Scheme & Syllabus

for

Bachelor of Technology

in

Electrical Engineering

From III to VIII Semester

Effective from Academic session 2021-22
For students admitted in session 2020-21

Department of Electrical Engineering
University Departments
Rajasthan Technical University, Kota

University Department, Electrical Engineering
Rajasthan Technical University Kota

Scheme 3rd Semester

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	IC	CEL101	Environmental Science	NA	NA	2	2	0	0		50	100	150
2	IC	HUL201	General Studies	NA	NA	2	2	0	0		50	100	150
3	DC	EEL131	Analog Electronics	NA	NA	3	3	0	0		50	100	150
4	DC	EEL132	Circuit Analysis and Synthesis	NA	NA	3	3	0	0		50	100	150
5	DC	EEL133	Electrical Measurements and Instrumentation	NA	NA	3	3	0	0		50	100	150
6	DC	EEL134	Transformer and Asynchronous Machines	NA	NA	3	3	0	0		50	100	150
7	DC	EEL135	Generation of Electrical Power	NA	NA	3	3	0	0		50	100	150
8	DC	EEP131	Analog Electronics Lab	NA	NA	1	0	0	2		50	25	75
9	DC	EEP132	Electrical Circuits & Programming Lab	NA	NA	1	0	0	2		50	25	75
10	DC	EEP133	Electrical Measurement and Instrumentation Lab	NA	NA	1	0	0	2		50	25	75
11	DC	EEP134	Transformer and Asynchronous Machines Lab	NA	NA	1	0	0	2		50	25	75
12	NG	TPN102	Soft Skill Development -1	NA	NA		0	0	2	1			
13	IC	SAA100	SODECA (Anandam)	NA	NA	0.5					100	-	100
			Total (T3 shall comply with Sec 3.10 of CBCSUG-2020)			**23.5**				**1**	**650**	**800**	**1450**

University Department, Electrical Engineering
Rajasthan Technical University Kota

Scheme 4th Semester

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	IC	MTL209	Advanced Mathematics (Branch Specific)	NA	NA	4	3	1	0		50	100	150
2	IC	HUL202	Economics and Financial Management	NA	NA	3	3	0	0		50	100	150
3	DC	EEL141	Electrical Machines	NA	NA	4	3	1	0		50	100	150
4	DC	EEL142	Digital Electronics	NA	NA	2	2	0	0		50	100	150
5	DC	EEL143	Transmission and Distribution of Electrical Power	NA	NA	3	3	0	0		50	100	150
6	OC		Open Category	NA	NA	3	3	0	0		50	100	150
7	DC	EEP141	Electrical Machines Lab	NA	NA	2	0	0	3		50	25	75
8	DC	EEP142	Digital Electronics Lab	NA	NA	1	0	0	2		50	25	75
9	DC	EEP143	Power System Design Lab	NA	NA	1	0	0	2		50	25	75
10	NG	TPN103	Soft Skill Development -2	NA	NA		0	0	2	1			
11	IC	SAA100	SODECA (Anandam)	NA	NA	0.5					100	-	100
			Total (T4 shall comply with Sec 3.10 of CBCSUG-2020)			**23.5**				**1**	**550**	**675**	**1225**

University Department, Electrical Engineering
Rajasthan Technical University Kota

Scheme 5th Semester

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	IC	HUL203	Indian Constitution	NA	NA	2	2	0	0		50	100	150
2	DC	EEL351	Power Electronics	AE, CAS	EEL131, EEL132	4	3	1	0		50	100	150
3	DC	EEL352	Control System	AM, CAS	MTL209, EEL132	3	3	0	0		50	100	150
4	DC	EEL153	Microprocessors	NA	NA	3	3	0	0		50	100	150
5	DE	**Elective –I**				2	2	0	0		50	100	150
		EEL154	1. EMFT	NA	NA								
		EEL255	2. Restructured Power Systems	GEP	EEL135								
6	DE	**Elective -II**				2	2	0	0		50	100	150
		EEL156	2. High Voltage Engineering	NA	NA								
		EEL257	3. Signals and Systems	AM	MTL209								
7	OC		Open Category			3	3	0	0		50	100	150
8	DC	EEP151	Power Electronics Lab	NA	NA	2	0	0	3		50	25	75
9	DC	EEP152	System Simulation Lab	NA	NA	1	0	0	2		50	25	75
10	DC	EEP153	Micro-processor Lab	NA	NA	1	0	0	2		50	25	75
11	NG	EEN201	Seminar 1 (Non-Graded)	NA	NA		0	0	2	1			
12	TR	EET301	Industrial Training (45 days)	NA	NA	2	0	0	2				
13	IC	SAA100	SODECA (Anandam)	NA	NA	0.5					100	-	100
			Sub- Total (T5 shall comply with Sec 3.10 of CBCSUG-2020)			**25.5**				**1**	**600**	**775**	**1375**

University Department, Electrical Engineering
Rajasthan Technical University Kota

Scheme 6th Semester

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	DC	EEL261	Modern Control theory	CS	EEL352	4	3	1	0		50	100	150
2	DC	EEL262	Advanced Power Electronics	PE	EEL351	3	3	0	0		50	100	150
3	DC	EEL163	Switchgear & Protection			3	3	0	0		50	100	150
4	DC	EEL364	Computer Aided Design of Electrical Machines	TAM, EM	EEL134, EEL141	3	3	0	0		50	100	150
5	DE		**Elective**			2	2	0	0		50	100	150
		EEL365	1. Smart Grid Technology	GEP, T&D	EEL135, EEL143								
		EEL266	2. Power Quality	PE	EEL351								
		EEL367	3. Power System Planning	GEP, T&D	EEL135, EEL143								
6	OC		Open Category			2	2	0	0		50	100	150
7	DC	EEP161	Control Systems Lab	NA	NA	1	0	0	2		50	25	75
8	DC	EEP162	Advance Power Electronics Lab	NA	NA	2	0	0	3		50	25	75
9	DC	EEP163	Power System Protection Lab	NA	NA	1	0	0	2		50	25	75
10	NG	EEN202	Seminar 2 (Non-Graded)	NA	NA		0	0	2	1			
11	IC	SAA100	SODECA (Anandam)	NA	NA	0.5					100	-	100
			Sub- Total (T6 shall comply with Sec 3.10 of CBCSUG-2020)			**21.5**				**1**	**550**	**675**	**1225**

University Department, Electrical Engineering
Rajasthan Technical University Kota

Scheme 7th Semester

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	DC	EEL371	Power System Analysis	GEP, T&D	EEL135, EEL143	4	3	1	0		50	100	150
2	DC	EEL372	Electric Drives & Control	M/C, APE	EEL141, EEL262	3	3	0	0		50	100	150
3	DC	EEL173	Power System Engineering	NA	NA	3	3	0	0		50	100	150
4	DE		Elective			3	3	0	0		50	100	150
		EEL274	1. HVDC Transmission Systems	APE	EEL262								
		EEL375	2. Electrical and Hybrid Vehicles	M/C, APE	EEL141, EEL262								
		EEL276	3. Digital Control Systems	MCT	EEL261								
5	OC		Open Category			2	2	0	0		50	100	150
6	DC	EEP171	Power System Modelling and Simulation Lab	NA	NA	2	0	0	3		50	25	75
7	DC	EEP172	Electric Drives & Control Lab	NA	NA	1	0	0	2		50	25	75
8	DC	EED411	Project Part- I	NA	NA	4	0	0	8		50	25	75
9	TR	EET302	Industrial Training (60 days)	NA	NA	3	0	0	2		50	25	75
10	IC	SAA100	SODECA (Anandam)	NA	NA	0.5					100	-	100
			Sub- Total (T7 shall comply with Sec 3.10 of CBCSUG-2020)			**25.5**					**550**	**600**	**1150**

University Department, Electrical Engineering
Rajasthan Technical University Kota

Scheme 8th Semester

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	IC	HUL204	Innovation & Entrepreneurship	NA	NA	3	3	0	0		50	100	150
2	DE		Elective-I			3	3	0	0		50	100	150
		EEL181	1. Artificial Intelligence	NA	NA								
		EEL282	2. Line-Commutated and Active PWM Rectifiers	APE	EEL262								
		EEL183	3. Optimization Techniques	NA	NA								
3	DE		Elective-II			3	3	0	0		50	100	150
		EEL184	1. Electrical Energy Conservation and Auditing	NA	NA								
		EEL385	2. FACTS Devices and their Application	PSA, PSE	EEL371, EEL173								
		EEL186	3. Wind and Solar Energy Systems	NA	NA								
4	DC	EED412	Project Part- 2	NA	NA	6	0	0	12		50	25	75
5	IC	SAA100	SODECA (Anandam)	NA	NA	0.5					100	-	100
			Total (T8 shall comply with Sec 3.10 of CBCSUG-2020)			**15.5**					300	325	625

University Department, Electrical Engineering
Rajasthan Technical University Kota

Open Category Courses to float by EED for other branches students

(Not for Electrical Engineering branch students)

S.No.	* Type of Course (Symbol)	Course Codes	Course	PRE-REQUISITE Course code	PRE-REQUISITE Course	Credits	Contact hrs/wk			Non Gr Units	IA	End term	Total
							L	T	P				
1	OC	EEL104	Electrical Machines and Drives	NA	NA	3	3	0	0		50	100	150
2	OC	EEL105	Power Generation Sources	NA	NA	3	3	0	0		50	100	150
3	OC	EEL106	Energy Audit and Demand side Management	NA	NA	2	2	0	0		50	100	150
4	OC	EEL107	Industrial Electrical Systems	NA	NA	2	2	0	0		50	100	150
			Total Credit			**10**							

University Department, Electrical Engineering
Rajasthan Technical University Kota

Courses for Minor in Electrical Engineering

For other branches students

(Not for Electrical Engineering branch students)

Students who opt for Minor in Electrical Engineering, have to register to complete 20 credits additionally. This requirement of 20 credits may be completed starting from 4th semester and till 8th semester or before 8th semester subject to maximum credit in single semester not exceeding 28. These 20 credits shall consist of MOOC courses and with/without mini project from the list given below in table.

S.N.	Course	MOOC Portal	Link	Cr.	Duration
1	Basic Electrical Circuits	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee99/preview	4	12 Weeks
2	Electrical Machines	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee24/preview	4	12 Weeks
3	Control engineering	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee67/preview	4	12 Weeks
4	Basic Electronics	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee55/preview	4	12 Weeks
5	Fundamental of Power Electronics	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee01/preview	4	12 Weeks
6	Power System Engineering	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee15/preview	4	12 Weeks
7	Microprocessors and Interfacing	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee41/preview	4	12 Weeks
8	Physics of Renewable Energy Systems	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ph33/preview	4	12 Weeks
9	Power System Analysis	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee77/preview	4	12 Weeks
10	Introduction to Smart Grid	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee68/preview	3	8 Weeks
11	Power System Protection	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee109/preview	4	12 Weeks
12	Signals and Systems	NPTEL, Swayam	https://onlinecourses.nptel.ac.in/noc21_ee28/preview	4	12 Weeks
13	Mini Project			5	
	Total Credit Required			**20**	

Proposed Areas for Department Specialization

(For Electrical Engineering branch students)

1. Electric Drives & Control
2. Systems & Control
3. Renewable Energy Technologies
4. Robotics & Automation

NOTE:

Students of Electrical Engineering branch desirous to get specialization in any one area listed above have to register to complete 20 credits additionally. This requirement of 20 credits may be completed starting from 4th semester and till 8th semester subject to maximum credit in single semester not exceeding 28. These 20 credits shall consist of MOOC courses and with/without mini project from the list given with each of specialization areas detailed now onwards; However, the exact details including proposd area of department Specialization shall be further finalized before the concerned semester classes begin as per the availability of courses at that time.

Department Specialization in Electric Drives and Control
(For Electrical Engineering branch students)

TENTATIVE DETAILS

S.N.	Course	MOOC Portal	Link	Cr.	Duration
1	Fundamentals of Electric Drives	NPTEL	https://nptel.ac.in/courses/108/104/108104140/		
2	Industrial Drives - Power Electronics	NPTEL	https://nptel.ac.in/courses/108/108/108108077/		
3	Advance Electric Drives	NPTEL	https://nptel.ac.in/courses/108/104/108104011/		
4	Motors and Motor Control Circuits	Coursera	https://www.coursera.org/learn/motors-circuits-design		
5	Electric Motor Control	Udemy	https://www.udemy.com/course/electrical-motor-control/		
6	Drives and Control	EKEEDA	https://ekeeda.com/degree-courses/electrical-engineering/drives-and-control		
7	Fundamentals of Power Electronics	NPTEL	https://nptel.ac.in/courses/108/101/108101126/		
8	Advance Power Electronics and Control	NPTEL	https://nptel.ac.in/courses/108/107/108107128/		
9	Mini Project			5	
	Total Credit Required				**20**

Department Specialization in Systems & Control
(For Electrical Engineering branch students)

TENTATIVE DETAILS

S.N.	Course	MOOC Portal	Link	Cr.	Duration
1	Linear Systems Theory	Swayam	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ee92/	4	12 weeks
2	Control and Tuning Methods in Switched Mode Power Converters	Swayam	https://onlinecourses.nptel.ac.in/noc21_ee104/preview	4	12 weeks
3	System Design Through VERILOG	Swayam	https://nptel.ac.in/courses/108/103/108103179/	3	8 weeks
4	LINEAR DYNAMICAL SYSTEMS	NPTEL	https://nptel.ac.in/courses/108/106/108106164/	3	8 weeks
5	SENSORS AND ACTUATORS	NPTEL	https://nptel.ac.in/courses/108/108/108108147/	4	12 weeks
6	INDUSTRIAL AUTOMATION AND CONTROL	NPTEL	https://nptel.ac.in/courses/108/105/108105088/	4	12 weeks
7	Intelligent Systems and Control	NPTEL	http://www.nptelvideos.in/2012/11/intelligent-systems-and-control.html		
8	Mini Project			5	
	Total Credit Required				**20**

Department Specialization in Renewable Energy Technologies

(For Electrical Engineering branch students)

TENTATIVE DETAILS

S.N.	Course	MOOC Portal	Link	Cr.	Duration
1	Technologies For Clean and Renewable Energy Production	NPTEL	https://onlinecourses.nptel.ac.in/noc21_ch42/preview	3	8 Weeks
2	Natural Resources for Sustainable Development	EDX	https://www.edx.org/course/natural-resources-for-sustainable-development	4	12 Weeks
3	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems	NPTEL	https://onlinecourses.nptel.ac.in/noc21_ch11/preview	3	8 Weeks
4	PHOTOVOLATIC SYSTEM	Coursera	https://www.coursera.org/learn/photovoltaic-systems		12 Hours
5	WIND ENERGY	Coursera	https://www.coursera.org/learn/wind-energy		36 Hours
6	RENEABLE ENERGY: FUNDAMENTALS AND JOB OPPORTUNITIES	Coursera	https://www.coursera.org/learn/renewable-energy-fundamentals		22 Hours
7	GLOBAL ENERGY AND CLIMATE POLICY	Coursera	https://www.coursera.org/learn/globalenergyandclimatepolicy		13 Hours
8	RENEWABLE POWER AND ELECTRICITY SYSTEM	Coursera	https://www.coursera.org/learn/renewable-power-electricity-systems		13 Hours
9	Design of photovoltaic systems	NPTEL	https://onlinecourses.nptel.ac.in/noc21_ee62/preview	4	12 Weeks
10	Incorporating Renewable Energy in Electricity Grids	EDX	https://www.edx.org/course/incorporating-renewable-energy-in-electricity-grid?index=product&queryID=2aaf1abdae251ca6e4aea731c95db82c&position=1		6 Weeks
11	Mini Project			5	
	Total Credit Required				**20**

Department Specialization in Robotics & Automation

(For Electrical Engineering branch students)

TENTATIVE DETAILS

S.N.	Course	MOOC Portal	Link	Cr.	Duration
1	Industrial Automation and Control	NPTEL	https://onlinecourses.nptel.ac.in/noc20_me39/preview	4	12 Weeks
2	Mechatronics	NPTEL	https://onlinecourses.nptel.ac.in/noc21_me27/preview	3	8 Weeks
3	Industrial Automation with PLC & SCADA	NIELIT	http://nielit.gov.in/calicut/calicut/content/online-course-industrial-automation-plc-scada		4 Weeks
4	Sensors and Actuators	NPTEL	https://onlinecourses.nptel.ac.in/noc21_ee32/preview	4	12 weeks
5	Design of Mechatronic Systems	NPTEL	https://onlinecourses.nptel.ac.in/noc21_me129/preview	4	12 weeks
6	Introduction to robotics	NPTEL	https://onlinecourses.nptel.ac.in/noc21_de13/preview	4	12 weeks
7	Fundamentals of Automotive Systems	NPTEL	https://onlinecourses.nptel.ac.in/noc21_de02/preview	4	12 weeks
8	Robotics and Control: Theory and Practice	NPTEL	https://onlinecourses.nptel.ac.in/noc21_me49/preview	3	8 Weeks
9	Mini Project			5	
	Total Credit Required				**20**

EEL131	Analog Electronics	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	**Semiconductor Diodes:** Theory of P-N junction, temperature dependence and break down characteristics, junction capacitances, Zener diode, Varactor diode, Tunnel diode, PIN diode, LED, Photo diode, Schottky diode, Diode applications: series –parallel configurations, full wave and half wave rectification, voltage multiplier circuits, diode testing	8
2.	**Transistors:** BJT, types& configuration, working principal, characteristics, and region of operation, load line, biasing methods, small signal analysis of transistor (low frequency) using h-parameters, thermal runaway and thermal stability, MOSFET, Transistor as an amplifier, gain, bandwidth, frequency response	8
3.	**Feedback amplifier and Oscillators:** Feedback amplifier, negative feedback, voltage-series, voltage shunt, current series and current shunt feedback, Sinusoidal oscillators, L-C (Hartley Colpitts) oscillators, RC phase shift, Wien bridge, and Crystal oscillators. Power amplifiers, class A, class B, class A B, C amplifiers, their efficiency and power Dissipation, Push-pull and complimentary symmetry push-pull amplifier.	8
4.	**Wave Shaping circuits:** Switching characteristics of diode and transistor, turn ON, OFF time, reverse recovery time, transistor as switch, Multivibrators, Bistable, Monostable, Astable multivibrators. Clipper and clamper circuit, Differential amplifier, calculation of differential, common mode gain and CMRR using h- parameters, Darlington pair, Boot strapping technique. Cascade and cascade amplifier	8
5.	**Operational Amplifier:** Operational amplifier basics, practical Op-amp circuits & characteristics, slew rate, bandwidth, offset voltage, basic current, application, inverting, non-inverting amplifier, summer, average, differentiator, integrator, differential amplifier, instrumentation amplifier, log and antilog amplifier, voltage to current and current to voltage converters, comparators Schmitt trigger, active filters, 555 timer and its application.	8

Text Books/ Reference Books

- Robert L Boylestad, Louis Nashelsky; Electronic Devices and Circuits; Pearson
- Jacob Millman, Cristos C Halkias, Satyabrata Jit; Electronic Devices and Circuits; McGrawHill
- Anil K Maini, Electronic Devices and Circuits, Wiley
- S Salivahanan, N Suresh Kumar; Electronic Devices and Circuits; McGraw- Hill

EEL132	Circuit Analysis and Synthesis	3L:0T:0P	3 credits

S.No.	CONTENTS	HOUR
1.	**Basic Elements of Circuit and Resonance:** Introduction to circuit elements and their characteristics, current and voltage reference. Response of single element, double element and triple element circuits. Resonance, selectivity & Q-factor in ac circuits, star-delta transformation, power in three phase circuits.	5
	Network Analysis: Network voltages. Mesh & node systems of network equations and their comparison. Graph of network, tree, incidence matrix, fundamental circuit functions, cut sets, f-circuits analysis and f-cut set analysis, node and node pair analysis. Duality and Method of obtaining dual network	5
2.	**Network Theorems:** Thevenin's, Norton's, Superposition, Reciprocity, Compensation, Millman's theorem Tellegen's, Maximum power transfer and Miller`s theorems in DC & AC Circuits.	6
3.	**Time Domain Analysis:** Initial conditions, Procedure for evaluating initial conditions, Transient analysis of DC & AC circuits	4
	Frequency Domain Analysis: Laplace transform of standard signals, Shifting theorem, initial and final value theorem, Solution of circuit equations by Laplace transform, Evaluation of circuit response for various signals.	4
4.	**Two Port General Networks:** Two port parameters (impedance, admittance, hybrid, ABCD parameters) and their inter relations Equivalence of two ports. Transformer equivalent, inter connection of two port networks. The ladder network, image impedance image transfer function, application to L-C network, attenuation and phase shift in symmetrical T and pi networks.	8
5	**Network Functions:** Calculation of network functions, Poles and Zeros of network functions and their restriction, time domain behavior from pole - zero plot.	4
	Network Synthesis: Hurwitz Polynomial, Properties of positive real function, necessary and sufficient conditions, basic synthesis procedure, synthesis of L-C, R-L and R-C driving point functions, Foster and Caver form.	4

Text Books/ Reference Books

- M E Van Valkenburg, Textbook of Network Analysis, Prentice Hall India.
- A Chakrabarti , Circuit Theory- Analysis and Synthesis, Dhanpat Rai & Co
- D. Roy choudhury Networks and Systems, New Age international
- Hayt W. H., Kemmerly J. E. and Durbin S. M., "Engineering Circuit Analysis", 6th Ed., Tata McGraw Hill Publishing Company Ltd

EEL133	Electrical Measurements and Instrumentation	3L:0T:0P	3 credits

S.No.	CONTENTS	Hr.
1.	**Theory of Errors:** Accuracy and precision, systematic and random errors, limits of error, probable error and standard deviation. Gaussian error curves, combination of errors.	3
	Measuring Instruments: Moving coil, moving iron, electrodynamic and induction instruments-construction, operation, torque equation and errors. Applications of instruments for measurement of current, voltage, single-phase power and single-phase energy. Errors in wattmeter and energy meter and their compensation and adjustment. Testing and calibration of single-phase energy meter by phantom loading	7
2.	**Polyphase Metering:** Blondel's Theorem for n-phase, p-wire system. Measurement of power and reactive kVA in phase balanced and unbalanced systems: One-wattmeter, two-wattmeter and three-wattmeter methods. 3-phase induction type energy meter.	4
	Instrument Transformers: Construction and operation of current and potential transformers. Ratio and phase angle errors and their minimization. Effect of variation of power factor, secondary burden and frequency on errors. Testing of CTs and PTs, Applications of CTs and PTs for the measurement of current, voltage, power and energy	4
3.	**Potentiometers:** General operation and standardization process of DC and AC potentiometers. Applications of potentiometers.	3
	Measurement of Resistances: Classification of resistance. Measurement of medium resistances – ammeter and voltmeter method, substitution method, Wheatstone bridge method. Measurement of low resistances – Potentiometer method and Kelvin's double bridge method. Measurement of high resistance: Price's Guard-wire method. Measurement of earth resistance	5
4.	**AC Bridges:** Generalized treatment of four-arm AC bridges. Sources and detectors. Maxwell's bridge, Hay's bridge and Anderson bridge for self-inductance measurement. Heaviside's bridge for mutual inductance measurement. De Sauty Bridge for capacitance measurement. Wien's bridge for capacitance and frequency measurements. Sources of error in bridge measurements and precautions. Screening of bridge components. Wagner earth device	8
5.	**Instrumentation:** Transducers & sensors, classification & selection of sensors, Measurement of force using strain gauges, Measurement of pressure using piezoelectric sensor, Measurement of temperature using Thermistors and Thermocouples, Measurement of displacement using LVDT, Measurement of position using Hall effect sensors. Concept of signal conditioning and data acquisition systems, Concept of smart sensors and virtual instrumentation.	6

Text Books/ Reference Books

- Golding E. W. and Widdis F. C., "Electrical Measurements and Measuring Instruments", 5th Ed., A.H. Wheeler and Compant
- Stout M. B., "Basic Electrical Measurements", Prentice Hall of India Private Limited.
- W. D. Cooper, Electronic Inst. & Measurement Techniques, Prentice Hall, India
- A. K. Sawhney: Advanced Measurements & Instrumentation, Dhanpat Rai & Sons 1994

EEL134	Transformer and Asynchronous Machines	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	**Magnetic circuits** Electromechanical energy conversion: Basic principles, conservation of energy, physical phenomenon involved in conversion, energy balance, energy stored in magnetic field.	6
2.	**AC Machines Fundamentals** Introduction, emf equation, mmf of three phase AC winding, production of rotating magnetic field, types of AC windings Concentric, distributed and chorded windings, pitch factor, distribution factor, effect of these factors on induced emf, effect of harmonics.	6
3.	**Poly-phase Induction Motor** Construction, principle, starting and running torque, condition for maximum torque, equivalent circuits, no load and block rotor test.	4
	Torque-slip characteristics, losses and efficiency, circle diagram, starting of induction motor, speed control, cogging and crawling, double cage rotor, induction generator, application.	4
4.	**Single Phase Induction Motor** Introduction, construction, principle, double revolving field theory, equivalent circuit, performance calculations, starting methods, and their types, torque slip characteristics of various types	6
5.	**Transformer** Construction, Principle, emf equation, no load and short circuit test, equivalent circuits, back-to-back (Sumpner's test), phasor diagram, Voltage regulation, Efficiency, Condition for maximum efficiency, all day efficiency, parallel operation, auto-transformer.	6
6.	**Poly-phase Transformer** Construction and connections, open delta connection, Scott connection, three-phase to two phase conversion and vice-versa, Applications, Parallel operation and its conditions	4
	Three to six phase conversions. Switching currents in transformers, inrush of magnetizing current. Three winding Transformer.	4
	Text Books/ Reference Books • P.S Bhimbra, Electrical machines Khanna publisher. • Kothari & Nagrath, Electric Machines, 3/e, TM • Smarajit Ghosh, Electrical Machines, 2/e, Pearson, 2012	

EEL135	Generation of Electrical Power	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	**Conventional Energy Generation Methods** (i) Thermal Power plants: Basic schemes and working principle. (ii) Gas Power Plants: open cycle and closed cycle gas turbine plants, combined gas & steam plants-basic schemes	5
	(iii) Hydro Power Plants: Classification of hydroelectric plants. Basic schemes of hydroelectric and pumped storage plants. (iv) Nuclear Power Plants: Nuclear fission and nuclear fusion. Fissile and fertile materials. Basic plant schemes with boiling water reactor, heavy water reactor and fast breeder reactor. Efficiencies of various power plants	3
2.	**New Energy Sources** Impact of thermal, gas, hydro and nuclear power stations on environment. Conservation of natural resources and sustainable energy systems.	4
	Indian energy scenario, Green House Effect (Global Warming). Introduction to electric energy generation by wind, solar and tidal	4
3.	**Loads and Load Curves** Types of loads, chronological load curve, load duration curve, energy load curve and mass curve. Maximum demand, demand factor, load factor, diversity factor, capacity factor and utilization factor.	4
	Power Factor Improvement Causes & effects of low power factor and advantages of power factor improvement. Power factor improvement using shunt capacitors and synchronous condensers	4
4.	**Power Plant Economics** Capital cost of plants, annual fixed and operating costs of plants, generation cost and depreciation. Effect of load factor on unit energy cost. Role of load diversity in power system economics	5
	Calculation of most economic power factor when (a) kW demand is constant and (b) kVA demand is constant. Energy cost reduction: off peak energy utilization, co-generation, and energy conservation	3
5.	**Tariffs** Objectives of tariffs. General tariff form. Flat demand rate, straight meter rate, block meter rate. Two-part tariff, power factor dependent tariffs, three-part tariff. Spot (time differentiated) pricing	4
6.	**Selection of Power Plants** Comparative study of thermal, hydro, nuclear and gas power plants. Base load and peak load plants. Size and types of generating units, types of reserve and size of plant. Selection and location of power plants	4

Text Books/ Reference Books

- V. K. Mehta, Principles of Power system (3/e), S. Chand Publication
- Soni, Gupta and Bhatnagar, Generation of Electrical Power, Dhanpat Rai & Sons
- L. Elgerd Olle, Electric Energy Systems Theory C. A. Gross, Power System Analysis, TMH

EEP131	Analog Electronics Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	Study the following devices: (a) Analog & digital multimeters (b) Function/ Signal generators (c) Regulated DC power supplies (constant voltage and constant current operations) (d) Study of analog CRO, Measurement of time period, amplitude, frequency & phase angle using Lissajous figures.
2.	Plot V-I characteristic of P-N junction diode & calculate cut-in voltage, reverse saturation current and static & dynamic resistances.
3.	Plot V-I characteristic of Zener diode and study of Zener diode as voltage regulator. Observe the effect of load changes and determine load limits of the voltage regulator.
4.	Plot gain- frequency characteristic of two stages RC coupled amplifier & calculate its bandwidth and compare it with theoretical value.
5.	Plot gain-frequency characteristic of emitter follower & find out its input and output resistances.
6.	Plot input and output characteristics of BJT in CB, CC and CE configurations. Find their h-parameters.
7.	Study half wave and full wave bridge rectifier with and without filters.
8.	Plot gain-frequency characteristics of BJT amplifier with and without negative feedback in the emitter circuit and determine bandwidths, gain bandwidth products and gains at 1 kHz with and without negative feedback.
9.	Study of series and shunt voltage regulators and measurement of line and load regulation and ripple factor.
10.	Study of push pull amplifier. Measure variation of output power & distortion with load.
11.	Study Wein bridge oscillator and observe the effect of variation in R & C on oscillator frequency.
12.	Study the following oscillators and observe the effect of variation of C on oscillator frequency: (a) Hartley (b) Colpitts.

EEP132	Electrical Circuits & Programming Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	Draw the circuit symbols.
2.	Verify theorems for A. C. & D. C. circuits.
3.	Programs for Circuit Analysis using C / C + +: ***(a)*** Calculate the resistance of a conductor, given its dimensions & resistivity or determine the change in conductor resistance when the temp changes. ***(b)*** D.C.: Analysis of resistor networks to determine all junction voltages, component voltages, and component currents. ***(c)*** Transient: Analysis RC & RL circuits to produce tables of component voltage & current levels for a given set of time instants. ***(d)*** Convert Y-connected resistor networks to delta-connected circuits.
4.	Simulation using Simulation Tools for Circuit Analysis: ***(a)*** DC: Analysis resistor networks to determine node voltages, components voltages, and component currents. ***(b)*** DC: Analysis of resistor networks that have several voltage and current sources and variable load resistors. ***(c)*** Transient: Analysis of RC & RL circuits to produce tables of component voltage & current levels for a given set of time instants & to produce graphs of voltages & currents versus time. ***(d)*** AC: Analysis of impedance networks to determine the magnitude & phase of node voltages, components voltages and component currents.
5.	Determine the magnitude & phase and component voltages and currents in resonant circuits & produce voltage and current verses frequency graph.

EEP133	Electrical Measurement and Instrumentation Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	Study working and applications of (i) C.R.O. (ii) Digital Storage C.R.O. & (ii) C.R.O. Probes.
2.	Study working and applications of Meggar, Tong-tester, P.F. Meter and Phase Shifter.
3.	Measure power and power factor in 3-phase load by (i) Two-wattmeter method and (ii) One-wattmeter method.
4.	Calibrate an ammeter using DC slide wire potentiometer.
5.	Calibrate a voltmeter using Crompton potentiometer.
6.	Measure low resistance by Crompton potentiometer.
7.	Measure Low resistance by Kelvin's double bridge.
8.	Measure earth resistance using fall of potential method.
9.	Calibrate a single-phase energy meter by phantom loading at different power factors.
10.	Measure self-inductance using Anderson's bridge.

EEP134	Transformer and Asynchronous Machines Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	To perform O.C. and S.C. test on a 1-phase transformer and to determine the parameters of its equivalent circuit its voltage regulation and efficiency.
2.	To perform back-to-back test on two identical 1-phase transformers and find their efficiency & parameters of the equivalent circuit.
3.	To determine the efficiency and voltage regulation of a single-phase transformer by direct loading.
4.	To perform the heat run test on a delta/delta connected 3-phase transformer and determine the parameters for its equivalent circuit.
5.	To perform the parallel operation of the transformer.
6.	Separation of no-load losses in single phase transformer.
7.	To make a Scott connection of transformer.
8.	To perform no load and blocked rotor test on a 3-phase induction motor and to determine the parameters of its equivalent circuits.
9.	Draw the circle diagram and compute the following: ***(i)*** Max. Torque ***(ii)*** Current ***(iii)*** Slips ***(iv)*** p. f. ***(v)*** Efficiency.
10.	Speed control of 3- Φ Induction Motor.

MTL209	Advanced Mathematics	3L:1T:0P	4 credits

S.No.	CONTENTS	HOURS
1.	**Laplace Transform** Definition and existence of Laplace transform, properties and formulae, unit step function, Dirac Delta function, Heaviside function, inverse Laplace transform, Convolution theorem, application of Laplace transform to ordinary differential equation, solution of integral equations.	10
2.	**Fourier Transform** Fourier Complex, Sine and Cosine transform, properties and formulae, inverse Fourier transforms, Convolution theorem.	6
3.	**Z-Transform:** Definition, properties and formulae, Convolution theorem, inverse Z-transform, application of Z-transform to difference equation. Solution of difference equation, Star transfer function.	8
4.	**Numerical Analysis:** Interpolation, difference operators- forward, backward, central, shift and average operators, Newton's forward and backward interpolation formulae, Gauss's forward and backward interpolation formulae, Stirling's formula, Lagrange interpolation formula for unequal intervals. Inverse interpolation. Numerical differentiation by Newton's, Gauss's and Stirling's formula. Numerical integration: Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule. Numerical solution of ODE of first order: Picard's method, Euler's method, Modified Euler's method, Runge-Kutta forth order method, Milne's Method	16

TEXT BOOKS:

1. Advanced Engineering Mathematics, Jain and Iyengar, Narosa Publications.

REFERENCE:

1. Advanced Engineering Mathematics, Irvin Kreyszig, Wiley, India.
2. Advanced Engineering Mathematics, M. Greenberg, Pearson Education, India.
3. Engineering Mathematics for semesters III and IV, C.B. Gupta, Mc Graw Hill Education, India.
4. Advanced Engineering Mathematics, Denis Zill and Warren Wright, Jones & Bartlett India Private Limited.
5. Advanced Engineering Mathematics, O'neil, Cengage Learning, India.
6. Higher Engineering Mathematics, B. V. Ramana, Mc Graw Hill Education, India.
7. Numerical Methods for Scientific & Engineering Computation, Jain and Iyengar, Jain, New Age International Publication, India.
8. Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Lerning, India.
9. Numerical Methods for Engineers, Chapra, Mc Graw Hill Education, India.
10. Integral Transforms, Goyal and Goyal, Jaipur Publishing House, India.

EEL141	Electrical Machines	3L:1T:0P	4 credits

S.No.	CONTENTS	HOUR
1.	**Synchronous Machine** Introduction, Construction, advantages of rotating field, types of rotors, emf equation, excitation systems, equivalent circuit and their phasor diagrams, voltage regulation, synchronous impedance method, mmf method.	5
	Zero power factor method, two reaction theory of salient pole rotor, phasor diagram, power developed and power angle characteristics of salient pole machine, determination of Xd and Xq	5
	Synchronization, synchronizing power and torque, parallel operation application, power and torque, speed torque characteristics, power factor control-effect of change of excitation.	5
	V curve and inverted V curve, synchronous condenser and reactors, synchronous phase modifiers, hunting causes and remedies, applications, synchronous induction motor application	5
2.	**DC Machine** Introduction, construction, types, emf equation, armature reaction, commutation, methods of improving commutation, various characteristics of shunt, series and compound DC machine, losses and efficiency, speed control (field and armature control methods), testing (Brake test and Swinburne test), Application.	8
3.	**Special Machines** **Hysteresis Motors**: Construction, principle of operation and performance of synchronous reluctance motors. **Stepper Motor**: Construction, principle of operation, control and performance of stepping motors.	6
	Switched Reluctance Motor: Construction, principle of operation, control and performance of switched reluctance motors. **Universal Motor**: Construction, principle of operation, control and performance of universal motor. **Servo Motors:** Construction, principle of operation, control and performance of servomotors; Techogenerator.	6

Text Books/ Reference Books

- Fitzgeraid A. E., Kingsley C. and Kusko A., "Electric Machinery", 6 th Ed., McGraw-Hill International Book Company. 2008.
- Say M. G., "The Performance and Design of Alternating Current Machines", CBS Publishers and Distributors.2005.
- Say M. G. and Taylor E. O., "Direct Current Machines", 3rd Ed., ELBS and Pitman. 1986
- Nagrath I. J. and Kothari D. P., "Electrical Machines", 3rd Ed., Tata McGraw-Hill Publishing Company Limited.2008.
- Langsdorf A. S., "Theory of AC Machines", 2nd Ed., Tata McGrawHill Publishing Company Limited. 2008.

EEL142	Digital Electronics	2L:0T:0P	2 credits

S.No.	CONTENTS	HOUR
1.	**Data Representation** Number Systems, Boolean algebra and Logic Gates; Simplification of Boolean Functions.	4
	Karnaugh -Map, Quine-Macluskey Minimisation Technique, Determination and Selection of Prime- Implicants; Conversion of truth tables in POS and SOP form. Incomplete specified functions. Variable mapping.	4
2.	**Digital Logic Gate Characteristics** TTL logic gate characteristics: Theory & operation of TTL NAND gate circuitry. Open collector TTL. Three state output logic.	4
3.	**Combinational Logic** Design Procedure, Adders and Subtractors, Code Conversion, Multilevel NAND and NOR Circuits, Binary Parallel Adder & Subtractor, BCD Adder & Subtractor, Magnitude Comparator, Encoder, Decoder, Multiplexer, Demultiplexer.	8
4.	**Sequential Systems** Latches, flip-flops, R-S, D, J-K, and Master Slave flip flops. Conversions of flip-flops.	3
5.	**Registers, Counters** Registers -Buffer Register, Shift Registers, Serial and Parallel Loading of Data. Counters - Ripple Counters, Modulus Counter, Ring Counter, Synchronous Counter, UP and DOWN Counters	5

Text Books/ Reference Books

- M. Morris Mano, Digital Logic and Computer Design, Pearson Edu. 2014
- Millman Taub, Pulse Switching and Network, TMH 2009
- Anand Kumar, Fundamentals of Digital circuits, PHI 2009
- Floyd, Digital Fundamentals, Pearson 2008
- S. Salivahanan, Sarivazhagan, Digital circuit design, Vikas publications 2009
- Leach, Digital Principles and Applications, ed. 7, TMH 2008

EEL143	Transmission and Distribution of Electrical Power	3L:0T:0P	3 credits

S.No.	CONTENTS	HOUR
1.	**Supply systems** Basic network of power system. Transmission and distribution voltage, effect of system voltage on size of conductor and losses. Comparison of DC 2- wire, DC 3-wire, 1-phase AC and 3-phase AC (3-wire and 4-wire) systems.	5
	Distribution Systems Primary and secondary distribution systems, feeder, distributor and service mains. Radial and ring- main distribution systems. Kelvin's law for conductor size.	3
2.	**Mechanical Features of Overhead Lines** Conductor material and types of conductors. Conductor arrangements and spacing.	4
	Calculation of sag and tension, supports at different levels, effect of wind and ice loading, stringing chart and sag template. Conductor vibrations and vibration dampers.	4
3.	**Parameters of Transmission Lines** Resistance inductance and capacitance of overhead lines, effect of earth, line transposition. Geometric mean radius and distance.	4
	Inductance and capacitance of line with symmetrical and unsymmetrical spacing Inductance and capacitance of double circuit lines. Skin and proximity effects; Equivalent circuits and performance of short and medium transmission lines.	4
4.	**Generalized ABCD Line Constants** Equivalent circuit and performance of long transmission line. Ferranti effect. Interference with communication circuits. Power flow through a transmission line.	6
	Corona Electric stress between parallel conductors. Disruptive critical voltage and visual critical voltage, Factors affecting corona. Corona power loss. Effects of corona.	2
5.	**Insulators** Pin, shackle, suspension, post and strain insulators. Voltage distribution across an insulator string, grading and methods of improving string efficiency.	4
	Underground Cables Conductor, insulator, sheathing and armouring materials. Types of cables. Insulator resistance and capacitance calculation. Electrostatic stresses and reduction of maximum stresses. Causes of breakdown. Thermal rating of cable. Introduction to oil filled and gas filled cables.	4

Text Books/ Reference Books

- Weedy B.M. and Cory B.J., "Electric Power Systems", 4th Ed., Wiley India. 2008
- Grainger J. J. and Stevenson W.D., "Elements of Power System Analysis", Tata McGraw-Hill Publishing Company Limited. 2008
- Nagrath I. J. and Kothari D. P., "Modern Power System Analysis", 3 rd Ed., Tata McGraw-Hill Publishing Company Limited. 2008

EEP141	Electrical Machines Lab	0L:0T:3P	2 credits

S.No.	CONTENTS
1.	Speed control of D.C. shunt motor by field current control method & plot the curve for speed verses field current.
2.	Speed control of D.C. shunt motor by armature voltage control method & plot the curve for speed verses armature voltage.
3.	To pre-determine the efficiency of a D.C shunt machine considering it as a motor by performing Swinburne's test on it.
4.	To perform Hopkinson's test on two similar DC shunt machines and hence obtain their efficiencies at various loads.
5.	To plot the O.C.C. & S.C.C. of an alternator.
6.	To determine Z_S , X_d and regulation of synchronous motor by synchronous impedance method.
7.	To Plot V-Curve and inverted V-Curve of synchronous motor for different values of loads.
8.	To synchronize an alternator across the infinite bus and control load sharing.

EEP142	Digital Electronics Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	To verify the truth tables of basic logic gates: AND, OR, NOR, NAND, NOR. Also to verify the truth table of Ex-OR, Ex-NOR (For 2, 3, & 4 inputs using gates with 2, 3, & 4 inputs).
2.	To verify the truth table of OR, AND, NOR, Ex-OR, Ex-NOR realized using NAND & NOR gates.
3.	To realize an SOP and POS expression
4.	To realize Half adder/ Subtractor & Full Adder/ Subtractor using NAND & NOR gates and to verify their truth tables.
5.	To realize a 4-bit ripple adder/ Subtractor using basic half adder/ Subtractor & basic Full Adder/ Subtractor.
6.	To verify the truth table of 4-to-1 multiplexer and 1-to-4 demultiplexer. Realize the multiplexer using basic gates only. To construct and 8-to-1 multiplexer and 1-to-8 demultiplexer using blocks of 4-to-1 multiplexer and 1-to-4 demultiplexer.
7.	Design & realize a combinational circuit that will accept a 2421 BCD code and drive a TIL - 312 seven segment display.
8.	Using basic logic gates, realize the R-S, J-K and D-flip flops with and without clock signal and verify their truth table.
9.	Construct a divide by 2,4& 8 asynchronous counter. Construct a 4-bit binary counter and ring counter for a particular output pattern using D flip flop.
10.	Perform input/output operations on parallel in/Parallel out and Serial in/Serial out registers using clock. Also exercise loading only one of multiple values into the register using multiplexer.

EEP143	Power System Design Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	Generating station design: Design considerations, basic schemes and single line diagram of hydro, thermal, nuclear and gas power plants. Electrical equipment for power stations.
2.	Auxiliary power supply scheme for thermal power plant.
3.	Distribution system Design: Design of feeders & distributors. Calculation of voltage drops in distributors. Calculation of conductor size using Kelvin's law.
4.	Study of short term, medium term and long-term load forecasting.
5.	Sending end and receiving end power circle diagrams.
6.	Instrument Transformers: Design considerations of CTs & PTs for measurement and protection.
7.	Substations: Types of substations, various bus–bar arrangements. Electrical equipment for substations.

NOTE: Problems should preferably be solved through Programming using any Generalised Mathematical Tool.

EEL351	Power Electronics	3L:1T:0P	4 credits

S.No.	CONTENTS	HOUR
1.	**Power Semiconductor Devices**: Construction, Principle of operation, Characteristics and applications of Power Transistor& Thyristor.	3
	Characteristics of GTO, DIAC, MCT, TRIAC, Power MOSFET and IGBT; Two Transistor Model of Thyristor, Thyristor Commutation methods.	5
2.	**SCR**: Construction and characteristics, specification and ratings, pulse transformer, optical isolators, methods of turn on, triggering circuits for SCR: R, RC, UJT relaxation oscillator.	4
	Rating extension by series and parallel connections, string efficiency. Protection of SCR-Protection against over voltage, over current, dv/dt, di/dt, Gate protection.	4
3.	**Converters-I**: Single Phase half & full wave converters with RL & RLE load, Single phase dual converters, Three phase half wave converters.	5
	Three phase full converters with RL load, Three phase dual converters.	3
4.	**Converters-II**: Single and three-phase semi converters with RL & RLE load. Power factor improvement Extinction angle control, symmetrical angle control, pulse width modulation control and sinusoidal pulse width modulation control.	6
	Inversion operation. Effect of load and source impedances.	2
5.	**DC-DC Converters**: Step Up/Down Chopper, Control strategies, Chopper Configurations, Analysis of type A Chopper.	4
	Voltage, current and load commutated chopper. Multiphase Chopper.	4

Text Books/ Reference Books

- M. D. Singh and K. B. Khanchandani: Power Electronics 2/e, MGH,2008
- M. H. Rashid: Power Electronics, Circuits Devices and Applications, Pearson,2011
- P. S. Bimbhra: Power Electronics, Khanna Publishers,2012
- V. R. Moorthi: Power Electronics-Devices, Circuits and Industrial Applications, Oxford, 2005.
- Theodore Wildi: Electrical Machines, Drives and Power Systems, Pearson,2007.
- Ned Mohan: Power Electronics, John Wiley,2013
- Krein P. T.: Elements of Power Electronics, Oxford,1999

EEL352	Control System	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	**Introduction:** Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems, brief idea of multivariable control systems.	5
	Mathematical Modeling of Physical Systems: Representation of physical system (Electro Mechanical) by differential equations, Determination of transfer function by block diagram reduction techniques and signal flow method, Laplace transformation function, inverse Laplace transformation.	3
2.	**Time Response Analysis of First Order and Second Order System**: Characteristic equations, response to step, ramp and parabolic inputs.	4
	Transient response analysis, steady state errors and error constants, Transient & steady state analysis of LTI systems.	4
3.	**Control System Components**: Constructional and working concept of ac servomotor, synchronous and stepper motor.	5
	Stability and Algebraic Criteria: concept of stability and necessary conditions, Routh-Hurwitz criteria and limitations. Root Locus Technique: The root locus concepts, construction of root loci.	3
4.	**Frequency Response Analysis**: Frequency response, correlation between time and frequency responses, polar and inverse polar plots, Bode plots.	5
	Stability in Frequency Domain: Nyquist stability criterion, assessment of relative stability: gain margin and phase margin, M and N Loci, Nichols chart.	3
5.	The design problem and preliminary considerations lead, lag and lead-lag networks, design of closed loop systems using compensation techniques in time domain and frequency domain.	4
	Brief idea of proportional, derivative and integral controllers.	4

Text Books/ Reference Books

- Smarjit Ghosh, Control Systems: Theory and Applications, 2/e, Pearson Publisher,2004.
- Dhannesh N. Manik: Control System, Cengage Learning,2012.
- B S Manke linear control with matlab khanna publisher
- J. Nagrath and M. Gopal: Control Systems Engineering, 3rd Ed, New Age Publication,2008.
- K. R. Varmah: Control Systems, MGH,2010.
- Anandnatrajan et. al.: Control Systems Engineering, 4th ed., Scitech Pub,2013.
- K. Ogata: Modern Control Engineering, Prentice Hall of India,2010.
- Norman S. Nise: Control System Engineering, John Wiley & Sons,2011.
- Richard C. Dorf, Robert H. Bishop: Modern Control Systems, Prentice-Hall,2000.
- Robert H. Bishop: Modern Control Systems, Boyd and Fraser pub,2000.

EEL153	Microprocessors	3L:0T:0P	3 credits

S.No.	CONTENTS	HOUR
1.	Basic Computer Architecture: Central Processing Unit, memory and input/output interfacing. Memory Classification Volatile and non-volatile memory, Primary and secondary memory, Static and Dynamic memory, Logical, Virtual and Physical memory.	4
2.	Introduction to 8085 Microprocessor Architecture: CPU, address bus, data bus and control bus. Input/Output devices, buffers, encoders, latches and memories.	4
	Internal Data Operations and Registers, Pins and Signals, Peripheral Devices and Memory Organization, Interrupts.	4
3.	8085 Microprocessor Instructions: Classification, Format and Timing.	4
	Instruction Set: 8 Bit and 16 Bit Instructions, Programming and Debugging, Subroutines.	4
4.	8085 Microprocessor Interfacing: 8259, 8257, 8255, 8253, 8155 chips and their applications.	5
	A/D conversion, memory, keyboard and display interface (8279).	3
5.	8086 Microprocessor: Architecture: Architecture of INTEL 8086 (Bus Interface Unit, Execution unit), register organization, memory addressing, memory segmentation, Operating Modes	6
	Instruction Set of 8086: Addressing Modes: Instruction format: Discussion on instruction Set:Groups: data transfer, arithmetic, logic string, branch control transfer, processor control. Interrupts: Hardware and software interrupts, responses and types.	2
6.	Types Of Memory: Magnetic core memory, binary cell, Rom architecture and different types of ROM, RAM architecture, PROM, PAL, PLA, Flash and Cache memory, SDRAM, RDRAM and DDRAM. Memory latency, memory bandwidth, memory seek time.	4

Text Books/ Reference Books

- Gaonkar, Ramesh S.: Microprocessor Architecture, programming and Applications with the 8085, Pen Ram International Publishing 5th Ed,2002.
- K. Udaykumar and B. S. Umashankar: The 8085 Microprocessor: Architecture, Programming and Interfacing, Pearson Publisher,2008
- Ray. A. K. & Burchandi, K. M.: Advanced Microprocessors and Peripherals, Architecture, Programming and Interfacing, MGH,2006
- Lyla B. Das: The X 86 Microprocessors: Architecture, Programming and Interfacing (8086 to Pentium), Pearson Publisher,2010
- Krishna Kant: Microprocessors and Microcontrollers, PHI Learning,2007
- M. Rafiquzzaman: Microprocessors-Theory and applications, PHI,1993
- B. Ram: Advanced Microprocessor & Interfacing. MGH,2000

EEL154	EMFT	2L:0T:0P	2 credits

S.No.	CONTENTS	HOURS
1.	**Introduction**: Vector Relation in rectangular, cylindrical, spherical and general curvilinear coordinate system. Concept and physical interpretation of gradient, Divergence and curl, Green's Stoke's and Helmholz theorems.	5
2.	**Electrostatics**: Electric field vectors-electric field intensity, flux density & polarization. Electric field due to various charge configurations. The potential functions and displacement vector. Gauss's law, Poisson's and Laplace's equation and their solution. Uniqueness theorem. Continuity equation. Capacitance and electrostatics energy. Field determination by method of images. Boundary conditions. Field mappings and concept of field cells.	6
3.	**Magnetostatics**: Magnetic field vector: Magnetic field intensity, flux density & magnetization, Bio-Savart's law, Ampere's law, Magnetic scalar and vector potential, self & mutual inductance. Energy stored in magnetic field, Boundary conditions, Analogy between electric and magnetic field, Field mapping and concept of field cells.	6
4.	**Time Varying Fields**: Faraday's law, Displacement currents and equation of continuity. Maxwell's equations, Uniform plane wave in free space, dielectrics and conductors, skin effect sinusoidal time variations, reflections, refraction & polarization of UPW, standing wave ratio. Pointing vector and power considerations.	6
5.	**Transmission Lines**: The high-frequency circuit. LCR ladder model. The transmission Line equation. Solution for loss-less lines. Wave velocity and wave impedance. Reflection and Transmission coefficients at junctions. VSWR.	5

Text Books/ Reference Books

- Hayt: Engineering Electromagnetics, 7/e, (With CD), MGH,2012.
- Matthew N. O. Sadiku: Principles of Electromagnetics, 4th ed., Oxford,2009.
- G. S. N. Raju: Electromagnetic Field Theory and Transmission Lines, Pearson,2006.
- J. D. Kraus: Electromagnetic. 5th edition, MGH,1999.
- S. Baskaran and K. Malathi: Electromagnetic Field and Waves, Scitech Pub,2013.
- R. S. Kshetrimayum, Electromagnetic Field Theory, Cengage Learning,2012.
- V.V. Sarwate: Electromagnetic Field and Waves, Willey Eastern Ltd,1993.
- Bhag Guru: Electromagnetic Field Theory Fundamentals, Cambridge Uni. Press,2004.

EEL255	Restructured Power Systems	2L:0T:0P	2 credits

S.No.	CONTENTS	HOU
1.	**Introduction to restructuring of power industry** Reasons for restructuring of power industry; Understanding the restructuring process, Entities involved, the levels of competition, The market place mechanisms, Sector-wise major changes required; Reasons and objectives of deregulation of various power systems across the world	4
2.	**Fundamentals of Economics** Consumer and suppliers behavior, Total utility and marginal utility, Law of diminishing marginal utility, Elasticity of demand and supply curve, Market equilibrium, Consumer and supplier surplus, Global welfare, Deadweight loss	5
3.	**The Philosophy of Market Models** Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, Four pillars of market design, Cournot, Bertrand and Stackelberg competition model	5
4.	**Transmission Congestion Management** Transfer capability, Importance of congestion management, Effects of congestion, Classification of congestion management methods, ATC, TTC, TRM, CBM, ATC calculation using DC and AC model, Nodal pricing, Locational Marginal Prices (LMPs), Implications of nodal pricing, Price area congestion management Capacity alleviation methods, Re-dispatching, Counter-trade, Curtailment	6
5.	**Ancillary Service Management** Type and start capability service, Provisions of ancillary services, Markets for ancillary services, Co-optimization of energy and reserve services, Loss of opportunity cost, International practices of ancillary services.	4
6	**Pricing of transmission network usage and Market power** Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing, Rolled-in transmission pricing paradigm. Attributes of a perfectly competitive market, The firm's supply decision under perfect competition, Imperfect competition, Monopoly, Oligopoly. Effect of market power, Identifying market power, HHI Index, Entropy coefficient, Lerner index.	6

Text Books/ Reference Books

- S R Paranjothi, "Modern Power systems" New Age International Publishers-2017
- Loi Lei Lai,"Power System Restructuring and Deregulation", John Wiley & Sons Ltd.
- K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.
- Lorrin Philipson and H. Lee Willis,"Understanding Electric Utilities and Deregulation", Marcel Dekker Inc, New York.
- Yong-Hua Song, Xi-Fan Wang, Operation of market-oriented power systems, Springer, Germany.

EEL156	High Voltage Engineering	2L:0T:0P	2 credits

S.No.	CONTENTS	HOURS
1.	**(i) Breakdown in Gases**: Introduction to mechanism of breakdown in gases, Townsend's breakdown mechanism. Breakdown in electromagnetic gases, Application of gases in power system. **(ii)Breakdown in Liquids**: Introduction to mechanism of breakdown in liquids, suspended solid particle mechanism and cavity breakdown. Application of oil in power apparatus. **(iii) Breakdown in solids**: Introduction to mechanism of breakdown in solids, electromechanical breakdown, treeing & tracking breakdown and thermal breakdown.	6
2.	**(i) High DC Voltage Generation**: Generation of high DC voltage, basic voltage multiplier circuit. **(ii) High AC Voltage Generation**: Cascaded Transformers. **(iii) Impulse Voltage generation**: Impulse voltage, basic impulse circuit, Marx multistage impulse generator. **(iv) Measurement of High Voltage**: Potential dividers - resistive, capacitive and mixed potential dividers. Sphere gap - Construction and operation. Klydonorgraph.	6
3.	**(i) Non-destructive Insulation Tests**: Measurement of resistively, dielectric constant and loss factor. High Voltage Schering Bridge- measurement of capacitance and dielectric loss. **(ii) Partial Discharges**: Introduction to partial discharge, partial discharge equivalent circuit. Basic wide-band and narrow band PD detection circuits.	6
4.	**(i) Over voltages**: Causes of over voltages, introduction to lightning phenomena, over voltages due to lighting. **(ii) Travelling Waves**: Travelling waves on transmission lines-open end line, short circuited line, line terminated through a resistance, line connected to a cable, reflection and refraction at a T-junction and line terminated through a capacitance. Attenuation of traveling waves.	6
5.	**(i) Over Voltage Protection**: Basic construction and operation of ground wires protection angle and protective zone, ground rods, counterpoise, surge absorber, rod gap and arcing horn, lighting arresters - expulsion type, non -linear gap type and metal oxide gapless type. **(ii) Insulation Coordination**: Volt-time curves, basic impulse insulation levels, coordination of insulation levels.	6

Text Books/ Reference Books

- Naidu: High Voltage Engineering 4/e, MGH,2013.
- John Kuffel, E. Kuffel and W. S. Zaengl: High Voltage engineering, Elsevier,2000.
- C. L.Wadhwa: High Voltage Engineering, Wiley Eastern Ltd,2007.
- Subir Ray: An Introduction to High Voltage Engineering, Prentice Hall of India,2013.

EEL257	Signals and Systems	2L:0T:0P	2 credits

S.No.	CONTENTS	HOURS
1.	Energy and power signals, continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability.	5
2.	Linear shift-invariant (LSI) systems, impulse response and step response, convolution, input output behavior with aperiodic convergent inputs. Characterization of causality and stability of linear shift-invariant systems. System representation through differential equations and difference equations	6
3.	Periodic and semi-periodic inputs to an LSI system, the notion of a frequency response and its relation to the impulse response, Fourier series representation, the Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem.	7
4.	The Laplace Transform, notion of eigen functions of LSI systems, a basis of eigen functions, region of convergence, poles and zeros of system, Laplace domain analysis. The Z-Transform for discrete time signals and systems- eigen functions, region of convergence, z-domain analysis.	6
5.	State-space analysis and multi-input, multi-output representation. The state-transition matrix and its role. The Sampling theorem and its implications- Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold and first order hold. Aliasing and its effects. Relation between continuous and discrete time systems.	6

Text Books/ Reference Books

- Haykin S. & Veen B.V., Signals & Systems, John Wiley
- Oppenheim A.V., Willsky A.S. & Nawab S.H., Signals and Systems, Pearson, 2015.
- Signals and Systems: I J Nagrarth- Tata McGraw Hill
- Bracewell R.N., Fourier Transform & Its Applications, McGraw Hill
- Farooq Husain , Signals and Systems, Umesh pub.
- Papoulis A., Fourier Integral & Its Applications, McGraw Hill
- Taylor F.H., Principles of Signals & Systems, McGraw Hill

EEP151	Power Electronics Lab	0L:0T:3P	2 credits

S.No.	CONTENTS
1.	Study the comparison of following power electronics devices regarding ratings, performance characteristics and applications: Power Diode, Power Transistor, Thyristor, Diac, Triac, GTO, MOSFET, MCT and SIT.
2.	Determine V-I characteristics of SCR and measure forward breakdown voltage, latching and holding currents.
3.	Find V-I characteristics of TRIAC and DIAC.
4.	Find output characteristics of MOSFET and IGBT.
5.	Find transfer characteristics of MOSFET and IGBT.
6.	Find UJT static emitter characteristics and study the variation in peak point and valley point.
7.	Study and test firing circuits for SCR-R, RC and UJT firing circuits.
8.	Study and test 3-phase diode bridge rectifier with R and RL loads. Study the effect of filters.
9.	Study and obtain waveforms of single-phase half wave controlled rectifier with and without filters. Study the variation of output voltage with respect to firing angle.
10.	Study and obtain waveforms of single-phase half controlled bridge rectifier with R and RL loads. Study and show the effect of freewheeling diode.
11.	Study and obtain waveforms of single-phase full controlled bridge converter with R and RL loads. Study and show rectification and inversion operations with and without freewheeling diode.
12.	Control the speed of a dc motor using single-phase half controlled bridge rectifier and full controlled bridge rectifier. Plot armature voltage versus speed characteristics.

Reference/Suggested Books

- O. P. Arora: Power Electronics Laboratory-Experiments and Organization, Narosa Pub.
- P. B. Zbar: Industrial Electronics- A Text-Lab Manual, MGH.

EEP152	**System Simulation Lab**	**0L:0T:2P**	**1 credit**

CONTENTS

Basics of MATLAB matrices and vectors, matrix and array operations, Saving and loading data, plotting simple graphs, scripts and functions, Script files, Function files, Global Variables, Loops, Branches, Control flow, Advanced data objects, Multi-dimensional matrices, Structures, Applications in linear algebra curve fitting and interpolation. Numerical integration, Ordinary differential equation. (All contents is to be covered with tutorial sheets).
Simulink: Idea about simulink, problems based on simulink. (All contents is to be covered with tutorial sheets). Write a program to generate Machine Op- code table using two pass Assembler.

Reference/Suggested Books

- Almos Gilat: MATLAB: An Introduction with Applications, Wiley India Ltd., 2004.
- Ram N. Patel et. al.: Programming in MATLAB, Pearson

EEP153	Micro-processor Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	Study the hardware, functions, memory structure and operation of 8085-Microprocessor kit.
2.	Program to perform integer division: (1) 8-bit by 8-bit (2) 16-bit by 8-bit.
3.	Transfer of a block of data in memory to another place in memory
4.	Transfer of black to another location in reverse order.
5.	Searching a number in an array.
6.	Sorting of array in: (1) Ascending order (2) Descending order.
7.	Finding party of a 32-bit number.
8.	Program to perform following conversion (1) BCD to ASCII (2) BCD to hexadecimal.
9.	Program to multiply two 8–bit numbers
10.	Program to generate and sum 15 Fibonacci numbers.
11.	Program for rolling display of message “India”, “HELLO”.
12.	To insert a number at correct place in a sorted array.
13.	Reversing bits of an 8-bit number.
14.	Fabrication of 8-bit LED interfaces for 8085 kit through 8155 and 8255.
15.	Data transfer on output port 8155 & 8255 & implementation of disco light, running light, and sequential lights on the above mentioned hardware.
16.	Parallel data transfer between two DYNA-85 kit using 8253 ports.
17.	Generation of different waveform on 8253/8254 programmable timer.

EEL261	Modern Control theory	3L:1T:0P	4 credits

S.No.	CONTENTS	HOUR
1.	**Introduction:** Concept of Linear vector space Linear Independence, Bases & Representation, domain and range. Concept of Linearity, relaxedness, time invariance, causality	5
	State Space Approach of Control System Analysis: Modern Vs conventional control theory, concept of state, state variable state vector, state space, state space equations, Writing state space equations of mechanical, Electrical systems, Analogous systems.	3
2.	State Space Representation using physical and phase variables, comparison form of system representation. Block diagram representation of state model. Signal flow graph representation.	5
	State space representation using canonical variables. Diagonal matrix. Jordan canonical form, Derivation of transfer functions from state-model.	3
3.	**Solution of State Equations:** Eigenvalues and Eigen vectors. Matrix. Exponential, State transition matrix, Properties of state transition matrix.	4
	Computation of State transition matrix concepts of controllability &observability, Pole placement by state feedback.	4
4.	**Digital Control Systems:** Introduction, sampled data control systems, signal reconstruction, difference equations.	4
	The Z-transform, Z-Transfer Function. Block diagram analysis of sampled data systems, z and s domain relationship.	4
5.	Modeling of sample-hold circuit, steady state accuracy, stability in Z-plane and Jury stability criterion, bilinear transformation.	4
	Routh-Hurwitz criterion on s-planes, digital PID controllers, Introduction to adaptive control	4

Text Books/ Reference Books

- J. Nagrath and M. Gopal: Control Systems Engineering, 3rd Ed, New Age Publication. 2008
- S. K. Bhattacharya: Control Systems Engineering, 3e, Pearson Publishers. 2009
- Dhannesh N. Manik: Control System, Cengage Learning. 2010
- Richard C. Dorf, Robert H. Bishop: Modern Control Systems, Prentice-Hall. 2008
- M. Gopal: Digital Control and State Variable Methods, MGH. 2012
- B. C. Kuo: Digital Control System, Oxford. 1980
- C. H. Houpis and G. B. Lamont, Digital Control Systems, MGH. 1992
- Donald E. Kiv: Optimal Control Theory- An Introduction, Prentice Hall. 2005

EEL262	Advanced Power Electronics	3L:0T:0P	3 credits

S.No.	CONTENTS	HOUR
1.	**AC Voltage Controllers:** Principle of On-Off Control, Principle of Phase control, Single Phase Bi-directional Controllers with Resistive Loads, Single Phase Controllers with Inductive Loads, Three Phase full wave AC controllers, AC Voltage Controller with PWM Control.	5
2.	**Cyclo-converters:** Basic principle of operation, single phase to single phase, three-phase to three-phase and three-phase to single phase cyclo-converters. Output equation, Control circuit.	8
3.	**Inverters:** Principle of Operation, Single-phase bridge inverters. Three phase bridge Inverters: 180 and 120 degree of conduction. VSI and CSI. Voltage control of Single Phase and Three Phase Inverters, Harmonic analysis, harmonic reduction techniques, Pulse width modulation techniques.	6
4.	**Resonant Pulse Inverter:** Series resonant inverter with unidirectional switches, parallel resonant inverter, class E resonant inverter, L-type and M-type ZCS resonant converter, ZVS resonant converter.	8
5.	**Power Supplies:** Switched Mode DC Power Supplies, fly-back converter, forward converter, half and full bridge converter, resonant DC power supplies, bi-directional power supplies.	4
	Resonant AC power supplies, bidirectional AC power supplies. Multistage conversions, Control Circuits: Voltage Mode Control, Current Mode Control.	4

Text Books/ Reference Books

- M. H. Rashid: Power Electronics: Circuits, Devices & Applications, Pearson Publishers. 2004
- Bimal Bose: Power Electronics & Motor Drives, Elsevier-2006. 2010
- V. R. Moorthy: Power Electronics: Devices, Circuits and Industrial Applications, Oxford. 2005
- P. C. Sen: Power Electronics, MGH. 1987
- Ned Mohan, T. M. Undeland and W. P. Robbins: Power Electronics- Converters, Applications and Design, Wiley India Ltd, 2008.
- R. Krishnan: electric motor drives- modeling, analysis and control, Pearson Edu. 2001

EEL163	Switchgear & Protection	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	**Static Relays:** Introduction to static relays, merits and demerits. **Comparators**: amplitude and phase comparators, duality between amplitude and phase comparators. Introduction to (a) amplitude comparators-circulating current type, phase splitting type and sampling type, (b) phase comparators-vector product type and coincidence type.	6
	Static Over Current Relays: Introduction to instantaneous, definite time, inverse time and directional overcurrent relays	2
2.	**Static Differential Relays:** Brief description of static differential relay schemes single phase and three phase schemes. Introduction to static differential protection of generator and transformer.	5
	Static Distance Relays: Introduction to static impedance, reactance and mho relays.	3
3.	**Carrier Current Protection**: Basic apparatus and scheme of power line carrier system. Principle of operation of directional comparison and phase comparison carrier protection and carrier assisted distance protection.	4
	Distance Protection: Effect of power swings on the performance of distance protection. Out of step tripping and blocking relays, mho relay with blinders. Introduction to quadrilateral and elliptical relays.	4
4.	**Circuit Breakers-I**: Electric arc and its characteristics, arc interruption-high resistance interruption and current zero interruption. Arc interruption theories– recovery rate theory and energy balance theory.	4
	Restriking voltage and recovery voltage, develop expressions for restriking voltage and RRRV. Resistance switching, current chopping and interruption of capacitive current. Oil circuit breakers-bulk oil and minimum oil circuit breakers. Air circuit breakers. Miniature Circuit breaker (MCB).	4
5.	**Circuit Breakers-II**: Air blast, SF6 and vacuum circuit breakers. Selection of circuit breakers, rating of circuit breakers.	4
	Digital Protection: Introduction to digital protection. Brief description of block diagram of digital relay. Introduction to digital overcurrent, transformer differential and transmission line distance protection.	4

Text Books/ Reference Books

- BhaveshBhalja, R. P. Maheshari and Nilesh G. Chothani: Protection and Switchgear, Oxford, 2011
- Bhuvanesh A. Oza and Nair: Power System Protection and Switchgear, MGH, 2010
- B. Ravindranath and M. Chander: Power system Protection and Switchgear, Wiley, 1977
- B. Ram and D. N. Vishwakarma: Power System Protection and Switchgear, MGH, 2001
- Y. G. Paithankar and S. R. Bhide: Fundamentals of Power System Protection, PHI, 2010
- T.S.M. Rao: Power System Protection- Static Relays with Microprocessor Applications, MGH,1989
- Arun Ingole, Switchgear and Protection, Pearson, 2018.

EEL364	Computer Aided Design of Electrical Machines	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	**Basic Principles of Electrical Machine Design:** Specifications, Factors affecting the design, Limitations, main dimension, loadings, output equation, factor affecting the size and rating.	4
	Electrical Engineering Materials: conducting, magnetic and insulating materials. Magnetic Circuit Calculation: Ohm's law for magnetic circuit, mmf required for air gap and iron parts, tapered teeth, real and apparent flux density, magnetizing current.	4
2.	**Heating and Cooling of Electrical Machines:** heat dissipation and heat flow equations, Newton's law of cooling, equations for temperature rise.	4
	Rating of Machines: Continuous, short and intermittent ratings, mean temperature rise, hydrogen cooling of turbo alternators, quantity of cooling medium	4
3.	**Computer Aided Design of Transformers:** Power and Distribution Transformers, core and yoke cross sections, square and stepped core, output equations, main dimensions, types & design of windings, optimization concepts.	8
4.	**Computer Aided Design of Synchronous Machines:** Turbo and Hydro alternators, choice of specific magnetic & electric loading, short circuit ratio and its effects air gap length, output equation, main dimensions, flow charts for design of synchronous machine, design of stator core & winding.	8
5.	**Computer Aided Design of Induction Machines**: Output equation, main dimensions, design criteria, flow charts for design of induction motor, air gap length, design of stator core and winding, rotor design.	8

Text Books/ Reference Books

- K. Sawhney: A Course in Electrical Machine Design, Dhanpat Rai & Sons. 1984
- Edikins: Generalized Theory of Electrical Machines. 1995
- Fitzegerald: Electrical Machinery, Kingsley. 2002
- M. G. Say: The Performance and Design of AC Machines, Pitman & Sons. 1958
- R. K. Agrawal: Electrical Machine Design 2009
- V Rajini & V S Nagarajan, Electrical Machine Design, Pearson, 2018.

EEL365	Smart Grid Technology	2L:0T:0P	2 credits

S.No.	CONTENTS	HOURS
1.	**Introduction to Smart Grid:** Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits. Difference between conventional & Smart Grid, Concept of Resilient &Self-Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.	6
2.	**Smart Grid Technologies:** Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring. Protection and Control, Distribution Systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).	6
3.	**Smart Meters and Advanced Metering Infrastructure:** Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives. AMI needs in the smart grid, Phasor Measurement, Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.	6
4.	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources. Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.	6
5.	**High Performance Computing for Smart Grid Applications:** Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL). IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.	6

Text Books/ Reference Books

- Vehbi C. Güngör, Dilan Sahin, TaskinKocak, SalihErgüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke: Smart Grid Technologies- Communication Technologies and Standards IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
- Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang: Smart Grid – The New and Improved Power Grid- A Survey, IEEE Transaction on Smart Grids, 2011
- Stuart Borlase: Smart Grid-Infrastructure, Technology and Solutions, CRC Press 2012

EEL266	Power Quality	2L:0T:0P	2 credits

S.No.	CONTENTS	HOUR
1.	**Introduction to Power Quality:** Power Quality, Voltage Quality, Concern about power quality, The power quality evaluation procedure-Need for a consistent Vocabulary, General classes of power quality problems, Transients, Long-Duration voltage variations, Short-Duration voltage variations, Voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations, Power quality terms	6
2.	**Voltage Sags and Interruptions:** Sources of sags and interruptions-Estimating Voltage sag performance-Fundamental principles of protection-Solutions at the End user level, evaluating the economics of different ride through, alternatives-Motor starting sags, Utility system fault clearing issues.	6
3.	**Fundamentals of Harmonics:** Harmonic Distortion-Voltage versus current distortion Harmonic versus Transients-Power system Quantities under non sinusoidal conditions-Harmonic indices-Harmonic sources from commercial loads-Harmonic sources from industrial loads Locating harmonic sources-System response characteristics-Effects of harmonic distortion Inter harmonics	6
4.	**Applied Harmonics:** Harmonic Distortion Evaluation-Principles of Controlling Harmonics Where to control Harmonics? - Harmonic studies-Devices for controlling Harmonic Design Harmonic filter Design.	6
5.	**Power Quality Monitoring:** Monitoring considerations-Historical perspective of power quality measuring instruments-Power quality measurement equipment-Assessment of power quality measurement data-Application of intelligent systems-Power quality monitoring standards	6

Text Books/ Reference Books

- Electrical power systems quality-Roger C.Dugan- McGraw- Hills 2003
- Power quality- C.Sankaran, CRC Press 2002
- M.H.J Bollen, 'Understanding Power Quality Problems: Voltage Sags and Interruptions',1990

EEL367	Power System Planning	2L:0T:0P	2 credits

S.No.	CONTENTS	HOUR
1.	**Introduction**: Introduction of power planning, National and Regional Planning, structure of Power System, planning tools, Electricity Regulation, Electrical Forecasting, forecasting techniques modeling.	6
2.	**Power system Reliability**: System Reliability, Reliability Planning Criteria for Generation, Transmission and Distribution, Grid Reliability, Reliability Target, Security Requirement, Disaster Management, Roadmap for Reliability and Quality.	6
3.	**Generation Planning**: Objectives & Factors affecting Generation Planning, Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors affecting interconnection under Emergency Assistance.	6
4.	**Transmission & Distribution Planning**: Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability. Radial Networks – Introduction, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices	6
5.	**Demand Side Planning**: Computer aided planning, wheeling. Environmental effects, the greenhouse effect. Technological impacts. Insulation coordination. Reactive compensation.	5

Text Books/ Reference Books

- Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company Ltd 1977/1982
- X. Wang, J. R. Mc Donald: Modern Power System Planning, MGH. 1994
- S. Pabla: Electrical Power System Planning, Machmillan India Ltd. 2012
- M. Tllic, F. Faliana and L. Fink: Power System Restructuring Engineering and Economics, Kulwar Academic Publisher. 2010
- L. L. Lie: Power System Restructuring and Deregulation, John Willey & Sons UK. 2001

EEP161	Control Systems Lab	0L:0T:1P	1 credit

S.No.	CONTENTS
1.	Introduction to MATLAB Computing Control Software.
2.	Defining Systems in TF, ZPK form.
3.	**(a)** Plot step response of a given TF and system in state-space. Take different values of damping ratio and wn natural undamped frequency. **(b)** Plot ramp response.
4.	For a given 2ndorder system plot step response and obtain time response specification.
5.	To design 1st order R-C circuits and observe its response with the following inputs and trace the curve. **(a)** Step **(b)** Ramp **(c)** Impulse
6.	To design 2nd order electrical network and study its transient response for step input and following cases. **(a)** Under damped system **(b)** Over damped System. **(c)** Critically damped system.
7.	**(a)** Log Network **(b)** Lead Network **(c)** Log-lead Network.
8.	To draw characteristics of ac servomotor
9.	To perform experiment on Potentiometer error detector.
10.	Check for the stability of a given closed loop system.
11.	Plot bode plot for a 2ndorder system and find GM and PM.

EEP162	Advance Power Electronics Lab	0L:0T:3P	2 credits

S.No.	CONTENTS
1.	Study and test AC voltage regulators using triac, antiparallel thyristors and triac & diac.
2.	Study and test single phase PWM inverter.
3.	Study and test buck, boost and buck- boost regulators.
4.	Study and test MOSFET chopper.
5.	Study and test Zero voltage switching.
6.	Study and test SCR DC circuit breaker.
7.	Control speed of a dc motor using a chopper and plot armature voltage versus speed characteristics.
8.	Control speed of a single-phase induction motor using single phase AC voltage regulator.
9.	**(i).** Study single-phase dual converter. **(ii).** Study speed control of dc motor using single-phase dual converter.
10.	Study one, two and four quadrant choppers (DC-DC converters).
11.	Study speed control of dc motor using one, two and four quadrant choppers.
12.	Study single-phase cycloconverter.

EEP163	Power System Protection Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	To determine fault type, fault impedance and fault location during single line to ground fault.
2.	To determine fault type, fault impedance and fault location during single line-to-line fault.
3.	To determine fault type, fault impedance and fault location during double line to ground fault.
4.	To study the operation of microcontroller based over current relay in DMT type and IDMT type.
5.	To analyze the operation of microcontroller based directional over current relay in DMT type and IDMT type.
6.	To study the microcontroller based under voltage relay.
7.	To study the microcontroller based over voltage relay
8.	To study the operation of microcontroller based un-biased single-phase differential relay.
9.	To study the operation of microcontroller based biased single-phase differential relay.
10.	To study the operation of microcontroller un-based biased three phase differential relay
11.	To study the operation of microcontroller based biased three phase differential relay.

EEL371	Power System Analysis	3L:1T:0P	4 credits

S.No.	CONTENTS	HOUR
1.	Percent and per unit quantities. Single line diagram for a balanced 3-phase system. Admittance Model: Branch and node admittances Equivalent admittance network and calculation of Y bus. Modification of an existing Y bus.	8
2.	Impedance Model: Bus admittance and impedance matrices. Thevenin's theorem and Z bus. Direct determination of Z bus. Modification of an existing bus. Symmetrical fault Analysis: Transient on a Transmission line, short circuit of a synchronous machine on no load, short circuit of a loaded synchronous machine. Equivalent circuits of synchronous machine under sub transient, transient and steady state conditions. Selection of circuit breakers, Algorithm for short circuit studies. Analysis of three-phase faults.	8
3.	Symmetrical Components: Fortescue theorem, symmetrical component transformation. Phase shift in star-delta transformers. Sequence Impedances of transmission lines, Synchronous Machine and Transformers, zero sequence network of transformers and transmission lines. Construction of sequence networks of power system. Fault Analysis: Analysis of single line to ground faults using symmetrical components, connection of sequence networks under the fault condition.	8
4.	Unsymmetrical Fault Analysis: Analysis of line-to-line and double line to ground faults using symmetrical components, connection of sequence networks under fault conditions. Analysis of unsymmetrical shunt faults using bus impedance matrix method.	8
5.	Load Flow Analysis: Load Flow problem, development of load flow equations, bus classification. Gauss Seidel, Newton Raphson, decoupled and fast decoupled methods for load flow analysis. Comparison of load flow methods.	8

Text Books/ Reference Books

- J. J. Grainger, William, D. Stevenson Jr.: Power System Analysis, MGH.
- T. K. Nagsarkar & M. S. Sukhija: Power System Analysis, Oxford University Press.
- J. D. Glover, M. S. Sharma & T. J. Overbye: Power System Analysis and Design, Cengage Learning.
- Nasser Tleis: Power System Modelling and Fault Analysis, Elsevier.
- Kothari &Nagrath: Modern Power System Analysis, MGH.
- Haadi Saadat: Power System Analysis.
- N.V. Ramana, Power System Analysis, Pearson, 2010.

EEL372	Electric Drives & Control	3L:0T:0P	3 credits

S.No.	CONTENTS	HOUR
1.	Dynamics of Electric Drives: Fundamental torque equations, speed-torque conventions and multi-quadrant operation, Nature and classification of load torques, steady state stability, load equalization, close loop configurations of drives.	8
2.	DC Drives: Speed torque curves, torque and power limitation in armature voltage and field control, Starting, Braking: Regenerative Braking, dynamic braking and plugging. Speed Control- Controlled Rectifier fed DC drives, Chopper Controlled DC drives.	8
3.	Induction Motor Drives-I: Starting, Braking-Regenerative braking, plugging and dynamic braking. Speed Control: Stator voltage control, variable frequency control from voltage source, Voltage Source Inverter (VSI) Control.	8
4.	Induction Motor Drives-II: Variable frequency control from current source, Current Source Inverter (CSI) Control, Cyclo-converter Control, Static rotor resistance control, Slip Power Recovery- Stator Scherbius drive, Static Kramer drive.	8
5.	Synchronous Motor Drive: Control of Synchronous Motor-Separately Controlled and VSI fed Self-Controlled Synchronous Motor Drives. Dynamic and Regenerative Braking of Synchronous Motor with VSI. Control of Synchronous Motor Using Current Source Inverter (CSI).	8

Text Books/ Reference Books

- G. K. Dubey: Fundamentals of Electrical Drives, Narosa Publishing House, New Delhi. 2002
- B. K. Bose: Power Electronics and Motor Drives, Elsevier. 2010
- V. Subrahmanyam: Electric Drives- Concepts and Applications, MGH. 2011
- Theodore Wildi: Electrical Machines, Drives and Power Systems, Pearson 2014.
- S. K. Pillai: A First Course on Electrical Drives, Wiley Eastern limited, India. 1989

EEL173	Power System Engineering	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	Economic Operation of Power Systems: Introduction, system constraints, optimal operation of power systems. Input output, heat rate and incremental rate curves of thermal generating units. Economic distribution of load between generating units within a plant. Economic distribution of load between power stations, transmission loss equation. Introduction to unit commitment and dynamic programming.	8
2.	Power System Stability-I: Power angle equations and power angle curves under steady state and transient conditions. Rotor dynamics and swing equation (solution of swing equation not included). Synchronizing power coefficient. Introduction to steady state and dynamic stabilities, Steady state stability limit.	8
3.	Power System Stability-II: Introduction to transient stability. Equal area criterion and its application to transient stability studies under basic disturbances. Critical clearing angle and critical clearing time. Factors affecting stability and methods to improve stability.	8
4.	Excitation Systems: Introduction of excitation systems of synchronous machines, types of excitation systems, Elements of various excitation systems and their control (functional block diagrams and their brief description)-DC excitation systems, AC excitation systems, brushless excitation system. Interconnected Power Systems: Introduction to isolated and interconnected powers systems. Reserve capacity of power stations, spinning and maintenance reserves. Advantages and problems of interconnected power systems. Power systems interconnection in India.	8
5.	Tap Changing transformer, phase angle control and phase shifting transformer. Series compensation of transmission lines, location and protection of series capacitors, advantages and problems. Introduction to power system security. Introduction to voltage stability.	8

Text Books/ Reference Books

- J. Nagrath and D.P. Kothari: Power System Engineering 2/e, MGH. 2011
- J. J. Grainger and W. D. Stevenson: Power System Analysis, MGH. 2003
- B. R. Gupta: Power System Analysis and Design, Third Edition, S. Chand & Co. 2008
- C. L. Wadhwa: Electrical Power Systems, New age international Ltd. Third Edition 2009
- B. R. Gupta: Generation of Electrical Energy, S. Chand Publication. 2009
- N.V. Ramana, Power System Operation & Control, Pearson, 2010.

EEL274	HVDC Transmission Systems	3L:0T:0P	3 credits

S.No.	CONTENTS	HC
1.	DC Transmission Technology: Comparison of AC and DC Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVDC Systems. Components of HVDC system. Line Commutated Converter and Voltage Source Converter based systems.	6
2.	Analysis of Line Commutated and Voltage Source Converters:Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links. Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six-pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.	8
3.	Control of HVDC Converters: Principles of Link Control in a LCC HVDC system. Control Hierarchy, Firing Angle Controls – Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVDC system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.	8
4.	Components of HVDC systems: Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes.	6
5.	Stability Enhancement using HVDC Control: Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/DC systems.	6
6.	MTDC Links: Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTDC systems using LCCs. MTDC systems using VSCs. Modern Trends in HVDC Technology. Introduction to Modular Multi-level Converters.	6

Text Books/ Reference Books

- K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 2011.
- J. Arrillaga, “High Voltage Direct Current Transmission”, Peter Peregrinus Ltd., 1983.
- E. W. Kimbark, “Direct Current Transmission”, Vol.1, Wiley-Interscience, 1971

EEL375	Electrical and Hybrid Vehicles	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	**Introduction:** Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.	3
2.	**Hybrid Electric Vehicles:** History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	7
3.	**Electric Trains:** Electric Drive-trains: Basic concept of electric traction, introduction to various electric drivetrain topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	10
4.	**Energy Storage:** Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems	10
5.	**Energy Management Strategies:** Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	9

Text Books/ Reference Books

- C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
- S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
- M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004
- T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

EEL276	Digital Control Systems	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	Discrete Representation of Continuous Systems: Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent.	8
2.	Discrete System Analysis: Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.	8
3.	Stability of Discrete Time System: Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design.	6
4.	State Space Approach for discrete time systems: State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reach-ability, Reconstructability and observability analysis. Effect of pole zero cancellation on the controllability & observability.	6
5.	Design of Digital Control System: Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.	6
6.	Discrete output feedback control: Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.	6

Text Books/ Reference Books

- K. Ogata, "Digital Control Engineering", Prentice Hall, Englewood Cliffs, 1995.
- M. Gopal, Digital control and state variable methods. Tata McGraw Hill New Delhi, 2001.
- G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison-Wesley, 1998.
- B.C. Kuo, "Digital Control System", Holt, Rinehart and Winston, 1980.
- V. I. George and C.P. Kurian, Digital Control Systems, Cengage publishers. New Delhi, 2012.

EEP171	Power System Modelling and Simulation Lab	0L:0T:3P	2 credits

S.No.	CONTENTS
Part – A:	
1.	Fault analysis (for 3 to 6 bus) and verify the results using MATLAB or any available software for the cases: (i) LG Fault (ii) LLG Fault (iii) LL Fault and (iv) 3-Phase Fault
2.	Load flow analysis for a given system (for 3 to 6 bus) using (i) Gauss Seidal (ii) Newton Raphson (iii) Fast Decoupled Method and verify results using MATLAB or any available software
3.	Study of voltage security analysis
4.	Study of overload security analysis and obtain results for the given problem using MATLAB or any software.
5.	Study of economic load dispatch problem with different methods. Study of transient stability analysis using MATLAB/ETAP Software
Part – B:	
1.	Simulate Swing Equation in Simulink (MATLAB)
2.	Modeling of Synchronous Machine.
3.	Modeling of Induction Machine.

EEP172	Electric Drives & Control Lab	0L:0T:2P	1 credit

S.No.	CONTENTS
1.	Study and test the firing circuit of three phase half-controlled bridge converter.
2.	Study and obtain waveforms of 3 phase half-controlled bridge converter with R and RL loads.
3.	Study and test the firing circuit of 3-phase full controlled bridge converter.
4.	Study and obtain waveforms of 3-phase full controlled bridge converter with R and RL loads.
5.	Study and test 3-phase AC voltage regulator.
6.	Control speed of dc motor using 3-phase half-controlled bridge converter. Plot armature voltage versus speed characteristic.
7.	Control speed of dc motor using 3-phase full controlled bridge converter. Plot armature voltage versus speed characteristic.
8.	Control speed of a 3-phase induction motor in variable stator voltage mode using 3-phase AC voltage regulator.
9.	Control speed of a 3-phase BLDC motor.
10.	Control speed of a 3-phase PMSM motor using frequency and voltage control
11.	Control speed of universal motor using AC voltage regulator.
12.	Study 3-phase dual converter.
13.	Study speed control of dc motor using 3-phase dual converter.
14.	Study three-phase cycloconverter and speed control of synchronous motor using cycloconverter.
15.	Control of 3-Phase Induction Motor in variable frequency V/f constant mode using 3- phase inverter.

EEL181	Artificial Intelligence	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	**Introduction to Artificial Intelligence:** Intelligent Agents, State Space Search, Uninformed Search, Informed Search, Two Players Games, Constraint Satisfaction Problems	6
2.	**Knowledge Representation:** Knowledge Representation and Logic, Interface in Propositional Logic, First Order Logic, Reasoning Using First Order Logic, Resolution in FOPL	6
3.	**Knowledge Organization:** Rule Based System, Semantic Net, Reasoning in Semantic Net, Frames, Planning	6
4.	**Knowledge Systems:** Rule Based Expert System, Reasoning with Uncertainty, Fuzzy Reasoning	6
5.	**Knowledge Acquisition:** Introduction to Learning, Rule Induction and Decision Trees, Learning Using neural Networks, Probabilistic Learning, Natural Language Processing	6
6.	**Control Strategies:** Concept of heuristic search, search techniques depth first search, Breath first search, Generate & test hill climbing, best first search	6

Text Books/ Reference Books

- Saroj Kaushik: Artificial Intelligence, Cengage Learning., 2007.
- Elaine Rich and Kevin Knight: Artificial Intelligence 3/e, MGH, 2004.
- Padhy: Artificial Intelligence & Intelligent Systems, Oxford 2005
- S. Rajsekaran & G. A. Vijayalakshmi Pai: Neural Networks, Fuzzy Logic and Genetic Algorithm- Synthesis and Applications, Prentice Hall of India. 2003.
- Dan. W Patterson: Artificial Intelligence and Expert Systems, Pearson, 1990
- Stuart J. Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, 3/e, Pearson, 2015.

EEL282	Line-Commutated and Active PWM Rectifiers	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	Diode rectifiers with passive filtering, Half-wave diode rectifier with RL and RC loads; 1- phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current waveshape, effect of source inductance; commutation overlap.	7
2.	Thyristor rectifiers with passive filtering, Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.	7
3.	Multi-Pulse converter, Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6- pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.	6
4.	Single-phase ac-dc single-switch boost converter Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.	6
5.	Ac-dc bidirectional boost converter, Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.	6
6.	Isolated single-phase ac-dc fly-back converter, dc-dc fly-back converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc fly-back converter, steady state analysis, unity power factor operation, closed loop control structure.	8

Text Books/ Reference Books

- G. De, “Principles of Thyristorise Converters”, Oxford & IBH Publishing Co, 1988.
- J.G. Kassakian, M. F. Schlecht and G. C. Verghese, “Principles of Power Electronics”, AddisonWesley, 1991.
- L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.
- N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.
- R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2001

EEL183	Optimization Techniques	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	**Introduction**: Engineering application of Optimization, Formulation of design problems as mathematical programming problems, classification of optimization problems.	8
2.	**Optimization Techniques**: Classical optimization, multivariable with no constraints, unconstrained minimization techniques.	4
	Penalty function techniques, Lagrange multipliers and feasibility techniques.	4
3.	**Linear Programming**: Graphical method, Simplex method, Duality in linear programming (LP), Sensitivity analysis Applications in civil engineering.	6
4.	**Non-Linear Programming Techniques/Method**: Unconstrained optimization, one dimensional minimization, golden section, elimination, quadratic and cubic, Fibonacci, interpolation.	6
	Direct search, Descent, Constrained optimization, Direct and indirect, Optimization with calculus, Kuhn-Tucker conditions.	2
5.	**Constrained Optimization Techniques**: Direct, complex, cutting plane, exterior penalty function methods for structural engineering problems	8

Text Books/ Reference Books

- Rao S. S.: Engineering Optimization- Theory and Practice, New Age International,2009.
- Hadley. G.: Linear programming, Narosa Publishing House, New Delhi,2003.
- Deb. K.: Optimization for Engineering Design- Algorithms and Examples, PHI,2012.
- Bhavikatti S. S.: Structural Optimization Using Sequential Linear Programming, Vikas Publishing House, New Delhi,2003.
- Spunt: Optimum Structural Design, Prentice Hall,1971.
- Uri Krisch: Optimum Structural Design, MGH,1981.

EEL184	Electrical Energy Conservation and Auditing	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	**Energy Scenario:** Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act- 2001 and its features.	6
2.	**Basics of Energy and its Various Forms:** Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.	8
3.	**Energy Management & Audit:** Definition, energy audit, need, types of energy audit. Energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.	8
4.	**Energy Efficiency in Electrical Systems:** Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, automatic power factor controllers, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses, energy efficient transformers. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors. Energy efficient lightening controls.	10
5.	**Energy Efficiency in Industrial Systems:** Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.	8

Text Books/ Reference Books

- Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
- Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
- S. C. Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
- Success stories of Energy Conservation by BEE, New Delhi. (www.bee-india.org)

EEL385	FACTS Devices and their Application	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	Problems of AC transmission systems, power flow in parallel paths and meshed system, factors limiting loading capability. Stability consideration. Power flow control of an ac transmission line. Basic types of facts controllers. Advantages of FACTS technology.	8
2.	**Voltage-Sourced Converters:** Basic concept of voltage-sourced converters, single and three phase bridge converters. Introduction to power factor control. Transformer connections for 12- pulse, 24 pulse and 48 pulse operations. **Static Shunt Compensators:** Mid-point and end point voltage regulation of transmission line, and stability improvement. Basic operating principle of Static Synchronous Compensators (STATCOM). Comparison between STATCOM and SVC.	8
3.	**Static Series Compensators:** Concept of series capacitive compensation, voltage and transient stabilities, power oscillation and sub synchronous oscillation damping. Introduction to thyristors switched series capacitor (TSSC), thyristor-controlled series capacitor (TCSC), and static synchronous series compensator, - operation, characteristics and applications.	8
4.	**Static Voltage and Phase Angle Regulators:** Voltage and phase angle regulation. Power flow control and improvement of stability by phase angle regulator. Introduction to thyristor-controlled voltage and phase angle regulators (TCVR and TCPAR) (ii) Introduction to thyristor controlled braking resistor and thyristor-controlled voltage limiter.	8
5.	**UPFC:** Unified Power Flow Controller (UPFC), basic operating principles, conventional transmission control capabilities. Comparison of UPFC to series compensators and phase angle regulator. Applications of UPFC. **IPFC:** Interline Power Flow Controller (IPFC), basic operating principles and characteristics. Applications of IPFC.	8

Text Books/ Reference Books

- K. R. Padiyar: Flexible AC Transmission Systems
- N. G. Hingorani, L. Gyugyi: Understanding FACTS: IEEE Press Book.
- Yong Hua Song, Allan T Johns: Flexible AC Transmission Systems FACTS
- Xiao Ping Zhang, Christian Rehtanz, Bikash Pal: Flexible AC Transmission Systems.
- R. Mohan & R. M. Mathur: Thyristor-based FACTS Controllers for Electrical Transmission Systems, John Wiley.

EEL186	Wind and Solar Energy Systems	3L:0T:0P	3 credits

S.No.	CONTENTS	HOU
1.	**Physics of Wind Power** History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.	5
2.	**Wind Generator Topologies** Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.	12
3.	**The Solar Resource** Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.	3
4.	**Solar Photovoltaic** Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.	8
5.	**Network Integration Issues** Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.	8
6.	**Solar Thermal Power Generation** Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.	3

Text Books/ Reference Books

- T. Ackermann, "Wind Power in Power Systems", John Wiley and Sons Ltd., 2005.
- G. M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley and Sons, 2004
- S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", McGraw Hill, 1984.
- H. Siegfried and R. Waddington, "Grid integration of wind energy conversion systems" John Wiley and Sons Ltd., 2006.
- G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004.
- J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes",

Syllabus for Open Category Courses

EEL104	Electrical Machines and Drives	3L:0T:0P	3 credits

S.No.	CONTENTS	HOUR
1.	BASIC CONCEPTS IN ROTATING MACHINES and DC MOTORS: Introduction to magnetic circuits – Magnetically induced e.m.f and force – AC operation of magnetic circuits – Hysteresis and Eddy current losses. Energy in magnetic systems – Field energy & mechanical force -Constructional features of DC machine – Principle of operation of DC generator – EMF equation.	8
2.	SINGLE PHASE & THREE PHASE INDUCTION MACHINES: Construction and principle of operation of single phase & three phase induction motor - Torque & Power equations – starting and speed control of induction machines - Slip – Torque characteristics.	8
3.	REVIEW OF ELECTRIC DRIVES: Electric Drives-Advantage of Electric Drives-selection of Motor power rating- Thermal model of motor for heating and cooling - Classes of duty cycle- Determination of motor rating - control of Electric drives modes of operation - speed control and drive classifications – closed loop control of drives.	6
4.	SOLID STATE CONTROL OF DRIVES: DC motor and their performance-Braking - uncontrolled rectifier control - controlled rectifier fed DC drives - Chopper controlled DC drives - Time ratio control and current limit control - Single, two and four quadrant operations	8
5.	SOLID STATE CONTROL OF INDUCTION MOTOR: Induction Motor Drives-Stator Control-Stator voltage and frequency control – V/f control, AC Controller based speed control. cycloconverter fed induction motor drives – slip power recovery schematic control of rotor resistance using DC chopper.	8

Text Books/ Reference Books

- Bose.B.K, "Power Electronics and Variable frequency drives", 1st ed, IEEE Press Standard Publications 2002.
- Kothari.D.P and Nagrath.I.J. “Electrical Machines”, Tata McGraw Hill Publishing Co.Ltd, New Delhi, 5th edition 2002.
- Dr. Murugesh Kumar K. DC “Machines & Transformers”, Vikas Publishing House Pvt. Ltd., 2003.
- Dubey. G.K, "Fundamentals of Electrical drives", Narora publications, 1995
- Krishnan.R, "Electric motor drives Modeling, Analysis and Control", 1st edition, Pearson Publications, 2002.

EEL105	Power Generation Sources	3L:0T:0P	3 credits

S.No.	CONTENTS	HOURS
1.	INTRODUCTION: World energy status, Current energy scenario in India, Environmental aspects of energy utilization, Environment - Economy - Energy and Sustainable Development, Energy planning.	4
2.	Conventional Energy Generation Methods: Thermal Power plants: Basic schemes and working principle. Gas Power Plants: open cycle and closed cycle gas turbine plants, combined gas & steam plants-basic schemes. Hydro Power Plants: Classification of hydroelectric plants. Basic schemes of hydroelectric and pumped storage plants. Nuclear Power Plants: Nuclear fission and nuclear fusion. Fissile and fertile materials. Basic plant schemes with boiling water reactor, heavy water reactor and fast breeder reactor. Efficiencies of various power plants	8
3.	SOLAR ENERGY: Basic concepts, Solar radiation – Measurement, Solar thermal systems – Flat plate and concentrating collectors, Solar passive space – Solar heating and cooling techniques – Solar desalination – Solar Pond - Solar cooker - Solar dryers-Solar furnaces - Solar pumping, Solar green house- Solar thermal electric power plant – Solar photo voltaic conversion – Solar cells – PV applications, Hybrid systems.	6
4.	WIND ENERGY: Introduction-Availability- Wind power plants , Power from the wind, Wind energy conversion systems, site characteristics, Wind turbines types – Horizontal and vertical axis-design principles of wind turbine – Blade element theory, Magnus effect- Performance. Wind energy Applications – Hybrid systems, Wind energy storage, Safety and environmental aspects.	6
5.	BIOMASS ENERGY: Biomass – usable forms- composition- fuel properties – applications, Biomass resources, Biomass conversion technologies – direction combustion - pyrolysis – gasification -anaerobic digestion, Bioethanol and Biodiesel Production - Economics - Recent developments. Energy farming, Biogas technology - Family biogas plants, Community and institutional biogas plants – design consideration – applications.	4
6.	OTHER RENEWABLE ENERGY SOURCES: Tidal energy – Wave energy – Open and closed OTEC Cycles – Small hydro – Geothermal energy – Social and environmental aspects. Fuel cell technology - types, principle of operation – applications. Hydrogen energy production - Storage – transportation – utilization.	8

Text Books/ Reference Books

- Godfrey Boyle, “Renewable Energy”, Power for a Sustainable Future, Oxford University Press, U.K, 1996.
- Twidell.J.W & Weir.A, “Renewable Energy Sources”, EFN Spon Ltd., UK, 1986
- Tiwari.G.N, “Solar Energy – Fundamentals Design”, Modelling and applications, Narosa Publishing House, NewDelhi,2002
- Freris.L.L, “Wind Energy Conversion systems”, Prentice Hall, UK, 1990.
- Veziroglu.T.N, “Alternative Energy Sources”, Vol 5 and 6, McGraw-Hill, 1978
- Renewable energy sources of conversion technology:N.K Bansal”, Manfred Kleen Man and Michael Meliss, TMH Publication.

- G.D. Rai, “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 1999.

EEL106	Energy Audit and Demand side Management	2L:0T:0P	2 credits

S.No.	CONTENTS	HOURS
1.	**Energy Scenarios:** Energy Conservation, Energy Audit, Energy Scenarios, Energy Consumption, Energy Security, Energy Strategy, Clean Development Mechanism.	3
2.	**Types of Energy Audits and Energy-Audit Methodology:** Definition of Energy Audit, Place of Audit, Energy – Audit Methodology, Financial Analysis, Sensitivity Analysis, Project Financing Options, Energy Monitoring and Training.	3
3.	**Survey Instrumentation:** Electrical Measurement, Thermal Measurement, Light Measurement, Speed Measurement, Data Logger and Data – Acquisition System, Thermal Basis.	3
4.	**Electrical-Load Management:** Electrical Basics, Electrical Load Management, Variable- Frequency Drives, Harmonics and its Effects, Electricity Tariff, Power Factor, Transmission and Distribution Losses.	4
5.	**Energy Audit of Motors:** Classification of Motors, Parameters related to Motors, Efficiency of a Motor, Energy Conservation in Motors, BEE Star Rating and Labelling.	3
6.	**Energy Audit of Lighting Systems:** Fundamentals of Lighting, Different Lighting Systems, Ballasts, Fixtures (Luminaries), Reflectors, Lenses and Louvres, Lighting Control Systems, Lighting System Audit, Energy Saving Opportunities.	3
7.	**Energy Audit Applied to Buildings:** Energy Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy Savings Tips Applicable to New as well as Existing Buildings.	3
8.	**Demand side Management:** Scope of DSM, Evolution of DSM concept, DSM planning and Implementation, Load management as a DSM strategy, Applications of Load Control, End use energy conservation, Tariff options for DSM, customer acceptance, implementation issues, Implementation strategies, DSM and Environment.	5
9.	**Energy Conservation:** Motivation of energy conservation, Principles of Energy conservation, Energy conservation planning, Energy conservation in industries, EC in SSI, EC in electrical generation, transmission and distribution, EC in household and commercial sectors, EC in transport, EC in agriculture, EC legislation.	3

Text Books/ Reference Books

- Handbook on Energy Audit Sonal Desai McGraw Hill 1st Edition, 2015
- Generation of Electrical Energy B R Gupta S. Chand 1stEdition, 1983
- Principles of Energy Conversion : A.W. Culp.
- Energy Conversion systems : Begamudre, Rakoshdas
- Direct Energy Conversion : W.R.Corliss
- Energy Economics -A.V.Desai (Wieley Eastern)
- Industrial Energy Conservation : D.A. Reay (Pergammon Press)
- S. C. Tripathy, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991
- Energy Audit and Management, Volume-I, IECC Press
- Energy Efficiency in Electrical Systems, Volume-II, IECC Press
- Energy Management: W.R.Murphy, G.Mckay, Butterworths Scientific
- Energy Management Principles, C.B.Smith, Pergamon Press 5. Industrial Energy Conservation, D.A. Reay, Pergammon Press

- Energy Management Handbook, W.C. Turner, John Wiley and Sons, A Wiley Interscience
- Hand Book of Energy Audits, Albert Thumann, P.E., C.E.M. William J. Younger, C.E.M., CRC Press.

EEL107	Industrial Electrical Systems	2L:0T:0P	2 credits

S.No.	CONTENTS	HOUR
1.	**Electrical System Components:** LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices.	6
2.	**Residential and Commercial Electrical Systems:** Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, design of a lighting scheme for a residential and commercial premise, flood lighting, earthing of commercial installation, selection and sizing of components.	8
3.	**Industrial Electrical Systems I:** Connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.	6
4.	**Industrial Electrical Systems II:** DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.	4
5.	**Industrial Electrical System Automation:** Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.	6

Text Books/ Reference Books

- S. L. Uppal and G. C. Garg, "Electrical Wiring, Estimating & Costing", Khanna publishers, 2008.
- K. B. Raina, "Electrical Design, Estimating & Costing", New age International, 2007.
- S. Singh and R. D. Singh, "Electrical estimating and costing", DhanpatRai and Co., 1997.
- Web site for IS Standards.
- H. Joshi, "Residential Commercial and Industrial Systems" McGraw Hill Education, 2008.

Minor Courses Syllabus / Layout

Basic Electrical Circuits:

Week 1: Preliminaries; Current and voltage; Electrical elements and circuits; Kirchhoff's laws, Basic elements: Voltage and current sources, R, L, C, M; Linearity of elements
Week 2: Elements in series and parallel, Controlled sources
Week 3: Power and energy in electrical elements, Circuit Analysis Methods
Week 4: Nodal analysis, Extending nodal analysis with different sources
Week 5: Mesh analysis, Circuit theorems
Week 6: More circuit theorems, two port parameters
Week 7: Two port parameters continued, Reciprocity in resistive networks
Week 8: Op-amp and negative feedback, Op-amps cont'd: Example circuits and additional topics
Week 9: First Order Circuits, First Order Circuits cont'd
Week 10: First order circuits with time-varying inputs, Sinusoidal steady state response and total response
Week 11: Second order system-Natural response, Second order system-Cont'd
Week 12: Direct calculation of steady state response from equivalent components, Magnitude and Phase plots; Maximum power transfer theorem

Electrical Machines:

Week 1: Introduction to Electrical machines, Review of single-phase and three-phase circuits, complex notation, power and power factor

Week 2: Magnetic circuits and flux calculations: MMF, Flux, permeability, reluctance, Ferromagnetic materials, BH loop, hysteresis, Eddy current losses

Week 3: Assignment No 1 and 2 on AC circuits & Magnetic Circuits

Week 4: Transformers: Principle of operation, ideal and practical transformer, efficiency and voltage regulation, Open circuit, short circuit and Load tests. Auto-transformer and instrument transformers. Parallel operation. Three-phase transformer fundamentals.

Week 5: Assignment No. 3 and 4 on single-phase and three-phase transformers

Week 6: Electromagnetic energy conversion principles: Filed energy, co-energy, Torque & power calculations, singly excited and doubly excited machines.

Week 7: DC machines: Generators and motors; Construction, Different types of DC machines, principle of operation, torque and emf equation, Characteristics of DC generators and motors, Starting Braking and Speed control of DC Motors.

Week 8: 3-phase induction machines: Construction, Different types of rotors, principle of operation, revolving magnetic field theory, Equivalent circuit, Torque expression,3 Torque-speed Characteristics of induction motors, Starting Braking and Speed control.

Week 9: Single-phase induction motor: Types, Construction, Principle of operation, equivalent circuit, Torque-speed characteristics

Week 10: Assignment No. 6 & 7 Problems on DC Generators and motors

Week 11: Single-phase induction motor: Types, Construction, Principle of operation, equivalent circuit, Torque-speed characteristics

Week 12: Three-phase Synchronous Machines: Construction, Different types, principle of operation, EMF equation, winding factor, OCC, SCC and calculation of synchronous reactance, Equivalent circuit, Voltage regulation and efficiency, Motoring operation, Power and Torque expressions, PF control, V and inverted V Characteristics of synchronous motors, Starting Braking and speed control.

Control engineering:

Week 1: Mathematical Modelling of Systems
Week 2: Laplace Transforms, transfer functions, block diagram representation.
Week 3: Block diagram reduction, Time response characteristics.
Week 4: Introduction to stability, Routh Hurwitz stability criterion.
Week 5: Root locus plots, stability margins.
Week 6: Frequency response analysis: Nyquist stability criterion, Bode plots and stability margins in frequency domain.
Week 7: Basics of control design, the proportional, derivative and integral actions.
Week 8: Design using Root Locus
Week 9: Design using Bode plots
Week 10: Effects of zeros, minimum and non-minimum phase systems.
Week 11: State space analysis
Week 12: Design using State space

Basic Electronics:

Week 1: Lecture 1: A brief history of electronics
Lecture 2: Superposition
Lecture 3: Useful circuit techniques-1
Lecture 4: Useful circuit techniques-2
Lecture 5: Phasors-1
Lecture 6: Phasors-2

Week 2: Lecture 7: RC/RL circuits in time domain-1
Lecture 8: RC/RL circuits in time domain-2
Lecture 9: RC/RL circuits in time domain-3
Lecture 10: RC/RL circuits in time domain-4
Lecture 11: RC/RL circuits in time domain-5
Lecture 12: Simulation of RC circuit

Week 3: Lecture 13: Diode circuits-1
Lecture 14: Diode circuits-2
Lecture 15: Diode circuits-3
Lecture 16: Diode circuits-4
Lecture 17: Diode circuits-5
Lecture 18: Diode circuits-6

Week 4: Lecture 19: Diode rectifiers-1
Lecture 20: Diode rectifiers-2
Lecture 21: Diode rectifiers-3
Lecture 22: Bipolar Junction Transistor-1
Lecture 23: Bipolar Junction Transistor-2
Lecture 24: Bipolar Junction Transistor-3

Week 5: Lecture 25: BJT amplifier-1
Lecture 26: BJT amplifier-2
Lecture 27: BJT amplifier-3
Lecture 28: BJT amplifier-4
Lecture 29: BJT amplifier-5
Lecture 30: BJT amplifier-6

Week 6: Lecture 31: BJT amplifier-7
Lecture 32: Introduction to op-amps
Lecture 33: Op-amp circuits-1
Lecture 34: Op-amp circuits-2
Lecture 35: Op-amp circuits-3
Lecture 36: Difference amplifier

Week 7: Lecture 37: Instrumentation amplifier-1
Lecture 38: Instrumentation amplifier-2
Lecture 39: Op-amp nonidealities-1
Lecture 40: Op-amp nonidealities-2
Lecture 41: Bode plots-1
Lecture 42: Bode plots-2

Week 8: Lecture 43: Bode plots-3
Lecture 44: Op-amp filters
Lecture 45: Simulation of op-amp filter
Lecture 46: Precision rectifiers-1
Lecture 47: Precision rectifiers-2
Lecture 48: Precision rectifiers-3

Week 9: Lecture 49: Simulation of triangle-to-sine converter
Lecture 50: Schmitt triggers-1
Lecture 51: Schmitt triggers-2
Lecture 52: Schmitt triggers-3
Lecture 53: Sinusoidal oscillators-1
Lecture 54: Sinusoidal oscillators-2

Week 10: Lecture 55: Introduction to digital circuits
Lecture 56: Boolean algebra
Lecture 57: Karnaugh maps
Lecture 58: Combinatorial circuits-1
Lecture 59: Combinatorial circuits-2

Lecture 60: Combinatorial circuits-3

Week 11: Lecture 61: Introduction to sequential circuits
Lecture 62: Latch and flip-flop
Lecture 63: JK flip-flop
Lecture 64: D flip-flop
Lecture 65: Shift registers
Lecture 66: Counters-1

Week 12: Lecture 67: Counters-2
Lecture 68: Simulation of a synchronous counter
Lecture 69: 555 timers
Lecture 70: Digital-to-Analog conversion-1
Lecture 71: Digital-to-Analog conversion-2
Lecture 72: Analog-to-Digital conversion

Fundamental of Power Electronics:

Week 1: Ideal switch, diode static characteristics, diode dynamic characteristics, reading the diode datasheet, thermal dissipation, heatsink design, diac and triac.
Week 2: Bipolar junction transistor - operation, static and dynamic characteristics, loss calculation, safe operation area, reading the datasheet, parallel operation, Darlington connection.
Week 3: MOSFETs and IGBTs - operation, static and dynamic characteristics of MOSFET and IGBT, parallel operation, loss calculation and simulation.
Week 4: Rectifier - Capacitor filter, circuit operation and waveforms, designing the circuit, setting up for simulation in Ng Spice, simulation of circuit.
Week 5: Inrush current limiting in rectifier-capacitor filter circuits, resistor solution, thermistor solution, transformer solution, MOSFET solution, relay and contactor solution, power factor concepts and measurement of power factor for rectifier capacitor filter circuit.
Week 6: Linear DC -DC converter or linear regulators, shunt regulator, operation, design and applications, series regulator, operation and design, improvement solutions, datasheet study.
Week 7: DC-DC switched mode converters: Buck, Boost and buck-boost converters, operation, waveforms, equations and simulation in Ng Spice.
Week 8: Forward converter operation, waveforms, core resetting methods, simulation in Ng Spice, Inductor design by area product approach, Flyback converter, operation and waveforms.
Week 9: Magnetics design, permeance, inductor value and energy storage, inductor design, transformer design area product approach,
Week 10: Push pull, half bridge and full bridge circuits, operation and waveforms, simulation example
Week 11: Drive circuits, BJT drive requirements, drive circuit non-isolated, drive circuits isolated, MOSFET drive requirements, drive circuit non-isolated and isolated, series snubber, shunt snubber.
Week 12: Close loop control, current control, slope compensation for current control, single phase inverter with sinusoidal PWM, simulation example

Power System Engineering:

Week 1: Overhead Line Insulators
Week 2: Underground Cables
Week 3: Transient Over voltages and Insulation Coordination

Week 4: Corona
Week 5: Sag and Tension
Week 6: Distribution System Load Flow and Voltage Stability
Week 7: Approximate Method of Distribution System Analysis
Week 8: Application of Capacitors for Radial Distribution Systems
Week 9: Load Frequency Control
Week 10: Load Frequency Control
Week 11: Unit commitment
Week 12: Unit Commitment

Microprocessors and Interfacing:

Week 1: 8086 Architecture
Week 2: 8086 Pins and Signals
Week 3: 8086 Instruction Set I
Week 4: 8086 Instruction Set II
Week 5: 8086 Instruction Set III
Week 6: 8086 Instruction Set IV
Week 7: 8086 Programming I
Week 8: 8086 Programming II
Week 9: Memory Interfacing
Week 10: 8255 Interfacing Examples
Week 11: Interfacing of DC and Stepper Motors
Week 12: Interfacing of Key board, Display, USART

Physics of Renewable Energy Systems:

Week 1 **:** Basics of semiconductor, nanomaterials and nanotechnology
Week 2 **:** Renewable energy sources and classifications
Week 3 **:** Solar Power
Week 4 **:** Wind Power
Week 5 **:** Hydro, Tidal and Geothermal Systems
Week 6 **:** Energy storage Technology: Classification and principle
Week 7 **:** Fuel cells: Principles, Classifications and Operations
Week 8 **:** Supercapacitors and Battery
Week 9 **:** Energy storage mechanism
Week 10: Effect of double layer in energy storage: Chemical approach
Week 11: Characterization techniques: I
Week 12: Characterization techniques II

Power system analysis:

Week 1: Structure of Power System and Few Other Aspects
Week 2: Resistance, Inductance, and Capacitance of Transmission Lines
Week 3: Power System Components and Per Unit System
Week 4: Characteristics and Performance of Transmission Lines
Week 5: Load Flow Analysis
Week 6: Load Flow Analysis (Contd.)

Week 7: Optimal System Operation
Week 8: Optimal System Operation (Contd.)
Week 9: Symmetrical Fault
Week 10: Symmetrical Components
Week 11: Unbalanced Fault Analysis
Week 12: Power System Stability

Introduction to Smart Grid:

Week 1: Introduction to Smart Grid-I
Introduction to Smart Grid-II
Architecture of Smart Grid System
Standards for Smart Grid System
Elements and Technologies of Smart Grid System
Week 2: Elements and Technologies of Smart Grid System-II
Distributed Generation Resources-I
Distributed Generation Resources-II
Distributed Generation Resources-III
Distributed Generation Resources-IV
Week 3: Wide Area Monitoring Systems-I
Wide Area Monitoring Systems-II
Phasor Estimation-I
Phasor Estimation-II
Digital relays for Smart Grid Protection
Week 4: Islanding Detection Techniques-I
Islanding Detection Techniques-II
Islanding Detection Techniques-III
Islanding Detection Techniques-IV
Smart Grid Protection-I
Week 5: Smart Grid Protection-II
Smart Grid Protection-III
Modelling of Storage Devices
Modelling of DC Smart Grid components
Operation and control of AC Microgrid-I
Week 6: Operation and control of AC Microgrid-II
Operation and control of DC Microgrid-I
Operation and control of DC Microgrid-II
Operation and control of AC-DC hybrid Microgrid-I
Operation and control of AC-DC hybrid Microgrid-II
Week 7: Simulation and Case study of AC Microgrid
Simulation and Case study of DC Microgrid
Simulation and Case Study of AC-DC Hybrid Microgrid
Demand side management. of Smart Grid
Demand response analysis of Smart Grid
Week 8: Energy Management
Design of Smart grid and Practical Smart Grid case study-I
Design of Smart grid and Practical Smart Grid case study-II
System Analysis of AC/DC Smart Grid

Conclusions

Power System Protection:

Week 1: Introduction to modern power system protection- philosophy and approach- Digital protection technology overview; Phasor measurement techniques
Week 2: Phasor measurement techniques
Week 3: Overcurrent protection
Week 4: Directional Relaying
Week 5: Distance Relaying
Week6: Distance Relaying
Week 7: CT and CVT response
Week 8: Transformer protection
Week 9: Differential protection of Line
Week 10: Network Protection with Renewable sources
Week 11: Travelling wave approach
Week 12: Synchro phasor technology application

Signals and Systems:

Week 1: Mathematical Preliminaries
Week 2: Types of Signals and Transformations
Week 3: Fourier Transform of Continuous-Time Signals
Week 4: Properties of Fourier Transforms
Week 5: LTI Systems
Week 6: Convolution and LTI System Properties
Week 7: Laplace Transform
Week 8: Laplace Transform Properties
Week 9: Fourier Series of Continuous-Time Periodic Signals and Properties
Week 10: Discrete-Time LTI Systems and Sampling
Week 11: Discrete-Time Fourier Transform (DTFT)
Week 12: Z-Transform

Department Specialization Courses Syllabus / Layout

1. Electric Drives and Control:

Fundamentals of Electric Drives (NPTEL):

Week 1: Introduction to Electrical Drives; Dynamics of Electrical Drives; Review of Torque-Speed Characteristics of DC Motors (Shunt and Series) including Motoring and Braking

Week 2: Converter (Half Controlled Converter, Full Controlled Converter, Dual Converters); Control of DC Motor Drives; Torque Speed Characteristics of Converter-fed DC Drives

Week 3: Chopper Controlled DC Drives (Single and Multi-quadrant Converters), Motoring and Braking operations

Week 4: Induction Motor Drives – Equivalent circuits; Torque-speed characteristics; Operation of Induction Motor with Unbalanced Source Voltages; Analysis of Induction Motor from Non-sinusoidal Voltage Supply; Starting and Braking of Induction Motor

Week 5: Stator Voltage Control of Induction Motor; Variable Voltage/ Current; Variable Frequency Control of Induction Motor Fed from VSI and CSI; Control of Slip-ring Induction Motor

Week 6: Synchronous Motor Characteristics (Cylindrical and Salient Pole); CSI-fed Synchronous Motor Drive; Permanent Magnet Synchronous Motor Drive; Brushless DC Motor Drives

Week 7: Traction Drives – Characteristics of Traction Drives; Drive Power Requirement; DC and AC Traction Week 8: Switched Reluctance Motor – Construction; Analysis and Closed-loop Control; Various Types of Stepper Motor and their Characteristics.

2. Industrial Drives - Power Electronics (NPTEL):

1. Introduction

a. Classification of Electric Drives

b. Requirements of Electric Drives

c. Some Applications

2. Converters and control

a. Phase controlled converters

b. Four quadrant operation

c. Choppers d. AC to DC converters

3. DC motor drives

a. Speed-torque characteristics DC shunt, PMDC and series motors

b. Dynamic model

c. Speed and position control methods

4. Inverters and PWM techniques

a. voltage source inverters

b. current source inverters

c. PWM techniques

i. sine-triangle comparison

ii. harmonic elimination

iii. hysteresis current controllers

iv. space vector pwm

5. AC motor drives

a. d-q model of induction motor

b. constant flux speed control structure

c. vector control model

d. vector control structure

3. Advance Electric Drives (NPTEL):

1. Generalized theory and Kron's primitive machine model
2. Modeling of dc machines

Modeling of induction machine

Modeling of synchronous machine

Reference frame theory and per unit system

3. Control of Induction Motor Drive

Scalar control of induction motor

Principle of vector control and field orientation

Sensorless control and flux observers

Direct torque and flux control of induction motor

Multilevel converter-fed induction motor drive Utility friendly induction motor drive

4. Control of Synchronous Motor

Self-controlled synchronous motor

Vector control of synchronous motor

Cycloconverter-fed synchronous motor drive

Control of synchronous reluctance motor

5. Control of Special Electric Machines
Permanent magnet synchronous motor

Brushless dc motor

Switched reluctance motor

Stepper motors and control

4. Motors and Motor Control Circuits (Coursera):

1. AC Motor Designs

Principles of operation of AC induction motors, both single and 3-phase types. interpret data from torque speed curves, and how to optimize data in these curves based on electrical resistance, inductance, and capacitance. Different types of single-phase motors, featuring a video analysis of a split phase motor used in a clothing dryer. Typical applications for single phase motors, which will assist in picking the right one for an application.

2. AC Motor Control

Details of AC motor specifications and enclosures, as well as how these details are governed by national and international design standards. Detailed methodology for researching design requirements for AC motors, and how to use these requirements to pick the right motor for specific needs. AC motor control components and systems, both manual and automatic. AC variable speed drives.

3. DC Motors

Principles of DC motors, traditional brushed motors, as well as electronically driven brushless motors. Shunt wound, series wound, compound wound, servo, stepper, and torque motors, with detailed explanation of how commutation and control is implemented in these designs. Lab exercise on DC motor speed measurement. Video analysis, this time featuring the teardown of a paper shredder. Detailed methodology for researching design requirements for DC motors, and how to use these requirements to pick the right motor for specific needs.

4. DC Motor Control and Stepper Motors

Hands-on experience with DC motor control. Then, we will illustrate a simplified stepper motor drive, stepper motor specs, operation and commercial driver chips and packages. Lab exercise, this time on

actuating a rotary sensor. Comparison of DC vs. AC motors, a core understanding of their pros and cons.

5. Course Projects

In this module students will perform lab work for the Course. There will be two labs.

5. Electric Motor Control (Udemy):

Electrical Control and Protective Devices

- Circuit Breakers
- Fuses
- Overload Relay
- Push Button
- Selector Switches
- Contactor
- Contactor Coil
- Limit Switches
- Limit Switch - Connection
- Relay
- Timer
- over-current relay, overvoltage and under-voltage relay
- Pressure Switches
- Float Switches
- Flow Switches
- Proximity Sensors
- Photoelectric Sensors
- Solenoid Valve

Sizing Motor Panel NEC

- Motor Full Load Current
- Cable
- Fuse
- Circuit Breaker
- Overload Protection
- Contactor
- Main Feeder

- Main Circuit Break
- Motor Power Circuit Practical Wiring
- Single Motor Control Circuit Start/Stop From one Location
- Control Circuit Start/Stop from one Location - Wiring
- Execution Recommendations
- Devices and Contacts Arrangement
- Motor Operation with Indicators
- Motor Operation with Indicators- Circuit Simulation
- Motor Operation with Indicators - Practical Wiring
- Control Panel Operating Voltage
- How To Get Voltage of The Control Circuit
- Single Motor Start/Stop from Two Locations
- conveyor Control Circuit
- Automatic Water Pump Control Circuit
- Single Motor Start/Stop from Three Locations
- Two Motors Power Circuit Practical Wiring
- Two Motors Run Independently Circuit Design
- Two Motors Stop Simultaneously in case of overload
- Motor Can't Run until Another Run
- Motor Disconnected automatically after operating the another
- Motor Can't Stop Until Stop The another
- Start Motor and Stop another at The Same Time
- Work on EKTS
- Three Motors Each Starts After the Previous
- Two Motors Start Automatically After the First
- Reversing Motor Rotation
- Reversing Motor Rotation Control Circuit Reduced
- Elevator Control Circuit - Design
- Elevator Control Circuit - Simulation
- Single Phase Motor Control
- Motor Braking Power Circuit
- Motor Braking Control Circuit
- motor starts after a period of time from running another motor
- Motor disconnects automatically after starting another motor
- Star and Delta Connection

- **Star Delta Motor Starter**
- Power in Start and Delta Connection
- Star/Delta Terminals
- Star/Delta Power and Control Circuit

6. Drives and Control (EKEEDA):

Electrical Drives: Introduction and Dynamics

- Introduction, Advantages of Electrical Drives, Parts of Electrical Drives
- Choice of Electrical Drives, Status of DC and AC Drives
- Fundamental Torque Equations,
- Torque Speed Conventions and Multi-Quadrant Operation
- Equivalent Values of Drive Parameter-Concept
- Problem Based on Equivalent Values of Drive Parameter
- Measurement of Moment of Inertia
- Components of Load Torques
- Nature and Classification of Load Torques
- Calculation of Time and Energy-Loss in Transient Operations
- Problem Based on Calculation of Time and Energy-Loss in Transient Operations
- Steady State Stability of Electrical Drive
- Load Equalisation

Selection of Motor Power Rating

- Thermal Model of Motor for Heating and Cooling
- Class of Motor Rating Part 1
- Class of Motor Rating Part 2
- Determination of Motor Rating
- Servo Drives and Position Control
- Types of Enclosures of Motor

Control of Electrical Drives:

- Modes of Operation and Speed Control
- Drive Classification
- Closed Loop Control of Drives- Speed Control Loop with Inner Loop of Current Control.
- Current Control Techniques- PWM and Hysteresis
- Static and Dynamic Performance of Drive.

DC Drives

- Basic Multi-Quadrant (T -? M) Characteristics and Equations of DC Motors.
- Problem 1 Based on Equations of DC Drives
- Single Phase Drives- Full Converter Drive and Its Performance Parameters
- Problem Based on Phase Full Converter Drive

- Dual Converter Drive
- Problem based on Dual Converter Drive
- Three Phase Drives- Half-Converter Drive, Fully-Converter Drive
- Problem 1 Based on 3 Phase Converter Drive
- Dc-Dc Converter Drive- Principle of Power Control (Step-Down Chopper)
- Plugging
- Regenerative Brake Control, Rheostatic Brake Control, Performance Parameters for Braking and Speed Control
- Control of Dc Drives- Open Loop and Closed Loop Control (Transfer Function Approach and Microcontroller Control) Clock Diagrams
- Closed Loop Control of Current Limit and Torque Control
- Close Loop Speed Control of DC Motor Below and Above Base Speed

AC Drives

- Basic Multi-Quadrant (T -? M) Characteristics of AC Drives
- Equations Induction Motor Drives
- Problem 1 Based on Equations of Induction Motor
- Review of Speed-Torque Relations
- Review of Starting Methods-1
- Review of Starting Methods-2
- Braking Methods- Regenerative, Plugging and AC Dynamic Braking Only
- Speed Control: Stator Voltage Control
- Problem based on Stator Voltage Speed Control Method
- Variable Frequency Control
- Problem based on Variable Frequency Control
- Static Rotor Resistance Control
- Slip Power Recovery Schemes
- Problem based on Slip Power Recovery Schemes
- Static Scherbius Drive
- Review of D-Q Model of Induction Motor,
- Introduction to Synchronous Motor Variable Speed Drives
- BLDC Motor Drives

Advanced Control Techniques

- Principle of Vector Control, Block Diagram of Direct Vector Control Scheme
- Comparison of Scalar Control and Vector Control
- Direct Torque Control (DTC)
- Field Oriented Control (FOC)
- Comparison Between Control Techniques

Industrial application of Drives

- Machine Tools
- Textile Mills
- Steel Rolling Mills
- Sugar Mills
- Traction Drives
- Crane and Hoist Drives
- Solar and Battery Powered Drives

7. Fundamentals of Power Electronics (NPTEL):

WEEK 1. Power Electronics – Introduction: Definitions and applications, Basic building blocks | Power Converters - Introduction & Classification: Switching Matrix | PE Converter: Passive components (R, L, C), Active components (introduction to switches).

WEEK 2. Review of basic concepts-Engineering Math, Elec. | Power Diodes | Thyristors (SCR) | Thyristors (GTO)

WEEK 3. Power BJT: Introduction, Structure, Operation, Characteristics, Equations., Losses, Drawbacks | Power MOSFET: Introduction, Structure, Operation. Characteristic, Losses, Merits, Demerits, Applications | Power IGBT: Introduction, Structure, Operation. Characteristics. Losses, Applications, Merits, Demerits, SiC, GaN devices.

WEEK4. AC-DC Conv. 1-φ half-wave Uncontrolled. & Controlled Rectifiers (R, R-L, R-L-E, R-E and pure L loads) | AC-DC Conv. Commutation: Effect Of source Inductance (R-L and RLE loads only) | AC-DC Conv. 1-φ Full-wave Uncontrolled. & Controlled Rectifiers (R, R-L, R-L-E, R-E and pure L loads) | AC-DC Conv. 1-φ Full-wave Eect Of source Inductance (R-L and RLE loads only) | AC-DC Conv. 3-φ rectifiers Uncontrolled. & Controlled Rectifiers (R and R-L loads only) | AC-DC Conv. 3-φ rectifiers Eect Of source Inductance (R-L load only).

WEEK5. AC-DC Conv. 3-φ reciters 12-Pulse rectifier DC-Transmission | AC-AC Conv. 1-φ AC voltage controllers | AC-AC Conv. 1-φ AC voltage controllers | AC-AC Conv. 3-φ AC voltage controllers | AC-AC Conv. 3-φ AC voltage controllers | Cyclo-converters- 1- φ operation with R & R-L load.

WEEK6. Cyclo-converters- Circulation mode operation Waveforms and Equations | Matrix converters | Introduction and basic operation | DC-DC Conv.- Introduction, Types of DC/DC | DC-DC Conv.- Drawbacks of Linear Power Supplies Basic Switching Converter | DC-DC Conv.- Introduction and Buck conv.

WEEK7. DC-DC Converter. - Boost Converter. | DC-DC Converter. - Buck-Boost Converter. | Synchronous Buck Converter | DC-DC Conv.- Cuk Converter. | DC-DC Conv.- SEPIC Converter. | 1st, 2nd and 4th quadrant operation of DC-DC converters.

WEEK8. DC-DC Isolated Converter.: Forward and back Conv., Push-Pull Conv. | Resonant DC-DC converters. Intro & Basic Operation | Resonant DC-DC converters. ZVS & ZCS | DC-AC Conv Intro: Types and Working principles | 1- φ half bridge inverter: Topology & working.

WEEK 9. 1- φ full bridge inverter: Topology & Working, Square wave & quasi wave operation | 1- φ half bridge inverter: square wave & quasi wave operation | PWM operation: SPWM-Bipolar, Unipolar, Merits & demerits, Applications | 3- φ VSI Topology & working.

WEEK 10. 3- φ VSI: Square wave operation, PWM operation (SPWM), Space vector modulation (SVPWM), etc. | Resonant Inverters: Basic Operation, Inverters Applications | CSI-Topology and Basic Operations | MLI – Topology: Operation and basic topologies.

WEEK 11. MLI – Topology (NPC) Basic Operations | Gate Drive: Need for drives, examples | Gate Drive Circuits: SCR drive | Gate drive: MOSFET & IGBT drive | Snubbers: Need for Snubbers, Types and examples | Snubber: Design Equations.

WEEK 12. Intro of basics of magnetic Concepts | Inductor Design: Area Product approach, Examples and Applications | Transformer Design: Area Product approach, Examples and Applications |Application of PE in Solar PV: Introduction, V-I Char. Types and MPPT.

8. Advance Power Electronics and Control (NPTEL)

Week 01: Basic Concept of Switches and Device Physics.

WEEK02: Device Physics, Application and Analysis of Switches and Single Phase.

WEEK03: Converter Single Phase Converter, Three Phase Converter, Multipulse Converter and Eect of Source Inductance and PWM Rectifiers.

WEEK04: PWM Rectifiers and Power Factor Improvement Techniques and non- isolated DC- DC converters.

WEEK05: Non- isolated and isolated DC- DC Converters and Choppers.

WEEK06: Isolated DC- DC Converters IV and VSI & CSI, MLI and ZSI.

WEEK07: SVM, AC to AC Converters, Cycloconverter and Matrix Converter.

WEEK08: Linear Control in Power Electronics, Nonlinear Control in Power Electronics, Applications and Conclusions.

2. Systems & Control

1. Linear Systems Theory:

Week 1: Introduction to Linear systems with Examples

Week 2: Math Preliminaries I - Vector Spaces, Bases, Coordinate Transformation, Invariant Subspaces, Inner product, Norms

Week 3: Math Preliminaries II - Rank, Types of Matrices, Eigen values, Eigen vectors, Diagonalization, Matrix Factorization

Week 4: State Transition Matrix, Solutions to LTI Systems, Solutions to LTV Systems

Week 5: Equilibrium points, Linearization, Types of Linearization with Examples

Week 6: Stability, Types of Stability, Lyapunov Equation

Week 7: Controllability, Reachability, Stabilizability, Tests, Controllable and Reachable Subspaces, Grammians, Controllable Decomposition

Week 8: Observability, Constructability, Detectability, Tests, Subspaces, Grammians, State Estimation, Observable Decomposition

Week 9: Kalman Decomposition, Pole Placement, Controller Design

Week 10: Observer Design, Duality, Minimal Realization

Week 11: Basics of Optimal Control, LQR, Ricatti Equation

Week 12: LMIs in Control

2. Control and Tuning Methods in Switched Mode Power Converters:

Week 1: Switched mode power converters and MATLAB simulation

Week 2: Modulation techniques in SMPCs

Week 3: Fixed frequency control methods

Week 4: Variable frequency control methods

Week 5: Modeling and Analysis techniques in SMPCs

Week 6: Small-signal performance analysis

Week 7: Small-signal design and tuning of PWM voltage mode control

Week 8: Small-signal design of current mode control

Week 9: Large-signal model and nonlinear control

Week 10: Boundary control for time optimal recovery

Week 11: Large-signal controller tuning method

Week 12: Performance comparison and simulation

3. System Design Through VERILOG:

Week-1: Introduction to Verilog

Week-2: Gate level modelling

Week-3: Behavioral modelling I

Week-4: Behavioral modelling II

Week-5: Data flow modelling

Week-6: Switch level modelling

Week-7: Synthesis of combinational logic using Verilog

Week-8: Synthesis of sequential logic using Verilog

4. LINEAR DYNAMICAL SYSTEMS:

Week 1: State-space solutions and realizations

Week 2: Stability

Week 3: Controllability: Part I

Week 4: Controllability: Part II

Week 5: State Feedback Controller Design: Part I

Week 6: State Feedback Controller Design: Part II

Week 7: Observability and minimal realization

Week 8: Observer Design and Output Feedback

5. SENSORS AND ACTUATORS:

Week 1: Basics of Energy Transformation: Transducers, Sensors and Actuators

Week 2: Understanding of thin film physics: Application in MOSFET and its variants

Week 3: Thin Film Deposition Techniques: Chemical Vapor Deposition (APCVD, LPCVD, UHVCVD, PECVD, ALCVD, HPCVD, MOCVD)

Week 4: Thin Film Deposition Techniques: Physical Vapor Deposition (Thermal Deposition, E-beam Evaporation, Sputtering, Pulsed Laser Deposition)

Week 5: Basic understanding of Photolithography for pattering layer. Detailed overview of Etching methods.

Week 6: Understanding various gas sensors: Optical gas sensor, Metal oxide semiconductor gas sensor, Field effect transistor gas sensor, Piezoelectric gas sensor, Polymer gas sensor, Nano-structured based gas sensors

Week 7: Design and fabrication process of Microsensors: Force Sensors, Pressure Sensors, Strain gauges and practical applications

Week 8: Explain working principles of Actuators. Piezoelectric and Piezoresistive actuators, micropumps and micro actuators with practical applications

Week 9: Understanding basics of microfluidics to assist Photomask design using Clewin Software, pattern transfer techniques, PDMS moulding and degassing, device bonding techniques.

Week 10: Simulation, Optimization and characterization of various sensors using COMSOL Multiphysics

Week 11: Understanding of Sensor Interfacing with Microprocessor to build electronic system

Week 12: Static and Dynamic Characteristic Parameters for Sensors and Actuators, Calibration of Sensor based electronics systems

6. INDUSTRIAL AUTOMATION AND CONTROL

Week 1: Introduction

Week 2: Measurement Systems Characteristics

Week 3: Introduction to Automatic Control

Week 4: Feedforward Control Ratio Control

Week 5: Special Control Structures

Week 6: Sequence Control. Scan Cycle, Simple RLL Programs

Week 7: PLC Hardware Environment

Week 8: Flow Control Valves

Week 9: Industrial Hydraulic Circuit

Week 10: Energy Savings with Variable Speed Drives

Week 11: The Fieldbus Network - I

Week 12: Course Review and Conclusion (Self-study)

7. Intelligent Systems and Control:

Module I (9 classes): Biological foundations to intelligent systems I: Artificial neural networks, Back-propagation networks, Radial basis function networks, and recurrent networks.

Module II (6 classes): Biological foundations to intelligent systems II: Fuzzy logic, knowledge representation and inference mechanism, genetic algorithm, and fuzzy neural networks.

Module III (6 classes): Fuzzy and expert control (standard, Takagi-Sugeno, mathematical characterizations, design example), Parametric optimization of fuzzy logic controller using genetic algorithm.

Module IV (6 classes): System identification using neural and fuzzy neural networks.

Module V (6 classes): Stability analysis: Lyapunov stability theory and Passivity Theory.

Module VI (4 classes): Adaptive control using neural and fuzzy neural networks, Direct and Indirect adaptive control, and Self-tuning Pill Controllers.

Module VII (5 classes): Applications to pH reactor control, flight control, robot manipulator dynamic control, underactuated systems such as inverted pendulum and inertia wheel pendulum control and visual motor coordination.

3. Renewable Energy Technologies

Technologies For Clean and Renewable Energy Production:

Week 1: Introduction, characterization of coal and conventional routes for energy production from coal
Week 2: Cleaner routes for energy production form coal
Week 3: Characterization of crude oil and conventional routes for crude oil utilization
Week 4: Cleaner routes for energy production form petroleum crude
Week 5: Cleaner energy production from gaseous fuels
Week 6: Solar and wind energy production
Week 7: Production of hydro and geothermal energy
Week 8: Energy production from biomass and wastes and energy conservation

Natural Resources for Sustainable Development:

Module 1: Challenges and opportunities

- History of oil, gas, and mining
- Challenges& opportunities: oil, gas, and mining
- The decision chain of natural resource management (I)
- The decision chain of natural resource management (II)

Module 2: Political economy of natural resources

- How natural resources shape and are shaped by political context
- Corruption trends in the extractive sector
- International governance
- Natural resources& the broader governance framework
- Transparency& accountability

Module 3: Fundamentals of oil, gas, and mining: industry considerations and policy

- From oil well to car - market, players, and extraction process
- From mine to mobile phone - market, players, and extraction process
- How a company decides to invest
- Project development
- Evolving technology

Module 4: Legal overview

- Legal& regulatory frameworks for extractive industries
- Allocation of rights
- Implementation& monitoring of legal frameworks
- International law& the extractive industries
- State-owned enterprises: Role and governance

Module 5: Fiscal regime design and revenue collection

- Resource economics& fiscal regime principles
- Fiscal instruments I: Royalty/tax systems
- Fiscal instruments II: Contract-based systems
- Fiscal regime implementation

Module 6: Anticipating and managing environmental issues

- Environmental challenges and trends: oil and gas
- Environmental challenges and trends: mining
- Managing environmental challenges
- Extractives and climate change
- Environmental impact assessments

Module 7: Community rights

- Social impact and engagement
- Human rights and the mining industry
- Mining and vulnerable populations
- Company-community agreements

Module 8: Artisanal mining

- Introduction to artisanal and small-scale mining (ASM)
- Challenges of ASM
- ASM and gender
- Tensions between ASM and large-scale mining
- The way forward

Module 9: Revenue management

- Challenges of revenue management
- Policy responses: savings, spending, public debt, and earmarking
- Natural resource funds
- Revenue sharing and decentralization

Module 10: Investing in sustainable development: Economic linkages to the extractives sector

- Introduction to economic linkages
- Local employment
- Local procurement
- Enabling tech transfer
- Downstream linkages

Module 11: Investing in sustainable development: Looking beyond extractives

Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems:

Week 1: Solar Energy: Basics and Concepts
Week 2: Concentrating and Non-concentrating Solar Collectors
Week 3: Thermal Energy Storage Systems and Solar Energy Utilization Methods
Week 4: Wind Energy: Basics and Concepts
Week 5: Characteristics and Power Generation from Wind Energy
Week 6: Biomass, Broad Classifications, Compositions, Characteristics, Properties, Structural Components
Week 7: Biomass Residues, Utilisation through Conversion Routes: Bio-chemical and Thermo Chemical, Bioconversion into Biogas, Mechanism
Week 8: Bioconversion of Substrates into Alcohols, Thermo Chemical Conversion of Biomass, Conversion to Solid, Liquid and Gaseous Fuels, Pyrolysis, Gasification, Combustion, Chemical Conversion Processes

PHOTOVOLATIC SYSTEM:

Introduction to Photovoltaics

The Solar Resource and Geometry

Physics of Solar Cells

Cell Interconnection and Module Design

PV Power Electronics

WIND ENERGY:

Introduction to wind energy

Wind resources

Test and measurements

Economy

Wind turbine technology

Aerodynamics

Materials

Structural mechanics

Electrical systems

RENEABLE ENERGY: FUNDAMENTALS AND JOB OPPORTUNITIES:

Clean Energy 101

Sustainability

Green Building

Solar Energy

Wind Energy

Nanotechnology for Renewable Energy

Final Project: Exploring Pathways to Renewable Energy Careers

GLOBAL ENERGY AND CLIMATE POLICY:

The future of fossil fuels in a carbon-constrained world

The nuclear option: the solution to the energy/climate conundrum?

Up-scaling renewable energy: policy incentives

Energy and climate governance: two become one?

Climate change and energy security: resolving a tri-lemma

What next for energy policy with the Paris Agreement on climate change

RENEWABLE POWER AND ELECTRICITY SYSTEM:

Introduction and Renewable Power Basics

Grid Operations and Grid Integration

Storage and Demand Flexibility

Power Structure Industry and ISOs

Course Summary and Review

Data Analysis Project – Wind Resource Assessment

Design of photovoltaic systems:

Week 1: THE PV CELL
Week 2: SERIES AND PARALLEL INTERCONNECTION
Week 3: ENERGY FROM SUN
Week 4: INCIDENT ENERGY ESTIMATION

Week 5: SIZING PV
Week 6: MAXIMUM POWER POINT TRACKING
Week 7: MPPT ALGORITHMS
Week 8: PV-BATTERY INTERFACES
Week 9: PELTIER COOLING
Week 10: PV AND WATER PUMPING
Week 11: PV-GRID INTERFACE-I
Week 12: PV-GRID INTERFACE-II and LIFE CYCLE COSTING

Incorporating Renewable Energy in Electricity Grids:

1. How do electricity systems work? An introduction
2. How do different types of electricity generation technology work?
3. How are electricity systems affected by increased penetrations of variable renewables?
4. Options for managing increased penetrations of variable renewables
5. What might the future hold?
6. Policies and incentives to overcome barriers

4. Robotics & Automation

Industrial Automation and Control:

Module I

1 Introduction

2 Introduction (Cont.)

3 Architecture of Industrial Automation Systems

4 Architecture of Industrial Automation Systems (Cont.)

Module II

5 Measurement Systems Characteristics

6 Measurement Systems Characteristics (Cont.)

7 Data Acquisition Systems

8 Data Acquisition Systems (Cont.)

Module III

9 Introduction to Automatic Control

10 Introduction to Automatic Control (Cont.)

11 P-I-D Control

12 P-I-D Control (Cont.)

13 PID Control Tuning

14 PID Control Tuning (Cont.)

15 Feedforward Control Ratio Control

16 Feedforward Control Ratio Control (Cont.)

17 Time Delay Systems and Inverse Response Systems

18 Time Delay Systems and Inverse Response Systems (Cont.)

19 Special Control Structures

20 Special Control Structures (Cont.)

21 Concluding Lesson on Process Control (Self-study)

22 Introduction to Sequence Control, PLC, RLL

23 Introduction to Sequence Control, PLC, RLL(Cont.)

24 Sequence Control. Scan Cycle, Simple RLL Programs

25 Sequence Control. Scan Cycle, Simple RLL Programs (Cont.)

26 Sequence Control. More RLL Elements, RLL Syntax

27 Sequence Control. More RLL Elements, RLL Syntax (Cont.)

28 A Structured Design Approach to Sequence Control

29 A Structured Design Approach to Sequence Control (Cont.)

30 PLC Hardware Environment

31 PLC Hardware Environment (Cont.)

Module IV

32 Flow Control Valves

33 Flow Control Valves (Cont.)

34 Hydraulic Control Systems - I

35 Hydraulic Control Systems - I(Cont.)

36 Hydraulic Control Systems - II

37 Hydraulic Control Systems - II(Cont.)

38 Industrial Hydraulic Circuit

39 Industrial Hydraulic Circuit (Cont.)

40 Pneumatic Control Systems - I

41 Pneumatic Control Systems - I(Cont.)

42 Pneumatic Systems - II

43 Pneumatic Systems - II(Cont.)

44 Energy Savings with Variable Speed Drives

45 Energy Savings with Variable Speed Drives (Cont.)

46 Introduction to CNC Machines

47 Introduction to CNC Machines (Cont.)

Module V

48 The Fieldbus Network - I

49 The Fieldbus Network - I(Cont.)

50 Higher Level Automation Systems

51 Higher Level Automation Systems (Cont.)

52 Course Review and Conclusion (Self-study)

Mechatronics:

Week 1: Introduction to Mechatronics: Introduction, Examples of Mechatronic systems, Electric circuits and components, Semiconductor Electronics, Transistor Applications

Week 2: Sensors and transducers: Performance terminology of sensors, Displacement, Position & Proximity Sensors-I, Displacement, Position & Proximity Sensors-II, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and Vibration measurement, Semiconductor sensor and MEM, SAW

Week 3: Actuators and mechanisms: Mechanical Actuation System, Hydraulic & Pneumatic Actuation System, Electrical Actuation System-I, Electrical Actuation System-II, Data Presentation system

Week 4: Signal conditioning: Introduction to signal processing & Op-Amp, Op-Amp as signal conditioner, Analogue to Digital Converter, Digital to Analogue Converter, Artificial intelligence

Week 5: Microprocessors and microcontrollers: Digital circuits-I, Digital circuits-II, Microprocessor Micro Controller, Programming of Microcontrollers

Week 6: Modeling and system response: Mechanical system model, Electrical system model, Fluid system model, Dynamic response of systems, Transfer function and frequency response.

Week 7: Closed loop controllers: P, I, PID Controllers, Digital Controllers, Program Logic Controllers, Input/output & Communication systems, Fault findings

Week 8: Design and mechatronics: Project using Microcontroller-Atmega 16, Myoelectrically Controlled, Robotic Arm, Robocon-Part I, Robocon-Part II, Design of a Legged Robot

Industrial Automation with PLC & SCADA:

Course Description: This online course introduces Programmable Logic Controllers (PLC), Field level Instrumentation and SCADA/HMI Systems used for Industrial Automation. The participants will get appropriate knowledge and exposure to configuration of Industrial Controllers and development of application programs using IEC-61131-3 PLC languages. Also covers Interfacing with SCADA/HMI systems used for remote monitoring & control of industrial process units and machines. The Course is planned with instructor led live sessions of lectures and demonstrations.

Course Contents:

- Industrial Field Instrumentation & Controllers
- Programmable Logic Controllers (PLC)

- SCADA / HMI (Supervisory Control and Data Acquisition / Human Machine Interface)

Sensors and Actuators:

Week 1: Basics of Energy Transformation: Transducers, Sensors and Actuators
Week 2: Understanding of thin film physics: Application in MOSFET and its variants
Week 3: Thin Film Deposition Techniques: Chemical Vapor Deposition (APCVD, LPCVD, UHVCVD, PECVD, ALCVD, HPCVD, MOCVD)
Week 4: Thin Film Deposition Techniques: Physical Vapor Deposition (Thermal Deposition, E-beam Evaporation, Sputtering, Pulsed Laser Deposition)
Week 5: Basics understanding of Photolithography for pattering layer. Detailed overview of Etching methods.
Week 6: Understanding various gas sensors: Optical gas sensor, Metal oxide semiconductor gas sensor, Field effect transistor gas sensor, Piezoelectric gas sensor, Polymer gas sensor, Nano-structured based gas sensors
Week 7: Design and fabrication process of Microsensors: Force Sensors, Pressure Sensors, Strain gauges and practical applications
Week 8: Explain working principles of Actuators. Piezoelectric and Piezoresistive actuators, micropumps and micro actuators with practical applications
Week 9: Understanding basics of microfluidics to assist Photomask design using Clewin Software, pattern transfer techniques, PDMS moulding and degassing, device bonding techniques.
Week 10: Simulation, Optimization and characterization of various sensors using COMSOL Multiphysics
Week 11: Understanding of Sensor Interfacing with Microprocessor to build electronic system
Week 12: Static and Dynamic Characteristic Parameters for Sensors and Actuators, Calibration of Sensor based electronics systems.

Design of Mechatronic Systems:

Week 1: Introduction: Elements of mechatronics system: Sensor, actuator, plant, and controller.
Week 2: Applications of mechatronics system. Systems like CDROM, scanner opened to see whats there inside and why?
Week 3: Integrated mechanical-electronics design philosophy. Examples of real-life systems. Smart sensor concept and utility of compliant mechanisms in mechatronics
Week 4: Microprocessor building blocks, combinational and sequential logic elements, memory, timing and instruction execution fundamentals with example of primitive microprocessor.
Week 5: Microcontrollers for mechatronics: Philosophy of programming interfaces, setting sampling time, and getting started with TIVA programming
week 6: Microcontroller programming philosophy emphasis on TIVA, programming different interfaces PWM, QEI etc. Mathematical modeling of mechatronic systems,
week 7: Modeling friction, DC motor, Lagrange formulation for system dynamics.

week 8: Dynamics of 2R manipulator, Simulation using MATLAB, Selection of sensors and actuators.
week 9: Concept of feedback and closed loop control, mathematical representations of systems and control design in linear domain
week 10: Basics of Lyapunov theory for nonlinear control, notions of stability, Lyapunov theorems and their application
week 11: Trajectory tracking control development based on Lyapunov theory, Basics of sampling of a signal, and signal processing
week 12: Digital systems and filters for practical mechatronic system implementation. Research example/ case studies of development of novel mechatronics system: 3D micro-printer, Hele Shaw system for microfabrication.

Introduction to robotics:

Week 1: Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defense, rehabilitation, medical etc., Laws of Robotics
Week 2: Robot mechanisms; Kinematics- coordinate transformations, DH parameters
Week 3: Forward kinematics, Inverse Kinematics
Week 4: Jacobians, Statics, Trajectory Planning
Week 5: Actuators (electrical)- DC motors, BLDC servo motors
Week 6: Sensors, sensor integration
Week 7: Control – PWM, joint motion control, feedback control
Week 8: Computed torque control
Week 9: Perception, Localisation and mapping
Week 10: Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches
Week 11: Simultaneous Localization and Mapping
Week 12: Introduction to Reinforcement Learning

Fundamentals of Automotive Systems:

Week 1: Course Overview, Classification of Internal Combustion Engines, Engine Components, Operation of Four Stroke Engines
Week 2: Two Stroke Engines, Engine Cycles
Week 3: Engine Performance, Supercharging, Combustion in Spark Ignition Engines
Week 4: Combustion in Compression Ignition Engines, Carburetion, Fuel Introduction Systems
Week 5: Engine Emissions, Emission Control Systems, Automotive Powertrain
Week 6: Automotive Clutch, Transmission, Powertrain Analysis
Week 7: Transmission Matching and Introduction to Brake System
Week 8: Components of Brake System, Hydraulic Brake
Week 9: Air Brake, Antilock Brake System
Week 10: Braking Analysis, Introduction to Steering System, Manual Steering System
Week 11: Power Steering System, Wheel Alignment, Introduction to Suspension System
Week 12: Components of Suspension System, Dependent and Independent Suspension, Introduction to Electric and Hybrid Powertrain, Tyres.

Robotics and Control: Theory and Practice

Week 1: Simple manipulators: Two /three arm manipulators and their kinematics equations, Work space Homogeneous Transformation: Rotation, Translation, Composition of homogeneous transformations

Week 2: Danavit-Hartimber Algorithm: D-H procedure for fixing joint coordinate frames, Robot parameters, Arm matrix, Inverse Kinematics for PUMA, SCARA manipulators.

Week 3: Introduction to Robotic Exoskeletons, Optimal Design of a Three Finger Exoskeleton for Rehabilitation Purpose

Week 4: Differential transformation and velocity of a frame: Derivative of a frame, Velocity, Jacobian, Inverse Jacobian, Trajectory Planning: Polynomial trajectory, Biped trajectory

Week 5: Dynamics: Lagrangian method, Robot dynamics equation, Control: Robot dynamics equation as a control system, Trajectory tracking control, PD controller, Neural network control design

Week 6: Redundancy Resolution of Human Fingers using Robotic Principles, Manipulability Analysis of Human Fingers during Coordinated Object Rotation, Kinematics of Flexible Link Robots,

Week 7: Robot Assisted Needling System for Percutaneous Intervention-An Introduction, Smart Robotic Needles for Percutaneous Cancerous Interventions

Week 8: Robust Force Control of a Two Finger Exoskeleton during Grasping, Neural Control of an Index Finger Exoskeleton – Lecture 1, Neural Control of an Index Finger Exoskeleton – Lecture 2