.Wadhwa – 3rd Edition, 2018, New Age, ISBN-10: 9788122420364, 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

Reference Books:

1. **Network Analysis**, M.E. Van Valkenburg, 3rd Edition, 2015, Pearson Education India, ISBN-

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10: 9789332550131
2. **Analysis and synthesis of electric circuits**, G. Zeveke, 1979, Mir Publishers

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Analog Electronics (EE2203)

Prerequisites: Semiconductor physics,basic electrical engineering, fundamentals of electronics

Weekly contact: 3 - 1- 0 (L- T- P) **Full Marks 100** **Credits: 4**

Module No.	Module Name and Topics	No. of Lecture-Hrs
1.	**Semiconductor Junctions:** Concept of free electrons and holes in semiconductor, continuity equation, drift and diffusion current, semiconductor p-n junction, current component across semiconductor p-n junction, p-n junction diode, the volt-ampere characteristic of p-n junction diode, diode resistance, space-charge or transition capacitance, reverse voltage break down, diode rating, few application of diodes, Zener diodes and its application,	**10**
2.	**BJTs and FETs:** Input and output characteristics of CE BJT amplifier and CS JFET amplifier. Use of BJTs and FETs as amplifier, biasing of amplifiers, h-parameter model and Hybrid-pi model of BJTs, model of FETs, frequency response of the amplifiers, coupling of multistage amplifier, high input impedance amplifier: bootstrapping, Darlington combination.	**10**
3.	**Feedback amplifiers and Oscillators:** Different feedback configurations. Use of negative feedback, Analysis of amplifier circuit using feedback concept, Use of positive feedback: Theory of sinusoidal oscillator –The Barkhausen criteria. Application, Multi-vibrators: astable, mono-stable, bi-stable multi-vibrators	**7**
4.	**Difference Amplifier:** Common mode and differential mode gains, CMRR. Realization of DIFF amplifier using BJT and FET and their difference mode and common mode gain. Internal circuit of a typical OPAMP (analysis); drift, offset. Buffers, Adders, subtractors, differentiators, integrators using OPAMPs.	**7**
5.	**Special Applications of OPAMPs:** Oscillators – Wien Bridge, Phase-Shift, and Quadrature; V-f and f-V, PLL, Triangle & Saw-tooth waveform generator circuits. 555 IC and its applications, Schematics and Principles; Comparators –ZCD, with Hysteresis	**5**
	Total:	**39L+13T**

Text Books:

1. **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. **OPAMP and Linear Integrated Circuits**- Ramakant A Gaykward **,** 4th Edition**,** Prentice Hall, 2000, 0132808684, 9780132808682
4. **Electronics Principles** – Albert Malvino and David Bates**,** Eighth Edition**,** McGraw-HillISBN13: 9780073373881

Reference Book:

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, 5th Edition,ISBN-13: 978-0750659147
3. **Design With Operational Amplifiers and Analog Integrated Circuits** – Sergio Franco, Tata McGraw-Hill, ISBN: 9780070530447, 0070530440
4. **Design With Operational Amplifiers and Analog Integrated Circuits** – Sergio Franco, Tata McGraw-Hill, ISBN: 9780070530447, 0070530440

Web resources: https://nptel.ac.in/ search for "Analog Circuits"

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CONTROL SYSTEMS I (EE2204)

Pre-requisites: Mathematics III, Signals and Systems, Higher Engineering Mathematics

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module No.	Module Name and Topics	No. of Lecture-Hrs
1.	**Introduction:** **Classification of Dynamic Systems:** Continuous/Discrete, Time-invariant/Time-varying, Linear/Nonlinear, Open loop/Closed loop, Concept of negative feedback, Examples. **Transfer Function:** Definition, Relation with Impulse Response Function, Order and type of transfer functions, Example: R-L-C series circuit or equivalent.	**2**
2.	**Representation of Systems:** Block diagram algebra, Mason's Gain Formula, Signal Flow graph.	**4**
3.	**Stability:** Definition of BIBO and Zero Input Stability, Routh Hurwitz's criterion.	**4**
4.	**Time domain analysis:** State Space Modelling of Physical Systems, Solution to State Equations, State Diagrams, State Space to Transfer Function, Linear Transformations.	**6**
	Transient analysis with Step Input, Time Domain Specifications, Transient and steady state errors – definitions, Error constants.	**4**
5.	**Frequency domain analysis:** Bode plot, Minimum/Non-minimum phase systems, Transportation lag, Pade approximation.	**5**
	Nyquist stability criterion, Relative stability.	**5**
	Construction of Root locus.	**5**
6.	**Controllers**: P, PI, PD and PID control, Lead and lag compensation (Mention only).	**2**
7.	**Control system components:** Synchros, Tachogenerators, A.C. and D.C. Servomotors.	**2**
	TOTAL:	**39L+13T**

Text Books:

1. **Control Systems Engineering** – N. Nise, 6 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, 5th Edition, Pearson.
2. **Automatic Control Systems** – B. C. Kuo and F. Golnaraghi, 9th Edition, Wiley.
3. **Feedback Control of Dynamic Systems** – Franklin, Powell and Naeimi, 5th Edition, Pearson.
4. **NPTEL lecture**: https://nptel.ac.in/courses/108101037/

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Digital Electronics (EE2205)

Prerequisites: Semiconductor physics, Basic electrical engineering, Basics of Electronics

Weekly contact: 3 - 0- 0 (L- T- P) **Full Marks 100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hrs
1.	**Combinational Logic Circuits:** Various logic gates and characteristics via truth table and Boolean Algebra; Karnaugh Mapping; SOP, POS; realization; Code Converter, Arithmetic Operations; MUX and DMUX, Encoder/Decoder – ROM &PLA, concept of Schmitt trigger, Tri-state Buffer etc.	**9**
2.	**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	**4**
3.	**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	**10**
4.	**Digital Integrated Circuits** BJT characteristics (recap), RTL, DTL and I^2L circuits; TTL circuits – conventional and open-collector architectures, tri-state TTL architecture, ECL and CMOS circuits	**8**
5.	**Data Acquisition Systems:** A to D and D to A conversion, Sample/Hold circuit, Acquisition time, Aperture time, Hold time, Conversion time, Different types of ADCs and DACs	**6**
6.	**Digital Micro-Computer System:** Basic Building Blocks of a Digital Micro-Computer System – a brief introduction	**2**
	Total:	**39L**

Text Books:

1. **Digital Logic and Computer Design,**– M. Morris Mano,1st Edition, ISBN No.: 9789332542525, 2016
2. **Digital Principles and Applications,** Donald P. Leach, Albert Paul Malvino and GautamSaha, McGraw Hill Education, 8th Edition, ISBN No.: 978-9339203405, 2014
3. **Digital Systems: Principles and Applications,** Ronald J. Tocci, Neal S. Widmer and Gregory L. Moss, Pearson, 10th Edition, ISBN No.: 978-8131727249, 2009

***Reference Book*:**

1. **Microelectronic Circuits –Theory and Applications,** A. S. Sedra and K. C. Smith, Oxford, 6th Edition, 978-0198089131, 2013.
2. **Digital Integrated Electronics,** Herbert Taub and Donald Schilling, McGraw-Hill Education, 1st Edition, ISBN No.: 978-0070265080, 2017.
3. **Integrated Electronics: Analog and Digital Circuits and Systems**, Jacob Milman and Christos C. Halkias, Tata McGraw-Hill Publishing Company Limited, Tata McGraw-Hill Edition 1991, ISBN No.:-0-070462245-5, 1999.
4. **Electronic Principles,** Albert Malvino and David J. Bates, McGraw-Hill Education, 7th Edition, ISBN No.: 978-0070634244, 2017.

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Electrical Machine Laboratory–II

(EE2271)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subjects Electrical Machine-I (EE2102) and Electrical Machines - II (EE2201).

Digital Electronics and Analog Electronics Laboratory

(EE2272)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subjects Digital Electronics (EE2205) and Analog Electronics (EE2203).

Laboratory on Network Theory

(EE2273)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subject Network Theory (EE2202) .

Mini Project-II

(EE2291)

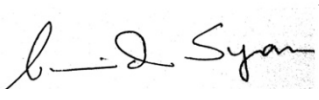
Class (0-0-0) (L-T-P) **Full Marks -50** **Credits:2**

General outline: Preferably, four to five students should form a group and each such group will have to undertake a 'Mini Project' in the 3rd semester which will continue in the 4th semester. A single student also may undertake such a project. The aim of such a 'Mini project' is to make the students aware of the concept of a project as beginners. The group/student should select/identify a specific engineering problem out of a broad area of electrical engineering and plan for its execution, employing scientific methods. The methods should

have components of analysis/ synthesis/ design/ simulation/ testing etc. towards the solution of the project problem with a focus to complete the project within two semesters. The project should have finite concrete deliverables and conclusions. A project report should be finally submitted at the end of each semester. Additionally, a seminar on the same must be presented by the group/individual at the end of each semester in front of a board of examiners where each student has to present at least a part of the project. On completion of the seminar, each student will have to answer questions asked by the board of examiners on the project undertaken. The evaluation of each student will depend on the work done, report submitted, seminar presentation and the viva-voce examination. The evaluation will test the capability of a student of working in an individual capacity as well as in a group to plan and execute a project.

Specific requirement for Mini project, 4th Semester:

The work for the 4th semester Mini project should start from where it was left in the earlier semester. This semester's work should predominantly include execution of all the remaining planned activities/modules by the end of the semester. Major stress should be given in applying scientific methods of analysis/ synthesis/ design/ simulation/ testing etc. for undertaking the activities towards the solution of the project problem. At the end of the 4th semester, after end of the work, the final project report should be submitted. It should consist of planning aspects and other important issues reported in the 3rd semester and the executing activities undertaken in the 3rd and 4th semester including components of analysis/ synthesis/ design/ simulation/ testing etc., as applicable, for the particular project including results and deliverables. The project report should be complete on its own. Existing books, datasheets, website URL's, research papers etc., as and when consulted for the project work, should be referenced and cited properly in the project report and in the seminar presentation. The project report should end with specific conclusions as on date and the scope for future work. The seminar presentation to be made should point-wise summarize the content written in the project report. Preferably, four to five students should form a group and each such group will have to undertake a 'Mini Project' in the 3rd semester which will continue in the 4th semester. A single student also may undertake such a project. The aim of such a 'Mini project' is to make the students aware of the concept of a project as beginners . The group/student should select/identify a specific engineering problem out of a broad area of electrical engineering and plan for its execution employing scientific methods. The methods should have components of analysis/ synthesis/ design/ simulation/ testing etc. towards the solution of the project problem with a focus to complete the project within two semesters. The project should have finite concrete deliverables and conclusions. A project report containing the above-mentioned points/elements should be finally submitted at the end of each semester. Additionally, a seminar on the same must be presented by the group/individual at the end of each semester in front of a board of examiners where each student has to present at least a part of the project. On completion of the seminar, each student will have to answer questions asked by the board of examiners on the project undertaken. The evaluation of each student will depend on the work done, report submitted, seminar presentation and the viva-voce examination. The evaluation will test the capability of a student of working in an individual capacity as well as in a group to plan and execute a project.



H.o.D, EE

Electrical Machines-III (EE3101)

Prerequisites: (i) Basic Electrical Engineering and (ii) Electrical Machines-I and II at the second year level.

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Module. No.	Module Name and Topics	No. of Lecture-hrs
1.	**Construction of Synchronous Machine:** Cylindrical and salient pole rotor construction. Damper winding- principle of operation as motor and generator	3
	Excitation system including brushless and static excitation system	1
2.	**Phasor Diagrams and Power Flow:** Flux-mmf relationship and armature reaction. Equivalent circuit. Phasor diagram (cylindrical rotor). Motor and generator action. Power flow and maximum power, power angle, torque angle	5
3.	**Steady state Characteristics:** Steady state characteristics (external characteristics, field compounding characteristics, frequency, active power, terminal voltage and reactive power characteristics)	5
5.	**V-Curves and Synchronous Condenser**: Effect of varying field excitation and V curves. Synchronous condenser and its application	4
6.	**Determination of parameters:** Determination of parameters of synchronous machine, Tests for the same, Separation of Xs into armature reaction and leakage reactance components	2
7.	**Voltage regulation:** Short circuit ratio and its significance. Determination of voltage regulation by different methods	3
8.	**Steady state analysis of Salient pole machine:** Two reaction theory and phasor diagram for salient pole machine	2
9.	**Operation and Control:** Excitation and power circles, synchronizing power, parallel operation of alternators, methods of synchronization	5
10.	**Starting methods :** Problems during starting and methods of starting, Synchronous induction motor (Mention only), principle of starting with position feedback (and self-synchronous or self-control concepts	3
11.	**Other type of synchronous motors:** Singly excited doubly salient machines – variable reluctance Stepper motor, universal motor,. Synchronous reluctance machines, SRM	4
12.	**Standards and codes:** National/International Standards and codes of Synchronous machines (discuss at least one)	2
	Total:	**39L+13T**

Text Books:

1. **The Performance and design of Alternating Current Machines,** M.G. Say –3rd Edition, 2002, CBS Publishers, New Delhi.
2. **Electrical Machines**, P.S. Bimbhra –7th Edition, 2011, Khanna Publishers, New Delhi
3. **The performance and design of AC Commutator motors,** Openshaw Taylor –.1st Edition, 1958, Pitman, London.
4. **Theory of AC Machinery**, A.S.Langsdorf – 2nd Revised Edition, 1984, McGraw Hill Education, Noida.
5. **Electric Machines,** S.K. Sen –4th Edition, 1977, Khanna Publishers, New Delhi
6. **A Course in Electrical Engineering, Vol-II**, Chester L. Dawes— 1st Edition, 1922, McGraw-Hill Book Company, New York
7. **Design and analysis of Electric Machines**, Kostenko and Piotrovsky –; 2nd Edition, 1969, Mir Publishers
8. **Theory of AC Machines,** Puchstein and Llyod –2nd Edition, 1942, John Wiley and Sons, New York
9. **Electric Machinery,** Fitzgerald & Kingsley –6th Edition, 2017, McGraw Hill Education

H.o.D, EE

Power System – I (EE3102)

Prerequisite: 1. Basic Electrical Engineering 2. Electrical Machines I

Weekly Contact: 3–0–0(L–T–P) **Full Marks: 100** **Credits: 3**

Module No	Course Content	No of Lecture-Hrs
1.	**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**
2.	**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**
3.	**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.	**4**
4.	**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**
5.	**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**
6.	**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**
7.	**Overhead line insulators and Corona:**– Types, Voltage distribution, String efficiency, Methods of equalizing potential, Insulator failure, Corona - its formation, Critical voltage, Corona loss and its reduction.	**3**
8.	**P-f and Q–V control**:– Concepts, Power-frequency (P-f) and Reactive Power-Voltage (Q-V)control mechanisms.	**3**
9.	**Symmetrical faults:**–Three phase short circuit on loaded and unloaded alternator, Calculation of short circuit kVA.	**4**
10.	**Power system grounding:**–Objective of Neutral grounding, Difference between grounded and ungrounded system, Different methods of grounding, Grounding transformer, Equipment grounding.	**3**
	Total	**39L**

Text Books:

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, ISBN0136919901, 9780136919902
5. **Power System Analysis Operation and Control**, Chakrabarti and Halder, 3rd edition, 2020, PHI Learning Pvt. Ltd, ISBN-10: 8120340159, ISBN-13: 978-8120340152

CONTROL SYSTEM-II (EE3103)

Prerequisites: Control Systems-I

Weekly Contact: 3-1-0 (L-T-P) **Full Marks: 100** **Credits: 4**

Sl. No.	Module Name and Topics	No. of Lecture-hrs
1.	**State Variable Control:** Controllability, Linear State Variable Feedback Control, Observability, Observers.	10
2.	**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 digital controllers.	11
3.	**Control Systems Design:** Design of Lag, Lead and Lag/Lead compensators. Design of PI and PD controllers, Case studies.	10
4.	**Introduction to Nonlinear Control:** Phase Plane Analysis, Lyapunov Stability.	04
5.	**Introduction to Optimal Control Systems:** Performance Index, Examples, Linear Quadratic Regulator.	04
	TOTAL:	39L +13T

***Text Books*:**

1. **Control Systems Engineering** , N. Nise, 6th edition, 2010, Wiley India Edition.
2. **Modern Control Engineering** , K. Ogata, 5th Edition, Pearson
3. **Control Systems Engineering**, Nagrath and Gopal, 6th Edition, New Age International Publishers.
4. **Automatic Control Systems**, B. C. Kuo and F. Golnaraghi, 9th Edition, Wiley
5. **Feedback Control of Dynamic Systems**, Franklin, Powell and Naeimi, 5th Edition, Pearson

Power Electronics (EE3104)

Prerequisite: Analog Electronics

Weekly contact: 3 – 0 – 0 (L-T-P) **Full Marks- 100** **Credits:3**

Module No.	Module Name and topics	No. of Lecture-Hrs
1.	**Solid State Devices for Power Control:** 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.	**6**
2.	**Uncontrolled & Controlled Rectifier circuits(single phase and three phase)** – voltage output, power output, Transformer Utilization Factor, Ripple Factor, Power Factor. Selection of rating of devices. Use of freewheeling Diodes. Effects of source and load inductances. Control strategies. Filter requirement.	**7**
3.	**AC Voltage Controller (single phase only):** Integral cycle control, phase control, their applications- transformer tap changer	**2**
4.	**DC/DC Converters** – Classifications, principles, design, analysis and uses	**5**
5.	**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.	**6**
6.	**Cycloconverter**- Principle, types, single and three phase circuits, uses	**3**
7.	**Power Supplies**– Principles, different topologies and uses of SMPS, UPS	**3**
8.	**Industrial Applications: DC Drives**: Speed Control of dc motors using power circuits. Steady state and transient analysis of open loop and close loop controlled DC motor using converters/choppers.	**4**
9.	**AC Drives** – Stator voltage control and PWM Control of three phase induction motors. Closed loop control principles and blocked schematics.	**3**
	Total:	**39L**

Text Books:

1. **Power Electronics- Circuits, Devices and Applications**, by M. H. Rashid; 4th Edition, 2014, Prentice Hall
2. **Thyristorised Power Converters** by G. K. Dubey et al.,1986, New Age International
3. **Power Electronics: Converters, Applications and Design** by N. Mohan, T. M. Undeland and W.P. Robbins; 3rd Edition, 2002, John Wiley & Sons.
4. **Power Electronics** by C. W. Lander; 3rd Edition, 1993, McGrow Hill.
5. **Power Electronics** by P. S. Bhimra; 1990, Khanna Publishers

H.o.D, EE

Laboratory and Practical

Electrical Machine Lab-III

(EE3171)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subject Electrical Machine-I (EE2102), Electrical Machine-II (EE2201) and Electrical Machine-III (EE3101)

"Power System Design and Estimation" and "Electrical Machine Design"

(EE3172)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Power System Design and Estimation is based on the following topics:

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.

Design of electrical power system for Hospital/Commercial building

Determination of practical line loadability and voltage regulation of a long compensated/uncompensated transmission line, selection of transmission line voltage and estimation of number of lines for power transfer. Validation of design using programming technique

Design of Lightning protection of High rise building

Design of Sub-Station Grounding Material

Any one of (i) and (ii) and any one of (iii), (iv) and (v) will be considered for a particular semester

Electrical Machine Design is based on the following topics:

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.

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.

Electric Drives (EE3201)

Prerequisite: Electrical Machines –I, II and III and Power Electronics

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-hrs
01.	**Concept of drives:** Group drives, multi-motor 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.	**4**
02.	**Solid state control of DC motors:** Basic principles. Drive schemes with armature voltage feedback and IR-compensations together with tacho feedback for both constant flux and field weakening. Modelling of the DC power converter system.	**5**
03.	**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 tacho feed-back, slip compensation. Vector control of induction machine, direct torque and flux control. Modelling of different AC converter system. Solid state control of synchronous motors.	**10**
04.	**Motor Control components:** DOL starters, contactors, limit switches, relays etc.	**2**
05.	**Power electronic control of starting of DC and AC motors:** Accelerating time, energy loss in starting. Effect of flywheels. Realization of the total converter system of AC and DC drives.	**6**
06.	**Braking:** Dynamic braking, regenerative braking, DC injection, plugging. Protection schemes for overall drive systems. Transient time and energy loss during transient process.	**4**
07.	**Heating and cooling of motors:** operating duty cycles. Enclosures of motors. Selection of motor rating. Choice of coupling and bearings.	**5**
08.	**Drives for Specific Applications:** Drive Considerations for Textile Mills, Steel Rolling Mills, Cranes and Hoist Drives. Cement Mills, Machine Tools, Paper Mills, Coal Mines. Centrifugal Pumps etc.	**3**
	Total:	**39L**

Text Books:

1. **Fundamentals of Electrical Drives**, G. K. Dubey; 2003, Narosa Publishing House,
2. **Electric Drives**, N. K. De and P. K. Sen; 2001, Prentice Hall of India Ltd.,
3. **Modern Power Electronics and AC Drives**, B. K. Bose:2003, Pearson Education
4. **Power Electronics: Converters. Applications and Design**. N. Mohan. T. M. Undeland. and W. P. Robbins: Ed., 2003, John Wiley & Sons.
5. **Power Electronics**- Circuits, Devices and Applications, M.H. Rashid 3rd Ed., 2004, Prentice Hall.

Power System – II (EE3202)

Prerequisite: 1. Power System – I , Electrical Machines I and II

Weekly Contact:3–0–0(L–T–P) **Full Marks: 100** **Credits: 3**

Module No.	Course Contents	No of Lecture-Hrs
1.	**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 equipments, power flow through DC links, control of power, HVDC protection system.	4
2.	**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 equations and application of numerical methods, Sparse matrix, computational issues in large power systems, basic aspects of Contingency analysis.	5
3.	**Analysis of faults in power systems** – Symmetrical and unsymmetrical faults, Step by step method of formation of ZBUS, symmetrical components – Fortescue's Theorem, Sequence impedance, Positive, negative and zero sequence networks, Unsymmetrical faults – single line to ground, line to line , double line to ground	5
4.	**Power system transients –** Lightning and switching surges, Travelling wave, Bewley's Lattice diagram, Basic Insulation level, Protection of systems and equipments against overvoltage, Insulation co-ordination.	4
5.	**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
6.	**Fuses and Circuit breaker** – Basic function of fuse operation, HRC fuse, Fuse application, circuit breaking mechanism during fault, Arc quenching mechanism, Types of circuit breakers, Current chopping, Arc Chute and Pre-Insertion resistors, Isolators, Rating of circuit breakers, Selection of Circuit breakers for each location and voltage rating, Co-ordination of fuses and circuit breakers.	5
7.	**Power System economics and management** – Interconnected system, Its advantages, Distribution of load between thermal units within a plant, Economic operation with and without transmission losses considered, concept of power exchange and spot pricing, deregulation and management.	5
8.	**Fundamental aspects of Power system protection** – Basic function, Elements in protective scheme – CT, PT, CVT connections, Types of relay, Electromagnetic induction and attraction type relay, Over-current, Overvoltage, Concepts of Directional and Non- directional over-current relay, Static and Numeric Relays.	6
	Total	**39L**

***Text Books*:**

1. **Power System Analysis**, Grainger and Stevenson, 1st Edition, 2010, McGraw Hill Education, ISBN-10: 9780070585157
2. **Power System Analysis**, Bergen and Vittal, 2nd edition, 2000, Prentice Hall, ISBN0136919901, 9780136919902
3. **Power System Engineering**, Kothari and Nagrath, 2008, Tata McGraw Hill Education, ISBN 0070647917, 9780070647916
4. **Power System Analysis Operation and Control**, Chakrabarti and Halder, 3rd edition, 2020, PHI Learning Pvt. Ltd, ISBN-10: 8120340159, ISBN-13: 978-8120340152
5. **Power System Stability and Control**, P S Kundur, Mcgrawhill HED, ISBN: 9780070635159,

9780070635159
6. **Electric Power Systems**, Weedy, Cory, Jenkins, Ekanayake, Strbse 5th Edition, 2012, Wiley ISBN-10**:** 047068268X, ISBN-13**:** 978-0470682685,

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H.o.D, EE

Switchgear and Power System Protection (EE3203)

Prerequisite: Fundamentals of Electrical Machines and Power Systems

Weekly contact: 3 - 1 - 0 (L- T- P) **Full Marks- 100** **Credits: 4**

Module No.	Module Name and topics	No. of lecture-hrs
1.	**Switchgear:** Basic functions of a circuit breaker. Basic principle of operation. Arc phenomenon, its initiation, maintenance and quenching. Restriking and recovery voltage. Ratings of a circuit breaker and its selection. Different types of circuit breakers – air, oil, vacuum and SF6 . Current chopping, breaking of capacitive current. DC circuit breaking	**7**
2.	**Basic Principle of protective relaying:** Basic function of relay, its attributes and categorisation. Magnitude relay, Directional relay, Differential relay, Fundamentals of Numerical Relaying	**6**
3.	**Transmission Line protection :** Distance Relaying and Pilot Relaying, Ordinary Impedance, Modified Impedance, Angle Impedance, Mho, Quadrilateral Relay; Reach, Over Reach, Under Reach of an impedance relay; Three step time lag distance Rely; Wire Pilot, Carrier Pilot and micro-wave pilot	**6**
4.	**Generator Protection:** Stator faults, Rotor faults, Abnormal operating conditions- unbalanced loading, loss of excitation, prime-mover failure	**5**
5.	**Transformer Protection:** Percentage Differential Relay, Inrush Phenomenon and Over-fluxing Phenomenon , Percentage Differential Relay with harmonic restrain, Incipient faults, Buchholz Relay and analysis of trapped gases	**4**
6.	**Bus bar protection and substation automation**: Differential Protection, IED , IEC protocols	**3**
8.	**Motor Protection:** Electrical faults, Mechanical faults and Abnormal Operating conditions in supply side- Unbalanced supply, Single phasing, low voltage	**2**
9.	**Capacitor Bank and Reactor Protection**: Short circuit, Over current, Differential and Earth Fault Protection	**2**
10.	**Recent Developments**: Digital Protection algorithms, System Protection	**4**
	Total	**39L+13T**

Text Books:

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**, BadriRam ,B.H. Vishwakarma, ',Second Edition 2011, New

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Age International Pvt Ltd Publishers.
4. **Protection and Switchgea**r, Bhavesh Bhalja, R.P. Maheshwari, Nilesh G. Chotani, 2011, Oxford University Press.

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H.o.D, EE

Microprocessors and Microcontroller (EE3204)

Prerequisite: Knowledge of Digital Electronics

Weekly contact: 3 – 0 – 0 (L – T – P) **Full Marks: 100** **Credit: 3**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**Evolution of microprocessor** – 4004 to Pentium – Advancement parameters	2
2.	**Number system**: Brief discussion on number systems and representation of fixed/floating point numbers in a microprocessor, BUS and system concept	2
3.	**Organization and Architectural Features of 8 bit processor:** 8-bit processor (Intel 8085)[including addressing modes, Machine Cycle and Timing, BUS Arbitration etc.], Instruction set and Programming; its drawbacks	11
4.	**Brief Organization and Architectural Features of 16-bit and 32-bit processors** - Intel 8086, 80286, 80486, Pentium	5
5.	**Organization and Architectural Features of an 8-bit microcontroller**: Intel 8051 [including addressing modes, timing diagram etc.], Instruction set and Programming; Brief mention of PIC / ARM / ATMEGA	11
6.	**Interfacing:** Interfacing with data ports, timers, interrupt controllers, data converters etc. Introduction to USART, RS-232C, USB, DMA.	8
	Total:	39L

Text books

1. **Microprocessor Architecture, Programming, and Applications with the 8085**: Ramesh S. Gaonkar, 5th Edition ,2002, Prentice Hall Series, Pearson.
2. **The 8051 Microcontroller**: K. Ayala, 3rd Edition, 2007, Thomson Delmar Learning, **Cengage**

Reference books:

1. **The Intel Microprocessors: 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro, and Pentium II Processors : Architecture, Programming, and Interfacing**, Barry B. Brey, Prentice Hall, imprint 2005, Pearson Education, ISBN 9788131726228
2. **Microprocessors and Interfacing: Programming and Hardware**. Douglas V. Hall, 2nd Edition, 1991, Tata McGraw Hill
3. **The 8051 Microcontroller and Embedded Systems Using Assembly And C (2/E),** Mazidi, 2007, Pearson Education
4. **Advanced Microprocessors and Peripherals,** Ray and Bhurchandi, 2006, Tata McGraw Hill
5. **Microprocessors and Interfacing 8086, 8051, 8096, and Advanced Processors**, Senthil Kumar, 2012, Oxford HED
6. **Microprocessors and Microcontrollers**, N. Senthil Kumar, M. Saravanan, S. Jeevananthan, 2010, Oxford University Press

Web resource:

1. **NPTEL video course - https://nptel.ac.in/courses/108105102/**

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H.o.D, EE

Transducers and Instrumentation (EE3205)

Prerequisites: Analog Electronics and Digital Electronics

Weekly Contact: 3-0-0 (L-T-P) **Full Marks: 100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**Introduction**: To instrumentation systems and its operation. Performance Characteristics – Static and Dynamic; Order of the instrumentation systems. Signal standards, Live and dead zero.	2
2.	**Sensors and Transducers**: Classifications, Transducers for measurement of non-electrical quantities: displacement, level, strain, pressure, force, torque, temperature, flow, velocity, acceleration, speed, etc.; seismic measurements. Transducers for measuring Electrical quantities.	6
3.	**Special Transducers**: Piezo-electric transducers, pH sensors, Electro-analytic transducers, Radioactive transducers.	4
4.	**Direct Digital Transducers**: position encoders, speed counters etc.	2
5.	**Instrumentation amplifier**s:	4
6.	**Signal Generators**: Diode Function Generator, Triangle, Saw-tooth and Staircase waveform generator.	2
7.	**Signal conditioners:** Level shifters, voltage to current, current to voltage converter; Peak detectors, Sample/Hold circuit, linearizers.	2
8.	**Signal Processors:**Window Comparators, Absolute value circuits, Precision rectifiers; Log- and Antilog- amplifiers – multiplier, divider, squarer, square rooter, RMS converter and True RMS circuits. F to V and V to F converters.	5
9.	**Data Acquisition System and Central monitoring**: Single and multichannel data acquisition; Analog and digital display devices, Data loggers, Recorders, Plotters, Application of microprocessors in Instrumentation System.	5
10.	**Programmable Logic Controllers:** Block diagram, operating sequence, input-output specifications and standards, response timings; Ladder diagram, programming; Simple problems.	3
11.	**Signal transmission and Telemetry systems**: Analog and Digital data transmission, voltage and current standards; p-i, i-p converters, modulators and demodulators, RZ, NRZ signals.	3
12.	Typical case studies and related modern topics.	1
	Total:	39L

Text Books:

1. **Measurement System,** E. O. Doebelin , 5th Edition, 2003, McGraw Hill.
2. **Transducers & Instrumentation,** D. V. S. Murthy, 2nd Edition, PHI. ISBN : 9788120335691

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3. **Electronic Measurements and Instrumentation,** H.S.Kalsi , 3rd Edition, 2012, Tata McGraw Hill.
4. **Instrumentation: Devices and Systems,** Rangan, Sarma and Mani, 2nd Edition, 2017, Tata McGraw Hill.
5. **Programmable Logic controllers and Industrial Automation-an Introduction,** Mitra and Sengupta**,** 2nd Edition, 2017, Penram.
6. **Telemetry Principles** D. Patranabis, 1999, Tata McGraw Hill.

Practical/Laboratory subjects

Power Systems and Drives Laboratory

(EE3271)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subjects "Power System-II"(EE3202) and "Electric Drives" (EE3201) .

"Microprocessors and Microcontrollers" and "Transducers and Instrumentation" Laboratory

(EE3272)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subjects " Microprocessors and Microcontrollers "(EE3204) and "Transducers and Instrumentation" (EE3205) .

Power Electronics and Control Systems Laboratory

(EE3273)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subjects " Power Electronics "(EE3104) and "Control Systems-I and Control System-II" (EE2204 and EE3103).

Digital Signal Processing and Embedded Systems (EE4101)

Prerequisite: Knowledge of microprocessors/microcontrollers

Weekly contact: 3 – 0 – 0 (L – T – P) **Full Marks: 100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-hrs
1.	**Introduction to Digital Signal Processing**: LTI systems, step and impulse responses, convolution; FIR and IIR, recursive and nonrecursive.	2
2.	**Discrete time systems in frequency domain**: Discrete Fourier Transform: DFT and FFT algorithms	5
3.	**Digital processing of continuous time signals**: Introduction to digital filters: Design of IIR and FIR filters, Finite word length effects in digital filters	4
4.	**Hardware:** Hardware for digital signal processing, DSP chips	2
5.	**Introduction to Embedded Systems:** Embedded Hardware	2
6.	**PIC:** Instruction Set, Peripherals on chip **ARM Processor:**Instructions, interrupt handling	8
7.	**System-on-chip:**Virtual Memory and Memory Management Unit; Bus structure; Serial interfaces	5
8.	**Programmable logic devices:** CPLD, FPGA, use of FPGA in real-time simulation	8
9.	**Software for embedded systems:** **Hardware development languages**: VHDL / Verilog.	3
	Total:	39L

***Text Books*:**

1. **Discrete Signal Processing,** Oppenheim, Schafer and Buck, 3rd Edition, 2010, Prentice Hall
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. **FPGA-based system design**, Wayne Wolf, 1st Edition, 2004, Pearson Education

Reference books:

1. **Digital Signal Processing,** Sanjit K. Mitra, 3rd Edition, 2008, Tata McGraw Hill
2. **Digital Signal Processing,** Ifeachor and Jervis, 2nd Edition, 2002, Pearson Education
3. **Embedded Systems Building Blocks,** Labrosse, 2nd Edition, Elsevier
4. **Programming and Customizing the ARM7 Microcontroller,** Predko, 2009, McGraw Hill
5. **Modern Embedded Computing,** Barry & Crowley, 2012, Morgan Kaufmann
6. **A VHDL Primer,** J. Bhasker, 3rd Edition, 1995, Prentice Hall

Web resources:

1. NPTEL course on Digital Signal Processing - https://nptel.ac.in/courses/117102060/
2. NPTEL course on Embedded Systems - https://nptel.ac.in/courses/108102045/

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Electrical Energy Utilization and Grid Interactive Control (EE4102)

Prerequisites: Basic Electrical Engineering, Power Electronics, Control Systems, Electrical Machines I, Electrical Machines II, Electrical Machines III

Weekly contact: 3 – 0 – 0 (L-T-P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-hrs
01.	**Electric Traction Fundamentals:**Traction-System of Track electrification, Train movement and energy consumption (speed- time curves, crest speed, average speed &schedule speed), Tractive effort Factors affecting energy consumption (dead weight, acceleration weight & adhesion weight) Protective devices ; Outlining the concept and use of SCADA in railways and Automatic Train Protection Sub-systems(ATP).	**6**
02.	**Electric Traction motor and their control**: Electric Traction motor & their control, starting, braking special emphasis onselection of motors, their control and protection; Current collectors in traction, Interference with telecommunication circuit. A brief review of power electronic controllers with respect to traction motors; A brief outline of Linear Induction Motor Principle in Traction.	**6**
03.	**Illumination**: Laws of illumination, polar curves, photometry, integrating sphere Types of Lamps, Basic Principles of light Control, Different Lighting Schemes and their Design, Flood-Lighting, Factory-Lighting and street Lighting Lamps, Basic principle of light control, Different lighting scheme and their design Factory, Flood and street lighting.	**8**
04.	**Electric Heating**: Electric heating fundamentals, Different important types of heating – arc, induction and dielectric heating, power supplies for such heating	**4**
05.	**Electric Welding:** Requirement for good welding, Resistance welding, arc welding, --- power supplies for different welding.	**4**
06.	**Smart Grid and Microgrids** : Introductory concept of Grid and Microgrids : DC and AC, special features of a Microgrid; SCADA /EMS for Energy Management in such Grids;	**3**
07.	**Distributed Generation (DG) and Grid interfacing of DG sources**: Concept of energy utilization from distributed generation (DG), issue of AC grid- connectivity of DG sources and role of interfacing converters, converter topologies, maximum power point tracking (MPPT) control	**4**
08.	**Control of Grid-Tied Inverters**: Discussion on Schemes of Grid-tie inverter control methodology of three phase inverters based on D-Q rotating reference frame, unit vector generation and role of phase locked loops (PLL), issues of islanding	**4**
	Total:	**39L**

Suggested readings:

1. **Utilisation of Electric Energy,** Openshaw Taylor, 1971, Orient Blackswan Pvt.Ltd. ISBN 8125016406, 9788125016403
2. **Utilisation of Electric Power and Electric Traction,** J.B. Gupta, 10th Edition, 2019, S.K. Kataria&Sons ISBN 978-93-5014-258-5
3. **Art and Science of Utilisation of Electrical Energy,** H. Partab; 2014, DhanpatRai& Co. (Pvt.) Ltd.
4. **Electric Traction,** S.N. Mahendra and J. Upadhyay, Allied

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Publishers Pvt. Ltd. ISBN: 9788177640052

5. **Renewable and efficient electric power systems ,** Gilbert M Masters, 2004, John Wiley & Sons, New Jersey, Print ISBN:9780471280606
6. **Control of power inverters in renewable energy and smart grid integration,** Quing-Chang Zhong and Tomas Hornik, 2012, John Wiley & Sons, IEEE Press 2013, Print ISBN:9780470667095
7. **Grid Converters for photovoltaic and Wind power systems,** Remus Teodorescu, MarcoLissere, P. Rodriguez, 2011, Wiley-IEEE Press, ISBN: 978-0-470-05751-3

Core Elective

High Voltage Engineering(EE4121)

Prerequisites:Physics,Basic Electrical Engineering, Power System

Weekly contact: 3 - 0- 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-hrs
01.	**Over-voltage Phenomena and Insulation-Coordination** Over-voltage and its impact on electrical power system. Over-voltage due to lightning, switching and other causes. Travelling wave theory, reflection and refraction of travelling waves. Protection against over-voltage. Principles of insulation-coordination inhigh and extra high voltage power systems.	**6L**
02.	**Breakdown in Dielectrics** **Breakdown in Gases:** Gases as insulating media, ionization processes, Townsend's theory of gas breakdown, Paschen's law, breakdown in electronegative gases, Streamer theory of breakdown in gases, breakdown in non-uniform fields and corona discharges, vacuum breakdown. **Breakdown in Liquids:** Liquids as insulators, pure liquids and commercial liquids, conduction and breakdown in pure liquids, conduction and breakdown in commercial liquids. **Breakdown in Solid Dielectrics:** Solid and composite-dielectrics, Intrinsic breakdown, Electromechanical breakdown, Thermal Breakdown, breakdown in voids.	**9L**
03.	**Generation of High Voltages and Currents** **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, Wave-shape Control, Multi-stage Impulse Generator – Triggering and Control mechanism Impulse Current: Circuits for producing Impulse Current	**9L**
04.	**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	**9L**
05.	**High Voltage Testing** **Non-Destructive Testing**: Measurement of Resistance, Measurement of Dielectric Constant and Loss Factor, High Voltage Schering Bridge, Measurement of Large Capacitances, Partial Discharges Measurement. High Voltage Testing of Electrical Equipment: High AC, DC and Impulse Voltage Tests, Testing of Insulators, Cables, Bushing, Circuit Breakers, Isolators and Transformers	**6L**
	Total:	**39L**

Text Books:

1. High Voltage Engineering, M. S. Naidu and V. Kamaraju, 5thEdition, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2015, ISBN: 9781259062896.

2. High Voltage Engineering, C.L.Wadhwa, New Age International Publishers, 3rd Edition, ISBN: 9788122430905.

3. High Voltage Engineering Fundamentals, E.Kuffel and W.S.Zaengl and J.Kuffel, Newnes Publication, Second Edition,

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2005, ISBN 0750636343.

Reference Book:

1. High-Voltage Engineering: Theory and PracticeMazen Abdel-Salam, Second Edition, CRC Press, 2019, ISBN 9780367398194

2. High Voltage Engineering, C.L.Wadhwa, New Age International Publishers, 3rd Edition, ISBN: 9788122430905.

New and Renewable Energy(EE4122)

Prerequisite: Basic Electrical Engineering and Fundamentals of Physics and Chemistry

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-Hrs
01.	**Introduction:** Concept of energy, energy scenario and conversion to electrical form, energy and society, energy and environment, necessity of non-conventional and renewable energy.	1
02.	**Solar energy**: Solar radiation and its characteristics, solar Geometry, Measuring solar radiation – Pyranometer, Pyheliometer, Sunshine recorder. Green house effects, Solar collector; - flat plate, focusing, water heating-natural circulation, forced circulation, Space heating – active and passive system, solar thermal energy storage, solar pond, Solar power plant.	7
03.	**Solar Photovoltaic 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
04.	**Wind energy**: Potential, development of wind turbines, wind electric system, wind pump, utilization and national scenario.	6
05.	**Microhydelenergy**: Potential, development of micro hydro-electric generators & auxiliaries. Non conventional [tidal, wave] hydro electric conversion system	5
06.	**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
07.	**Magnetohydrodynamics energy conversion**: Concept, present and future concept, economic and environmental aspects of MHD generator plant.	3
08.	**Bioenergy**: Resources and conversion process – biogas conversion, biogas plant, present gasfires and bio gas plants used in India, Ocean thermal energy conversion, fuel cell, electric and hybrid vehicles, space vehicles.	4
09	**Thermal energy:** Ocean thermal energy conversion, Geothermal Energy conversion	1
10	**Concept of micro grid**: the interfacing of renewable energy micro sources into the micro-grid, the smart grid and its relevance while using renewable energy sources.	3
11	**Rural energy security**: Hybrid system of renewable energy sources – necessity, implementation, national policy.	1
	Total:	39L

Text Books:

1. **Renewable Energy**, Bent Sorensen, 5th edition, Academic Press, ISBN:9780128045671
2. **Renewable Energy Sources and Energy Technology**, Kothari, Singal and Ranjan, 2nd edition , Prentice Hall India, ISBN:9788120344709
3. **Solar Energy**, S. P. Sukhatme, J. K. Nayak, 4th edition, Tata McGraw-Hill, ISBN: 9789352607112

Reference books

1. **Renewable Energy Resources**, J. Twidell and T. Weir, 2nd Edition, 2005, Taylor and Francis
2. **Renewable and efficient electric power systems**, G.M. Masters, 2nd edition ,John Wiley and Sons, ISBN: 9781118140628
3. **Renewable energy engineering and Technology**. V V N Kishore, 2010, TERI, ISBN 8179932214, 9788179932216
4. **Biofuels Engineering Process Technology,** Caye M. Drapcheo, N P Nhuan, T.H Walkar,1st edition, McGraw-Hill, ISBN: 9780071487498

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5. **Biohydrogen production: Fundamentals and Technology Advantages**, D. Das, N. Khanna , C. Nag, 1st edition, CRC Press, ISBN 9781138073203
6. **Solar Engineering of Thermal Processes**, J. A. Duffie and W. A. Beckman, 4th edition , John Wiley, New York, ISBN: 978-0-470-87366-3
7. **Principles of Solar Engineering**, D. Y. Goswami, F. Kreith and J. F. Kreider, 2nd edition, Taylor and Francis, Philadelphia, ISBN: 978-1560327141
8. **Biomass Regenerable Energy**, D. D. Hall and R. P. Grover,1987, John Wiley, New York
9. **Solar Cells**, M. A. Green, 1982 , Prentice-Hall, Englewood Cliffs.

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Illumination Engineering (EE4123)

Prerequisite: Fundamentals of Physics

Weekly contact: 3-0-0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name	No. of Lecture-hrs
1.	**Sources of light:** Day light, artificial light source; energy radiation, visible spectrum of radiation, black body radiation and full radiator.	5
2.	**Production of light:** Incandescence, dependence of light o/p on temperature. Theory of gas discharge.	5
3.	**Perception of light and colour:** optical system of human eye, eye as visual processor. Reflection, refraction and other behaviors of light. Mesopic Photometry	5
4.	**Measurement of light** — radiometric and photometric quantities and their units of measurement. Standardization, measurement of light distribution, direct & diffused reflection, fundamental concept of colorimeters and measurement of color.	7
5.	**Types of lamps**: GLS Tungsten —halogen, Discharge, low pressure sodium vapour, high pressure sodium mercury vapour, fluorescent, Metal- halide IR and UV lamps, their construction , filament material , theory of operation , life , characteristics and application Xenon Lamps, LED lamps, Fibre Optic and Laser Lighting	6
6.	**Design of Lighting:** Objectives and specification of lighting & system design of luminaire; their electrical circuits and auxiliaries. Basic Lighting Design Considerations and Lighting parameters for interior lighting, exterior lighting and day lighting	4
7.	**Other aspects of Lighting:** Design and Installation of Lighting Systems, Smart Control and Energy efficient lighting; the physiological effects of lighting ,	4
8.	A Case Study with Lighting design Software to learn an optimized design approach	3
	TOTAL	**39L**

Suggested Readings:

1. **Illuminating Engineering: From Edison's Lamp to the LED**, Joseph B. Murdoch, Visions Communication, ISBN1885750056, 9781885750051
2. **Human Factors in Lighting**, Peter Robert Boyce, 3rd Edition, Applied Science Publishers, ISBN 0853349126, 978085334912
3. **Road Lighting Fundamentals, Technology and Application,** Wout Van Bommel, Springer Publishers 978-3-319-11466-8

Web-resource:

1. **IESNA [www.iesna.org]** and **CIE[www.cie.co.at]** lighting design guidelines/ recommendation etc.
2. **NPTEL Lectures on Illumination Engineering**

Laboratory/Practical

Laboratory/Practical

Laboratory on "Digital Signal Processing and Embedded System" and Core Elective Papers

(EE4171)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subjects " Digital Signal Processing and Embedded System "(EE4101) and "Core Elective-I" (EE412x).

Core Elective-I

1. **High Voltage Engineering (EE4121)**
2. **New and Renewable Energy (EE4122)**
3. **Illumination Engineering (EE4123)**

Switchgear and Power System Protection Lab

(EE4172)

Class (0-0-3) (L-T-P) **Full Marks -50** **Credits: 2**

Laboratory experiments related to theoretical subject "Switchgear and Power System Protection "(EE3203).

B. Tech Project Part-1

(EE4191)

Weekly contact (0-0-2)(L-T-P) **Full Marks – 100** **Credits-4**

Each candidate or a group will be assigned a problem related to Electrical Engineering on which the candidate(s) will carry out preliminary work with literature review/study and/or analysis. The candidate will submit a brief report and present the project-work, and appear for viva-voce at the end of semester.

Internship Evaluation

(EE4192)

Weekly contact (0-0-0)(L-T-P) **Full Marks – 50** **Credits-2**

The student shall have to submit a report on the internship program (academic/industrial work/project/assignments) that the student has performed at the end of the SIXTH semester in any institute/organisation along with a copy of participation/endorsement certificate from the host institute/organisation, within one month from the commencement of the SEVENTH semester. The student as an individual or in a small group shall have to present their internship performance before a board of examiners duly constituted by the electrical Engineering Department for assessment. The seminar assessment may be done some time just before or after the mid-term examination of the SEVENTH semester.

Power System Planning and Reliability (EE4201)

Prerequisite: Probability theory & Power system-II

Weekly contact (3-1-0) (L-T-P) **Full Marks- 100** **Credits: 4**

Model No.	Module Name and Topics	No. of Lecture-hrs
1.	**Introduction** Basic planning and project planning, Tools and techniques for power system planning	2
2.	**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.	8
3.	**Planning Principles and Planning Criterion** Basics of planning, Voltage criteria, Loading and stability criteria	5
4.	**Generation Planning** Relationship between capacity reserve and reliability, Reliability technique, Cost evaluation technique, Capacity resource planning	3
5.	**Transmission and Distribution Planning** Selection of transmission corridor, Selection of voltage level for transmission and distribution,secondary distribution system, feeder and distributor, Reactive power planning,series and shunt capacitor, capacitor sizing, Rural electrification	5
6.	**Economic Planning** Objective of economic planning, Mixed economic, Rural electrification investment, Credit risk assessment, Rational tariffs	4
7.	**Tendering and Contracting** Objective, Project planning, Form of tendering, planning and design, General technical specifications, Tendering period and evaluation of tender	3
8.	**Reliability Analysis** Definition of reliability, reliability indices, outage classification **Reliability functions:** Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution – expected value and standard deviation of exponential distribution – Bath tub curve – reliability analysis of series parallel networks using exponential 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. **Distribution system reliability analysis:** Weather state modelling	9
	TOTAL	**39L+13T**

Text Books:

1. **Reliability Evaluation of Power Systems**, RoyBillinton 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

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3. **Electrical Power Systems Planning**, A. S. Pabla, 1st Edition,Macmillan India Ltd, 1998,ISBN: 0333930673)

Reference Books:

1. **Power System Planning**, R.L. Sullivan , McGraw Hill , 1977, ISBN-10: 0070618003
2. **Modern Power System Planning**, X. Wang & J.R. McDonald ,McGraw Hill ,1994,ISBN-10: 0077074149.
3. **New Computational Methods in Power system Reliability**, D. Elmakias, 1st Edition, Springer, 2008, ISBN-10: 3642096573.

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CORE ELECTIVE-II

Advanced Programming for Electrical Engineering (EE4221)

Prerequisites: Introduction to C Programming and Programming Environment

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No	Module Name and Topics	No. of Lecture-Hrs
1.	**Types of Data sharing:** Shared memory, Socket programming under UNIX/LINUX and C environment	**7**
2.	**Advanced topics in numerical computation:** Eigen value computations, Sparse Matrix, Ordering, Partitioning and relevant topics	**7**
3.	**Basic of Parallel processing:** Parallel Programming and Message Passing Interface (MPI)	**4**
4.	**Familiarisation 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.	**4**
5.	**Basic Network protocols for LAN & WAN:**TCP/IP services - DHCP, DNS, HTTP, SSL,Telnet, ftp and ssh	**3**
6.	**Web Base application development:** using HTML/ JAVA or some other advance scripting languages, concepts of digital certificates, signature etc.	**5**
7.	**RDBMS – Concept:** SQL — DDL, DML, DCL; concept of functions, triggers and PL/SQL	**9**
	Total:	**39L**

Text Books:

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**, Ivan Bayross, 4th revised edition, BPB Publications, ISBN: 9788176569644, 9788176569644

Soft Computing and Intelligent Systems (EE4222)

Prerequisite: Engineering Mathematics

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module name and topics	No. of Lecture-hrs
1.	**Introduction to Intelligent Systems and Soft Computing**: Need for intelligent systems and data driven approaches; Inspiration behind soft computing, difference between hard and soft computing, computational intelligence	**3**
2.	**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; Soft introduction to Convolution Neural Networks(CNN) and Recurrent Neural Networks(RNN)	**8**
3.	**Applications of Artificial Intelligence(AI) and ML:** Introduction to Python, Python basics and Tensor flow; Algorithmic development of intelligent systems with typical examples in electrical engineering	**8**
4.	**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 andfuzzy logic controllers	**6**
6.	**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**
7.	**Applications of Evolutionary Optimization Techniques** Development of**GA** and **PSO**based algorithms in typical electrical engineering applications	**4**
8.	**Hybrid Intelligent System:** Neuro-fuzzy, ANN-EA, Fuzzy-EA based inference systems, advantages and applications	**4**
	TOTAL	**39L**

Text Books:

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

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Digital Communication in Electrical Systems (EE4223)

Prerequisites: Basic courses on Digital Electronics, Microprocessors and Microcontrollers

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hrs
1.	**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)	**6**
2.	**Cabling and Interference**: Copper based cable, Coaxial cable, Twisted pair cable, Fiber optic cable, Definition of noise, Frequency analysis of noise, Source of electrical noise, Electrical coupling of noise, Shielding, Cable ducting, Cable spacing, Earthing and grounding requirement, Suppression techniques.	**4**
3.	**Serial Communication**: Different Protocols - RS 232C, RS 422, RS 485, 20 mA current loop, I2C, ZigBee, USB, Blue Tooth, Mobile Communication	**8**
4.	**Computer Communication**: Network Topologies, Basic concepts of LAN, Ethernet, Wireless LAN, Internet, TCP/IP, 7 layer OSI model, IoT.	**6**
5.	**Industrial Communication Interface**: MODBUS, CANBUS, PROFIBUS, HART, Field bus and Device Net system.	**5**
6.	**Applications in Power Engineering**: IEC 61850, Power Line Communication, Smart metering, other recent developments	**10**
	Total:	**39L**

Text Books:

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
   PDHonline Course E497 (3 PDH), Industrial Communications and Control ProtocolsBy Michael J. Hamill, P.E.
2. https://doi.org/10.1155/2017/9324035 Internet of Things: Architectures, Protocols, and Applications, PallaviSethi 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
6. https://nptel.ac.in/content/storage2/courses/106105080/pdf/M2L2.pdf
7. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106105081/lec20.pdf
8. https://nptel.ac.in/content/storage2/courses/108105057/Pdf/Lesson-26.pdf
9. https://nptel.ac.in/content/storage2/courses/106105080/pdf/M5L8.pdf

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10. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/106105166/lec12.pdf
11. https://www.swarthmore.edu/NatSci/echeeve1/Class/e91/Lectures/E91(10)Serial.pdf

Practical/Laboratory

B. Tech Project Part-2

(EE4291)

Weekly contact (0-0-2)(L-T-P) **Full Marks – 200** **Credits-8**

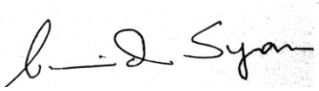
The work is primarily the continuation of the work undertaken as B.Tech Project Part-1 (EE4183). The candidate should work either alone or in groups as assigned by the Department in the seventh semester under B.Tech Project Part-1 (EE4183). Each group will submit project-report in printed and bound form. The report will embody the results of work and should include also the review work and further theoretical/experimental/simulation based studies. The purpose of this project-work is to intimate the candidate into realm of critical study.

Seminar

(EE4292)

The candidate will present a seminar on the B. Tech. project-work, and appear for viva-voce at the end of semester.

Syllabi of the Theory subjects taken from the M-Tech 2 years course in DD curriculum.



Modelling and Control of Physical Systems
(EE 5101)

Prerequisites: Signals and Systems basics, Control System basics, Advanced Engineering Mathematics

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hrs.
01	**Recapitulation:** State Space Modelling of SISO and MIMO systems (Assignments**)**. Examples-Power Systems Applications, Power Electronic Applications and Nonlinear Systems (Assignments). Solution to State Equations, State Transition Matrix, Time response, BIBO and Zero Input Stability, Diagonalisation, Block Jordan Form.	10
02	**Synthesis of Linear State Variable Feedback (LSVF) Controllers (SISO, LTI):** Controllability, Observability, Canonical Forms, Arbitrary Pole Placement, Design of Controllers – Case Studies- Examples form Power Systems, Power Electronics etc. Linearisation of Nonlinear State Equations. Controller design for linearised system. **Advanced Topics**: Integral LSVF Controller design with examples, MIMO Controller design.	7
03	**Synthesis:** Implementation of LSVF Controllers, Design of Observers, Estimation Error, Separation Principle, Numerical Examples. **Advanced Topics:** Design of Reduced Order Observers, Implementation, Examples.	4
06	**Introduction to Optimal Control:** Performance Index (PI) in Classical Control, Linear Optimal Control, Related Mathematics, Numerical Examples.	4
07	**Introduction to Artificial Neural Networks:** Basic Definitions, Activation Functions, Mathematical Model of a Neuron, Network Architectures, Basic Idea of Control with Neural Networks	4
08	**Introduction to Robust Control:** Basic Definitions, Robust Control Problems and Solutions. Other advanced Topics	4
09	**Case Studies:** Examples from Power Systems; Power Electronics; and other systems from Electrical Engineering	6
	Total:	**39L**

Suggested readings

1. Linear System Theory and Design, C. T. Chen, 3rd Edition, 1999.
2. Modern Control Theory, M. Gopal, Second Edition, 2005.
3. Automatic Control Systems, B.C. Kuo and F. Golnaraghi, 9th Edition, 2014.
4. Control Systems: Principles and Design: Gopal, Second Edition, 2002.
5. Digital Control and State Variable Methods: M. Gopal, Second Edition, 2003.
6. Optimal Control: Linear Quadratic Methods, Anderson and Moore, Dover Edition, 1990.
7. An Introduction to Neural Networks for beginners – Andy Thomas (https://adventuresinmachinelearning.com/wp-content/uploads/2017/07/An-introduction-to-neural-networks-for-beginners.pdf)
8. Multivariable Feedback Control: Analysis and Synthesis, Skogestad and Postlewaite, Second Edition, 2005.
9. Feedback Control Theory- Doyle, Francis and Tannenbaum, 1990.

Theory of Discrete and Digital Control Systems

(EE-5102)

Prerequisites: Signals and Systems, Control Systems and Discrete Time Systems

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hrs.
01	**Recapitulation of Discrete signals and Systems**: Discrete-time and sampled data system; Time invariant system response, Recursive solution; Discrete convolution; Digital simulation of analog system.	2L
02	**Sampling and Reconstruction of signals**: Impulse sampling; Frequency domain consideration; zero-order and first-order holds; Shanon's sampling theorem.	3L
03	**Z-transform and its application**: Z-transform analysis of sampled data system; Obtaining z-transform by convolution integral; Inverse z-transform; Mapping between s-plane and z-plane; Discrete-time transfer function; signal flow graph; Pulse transfer function using convolution sum; System with dead time/transportation lag; Modified z-transform; Bilinear transformation; Frequency pre-warping.	4
04	**Design of Discrete-time controller**: Time-domain specifications; Error constants for different discrete control configurations; Digital PID controller; Relationship with analog and digital controller parameters: Frequency responses; Realization of position and velocity form of discrete-time PID controller.	5
05	**Stability Analysis**: Jury's stability criterion; Schur-Cohn criterion; Routh's stability criterion; State variable representation of discrete time systems; controllability and observability. Canonical forms.	6
06	**Multirate and Skip sampling**: Skip sampled components; Transfer function of complex system with mixed sampling rates.	4
07	**Realization of discrete time systems**: Direct and Standard programming; Series, Parallel and ladder programming; errors in realization.	6
08	**Discrete and Truncated Fourier series**: Discrete and First Fourier Transforms; Digital Data transmission and digital modulation systems; Error control codes.	4
	Total:	**39L**

Suggested Readings:

1. **K. Ogata**- Discrete Time Control Systems, Prentice Hall Inc., 2e, © 2001.
2. **M. Gopal** - Modern Control System Theory, TMH, 2e, © 2005.
3. **B. C. Kuo** - Digital control systems, Oxford, 2e, © 2012.
4. **Landau, IoanDoré, Zito**, **Gianluca** - Digital Control Systems - Design, Identification and Implementation, Springer, © 2006.

Advanced Process Control & Instrumentation

(EE5103)

Prerequisite: Fundamentals of Control System and Instrumentation

Weekly contact: 3 - 1 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-Hrs.
01	**Some terminologies related to a process:** (i) Balanced Condition ii) Self regulation iii) Time Lag iv) Process disturbance v) Process reaction Curve	3
02	**Realisation of Control Actions**: Applying pneumatic, hydraulic and electronic principles	6
03	**Special Control Techniques** : Feed forward, cascade and ratio control	3
04	**Fluidics:** Fluidic devices, Fluidic devices, Coanda Action, Fluidic Oscillator, Bistable amplifier, Proportional amplifier	3
05	**Actuator and Control valves:** Operation and types of Actuator, Types of control valves and their working principles, Valve Characteristics, Rangeability and Turn down, Selection of valve for different process variables	6
06	**Special Sensors:** pH, flow sensor etc. Piezoelectric transducers	7
07	**Programmable Logic Controller:** Relay Ladder Diagram, PLC programming	7
08	**Industrial Buses:** Field bus, Profibus and Device Net systems	3
09	**Computer aided process control:** Distributed Control System, SCADA	4
10	**Thermal Power plant:** Instrumentation and Control	5
11	**Probable Research Direction based on the above topic:** Process Parameter Optimization Algorithm, Data-driven fault diagnosis and process Monitoring, Data mining in monitoring and knowledge discovery	5
	Total:	**52L**

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H.o.D, EE

Suggested Readings:

1. S. Bhanot – Process Controls : Principles and Applications ; Oxford Higher Educations, 2008
2. B. G. Liptak – Instrumentation Handbook.CRC Press,4th Edition, 2003
3. D. M. Considine – Instrumentation Handbook. 1993
4. D. Patranabis – Sensors and Transducers; PHI Learning Private Limited, 2013
5. J. W. Webb & R. A. Reis – Programmable Logic Controllers; Prentice Hall India. 2003
6. J Park, S. Mackay & E Wright – Data Communication for Instrumentation & Control; Newnes 2003

Advanced Power System Analysis

(EE5104)

Prerequisite: Power Systems

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-Hrs.
01	**Introduction:** Incidence Matrix and Loop Matrix	3
02	**Formation of Y-bus and Z-bus matrix:** Y-bus matrix without and with transformer, Y-bus matrix modification with addition and deletion of branch, Y-bus for large network, Z-bus matrix, Addition of a branch or link, Modification of Z-bus, Direct building of Z-bus, Power invariant transformation, Application of computer methods (Gaussian Elimination, Triangular factorization method)	6
03	**Network Modeling:** Balanced and Unbalanced excitation, Modeling of network elements, Transformation matrices, Diagonalization	4
04	**Short Circuit Studies:** Fault current and voltages, Short Circuit calculations for balanced network using Z-bus, Fault analysis (3-phase, L-G, L-L, L-L-G) using Z-bus algorithm	7
05	**Load Flow Studies:** Review of Load Flow Methods (GSLF, NRLF, DCLF and FDLF), Sparsity and near optimal ordering, Sparse matrix storage techniques, Matrix Decomposition	7
06	**Contingency Analysis:** Addition and deletion of transmission lines, generators and loads. Current Injection Distribution Factor (CIDF) and Line Outage Distribution Factor (LODF), Single and multiple contingencies	6
07	**State Estimation and Load Forecasting:** Fundamental concept, Basic methods of State Estimation, External system equivalencing, Bad data detection and suppression, Observability, Load Forecasting Techniques	4
08	**Current Topics:** Restructuring of power system, distributed generation, open access market	2
	Total:	**39L**

Suggested Reading:

1. Grainger J.J. and Stevenson W.D., Power System Analysis, McGraw Hill Education, 2003
2. Kothari D.P. and Nagrath I.J., Modern Power System Analysis, McGraw Hill, Education, 2003
3. Singh L.P., Advanced Power System Analysis, Wiley Eastern, India
4. Chakrabarti A. and Haldar S., Power System Analysis, Operation and Control, PHI India.
5. Stagg and El-Abiad,Computer Methods in Power System Analysis, McGraw Hill. 1968

Power System Operation and Control

(EE5105)

Prerequisite: Power Systems

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-Hrs.
01	**Introduction:** Structure and Representation of a Power System, Necessity of Control and Control Methods, Types of Control, Common Operating Problems, Operating States, Use of Computer Control and Modern Methods in Power System Operation and Control, SCADA system	5
02	**Economic Operation and Unit Commitment:** Input/Output characteristics of unit, Incremental cost curves , Constraints in economic operation, Analytical approach to determine economic operation criterion with and without network losses for thermal plants, thermal plant scheduling, Transmission loss allocation and penalty factor, Hydrothermal scheduling (Long Range and Short Range with and without network losses), Scheduling of hydraulically coupled unit, Scheduling of pumped storage plants, Concept of unit commitment and solution methods, Computer application in economic dispatch	11
03	**Automatic Generation Control:** Types of exciter, AVR loop and its static and dynamic performance, Automatic Load Frequency Control (ALFC), Primary ALFC loop and secondary ALFC loop model, Static and dynamic performance of ALFC Loop, Two area control, Optimal control concept in ALFC, Optimal Line Regulator (OLR) design	10
04	**Sub Synchronous Resonance (SSR):** Introduction to SSR, Torsional interaction, Eigen value analysis, Modern topics	3
05	**Power System Compensation and FACTS Devices:** Operation of transmission line during no-load and heavy loading condition, Voltage regulation and Maximum Power Transfer in uncompensated line, Concept of SIL and Line Loadability, Passive compensators, FACTS devices	7
06	**Power System Economics:** Tariffs, Concept of Deregulation, Power Pool and Service Operator, Network Restructuring, Congestion Management and Electricity Pricing	3
	Total:	**39L**

Suggested Reading:

1. Wood A.J., Woolenberg, Power Generation Operation and Control, John Wiley and Sons Inc, USA.
2. Chakrabarti A. and Haldar S., Power System Analysis, Operation and Control, PHI India
3. Kothari D.P. and J.S. Dhillon, Power System Optimization, PHI, New Delhi
4. Mahalanabis A.K., Kothari D.P. and Ahson S.I., Computer Aided Power System Analysis and Control, McGraw Hill, India

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H.o.D, EE

Power Transmission and Power Quality

(EE5106)

Prerequisite: Power Systems & Power Electronics

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-Hr.
01	**EHVAC Transmission**: Review of Basic Concepts, Surge Impedance loading of EHV Lines and its implication, operation of EHV Line during no-load and heavy loading condition, Maximum Power Transfer, Line Loadability, Implication of Voltage Regulation, Stability aspects and line length limitation, Line Congestion. Protection Sub- systems(ATP).	6L
02	**Reactive Power Compensation in EHVAC lines**: Shunt inductive and Capacitive compensation, series compensation, Comparison between shunt and series compensation, role of location of series capacitor and effect of capacitor busing arrangement, synchronous condenser, Fundamentals of FACTS Devices, Classification, Types of Series FACTS controllers (SSSC, TCSC and TCSR), Types of Shunt FACTS controllers (SVC, SSG, STATCOM), Combined Shunt- Series FACTS Controllers (SPS, UPFC), Advantages of FACTS devices.	10L
03	**Power Electronic Converters and HVDC Transmission:** Review of Concept of Controlled Rectification, 3- Phase Controlled Rectifiers, Thyristor Protection Devices, Poly-phase Converter Expressions, 6-Pulse and 12-Pulse Configurations, Effect of Source Inductance, Rectifier Transformer Rating, Principle of Inversion, Necessity of Filters, IGBT Converters, Advantages and Disadvantages of HVDC Transmission, HVDC System Configuration, HVDC Control (Basic requirements, control characteristics, selection of controls), HVDC line and line reactors, HVDC Terminal Equipments, HVDC System Protection, Modeling of HVDC systems, MTDC System, Current Topics	8L
04	**Power Quality:** Concept of Quality of Power in utility industries, Role of harmonics in Power Quality, Representation and Characteristics of Harmonics in Power Systems, Computation of Harmonic Distortion, Sources of Harmonics in Transformers, Rotating Machines, Power Systems, Role of Power Electronic Converters in generation of harmonics, Implication of harmonic distortion on Thermal losses, Core losses, and dielectric losses, Effect of harmonics on Power system equipments, Power Quality Measurement, Power system harmonics mitigation, Current Topics	15L
	Total:	**39L**

Suggested Reading:

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H.o.D, EE

1. Adamson and Hingorani, High Voltage Direct Current Power Transmission, Garraway, London
2. Arrillaga J., HVDC Transmission, Peter Peregrinus, London
3. Gonen T., Electric Power Transmission System Engineering, John Wiley
4. Chakrabarti A., Power System Dynamics and Simulation, PHI
5. Heydt. G.T., Electric Power Quality, Circle Publications
6. Ghosh A and G. Ledwich, Power Quality Enhancement Using Custom Power Devices, Kluwer Academics

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H.o.D, EE

Advanced Power Electronics
(EE5107)

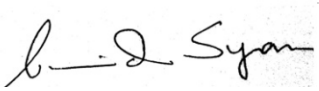
Prerequisite: The course on basic power electronics

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Introduction:** Review of existing solid state power devices. Quadrant operation of devices. Modern solid state devices (GaN and SiC), special driver circuits, SOA and switching trajectory, losses in power electronic devices, pulse transformer.	8
02	**DC-DC converters:** Discontinuous conduction, 2-quadrant and 4-quadrant DC-DC converters. Forward, flyback, push-pull, half-bridge and full-bridge topologies and their open-loop control. Dynamic modeling of DC-DC converters and closed loop control, efficiency issues of DC-DC converters.	9
03	**AC-DC converters:** Review of diode based and thyristor based rectifiers, discontinuous conduction, effect of source inductance, effect on AC side, efficiency issues of rectifiers..	3
04	**DC-AC conversion:** Single phase and three phase inverters, concept of space vectors, analysis of 2-level inverters with Sine-PWM and Space vector pulse width modulation. Concept of current source inverters, efficiency issues of inverters. .	8
05	**AC-AC conversion:** Review of cycloconverters, matrix converters.	6
06	**Passive components:** Magnetics and capacitors for PE applications, design of heat sink for dissipation of losses	5
	TOTAL	**39L**

Suggested Readings:

1. N. Mohan, T. M. Undeland and W.P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
2. C. W. Lander, "Power Electronics", McGraw Hill Book Co, 1987.
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics, 2nd Edition", Kluwer Academic Publishers, New York, 2001.
4. M. H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall, Pearson Education, 2014.
5. G. K. Dubey, S. R. Doradla, A. W. Joshi, R. M. K. Sinha, "Thyristorised Power Controllers", Wiley, 1986.
6. A. I. Pressman, K. Billings, T. Morey, "Switching Power Supply Design", 3rd Edition, McGraw-Hill, 2009.
7. Modern research literatures



H.o.D, EE

Generalized Theory of Electrical Machines
(EE5108)

Prerequisites: Courses on electrical machines and basic power electronics

Weekly contact: 3 – 0 – 0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Introduction:** Review of coupled circuits, electro-mechanical energy conversion basics, energy and co-energy, concept of virtual work and electromagnetic torque production, origin of reluctance torque.	4
02	**Generalized machine theory and reference frame theory: Assumptions behind the theory, Park's transformation, Clarke's transformation.**	4
03	**Transformations: D**ifferent types of d-q transformation used in modern research literatures, stationary, rotor, synchronously rotating and arbitrarily rotating reference frame, mathematical relationships existing between above reference frames, torque and motional impedance matrices.	5
04	**Application of the theory on induction machines:** Transient and steady state modeling and analysis of 3-phase induction machine in terms of above reference frames, case studies showing applications, equivalent circuits.	6
05	**Application of the theory on synchronous machines:** Transient and steady state modeling and analysis of 3-phase wound-field synchronous machine in terms of above reference frames, case studies showing applications, equivalent circuits, steady state and transient/sub-transient operations of synchronous machines	7
06	**Generalized theory applied to D.C. and cross field machines:** **a) Introduction:** Adaptability of the theory, transformations, equation for small changes, short circuit studies on D.C. separately excited generator, rototrol, shunt generator, block diagrams. **b) Analysis with emphasis on saturation:** Expressions of voltage build up, effect of saturation, Froelich & Rudenburg graphical analysis, measurement of parameters. **c) Control applications of D.C. machines**: Ward Leonard method, cross field machines, rotating amplifiers.	5 4 4
	TOTAL	**39L**

Suggested Readings:

1. Denis O' Kelley, S. Simmons, "Introduction to generalized electrical machine theory", McGraw-Hill, 1968.
2. Paul Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven Pekarek, "Analysis of Electric Machinery and Drive Systems", 3rd Edtion, IEEE Press, 2013.
3. B. Adkins and R. G. Harley, "The General Theory of Alternating Current Machines: Applications to Practical Problems", Springer Science and Business Media, B. V, 1978.
4. Modern research literatures

H.o.D, EE

Optimal And Robust Control Theory

(EE5201)

Prerequisites: EE 5101, Matrices, Linear Algebra, Integration, Ordinary Differential Equations

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits:3**

Module No.	Module Name and Topics	No. of Lecture-Hrs.
01	**Introduction to Calculus of Variations:** Euler's Equation. Legendre's Condition, Conditional Extremum Problems; Examples. **Advanced topics**: Transversality Conditions, Sufficient Conditions for an extremum.	**10**
02	**Quadratic Forms:** Solution to Lyapunov Equation, Stability of unforced linear state equations	**4**
02	**Linear Optimal Control:** Linear Quadratic Regulator Problem; State Feedback Solution; LTI Infinite Horizon problem; Algebraic Riccati Equation (ARE); Hamiltonian Matrix; Numerical Design Examples.	**7**
03	**Robust Control:** Robust Control Problems; H_2 Control; H_∞ Optimization; Standard Problem; Different configurations; Solution; Numerical Examples.	**7**
04	**Linear Matrix Inequalities:** Definition of Convexity, Convex Optimization, LMIs; Formulation of standard optimization problems as LMIs; Numerical Examples.	**6**
06	**Case Studies:** Study of standard benchmark problems; Design Examples..	**5**
	Total:	**39L**

Suggested Readings:

1. Variational Methods in Optimum Control Theory – I. Petrov, 2012.
2. Optimal Control: Linear Quadratic Methods, Anderson and Moore, Dover Edition, 1990.
3. Robust Control Systems: Theory and Case Studies – U. Mackenroth, 2004.
4. Feedback Control Theory – J. C. Doyle, B. Francis and A. Tannenbaum, 1990.
5. Multivariable Feedback Control: Analysis and Synthesis, Skogestad and Postlewaite, Second Edition, 2005.
6. Linear Matrix Inequalities in System and Control Theory – Boyd, El Ghaoui, Feron and Balakrishnan (https://web.stanford.edu/~boyd/lmibook/lmibook.pdf)
7. A Course in Robust Control Theory: A Convex Approach – G. E. Dullerud and F. Paganini, 2000.
8. Linear Matrix Inequalities in Control – C. Scherer and S. Weiland
9. (http://www.eeci-institute.eu/pdf/M012/lec1.pdf)
10. Essential of Robust Control – K. Zhou and J. C. Doyle, 1999.

Signal and Image Processing for Instrumentation and Control

(EE 5202)

Prerequisite: Engineering Mathematics

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hrs.
01	**Signal Transforms:** Ortho-normal vector and functional space, Fourier transform, Fourier series, Generalized Fourier transform property and convolution theorem Hilbert Transform, Hilbert-Huang Transform,Discrete Cosine Transform (DCT), Discrete Sine Transform (DST), Short Time Fourier Transform (STFT)	12
02	**Wavelet Transform:** Method , Different variety Properties, Applications to Instrumentation and control	7
03	**Mathematical Preliminaries of signal processing**: Spectral Representation and Analysis, Sparse Signal Processing, Blind Signal Processing	5
04	**Image processing fundamentals:** Steps in Image processing, Components of an image processing system, Image sampling and quantization, Image representation, Image description. Noise models, Color image processing.	7
05	**Image Processing Applications:** Image enhancement in spatial domain, Image enhancement in frequency domain, Image restoration, Image compression, Morphological image processing, Image segmentation	8
	Total	**39L**

Suggested Readings:

1. Truong Nguyen & Gilbert Strang, - Wavelets and Filter Banks, Wellesley-Cambridge Press. 1996
2. K. R. Rao and P. Yip- Discrete Cosine Transform: Algorithms, Advantages, Applications, Academic Press, 1990
3. Khalid Sayood- Introduction to Data Compression, Elsevier, 2006
4. Gilbert Strang, Nelson Engineering-Linear Algebra and Its Applications, 1986
5. Rafael C Gonzalez, Richard E Woods-Digital Image Processing, Pearson Education, 2008
6. A.K. Jain- Fundamentals of Digital Image Processing, PHI, 2004
7. R.C. Gonzalez, R.E. Woods, and S. L. Eddins- Digital Image Processing using MATLAB, Pearson Prentice-Hall, 2009
8. J. R. Parker, Wiley and Sons-Algorithms for Image Processing and Computer Vision,2011

Optimal Filtering and Stochastic Processes

(EE5203)

Prerequisites: Control Systems, Statistics, Random Variables

Weekly contact: 3 - 0 - 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Basics of Stochastic Processes:**Langevian Equation, White noise process and Wiener noise process.	2L
02	**Probability and Random Variables:** Probability Distribution and Densities; Expectancy & Moment; Function of RV; Mean, Correlation, Covariance, Standard Deviation.	3L
03	**Random Processes and Sequences**: Brownian, Ergodic, Markov and Gaussian processes and sequences; Linear System model of Random Processes and sequences; Stochastic differential equations and stochastic integrals, Kolmogorov equations; Orthogonality principle	4L
04	**Estimation Techniques:** Least Square Estimation; Grammian Matrix &Observability: Weiner Filter;The AR and ARMA Model.	3L
05	**Kalman Filter:** Computational Origin, Description of Noise processes; Discrete-time Kalman Filter algorithms; Filter equations and their significances; Alternative form of Discrete Kalman algorithm; Deterministic Least Square Estimation and Kalman Filtering; Stability with Kalman Filter; Kalman-Bucy Filter.	7L
06	**Non-linear Application of Kalman Filter:** Linearized and Extended Kalman Filter Algorithms. Gaussian Sum estimation;Unscented Kalman Filter; General Optimal Filtering, FIR and IIR case.	6L
07	**Practical Implementation Considerations**: Predicted and unpredicted non-convergence problems and remedies; Bad-data problem. Round-off error etc.	2L
08	**Filtering, Prediction and Smoothing**: Fixed point, fixed lag and fixed interval smoothing: Maximum Likelihood Estimator, Particle Filter.	3L
09	**Control of Stochastic Processes**: LQ Theory, LQR Problem, LQG Problem, LQ estimator and LQ optimization of controller, Separation Principle, Discrete time LQG problem, LQG controller design for a regulator problem. Robustness of LQG controllers, Disturbance Modelling – Augmented model of systems.	7L
10	**Examples of Stochastic Processes:** Physiological System, Room temperature control, Inventory Control, market economic process etc.	2L
	Total:	**39L**

H.o.D, EE

Suggested Readings:

1. Grewal & Andrews, Kalman Filtering, Prentice Hall, 2e, © 1993.
2. Grewal & Andrews, Kalman Filtering: Theory and Practice with MATLAB, - Wiley, 4e, © 2015.
3. R. E. Kalman, "A New Approach to Linear Filtering and Prediction Problems", *Transactions of ASME – Journal of Basic Engg*., Vol 82, *pp*.35-45, March 1960.
4. R. E. Kalman and R. S. Bucy, "New Results in Linear Filtering and Prediction Theory", *Transactions of ASME – Journal of Basic Engg*., Vol 83, *pp*.95-107, December, 1961.
5. M. Athans, "The Role and Use of Stochastic Linear-Quadratic-Gaussian Problem in Control System Design"; IEEE *Transactions on Automatic Control, Special issue on LQG Problem,* Vol AC-16, No. 6, *pp*.529-552, December 1971.
6. B. D. O. Anderson and J. B. Moore; Optimal Control : Linear Quadratic Methods, PHI, New Delhi, © 2007.
7. T. Glad, L. Ljung; Control Theory: Multivariable and Nonlinear Methods, 1e, Taylor and Francis, © 2000.

Advanced Power System Protection
(EE5204)

Prerequisite: Power System Protection

Weekly contact:3 – 0 – 0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name and topics	No. of Lecture-Hr.
01	**Circuit Breaker:** Review of concepts, Current chopping, Breaking of capacitive current, Rating, Testing and Selection of Circuit Breakers, HVDC Circuit breaker	3
02	**Philosophy of Differential Protection:** Principles of Differential and Percentage Differential Relay, Pilot Relaying, Circulating Current and Opposed Voltage Type Relaying, Carrier Current and Microwave Pilot Relaying	3
03	**Philosophy of Distance Protection:** Impedance Relay, Reactance and Admittance Relay - their characteristics and uses, Modified Distance Relays, Transmission Line Protection using Distance Relays	3
04	**Generator Protection:** Circulating Current Differential Relay, Stator Earth Fault Relay, Restricted Earth Fault Relay, Rotor Earth Fault Relay, Loss of Excitation Relay, Reverse Power Relay, Negative Sequence Protection Relay, Back up Relaying.	4
05	**Transformer Protection:** Circulating Current Differential Relay, Over Current and Earth Fault Protection, Over Fluxing Protection, Incipient Fault Protection	3
06	**Bus bar Protection:** Differential and Back up Protection	2
07	**Motor Protection (Large and Medium Size):** Differential Protection, Short Circuit and Overload Protection, Under Voltage Protection, Earth Fault Protection, Locked Rotor Protection, DC Motor Protection	3
08	**Capacitor Bank and Reactor Protection:** Short Circuit, Over Current, Differential and Earth Fault Protection	2
09	**System Protection Requirements:** Annunciation and Indication, Tripping and Control Circuit, Interlocking, Co-ordination of Protection Devices, Signal Derivation, Transient Characteristics, System Behaviour and Protection during Power Swing, Under Frequency and Islanding	3
10	**Digital Protection and PMU Based Measurements:** Two and Multi-input Comparator, Phase and Amplitude corrections, Types of Comparators, Practical Realization of Modern Relay Characteristics, Switched and Polarized Protection Systems, , Signal Processing Techniques for Digital Protection, Numerical Relays and Development of Relaying Algorithms ; Concept and Application of Adaptive Relaying, **Substation Automation**; Synchronized Phasor Measurement Unit and its Role in Wide Area Monitoring System for Enabling the Smart Grid.	13
	TOTAL	**39L**

Date:07/07/2020 Last modified on 13_07_2020

H.o.D, EE

Suggested Reading:

1. Synchronized Phasor Measurements and Their Applications, A.Phadke, J Thorp, Springer Publishers ISBN: 9781441945631, 1441945636
2. Digital Protection for Power Systems A.T Johns, S.K. Salman, Publisher IET, 1997 ISBN-13:9780863413032
3. Digital Signal Processing in Power System Protection and Control, Waldemar Rebizant Janusz Szafran, Andrzej Wiszniewski, Springer-Verlag London Limited 2011.

Power System Stability, Security and High Voltage Engineering (EE5205)

Prerequisite: Power Systems

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits: 3**

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Review of Stability:** Steady State and Transient State Stability and Security, Stability Limits, Criterion for determination of Steady State and Transient Stability Limits, Swing Equation and Methods of Solution, Critical Clearing Time	4L
02	**Transient Stability:** Transient Stability Study in multi-machine power network, Development of Computer Algorithms in Transient Stability study, Modern Concepts	6L
03	**Small Signal Stability:** Nature of oscillations and modes, Concept of Small Signal Stability, Eigen properties of system matrix, Small Signal Stability modeling of a Single Machine Infinite Bus system (SMIB), State Space model, Role of Excitation systems, Application of Power System Stabilizer, Modern Topics	7L
04	**Voltage Stability and Security:**Role of Reactive power on Steady State Operation, Voltage to Reactive Power Sensitivity, Concept of Voltage Stability, Voltage Collapse and Voltage Security, Receiving end bus voltage and Critical Angle at Voltage Stability Limit, Fast Voltage Stability index, Line Voltage Stability Index, Line Quality Factor, Direct Indicator of Voltage Stability, L-Index, Global Voltage Stability Indicator, Modal Analysis in Voltage Stability, Modern Topics	9L
05	**High Voltage Engineering:** **a)** Dielectric Breakdown, Surface and Partial Discharges.Breakdown phenomena in Solid, Liquid and Gaseous dielectrics. Essential properties of dielectric materials for use in Power Equipment.	5L
06	**b) G**eneration of High AC, DC and Impulse Voltage for Dielectric Testing. High-voltage Testing transformer, Cascaded transformer, Resonant transformer, Marx generator.	5L
07	**c)** Over-voltage phenomena and Insulation-Coordination	3L
	TOTAL	**39L**

Suggested Reading:

1. Grainger and Stevenson, Power System Analysis, McGraw Hill, India.
2. Kothari and Nagrath, Modern Power System Analysis, McGraw Hill
3. Taylor C.W., Power System Voltage Stability (EPSR), McGraw Hill, USA.
4. Chakrabarti A., Kothari D.P., Mukhopadhyay A.K., De A., Reactive Power and Voltage Stability of EHV Power Transmission System, PHI
5. P. Kundur, Power System Control and Stability
6. E.Kuffel and W.S. Zaengl, J.Kuffel, "High Voltage Engineering Fundamentals", Newnes, Second Edition, Elsevier, 2005.

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7. C. L. Wadhwa, "High voltage Engineering", New Age International Publishers, Third Edition, 2010
8. L. L. Alston, "High Voltage Technology", Oxford University Press, First Indian Edition 2011.
9. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", 4th Edition, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2009.

Smart Grid Technologies and Energy Informatics
(EE5206)

Prerequisite: Power Systems

Weekly contact: 3 – 0 – 0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Introduction to Smart Grids:** Definition, justification for smart grids, smart grid conceptual model, smart grid architectures, Interoperability, communication technologies, role of smart grids standards, intelligent grid initiative, national smart grid missions by Govt. of India	5
02	**Smart Transmission Technologies:** Substation automation, Supervisory control and data acquisition (SCADA), energy management system (EMS), phasor measurement units (PMU), Wide area measurement systems (WAMS), role of Communication and Information Technology(ICT)	5
03	**Smart Distribution Technologies:** Distribution automation, outage management systems, automated meter reading (AMR), automated metering infrastructure (AMI), fault location isolation and service restoration, Outage Management Systems, Energy Storage, Renewable Integration	6
04	**Distributed Generation and Smart Consumption:** Distributed energy resources, smart appliances, low voltage DC distribution in homes / buildings, home energy management system, Smart Metering, Building to Grid B2G, Vehicle to Grid V2G, Solar to Grid, Micro grid	6L
05	**Regulations and Market Models for Smart Grid:** Demand Response, Demand side Management, Tariff Design, Time of the day pricing, Critical Peak Pricing, Time of use pricing, Consumer privacy and data protection, consumer engagement.	4
06	**Introduction to Energy Informatics:** Energy, sustainability and climate change, Green IT : policy and standards, Green IS , Energy efficiency design principles, Energy efficient logistics, farming, transportation, buildings , Energy system modelling	7
07	**Data Driven Energy Management System:** Processing energy data streams :Big Data-driven smart Energy Management Systems, Data analytics for energy-cost efficient system operation.	6
	TOTAL	**39L**

Suggested Reading:

1. Stuart Borlase. "Smart Grid: Infrastructure Technology Solutions" CRC Press, **2017**
2. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE,**2011**.
3. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press, **2009**.
4. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley **2012**.
5. A.G.Phadke , "Synchronized Phasor Measurement and their Applications", Springer, **2017**

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6 .James Momoh, “Smart Grid: Fundamentals of Design and Analysis” – Wiley, IEEE Press, **2012**.
7. H. Lee Willis, Walter G. Scott, “Distributed Power Generation – Planning and Evaluation”, Marcel Dekker Press, **2000**
8. India Smart Grid Knowledge Portal
9. Information Systems and Environmentally Sustainable Development : Energy Informatics and New Directions for the IS community, by R. T. Watson et al., MIS Quarterly, **2010**
10. Advances and New Trends in Environmental and Energy Informatics, by J. M. Gomez et. al., Springer,2014
11.Energy Informatics: Fundamentals and Standardizations, by B. Huang et al., ICT Express(Elsevier), **2017**

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Advanced Electrical Drives
(EE 5207)

Prerequisite: Advanced Power Electronics (EE – 5107), Generalized Machine Theory (EE-5108), a basic course on electric drives

Weekly contact: 3 – 0 – 0 (L- T- P) **Full Marks-100** **Credits:3**

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Introduction:** Review of two-loop control of adjustable speed DC drives, speed and current loop design, multi-quadrant control of DC drives	6
02	**Induction motor (IM) drives:** Review of **s**olid state scalar V/f control of 3-phase induction motors (IM based VFD's). CSI-fed cage IM drives, comparison with VSI-fed drives, details of field-oriented control and direct torque control. Detailed analysis of wound rotor IM drives – chopper based control of rotor, Scherbius drives.	15
03	**Wound-field Synchronous motor drives:** Synchronous motor as a variable speed motor – true-synchronous mode and self-synchronous modes of operation, soft-starting of large synchronous motor drives from weak grids,LCI-fed synchronous motor drive, its performance comparison with VFD-fed synchronous motor drive, vector control of synchronous motors. (PMSM machines and drives are discussed in the other core course, 'Selected Machines on Electric Vehicle and Wind Power Applications'.)	9
04	**Switched reluctance motor drives**: Introduction, power converter circuits, control methodologies, analysis.	5
05	**Sensorless AC motor drives:** Role of sensors in motor drives, sensorless operation of AC drives and techniques.	2
06	**Special Industrial perspective of AC drives:** Energy efficiency of AC drives, effects of PWM switching on motors – issues related to dv/dt stress, effects of partial discharge and corona on machine insulation, effects of bearing currents, effects of vibration and noise, possible remedial measures	2
	TOTAL	**39L**

Suggested Readings:

1. G. K. Dubey, "Fundamentals of Electric Drives", Narosa Publishing House, 2003.
2. G. K. Dubey, "Power Semiconductor Controlled Drives",Prentice Hall, 1989.
3. B. K. Bose, "Power Electronics and AC Drives", Prentice Hall, 1986.
4. J. Murphy and F. G. Turnbull, "Power Electronic Control of AC Motors",Pergamon Press, 1988.
5. Krishnan Ramu, "Switched Reluctance Motor Drives", CRC Press, 2001.
6. T.J.E Miller, "Switched Reluctance Motors and their control", Magna Physics Publishing, Oxford Science Publications, 1993.
7. Modern research literature

Special Topics in Power Electronics
(EE 5208)

Prerequisite: Advanced Power Electronics (EE 5107) and Generalized Theory of Electrical Machines (EE 5108)

Weekly contact: 3 – 0 – 0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Digital signal based control of Power Electronic Installations**: For electrical machine drives and for applications – interfacing, generation and sequencing of trigger pulses, sensing issues, applications to different types of solid state power converters, monitoring and signaling, DSP and FPGA applications.	12L
02	**Soft-switched Converters:** Resonant converters, synchronous link converters, hybrid resonant link converters, quasi-resonant link inverters.	8L
03	**Special topics:** Multilevel inverters, Active filters, power electronic converters for induction heating and welding applications	8L
04	**Converters for electrical power systems:** STATCOM and UPQC	6L
05	**Converters for distributed generation:** Power Electronics-related issues in Wind energy applications, micro-hydel and PV-based power conditioning and grid integration.	5L
	TOTAL	**39L**

Suggested Readings:

1. Hamid Toliyat and S. G. Campbell, "DSP-based Electromechanical Motion Control", CRC Press, 2003.
2. N. Mohan. T. M. Undeland and W. P. Robbins, "Power Electronics – Converters, Applications and Design", 2nd Edition, John Wiley & Sons, 1995.
3. N. G. Hingorani, L. Gyugyi, "Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems" IEEE Press, 2013.
4. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", 2nd Edition, John Wiley & Sons, 2013.
5. Bin Wu, Mehdi Narimani, "High-Power Converters and AC Drives", John Wiley & Sons, 2016.
6. S. Zinn& S. L. Semiatin, "Elements of Induction Heating: Design, Control, and Applications", ASM International & EPRI, 1988.

Selected Machines for Electric Vehicle and Wind Power Applications (EE 5209)

Prerequisite: Generalized Theory of Electrical Machines (EE 5108)

Weekly contact: 3 – 0 – 0 (L- T- S) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hrs.
A. Permanent Magnet Synchronous Machines for Electric Vehicle(EV) applications:		
01	Introduction, principle of operation, outline of Permanent Magnet (PM) materials	2
02	Steady state and dynamic model and equivalent circuit of PMSMs, magnetic circuit.	3
03	Construction, classification and types, comparison between PMSM and BLDC machines	2
04	Special requirements of EV power-train components, review of DC series motors with their advantages and disadvantages, PMSM and BLDC motors and drives for EV applications, their similarities and differences, converters topologies.	4
05	Drive Control strategies viz., vector control (VC), maximum torque per ampere (MTPA) control and direct torque control (DTC).	11
06	Effects of these motor drives on the EV battery, battery power and energy density issues.	2
B. Doubly-fed induction machines (DFIM) for wind power applications:		
01	Steady state operation – equivalent circuit in a-b-c frame, operating modes with respect to speed and power flows, active and reactive power exchanges, steady state characteristics, design requirements for the DFIM in wind energy generation applications.	4
02	Dynamic modelling in α-β and d-q reference frames.	2
03	Introduction to a wind energy generating system – Wind energy and wind turbine fundamentals, fixed speed wind energy conversion systems, variable speed wind energy conversion systems, Variable Speed Wind Energy Generation System based on DFIM, Maximum power point tracking for grid-connected DFIG.	4
04	Drives for grid-connected DFIM, vector control of DFIM from rotor side, startup of the DFIM for grid-connected applications	5
	TOTAL	**39L**

Suggested Readings:

1. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", 2nd Edition, Wiley, paperback, 2010.
2. K. Venkataratnam, "Special Electrical Machines", University Press (India) Pvt. Ltd., Hyderabad, India, 2009.
3. J. R. Hendershot Jr. and T. J. E. Miller, "Design of Brushless Permanent-Magnet Motors", Magna Physics Publishing and Clarendon Press, Oxford 1994.
4. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, Taylor and Francis Group, Boca Raton, USA, 2010.
5. Gonzalo Abad, Jesus Lopez, Miguel Rodriguez, Luis Marroyo, Grzegorz Iwanski, ",Doubly Fed Induction Machine: Modeling and Control for Wind Energy Generation", WILEY-IEEE Press, USA, 2011.
6. Modern research literatures

Nonlinear Control System

(EE5222)

Prerequisite: Fundamentals of Control System and Engineering Mathematics

Weekly contact: 3 – 0 – 0 (L-T-P) **Full Marks- 100** **Credits: 3**

Module No.	Module Name and topics	No. of Lecture-Hr.
01	**Classification of Nonlinear Phenomena:** Saturation, Dead-zone, Backlash, Hysteresis, Limit Cycle, Multiple isolated equilibrium, Finite Escape Time, Sub harmonic /Harmonic Oscillations, Chaos and Bifurcation	4
02	**Types of Systems:** Autonomous, Non autonomous, Time invariant and Time varying	1
03	**State space Approach to Nonlinear System**: Inverted Pendulum and Orbiting Satellite Problem	4
04	**Linearization Techniques:** Feedback Linearization, Input-Output Linearization, Full state Linearization	5
05	**Describing Function methods:** Describing function of saturation, dead-zone, on-off non-linearity, backlash, hysteresis,Compensation and design of nonlinear system using describing function method	5
06	**Phase-Plane analysis:** Phase portraits, Analysis of nonlinear systems using phase plane technique	4
07	**Notions of Stability:** Absolute Stability, Lyapunov Stability, Zero-input and BIBO stability.	6
08	**Nonlinear system dynamics:** Series Approximation method for small non-linearity	4
09	**Concept of variable-structure controller and Sliding control**: Sliding Mode Control Design, Reaching condition and reaching mode, implementation of switching control laws. Reduction of chattering in sliding and steady state mode.	6
	Total:	**39L**

Suggested Readings:

1. Nonlinear System, 3rd Edition, Hassan. K.Khalil, Pearson, 2015
2. Nonlinear Automatic Control, J.E.Gibson,1st Edition,1963
3. Nonlinear System Analysis, M.Vidyasagar, 2nd Edition,1993
4. Applied Nonlinear Control, Slotine and Li, 1991

Power System Reliability and Load Forecasting Techniques (EE5224)

Prerequisite: Probability Theory & Power systems

Weekly contact: 3 – 0 – 0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**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, single and double exponential smoothing technique, ARIMA model.	9
02	**Reliability analysis**: Definition of reliability, reliability indices, outage classification Reliability functions: Survivor function, cumulative failure distribution function, hazard rate, their relationships – exponential distribution – expected value and standard deviation of exponential distribution – Bath tub curve – reliability analysis of series parallel networks using exponential distribution – reliability measures MTTF, MTTR, MTBF.	4
03	**Markov modelling**: Continuous Markov processes, evaluation of time dependent and limiting state probabilities for one component repairable system. **Network modelling and reliability analysis:** Analysis of Series, Parallel, Series-Parallel networks– decomposition method.	5
04	**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.	5
05	**Generating system reliability analysis:** Generation system model – capacity outage probability tables – Recursive relation for capacitymodel building – sequential addition method – unit removal – Evaluation of loss of load and energy indices, Frequency and Duration methods – Evaluation of equivalent transitional rates of identical andnon-identical units – Evaluation of cumulative probability and cumulative frequency of non-identicalgenerating units – 2- level daily load representation - merging generation and loadmodels.	6

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06	**Distribution system reliability analysis:** State space diagram, network reduction method of evaluating load point reliability index**.** Substations and Switching Stations: Effects of short-circuits - breaker operation – Open and Short-circuit failures – Active and Passive failures – switching after faults – circuit breaker model – preventive maintenance – exponential maintenance times. Bus bar failures, scheduled maintenance – temporary and transient failures – weather effects – common mode failures –Evaluation of various indices.	6
07	**Reliability assessment of interconnected systems**: Probability array method – Two inter connected systems with independent loads – effects oflimited and unlimited tie capacity - imperfect tie – Two connected Systems with correlated loads –Expression for cumulative probability and cumulative frequency.	4
	TOTAL	**39L**

Suggested Reading:

1. Reliability Evaluation of Power Systems by Roy Billinton and Roland Allan (Springer)-1996
2. Introduction to Time series Analysis and Forecasting by Douglas Montgomery, C.L. Jennings and M. Kulahci (Wiley) -2008
3. Power System Planning by R.L. Sullivan (Tata McGraw Hill Publishing Company Ltd) -1977
4. Modern Power System Planning by X. Wang & J.R. McDonald (McGraw Hill Book Company)-1994
5. New Computational Methods in Power system Reliability by D. Elmakias (Springer)-2008

Special Electrical Machines
(EE5225)

Prerequisite: Basic courses on DC and AC machines, Generalized Machine Theory (EE 5108)

Weekly contact: 3 – 0 – 0 (L- T- S) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hr.
01	**Space vector theory of Electrical Machines**: Space vector concept as applied to electrical machines: Its application in modeling of electrical machines in both steady state and dynamics, control of machines using space vector concepts	10
02	**Linear Motors**: Basic principle of operation and types, end effects & transverse edge effects, depth of penetration and its effects, field analysis & propulsion force, mathematical modeling, equivalent circuit. Linear Induction Motors (LIM), Linear Permanent Magnet Synchronous Machine (LPMSM), LSRM etc., TLIM, their applications, design challenges, modeling and analysis. Difficulties in constructing TLPM machines or TLSRM.	9
03	**Switched Reluctance Motors (SRM)**: Construction, Basic principle of operation, importance of stator & rotor arc angles, design aspects and profile of the SRM, position sensor & indirect rotor position sensing, torque expression, steady state and dynamic performance.	6
04	**Special Permanent Magnet (PM) Machines**: Outer rotor varieties, details of issues related to PM materials and design, use of Halbach array configuration in PM machines Non-overlapping winding PM machines and their applications: Concepts, design changes with regard to distributed winding machines, effects on performance, applications of both inner and outer rotor varieties.	7
05	**Axial Flux Machines**: Axial flux varieties of SRM, BLDC and PMSM, applications, their design challenges, modeling and analysis.	7
	TOTAL	**39L**

Suggested Readings:

1. K.Venkataratnam, "Special Electrical Machines", Universities Press (India) Private Limited, 2008.
2. T.J.E. Miller, "Brushless Permanent-Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
3. T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motors", Clarendon Press, London, 1988.
4. R. Krishnan, "Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design and Applications", CRC press, 2001.
5. E. R. Laithwaite, "Induction Machines for Special Purposes", George Newnes, London, 1966.
6. S. A. Nasar& I. Boldea, "Linear Motion Electric Machines", Wiley 1976.

Application of Soft Computing Techniques in Electrical Engineering (EE5123)

Prerequisite: Engineering Mathematics

Weekly contact: 3 – 0 – 0 (L- T- P) Full Marks-100 Credits: 3

Module No.	Module Name and Topics	No. of Lecture-Hr.
01.	**Introduction to Soft Computing**: Inspiration behind soft computing, difference between hard and soft computing, computational intelligence, machine learning and computer vision	3
02.	**Artificial Neural Network (ANN)**: Introduction to Neural Computing (NC) & Artificial Neural Network, comparison between biological and artificial neural network, major types of variants of ANN, neural network training, supervised and unsupervised learning algorithms	8
03.	**Typical Applications of ANN:** *Applications of Supervised Learning*: Enhancement of Voltage Stability in Multi-Bus Power Systems by Network Reconfiguration assisted by ANN, Load forecasting using MLP with Back Propagation algorithm, Fault diagnosis of electrical machines and drives, *Applications of Unsupervised Learning*: Kohonen's SOM based Differential Relay for Protection of Synchronous Generators, Fault Diagnosis in Transformer Winding Insulation using SOM	6
04.	**Fuzzy Logic and Fuzzy:** System: 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	5
05.	**Typical Applications of Fuzzy Logic:**fuzzy logic controllers, neuro-fuzzy model in load forecasting, Fuzzy and neuro fuzzy techniques in fault detection	4
06.	**Genetic algorithms (GA)**: Introduction to search optimization method, evolutionary algorithms (EA), biological inspiration behind GA, working principles, encoding, crossover and mutation, basic GA algorithm	4
07.	**Typical Applications of Genetic Algorithm** Optimal sizing and placement of Capacitor bank in power network using GA, Economic load dispatch and optimal allocation of resources using GA, Optimization of distribution network for economic operation using GA	3
08.	**Recent Trend in Machine Learning:** Recurring Neural Networks (RNN), Deep Learning, "Big data Analysis", Time series prediction and other current issues	6
	TOTAL	**39L**

Suggested Readings:

1. Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis And Applications, By S. Rajasekaran and G. A. VijayalakshmiPai, PHI Learning Ltd, 2003
2. Soft Computing : Techniques and is Applications in Electrical Engineering, By D. K. Chaturvedi, Springer 2008
3. Tutorial on Fuzzy Logic Applications in Power System, IEEE –PES winter meeting in Singapore, January, 2000
4. Neural Network Applications in Power Electronics and Motor Drives- An Introduction and Perspective, B. K. Bose,

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IEEE Transaction on Industrial Electronics, 2007
5. Genetic Algorithm in Applications, Edited by Dr. RustemPopa, March 2012

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