B.Tech. Electrical Engg. (New Scheme)

Year: Semester V

Sr. No.	Course Category	Course Title	Course Code	Lecture (L) / Tutorial (T) / Practical (P) per week			Credit
				L	T	P	
1	PC	Power System Protection	EEPC301	3	0	0	3
2		Microprocessors and Microcontrollers	EEPC302	3	0	0	3
3		Digital and Nonlinear Control Systems	EEPC303	3	0	0	3
4		Power Electronics-II	EEPC304	3	0	0	3
5	Lab	Electrical Machines Lab-II	EEPC305	0	0	3	1
6		Control Systems Lab-I	EEPC306	0	0	3	1
7		Power Engineering Lab-I	EEPC307	0	0	3	1
8		Power Electronics Lab-I	EEPC308	0	0	3	1
9	PC	# Summer Internship	EEPC309	0	0	0	1
10	PE	** Program Elective 1	EEPE310	3	0	0	3
11	OE	***Open Elective 1	OE***	3	0	0	3
12	AU	NCC/NSS/ Yoga	SWAU11	0	0	2*	1*
13		Sports/Clubs/Technical Societies	SWAU12	0	0	2*	1*
Total				**18**	**0**	**12**	**23**

* (to be awarded at the end of 6th Semester based on Cumulative performance up to 6th Semester)

After the end of 4th Semester, students will have two-month internship/Industrial Training program of one credit. The viva voce examination will be conducted in 5th semester.

** Elective(s) [PE] offered from the Department list.
*** Elective(s) [OE] offered from the Institute list.

B.Tech. Electrical Engg. (New Scheme)

Year: Semester VI

Sr. No.	Course Category	Course Title	Course Code	Lecture (L) / Tutorial (T) / Practical (P) per week			Credit
				L	T	P	
1	PC	Power System Operation and Control	EEPC311	3	0	0	3
2		Power Quality	EEPC312	3	0	0	3
3		Industrial Control and Automation	EEPC313	3	0	0	3
4	Lab	Microprocessors and Microcontrollers Lab	EEPC314	0	0	3	1
5		Power Engineering Lab-II	EEPC315	0	0	3	1
6		Power Electronics Lab-II	EEPC316	0	0	3	1
7		Control Systems Lab-II	EEPC317	0	0	3	1
8	PE	** Program Elective 2	EEPE318	3	0	0	3
9	OE	***Open Elective 2	OE***	3	0	0	3
10	AU	NCC/NSS/ Yoga	SWAU11	0	0	2*	1
11		Sports/Clubs/Technical Societies	SWAU12	0	0	2*	1
Total				**15**	**0**	**12**	**21**

** Elective(s) [PE] offered from the Department list.
*** Elective(s) [OE] offered from the Institute list.

After the end of 6th Semester, students will have two months internship/R&D Organizations/Industrial Training program of one credit. The viva voce examination and will be conducted in 7th semester

17/7/23 17/7 17/7 17/7 17/7 17/7/23

17/7/23 17-07

B.Tech. Electrical Engg. (New Scheme)

Year: Semester VII

Sr. No.	Course Category	Course Title	Course Code	Lecture (L) / Tutorial (T) / Practical (P) per week			Credit
				L	T	P	
1	IC	Entrepreneurship and start-up		3	0	0	3
2	PC	Electric Drives	EEPC401	3	0	0	3
3	Lab	Drives Lab	EEPC402	0	0	3	1
4	PC	#Summer Internship	EEPC403	0	0	0	1
5	PC	Design Project	EEPC404	0	0	3	1
6	PE	** Program Elective 3	EEPE405	3	0	0	3
7		** Program Elective 4	EEPE406	3	0	0	3
8	OE	***Open Elective 3	OE***	3	0	0	3
Total				**15**	**0**	**6**	**18**

** Elective(s) [PE] offered from the Department list.
*** Elective(s) [OE] offered from the Institute list.

17/7 17/7 17/7 17/7 17/7 17/7/23 17/7/23 17/07

B.Tech. Electrical Engg. (New Scheme)

Year: Semester VIII

Sr. No.	Course Category	Course Title	Course Code	Lecture (L) / Tutorial (T) / Practical (P) per week			Credit
				L	T	P	
1	PC	Electric Vehicles	EEPC407	3	0	0	3
4	PC	Seminar	EEPC408	0	0	2	1
5		Major Project	EEPC409	0	0	6	2
6		Comprehensive Viva	EEPC410	0	0	0	1
2	PE	**Program Elective 5	EEPE411	3	0	0	3
3		**Program Elective 6	EEPE412	3	0	0	3
7	OE	***Open Elective 4	OE***	3	0	0	3
Total				**12**	**0**	**8**	**16**

** Elective(s) [PE] offered from the Department list.

*** Elective(s) [OE] offered from the Institute list.

Total Credits

Semeste r	I	II	III	IV	V	VI	VII	VIII	Total
Credits	22	23	22	21	23	21	18	16	**166**

Institute Core

Semester	Sem	I	II	III	IV	V	VI	VII	VIII	Total
Credits	Credits	22	19	03	03	-	02	03	-	**52**

Program Core (Theory)

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	-	04	18	15	12+1=13	9	3+1+1=5	3+1+1 +2=7	**71**

Program Core (Lab)

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	-	-	1	3	4	4	1	-	**13**

Program Elective

Semeste r	I	II	III	IV	V	VI	VII	VIII	Total
Credits	-	-	-	-	03	03	06	06	**18**

Open Elective

Semeste r	I	II	III	IV	V	VI	VII	VIII	Total
Credits	-	-	-	-	03	03	03	03	**12**

%age share of Total Credits 166

Institute Core	Program Core (Theory)	Program Core (Lab)	Program Elective	Open Elective	**Total Credits**
31.3253%	42.77%	7.83%	10.843%	7.228%	**100%**

17/7 17/7 17/7 17/7 17/7

17/7/23 17/7/23 17/07

B.Tech.(Electrical Engineering)

List of Program Electives (PE)

Sr. No.	PE Semester	Course Title	Course Code	Lecture (L) / Tutorial (T) / Practical (P) per week			Credit
				L	T	P	
1	PE1 Sem-5	Renewable Power Generation	EEPE310 A	3	0	0	3
2		Signal Processing	EEPE310 B	3	0	0	3
3		Special Machines and Drives	EEPE310 C	3	0	0	3
4		High Voltage Engineering	EEPE310 D	3	0	0	3
5		Optimization Theory	EEPE310E	3	0	0	3
6		Electrical Safety And Standards	EEPE310F	3	0	0	3
7	PE2 Sem-6	Distribution System Analysis	EEPE318 A	3	0	0	3
8		Economic and Project Evaluation in Electricity Industry	EEPE318 B	3	0	0	3
9		High Power Converter	EEPE318 C	3	0	0	3
10		Guidance and Control	EEPE318 D	3	0	0	3
11		Data Communication Networks	EEPE318E	3	0	0	3
12		Soft Computing Techniques	EEPE318F	3	0	0	3
13	PE3 Sem-7	System Identification	EEPE405 A	3	0	0	3

17/7 17/7 17/7 17/07 17/7/23 17/7/23

10

14		Robot Dynamics & Control	EEPE405 B	3	0	0	3
15		Custom Power Devices	EEPE405 C	3	0	0	3
16		Energy Storage Systems	EEPE405 D	3	0	0	3
17		Earthing Practices	EEPE405E	3	0	0	3
18		Energy Auditing, Conservation & Management	EEPE405F	3	0	0	3
19	PE4 Sem-7	EHV AC and DC Transmission	EEPE406 A	3	0	0	3
20		Smart Grid Technology	EEPE406 B	3	0	0	3
21		Power Systems Security and Optimization	EEPE406 C	3	0	0	3
22		Mechatronics	EEPE406 D	3	0	0	3
23		Reliability Engineering	EEPE406E	3	0	0	3
24		AC-DC Micro-grids	EEPE406F	3	0	0	3
25	PE5 Sem-8	Power Converters for Renewable Energy Systems	EEPE411 A	3	0	0	3
26		Reliable Fault Tolerant Systems	EEPE411 B				
27		Intelligent Modelling and Control	EEPE411 C	3	0	0	3
28		Metaheuristic Optimization Techniques	EEPE411 D	3	0	0	3
29		Power System Restructuring	EEPE411E	3	0	0	3
30		Virtual Instrumentation	EEPE411F	3	0	0	3
32	PE6 Sem-8	Drone Technology	EEPE412 A	3	0	0	3
33		Analysis of Wind and Solar Systems	EEPE412 B	3	0	0	3

17/7 17/7/23 17/7 17/7 17/7 17/7

34		Advanced Control Techniques	EEPE412 C	3	0	0	3
35		Power System Dynamics & Control	EEPE412 D	3	0	0	3
36		Flexible AC Transmission Systems	EEPE412E	3	0	0	3
37		Multi-Agent Systems: Consensus & Control	EEPE412F	3	0	0	3
38		Industrial Drives	EEPE412 G	3	0	0	3

17/7/23 17/7 17/7 17/7 17/7 17/7/23 17/7 17-07

General Institute Requirements

Summer Internship

Sr. No	Course Code	Course title	Credits
1	EEIC	Internship/Industrial Training (7 to 8 weeks during summer vacations end of the 4th semester	1
2.	EEIC	Internship/Industrial Training (7 to 8 weeks during summer vacations end of the 6th semester	1

Comprehensive Viva

Sr. No	Course Code	Course title	Credits
1	EEIR	Comprehensive Viva Voce examination	1

Essential Program laboratory requirements (EEPC)

Sr. No.	Course Code	Name of the laboratory	ODD Sem	Even Sem
1	EEPC	Analog and Digital Electronics Lab		4-Analog and Digital Electronics Lab
2	EEPC	Power EC Lab	5-Power Electronics Lab-I	6-Power Electronics Lab-II
3	EEPC	Machine Lab	5-Electrical Machines Lab-II 7-Drives Lab	4-Electrical Machines Lab-I
4	EEPC	Signal and System	3-Computational Techniques Lab	6-Microprocessor and Microcontroller Lab
5	EEPC	Power System Lab	5-Power Engineering Lab-I	4-Measurement and Instrumentation Lab
6	EEPC	CAD Lab		6-Power Engineering Lab-II
7	EEPC	Control System	5-Control Systems Lab-I	6-Control Systems Lab-II

OPEN ELECTIVES (OE) The courses listed below are offered by the Department of Electrical Engineering for students of other Departments.

Sr. No.	Semester	Course Code	Course Title	Pre-requisites	Credits
1	V	EEOE301	Electrical Circuits	-	3
2		EEOE302	Electrical Machines	-	3
3		EEOE303	Control Systems Engineering	-	3
4		EEOE304	Analog and Digital Electronics	-	3
5	VI	EEOE305	Power Electronic Systems	-	3
6		EEOE306	Elements of Power Systems Engineering	-	3
7		EEOE307	Renewable Power Generation Systems	-	3
8		EEOE308	Fuzzy Systems and Applications	-	3
9	VII	EEOE401	Introduction to Microcontrollers	-	3
10		EEOE402	Electric Vehicle Technology	-	3
11		EEOE403	Virtual Instrumentation	-	3
12		EEOE404	Digital Control Systems	-	3
13	VIII	EEOE405	AC-DC Microgrids	-	3
14		EEOE406	Energy Conservation Utilization and Safety Standards	-	3
15		EEOE407	Robotics	-	3
16		EEOE408	Reliability Engineering	-	3

MINOR (MI)

Students who have registered for B.Tech. (Minor) in Electrical Engineering will study 4 integrated courses of 16 credit courses below.

* Compulsory Courses

Students from any branches can opt for this Minor Programme.

Sr. No.	Domain				L-T-P	Credits	Semester
	Renewable Energy Systems & Management	System Automation & Control	Power Converter and Drives	Computational and Artificial Intelligence			
1	EEMI301* Fundamentals of Electrical Engineering (Circuits, measurements and control systems)	EEMI301* Fundamentals of Electrical Engineering (Circuits, measurements and control systems)	EEMI301* Fundamentals of Electrical Engineering (Circuits, measurements and control systems)	EEMI301* Fundamentals of Electrical Engineering (Circuits, measurements and control systems)	3-0-2	4	V
2	EEMI302* Basics of Energy Systems (Power systems, machines and power electronics)	EEMI302* Basics of Energy systems (Power systems, machines and power electronics)	EEMI302* Basics of Energy systems (Power systems, machines and power electronics)	EEMI302* Basics of Energy systems (Power systems, machines and power electronics)	3-0-2	4	VI
3	EEMI401A Energy conservation and management	EEMI402A Control System Analysis & Design	EEMI403A Power Quality	EEMI404A Artificial Intelligence	3-0-2	4	VII
	EEMI401B Economics of Renewable energy Systems	EEMI402B Industrial Control & Automation	EEMI403B Flexible AC Transmission Systems	EEMI404B Metaheuristic Optimization Techniques			
4	EEMI405A Wind Energy Systems	EEMI406B Robotics & Control	EEMI407A Electric Vehicles	EEMI408A Big Data Analytics	3-0-2	4	V
	EEMI405B Solar Energy Systems	EEMI406B Autonomous Vehicles/ Drone Technologies	EEMI407B Power Converters for Renewable Energy	EEMI408B Modelling and Simulation			

17/7 17/7/23 17/7 17/7 17/7 17/7 17/7

Program Core (Semester V)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC301 POWER SYSTEM PROTECTION

Pre-requisite: EEPC203, EEPC209

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

This course provides a broad coverage on all types of protective relays, circuit breakers and provide a strong background for working in a practical power system protection.

Course Content

Unit - I Introduction **(5)**

Need for protective system, Nature, cause, types and effects of faults, components of protection system, Essential qualities of protection system, Zones of protection, Primary and back-up protection, Basic relay terminology, Elements of Circuit Breakers, their operating mechanisms, Auto reclosing

Unit – II Switchgear **(10)**

Introduction, Theory of arcing and arc interruption in circuit breakers, Re-striking and recovery voltage, Resistance switching, Current chopping, Interruption of capacitive current.

Classification, selection and ratings of circuit breakers, Oil circuit breaker, Air break and air blast circuit breakers, SF6 circuit breaker, Vacuum CBs, High voltage d.c. breakers.

Unit – III Protective Relays and Apparatus Protection **(13)**

Protective Relays-General classification of relays, Principle of operation of electromagnetic and induction type relays, Over-current, Directional, Earth Fault, Negative phase sequence, Distance and Differential relays.

Apparatus Protection- Generator protection, Transformer Protection, Transmission line protection, Bus-bar protection.

Unit – IV Protection against Overvoltage and Modern Relays **(14)**

Protection against Overvoltage- Causes of over voltage, Ground wires, Surge absorbers and diverters, Insulation co-ordination.

17/7/23

Static Relays- Introduction to static relays, Phase and amplitude comparator, Static overcurrent relays.
Microprocessor based protective relays- Over current relay, impedance relay, directional relay, reactance relay and mho relay.
Digital Relays- Basics of numerical relays, Numerical overcurrent, distance and differential protection, AI based numerical protection.
Introduction of Phasor Measurement Units and Wide Area Monitoring and Protection Systems

References/Textbooks:

1. Badri Ram and Vishwakarma, D.N., "Power System Protection and Switchgear", Tata McGraw Hill publishing company Ltd., 2nd Edition, 2011.
2. Y. G. Paithankar and S. R Bhide, "Fundamentals of Power System Protection", PHI Learning Private Limited, 2nd Edition, 2010.
3. D.P. Kothari and I.J. Nagrath, "Power System Engineering", Tata McGraw Hill Education, 2nd Edition.
4. Blackburn, J. Lewis, and Thomas J. Domin. Protective relaying: principles and applications. CRC press, 2015.
5. Anderson, Paul M., et al. Power system protection. John Wiley & Sons, 2022.
6. S.S. Rao, "Protective Switch Gear", Khanna Publishers, New Delhi, 13th Edition, 2008.
7. C.L. Wadhwa, Power System Analysis, New Age Publishers.
8. https://nptel.ac.in/courses/108107167
9. https://nptel.ac.in/courses/108105167

Course Outcomes:

On successful completion of the course, students will be able to

CO1 Understand protection system components and terminology for circuit breakers and relays.

CO2 Classify different circuit breakers and their operating principles.

CO3 Describe the operation of different protective relays and protection of different power apparatus.

CO4 Evaluate the impact of over-voltages and static and numerical relays and concept of wide area protection system

12/7/23

ELECTRICAL ENGINEERING DEPARTMENT

ECPC302 MICROPROCESSORS AND MICROCONTROLLERS

Pre-requisite: EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

Objective is to study the Architecture of 8085, 8051, the addressing modes & instruction set of 8085 & 8051, the need & use of Interrupt structure 8085 & 8051, develop skill in program writing for 8051 & 8085 and applications, understand peripheral / interfacing ICs

Course Content

UNIT-I **(12)**

Microprocessor Architecture:

8085 microprocessor architecture, timing and control unit, machine cycles, interrupt diagram.

Programming:

Addressing modes, instruction set, assembly language programming, program for multibyte addition/subtraction, multiplication, division, block transfer etc.

UNIT-II **(10)**

Interfacing:

Basic principles of interfacing I /O devices with microprocessor. Data transfer techniques – programmed interrupt and DMA. Details of interfacing devices 8255 and 8253.Interfacing of D/A and A/D converter.

UNIT-III **(10)**

Microcontroller:

Architecture of 8051 microcontroller. Interrupt, serial and timer control. Instruction set and programming. Interfacing with D/A and A/D converter.

UNIT-IV **(10)**

Semi-Conductor Memory:

Read only memories, random access memories. Case study of interfacing of memories with 8085, 8051.

References/Textbooks:

12/7/23

1. R.S. Gaonkar, "Microprocessor Architecture, Programming and Applications", Penram International, 6th Edition, 2013.
2. A.P. Mathur, "Introduction to Microprocessor", TMH, 3rd Edition, 1990.
3. K.J. Ayala, "8051 Microcontroller", Penram International, 2nd Edition, 1996.
4. D.V. Hall, "Advanced Microprocessor".
5. Muhammad Ali Mazidi and Mazidi: The 8051 Microcontrollers and Embedded systems, PHI, 2nd Edition, 2009.

Course Outcomes

On successful completion of the course, students will be able to

CO1 Develop basic understanding of microprocessor and microcontroller architecture.

CO2 The students will be able to design and implement programs on 8085 microprocessor and 8051 microcontroller

CO3 Understand concept of interfacing of peripheral devices with microprocessor and microcontroller.

CO4 To design memory interfacing circuits with microprocessor and microcontrollers.

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC303 DIGITAL AND NONLINEAR CONTROL SYSTEMS

Pre-requisite: EEPC101, EEPC204, EEPC205, EEPC206, EEPC208

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:
Aims to give fundamental concepts of digital control system problems and their solution possibilities, time-domain response (transient and steady-state response) and frequency-domain analysis, and basics of stability analysis of the discrete-time systems of the discrete-time systems. To study the basics and stability analysis of the Non-Linear Systems,

Course Contents:

Unit-I **(12)**

Introduction to digital control: The digital control problem and solution possibilities, Signal processing in digital control, principles of signal conversion, sampling and reconstruction, principles of discretization, impulse and step invariance, finite difference approximation, and bilinear transformation.

Mathematical models of discrete-time systems: Pulse Transfer function and state space models, Block diagram algebra and system response, stability in the z-plane, the Jury stability criterion and Lyapunov stability criterion.

Unit-II **(10)**

Digital control design: z-Plane Specifications of Control System Design, Digital Compensator Design using Frequency Response Plots, Digital Compensator Design using Root Locus Plots, z-Plane Synthesis State variable feedback design.

Unit-III **(10)**

Introduction to nonlinear systems: Characteristics of nonlinear systems, inherent and intentional nonlinearities, qualitative behavior of linear Vs nonlinear systems, multiple equilibrium points, limit cycle, bifurcation, jump response, chaos,

Stability analysis of nonlinear systems: Describing function of common nonlinear functions and stability analysis, phase plane analysis, construction of phase portraits, singular points, the

17/7/23

concept of stability in the sense of Lyapunov, asymptotic stability, local and global stability, construction of Lyapunov function using Krasovskii and variable gradient method.

Unit-IV **(10)**

Case Studies: Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature Control Systems, Digital Position Control Systems, Stepper Motors and Their Control, Programmable Logic Controllers.

References/Textbooks:

1. Raymond T. Stephani, Design of Feedback Control Systems, Oxford University Press, Edition No. 04, 2002.
2. Donald M. Wiberg, State Space and Linear Systems, Schuam's Outline Series, Edition No01, 1971.
3. Katsuhiko Ogata, Discrete-Time Control Systems, Prentice-Hall, Edition No. 02, 2015.
4. M. Gopal, Digital Control and State Variable Methods, Tata McGrow Hill, Edition No. 04,2012.
5. B. C. Kuo, Digital Control System, Oxford University Press, Edition No. 02, 2006.
6. J. J. E. Slotine and W. Li, Applied Nonlinear Control, Prentice Hall, Edition No. 01, 1991.
7. Hassan. K. Khalil, Nonlinear Systems, Prentice-Hall, Edition No. 03, 2002.

Course outcomes:

On successful completion of the course, students will be able to

CO1 Fundamental knowledge of digital control system, mathematical modelling of various physical systems in continuous/discrete-time using transfer function

CO2 Digital control design and stability analysis using time-domain as well as frequency-domain methods,

CO3 Design and implementation of input and output feedback controllers with Lyapunov theoryof stability.

CO4 Learn characteristics of linear Vs nonlinear systems behavior and stability analysis withthe concept of local and global stability.

ELECTRICAL ENGINEERING DEPARTMENT

EEPC304 POWER ELECTRONICS-II

Pre-requisite: EEPC210

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: The DC/DC converters, DC/AC converters and the converter-fed electric motor drives are covered in this course. An in-depth knowledge of these topics is necessary to understand the manufacturing, production and operation of various appliances and industrial products, based on the power electronics converters.

Course Contents

Unit-1:
DC to DC Non-Isolated Converters **(10)**
Introduction to Choppers; Voltage and current commutated choppers; step up and step-down choppers; DC-DC switch mode converters; buck, boost, buck-boost converters and Cuk converter in continuous and discontinuous conduction mode;

Unit-II:
DC to DC Isolated Converters **(10)**
Introduction to isolated DC to DC converters; Fly-back converter, Forward Converters, Bridge Converters, Push-Pull Converter, Resonant Converter: Series and Parallel.

Unit-III
DC to AC converters **(10)**
Classification; Series and parallel inverters; Single phase voltage source inverter and analysis with various types of loads; Three phase voltage source inverter with 180° and 120° conduction modes; PWM inverters; PWM techniques, Reduction ofharmonics; Voltage regulation in single phase inverters;Single phase current source inverter; Application of voltage source inverter in households and industries.

Unit-IV:
Design and Development of Converters **(12)**

13/7 17/7/23

Design of regulated power supplies, UPS and SMPS using DC to DC and DC to AC converters with device selection, inductor and transformer design, EMI analysis, power factor and harmonic correction, heat sink, gate drivers, filters, protection features etc.; recent technologies on the development of these power supplies; Application of DC-to-DC converters in SMPS.

References/Textbooks:

1. GK Dubey, "Power semiconductor Controlled Drives," Prentice Hall, Englewood cliffs, NewJersey, 1988.
2. P.S.Bhimbra, "Power Electronics," Khanna Publishers, 2018.
3. A Fitzgerald, Charles Kingsley and Stephen Umans, "Electric Machinery," McGraw Hill Education; 6th edition, 2017
4. Mohan N., Undeland T. M. and Robbins W. P., "Power Electronics Converters, Applicationsand Design", 3rd Ed, Wiley India.
5. B. K. Bose, "Modern power electronics and ac drives," Prentice Hall, 2001.

Course Outcomes

On successful completion of the course, students will be able to

CO 1: To understand the role of DC to DC and DC to AC converters in modern household and industrial products.

CO 2: To apply the theory in the design and development of practical circuits and components for various medium and high capacity-power supplies.

CO 3: To identify the significance of DC to DC and DC to AC converters and their design for motor control.

CO 4: To incorporate the power converter with their appropriate control in recent sustainable development such as Electric vehicles and renewable energy.

12/12/23

Program Elective 1 (Semester V)

ELECTRICAL ENGINEERING DEPARTMENT

EEPE310A RENEWABLE POWER GENERATION

Pre-requisite: EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:
The course introduces to various sources of power generation from renewable energy sources.

Course Content

Unit – I: Solar and Wind Power Generation **(10)**
Introduction to Photovoltaic effect, characteristics of photovoltaic cells, conversion efficiency, and applications.
Introduction to characteristics of suitable wind power sites, wind turbines, wind generators, advantages and limitations.

Unit – II: Fuel Cell and Hydro Power Generation **(11)**
Fuel Cell: Principle of fuel cells, thermodynamic analysis of fuel cells, types of fuel cells, applications of fuel cells.
Hydro power generation: Essential features of water power plant, classification of hydro-plant, hydraulic turbine, surge tanks, governing of hydraulic turbine, selection of water turbine.

Unit – III: Geothermal and Ocean Energy **(11)**
Geothermal: Potential sites, estimations of geothermal power, nature of geothermal sites, Advantages and disadvantages of geothermal energy.
Ocean Energy: Principle of ocean thermal energy conversion (OTEC), Tidal power generation, Tidal energy potential and technologies, Energy from waves, Wave energy conversion, Wave energy technologies, advantages and limitations.

Unit – IV: Biomass based Energy Generation **(10)**
Biomass: Energy from biomass, sources of biomass, different species, conversion of biomass into fuels, Energy through fermentation, Pyrolysis, gasification and combustion Biogas plants, Properties and characteristics of biogas.

17/7/23

Case study on different Renewable Power Plants. Design of integrated renewable energy systems using software tools.

References/Textbooks:

1. D.P. Kothari, K.C. Singal and Rakesh Ranjan, “Renewable Energy Sources and Emerging Technologies”, 2nd Edition, PHI.
2. Gupta, B. R. Generation of electrical energy. S. Chand Publishing, 2017.
3. Robest L Loftness, “Energy hand book”, 1st Edition, Van Nostrand Reinhold Co.
4. Mehmet Kanoglu, Yunus A. Cengel, John M. Cilbala, “Fundamentals and applications of Renewable Energy”, McGraw Hill., 2020.
5. 1. https://nptel.ac.in/courses/108/102/108102145/
6. 2. https://nptel.ac.in/courses/103/103/103103206/

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand working principle of different Renewable energy generation.

CO 2 Describe different types of wind and hydro turbines

CO 3 Analyze different types of Fuel cell, Geo-Thermal and Biomass energy.

CO 4 Evaluate hybrid system with renewable energy sources.

12/7

12/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE310B SIGNAL PROCESSING

Pre-requisites: MAIC11, MAIC12, EEPC101, EEPC204

L	T	P	Credits	Total contact hours
3	0	0	3	3

Brief description:

Signal Processing is a broad and growing discipline concerned with analysis of both analog and digital (sampled and quantized) signals. Increasingly sophisticated uses of signal processing have appeared in several interdisciplinary areas including communications, control, image and video processing, radarand consumer electronics. This expanded use of signal processing techniques has been prompted by advances in both the mathematical theory and the physical devices such as computers or special-purpose digital hardware. The field of signal processing includes the mathematical theory of the subject as well as the design and analysis of the necessary devices for carrying out the processing.

Course Content:

Unit-I **(10)**

Z-transform and its applications, one sided Z-transform and solution of difference equations. Analysis of LTI systems in Z-domain, stability tests, relationship between Z-transform and Fourier transform.

Frequency domain sampling and DFT, properties, linear filtering methods based on DFT, efficient computation of DFT using FFT, divide and conquer approach, radix-2, radix-4 FFT algorithms, applications of FFT, computation of DFT of real sequences. Introduction to wavelets.

Unit-II **(10)**

Introduction, structures for FIR: direct form, cascade form, frequency sampling and lattice structures and IIR systems: direct form, transposed, cascade and parallel forms, lattice and lattice ladder structures.

Unit-III **(12)**

Introduction, characteristics of practical frequency selective filters, filter design specifications, types of FIR filters, design of FIR filters using windows and frequency sampling method.

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17/7/23

Introduction, design of IIR filters from analog filters, design by approximation of derivatives, impulse invariance method, bilinear transformation of Butterworth and Chebyshev filters, frequency transformation, least square methods, design of IIR filters in frequency domain.

Unit-IV **(10)**

Applications of Signal Processing in various sustainable technologies, case studies from the Indian knowledge system.

References/Textbooks:

1. John G. Proakis, Digital Signal Processing, PHI
2. S. K. Mitra, Digital Signal Processing , TMH
3. Rabiner and Gold, Digital Signal Processing, PHI
4. Salivahan, Digital Signal Processing , TMH

Course outcomes

On successful completion of the course, students will be able to

CO1 Understand discrete- time sequences and Z-transform.

CO2 Compute DFT and FFT of discrete time signals.

CO3 Design FIR and IIR filters using different techniques.

CO4 Practicing different signal processing techniques for various applications.

12/2/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE310C SPECIAL MACHINES AND DRIVES

Pre-requisite: EEPC201, EEPC210, EEPC211, EEPC304

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description: To get an overview of some of the special machines for control and industrial applications.

Course Content

Unit - I: **(12)**
Electrical Machines: Construction, working, characteristics and applications of following electrical machines; Stepper Motor, Brushless DC motor, Servomotors, Shaded Pole Motor, Reluctance Motor, Hysteresis Motor, Single Phase Series Motor, Repulsion Motor, Schrage Motor, Linear Induction Motor

Unit – II: **(10)**
Slip Power Recovery Drives: Concept of Slip Power in Induction Motors, Static Kramer and Scherbius Drives, Static Rheostatic Control of Induction motors. Rotor Energy Loss of Cage Induction Motors: During Acceleration, Stop and Reversal of Speed, Time taken during acceleration.

Unit - III: **(10)**
Dynamic Analysis of Brushless PMSM control and applications for Electric Vehicles.

Unit – IV: **(10)**
Wind energy Based Asynchronous Generators: Comparison with Conventional Generators, self-excitation induction generator and WRIM.

References/Textbooks:
1.M G Say, Theory Performance and Design of AC Machines, CBS Publishers.
2. Alexander S Lansdorf, AC Machines, CBS Publishers.
3. AshfaqHussain, Electric Machines,DhanpatRai& Co.
4. NagtarthandKothari, Electric Machines, Tata Mc-Graw Hill Publication.
5. Syed A Nasar, Electric Machines and Power Systems, Tata McGraw Hill Publication.

17/7/23

6. Bimal K Bose, Modern Power Electronics and AC Drives. PHI Publication
7. G K Dubey, Fundamentals of Electrical Drives, Narosa Publication

Course Outcomes:

On successful completion of the course, students will be able to

CO 1 Describe various industrial motors and drive systems.

CO 2 Apply knowledge of power electronics to drive systems.

CO 3 Learn speed control of EV drives in an energy efficient manner using power electronics

CO 4. Understanding of the wind Energy based systems

12/2/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE310D HIGH VOLTAGE ENGINEERING

Pre-requisite: EEPC203, EEPC209

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:
To understand the fundamentals of breakdown of insulating media, generation of high voltage AC/DC/ Impulses, measurements of high voltages and high currents. applications of insulating materials, partial discharges and their measurement, to know the testing techniques, pulse power systems and nanomaterials applications in High voltage

Course Content

Unit – I: Conduction & Breakdown in Gases, Liquid & Solid Dielectrics **(12)**
Gases - Ionization process, town send's current growth equation. 1st& 2ndionisation coefficients. Town send's criterion for breakdown. Streamer theory of breakdown. Paschen's law of gases. Gases used in practice.
Liquid Dielectrics- Conduction& breakdown in pure & commercial liquids, suspended particle theory, stressed oil volume theory, liquid dielectrics used in practice.
Solid Dielectrics- Intrinsic, electromechanical, & thermal breakdown, composite dielectric, solid dielectrics used in practice, Applications of insulating materials

Unit – II: Generation of High Voltages & Currents **(12)**
Generation of high D.C., A.C., impulse voltage & impulse currents. Tripping & control of impulse generators. Measurement of High Voltages & Currents:
Measurement of high D.C., A.C. (Power frequency & high frequency) voltages, various types of potential dividers, peak reading A.C. voltmeter, Sphere gap method, factors influencing the spark voltage of sphere gaps

Unit - III: High Voltage Testing of Electrical Apparatus **(8)**
Testing of insulators, bushings, circuit breakers power capacitors and power transformers. Partial discharge test and measurements.

Unit – IV: Pulsed power **(10)**
Pulse power generation principles and application

17/7 Lalit 17/7/23

Pulsers and topologies: Capacitive discharge, Charging supplies, Voltage multiplication, Pulse compression, application in HV industries, nanomaterials/nanotechnology in high voltage and their applications. Case study and application of software's.

References/Textbooks:

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., 5th edition, 2013.
2. C. L. Wadhwa, "High Voltage Engineering",New Agc International Publisgher, 2012
3. E. Kuffel, W.S. Zaengl, J. Kuffel, "High Voltage Engineering", IInd Edition. Newnes OXFORD.
4. A Haddad and D.F. Warne, "Advances in High Voltage Engineering" IEE Power & Energy Series 40
5. Hugh McLaren Ryan, Institution of Electrical Engineers, High Voltage Engineering and Testing, IET, Second Edition, 2001.
6. Ravindra Arora & Wolfgang Mosch "High Voltage and Electrical Insulation Engineering',Wiley-IEEE Press, 2011
7. HansjoachimBluhm, Pulsed Power Systems Principles and Applications, Springer
8. 1. High Voltage Engineering: https://nptel.ac.in/courses/108/104/108104048/

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Understand the fundamental behavior of gaseous, liquid and solid dielectrics and their breakdown and their applications

CO 2 Describe the techniques for generation of high AC, DC and impulse voltages and impulse currents to Familiar with measurement techniques.

CO 3 Analyze the methods of Testing techniques high voltage electrical Equipment's

CO 4 Understand the Basics of Pulse power generation, nanoparticles and applications

ELECTRICAL ENGINEERING DEPARTMENT

EEPE310E OPTIMIZATION THEORY

Pre-requisite: MAIC11, MAIC12, CSIC13, EEPC206

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

This course is intended to understand the concept of optimization and its theory. Students will be able analyse the advantages and disadvantages associated with the large-scale optimization techniques when applied to engineering problems. Additionally, students will be able to implement selected optimization algorithm approaches to commonly used engineering systems and other specific areas.

Course Content:

Unit-I **(10)**

Introduction to optimization theory, Importance in solving system engineering problems, Convex sets & functions, Supporting & separating hyper planes, Dual cones and generalized inequalities, Multi objective optimization.

Unit-II **(10)**

Linear programming problem: Formulation & solution of Linear programming problems by different methods, Duality in linear programming, Sensitivity analysis, Integer linear programming, Linear programming approach to game theory, Dynamic programming problems.

Unit-III **(10)**

Introduction to nonlinear programming: Unconstrained optimization- Formulation of quadratic optimization problem, constrained optimization- quadratic programming, separable programming.

Unit-IV **(12)**

Brief introduction to heuristic optimization, Convex & Non convex optimization, Application of optimization in different fields, Case study & simulation.

References/Textbooks:

1. Optimization Theory & Applications by SS Rao, Wiley Eastern Ltd.
2. Convex Optimization by Boyd & Vandenberghe, Cambridge University Press.

7/7 12/7/23

3. Operational Research: An Introduction by Hamdy A Taha, Pearson Prentice Hall, New Jersey
4. Nonlinear Programming by D. Bertsekas, Athena Scientific, Nashua, USA
5. Linear Programming by V. Chvatal, W .H Freeman, New York
6. Practical Methods of Optimization by R. Fletcher, Wiley, New York.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1. Understand the different optimization algorithms, multidisciplinary design optimization; formulate optimization problems.

CO 2. Apply knowledge of optimization to formulate and solve engineering problems.

CO 3. Understand the different methods of optimization and be able to suggest a technique for a specific problem.

CO 4. Understand optimization technique using algorithms.

ELECTRICAL ENGINEERING DEPARTMENT

EEPE310F ELECTRICAL SAFETY AND STANDARDS

Pre-requisite: EEPC101, EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

The course aims to provide basics of electrical safety and methodology to avoid any electrical hazards.

Course Content

Unit-I Electrical Installation and Wiring Safety **(11)**

Understanding electrical hazards, Importance of electrical safety, Basic principles of electricity, Voltage, current, and resistance, Electrical circuits and components Skin Effect, Cable Inductance, Surge Impedance, Bus Bar Impedance Calculations, Cable Capacitance, Electrical Hazards of Resistance and Capacitance, Safe wiring practices, Proper installation and maintenance of electrical systems, Electrical distribution and control equipment

Unit II Electric Shocks and Human Body and Grounding **(15)**

Electrical Shock and Circuit Model of the Body, Frequency Response of the Human, Effect of Current on the Human, Electrical Shock, Human and Animal Sensitivities to Electric Current, Human Body Impedance, Effects of Various Exposure Conditions, Current Paths Through the Body, Human Response to Electrical Shock, Medical Imaging and Simulations, Types of injury, Electric shock, Hold on current and permissible leakage, Ventricular fibrillation, Limitations of experimental results (subjective effects), Body resistance, limits of safety, Heart as a control system, Effect of frequency, Shocks involving the head, Respiratory arrest, Experience of artificial respiration, Importance of artificial respiration, Other injuries, Acoustic shock, Arc eye or conjunctivitis, Fractures and torn muscles, Burns and side effects, Protection against electrical injuries, Toxic hazards

Unit III Arc Flash Hazard and Electrical Hazard **(8)**

Arc Flash Hazards, Factors Affecting the Severity of Arc Flash Hazards, Remediation of Arc Flash Hazards, Coordination of Low-Voltage Breaker, Instantaneous Trips for Arc Flash Hazard Reduction, Low-Voltage Transformer, Secondary Arc Flash Protection using Fuses

Unit IV Regulations, Standards, and Case Studies **(8)**

17/7 Lalit 17/7/23

Overview of applicable regulations and standards, National and international safety codes, Compliance requirements, Identifying electrical hazards in various environments, Site Safety: Industrial, Construction, and Residential, Working on energized equipment, Emergency response and evacuation plans Real-life examples of electrical accidents and their prevention, Best practices for electrical safety implementation,

References/Textbooks:

1. Sutherland, Peter E. Principles of electrical safety. John Wiley & Sons, 2014.
2. Fordham-Cooper, W. Electrical safety engineering. Elsevier, 1998.
3. John Cadick, P. E., Mary Capelli-Schellpfeffer, Dennis K. Neitzel, and Al Winfield. Electrical safety handbook. McGraw-Hill Education, 2012.
4. PEBSEE, David J. Marne. McGraw-Hill's National Electrical Safety Code (NESC) 2017 Handbook. McGraw-Hill Education, 2017.

Course Outcomes

On successful completion of the course, students will be able to

CO1 Identify and assess electrical hazards in various environments

CO2 Analyze the factors affecting human response to electric shock, such as frequency, current paths, and body impedance.

CO3 Design and coordinate low-voltage breaker systems for arc flash hazard reduction.

CO4 Demonstrate knowledge of national and international safety codes and compliance requirements.

12/7/23

12

Program Core (Semester VI)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC311 POWER SYSTEMS OPERATION AND CONTROL

Pre-requisite: EEPC203, EEPC209

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

This course provides an in-depth understanding of economic operation and control power system, focusing on the principles, techniques, and strategies employed in the efficient and reliable operation of electrical power systems. Students will learn about the operation and control of power generation, transmission, and distribution systems, including topics such as economic dispatch, optimal power flow, unit commitment and automatic generation control. Emphasis will be placed on practical applications and the use of computer tools for power system operation and control.

Course Content

Unit – I: Economic Operation in Power Systems **(12)**

Introduction, historical development of economic operation, incentives for economic operation. Cost characteristics of power generation, generation planning, scheduling and dispatch.
Economic Dispatch (ED) problem. Solution of ED – Kuhn-tucker conditions, equal incremental cost criterion, considering generation constraints and transmission losses. Computational techniques for solution ED: lambda search technique, gradient search, piece-wise linear approach, evolutionary programming, HNN.

Unit – II: Optimal Power Flow & Unit Commitment **(10)**

Power flow equations, Optimal Power Flow (OPF) modelling, DC optimal power flow, security constrained OPF, modified OPF models for power system operation.
Unit Commitment (UC) Problem, illustrative example, mathematical model of UC: startup cost, minimum up-time and down-time constraints, solution techniques, priority listing method. Hydro-thermal coordination, scheduling energy problem, continuity equation, short term scheduling, lambda gamma iterative technique.

17/7 17/7/23

Unit – III: Power System Control **(10)**

Generation control loops, Functions of Automatic generation control. Turbine-generator model, load model, prime-mover model, speed governor model, load sharing between parallel units. Complete ALFC model, steady state analysis, dynamic response, integral control action. Multi-generator case, control areas, tie-line model, two-area system, tie-line bias control. Area control error and AGC implementation. Excitation systems and voltage control, reactive power compensation and power factor improvement.

Unit – IV: Low Carbon Power System Operation **(10)**

Low carbon power system operation, emission dispatch model, emission reduction policies, emission trading. Deregulation of power sector, creation of new entities, challenges for power system operation in new environment.

Indian power sector, regulations, economic operation, availability-based tariff mechanism, renewable energy certificates.

References/Textbooks:

1. K. Uma Rao, Power System Operation & Control, Wiley India 1st Edition, 2013.
2. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheble, "Power Generation, Operation and Control", IEEE Wiley 3rd Edition, 2014.
3. O. I. Elgerd, Electric Energy Systems Theory: An Introduction, Tata McGraw Hill.
4. R. H. Miller, J. H. Maliwski, Power System Operation, Tata McGraw Hill.
5. JinZhong, Power System Market and Economic Operations, CRC Press, 2018.
6. Jizhong Zhu, Optimization of Power System Operation, IEEE Wiley, 2nd Edition, 2015.
7. James Momoh, Electric Power System Application of Optimization, CRC Press.
8. 1. https://nptel.ac.in/courses/108/104/108104052/
9. 2. https://nptel.ac.in/courses/108/105/108105133/
10. 3. https://nptel.ac.in/courses/108/106/108106026/
11. 4. https://nptel.ac.in/courses/108/102/108102080/

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand the concepts and principles of economic operation of power systems

CO 2 Analyze and solve the complex problems of optimal power flow, unit commitment and hydrothermal coordination

CO 3 Apply frequency and voltage control in multi-area interconnected power systems

CO 4 Demonstrate knowledge of low carbon power systems and operational issues in Indian power sector.

12/12/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC312 POWER QUALITY

Pre-requisite: EEPC210, EEPC304

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

To learn different types of power quality phenomena. To identify sources for voltage sag, voltage swell, interruptions, transients, long duration over voltages and harmonics in a power system. To describe power quality terms and study power quality standards. To learn the principle of voltage regulation and power factor improvement methods.

Course Content

UNIT I: INTRODUCTION TO POWER QUALITY **(12)**

Terms and definitions & Sources – Overloading, under voltage, over voltage - Concepts of transients - Short duration variations such as interruption - Long duration variation such as sustained interruption - Sags and swells - Voltage sag - Voltage swell - Voltage imbalance – Voltage fluctuations - Power frequency variations - International standards of power quality – Computer Business Equipment Manufacturers Associations (CBEMA) curve

UNIT II: HARMONICS **(10)**

Harmonic sources from commercial and industrial loads - Locating harmonic sources – Power system response characteristics - Harmonics Vs transients. Effect of harmonics – Harmonic distortion - Voltage and current distortions - Harmonic indices - Inter harmonics – Resonance Harmonic distortion evaluation, IEEE and IEC standards.

UNIT III: PASSIVE POWER COMPENSATORS **(10)**

Principle of Operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators Simulation and Performance of Passive Power Filters- Limitations of Passive Filters Parallel Resonance of Passive Filters with the Supply System and Its Mitigation. Fundamentals of load compensation – voltage regulation & power factor correction.

UNIT IV: POWER QUALITY MONITORING & CUSTOM POWER DEVICES **(10)**

Monitoring considerations - Monitoring and diagnostic techniques for various power quality problems - Quality measurement equipment - Harmonic / spectrum analyzer - Flicker meters

Disturbance analyzer - Applications of expert systems for power quality monitoring. Principle& Working of DSTATCOM – DSTATCOM in Voltage control mode, current control mode, DVR Structure – Rectifier supported DVR – DC Capacitor supported DVR -Unified power quality conditioner.

References/Textbooks:

1. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H.WayneBeaty, Electrical Power Systems Quality, McGraw Hill, 2003.
2. G.T. Heydt, Electric Power Quality, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
3. M.H.J Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, (New York: IEEE Press, 1999)
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad," Power Quality Problems & Mitigation Techniques" Wiley, 2015.

Course outcomes:

On successful completion of the course, students will be able to

CO1: Differentiate between different types of power quality problems.

CO2: Explain the sources of voltage sag, voltage swell, interruptions, transients, long duration over voltages and harmonics in a power system.

CO3: Analyse power quality terms and power quality standards.

CO4: Explain the principle of voltage regulation and power factor improvement methods, the power quality monitoring concepts and the usage of measuring instruments

12/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC313 INDUSTRIAL CONTROL AND AUTOMATION

Pre-requisite: EEPC101, EEPC204, EEPC205, EEPC206, EEPC208, EEPC303

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:
This course aims to provide fundamental concepts of control of most process variables and how these measured quantities are transformed and transmitted, process control, including principles of industrial practices and computer control, knowledge and actions of various types of control systems, including analog and digital types, online and real-time, PLC program for industrial applications.

Unit-I: **(10)**
Introduction to Process Control Systems: Representative process control problems, control objectives and configurations of process control, role of control engineer, process control operations.

Mathematical modeling of processes: Type of models,modeling procedure steps, empirical model identification.

Unit-II: **(10)**
Blending Process: Problems, dynamics, modeling, selection, temperature sensors, concentration-response of isothermal CSTR with no chemical reaction, liquid level system analysis of non-interacting and interacting tanks.

Feedback Control Analysis: Transient response with regulatory, set-point, and tracking control for second and higher-order processes with PID controllers, effect of measurement lag and process dead time on response, control architectures, control valves.

Unit-III: **(10)**
Enhanced Process Control Strategies: Feed-forward control, cascade control, selectors and redundant control, concept of computer control, sequential, supervisory and DDC modes, computer control architecture.

Advanced Process Control Strategies: Electronic controller design using op-amps and microcontroller, dead time compensation, internal model control, inferential control.

17/7/23

Unit-IV: **(12)**

Introduction to Automation: Peripherals required in automation systems, architecture of distributed control systems, local control unit architecture, and process interfacing issues.

PLC& SCADA: Organization of programmable logic controllers, standards programming for basic actuators and motors, ladder programming, sequential function charts, architecture of SCADA, supervision,and control,HMI, RTU,supervisory stations, trends in SCADA, and security issues.

Industrial Visits: Case studies, visit to SCoE Labs, seminars, workshops, etc.

References/Textbooks:

1. Peter Harriot, Process control, McGrow Hill, Edition No. 01, 1964.
2. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, F. J. Doyle, Process Dynamics and Control, Wiley, Edition No. 04, 2016.
3. S. K. Singh, Computer Aided process control, PHI, Edition No. 01, 2004.
4. S. Bhanot, Process Control-Principles and Applications, Oxford University Press, Edition No. 04, 2010.
5. T. E. Marlin, Process Control: Designing Processes and Control Systems for Dynamic Performance, McGrow Hill, Edition No. 02, 2000.
6. Richard L. Shell, Ernest L. Hall, Handbook of Industrial Automation, CRC Press, UK, 2009.
7. John W. Webb, Ronald A. Reis, "Programmable Logic Controllers", 5th Ed., PHI, 2012.

Course outcomes:

On successful completion of the course, students will be able to

CO1 Understand the basic principles & importance of process control in industrial process plants

CO2 Explain the construction, working, and control strategies of different industrial processes and drives.

CO3 Build and experiment with PLC-based SCADA systems program for various industrial applications

CO4 Implement HMI, Distributed Control System, and Industry standards.

12/7/23

Program Elective 2 (Semester VI)

ELECTRICAL ENGINEERING DEPARTMENT

EEPE318A DISTRIBUTION SYSTEM ANALYSIS

Pre-requisite: EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

To understand concept of distribution systems, layouts of substation and lines, nature of consumer loads, distribution transformers and their types, power flow analysis

Course Content

Unit - I Distribution systems **(12)**

General aspects, A.C/DC distribution, comparison of volume of conductors, single phase and three phase Underground cables – Comparison with overhead line – Types of cables – insulation resistance –potential gradient – capacitance of single core and three core cables, customer loads, feeders loads, load characteristics load models, Types of distribution substations, their Layout, types of feeders.

Unit – II **(10)**

Application of Distribution Transformers: Types of distribution transformers, voltage regulation, efficiency calculations, vector groups, single and three phase transformers, booster transformers, grounding transformers.

Unit – III: Voltage-Drop and Power-Loss Calculations **(10)**

Application of Capacitors to distribution systems: Series and shunt capacitors, power factor correction, optimal power factor based on constant KW and KVA, Computerized Method to Determine the Economic Power Factor, Kelvin,s Law, Voltage drop calculation, Method of analysis: voltage drop calculations, K-factors, uniformly distributed loads, lumping loads in geometric configuration.

Economic Justification for Capacitors, Types of capacitors, Distribution System Voltage Regulation, Feeder Voltage Regulators and their types., power loss calculations.

Unit – IV **(10)**

17/7

17/7/23

Distribution System Protection, Overcurrent Protection Devices: fuses, types, Automatic Circuit Reclosesers. Fuse-to-Fuse Coordination, Fuse-to-Circuit-Breaker Coordination, Power flow of distribution system, simulation study using softwares.

References/Textbooks:

1. MTuranGonen., 'Electric Power Distribution System Engineering', BSP Books, Pvt. Ltd, 2007.
2. William H. Kresting, Distribution system modeling and Analysis, CRSC press, Taylor and Francis group, 2007.
3. Momoh A. Momoh, James A. Momoh., 'Electric Power Distribution, Automation, Protection, and Control', CRC Press, 2007.
4. Robert H.Miller, James H.Malinowski, 'Power System Operation', Tata McGraw-Hill, 2nd Edition,2009.

Course Outcomes

On successful completion of the course, students will be able to

CO1: Classify the distribution system types and comparison of AC and DC distribution system.

CO2: Understand the types of distribution transformers, booster transformers and their application.

CO3: Determine voltage drop, power factor correction using capacitors and voltage regulators

CO4: Analyze protection schemes for distribution systems, fuse and CBs coordination and fundamentals of distribution system automation.

12/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE318B ECONOMIC AND PROJECT EVALUATION IN ELECTRICITY INDUSTRY

Pre-requisite: EEPC203, EEPE310A

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

The course aims to provide the methodologies of project evaluation in order to comprehend and analyses investment proposals and decisions.

Course Content

Unit I: Project evaluation and financial evaluation **(12)**

Energy return on energy invested, Capacity factor, Investments in the electricity sector, Project selection and evaluation, Project development, Time value of money, Discounted cash flows, Net present value, Inflation in cash flows, Discount rate and its calculations and forms, Weighted-average cost of capital, multiple discount rates, costs and benefits evaluation, Project financial costs and benefits, Least-cost solution, Worth of the investment, Owner's evaluation of profitability, Base cost estimate and contingencies, Sunk costs, Depreciation and interest charges, Financial projections, Evaluation of benefits in the electricity supply industry, Timing of projects, Projects with different lives and construction periods, Expansion projects, System linkages (system effects), financial evaluation to economic evaluation, Border and shadow pricing, Investment costs in reducing dangers to health and environmental impacts, The welfare discount rate, Climate change costing, Discounting concepts in climate change

Unit II Renewable Energy Project Evaluation and Carbon Economy **(10)**

Economics of renewables and the role of the state, Utilisation factor (capacity factor), Dispatching and transmission cost, Costing of renewables generation, Assessing the returns on investment in renewables, Value factor, Merit-order effect, Carbon dilemma, Climate conventions: Kyoto and beyond, Carbon taxation, Emissions trading, The negative effect of power sector subsidies, Prospects for non-fossil-fuel power generation, Future prospects for solar cells, Virtual power plant, Carbon usage and its economy

Unit III Risk Management in Electricity Markets **(10)**

Liberalization of Electricity Sector, Opportunities presented by liberalization, Barriers in liberalised markets, Utility of the future, Electricity and the new digital economy, Virtual utility, DSM programmes in deregulated markets, Need for a regulator,
Generation investment, Deterministic generation investment decisions, Project risks, Sensitivity analysis, Break-even point analysis, Decision analysis, Risk analysis (the Monte Carlo simulation), Consideration in risk analysis, Value of risk management in liberalised markets, Qualifying and managing financial risks, Quantifying and managing risk, Decision making process

Unit IV Economics of reliability of the power supply (10)
Reliability in system planning, Empirical planning rules, Detailed financial and economic evaluation, Financial and economic evaluation of quality of electrical power, Evaluation of investment in generation, Valuing cost of interruptions, Renewables and reliability of supply
Use of software for project and economic evaluation of energy projects

References/Textbooks:

1. Khatib, Hisham. Economic evaluation of projects in the electricity supply industry. No. 44. IET, 2003.
2. Short, Walter, Daniel J. Packey, and Thomas Holt. A manual for the economic evaluation of energy efficiency and renewable energy technologies. No. NREL/TP-462-5173. National Renewable Energy Lab.(NREL), Golden, CO (United States), 1995.
3. Park, Chan S. Fundamentals of engineering economics. Upper Saddle River, NJ: Pearson/Prentice Hall, 2004.
4. G. Mankiw, "Principle of Economics", Wiley Eastern, 6 th Edition, 1998.

Course Outcomes
On successful completion of the course, students will be able to

CO1 Understand the concepts and techniques of project selection and evaluation in the electricity sector
CO2 Understand the economics of renewable energy technologies
CO3 Analyze Risk Management in Electricity Markets
CO4 Apply the knowledge of reliability in system planning to conduct detailed financial and economic evaluations

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE318C HIGH POWER CONVERTERS

Pre-requisite: MAIC12, EEPC101, EEPC210, EEPC304

L	T	P	Credits	Total contact hours
3	0	0	**3**	**42**

Brief Description about the course: This course helps to understand difference between low power and high power converters. Course will provide the in-depth knowledge of circuit topologies of high power converters, their working principles and applications.

Course Content

Unit – I: Basic Understanding of Converter: **(10)**

Introduction to Power Converters, Half Bridge and Full Bridge circuit Operation, Sinusoidal Pulse Width Modulation and Three Phase circuit, Harmonics in Sinusoidal PWM.

Unit – II Advanced PWM Schemes: **(12)**

Third harmonic addition in Sine PWM, Introduction to Space Vectors, Space Vector PWM-Timing Calculation, Switching Sequence, SVPWM- Using Carriers.

Unit – III Multilevel Converters: **(10)**

Introduction to Multilevel Converters, Cascaded H-bridge Multilevel Converters, Output Voltage Waveform Synthesis in CHB Converter and Basic of Asymmetrical CHB Converters, Cascaded H-Bridge Converters: Phase-Shifted PWM & Level-Shifted PWM. Neutral Point Clamped Converter - Circuit Topology, Sinusoidal PWM and Space Vector PWM, Mid-point Voltage Fluctuations, Capacitor Voltage Balancing. Other Topologies of NPC Converters- higher Level NPC, TNPC and Active NPC.

Unit – IV Modular Multilevel Converter: **(10)**

Topology and operation, arm and cell voltage ratings, arm currents, arm energy balancing, different circuit topologies, PWM technique and capacitor voltage balancing, design of components in mmc. Multi-Pulse transformer, a case study onMMC and CHB.Basics of gate driver circuits, turn-on and turn-off process, features of gate drivers and basics of bootstrap functionality.

References/Textbooks:

1. Bin Wu, Mehdi Narimani "High-Power Converters and AC Drives, 2nd Edition" Wiley-IEEE Press, 2017.
2. Sergio Alberto Gonzalez, Santiago Andres Verne, Maria Ines Valla "Multilevel Converters for Industrial Applications, 1st Edition" CRC Press, 2017.
3. Sixing Du, ApparaoDekka, Bin Wu, NavidZargari "Modular Multilevel Converters: Analysis, Control, and Applications" (IEEE Press Series on Power Engineering) Hardcover – Import, 2018.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 Understand the operation of low and high power converters

CO2 Evaluate the performance of switching schemes for different Converters

CO3 To understand Multi-level converters and Different Topologies

CO4 Design and Analysis capability of various modular multilevel converters

12/7

12/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE318D GUIDANCE AND CONTROL

Pre-requisite: EEPC208, EEPC303, EEPC313

L	T	P	Credits	Total contact hours
3	0	0	03	42

Course contents:

Unit-I **(9)**

Modeling, control, Guidance and Navigation of Autopilots; Missiles, Guidance Systems, Guidance information requirements-Energy Conservation Methods-Time Conservation Methods-Collision Warning and Avoidance

Unit-II **(12)**

Missile guidance and Control: Guided missile - surface to surface, surface to air, air to surface and air to air missiles-Tactical and strategic missile- Subsystems of a missile – airframe, flight control and guidance, warhead, data link, fuse, propulsion, telemetry- Control – Canad, wing and tail control- Steering policy – skid to turn (STT), preferred orientation control (POC), bank to turn (BTT) and hybrid- Aerodynamic and Ballistic missiles-Auto pilots Types of fuse, warhead and propulsion systems-Guidance sequence- different schemes of guidance during launch, midcourse and terminal phases- Collision avoidance.

Unit-III **(11)**

Satellite Orbit maintenance-Inertial navigation-block diagram representation of essential components-Inertial sensors, Gyros: Principle of operation-TDF and SDF- gyro precession-Nutation-gimbal - lock-gimbal flip-gyro transfer function- rate gyro-integrating gyro Constructional details and operation of floated rate integrating gyro-Dynamically tuned gyro-Ring laser gyro-Fiber optic gyro -gyro performance parameters-Accelerometers-transfer function-Pendulous gyro integrating accelerometer Vibrating String accelerometer-Accelerometer performance parameters Navigation equations-Schuler principle and mechanization.

Unit-IV **(10)**

Space vehicle dynamics and control Powered flight-unpowered Flight-Orbital mechanics-Orbital parameters- circular, elliptical, parabolic, hyperbolic and rectilinear orbits- energy of the orbit- orbital transfer and rendezvous

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Case studies and Applications in DRDO, CSIR and ISRO applications.

References/Textbooks:

1. M. H. Kaplan, Modern Spacecrafts dynamics and control, John Wiley & Sons, 1976.
2. H. Schaub and J. L. Junkins, Analytical Mechanics of Space Systems, AIAA, USA, 2003.
3. E. V. B. Stearns, Navigation and Guidance in Space, Prentice Hall, 1983.
4. M. Fernandez and G.R. Macomber, Inertial Guidance Engineering, Prentice Hall, 1962.
5. C. F. Lin, Modern Navigation, Guidance, and Control Processing, Prentice-Hall, 1991.
6. M. J. Zucrow, Aircraft & Missile Propulsion, John Wiley & Sons, 1958.
7. D. B. Newman, Space Vehicle Electronics, D. Van Nostrand Co., 1964.
8. A. C. Kermode, Mechanics of Flight, Pearson Education, 2004.
9. P. Zarchan, Tactical and Strategic Missile Guidance, AIAA, 2007.

Course Outcomes

On successful completion of the course, students will be able to

CO1: Identify the features of satellite based navigation systems, GPS and GNSS

CO2: Summarize the guidance system components: gyros and accelerometers

CO3: Construct dynamic models of space vehicles and missiles

CO4: Design guidance and control schemes for space vehicles and missiles

17/7/23

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ELECTRICAL ENGINEERING DEPARTMENT

EEPE318E DATA COMMUNICATION NETWORKS

Pre-requisite: CSIC13

L	T	P	Credits	Total contact hours
3	0	0	3	42

Unit-I **(10)**

Introduction, Network Models, Data and Signals, Data Representation, Data Flow, Digital Transmission, Analog Transmission, Bandwidth Utilization: Multiplexing and Spreading, Transmission Media, Switching, Using Telephone and Cable Networksfor Data Transmission.The Internet - A Brief History, the Internet Today, Protocol and Standards - Protocols, Standards, Standards Organizations, Internet Standards.

Unit-II **(10)**

Error Detection and Correction, Data Link Control, Multiple Accesses, Wired LANs: Ethernet, Wireless LANs, Wireless Links and Network Characteristics,Connecting LANs, Backbone Networks, and Virtual LANs, Wireless WANs: Cellular Telephone and Satellite Networks, SONETISDH, Virtual-Circuit Networks: Frame Relay andATM.

Unit-III **(10)**

Logical Addressing, Internet Protocol (IP), Address Mapping, Error Reporting, and Multicasting, Delivery, Forwarding and Routing, Network Service Models, Virtual Circuit and Datagram Networks-Virtual-Circuit Networks, Datagram Networks.

Unit-IV **(10)**

Transport Layer: Process-to-Process Delivery: UDp, TCP, and SCTP, Congestion Control and Quality of service.

Application Layer: Domain Name System, Remote Logging, Electronic Mail, and File Transfer, WWW and HTTP, Network Management: SNMP, Multimedia,Introduction toDNS-the Internet's Directory Service, and Case studies.

References/Textbooks:

1. Data Communications and Networking Behrouz A. Forouzan 4th Edition McGraw-Hill Education
2. Computer Networking A Top-Down Approach – Kurose James F, Keith W, 6th Edition, Pearson.
3. Data communication and Networks - Bhusan Trivedi, Oxford university press, 2016

17/7 17/7 17/7/23 17/7/23 17/7/23

4. Computer Networks -- Andrew S Tanenbaum, 4th Edition, Pearson Education
5. Understanding Communications and Networks, 3rd Edition, W. A. Shay, Cengage Learning.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1. Know the Categories and functions of various Data communication Networks

CO 2. Design and analyze various error detection techniques.

CO 3. Demonstrate the mechanism of routing the data in network layer

CO 4. Know the significance of various Flow control and Congestion control Mechanisms and the functioning of various Application layer Protocols.

17/7/23

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE318F SOFT COMPUTING TECHNIQUES

Pre-requisite: CSIC13

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

Soft computing is an emerging approach to computing which parallel the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision. Soft computing is based on some biological inspired methodologies such as genetics, evolution, ant's behaviors, particles swarming, human nervous systems, etc. Now, soft computing is the only solution when we don't have any mathematical modeling of problem solving (i.e., algorithm), need a solution to a complex problem in real time, easy to adapt with changed scenario and can be implemented with parallel computing. It has enormous applications in many application areas such as medical diagnosis, computer vision, hand written character recondition, pattern recognition, machine intelligence, weather forecasting, network optimization, VLSI design, etc.

Course Content:

Unit-I **(10)**

Soft Computing: Introduction, requirement, different soft computing techniques and their characteristics, comparison with hard computing, applications.

Unit-II **(10)**

Fuzzy sets and Fuzzy logic: Introduction, Fuzzy sets versus crisp sets, properties of fuzzy sets, operations on fuzzy sets, Extension principle, Fuzzy relations, Linguistic variables, linguistic terms, Linguistic hedges, Fuzzy reasoning, Mamdani and TSK fuzzy inference systems, Applications, fuzzy controllers, Theoretical and implementation issues.

Unit-III **(11)**

Artificial Neural Network: Introduction, comparison with biological neural network, basic models of artificial neuron, different architectures of ANN, Learning techniques, ANN based system modeling, ANN based controller design, theoretical and implementation issues, Applications.

Unit-IV **(11)**

17/7 17/7 17/7 12/7/23

Hybrid systems: Neural-Network-Based Fuzzy Systems, Fuzzy Logic-Based Neural Networks, Fuzzy Logic design, Introduction to Evolutionary algorithms. Matlab simulations using the fuzzy toolbox, case studies and applications, intelligent control of complex systems.

References/Textbooks:

1. Neuro Fuzzy & Soft Computing - J.-S.R.Jang, C.-T.Sun, E.mizutani, Pearson Education
2. Neural Networks and Fuzzy Systems: Dynamical Systems Application to Machine Intelligence - Bart Kosko, Prentice Hall.
3. T.J. Ross, "Fuzzy Logic Control", TMH Publications.
4. S. Hekins, "Comprehensive Neural Networks", Pearson Publications.
5. S. Rajsekharan, Vijayalaxmi Pai, "Neural Networks, Fuzzy logic and Genetic Algorithms, Synthesis and applications", Prentice Hall
6. V. Kecman, "Learning and Soft Computing", MIT Press.
7. D. Ruan, "Intelligent Hybrid Systems", Kluwer Academic Publisher.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1. Understand the importance of soft computing.

CO 2. Understand different soft computing techniques like Fuzzy Logic, Neural Networks& introduction to evolutionary algorithms and their combination.

CO 3. Implement algorithms based on soft computing.

CO 4. Identify when and where to use soft computing methodologies and apply soft computing techniques to solve engineering or real life problems

17/7/23

17/7/23

Program Core (Semester VII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC401 ELECTRIC DRIVES

Pre-requisite: EEPC210, EEPC304, EEPC201, EEPC211

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description: To provide state-of-the-art speed control techniques used in modern drives for high-performance requirements

Course Content

Unit - I **(12)**

Converter Fed DC Drives: Basic of Electric Drives; Types of Drives; Torque-speed characteristics; multi-quadrant operation; Methods of DC motor control, DC to DC converter fed dc motor drives and their control techniques; non-regenerative controlled rectifiers, fully controlled converters, Single-phase half controlled and fully controlled AC to DC converter fed dc motor drives; Three-phase fully controlled AC to DC converter fed dc motor drives; field control, switching systems for DC motors, chopper regulators, aspects of analysis, performance and stability of variable speed dc drives.

Unit – II **(10)**

High-Performance Control of Induction Machines EV drives: Voltage source inverter fed induction motor drive in open loop; Frequency and voltage control in PWM VSI; Current source inverter fed induction motor drives. Introduction Field-Oriented Control (Vector Control), Direct Torque Control and parameter sensitivity.

Unit – III **(10)**

High-Performance Control of Synchronous Machines: Introduction Three-Phase Permanent Magnet Synchronous Machine Modelling Torque Control of a PMSM and parameter sensitivity

Unit – IV **(10)**

Application of Intelligent Controllers for AC and DC Drives: Introduction to ANN, Fuzzy. Implementation of ANN, Fuzzy and ANFIS on DC and AC drives.

17/7 17/7 17/7/23

References/Textbooks:

1. Dubey G. K., "Fundamentals of Electric Drives", 2nd Ed., Narosa 2007, Publishing House.
2. Pillai S. K., "A First Course in Electric Drives", 2nd Ed., New Age 2008, International Private Limited.
3. Sen P. C., "Thyristor DC Drives", John Wiley and Sons. 1991
4. Dubey G. K., "Power Semiconductor Controlled Drives", Prentice Hall International Edition.1989
5. Murphy J. M. D. and Turnbull F. G., "Power Electronics Control of AC Motors", Peragmon Press. 1990
6. Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1 Able to describe various industrial DC motors and drive systems.

CO 2 Can apply knowledge of power electronics to AC drive systems.

CO 3 Learn advanced control methods of EV based motor drive systems

CO 4 Understanding Intelligent control methods of EV based AC motor drives

17/7/23

Program Elective 3 (Semester VII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPE405A SYSTEM IDENTIFICATION

Pre-requisite: EEPC204, EEPC205, EEPC206, EEPC208, EEPC303

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:
Aims to give fundamental concepts of system identification, probability theory, random variable, non-parametric and parametric methods, non-recursive and recursive methods, Basic of Kalman filter design.

Unit-I **(10)**
Review of probability theory and random processes, problem formation for identification and estimation.

Unit-II **(10)**
Models: Review of continuous and discrete, state space and input-output, disturbance models.

Identification: Impulse response and transfer function approach (only nonparametric methods).

Unit-III **(12)**
Parameter Estimation: Introduction, maximum likelihood method, mean square method, linear regressions and least-squares methods and properties, prediction error approach

Unit-IV **(10)**
Non- recursive and recursive methods, Kalman filter

Design exercises in MATLAB/LABVIEW and case studies.

References/Textbooks:

1. Lennart Ljung. "System Identification: Theory for the user", Prentice Hall Inc, NJ 1991.
2. B.N Chatterji and K.K. Parmer, "System Identification Techniques" Oxford & IBH Pub. New Delhi. 1989.
3. A. Papoulis & S U Pillai "Probability, Random Variables and Stochastic Process" 4th edition Mc Graw Hill, 2002.

17/7 17/7 17/7/23

4. Arun K. Tangirala, "Principles of System Identification:Theory and Practice", CRC Press, 2015.

Course outcomes:

On successful completion of the course, students will be able to

CO1: Understand statistical properties and modeling of system with Random variables.

CO2: Identify system models using identification methods both in transfer function and state space representation.

CO3: Understand the need for estimators and estimation process for linear systems using different techniques.

CO4: Apply the theory learned on case studies and understand computational aspects in estimation and identification.

17/7/23

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE405B ROBOT DYNAMICS & CONTROL

Pre-requisite: EEPC208, EEPC303, EEPC313

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

Aims to give fundamental concepts of kinematics, dynamics and control of industrial Robotic manipulator

Unit-I **(10)**

Definition, Motivation, Historical development, Basicstructure, Classification, Workspace, Grippers.Rigid motion and frame Transformations. DH parameters

Unit-II **(10)**

Robot Arm Forward and Inverse Kinematics, Forward and Inverse Kinematics, redundancy resolution, Velocity kinematics and Jacobian, Singular value decomposition, singularity and manipulation ability

Unit-III **(10)**

Lagrange formulation of dynamics.

Trajectory generation: Cartesian Scheme, Joint space scheme

Teaching methods: Manual teaching, Lead through teaching

Sensors and actuators as used in robotics.

Unit-IV **(12)**

Control Scheme: Position Control, Force control, Hybrid position and force control, Industry Multi DOF robotic manipulator case studies.

Design exercises in MATLAB/LABVIEW and case studies.

References/Textbooks:

1. J.J. Craig, "Introduction to Robotics – Mechanics A Control", Addison Wesley, 2001.
2. A.J. Koivo, "Fundamentals for Control of Robotic Manipulation", John Wiley Inc. New York, 2001.
3. Spong and Vidyasagar, "Robot Dynamics and Control", John Wiley and Sons, 2005.
4. Sciavicco and Siciliano, "Modeling and Control of Robot Manipulators", McGraw Hill International Edition, 1998.

17/7/23 17/7/23 17/7/23

5. Foundations of Robotics : T. Yoshikawa , PHI India

Course Outcomes:

On successful completion of the course, students will be able to

CO1: Understand the basic concept of industrial robotic Manipulator

CO2: Derive direct and inverse kinematic equations of a given robot.

CO3: Derive the dynamic equations of an industrial robot.

CO4: Develop the control algorithm necessary to run the given robot

17/7

17/7/23

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE405C CUSTOM POWER DEVICES

Pre-requisite: EEPC210, EEPC304, EEPC312

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description: aims to give a basic understanding of various power quality issues such as causes and mitigation techniques. Power quality standards, classification of power quality problems and their active and passive solutions.The role of Custom Power Devices for the mitigation of various voltage and current based distortions.

Course Content

Unit - I **(12)**

Power Quality

Introduction to Power Quality, Concern about the Power Quality, GeneralClasses of Power Quality Problems, Voltage Unbalance, Waveform Distortion, Voltage fluctuation, PowerFrequency Variations, Power Quality Terms, Voltage Sags, swells, flicker and Interruptions - Sources ofvoltage and current interruptions, Nonlinear loads.

UNIT-II **(10)**

Passive and Active compensation of Power Quality problems

Introduction to Passive and Active filters, Various type of passive filters, Classification of passive filters, application of passive filters, disadvantages of passive filters, Various type of active filters, Classification of active filters, application of active filters, Hybrid filters

UNIT-III **(12)**

Custom Power Devices

Custom power and custom power devices, voltage source inverters, reactivepower and harmonic compensation devices, compensation of voltage interruptions and currentinterruptions, static series and shunt compensators, compensation in distribution systems, interaction withdistribution equipment, installation considerations.

UNIT-IV **(8)**

Application of Custom Power Devices in Distribution System

17/7/23

17/7/23

17/7/23

Static and hybrid Source Transfer Switches,Solid state current limiter - Solid state breaker. P-Q theory – Control of P and Q, Dynamic VoltageRestorer (DVR): Operation and control – Interline Power Flow Controller (IPFC): Operation and controlof Unified Power Quality Conditioner (UPQC); Generalized power quality conditioner

References/Textbooks:

1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W,Second Edition, McGraw-Hill, 2002.
2. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, 1st Edition, IEEE Press; 2000.
3. Guidebook on Custom Power Devices, Technical Report, Published by EPRI, Nov 2000
4. Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, ArindamGhosh, Kluwer Academic Publishers, 2002.
5. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.
6. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons,2003.
7. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van NostradReinhold, New York.
8. Power Quality c.shankaran, CRC Press, 2001
9. Harmonics and Power Systems –Franciso C.DE LA Rosa-CRC Press (Taylor & Francis).
10. Power Quality in Power systems and Electrical Machines-EwaldF.fuchs, Mohammad A.S.Masoum-Elsevier
11. Instantaneous Power Theory and Application to Power Conditioning, H. Akagiet.al., IEEE Press,2007.
12. Custom Power Devices - An Introduction, ArindamGhosh and Gerard Ledwich, Springer, 2002

Course outcomes:

On successful completion of the course, students will be able to

CO1: Identify the issues related to power quality in power systems

CO2: Analyze the effects of harmonics and study of different mitigation technique

CO3: Identify the importance of custom power devices and their applications

CO4: Acquire knowledge on different compensation techniques to minimize power quality disturbances

17/7 17/7/23 17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE405D ENERGY STORAGE SYSTEMS

Pre-requisites: CHIC13, PHIC11

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description: Objective is to know about different type of energy storage systems which may be stand-alone or grid connected, storage efficiency

Course Content

Unit-I **(10)**

Introduction to Energy Storage: Relevance and scenario. Perspective on development of Energy storage systems. Energy storage criteria, General concepts. Conventional batteries – fundamentals and applications.

Unit-II **(10)**

Grid connected and Off-grid energy storage systems and requirements. Thermal storage: Thermal properties of materials, Principle of operations, Efficiency factors, large scale and Medium scale operations, Pros and Cons. Advances in thermal storage.

Unit-III **(10)**

Mechanical Storage: Types of systems, Principle of operations, Emerging advances and Technologies. case study: Flywheel Electrochemical Storage: Materials, Principle of Operation, Challenges and research survey. Positive electrode materials, negative electrode materials, electrolytes. Fuel Cells and Hydrogen storage: Principle of operation, challenges and Case studies.

Unit-IV **(12)**

Magnetic storage: Principle of operation, emerging challenges, devices and technology review Electro-optic and Optical storage: Principles of operation, device fabrication, emerging devices and upcoming technologies.

Super-capacitors: Principle of operation, device fabrication, challenges and technical review.

References/Textbooks:

17/7

17/7/23

17/7/23

1. Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.
2. Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
3. Lithium ion rechargeable batteries by edited by Kazunori Ozawa, Wiley.
4. E. Lipman, A. Z. Weber, Fuel Cells and Hydrogen Production, A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, Springer reference.
5. Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and design by MehrdadEhsani, YiminGao, Sebastien E. Gay, Ali Emadi, CRC press

Course outcomes:

On successful completion of the course, students will be able to

CO1: Understand different types storage technologies

CO2: Design a thermal storage system, model battery storage system

CO3: Analyze the thermodynamics of fuel cell,analyze the appropriate storage technologies for different applications

CO4: Explore the alternate energy storage technologies

17/7/23

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE405E EARTHING PRACTICES

Pre-requisite: EEPC101, EEPC203, EEPC209

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

The course aims to provide fundamental knowledge and application of Power System Earthing

Course Content

Unit-I Fundamental Concepts **(10)**

Maxwell Equations, return current Path Impedance, Transmission Line Fundamentals, Characteristics of Signals and Circuits, Interaction Between Sources of Radiated Field,
Grounding and Objective, Grounding Symbols and Classification, Case Studies, Definition: Ground, Grounding, Ground Current, Ground Electrode, Grounding System, Ground Impedance, Remote Earth, Fundamental Grounding Topologies, Rack and Cabin System Grounding Architecture, Grounding as per system size and layout

Unit-II Soil Resistivity & Ground Resistance Measurement Power System Earthing **(14)**

Soil resistance and resistivity, Types of soil, Permeability and permittivity of soil, Factor influencing Soil resistivity, Current Density, Continuity of Earth Current, Current Density at Soil Interface, Methods for soil resistivity measurements, Methods for ground resistance measurements, Determination of Soil Model: Wenner Method, Driven Rod Method
Objectives of Power System Earthing, Ungrounded System, Ground Resistance, Electric Potential, Ground resistance with Hemisphere Conductor, sphere electrode, Cylindrical Rod, circular plate, Conductor type electrode, Methods of Earthing, Electric Shock Hazards, Earthing for Low Voltage Distribution Systems: TN, TT, and IT systems, Temporary Overvoltage in Low Voltage Installations, Earthing and EMC, Residual Current Devices for Shock Protection, Maximum Ground Potential Rise

Unit-III Analyzing Power System Earthing **(10)**

Grounding System Safety Assessment, Numerical Analysis Techniques: Basic Equations, Matrix Method, Combined Integration Method; Analysis of Grounding System, Equivalent Circuit Representation, Parametric Analysis of Substation Ground Mats, Touch and Step Potential, Measurement of Touch and Step Potentials, Mitigation of touch and step potential, Neutral Earthing of Power System.

17/7/23 17/7/23 17/7/23

Unit-IV Lightening Protection and Computer Application **(8)**

Lightening Protection system and its components, Influence of LV Earthing of Lighting, Types of Earth Electrode: The Earth Rods, Earth Plates, Round Conductor Electrode, Mesh Electrode, Ring Earth Electrode, Foundation Earth Electrode, Design of Earth Electrodes and Their Layout, Fundamental of Cable Shielding

Use of software for calculation of different grounding parameters and design of the grounding system.

References/Textbooks:

1. Md. A. Salam, Q. M. Rahman, Power System Grounding, Springer Nature Singapore, 2016
2. A. P. S. Meliopoulos, Power System Grounding and Transients: An Introduction, CRC Press
3. Joffe, Elya B., and Kai-Sang Lock. Grounds for grounding: A circuit to system handbook. John Wiley & Sons, 2011.
4. IEEE Std 142. "IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems." (2007).
5. Vijayaraghavan, G., Mark Brown, and Malcolm Barnes. Practical grounding, bonding, shielding and surge protection. Elsevier, 2004.
6. "IEEE Guide for Safety in AC Substation Grounding," in IEEE Std 80-2013 (Revision of IEEE Std 80-2000/ Incorporates IEEE Std 80-2013/Cor 1-2015) , vol., no., pp.1-226, 15 May 2015,

Course Outcomes

On successful completion of the course, students will be able to

CO1 Understand the fundamental principles and concepts of power system grounding

CO2 Analyse and design effective grounding systems for power distribution networks

CO3 Understanding of the relationship between grounding and lightning protection

CO4 Examine and identify grounding issues and make informed decisions

17/7 17/7/23 17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE405F ENERGY AUDITING, CONSERVATION & MANAGEMENT

Pre-requisite: EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

The course aims to provide methodology for energy auditing, the principles of energy management and the energy conservation using technology and the policies related to it.

Course Content

Unit I Energy Audit **(13)**

Definition and importance of energy auditing, conservation, and management, Overview of energy management systems and standards, Role of energy auditors and energy managers, Fundamental concepts of energy, power, and energy units, Forms of energy and energy conversions, Energy efficiency and energy intensity metrics

Energy audit process, Pre-audit activities: data collection, energy bills analysis, and site survey, Energy audit objectives and scope definition, Energy measurement and monitoring techniques, Energy audit tools and equipment, Benchmarking and energy performance indicator

Energy Audit Techniques - Lighting Systems, HVAC Systems, Building Envelope and Insulation, Electrical Systems, Renewable Energy Systems, Energy Audit Report Preparation and Presentation

Unit II Energy Management Systems, Policy and Regulations **(10)**

Introduction to energy management systems (EnMS), ISO 50001 standard for energy management, Steps for implementing an effective energy management system, Overview of energy policy and regulations. Energy efficiency standards and incentives, Impact of policy and regulation on energy management practices, Overview of national and international energy efficiency policies and targets, Energy conservation programs and regulations, Energy planning and energy efficiency policy developmen

Unit III Energy Conservation **(11)**

Energy Conservation Measures - Lighting Upgrades, HVAC Upgrades, Building Envelope Improvements, Renewable Energy Integration with Cost-benefit analysis and return on investment calculations, Life-cycle cost analysis and payback period calculations in each study. Energy Conservation Measures - Motor Systems, Data Centers, Energy Efficiency in Industrial

Processes: Assessment of energy efficiency in industrial processes, Identification of energy-saving opportunities in manufacturing, production, and operations, Case studies and best practices for energy efficiency improvements in industrial settings

Unit IV Case Studies and Application **(8)**

Energy Auditing and Conservation in Transportation and Healthcare Facilities, Energy Conservation Measures - Renewable Energy Procurement

Energy Audit Case Studies: Detailed analysis of real-world energy audit case studies, Evaluation of energy-saving measures and their implementation, Lessons learned and best practices from successful energy audit projects, Energy Management in the Context of Climate Change, Emerging Trends in Energy Auditing and Management

References/Textbooks:

1. Kumar, L. Ashok, and GokulGanesan, eds. Energy Audit and Management: Concept, Methodologies, Procedures, and Case Studies. CRC Press, 2022.
2. Al-Shemmeri, Tarik. Energy audits: a workbook for energy management in buildings. John Wiley & Sons, 2011.
3. Wayne C. Turner, Steve Doty, Energy Management Handbook, The Fairmont Press, Inc.
4. "ISO 50001:2018 - Energy management systems - Requirements with guidance for use" by the International Organization for Standardization (ISO)
5. Barney L. Capehart, Wayne C. Turner, William J. Kennedy, Guide to Energy Management, CRC Press.
6. Shapiro, Ian M. Energy audits and improvements for commercial buildings. John Wiley & Sons, 2016.
7. Handbook, A. S. H. R. A. E. HVAC systems and equipment. Vol. 39. chapter, 1996.
8. Sharp, Terry R. 2019 ASHRAE Handbook: HVAC Applications-Chapter 37-Energy Use and Management. Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States), 2020.

Course Outcomes

On successful completion of the course, students will be able to

CO1 Understanding of energy auditing, conservation, and management, including the definition and significance of these practices.

CO2 Evaluate energy audits by understanding the energy audit process

CO3 Identify and implement energy conservation measures in various areas

CO4 Analyze detailed case studies of energy audits, evaluate energy-saving measures, and gain insights from successful projects, learning valuable lessons and best practices.

17/7 17/7/23 17/7/23

Program Elective 4 (Semester VII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPE406A EHV AC AND DC TRANSMISSION

Pre-requisite: EEPC209, EEPC301

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

To understand the basic concepts of EHV AC and DC transmission, HVDC links, converters, their configuration, analysis of valve conduction mode, HVDC control concept of travelling eave theory and impacts of overvoltage's and their protection.

Course Content

Unit - I Introduction, Necessity for EHV Transmission, Problems involved in EHV (10)

Transmission, Operational Aspects of EHV power transmission, Standard Voltage levels for Transmission lines, Hierarchical levels of Transmission Network, Gas insulated EHV lines-Environmental and biological aspects. Advantages and Limitations and of AC. and DC transmission, Principal application of AC and DC transmission, Trends in EHV AC and DC transmission, HVDC Transmission: DC Power Transmission: Need for power system interconnections, Evolution of AC and DC transmission systems, Comparison of HVDC and HVAC Transmission, systems, Types of DC links, relative merits, Components of a HVDC system, Modern trends in DC Transmission systems

Unit – II (10)

Analysis of HVDC Converters: Pulse number, choice of converter configurations, Analysis of Graetz circuit with and without overlap, voltage waveforms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms.

Unit - III (12)

HVDC Control: Principles of DC link control, Converter Control characteristics, Control hierarchy Constant current Control, CEA Control, firing angle control of valves, starting and stopping of a dc link, Power control Harmonics and Filters: Effects of Harmonics, sources of harmonic generation, Types of filters–Design examples

17/7/23 17/7 17/7/23

Unit – IV **(10)**

Average values of line parameters, Power handling capacity and line losses, Bundled conductors, parameters , Mechanical consideration in line performance, Introduction to UHV AC and DC line, applications and issues in Commission of UHV AClines, Development of UHV lines in India. Examples of Giant power pools in the world.

Travelling wave theory: Travelling waves on transmission systems, Their shape, Attenuation and distortion, effect of junction and termination on propagation of traveling waves. Over voltages in transmission system. Lightning, switching and temporary over voltages: Control of lightning and switching over voltages

References/Textbooks:

1. HVDC Power Transmission Systems –Technology and System Interactions, K.R.Padiyar,New Age International Publishers, 2017,Third edition.
2. Direct Current Transmission, Kimbark, Wiley–Blackwell Publishers, Vol.1, 1971.
3. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", Third Edition,New Age International (P) Limited, Publishers, 2009.
4. E. Kimbark, HVDC Transmission, Jhon Wiley and Sons.
5. P.Kundur, H.V.D.C. Transmission,Tata McGraw Hill

Reference Books:

1. Jos Arrillaga High Voltage Direct Current Transmission, Institution of Engineering and Technology, 1998,2nd edition.
2. K. R. Padiyar, HVDC Transmission, New age international publishers Ltd, 2008.
3. T.K. Nagsarkar,M.S.Sukhiza, Power System Analysis, Oxford University
4. Yong Hua Song, Allan T Johns, Flexible AC Transmission Systems, Institution of Engineering and Technology, 1999.
5. S. Rao, EHV AC & DC Transmission. Khanna publishers
6. Narain.G. Hingorani, l. Gyugyi, Understanding of FACTS concept and technology, John Wiley and Sons.

Online resources:

1. HVDC Transmission: https://nptel.ac.in/courses/108/104/108104013/
2. FACTS: https://nptel.ac.in/courses/108/107/108107114/

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand the EHVAC and DC transmission, HVDC links operation of conventional generating stations and renewable sources of electrical power.

CO 2 Analyze converter configurations for HVDC and their performance metrics.

CO 3 Understand the operation of HVDC converter control

CO 4 Determine the impact of attenuation of travelling waves and concept of UHV AC and DC Transmission.

17/7 17/7/23 17/7/23

DEPARTMENT OF ELECTRICAL ENGINEERING

EEPE406B SMART GRID TECHNOLOGY

Pre-requisite: EEPC203, EEPC209, EEPC311

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

Smart Grid Technology is an undergraduate-level course that focuses on the study of modern power grid systems. This course provides the students with a comprehensive understanding of the concepts, theories, and practical applications of smart grid technologies. The course will cover the technical aspects of smart grid technology, such as grid integration of renewable energy sources, energy storage systems, demand response programs, and advanced metering infrastructure. The course will also explore the economic, regulatory, and environmental issues that have contributed to the advent of smart grid technologies.

Course Content

Unit - I Introduction to Smart Grid **(8)**

Background and history, definition, characteristics and benefits of smart grid. Smart grid vs. conventional grid. Smart grid architecture and overview of smart grid infrastructure.

Unit – II Smart Grid Components **(16)**

Advanced metering infrastructure: evolution of electric meters, AMI benefits and requirements, AMI protocols, standards and initiatives.

Demand Response: Definition, benefits and classification. Smart Home Energy Management Systems, Smart EV Charging System

Distribution Automation: Feeder switching equipment, automatic restoration, outage management system, volt-var optimization, CVR, mobile workforce management.

Monitoring and Control: SCADA, Energy Management Systems, Wide area monitoring protection and control, Distribution Management Systems, Distributed energy resource management.

Unit – III Smart Grid Information andCommunication **(10)**

Smart Grid Communication Technologies, communication architecture, applications and communication requirements.

Information technologies: Application of IoT, Big data analytics, Machine learning and block chain in smart grid. Role of cloud computing in advanced power grid.

17/7/23 17/7 17/7/23

Cyber security challenges in smart grid: common threats and vulnerabilities, cyber security solutions.

Unit – IV Smart Grid Initiatives and Standardization **(8)**

Standardization and Interoperability: Introduction to standards and technology, organizations in smart grid standardization, gap identification and decomposition, deployment issues, substation automation, IEC 61850 based substation design.

Smart Grid Initiatives: Initiatives worldwide and in India, National Smart Grid Mission, pilot projects in India. Smart grid for sustainable development and Smart Cities.

References/Textbooks:

1. S.K. Salman, "Introduction to the Smart Grid: Concept, Technologies and Evolution", The Institution of Engineering and Technology (IET), 2017.
2. Stuart Borlase (ed.), "Smart Grids: Advanced Technology and Solutions", 2nd Edition, CRC Press, 2018.
3. James Momoh, "Smart Grid: Fundamentals of Design and Analysis" IEEE Press, 2012.
4. JanakaEkanayakeet al., "Smart Grid: Technology and Applications" Wiley, 2012.
5. David Bakken (ed.), "Smart Grids: Clouds, Communication, Open Source and Automation", CRC Press, 2014.
6. V. CagriGungoret al., "A Survey on Smart Grid Potential Applications and Communication Requirements", IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 9, NO. 1, FEBRUARY 2013.
7. EKLAS HOSSAIN et al., "Application of Big Data and Machine Learning in Smart Grid, and Associated Security Concerns: A Review" IEEE ACCESS, 2019. Digital Object Identifier 10.1109/ACCESS.2019.2894819.
8. AHMED S. MUSLEH et al., "Blockchain Applications in Smart Grid–Review and Frameworks", IEEE ACCESS, 2019. Digital Object Identifier 10.1109/ACCESS. 2019.2920682

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand the concepts and principles of smart grid technologies

CO 2 Analyze and evaluate the different components of smart grid systems

CO 3 Understand the importance of communication technology, data analytics and cyber security and in smart grid systems

CO 4 Demonstrate knowledge of the practical aspects of smart grids, such as standardization, interoperability, deployment and sustainability.

18/7 17/7/23 17/7/23

DEPARTMENT OF ELECTRICAL ENGINEERING

EEPE406C POWER SYSTEMS SECURITY AND OPTIMIZATION

Pre-requisite: EEPC209

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

This course provides an in-depth understanding of power system security and optimization, focusing on the principles, techniques, and strategies employed in the secure and optimal operation of electrical power systems. Students will learn about the power system security, optimal power flow and its solution techniques, state estimation and forecasting of load and electricity price. Emphasis will be placed on practical applications and the use of computer tools for power system operation and control.

Course Content

Unit - I Power System Security **(10)**

Introduction, Power System States, Factors Affecting Power System Security, Contingency Analysis: Detection of Network Problems, Linear Sensitivity Factors, Flowgates, Voltage Collapse.

Unit – II Optimal Power Flow **(10)**

Power flow equations, Optimal Power Flow (OPF) modelling, DC optimal power flow, security constrained OPF, modified OPF models for power system operation, applications of OPF. Solution of DCOPF, Linear Programming. Solution of ACOPF, Newton method, Gradient Method, Evolutionary Algorithm, Swarm Optimization.

Unit – III State Estimation **(10)**

Introduction, Problem Formulation, Network and Measurement Model, Solution through normal equations, fast decoupled estimator, observability analysis, orthogonal factorization, hatchtel's matrix based solution, bad data detection and identification. Non-quadratic State Estimators, Inclusion of PMUs in SE.

Unit – IV Short-Term Forecasting **(12)**

17/7/23

17/7

17/7/23

Forecasting in electrical power systems, Analytic Methods, Demand Model, Econometric Models, Time Series, System Identification, Model development, forecasting errors, Model Integration. Artificial Neural Networks, Back propagation, Recurrent neural networks,

References/Textbooks:

1. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheble, "Power Generation, Operation and Control", IEEE Wiley 3rd Edition, 2014.
2. Joao P.S. Catalao, Electric Power System: Advanced Forecasting Techniques and Optimal Generation Scheduling, CRC Press 2012
3. D. P. Kothari, and J. S. Dhillon, Power System Optimization, PHI Learning, 2010
4. Antonio Gómez-Expósito, Antonio J. Conejo, Claudio A. Cañizares, Electric Energy Systems: Analysis and Operation, Second Edition, CRC Press 2018.
5. James Momoh, Electric Power System Application of Optimization, CRC Press.
6. Jizhong Zhu, Optimization of Power System Operation, IEEE Wiley, 2nd Edition, 2015.
7. S. S. Rao, Engineering optimization: Theory and Practice, John Wiley & Sons, 2019, Fifth Edition.
8. https://nptel.ac.in/courses/108/104/108104052/
9. https://nptel.ac.in/courses/108/105/108105133/
10. https://nptel.ac.in/courses/108/106/108106026/
11. https://nptel.ac.in/courses/108/102/108102080/

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand the power systems security concepts and perform contingency analysis

CO 2 Explore different techniques for solution of optimal power flow

CO 3 Apply techniques for state estimation of electric power system

CO 4 Appraise techniques for short term load and price forecasting.

17/7 17/7/23 17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE406D MECHATRONICS

Pre-requisite: EEPC208

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

Principles, modeling, interfacing and signal conditioning of motion sensors and actuators; hardware in- the-loop simulation and rapid prototyping of real-time closed-loop computer control of electromechanical systems; modeling, analysis and identification of discrete-time or samples- data dynamic systems; commonly used digital controller design methods; introduction to nonlinear effects and their compensation in mechatronic systems.

Course Contents:

Unit-I **(9)**

Introduction to Mechatronics system – Key elements – Mechatronics Design process – Types of Design – Traditional and Mechatronics designs – Advanced approaches in Mechatronics – Man machine interface, industrial design and ergonomics, safety

Unit-II **(9)**

Real-time interfacing – Introduction - Elements of data acquisition and control - Overview of I/O process, Analog signals, discrete signals, and Frequency signals – Over framing.

Unit-III **(9)**

Case studies on Data Acquisition: Introduction – Cantilever Beam Force Measurement system– Testing of Transportation bridge surface materials – Transducer calibration system for Automotive applications – Strain gauge weighing system – Solenoid Force-Displacement calibration system – Rotary optical encoder – Controlling temperature of a hot/cold reservoir –pick and place robot.

Unit-IV **(9)**

Case studies of design of mechatronic products –Motion control using D.C.Motor& Solenoids - Car engine management systems.Thermal cycle fatigue of a ceramic plate – pH control system

References/Textbooks:

12/7/23

13/7

13/7/23

1. Devdas shetty, Richard A. Kolk, “Mechatronics System Design”, Thomson Learning Publishing Company, Vikas publishing house, 2021.
2. Bolton, -Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering, 2nd Edition, Addison Wesley Longman Ltd., 1999.
3. Brian Morriss, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
4. Bradley, D.Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products and Processes, Chapman and Hall, London, 1991.

Course Outcomes:

On successful completion of the course, students will be able to

CO1: Able to identify, select, and integrate mechatronic components

CO2: Able to use commercial software tools for modeling and simulation of mechatronic systems

CO3: Able to design, analyze, and optimize mechatronic products

CO4: Able to present engineering design solutions efficiently

ELECTRICAL ENGINEERINGDEPARTMENT

EEPE406E RELIABILITY ENGINEERING

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Course Description:
To apply knowledge in the field of probability theory to derive reliability function, reliability modeling. To study methods to evaluate, to increase, to optimize reliability will be discussed. Concept of maintainability, availability and reliability testing will also be discussed.

Unit 1 **(12)**
Introduction: Reliability and its importance, mortality curve, hazard rate, causes of failures, modes of failure, general reliability function and other reliability functions. Mean time to failure (MTTF), repair rate, mean-time-between failures (MTBF), availability, uptime, downtime. Failure frequency and failure distributions.

Unit 2 **(10)**
Learning Deterministic Models: Reliability models – statistical, structural, Markov, and fault tree. Reliability evaluation using various models.

Unit 3 **(10)**
Statistical Learning& Data Clustering: Redundancy techniques. Reliability allocation and Redundancy optimization. Reliability Testing

Unit 4 **(10)**
Learning with Neural Networks: Basic principles of maintainability, availability and security. Availability evaluation using Markov Technique. Basic concepts of fuzzy reliability, failure frequency and loss of load probability.

Typical case studies of practical systems.

References/Textbooks:

1. E. Balagurusamy, "Reliability Engineering", Tata McGraw-Hill Education. 1984
2. K K Aggarwal, "Reliability Engineering", Springer.2007
3. Martin L. Shooman, "Probabilistic Reliability-An Engineering approach" , Krieger Publishing Company.

17/7/23 17/7 17/7/23

4. Ram Kumar, "Reliability Engineering", Prentice Hall ,1993.
5. A.K. Govil, "Reliability Engineering", McGraw-Hill Inc. US

Course Outcomes

On successful completion of the course, students will be able to

CO1: Explain the concept of probability. Define random variable, density & distribution function.

CO2 Develop reliability models of simple and complex systems.

CO3 Describe/apply various methods of reliability evaluation to compute reliability of simple and complex systems.

CO4 To enhance system reliability using reliability allocation and redundancy optimization/allocation of practical/physical systems.

CO5 Design and develop fault trees, Markov graphs and evaluate reliability, availability using Fault tree and Markov techniques.

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ELECTRICAL ENGINEERING DEPARTMENT

EEPE406F AC-DC MICRO-GRIDS

Pre-requisite: MAIC12, EEPC101, EEPC210, EEPC304

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: This course helps to understand advanced modelling, control, resilience and security technologies useful for the grid modernization from a unique angle of microgrid design, analysis and operation.

Course Content

Unit - I Introduction to Microgrid **(9)**

Power systems resilience, The concept of microgrids, Introduction to distributed energy resources (DERs): PV system, Micro-turbine, energy storage, wind energy system and diesel generators, Microgrid converter's structure, Different topologies of Microgrids, Brief introduction to AC and DC microgrids.

Unit – II DC Microgrid **(9)**

Introduction to DC microgrid, Merits & Challenges of DC microgrids, modelling of PV system, DC-DC converter's, MPPT, and battery tied standalone DC system, DC bus voltage regulation and stability issues, Centralized control, Hierarchical principle: Primary, secondary and tertiary control, Distributed control.

Unit – III AC Microgrid **(12)**

Introduction to AC Microgrid, Merits & Challenges of AC microgrids, grid-tied interface, Microgrid inverter structures, Distribution power flow, power flow analysis for droop-control-based microgrids and networked microgrids.

Unit – IV Hybrid Microgrid **(12)**

Introduction to Hybrid Microgrid, Merits & Challenges of Hybrid microgrid, Interface of AC & DC Microgrid, Load line control (DC bus and AC bus), voltage regulation control, active & reactive power control, power sharing concept of inverters, distributed and centralized control.

Case Study: Simulation of DC microgrid using PV system and battery with AC and DC loads.

References/Textbooks:

17/7/23 17/7 17/7/23

1. P. Zhang, "Networked Microgrids" Cambridge University Press, 2020.
2. Stephen A. Roosa "Fundamentals of Microgrids: Deveiopment and Implementation" CRC Press, 2021.
3. Puladasu Sudhakar, Yogini Dilip Borole, Anurag Shrivastava"Autonomous Microgrid Operation Protection & Control" INSC International Publisher (IIP), 2021.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 To Understand the concepts of microgrids, and networked microgrids

CO2 To demonstrate the performance of different power converters in microgrid

CO3 To Analyze distribution grid power flow in different microgrid scenario's

CO4 To Design and Analysis capability of various microgrid topologies

17/7/23

Program Core (Semester VIII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC407 ELECTRIC VEHICLES

Pre-requisite:EEPC210, EEPC208, EEPC304, EEPC211, EEPC401

L	T	P	Credits	Total contact hours
3	0	0	3	**42**

Brief Description about the course: This course helps to explore and understand components of the Electric Vehicles and their complexity requirements of EV technology, existing EV architecture models, fundamentals of batteries, BMS, Charging/discharging and various electric motors drives suitable for EV.

Course Content

Unit - I Introduction to EVs **(8)**

Intro to EV, motivation, history, overview, basic definitions, some interesting vehicle concepts and problems/challenges of EVs, future directions, Architecture of an EV (both conventional and in wheel mounted motors) and its operation starting from pedal to wheels, EV-Types, their merits & demerits.

Unit – II Vehicle dynamics and Battery Basics **(12)**

Drive cycles and their impact on the vehicle operation, Basic Concepts and Terminology, Longitudinal and Lateral dynamics.Introduction to battery energy storage and battery technologies, Lithium-ion (Li-ion) battery and its charging/discharging guidelines.

Unit – III Battery Management System & charging System **(12)**

Introduction to battery management system (BMS), Modeling techniques of Li-ion battery cells, Estimation of state of charge (SOC): Model based and data driven, Battery pack system and battery cell balancing, Introduction to battery chargers – On-board and off-board chargers, standards, AC-DC power conversion and power factor correction, Isolated DC-DC power conversion and battery chargers.

Unit – IV EV Power-train modelling& Control **(10)**

Powertrain architectures and major components, power electronics, 3-phase DC-AC inverter and Space Vector PWM, Modelling of DC motor and closed loop control, Dynamic Modelling of IM, design of FOC & DTC Control schemes for IM, Introduction & basic operation of

17/7/23 17/7 17/7/23

BLDC/PMSM motor, Modelling and vector control of PMSM, Modelling and control of SRM. Case Study: MATLAB Simulation of DTC control for speed control of IM.

References/Textbooks:

1. Iqbal Husain," Electric and Hybrid Vehicles –Design Fundamentals", CRC Press, 2010.
2. D. A. J. Rand, R. Woods, and R. M. Dell, "Batteries for Electric Vehicles," Society of AutomotiveEngineers," Warrendale PA, 2003.
3. K Wang Hee Nam: AC Motor Control & Electrical Vehicle Application, CR Press, Taylor & Francis Group, 2019.
4. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 To analyzebattery as energy storage device and charging techniques for Electric Vehicle.

CO2 To understand battery management systems and state-of-charge estimation.

CO3 To evaluate the suitability of electric motor & their control for EV.

CO4 To illustrate the characteristics, modelling and control of different motors for EV application.

17/7 17/7/23 17/7/23

Program Elective 5 (Semester VIII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPE411A POWER CONVERTERS FOR RENEWABLE ENERGY SYSTEMS

Pre-requisite: EEPC210, EEPC304, EEPE310A

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: This course helps to understand advanced modelling, control, and integration of different renewable energy sourceswith loads and main power network. It also helps to design, analysis and operation of power converters for different renewable energy systems under varied environmental and operating conditions.

Course Content

Unit - I Fundamentals of Power Converters **(9)**

DC/DC converters, AC/DC converters, DC/AC converters, Classical Multilevel Inverters, SPWM, SVPWM, ratings and selection criteria of converter's for different renewable energy systems, topologies of energy systems associated with PV and wind energy system.

Unit – II Modeling of Power Converters **(10)**

Introduction to Power Electronic Converters Modeling, Switched Model of DC-DC isolated and non-isolated converters, Switched Model of Single and Three phase Inverters, Classical Averaged Model, Generalized Averaged Model, Small Signal Analysis of DC-DC and DC-AC power converter's.

Unit – III Control of Power Converters **(11)**

General Control Principles of Power Electronic Converters, Linear Control Approaches for DC-DC Power Converters, Linear Control Approaches for DC-AC and AC-DC Power Converters, Energy-Based Control of Power Electronic Converters, Variable-Structure Control of Power Electronic Converters.

Unit – IV Control of Renewable Energy Systems **(12)**

Control of voltage source converters with LCL filters, Control of three-phase converters including Phase Locked Loop, Control of PV systems, Control of Wind Energy Systems.

Case Study: Simulation of grid connected PV system and wind energy system.

17/7/23 17/7 17/7/23

Reference

1. Antoneta Iuliana Bratcu, Iulian Munteanu, and Seddik Bacha "Power Electronic Converters Modeling and Control" Springer Press, 2013.
2. Frede Blaabjerg, "Control of Power Electronic Converters and Systems" Academic Press, 2018.
3. Felix A. Farret, M. Godoy Simões "Modeling Power Electronics and Interfacing Energy Conversion Systems" John Wiley & Sons, 2016.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 To understand basic working principles of different power converters

CO2 To impart knowledge of power converters modeling

CO3 To understand the design and analysis of power converters control

CO4 To provide knowledge of power converters applications in Renewable Energy Systems

17/7 17/7/23

17/7/23

ELECTRICAL ENGINEERINGDEPARTMENT

EEPE411B RELIABLE FAULT TOLERANT SYSTEMS

Pre-requisite: EEPE406E

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

The course enables the students to know the importance, basics, modelling of fault tolerant systems. Reliability data sources, data collection, storage and recovery of data, reliability data analysis have been discussed in this course. Students will be enabled to understand structure function and hence evaluate system reliability of simple and complex systems. The subject discusses design for reliability and safety and safety analysis using fault tree analysis.

Course Contents:

Unit-I **(10)**

Fault tolerance concepts, fault detection techniques: test generation, design of testable circuits, Fault tolerant system modelling. Redundancy techniques: voting schemes, radial logic, use of error -correcting codes, N-version and modular redundancy, SIFT, replicas, alternatives.

Unit-II **(11)**

Reliability data analysis: Reliability function, mean –time to failure, Bathtub curve (PoF interpretation) Hazard models: Linear, polynomial, exponential, normal, lognormal, Weibull. Analysis of failure data, Estimation of failure data: least –square, maximum likelihood.

Unit-III **(10)**

System Reliability modeling using structure function concepts, reliability evaluation technique, safety analysis through fault trees.

Unit-IV **(11)**

Reliability data management: Data collection, storage and recovery of data, Data banks, reliability data sources, design of reliability and safety, Reliability improvement.

Typical case studies of engineering systems.

Reference/Text Books:

17/7/23

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17/7/23

1. M.L. Shooman,"Probabilistic Reliability, An Engineering Approach", McGraw Hill,2002
2. M.L. Shooman, "Reliability of Computer Systems and Networks", John Wiley & Sons, 2002
3. E. Balagurusamy, "Reliability Engineering", Tata McGraw-Hill Education. 1984
4. Shem, Tov-Levi, Ashok K. Agarwal ""Fault Tolerant System Design," McGraw-Hill, 1994
5. Israel Koren and C Mani Krishna, "Fault Tolerant Systems", Morgan Kaufmann Publishers, Elsevier, 2007
6. Friedman & Menon, "Fault detection in digital circuits", Prentice –Hall,1971
7. VN Yarmolik "Fault Diagnosis of Digital Circuits", John Wiley & Sons, 1990

Course Outcomes

On successful completion of the course, students will be able to

CO1 Analyze the static and dynamic fault tolerance and reliability of complex systems.

CO2 Analysis and estimation of failure data using graphical techniques and empirical distribution.

CO3 Formulate fault tree models and evaluation of top event probability of systems.

CO4 Design for reliability, safety of practical system.

17/7/23

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPE411C INTELLIGENT MODELING AND CONTROL

Pre-requisite: MAIC11, MAIC12, EEPC208, EEPC303

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

This course introduces the students with the variety of neural network structures, their mathematical modeling. They will learn how to apply ANN models in identification and control of nonlinear systems. They will understand the tuning procedures for updating ANN parameters and the importance of adaptive learning rate scheme and the stability analysis of the ANN based modeling and control configurations.

Course Contents:

Unit-I **(8)**

Types of ANN: Feed-forward neural network (FFNN) & Recurrent neural network (RNN), Concept of Activation functions, Multi-layered perceptron, Radial Basis Function network, Elman, Jordan, Locally and fully connected recurrent neural networks, Pi-Sigma neural networks and their mathematical modeling.

Unit-II **(10)**

Conversion of the differential equation to difference equation, Representation of nonlinear systems using differential equations. Parallel-Parallel and Series-parallel modeling configurations based on ANN models, Concept of training & testing of ANN models, Error-based performance indicators, need for normalization procedures

Introduction to Backpropagation (BP) method (Gradient-descent based approach), Derivation of weight/parameter tuning equations for FFNN and recurrent neural networks. Online mode and epoch mode training procedures.

Unit-III **(14)**

Concept of the model-reference adaptive control scheme, Adaptive control based on FFNN and RNN models, Development of tuning equations for ANN-based controller using BP method, Simultaneous modeling and control procedures, offline and online training approaches.

19/7

Brief introduction about nature-inspired & evolutionary algorithms and their application in finding the tuning equations for ANN model's parameters. Design of action-critic neural network-based control configuration using the adaptive dynamic programming.

Unit-IV **(10)**

Introduction to the concept of the adaptive learning rate, algebraic methods of developing adaptive learning rate, Introduction to Lyapunov-stability methods, Derivation of stable weight update laws using the Lyapunov-stability methods, derivation of adaptive learning rate scheme using the Lyapunov stability method.

Some case studies involving application of ANN models for solving some real-world problems such as time series prediction, prediction of energy consumption, etc.

References/Textbooks:

1. Haykin, S., Neural networks and learning machines, 3/E. Pearson Education India.2009.
2. Gopal, M., Applied machine learning. McGraw-Hill Education.2019.
3. Jacek M. Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House,2012.
4. Stuart J. Russel & Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, PHI, 2009.
5. Sivanandam, S. N. Deepa, "Introduction to Neural Networks Using Matlab 6.0", TMH,2006.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 Understand various ANN models and their potential in modeling and control

CO2 Understand mathematical modeling of various ANN models and their parameters tuning.

CO3 Understand the modeling and control of nonlinear systems using ANN models

CO4 Understand the stability issues of the ANN-based modeling and control configurations.

CO5 Able to apply ANN models for solving some real-world problems such as time series prediction, prediction of energy consumption, etc.

1/7/17

ELECTRICAL ENGINEERINGDEPARTMENT

EEPE411D METAHEURISTIC OPTIMIZATION TECHNIQUES

Pre-requisite: MAIC11, MAIC12, EEPC207, EEPC303

L	T	P	Credits	Total contact hours
3	0	0	3	42

Course Description:
This course introduces the students with the basic principles of metaheuristic methods such as population and swarm-based techniques. They will also learn how to implement metaheuristic algorithms for solving some real-world problems

Course Contents:

Unit-I **(6)**
Concept of optimization, Limitation of conventional optimization methods such as linear and nonlinear programming and dynamic programming, Concept of metaheuristic optimization, a brief overview of Objective Functions; Constraints, Parameter Tuning; Performance Analysis.

Unit-II **(13)**
Overall structure: Main components of Population-based metaheuristics (exploration and exploitation operators). Some population-based metaheuristics techniques such as Genetic algorithm: Genetic Algorithm (GA) vs Traditional Algorithm, Terminologies in GA, Operation in GA, stopping condition/criteria for GA, Constraints in GA, Problem-solving using GA (maximizing and minimizing of a function). Differential Evolution: Basic Differential Evolution-Difference Vectors, various operations in Differential Evolution (DE), control parameters, Variations to Basic Differential Evolution- Gradient-Based Hybrid Differential Evolution.
Or any other two population-based metaheuristics techniques.

Unit-III **(13)**
Overall structure: Main components of swarm-based metaheuristics such as Particle Swarm Optimization (PSO)–notions for Global Best (gbest), Local Best (lbest), Velocity& position components calculation, Geometric Illustration, stopping conditions, iteration and function evaluation. Artificial Bee Colony (ABC) optimization- Initialization Phase, notions for employed bees' phase-generate new solution, etc., onlooker bees' phase, scout bees' phase.
Or any other two swarm-based metaheuristics techniques.

Unit-IV **(10)**

17/2

Some case studies related to Engineering problem solving using metaheuristics-based optimization algorithms, tuning of ANN, fuzzy model parameters etc.

References/Textbooks:

1. Engelbrecht, A.P., 2007. Computational intelligence: an introduction. John Wiley & Sons.
2. Z. Michalewicz, D. Fogel: How to Solve It. Modern Heuristics. Springer, 1999

Course Outcomes

On successful completion of the course, students will be able to

CO1 Identify the metaheuristic technique appropriate for a specific problem

CO2 Implement and validate a computational model based on metaheuristic algorithms

CO3 Solve a real-world problem using computational intelligence tools.

CO4 Application of metaheuristic algorithms for parameter tuning.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPE411E POWER SYSTEMS RESTRUCTURING

Pre-requisite: EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

The restructuring of power industry has changed the operation and control practices in traditional power systems. Understanding the restructured power systems requires basic knowledge of electrical engineering, power systems, and the economics. This course will provide the students an understanding of the power system operation in the new environment and technical issues.

Course Content

Unit - I Introduction to restructuring of power industry **(10)**

Reasons for restructuring deregulation of power industry, Understanding the restructuring process and unbundled structure - entities involved, the levels of competition, the market place mechanisms, Issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world, US and European market evolution. Fundamentals of Economics: Consumer behavior, Supplier behaviour –Short-run and Long-run costs; Perfectly competitive market, Reforms in Indian power sector: Framework of Indian power sector, Historical Developments, National and Transnational Grids, Reform initiatives during 1990-1995, The Independent Power Plants, Accelerated Power Development and Reforms Program (APDRP), The availability based tariff (ABT) and its mechanism, The Electricity Act 2003, Open Access issues - Operational Practices, Power exchanges in India and their operation, Reforms in near future.

Unit – II Basics of Market Models: **(8)**

Market models based on contractual arrangements – Monopoly model, Single buyer model, Wholesale competition model, Retail competition model; Comparison of various market models; Electricity vis-à-vis other commodities – Distinguishing features of electricity as a commodity, Four pillars of market design – (i) Imbalance, (ii) Scheduling and Dispatch, (iii) Congestion Management, (iv) Ancillary Services; Market architecture - Timeline for various energy markets, Bilateral / forward contracts, the spot market – (i) Discriminatory or non-discriminatory pricing, (ii) Simple bids or complex bids, (iii) Day-ahead and real-time market; Models for trading arrangements – Integrated or centralized model, Decentralized model, Comparison between trading arrangement models, ISO or TSO model.

Unit – III Transmission Pricing and Ancillary Service Management **(12)**

Pricing of transmission network usage: Introduction to transmission pricing, Power wheeling, Principles of transmission pricing, Classification of transmission pricing methods, Rolled-in transmission pricing methods - Postage stamp method, Incremental postage stamp method, Contract path method, MW-Mile method, (i) Distance based, (ii) Power flow based, Power flow tracing method, Z bus cost allocation method. Introduction, Types of ancillary services, Classification, Load generation balancing related services: Frequency regulation, Load following, Spinning reserve services; Voltage control and reactive power support services, Different sources of reactive power, Comparison between different sources of reactive power, Issues in reactive power management, Black start capability service. How to obtain ancillary services? Mandatory provision of ancillary services, Markets for ancillary services.

Unit – IV: Available Transfer capability and Transmission Congestion Management **(12)**

Definition of congestion; Reasons for transfer capability limitation; Importance of congestion management in deregulated environment; Effects of congestion, Desired features of congestion management schemes; Classification of congestion management methods - Basis for classification, Non-market methods, Market methods, Definition of various terms: ATC, TTC, TRM, CBM.Application of software's and programming for simulation.

References/Textbooks:

1. L. L. Lai, Power System Restructuring and Deregulation: Trading Performance and Information Technology, John Wiley and Sons, 2001
2. Daniel Kirschen and Goran Strbac, Fundamentals of Power System economics, John Wiley & Sons Ltd, 2004.
3. Y.H. Song and Xi-Fan Wang, Operation of market oriented power systems, Springer, 2003.
4. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Bollen, Operation of restructured power systems Kluwer Academic Pub., 2001.
5. Sally Hunt, Making competition work in electricity, John Wiley & Sons, Inc., 2002.
6. Shahidehpour, M., and M. Alomoush. "Restructured electrical power systems, Marcel Dekker." New York (2001).
7. Power System Deregulation: Loss Sharing in Bilateral Contracts and Generator Profit Maximization, Ashikur Bhuiya: Publisher VDM Verlag, 2008
8. https://nptel.ac.in/courses/108101005NPTEL–Restructured Power Systems–Prof. S.A.

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Understand the concept of power system restructuring and framework in Indian Power sector

CO 2 Demonstrate the basics of various electricity market models

CO 3 Understand and analyze the technical issues of transfer capability and congestion management in Electricity markets

CO 4 Analyze the role of ancillary services in the Electricity market and transmission pricing methods

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPE411F VIRTUAL INSTRUMENTATION

Pre-requisite: EEPC212

L	T	P	Credits	Total contact hours
3	0	0	3	42

Course description: The students will learn about the basic building blocks of virtual instrumentation. They will learn about the Lab VIEW software on which VI will be implemented. They will also understand how the sensor signals are communicated to computer and further processed by the algorithm build in the Lab VIEW. They will be expected to design various systems for solving Engineering problems.

Course Contents:

Unit-I **(10)**
A brief history of the development of Virtual Instrumentation (VI) systems, Block diagram of VI, the role of hardware & software in VI, VI for Test, Industrial I/O & Control and Design, VI applications in the engineering process (Research and Development, Test and Validation, Manufacturing Test), Difference between the traditional/conventional instrument and the VI: Flexibility and cost cutting, Mode of interaction, Architecture & computational capability. Data-flow Techniques: Graphical & textual programming in the data flow, Comparison with conventional programming.

Unit-II **(14)**
VI Programming Techniques: Front panel &block diagram, controls, indicators & data types, various functions/operations in block-diagram, the concept of sub-VIs, the Icon, and the Connector pane, Repetition and Loops: For & while Loops, Case and sequence structures, structure tunnels, shift & stacked registers, Feedback nodes, Local & global variables Charts, Arrays, Matrix &Clusters and their operations & conversions, Polymorphism, Graphs: waveform graphs & charts, Formula nodes, String and file I/O.

Unit-III **(14)**
Data Acquisition Basics: Analog, discrete and digital signals, resolution, Brief overview of registers and counters, Analog to Digital Converters (R-2R ladder network, weighted resistor method, etc.), Digital to Analog converters (Counter type, tracking type, dual slope, and flash type, SAR, etc.), timing and interrupts, Data Acquisition Systems: sensor module, signal conditioning, Multiplexing, and Sample &hold circuit.

Unit-IV **(6)**

Some case studies and applications of VI related to control systems, power electronics & power systems, Development of PID Controller etc.

References/Textbooks:

1. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, New York, 1997.
2. Lisa K. Wells & Jeffery Travis, LabVIEW for Everyone, Prentice Hall, New Jersey, 1997.
3. Travis, J., LabVIEW for Everyone, Dorling Kingsley (2009).
4. Kevin James, PC interfacing and Data Acquisition: Techniques for Measurement.
5. Gupta, S. and Gupta, J.P., PC Interfacing for Data Acquisition and Process Control, Instrument Society of America (1994) 2nd ed.

Course outcomes

On successful completion of the course, students will be able to

CO1: Students will be familiarized with Virtual Instrumentation.

CO2: Students will be able to do Graphical language programming.

CO3: Students will have knowledge of various functionalities about the LabVIEW software

CO4: Students can build the VI for various applications

Program Elective 6 (Semester VIII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPE412A Drone Technology

Pre-requisite: EEPC208, EEPC212, EEPC303, EEPC302

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:
The course is meant to help students understand and get acquainted with the droning technology currently used and at the same time acquire and develop high-quality skills and competences, including entrepreneurial and digital competencies. The course also provides information on programming, operating, maintaining and using them safely

Course Contents:

Unit-I **(12)**
Introduction to drones and their applications: - Definition of drones, history of drones, India and drones, tinkering and drones.

Structural classification of drones: - fixed wing structure, lighter than air systems, rotary wings aircraft, and applications of drones

Key features of drone regulations:- Notification of final regulations for civil use, operational and procedural requirements, no drone zones, operations through digital platform, enforcement actions, relevant sections of aircraft act-1934

Unit-II **(10)**
Drone mechanics: concepts of engineering mechanics, Free body diagrams types of loads, force analysis in drones, forces and force systems during drone operations, aerodynamics of drones-dynamics of aerial systems, forces of flight, principle axes and rotation of aerial systemsstability and control of drones, force balancing of rotating masses.

Drone flying and operation Flight modes, small drone operations in a controlled environment, Drone controlled Flight operations, management tool ,Sensors, Onboard storage capacity, Removable storage devices

17/7

Unit-III **(10)**

Radio control system: Introduction of radio control system, Controllers, Transmitter and Receiver, Flight Controllers, Electronic Speed Controller, Battery Eliminator Circuit, Universal Battery Eliminator Circuit, OPTO Coupler. Connections and Interfaces of Devices in Drone

Unit-IV **(10)**

Introduction to drone programming: Introduction to programming language used in drone: C and Python. Installation of cards.Auto Pilot software i.e. Ardupilot, Openpilot.

Case studies in the drones' industry

References/Textbooks:

1. Daniel Tal and John Altschuld, Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation, 2021 John Wiley & Sons, Inc.
2. Terry Kilby and Belinda Kilby, Make:Getting Started with Drones ,Maker Media, Inc, 2016
3. John Baichtal, Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs, Que Publishing, 2016
4. Zavrsnik, Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance, Springer, 2018.
5. Robert L. Boylestad / Louis Nashelsky, "Electronic Devices and Circuit Theory", Latest Edition, Pearson Education.

Course outcomes:

On successful completion of the course, students will be able to

CO1 Understand the historical development of unmanned aerial vehicles, guidelines of drone flying in India and structure of unmanned aerial vehicles

CO2 Understand different drone parts and their contribution for successful flight operation and different types of drone circuits /electronic parts

CO3 Understand various communication systems and their up gradation phenomenon.

CO4 Understand the multidisciplinary theory of engineering branches in drone technology viz. mechanical engineering, electrical engineering and electronics engineering

ELECTRICAL ENGINEERING DEPARTMENT

EEPE412B ANALYSIS OF WIND AND SOLAR SYSTEMS

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course:

The course familiarize with the wind and solar energy generation. It throws light on concepts of aerodynamics mapped for wind turbine design. It highlights the bottlenecks in design of PV panels and measures to mitigate them.

Course Content

Unit – I Wind Power Energy and Turbines **(10)**

Historical developments and current status of wind power, Wind characteristics, Wind energy conversion system, Wind Turbines: Technological developments, Aerodynamics of wind turbines.

Unit – II Wind Power Generators and Control **(12)**

Wind power generators, Isolated and grid connected operation, Basic grid integration issues, power quality issues of wind energy, Wind energy economics. Attributes of offshore and onshore wind farms.

Unit – III Solar Energy Conversion Systems **(14)**

Fundamentals of solar PV systems, Solar cell structure and characteristics, Single- crystalline, multi-crystalline, thin film silicon solar cells, Third generation solar cells, electrical characteristics of the solar cell, equivalent circuit, design of solar panels/park, Cutting-edge technologies in solar PV: building-integrated photovoltaic (BIPV), Net -zero buildings (NZB), floating photovoltaic (FPV), photovoltaic noise barriers (PVNBs) etc.

Unit – IV Balance of System (BoS) **(8)**

Inverter: Types of inverter, characteristic for stand-alone and grid-connected inverters, selection of inverter, micro inverters

Battery: Concepts and terms used in battery, types of battery, characteristics of different batteries, Comparison, Different losses in batteries, Maintenance.

17/7

Meters & Chargers: Gross metering, Net energy metering, Solar charge controller, types of charge controllers

Solar power conditioning systems; Maximum power point tracking techniques

Case study on Solar and Wind Power Plant; Design of Hybrid Renewable Energy System using software tools. Applying AI/ML techniques for Solar Irradiance and Wind Speed forecasting.

Text Books

1. T. Ackerman, 'Wind Power in Power Systems', John Wiley & Sons Ltd., 2012.
2. Chetan Singh Solanki, Solar photovoltaics: Fundamentals, Technologies and Applications, 2nd edition, PHI, 2009.

References/Textbooks:

1. Phillip Hurley, Solar II: How to Design, Build and Set Up Photovoltaic Components and Solar Electric Systems, Paperback, 2012.
2. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 3rd edition, 2012.
3. https://archive.nptel.ac.in/courses/103/103/103103206/
4. https://onlinecourses.nptel.ac.in/noc22_ch27/preview

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand and analyze wind energy conversion system and wind turbines.

CO 2 Analyze theoperation of electrical generators for wind energy conversion.

CO 3 Understand the solar energy conversion systems and their applications.

CO 4 Apply various MPPT algorithms and case studies.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPE412C ADVANCED CONTROL TECHNIQUES

Prerequisites Courses: EEPC101, EEPC204, EEPC208, EEPC303,

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

This subject deals with the needs of various complex technical processes that need a highly dynamic and steady-state performance, including the robustness. Advanced controlsystems that include advanced control techniques like MPC, sliding mode control, VSS, jump systems, event based control etc. have been studied to cater to various uncertainties and disturbances of many processes.

Course Contents:

Unit-I **(11)**

Motivation for advanced control techniques, Introduction to Model Predictive Control (MPC), its principle, Control horizon and prediction models, Optimization techniques for MPC, Constraint handling in MPC.

Unit-II **(10)**

Fundamentals of sliding mode control, Sliding mode control design, Sliding mode observers, Chattering phenomenon and its mitigation, Applications of sliding mode control.

Introduction of variable structure systems (VSS), Importance of phase plane analysis in VSS

Unit-III **(11)**

Introduction to continuous and discrete time jump linear systems. Analysis, Control and filtering issues in jump linear systems. Introduction to Event based control and time delay systems.

Unit-IV **(10)**

Applications of Advanced Control Techniques in various sustainable technologies, case studies from the Indian knowledge system.

References/Textbooks:

1. E. F. Camacho and C. Bordons, "Model Predictive Control", Second Edition, Springer Verlag, 2007.
2. C Edwards and S. K. Spurgeon, Sliding Mode Control Theory and Applications, CRC Press, UK, 1998
3. O. L. V. Costa, M. D. Fragoso and R. P. Marques, "Discrete-Time Markov Jump Linear Systems", Springer, 2005.
4. Marek Miskowicz, Event Based Control and Signal Processing, 1st Edition, CRC Press, 2017
5. E. Fridman,"Introduction to Time Delay Systems", Birkhauser, 2014.
6. V.I. Utkin, "Sliding Modes in Control and Optimization", Springer-Verlag1992.

Course Outcomes

On successful completion of the course, students will be able to

CO1: Learn various aspects of advanced control technique viz. MPC and its various aspects.

CO2: Learn SMC and VSS and their applications

CO3: Understand jump linear systems and event-based control techniques

CO4: Practicing various advanced control techniques in developing sustainable technologies utilizing the existing knowledge from the Indian system.

1/7/2

ELECTRICAL ENGINEERING DEPARTMENT

EEPE412D POWER SYSTEM DYNAMICS AND CONTROL

Pre-requisite: EEPC211, EEPC209, EEPC311

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

To understand the Dynamic modeling, stability analysis, and control of multi-machine power systems. Single-machine dynamic modeling, multi-machine dynamic modeling, network differential-algebraic equations and solution methods, small-signal stability analysis, and design of power system stabilizers.

Course Content

Unit - I Introduction **(8)**

Basics of system dynamics –.Concept and importance of power system stability in the operation and design - distinction between transient and dynamic stability - complexity of stability problem in large system – necessity for reduced models - stability of interconnected systems, numerical techniques – introduction to software packages to study the responses

Unit – II Synchronous Machine Modelling **(12)**

Synchronous machine - flux linkage equations - Park's transformation - per unit conversion - normalizing the equations - equivalent circuit - current space model - flux linkage state space model. Sub-transient and transient inductances - time constants. Simplified models (one axis and constant flux linkage) - steady state equations and phasor diagrams.

Unit – III Machine Controllers **(12)**

Exciter and voltage regulators - function and types of excitation systems - typical excitation system configuration - block diagram and state space representation of IEEE type 1 excitation system - saturation function - stabilizing circuit. Function of speed governing systems - block diagram and state space representation of IEEE mechanical hydraulic governor and electrical hydraulic governors for hydro turbines and steam turbines.

Unit – IV **(10)**

Transient Stability State equation for multi machine system with one axis model and simulation – modelling of multi machine power system with one axis machine model including excitation system and speed governing system and simulation using R-K method of fourth order (Gill's technique) for transient stability analysis - power system stabilizer. For all simulations, the algorithm and flow chart have to be discussed.

Dynamic Stability System response to small disturbances - linear model of the unregulated synchronous machine and its modes of oscillation - regulated synchronous machine - distribution of power impact - linearization of the load equation for the one machine problem – simplified linear model - effect of excitation on dynamic stability - approximate system representation - supplementary stabilizing signals - dynamic performance measure - small signal performance measures.

Text Books:

1. P.M. Anderson and A.A.Fouad, 'Power System Control and Stability', Galgotia Publications, New Delhi, 2003.
2. P. Kundur, 'Power System Stability and Control', McGraw Hill Inc., USA, 1994.
3. R.Ramanujam, "Power System Dynamics – Analysis and Simulation", PHI, 2009.

References/Textbooks:

1. M.A.Pai and W.Sauer, 'Power System Dynamics and Stability', Pearson Education Asia, India, 2002
2. James A.Momoh, Mohamed. E. EI-Hawary. " Electric Systems, Dynamics and Stability with Artificial Intelligence applications", Marcel Dekker, USA First Edition, 2000.
3. C.A.Gross, "Power System Analysis," Wiley India, 2011.
4. B.M.Weedy, B.J.Lory, N.Jenkins, J.B.Ekanayake and G.Strbac," Electric Power Systems", Wiley India, 2013.
5. K.Umarao, "Computer Techniques and Models in Power System," I.K. International, 2007.
6. Power System Dynamics : NPTEL (Video) , NPTEL (Video)
7. Power System Stability and Control : NPTEL (Web)

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Understand synchronous machine models, automatic voltage controllers, Turbine models and speed governors

CO 2: Derive single machine and multi-machine power system dynamic models

CO 3: Evaluate and apply numerical solution methods of differential-algebraic equations governing multi-machine power systems

CO 4: Analyze methods of small-signal stability and transient stability of multi-machine power systems.

1/7/2

ELECTRICAL ENGINEERING DEPARTMENT

EEPE412E FLEXIBLE AC TRANSMISSION SYSTEMS

Pre-requisite: EEPC209, EEPC101, EEPC210, EEPC304

L	T	P	Credits	Total contact hours
3	0	0	**3**	**42**

Brief Description
To review the concept of voltage control and reactive power compensation, power flow control, operational aspects of various FACTS compensators and their usage for power flow and stability improvement.

Course Content

Unit – I Power Transmission control **(12)**
Fundamentals of ac power transmission, Transmission problems and needs, Overview of stability, voltage and reactive power control requirements, the emergence of FACTS, Static power convertors, their structures and Review of Power Electronics fundamentals, AC controller based structure, DC link convertor topologies.

Unit – II Shunt Compensation **(9)**
Fundamental of shunt compensation, Principle of operation, Shunt SVC principles, Configuration and control, STATCOM, Configuration applications.

Unit – III Series Compensation **(12)**
Fundamental of series compensation, Principle of operation, Application of TCSC for different problems of power system, TCSC lay out, SSSC principle of operation.
Phase Shifter: Principle of operation, Steady state model of static phase shifter, Operating characteristics of SPS, Power current configuration of SPS application.

Unit – IV Unified Power Flow Controllers **(9)**
Basic operating principles and characteristics, Control, UPFC installation applications, UPFC model for power flow studies.

References/Textbooks:

1. Hingorani, N.G. and Gyugi,L., Understanding FACTS :Concepts and Technology of Flexible AC Transmission System, Standard Publishers and Distributors (2005).

2. Sang, Y.H. and John, A.T., Flexible AC Transmission Systems, IEEE Press (2006).
3. Ghosh,A. and Ledwich,G., Power Quality Enhancement Using Custom Power Devices, Kluwer Academic Publishers (2005),
4. Padiyar, Krishna R. "FACTS controllers in power transmission and distribution." (2020).
5. Mathur, R.M. and Verma, R.K., Thyristor Based FACTS Controllers for Electrical Transmission.
6. V. K. Sood, HVDC and FACTS Controllers: Applications of Power Converters to Power Systems, Kluwer Power Electronics and Power Systems Series
7. HVDC Transmission: https://nptel.ac.in/courses/108/104/108104013/
8. FACTS: https://nptel.ac.in/courses/108/107/108107114/

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Understand reactive power control requirements and need of FACTS in power systems applications of the converters.

CO 2: Classify various compensators and analyses power system behavior with them.

CO 3: Appraise series compensated power system with different series compensators.

CO 4: Analyze system operation with hybrid shunt-series compensators

ELECTRICAL ENGINEERING DEPARTMENT

EEPE412F MULTI-AGENT SYSTEMS: CONSENSUS & CONTROL

Pre-requisite: EEPC208, EEPC303

L	T	P	Credits	Total contact hours
3	0	0	3	42

About the course:
The course aims to introduce agent based architectures for system engineering tasks under constrained environments. Learner will conceptualize common related tasks in terms of multi agent architectures. Further, arriving at a consensus in resource crunched agents will be explored. The course aims to introduce control under communication case – simple as well as advanced control, with applications to engineering systems.

Course Contents:

Unit-I **(10)**
Introduction to multi agent systems, mathematical models of agent dynamics, basics of cooperative control and consensus issues, fundamentals of graph theory, graph based models of distributed control systems.

Unit-I **(11)**
Optimization issues and consensus problems in multi agent systems. cooperative control, leader-follower architecture, formation Control in multi agent systems, position, displacement and distance based formation control,

Unit-I **(10)**
Control under communication constraints, introduction to modeling of communication channels, modeling of network delays, stability assessment under network delays.

Unit-I **(11)**
Advanced control issues in linear multi-agent systems, event triggered control of multi agent systems, applications to coordinated control of networked power systems.

Case Studies & Simulations

References/Textbooks:

1. Magdi H. Mahmoud, "Multiagent Systems: Introduction and Coordination Control", CRC Press, 2020.
2. Zhongkui Li and Zhisheng Duan, "Cooperative Control of Multi-agent Systems: A Consensus Region Approach", CRC Press, 2015.
3. Cheng-Lin Liu and Fei Liu, "Consensus Problem of Delayed Linear Multi-agent Systems: Analysis and Design", Springer Verlag, 2017.
4. Frank L. Lewis, Hongwei Zhang, K Movric and Abhijit Das, "Cooperative Controlof Multi-Agent Systems Optimal and Adaptive Design Approaches", Springer-Verlag, 2014.

COURSE OUTCOMES:

On successful completion of the course, students will be able to

CO 1 Understand and apply the background mathematical theory of matrices and graph theory to describe multi agent systems.

CO 2 Recognize the need for distributed systems in place of centralized systems, and distributed computational intelligence.

CO 3 Formulate the consensus problems and their solution with application to simple problems

CO 4 Apply output and observer based consensus protocols on multi agent systems as well as extend robust control results to such systems with applications.

12/7

ELECTRICAL ENGINEERING DEPARTMENT

ECPC412G INDUSTRIAL DRIVES

Pre-requisite: EEPC201, EEPC210, EEPC211, EEPC304, EEPC401, EEPE310C

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description: To explore the various DC, AC machine drives for industrial applications. To study the various open loop and closed loop control schemes for drives and also introduce the hardware implementation of the basic controllers using real-time simulators

Course Content

Unit – I **(11)**

Control Techniques for Electrical Drives: Rating and heating of motors, basic features of an electric drive, block diagram representation of drive, systems signal flow graph representation of the systems, transfer functions, transient response of closed loop drive systems, frequency response approach, stability of controlled drives compensation and the use of controllers to improve the performance.

Unit – II **(10)**

Drives for Specific Applications: Drive considerations for textile mills, steel rolling mills, cranes and hoist drives, cement mills, sugar mills, machine tools, paper mills, coal mines, centrifugal pumps, turbo compressors summary of thyristorised ac and dc drives.

Unit – III **(11)**

Microprocessors and Control of Electrical Drives: Introduction, dedicated hardware systems versus microprocessor control, application areas and functions of microprocessors in drive technology, control of electric drives using microprocessors, some aspects of control system design of microprocessor based variable speed drives and stepper motors

Unit – IV **(10)**

Sensor less Drives: Permanent magnet synchronous motor - field oriented control direct torque control – sensor-less control, Brushless direct current (BLDC) machine control strategies, and voltage source inverter fed BLDC-torque ripple minimization application.

References/Textbooks:

1. Dubey G. K., "Fundamentals of Electric Drives", 2nd Ed., Narosa 2007, Publishing House.
2. VedamSubramanyam, "Electric Drives – Concepts and Applications", Tata McGraw Hill, 2011.
4. Dubey G. K., "Power Semiconductor Controlled Drives", Prentice Hall International Edition.1989
5. R. Krishnan, „Permanent Magnet Synchronous and Brushless DC Motor Drives", Taylor and Francis, 2010
6. Bose B. K., "Power Electronics and Variable Frequency Drives", IEEE Press, Standard Publisher Distributors 2001.

Course Outcomes

On successful completion of the course, students will be able to

CO1 Able to describe basic components of the drive system from automation perspective various industrial drive systems.

CO2 To apply knowledge of specific application of drive systems.

CO3 Learn advanced real time controllers methods of basic motor drive systems

CO4 To Understanding sensor less control based motor drives

17/7

Open Electives (Semester V)

ELECTRICAL ENGINEERING DEPARTMENT

EEOE301 ELECTRICAL CIRCUITS

Pre-requisite: MAIC11, MAIC12

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

This course is intended to develop skills in diagnosing and resolving electrical circuit and network problems. Throughout the course, students will learn various techniques and methodologies for analyzing electrical circuits and networks. Understanding the principles of circuit analysis lays the foundation for understanding the courses of higher-level.

Unit-I **(10)**

Fundamental concepts of R, L, C element classification of DC and AC circuits. Sources and Signals, Mesh circuit and node voltage method of analysis of DC and AC circuits. Source transformation, analysis of circuits with dependent sources.

Unit-II **(10)**

Network Theorems and their applications - Superposition, Reciprocity, Thevenin's, Norton, Maximum power transfer, Substitution, Compensation, Tellegen's theorem.

Network Topology, Graph matrices, formulation and solution of circuit equations based on graph theory.

Unit-III **(10)**

Analysis of electric circuits using Laplace transform for Standard test signals, transformed network with initial conditions.

Transient analysis of RL and RC circuits under DC excitation and behavior of circuit elements under switching actions ().

Unit-IV **(12)**

Series, Parallel resonance circuits, Analysis of three phase circuits, Power measurement in three phase circuit.

1/3/2

Two port network, Relationship between parameter set and Interconnection of two port network. Open circuit impedance, short circuit admittance & transmission parameters and their evaluation for simple networks.

Case study and simulation.

References/Textbooks:

1. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, “Engineering Circuits Analysis”, McGraw Hill publishers, 9th edition, New Delhi, 2020.
2. Charles K. Alexander, Mathew N.O. Sadiku, ”Fundamentals of Electric Circuits”' Second Edition, McGraw Hill, 2019.
3. Allan H. Robbins, Wilhelm C. Miller, ”Circuit Analysis Theory and Practice”' Cengage Learning India, 2013.
4. ChakrabartiA,”Circuits Theory (Analysis and synthesis)”, Dhanpat Rai & Sons, New Delhi, 2020.
5. Joseph A. Edminister, Mahmood Nahvi, ”Electric circuits”, Schaum’s series, McGraw-Hill, First Edition, 2019.
6. Desoer&Kuh, ”Basic Circuit theory”, McGraw Hill.
7. M E Valkenburg, ”Network Analysis”, Prentice-Hall of India Pvt Ltd, New Delhi, 2015.
8. Trick, “Introduction to circuit Analysis”, Wiley.
9. Roy Choudhary, “Network & systems”' Wiley.
10. Richard C. Dorf and James A. Svoboda, “Introduction to Electric Circuits”, 7th Edition, John Wiley & Sons, Inc. 2018.
11. Sudhakar A and Shyam Mohan SP, “Circuits and Networks Analysis and Synthesis”' McGraw Hill, 2015.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1. To understand the basic concepts, basic laws & methods for analysis of D.C & A.C networks and reduce the complexity of network using source transformation.

CO 2. To impart knowledge on solving complex electric circuits using network theorems and network topology.

CO 3. To educate on obtaining the transient response of circuits and understanding transformed network.

CO 4. To introduce phasor diagram and analysis of single and three phase electrical circuits along with the understanding of resonance and also evaluate the performance of two port network

ELECTRICAL ENGINEERING DEPARTMENT

EEOE302 ELECTRICAL MACHINES

Pre-requisite: EEPC101

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description: This course helps to understand different types of electrical machines, their basic operations and steady state analysis. Focus on the study of electro mechanical energy conversion & different parts of electrical machine, address the underlying concepts & methods behind electrical machines and their applications.

Course Content

Unit - I Introduction to Transformer: (10)

Basics of Magnetic Circuits, history, operation of ideal transformer, Dot convention, Phasor diagram, equivalent circuit of ideal transformer, Analysis of practical transformer, Losses, voltage regulation and efficiency of practical transformer, various tests and their uses for practical transformer.

Unit – II DC Machines: (10)

Introduction to DC machine, Single conductor DC machine basic operation, Construction features, Types of DC generator, Characteristics, armature reaction, losses and power flow, Types of DC motors, Characteristics and control of DC motors, losses and efficiency calculations, Brief of Armature windings.

Unit – III Induction Machines: (12)

Introduction to rotating magnetic fields, Synchronous speed and induced voltage in a coil, introduction to 3-phase induction motor, equivalent circuit and phasor diagram, air-gap power, torque expression, torque-slip characteristics, starting methods and speed control of IM, Basic operation and equivalent circuit of 1-phase IM, types of 1-phase IM.

Unit – IV Synchronous Machines: (10)

Synchronous machine construction, Introduction of synchronous generator, basic operation, OC and SC characteristics, voltage regulation methods, analysis of cylindrical and salient pole synchronous machines, phasor diagrams, expressions for load angle and power.

References/Textbooks:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2 P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
3. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
4. Stephen J. Chapman , "Electric Machinery Fundamentals," 5th Edition, McGraw Hill.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1 Understand the working of different types of transformers and rotating machines.

CO 2 Analyze the equivalent circuit of electrical machines andevaluate their performances.

CO 3 Evaluate the suitability of electrical machinesin different applications.

CO 4 Illustrate the characteristics&various tests to be performed to evaluate their performances.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE303 CONTROL SYSTEM ENGINEERING

Pre-requisite: EEPC101, EEPC204, EEPC205, EEPC206

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description: This course aims to provide fundamental concepts of control system problems and their solution possibilities, mathematical modeling of the various physical systems, analysis of the systems in time and frequency domain, stability analysis, controller and compensator design specifications.

Unit-I: **(12)**

Basics of control system: Control systems elements, concept of open-loop and closed-loop systems with applications.

Mathematical modeling: Electrical systems, mechanical systems, electro-mechanical systems, pneumatic and thermal systems, electrical analogues of dynamical systems, model simplification using block diagram reduction and signal flow methods, sensitivity analysis.

Control system components: concept of AC & DC servomotor, synchro, stepper motor and tachometer, etc.

Unit-II: **(10)**

Time domain analysis: Transient response analysis, first order systems, initial condition response, time response specifications of second order system for typical test signals, Response of higher order systems: steady state error and error constants, dynamic error constants. Routh-Hurwitz Stability Criterion, System analysis using Root-locus techniques.

Unit-III: **(10)**

Frequency Domain Analysis: Sinusoidal transfer functions, Frequency response specifications, Polar plot, Nyquist plot, and Bode plot for stability analysis, Concept of gain margin & phase margin, relative stability.

Unit-IV: **(10)**

Conventional Controller: Basic idea of feedback control systems, Concept of PID controller, Effect of P, PI, PD and PID controllers on system.

Case Studies and Numerical Simulations in MATLAB/SCILAB/LABVIEW, etc.

References/Textbooks:

1. Richard C. Dorf, Robert H. Bishop, "Modern Control Systems", Pearson, 13th Edition, 2016.
2. Kuo B.C., Automatic Control Systems, Prentice-Hall of India Pvt. Ltd., New Delhi, 6th Edition, 1991.
3. Ogata K., Modern Control Engineering, Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition, 2000.
4. M. Gopla, "Control System Principles and Design", McGraw Hill, 4th Edition, 2012.
5. William J. Palm III, Control Systems Engineering, John Wiley & Sons Inc., 1986
6. Joseph J. Distefano III, Allen R. Stubberud, Ivan J. Williams, "Control Systems", 3rd Edition, McGraw Hill, Special Indian Edition, 2010. (Schaums Outlines Series)
7. J. Nagrath & M. Gopal, "Control System Engineering", 6th Ed. New Age International Publishers, 4th Edition 2018.
8. Norman S. Nise, "Control Systems Engineering", 5th Ed., Wiley, 2009.

Course Outcomes:

On successful completion of the course, students will be able to

CO1: Fundamental knowledge of control system, mathematical modelling of various physical systems

CO2: Determine the response of systems for various inputs, and transient and steady-state analysis of open-loop and closed-loop systems

CO3: Analyze the stability of the linear systems in time-domain and frequency-domain

CO4: Design and implementation of PID controller and various compensators

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE304 ANALOG & DIGITAL ELECTRONICS

Pre-requisite: EEPC101

L	T	P	Credits	Total contact hours
3	0	0	3	**42**

Brief Description about the course: The objectives are to acquire the basic knowledge of analog and digital logic levels and application ofknowledge to understand analog and digital electronics circuits.Alsoto prepare students to perform the analysis and design of various analog and digital electronic circuits.

Course Content

Unit -I **(10)**

BJT BIASING: DC Biasing Voltage divider bias Self bias emitter bias, AC Biasing, R_E model, Amplifiers: Class A, Class B, Class C& Class D, Push Pull amplifier.

UNIT-II **(12)**

OP-AMP: OP-AMP characteristics, Non-Inverting/Inverting Amplifier. Linear and Non-Linear OP-AMP circuits, Regulated power supplies.Oscillators- Barkhausen criteria of oscillations, Wein-bridge, RC oscillator.

UNIT-III **(10)**

Number System, Logic gates, K-map reduction techniques, Introduction combinational circuits, Design of half adder and full adder, Introduction to sequential circuit, Flip-flop (RS JK D &T)

UNIT-IV **(10)**

555 timer: its monostable and astable operation, Schmitt triggers, Sample and hold circuits, A/D and D/A converters, Low pass filter, High pass filter, Counter & Register. Case study of simulation circuits.

References/Textbooks:

1. Millman and Halkias, "Integrated Electronics", Mc Graw Hill. 2nd Editio,2017.
2. R. Boylested and L. Nashelsky, "Electronics Devices and Circuits", Prentice Hall India.10th Edition 2009.
3. Millman and Halkias, "Electronics Devices and Circuits", TMH 4th Edition 2015.
4. Malcolm Goodge, "Analog Electronics Analysis and Synthesis", TMH Edition.

5. Malvino, "Electronics Principles", TMH 7th Edition 2017
6. AP Malvino and DP Leach, 'Digital Principles and applications' TMH, 8th Edition, 2014
7. Charles Roth, 'Fundamentals of Logic Design'.Wadsworth Publishing, 5th Edition, 2005.

Course Outcomes

On successful completion of the course, students will be able to

CO1: Have a thorough understanding of the fundamental concepts and techniques used inanalog and digital electronics.

CO2: To understand and examine the structure of various number systems and itsapplication in digital design.

CO3 The ability to understand, analyze and design various combinational and sequentialcircuits.

CO4: To develop skill to build, and troubleshoot analog and digital circuits.

12/7

Open Electives (Semester VI)

ELECTRICAL ENGINEERING DEPARTMENT

EEOE305 POWER ELECTRONIC SYSTEMS

Pre-requisite: EEPC101, EEPC202

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course:

Unit I **(10)**

Modern Power Electronics Devices:

Principle of operation of SCR, dynamic characteristic of SCR during turn ON and turn OFF, Two transistor analogy, Protection of SCR, Snubber circuit, Commutation circuits, SCR ratings, Triggering Methods, Series and Parallel operation of SCR. Principle of operation of, IGBT, GTO, DAIC, TRAIC, their operating characteristics

Unit II **(12)**

A.C. to D.C. Converter:

Single-phase Converter: Half-wave converter, 2-pulse midpoint converter, half-controlled and fully-controlled bridge converters, input current and output voltage waveforms, effect of load and source impedance, expressions for input power factor, displacement factor, harmonic factor and output voltage, effect of free-wheeling diode, triggering circuits, Dual converter.

Three-phase Converter: Half wave, full wave, half controlled and fully controlled bridge converters, effect of load and source impedance, expressions for input power factor, displacement factor, harmonic factor and output voltage

Unit III **(10)**

D.C. to D.C. Converter: Classification of choppers. Principle of operation, steady state analysis of class A chopper, step up chopper, switching mode regulators: Buck, Boost, Buck-Boost.

A.C. to A.C. Converter: Principle of operation of single-phase ac regulator, effect of load inductance, firing pulse requirement. Principle of operation of cyclo-converter, waveforms, control technique

Unit IV **(10)**

Applications of Power Converters to Renewable Energy Systems

Introduction toMulti-level converters, topologies and control techniques, PWM techniques. DC-DC converter, Interleaved buck/boost converter, advanced modulation techniques. Multi-channel interleaved boost converters, voltage source converters, control of grid-tied converters.

References/Textbooks:

1. M. Ramamoorthy. Thyristor and their applications, East West Publication, 1991.
2. PS Bhimbra.Power Electronics, Khanna Publishers, 2015.
3. MD Singh and KB Khanchandani, Power Electronics, TMH Edition, 2007.
4. G.K. Dubey, S. R. Doradla, A. Joshi, and R. M. K. Sinha, “Thyristorised Power Controllers”, New Age International Private Ltd.
5. Mohan N., Undeland T. M. and Robbins W. P., “Power Electronics Converters, Applications and Design”, 3rd ED, Wiley India.
6. V. Yaramasu and B.Wu, "Model Predictive Control of Wind Energy Conversion Systems," Wiley- IEEE Press, 2016.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 Understand fundamental concepts in power electronics.

CO2 To analyze power converter circuits and power electronics-based design and application

CO3 To troubleshoot power electronics circuits, adaptability to analyze power converter-based renewable energy systems

CO4 To troubleshoot gird compatibility issues with power electronics circuits

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE306 ELEMENTS OF POWER SYSTEMS ENGINEERING

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

To understand the basic concepts of power generation, economics of generation, the concept of transmission and distribution systems, layouts of substation and lines, insulators, and basics' of technologies related to distributed energy resources

Course Content

Unit - I Introduction **(10)**

Typical Layout of an Electrical Power System Present Power Scenario in India. Generation of Electric Power (Qualitative): Conventional Sources: Hydro station, Steam Power Plant, Nuclear Power Plant and Gas Turbine Plant. Renewable energy Sources: Wind Energy, Fuel Cells, and Solar Energy, Tidal.

Unit – II Economics of Generation **(10)**

Introduction, definitions of connected load, maximum demand, demand factor, load factor, diversity factor, Load duration curve, number and size of generator units. Base load and peak load plants. Cost of electrical energy-fixed cost, running cost, Tariff structure to customer.

Unit – III AC Transmission and Distribution **(12)**

Introduction, single line diagram of a typical power system, AC distribution, Single phase, 3-phase, 3 phase 4 wire system, bus bar arrangement, Selection of site and layout of substation, Overhead Line Insulators: Introduction, types of insulators, Potential distribution over a string of suspension insulators, Methods of equalizing the potential, testing of insulators. Insulated Cables: Introduction, insulation, insulating materials, high voltage cables, grading of cables, insulation resistance of a cable, Capacitance of a single core and three core cables, Overhead lines versus underground cables, types of cables.

Unit – IV Renewable Energy Systems **(10)**

Sustainability of renewable energy sources in Power System: environmental sustainability, economic sustainability, social sustainability, technology Drivers (Qualitative): basics of

Technologies associated with Distributed energy Resources (e.g. Fuel cells, Microturbines, Solar PV)

References/Textbooks:

1. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New-Age International, Second Edition, 2009.
2. C.L. Wadhwa, Electrical Power Systems, New-Age International, Fifth Edition, 2009.
3. W.D. Stevenson, Elements of Power System Analysis, McGraw Hill, Fourth Edition, 1984
4. B. R. Gupta, Generation of Electrical Energy, 7th Edition, S. Chand Publishing, 2017.
5. B. R. Gupta, Power System Analysis And Design, A H Wheeler Publishing Company Limited, 1998.
6. Sustainable Power Systems, Nava Raj Karki, Rajesh Karki, Ajit Kumar Verma, Jaeseok Choi, Springer Singapore, 2017.
7. Modeling and Control of Sustainable Power Systems, Lingfeng Wang, Springer-Verlag Berlin Heidelberg, 2012.
8. Elements of Electrical Power Station Design, M.V.Deshpande, Wheeler Pub., Third Edition, 1998.
9. https://www.coursera.org/learn/electric-power-systems
10. https://onlinecourses.nptel.ac.in/noc19_ee62/preview

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Understand the operation of conventional generating stations and renewable sources of electrical power.

CO 2 Analyze the power economics and power tariff methods.

CO 3 Analyze the AC transmission and distribution systems, insulators and cables

CO 4 Understand renewable energy sustainability and technology drivers.

12/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE307 RENEWABLE POWER GENERATION SYSTEMS

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

The course introduces to various sources of power generation from renewable energy sources.

Unit – I Solar and Wind Power Generation **(10)**

Introduction to Photovoltaic effect, characteristics of photovoltaic cells, conversion efficiency, and applications.

Introduction to characteristics of suitable wind power sites, wind turbines, wind generators, advantages and limitations.

Unit – II Fuel Cell and Hydro Power Generation **(10)**

Fuel Cell: Principle of fuel cells, thermodynamic analysis of fuel cells, types of fuel cells, applications of fuel cells.

Hydro power generation: Essential features of water power plant, classification of hydro-plant, hydraulic turbine, surge tanks, governing of hydraulic turbine, selection of water turbine.

Unit - III Geothermal and Ocean Energy **(10)**

Geothermal: Potential sites, estimations of geothermal power, nature of geothermal sites, Advantages and disadvantages of geothermal energy .

Ocean Energy: Principle of ocean thermal energy conversion (OTEC), Tidal power generation, Tidal energy potential and technologies, Energy from waves, Wave energy conversion, Wave energy technologies, advantages and limitations.

Unit – IV Biomass based Energy Generation **(10)**

Biomass: Energy from biomass, sources of biomass, different species, conversion of biomass into fuels, Energy through fermentation, Pyrolysis, gasification and combustion Biogas plants, Properties and characteristics of biogas.

Case study on different Renewable Power Plants. Design of integrated renewable energy systems using software tools.

References/Textbooks:

17/12

1. D.P. Kothari, K.C. Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", 2nd Edition, PHI.
2. Gupta, B. R. Generation of electrical energy. S. Chand Publishing, 2017.
3. Robest L Loftness, "Energy hand book", 1st Edition, Van Nostrand Reinhold Co.
4. Mehmet Kanoglu, Yunus A. Cengel, John M. Cilbala, "Fundamentals and applications of Renewable Energy", McGraw Hill., 2020.
5. https://nptel.ac.in/courses/108/102/108102145/
6. https://nptel.ac.in/courses/103/103/103103206/

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand working principle of different Renewable energy generation.

CO 2 Describe different types of wind and hydro turbines

CO 3 Analyze different types of Fuel cell, Geo-Thermal and Biomass energy.

CO 4 Evaluate hybrid system with renewable energy sources.

1/7/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE308 Fuzzy Systems and Applications

Pre-requisite: MAIC11, MAIC12, EEPC207

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

The Fuzzy Systems & Applications course gives a solid grounding of fundamental concepts of fuzzy logic and its applications. This course is aspiring to be a part of computational intelligence directly or indirectly in near future should get these concepts and deals with the fuzzy systems theory, the multiple values in fuzzy logic system deals with, are described in the course. This course also provides case studies of certain fuzzy logic usage in real-life.

Course Contents:

Unit-I **(10)**

Introduction to Fuzzy Sets, Logic and Systems & Applications, Classical Set Theory, Fuzzy sets versus crisp sets, Fuzzy set theory: Representation of fuzzy set, Operations on Fuzzy Sets-complements, union and intersection, Properties of Fuzzy Sets.

Unit-II **(12)**

Membership Functions: Mathematical Notation, Features of Membership Functions, Linguistic variables, linguistic hedges, Fuzzy relations and fuzzy quantities, fuzzy intervals, fuzzy numbers, Fuzzy Arithmetic, extension principle, Fuzzy reasoning, fuzzy implications, generalized modus ponens, Fuzzy If-Then Rule Base, Inference Engine, Fuzzy inference system, Mamdani fuzzy models, Defuzzification, Takagi-Sugeno fuzzy models, Tsukamoto fuzzy models.

Fuzzification, fuzzy arithmetic, numbers, extension principle – fuzzy inference system-Defuzzification –fuzzy rule based systems –fuzzy nonlinear simulation –fuzzy decision making–fuzzy optimization

Unit-III **(10)**

Fuzzy logic controllers, principles, review of control systems theory, various industrial applications of FLC adaptive fuzzy systems, fuzzy decision making, Multi objective decision making, fuzzy classification, means clustering, fuzzy pattern recognition, image processing applications, and fuzzy optimization.

Unit-IV **(10)**

MatLab simulations using the fuzzy toolbox, case studies and applications, intelligent control of complex systems.

Case Studies

References/Textbooks:

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, John Wiley and sons, 2010.
2. J.-S.R.Jang, C.-T.Sun, E.mizutani, Neuro Fuzzy & Soft Computing, Pearson Education
3. S. Rajsekharan, Vijayalaxmi Pai, "Neural Networks, Fuzzy logic and Genetic Algorithms, Synthesis and applications", Prentice Hall.
4. Klir.G, Yuan B.B. "Fuzzy sets and Fuzzy Logic Prentice Hall of India private limited, 1997.

Course Outcomes:

On successful completion of the course, students will be able to

CO 1. Understand the basic ideas of fuzzy sets and crisp sets, operations and properties of fuzzy sets, membership functions and also about fuzzy relations & reasoning. Develop the skill in basic understanding on fuzzy set theory and systems.

CO 2. Explore the knowledge of fuzzy inference systems & classification of fuzzy inference systems and defuzzification process.

CO 3. Able to combine the information of decision theory &fuzzy set theory to solve problems that include uncertainty.

CO 4. Develop and implementation of a fuzzy logic controller for various systems.

17/7

Open Electives (Semester VII)

ELECTRICAL ENGINEERING DEPARTMENT

EEOE401 INTRODUCTION TO MICROCONTROLLERS

Pre-requisite: EEPC202

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:

Objective is to study the Architecture of PIC microcontroller, the addressing modes & instruction set,the need & use of Interrupt structure, develop skill in program writing and applications, understand peripheral / interfacing ICs

Course Content

UNIT-I **(12)**

Microcontroller Architecture:

PIC microcontroller architecture, timing and control unit, machine cycles, interrupt diagram.

Programming:

Addressing modes, instruction set, assembly language programming, program for multibyte addition/subtraction, multiplication, division, block transfer etc.

UNIT-II **(10)**

Interfacing:

Basic principles of interfacing I /O devices with microcontroller. Data transfer techniques – programmed interrupt and DMA. Interfacing of D/A and A/D converter.

UNIT-III **(10)**

Microcontroller:

PIC timer control.Watch dog timer and its use.

UNIT-IV **(10)**

Semi-Conductor Memory:

Read only memories, random access memories. EEPROM memory access and programming

17/12

References/Textbooks:

1. Data sheet of PIC microcontroller from Micro Chip

Course Outcome

On successful completion of the course, students will be able to

CO1: Develop basic understanding of microcontroller architecture.

CO2: The students will be able to design and implement programs on PIC microcontroller

CO3: Understand concept of interfacing of peripheral devices with microcontroller.

CO4: To design memory interfacing circuits with microprocessor and microcontrollers.

ELECTRICAL ENGINEERING DEPARTMENT

EEOE402 ELECTRICAL VEHICLE TECHNOLOGY

Pre-requisite: EEPC101, EEPC201, EEPC210

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: This course contains, introduction to Electrical Vehicles, EV Subsystems. Illustrate the various electric drive configurations and their architectures suitable for electric vehicles and Vehicle Dynamics. Various types of electric machines used in electric vehicles and variousenergy management strategies employed in electric vehicles.

Course Content

Unit – I **(7)**

Introduction to EV: Importance and need for electric vehicles (EV), history and evolution of automobile systems, technology and grid infrastructure side barriers in EV adoption, socio-economic barriers.Classification of EVs, types of hybrids and their operating modes, hybridization ratio.BEVs and their key components, FCEVs and their key components, solar EV, EV versus ICE, emissions due to the electrical grid.

Unit – II **(10)**

Vehicle Dynamics: Vehicle dynamics, vehicle load forces, aerodynamic drag, rolling resistance, climbing resistance.Estimation of BEV range and effect of auxiliary loads on range, downgrade force and regeneration, rated speed.Gradeability, vehicle acceleration, traction motor characteristics, simple drive cycle for vehicle comparisons.Downgrade force and regeneration, simple drive cycle.

Unit - III **(12)**

Power Electronic Converters and Electrical Machines in EV: Power electronics circuits used for control and distribution of electric power in DC-DC, AC-DC, DC-AC converters used for EV. Fundamental of Drives and Control of EV with DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Design and Sizing of Traction Motors.

Unit – IV **(13)**

Energy Storage Devices and Management in EV: Overview of battery chemistries, EV battery and its required characteristics, cell, modules & pack. Battery terminologies: C-Rate, SOC, DOD, rated voltage, specific energy, specific power, cycle life, self-discharge. BOL, EOL. Charging characteristics of typical Lithium ion battery used in EVs. Hydrogen fuel cell based energy storage for EV, balance of plant (BOP), fuel cell polarization curve and power curve, fuel cell and plant efficiencies, sizing the fuel cell plant. Super-capacitor based energy storage and it's importance in BEV. EV charging: EV charging modes, DC fast charger - Operation, types, limitations. SAE J1772 connector, AC Level 1, 2 & 3 charging, Bharat AC-01 charger. EV charging standards: DC fast charging - CHAdeMO, CCS-combo 1, CCS-combo 2, GB/T, Bharat DC-02, GB/T charger, supercharger.

References/Textbooks:

1. John G. Hayes and G. AbasGoodarzi, "Electric Powertrain- Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles" John Wiley & Sons Ltd, 2018
2. Iqbal Husain, Electric and Hybrid Vehicles – Design Fundamentals, 2 ed., CRC Press, 2016.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, 2 ed., Wiley, 2012.
4. MehrdadEhsani, YiminGao, Sebastien E. Gay, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles – Fundamentals, Theory, and Design, CRC Press, 2005.

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Interpret the importance of electric vehicles, barriers in their adoption, and their Impact on power system.

CO 2: Illustrate the various electric drive configurations and their architectures suitable for electric vehicles and Vehicle Dynamics

CO 3: Discuss the various types of electric machines used in electric vehicles and various energy management strategies employed in electric vehicles

CO 4: Describe the different energy storage devices, battery charging-discharging Characteristics, and various AC and DC charging standards.

ELECTRICAL ENGINEERING DEPARTMENT

EEOE403 Virtual Instrumentation

Pre-requisite: EEPC212

L	T	P	Credits	Total contact hours
3	0	0	3	42

Course description:

The students will learn about the basic building blocks of virtual instrumentation. They will learn about the Lab VIEW software on which VI will be implemented. They will also understand how the sensor signals are communicated to computer and further processed by the algorithm build in the Lab VIEW. They will be expected to design various systems for solving Engineering problems.

Course Content

Unit-I **(8)**

A brief history of the development of Virtual Instrumentation (VI) systems, Block diagram of VI, the role of hardware & software in VI, VI for Test, Industrial I/O & Control and Design, VI applications in the engineering process (Research and Development, Test and Validation, Manufacturing Test), Difference between the traditional/conventional instrument and the VI: Flexibility and cost cutting, Mode of interaction, Architecture & computational capability. Data-flow Techniques: Graphical & textual programming in the data flow, Comparison with conventional programming.

Unit-I **(14)**

VI Programming Techniques: Front panel &block diagram, controls, indicators & data types, various functions/operations in block-diagram, the concept of sub-VIs, the Icon, and the Connector pane, Repetition and Loops: For & while Loops, Case and sequence structures, structure tunnels, shift & stacked registers, Feedback nodes, Local & global variables Charts, Arrays, Matrix &Clusters and their operations & conversions, Polymorphism, Graphs: waveform graphs & charts, Formula nodes, String and file I/O.

Unit-III **(14)**

Data Acquisition Basics: Analog, discrete and digital signals, resolution, Brief overview of registers and counters, Analog to Digital Converters (R-2R ladder network, weighted resistor method, etc.), Digital to Analog converters (Counter type, tracking type, dual slope, and flash type, SAR, etc.), timing and interrupts, Data Acquisition Systems: sensor module, signal conditioning, Multiplexing, and Sample &hold circuit.

Unit-IV **(6)**

Some case studies and applications of VI related to Engineering domain, Development of Control System, PID Controller etc.

References/Textbooks:

6. Gary Johnson, LabVIEW Graphical Programming, Second edition, McGraw Hill, New York, 1997.
7. Lisa K. Wells & Jeffery Travis, LabVIEW for Everyone, Prentice Hall, New Jersey, 1997.
8. Travis, J., LabVIEW for Everyone, Dorling Kingsley (2009).
9. Kevin James, PC interfacing and Data Acquisition: Techniques for Measurement.
10. Gupta, S. and Gupta, J.P., PC Interfacing for Data Acquisition and Process Control, Instrument Society of America (1994) 2nd ed.

Course outcomes

On successful completion of the course, students will be able to

CO1 Students will be familiarized with Virtual Instrumentation.

CO2 Students will be able to do Graphical language programming.

CO3 Students will have knowledge of various functionalities about the LabVIEW software

CO4 Students can build the VI for various applications

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE404 DIGITAL CONTROL SYSTEMS

Pre-requisite: EEPC101, EEPC204, EEPC208

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description: With the implementation of microprocessors, programmable logic devices and DSP chips as controllers in modern systemscorresponding knowledge of digital control systems is also required. This course provides asystematic approach for the vital theories required for appreciating the past and present status ofcontrol system

Course Contents:

Unit-I **(12)**

Introduction and signal processing: Introduction to digital control systemAnOverview of the Classical Approach to Analog ControllerDesign., Advantages of digital control, Configuration of the Basic Digital Control Scheme, Principles of Signal Conversion, Discrete-Time Signals,

Sample-and-hold systems: The Sampling operation, The Hold operation, Practical Sample-and-Hold Circuit, the sampling theorem, SampledSpectra and Aliasing, reconstruction of Analog Signals, Practical Aspects of the Choice of Sampling Rate, Principles ofDiscretization

Time-domain models for discrete-time systems, Transfer Function Models, Stability on the z-Plane andthe Jury Stability Criterion.

Unit-II **(10)**

Design of digital control: z-Plane Specifications of Control System Design, DigitalCompensator Design using Frequency Response Plots, Digital Compensator Design using Root Locus Plots, z-Plane Synthesis

Unit-III (10)

Control system analysis using state variable methods: State variable representation, conversion of state variablemodels to transfer functions, conversion of state variablemodels to transfer functions to canonical state variable models, Eigen values and eigen vectors, Concept of Controllability andObservability;

Unit-IV **(10)**

Case studies: Implementation of Digital Controllers, Tunable PID Controllers, Digital Temperature Control System, Digital Position Control System, Stepping Motors and Their Control, Programmable Logic Controllers

References/Textbooks:

1. M. Gopal, "Digital Contro! and State Variable Methods", McGraw Hill Education
2. Hemchandra Madhusudan Shertukde, "Digital Control Applications Illustrated with MATLAB" 2015, CRC Press
3. B. C. Kuo, "Digital Control Systems", Oxford University Press-New Delhi
4. Landau Landau, Zito Landau, "Digital Control Systems: Design, Identification and Implementation", Springer-Verlag
5. V. I. George, C.P. Kurian, " Digital Control Systems", Cengage Learning 6. K. Ogata, "Modern Control Engineering", Prentice Hall publication.

Course outcomes:

On successful completion of the course, students will be able to

CO1 Learn the fundamentals of digital control systems and signal processing.

CO2 Knowledge to design digital controllers and asses their design through the constraint specifications.

CO3 Model and analyze digital system in state space

CO4 Learn the applications of digital control for various engineering problems.

17/7

Open Electives (Semester VIII)

ELECTRICAL ENGINEERING DEPARTMENT

EEOE405 AC-DC MICROGRIDS

Pre-requisite: EEPC203

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: This course helps to understand advanced modelling, control, resilience and security technologies useful for the grid modernization from a unique angle of microgrid design, analysis and operation.

Course Content

Unit - I Introduction to Microgrid **(9)**

Power systems resilience, The concept of microgrids, Introduction to distributed energy resources (DERs): PV system, Micro-turbine, energy storage, wind energy system and diesel generators, Microgrid converter's structure, Different topologies of Microgrids, Brief introduction to AC and DC microgrids.

Unit – II DC Microgrid **(9)**

Introduction to DC microgrid, Merits & Challenges of DC microgrids, modelling of PV system, DC-DC converter's, MPPT, and battery tied standalone DC system, DC bus voltage regulation and stability issues, Centralized control, Hierarchical principle: Primary, secondary and tertiary control. Distributed control.

Unit – III AC Microgrid **(12)**

Introduction to AC Microgrid, Merits & Challenges of AC microgrids, grid-tied interface, Microgrid inverter structures, Distribution power flow, power flow analysis for droop-control-based microgrids and networked microgrids.

Unit – IV Hybrid Microgrid **(12)**

Introduction to Hybrid Microgrid, Merits & Challenges of Hybrid microgrid, Interface of AC & DC Microgrid, Load line control (DC bus and AC bus), voltage regulation control, active & reactive power control, power sharing concept of inverters, distributed and centralized control.

Case Study: Simulation of DC microgrid using PV system and battery with AC and DC loads.

References/Textbooks:

5. P. Zhang, "Networked Microgrids" Cambridge University Press, 2020.
6. Stephen A. Roosa "Fundamentals of Microgrids: Development and Implementation" CRC Press, 2021.
7. Puladasu Sudhakar, Yogini Dilip Borole, Anurag Shrivastava"Autonomous Microgrid Operation Protection & Control" INSC International Publisher (IIP), 2021.

Course Outcomes:

On successful completion of the course, students will be able to

CO1 To Understand the concepts of microgrids, and networked microgrids

CO2 To demonstrate the performance of different power converters in microgrid

CO3 To Analyze distribution grid power flow in different microgrid scenario's

CO4 To Design and Analysis capability of various microgrid topologies

17/12

ELECTRICAL ENGINEERING DEPARTMENT

EEOE406 ENERGY CONSERVATION UTILIZATION AND SAFETY STANDARDS

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

This course aims to provide students with the basics of energy conservation and management, utilization of the electrical energy and safety hazards.

Course Content

Unit 1: Energy Conservation and Management **(14)**

Overview of energy conservation and management, Importance of energy conservation and its role in sustainable development, Energy management principles and practices, Energy auditing and benchmarking, Energy policy and regulations

Energy-efficient technologies and systems, Building energy conservation measures, Industrial energy conservation practices, Transportation energy efficiency, Renewable energy integration and optimization

Unit 2: Electrical Energy Conservation and Utilization-I **(11)**

Laws of illumination, coefficient of Utilization and depreciation, Polar curves, photometry, integrating sphere, Types of Lamps and their usage as per energy conservation, Basic principles of light control, Types and design of lighting scheme, lighting calculations.

Principles of Electric Heating, Various Schemes and methods of Resistance heating-Direct and Indirect heating, Induction heating, Dielectric heating and Microwave heating. Applications of Heating and modern heating methods. Simple problems.

Unit 3: Electrical Energy Conservation and Utilization-II **(11)**

Systems of electric traction and track electrification- DC system, single phase and 3-phase low frequency and high frequency system, composite system, kando system, comparison between AC and DC systems, problems of single-phase traction with current unbalance and voltage unbalance. Systems of train lighting, special requirements of train lighting, methods of obtaining unidirectional polarity constant output- single battery system, Double battery parallel block system, coach wiring, lighting by making use of 25 kV AC supply, Speed control of Traction motors(DC Series motors) series-Parallel connection, Shunt Transition, Bridge Transition. Problems on series-parallel control.

Unit 4: Safety Standards **(6)**

Overview of applicable safety standards, National and international safety codes, Compliance requirements, Identifying electrical hazards in various environments, Site Safety: Industrial, Construction, and Residential, Working on energized equipment, Emergency response and evacuation plans Real-life examples of electrical accidents and their prevention, Best practices for electrical safety implementation,

Text Books

1. Smith, Craig B., and Kelly E. Parmenter. Energy, management, principles: Applications, benefits, savings. Elsevier, 2013.
2. Art and Science of Utilization of Electrical Energy, H. Partab, Dhanpat Rai and Sons, 2017.
3. Sutherland, Peter E. Principles of electrical safety. John Wiley & Sons, 2014.

References/Textbooks:

1. Generation Distribution and Utilization of Electrical Energy, C.L. Wadhwa, New Age International Publishers, 3rd Edition, 2017
2. Kreith, Frank, and D. Yogi Goswami, eds. Energy management and conservation handbook. CRC Press, 2007.
3. Fordham-Cooper, W. Electrical safety engineering. Elsevier, 1998.
4. John Cadick, P. E., Mary Capelli-Schellpfeffer, Dennis K. Neitzel, and Al Winfield. Electrical safety handbook. McGraw-Hill Education, 2012.

Course Outcomes

On successful completion of the course, students will be able to

CO1 Understand the principles and importance of energy conservation.

CO2 Determine the lighting requirements for flood lighting, household and industrial needs

CO3 Understand basic principles of electric heating and Traction

CO4 Identify and assess electrical hazards in various environments

ELECTRICAL ENGINEERING DEPARTMENT

EEOE407 ROBOTICS

Pre-requisite: MAIC11, EEPC241

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

Aims to give fundamental concepts of kinematics, dynamics and control of industrial Robotic manipulator

Unit-I **(10)**

Definition, Motivation, Historical development, Basic structure, Classification, Workspace, Grippers. Rigid motion and frame Transformations. DH parameters

Unit-II **(10)**

Robot Arm Forward and Inverse Kinematics, Forward and Inverse Kinematics, redundancy resolution, Velocity kinematics and Jacobian, Singular value decomposition, singularity and manipulation ability

Unit-III **(12)**

Lagrange formulation of dynamics.

Trajectory generation: Cartesian Scheme, Joint space scheme

Teaching methods: Manual teaching, Lead through teaching

Sensors and actuators as used in robotics.

Unit-IV **(10)**

Control Scheme: Position Control, Force control, Hybrid position and force control, Industry Multi DOF robotic manipulator case studies.

Design exercises in MATLAB/LABVIEW and case studies.

References/Textbooks:

1. J.J. Craig, "Introduction to Robotics – Mechanics A Control", Addison Wesley, 2001.
2. A.J. Koivo, "Fundamentals for Control of Robotic Manipulation", John Wiley Inc. New York, 2001.
3. Spong and Vidyasagar, "Robot Dynamics and Control", John Wiley and Sons, 2005.
4. Sciavicco and Siciliano, "Modeling and Control of Robot Manipulators", McGraw Hill International Edition, 1998.

5. Foundations of Robotics : T. Yoshikawa , PHI India

COURSE OUTCOMES:

On successful completion of the course, students will be able to

Upon completion of the course, the students will be able to

CO1: Understand the basic concept of industrial robotic Manipulator

CO2: Derive direct and inverse kinematic equations of a given robot.

CO3: Derive the dynamic equations of an industrial robot.

CO4: Develop the control algorithm necessary to run the given robot

17/7/23

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEOE408 RELIABILITY ENGINEERING

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

To apply knowledge in the field of probability theory to derive reliability function, reliability modeling. To study methods to evaluate, to increase, to optimize reliability will be discussed. Concept of maintainability, availability and reliability testing will also be discussed.

Unit 1 **(12)**

Introduction: Reliability and its importance, mortality curve, hazard rate, causes of failures, modes of failure, general reliability function and other reliability functions. Mean time to failure (MTTF), repair rate, mean-time-between failures (MTBF), availability, uptime, downtime. Failure frequency and failure distributions.

Unit 2 **(10)**

Learning Deterministic Models: Reliability models – statistical, structural, Markov, and fault tree. Reliability evaluation using various models.

Unit 3 **(10)**

Statistical Learning& Data Clustering: Redundancy techniques. Reliability allocation and Redundancy optimization. Reliability Testing

Unit 4 **(10)**

Learning with Neural Networks: Basic principles of maintainability, availability and security. Availability evaluation using Markov Technique. Basic concepts of fuzzy reliability, failure frequency and loss of load probability.

Typical case studies of practical systems.

References/Textbooks:

6. E. Balagurusamy, "Reliability Engineering", Tata McGraw-Hill Education. 1984
7. K K Aggarwal, "Reliability Engineering", Springer.2007
8. Martin L. Shooman, "Probabilistic Reliability-An Engineering approach" , Krieger Publishing Company.
9. Ram Kumar, "Reliability Engineering", Prentice Hall ,1993.
10. A.K. Govil, "Reliability Engineering", McGraw-Hill Inc. US

17/12

Course Outcomes

On successful completion of the course, students will be able to

CO1: Explain the concept of probability. Define random variable, density & distribution function.

CO2 Develop reliability models of simple and complex systems.

CO3 Describe/apply various methods of reliability evaluation to compute reliability of simple and complex systems.

CO4 To enhance system reliability using reliability allocation and redundancy optimization/allocation of practical/physical systems.

CO5 Design and develop fault trees, Markov graphs and evaluate reliability, availability using Fault tree and Markov techniques.

17/7 27/7/23

Minor (Semester VIII)

ELECTRICAL ENGINEERING DEPARTMENT

EEMI301 FUNDAMENTALS OF ELECTRICAL ENGINEERING (CIRCUITS, MEASUREMENTS AND CONTROL SYSTEMS)

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

This course is intended to familiarize the students with basic concepts of electric circuits, measurement of different electrical quantities and the basic concept of control system.

COURSE CONTENTS:

Unit I **(10)**

Review of KCL, KVL and DC circuit analysis, Network theorems and their applications – Superposition, Thevenin, Norton & maximum power transfer, Analysis of three phase circuit and their properties, Power in three phase circuits.

Unit II **(12)**

Error analysis, Concept of instruments to measure voltage, current, energy, phase or frequency. Classification and brief description about Analog and Digital instruments, Measurements of resistance, inductance and capacitance, Instrument transformers.

Unit III **(12)**

Concept of control, Control system terminologies, Classification of control system, Block diagram, Signal flow graph, Transfer function, State space, Characteristics of control system, Concept of stability analysis.

Unit IV **(8)**

Application of measurement systems – transducers & sensors.
Real life examples & applications of control system.

References/Textbooks:

1. Chakrabarti A,"Circuits Theory (Analysis and synthesis), Dhanpat Rai & Sons, New Delhi, 2020.
2. Van Valkenberg, "Network Analysis", PHI.
3. V. Del Toro, "Principles of Electrical engineering", PHI.

4. K. Ogata, Modern Control Engineering, 5th edition, PHI, 2012.
5. E. Hughes, "Electrical Technology", ELBS.
6. J. Nagrath and M. Gopal, -Control System Engineering, New Age International Publishers, 5th Edition, 2007.
7. S.K. Bhattacharya, Control System Engineering, 3rd Edition, Pearson, 2013.
8. AK Sawhney, "Electrical and Electronic Measurements & amp; Instrumentation", Dhanpat Rai, Delhi.
9. W.D. Cooper- "Electronics Instrumentation and Measurement Techniques"' Prentice hall India.
10. C.T Baldwin, "Fundamentals of Electrical Measurement", Lyall Book Depot.

COURSE OUTCOMES

On successful completion of the course, students will be able to

CO 1: To understand and apply the basic principle of electrical circuit to see problem related to electric circuits.

CO 2: To understand the basic of different instrument for the measurements of electrical quantities.

CO 3: To understand the basic concept of control system and the concept of stability analysis.

CO 4: To apply measurement & control systems in real life.

ELECTRICAL ENGINEERING DEPARTMENT

EEM1302 BASICS OF ENERGY SYSTEMS (POWER SYSTEMS, MACHINES AND POWER ELECTRONICS)

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description

To understand the basic concepts of energy systems with basics of power generation, concepts of transmission and distribution systems, electrical machines fundamentals, and basics of power electronics and drives

Unit 1 **(10)**

Introduction: Typical Layout of an Electrical Power System Present Power Scenario in India. Generation of Electric Power (Qualitative): Conventional Sources: Hydro station, Steam Power Plant, Nuclear Power Plant and Gas Turbine Plant. Renewable energy Sources: Wind Energy, Fuel Cells, and Solar Energy, Tidal energy, Base load and peak load plants. Cost of electrical energy-fixed cost, running cost, Tariff structure to customers.

Unit 1I **(10)**

AC Transmission and Distribution: Introduction, single line diagram of a typical power system, AC distribution, Single phase, 3-phase, 3 phase 4 wire system, bus bar arrangement, layout of substation, Fuses, Miniature Circuit breakers, MCCBs, basic fundamentals of All types of CBs, their principle of working, overcurrent and earth fault relays, fundamentals of distance relays

Unit 1II **(10)**

Construction, working principle of single phase and three phase transformers, their types, efficiency calculation, no-load, full load tests, working principle of single and three phase induction motor, brief construction, their types, working principle of DC machines, their types and construction, principle of operation and construction o=f synchronous machines, applications of machines.

Unit 1V **(12)**

Power Semiconductor Devices: Principle of operation of SCR, dynamic characteristic of SCR during turn ON and turn OFF, Two-transistor analogy, Protection of SCR, Snubber circuit, Commutation circuits, SCR ratings, Triggering Methods, Series and Parallel operation of SCR. Principle of operation of, IGBT, GTO, MCT, DAIC, TRAIC, IGCT, their operating characteristics. Classification of Power Converters, Construction and characteristics of Thyristors, MOSFET, IGBT, IGCT and GTO, Comparison of Controllable switches. Phase

Controlled (AC to DC) Converters (Rectifiers): Half wave converter, 2-pulse midpoint converter, half controlled and fully controlled bridge converters, input current and output voltage waveforms, effect of load and source impedance, expressions for input power factor, displacement factor, harmonic factor and output voltage, effect of free-wheeling diode, triggering circuits, Dual converter.

References/Textbooks:

1. C.L. Wadhwa, Electrical Power Systems, New-Age International, Fifth Edition, 2009.
2. B. R. Gupta, Power System Analysis and Design, A H Wheeler Publishing Company Limited, 1998.
3. P.S. Bhimbra, 'Electrical Machinery', Khanna Publications.
4. Nagrath, I.J. and Kothari, D.P., 'Electrical Machines', Tata McGraw Hill Education Private Limited Publishing Company Ltd.
5. PS Bhimbra, Power Electronics, Khanna Publishers, 2015.
6. MD Singh and KB Khanchandar.i, Power Electronics, TMH Edition, 2007.
7. B. R. Gupta, Generation of Electrical Energy, 7th Edition, S. Chand Publishing, 2017.
8. W.D. Stevenson, Elements of Power System Analysis, McGraw Hill, Fourth Edition, 1984.
9. C.L. Wadhwa, Generation, Distribution and Utilization of Electrical Energy, New-Age International, Second Edition, 2009.
10. Arthur Eugene Fitzgerald and Charles Kingsley, 'Electric Machinery', Tata McGraw Hill Education Publications
11. G.K. Dubey, S. R. Doradla, A. Joshi, and R. M. K. Sinha, "Thyristorised Power Controllers", New Age International Private Ltd.
12. Muhammad H. Rashid, Power Electronics - Circuits, Devices and Applications, Pearson, 4th Edition, 2018
13. https://www.coursera.org/learn/electric-power-systems
14. https://onlinecourses.nptel.ac.in/noc19_ee62/preview
15. https://nptel.ac.in/courses/108/101/108101038/
16. https://nptel.ac.in/courses/108/102/108102145/
17. https://nptel.ac.in/courses/108/101/10810126/
18. http://www.nptelvideos.com/course.php?id=493
19. https://nptel.ac.in/courses/108/104/108104011/

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Understand the operation of conventional generating stations and renewable sources of electrical power.

CO 2 Appraise about AC transmission and distribution systems and protective devices.

17/7/23

12/7

CO 3 Understand the constructional details and principle of operation of transformers, and AC/DC Machines

CO 4 Understand fundamental concepts in power electronics and analyze power converter circuits.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEM1401A ENERGY CONSERVATION AND MANAGEMENT

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

The course aims to provide the students with different approaches for conversing the energy utilization and its management techniques with energy auditing, energy policy and regulations.

Unit I: Introduction to Energy Conservation and Management **(12)**

Overview of energy conservation and management, Importance of energy conservation and its role in sustainable development, Energy management principles and practices, Energy auditing and benchmarking, Energy policy and regulations, utilization of Electrical Lighting, Heating systems for energy conservation.

Energy-efficient technologies and systems, Building energy conservation measures, Industrial energy conservation practices, Transportation energy efficiency, Renewable energy integration and optimization

Unit II: Energy Auditing and Energy Performance Assessment **(10)**

Basics of energy auditing, Energy performance assessment methodologies, Energy data collection and analysis, Identification and evaluation of energy-saving opportunities, Energy conservation measures implementation and verification

Unit III: Energy Policy and Regulations **(10)**

Energy policy framework and goals, Government initiatives and incentives for energy conservation, Energy codes and standards, International agreements and protocols, Environmental considerations in energy management

Unit IV: Energy Management in Practice **(10)**

Energy management strategies and planning, Energy monitoring and control systems, Demand-side management techniques, Financial analysis and investment evaluation, Case studies on successful energy management projects

References/Textbooks:

1. Smith, Craig B., and Kelly E. Parmenter. Energy, management, principles: Applications, benefits, savings. Elsevier, 2013.
2. Kreith, Frank, and D. Yogi Goswami, eds. Energy management and conservation handbook. CRC Press, 2007.

17/7

17/7/23

3. Shapiro, Ian M. Energy audits and improvements for commercial buildings. John Wiley & Sons, 2016.
4. Turner, Wayne C., and Steve Doty. Energy management handbook. Vol. 6. Lilburn, GA, USA: Fairmont press, 2001.
5. Thumann, Albert, and William J. Younger. Handbook of energy audits. The Fairmont Press, Inc., 2008.
6. Morvay, Zoran, and Dušan Gvozdenac. Applied industrial energy and environmental management. John Wiley & Sons, 2008.
7. Thumann, Albert, and Scott C. Dunning. Plant engineers and managers guide to energy conservation. CRC Press, 2020.
8. Davies, L. L., Klass, A. B., Osofsky, H. M., Tomain, J. P., & Wilson, E. J. (2020). Energy Law and Policy. Energy Law and Policy (West Academic Publishing, 2d.

Course Outcomes

On successful completion of the course, students will be able to

CO1: Understand the principles and importance of energy conservation.

CO2: Apply energy management techniques and strategies for energy conservation

CO3: Conduct energy audits and assess energy performance

CO4: Understand energy policy and regulations

ELECTRICAL ENGINEERING DEPARTMENT

EEMI401B ECONOMICS OF RENEWABLE ENERGY SYSTEMS

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course

The course aims to provide the students with the different approaches to evaluate the projects related to the renewable energy systems.

Unit I: Project evaluation **(10)**

Energy return on energy invested, Capacity factor, Investments in the electricity sector, Project selection and evaluation, Project development, Time value of money, Discounted cash flows, Net present value, Inflation in cash flows, Discount rate and its calculations and forms, Weighted-average cost of capital, multiple discount rates, costs and benefits evaluation, Project financial costs and benefits, Least-cost solution, Worth of the investment,

Unit II: Financial evaluation **(10)**

Owner's evaluation of profitability, Base cost estimate and contingencies, Sunk costs, Depreciation and interest charges, Financial projections, Evaluation of benefits in the electricity supply industry, Timing of projects, Projects with different lives and construction periods, Expansion projects, System linkages (system effects), financial evaluation to economic evaluation, Border and shadow pricing, Investment costs in reducing dangers to health and environmental impacts, The welfare discount rate, Climate change costing, Discounting concepts in climate change

Unit III Renewable Energy Project Evaluation **(8)**

Economics of renewables and the role of the state, Utilisation factor (capacity factor), Dispatching and transmission cost, Costing of renewables generation, Assessing the returns on investment in renewables, Value factor, Merit-order effect,

Unit IV Carbon Economy **(7)**

Carbon dilemma, Climate conventions: Kyoto and beyond, Carbon taxation, Emissions trading, The negative effect of power sector subsidies, Prospects for non-fossil-fuel power generation, Future prospects for solar cells, Virtual power plant, Carbon usage and its economy

Unit V: Renewable Energy Economics **(7)**

Energy transition from fossil fuels and renewable energy source, comparison of costs of different energy sources, case studies on renewable energy source pricing in India and other parts of the world, social and economic impact of the renewable energy economics.

17/7 17/7/23

References/Textbooks:

1. Khatib, Hisham. Economic evaluation of projects in the electricity supply industry. No. 44. IET, 2003.
2. Short, Walter, Daniel J. Packey, and Thomas Holt. A manual for the economic evaluation of energy efficiency and renewable energy technologies. No. NREL/TP-462-5173. National Renewable Energy Lab.(NREL), Golden, CO (United States), 1995.
3. Park, Chan S. Fundamentals of engineering economics. Upper Saddle River, NJ: Pearson/Prentice Hall, 2004.
4. G. Mankiw, "Principle of Economics", Wiley Eastern, 6 th Edition, 1998.

Course Outcomes

On successful completion of the course, students will be able to

CO1 Understand the concepts and techniques of project selection in the electricity sector

CO2 Evaluate the economic criteria for selection of different renewable energy projects

CO3 Understand of the economics of renewable energy technologies

CO4 Apply the knowledge in economic system planning to conduct detailed financial and economic evaluations

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEMI402A CONTROL SYSTEMS ANALYSIS & DESIGN

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

Aims to give fundamental concepts of control system design, performance analysis of systems, modeling errors,sensitivity, robustness, feedback control design, predictive controllers, and anti-wind-up schemes, etc.

Unit-I **(10)**

Review of system models, model simplifications and associated modeling errors, control-ratio modeling, discrete time and hybrid models, Canonical Decomposition.

Unit-II **(10)**

Stability and performance specifications, limits of performance,modeling errors, constraints on sensitivity, complementary sensitivity, robustness.

Unit-III **(10)**

Design of linear state feedback, compensating delays, Smith predictors, Predictive controllers, internal model control,

Unit-IV **(12)**

Recent trends in design of control systems. Control design based identification of complex systems, integrator wind up and anti-wind up schemes, PID synthesis using the affine parameterization.

Design exercises and case studies.

References/Textbooks:

On successful completion of the course, students will be able to

1. Goodwin, G.C.,Graebe, S.F. and M.E. Salgado, "Control System Design", Prentice Hall of India, 2001.
2. Friedland, B. "Advanced Control System Design", Prentice Hall Int. Inc. NY.1966.
3. John J. D'Azzo and Constantine H. Houpis,"Linear Control System Analysis and Design: Conventional and Modern", McGraw-Hill, US, 4th Edition, 1995.

17/7/23

17/7

4. Raymond. T. Stefani, Bahram Shahian, Clement J. Savant, and Gene H. Hostetter, "Design of Feedback Control Systems", OUP USA; 4th edition, 2001.

Course outcomes:

CO1: Develop mathematical models and understands the mathematical relationships between the sensitivity functions.
CO2: Stability analysis & study the performance of the closed-loop systems
CO3: Design feedback controller and the specific design procedure.
CO4: Develop predictive controllers and identification of complex systems

1/7/7

ELECTRICAL ENGINEERING DEPARTMENT

EEMI402B INDUSTRIAL CONTROL & AUTOMATION

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:
This course aims to provide fundamental concepts of control of most process variables and how these measured quantities are transformed and transmitted, process control, including principles of industrial practices and computer control, knowledge and actions of various types of control systems, including analog and digital types, online and real-time, PLC program for industrial applications.

Unit-I: **(10)**
Introduction to Process Control Systems: Representative process control problems, control objectives and configurations of process control, role of control engineer, process control operations.

Mathematical modeling of processes: Type of models, modeling procedure steps, empirical model identification.

Unit-II: **(10)**
Blending Process: Problems, dynamics, modeling, selection, temperature sensors, concentration-response of isothermal CSTR with no chemical reaction, liquid level system analysis of non-interacting and interacting tanks.

Feedback Control Analysis: Transient response with regulatory, set-point, and tracking control for second and higher-order processes with PID controllers, effect of measurement lag and process dead time on response, control architectures, control valves.

Unit-III: **(10)**
Enhanced Process Control Strategies: Feed-forward control, cascade control, selectors and redundant control, concept of computer control, sequential, supervisory and DDC modes, computer control architecture.

Advanced Process Control Strategies: Electronic controller design using op-amps and microcontroller, dead time compensation, internal model control, inferential control.

17/7/23

17/7

Unit-IV: **(12)**

Introduction to Automation: Peripherals required in automation systems, architecture of distributed control systems, local control unit architecture, and process interfacing issues.

PLC& SCADA: Organization of programmable logic controllers, standards programming for basic actuators and motors, ladder programming, sequential function charts, architecture of SCADA, supervision, and control,HMI, RTU,supervisory stations, trends in SCADA, and security issues.

Industrial Visits: Case studies, visit to SCoE Labs, seminars, workshops, etc.

References/Textbooks:

1. Peter Harriot, Process control, McGrow Hill, Edition No. 01, 1964.
2. D. E. Seborg, T. F. Edgar, D. A. Mellichamp, F. J. Doyle, Process Dynamics and Control, Wiley, Edition No. 04, 2016.
3. S. K. Singh, Computer Aided process control, PHI, Edition No. 01, 2004.
4. S. Bhanot, Process Control-Principles and Applications, Oxford University Press, Edition No. 04, 2010.
5. T. E. Marlin, Process Control: Designing Processes and Control Systems for Dynamic Performance, McGrow Hill, Edition No. 02, 2000.
6. Richard L. Shell, Ernest L. Hall, Handbook of Industrial Automation, CRC Press, UK, 2009.
7. John W. Webb, Ronald A. Reis, "Programmable Logic Controllers", 5th Ed., PHI, 2012.

Course outcomes:

On successful completion of the course, students will be able to

CO1 Understand the basic principles & importance of process control in industrial process plants

CO2 Explain the construction, working, and control strategies of different industrial processes and drives.

CO3 Build and experiment with PLC-based SCADA systems program for various industrial applications

CO4 Implement HMI, Distributed Control System, and Industry standards.

ELECTRICAL ENGINEERING DEPARTMENT

EEMI403A POWER QUALITY

Pre-requisite: Fundamentals of Electrical Engineering, Basics of energy systems

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: The terminologies of power quality problems in distribution system and power converter-based products are covered in this course. The drawbacks, causes and mitigation methods of power quality problems are thoroughly included. The reduction in energy consumption by power quality improvement is numerically explained.

Course Contents

UNIT-I **(11)**

Introduction to Power Quality and its Standards

Overview of power quality; Voltage and current-based power quality problems; Power quality standards; EMC standards; loads which cause power quality problems; Harmonic analysis

UNIT-II **(10)**

Harmonic Mitigation Using Passive Filters

Classification; Principle of operation; Selection criteria; Limitations; Design of passive tuned filters for single and three-phase non-linear loads.

UNIT-III **(11)**

Power Quality Improvement Using Active Filters

Classification; Principle of operation; Control techniques for single-phase and three-phase shunt active power filters; Design of single-phase and three-phase shunt and series active power filters.

UNIT-IV **(10)**

Design of Improved Power Quality Converters

Classification; Operating principle; Design and simulation of single-phase and three-phase-power factor corrected buck, boost and buck-boost converters in continuous conduction mode.

References/Textbooks:

17/7/23

1. Math H. Bollen, "Understanding Power Quality Problems," John Wiley IEEE Press, 2000.
2. H. Wayne Beaty, Mark McGranaghan, Roger Dugan and Surya Santoso, "Electrical Power System Quality," McGraw Hills, 3rd Ed., 2012.
3. G.T. Heydt, "Electric Power Quality," West Lafayette, IN, Stars in a Circle Publications, 1994.
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems and Mitigation Techniques," Wiley, 2015.
5. Arrillaga Jos, "Power System Quality Assessment," John Wiley & Sons, 2000.

Course Outcomes

On successful completion of the course, students will be able to

CO 1: understand the concept of power quality and its standards.

CO 2: understand the causes and mitigation of power quality problems in distribution system.

CO 3: understand the role of various passive and active filters for power quality improvement .

CO 4: design the power factor corrected converters for efficiency improvement.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEMI403B FLEXIBLE AC TRANSMISSION SYSTEMS

Pre-requisite: ....

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course:

To enhance the transmission capability of transmission system by shunt and series compensation using static controllers. This course introduces the application of a variety of high power-electronic controllers for active and reactive power in transmission lines. Students are exposed to the basics, modelling aspects, control and scope for different types of FACTS controllers.

UNIT I **(12)**

INTRODUCTION

The concept of flexible AC transmission - reactive power control in electrical power transmission lines -uncompensated transmission line – series and shunt compensation. Overview of FACTS devices - Static Var Compensator (SVC) – Thyristor Switched Series capacitor (TCSC) – Unified Power Flow controller (UPFC) - Integrated Power ,Flow Controller (IPFC).

UNIT II **(10)**

STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS

Voltage control by SVC – advantages of slope in dynamic characteristics – influence of SVC on system voltage. Applications - enhancement of transient stability – steady state power transfer – enhancement of power system damping – prevention of voltage instability.

UNIT III **(10)**

THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC)AND APPLICATIONS

Operation of the TCSC - different modes of operation – modeling of TCSC – variable reactance model – modeling for stability studies. Applications - improvement of the system stability limit – enhancement of system damping – voltage collapse prevention.

UNIT IV **(10)**

EMERGING FACTS CONTROLLERS

Static Synchronous Compensator (STATCOM) – operating principle – V-I characteristics– Unified Power Flow Controller (UPFC) – Principle of operation - modes of operation applications – modeling of UPFC for power flow studies

17/7/23 17/7

References/Textbooks:

1. Mohan Mathur, R., Rajiv. K. Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc. 1st Edition, 2002.
2. A.T.John, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
3. Narain G.Hingorani, Laszio. Gyugyl, "Understanding FACTS Concepts and Technology of Flexible AC Transmission System", Standard Publishers, Delhi 2001.

Course Outcomes:

On successful completion of the course, students will be able to

CO1: To understand various types of power controllers in transmission lines.

CO2: To understand the static VAR compensator and its applications, to understand the TCSC controller and its applications.

CO3: To understand the transient stability and modelling of STATCOM.

CO4: To learn the concept of coordination of FACTS controllers.

ELECTRICAL ENGINEERINGDEPARTMENT

EEMI404A ARTIFICIAL INTELLIGENCE

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Course Description:
This course will enrich the students with various AI techniques and make them familiar with the applicability, strengths, and weaknesses of basic knowledge representation, problem-solving, machine learning, knowledge acquisition, and learning methods in solving particular engineering problems.

Course Contents:

Unit-I **(8)**
Introduction Concept of AI, history, current status, scope, reactive, deliberative, goal-driven, utility-driven, learning agents, environments, and problem formulation.

Unit-II **(12)**
Learning deterministic models Supervised Learning algorithms, Regression: Simple Linear Regression, Multiple Linear Regression, Underfitting, Overfitting and Cross Validation, Parameter Estimation: Estimating the Parameters for Simple Linear Regression, Gradient Descent Optimization, Variants of Gradient Descent.

Unit-III **(10)**
Statistical learning & data clustering Bayes theorem, General Bayes Theorem, Naive Bayes Classifier, Bayesian Belief Networks, k-Nearest Neighbor (k-NN) Classifier, Linear Regression with Least Square Error Criterion- Minimal Sum-of-Error-Squares and the Pseudo-inverse, Least Mean Square (LMS) Algorithm. Overview of Basic Clustering Methods: Partitional Clustering, Hierarchical Clustering, Spectral Clustering, Clustering using Self-Organizing Maps, K-Means Clustering

Unit-IV **(12)**
Convolutional and recurrent neural networks Image classification, Text classification, hyper-parameter tuning, Emerging NN architectures, Builαing recurrent NN, Long Short-Term Memory, and Time Series Forecasting. Case studies involving AI applications in Engineering problems solving.

17/7/23

17/7

Case Studies

References/Textbooks:

1. Rich E., Knight K. and Nair B. S., Artificial Intelligence, Tata McGraw Hills (2009) 3rd ed.
2. Luger F. G., Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education Asia (2009) 6th ed.
3. Neapolitan, R.E. and Jiang, X., 2018. Artificial intelligence: With an introduction to machine learning. CRC Press.
4. Gopal, M., 2019. Applied machine learning. McGraw-Hill Education.
5. Haykin, S., 2009. Neural networks and learning machines, 3/E. Pearson Education India.

Course Outcomes

On successful completion of the course, students will be able to

CO1: Understands the fundamentals and development of AI.

CO2: Acquire knowledge of various strategies for AI systems.

CO3: Analyze basic and advanced search techniques.

CO4: Apply CNN and RNN for various applications.

ELECTRICAL ENGINEERINGDEPARTMENT

EEMI404B METAHEURISTIC OPTIMIZATION TECHNIQUES

Pre-requisite: MAIC11, MAIC12, EEPC237

L	T	P	Credits	Total contact hours
3	0	0	3	42

Course Description:
This course introduces the students with the basic principles of metaheuristic methods such as population and swarm-based techniques. They will also learn how to implement metaheuristic algorithms for solving some real-world problems

Course Contents:

Unit-I **(6)**
Concept of optimization, Limitation of conventional optimization methods such as linear and nonlinear programming and dynamic programming, Concept of metaheuristic optimization, a brief overview of Objective Functions; Constraints, Parameter Tuning; Performance Analysis.

Unit-II **(13)**
Overall structure: Main components of Population-based metaheuristics (exploration and exploitation operators). Some population-based metaheuristics techniques such as Genetic algorithm: Genetic Algorithm (GA) vs Traditional Algorithm, Terminologies in GA, Operation in GA, stopping condition/criteria for GA, Constraints in GA, Problem-solving using GA (maximizing and minimizing of a function).Differential Evolution: Basic Differential Evolution-Difference Vectors, various operations in Differential Evolution (DE), control parameters, Variations to Basic Differential Evolution- Gradient-Based Hybrid Differential Evolution.
Or any other two population-based metaheuristics techniques.

Unit-III **(13)**
Overall structure: Main components of swarm-based metaheuristics such as Particle Swarm Optimization (PSO)–notions for Global Best (gbest), Local Best (lbest), Velocity& position components calculation, Geometric Illustration, stopping conditions, iteration and function evaluation. Artificial Bee Colony (ABC) optimization- Initialization Phase, notions for employed bees' phase-generate new solution, etc., onlooker bees'phase, scout bees' phase.
Or any other two swarm-based metaheuristics techniques.

Unit-IV **(10)**

17/7/23

17/7

167

Some case studies related to Engineering problem solving using metaheuristics-based optimization algorithms, tuning of ANN, fuzzy model parameters etc.

References/Textbooks:

1. Engelbrecht, A.P., 2007. Computational intelligence: an introduction. John Wiley & Sons.
2. Z. Michalewicz, D. Fogel: How to Solve It. Modern Heuristics. Springer, 1999

Course Outcomes

On successful completion of the course, students will be able to

CO1 Identify the metaheuristic technique appropriate for a specific problem

CO2 Implement and validate a computational model based on metaheuristic algorithms

CO3 Solve a real-world problem using computational intelligence tools.

CO4 Application of metaheuristic algorithms for parameter tuning.

ELECTRICAL ENGINEERING DEPARTMENT

EEMI405A WIND ENERGY SYSTEMS

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	**42**

Brief Description about the course

The course provides fundamental concepts of the wind energy sources, design operation of wind power system, wind energy conversion system and power conditioning schemes

Unit - I **(10)**

Anemometer and wind vane Site selection, wind speed, wind direction and its relationship with wind power, wind turbines, wind generators, advantages and limitations. Wind energy conversion principles; General introduction; Types and classification of WECS; General Classification of Wind Turbines-Rotor Turbines-Multiple-Blade Turbines Drag Turbines -Lifting Turbines-Generators, Power, torque and speed characteristics, Wind turbine types and their construction Drag and lift principle of rotation of the wind turbine rotor. Geared WPPs, direct drive WPPs and Hybrid WPPs Stall control, pitch control and active stall control of WPPs.

Unit – II **(12)**

OPERATION OF WIND POWER SYSTEM: Wind Power System: Components, turbine rating, Principles of Operation-Representation of Steady-State Operation-Power and Losses Generated-Self-Excited Induction Generator-Magnetizing Curves and Self-Excitation, Squirrel cage Induction Generators (IG), wound rotor IG, doubly fed IG, Wound rotor synchronous generator, Permanent magnet synchronous generator Direct-drive and geared small wind turbines

Mathematical Description of the Self-Excitation Process-Interconnected and Stand-alone operation -Speed and Voltage Control, electrical load matching, variable-speed operation, maximum power operation, system control requirements, speed control, rate control.

Unit – III **(10)**

WIND ENERGY CONVERSION SYSTEMS: Wind energy Conversion system (WECS): wind energy conversion systems and their classification, Performance of Induction generators for WECS, Self-excited induction generator (SEIG) for isolated power generators. Controllable DC power from SEIGs, system performance, Grid related problems, generator control, AC voltage controllers, Harmonic reduction and Power factor improvement.

17/7/23

17/7

Unit - IV **(10)**

Wind pumps: Performance analysis, Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy. Utilization; Wind energy in India; environmental aspects, Case studies.

References/Textbooks:

1. D.P. Kothari, K.C. Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", 2nd Edition, PHI.
2. Mukund R Patel, "Wind and Solar Power Systems", CRC Press, 1st Edition, 1999.
3. D. Mukherjee: Fundamentals of Renewable Energy Systems, New Age International publishers, 2007.
4. G D Rai , "Non- Conventional Energy Resources", Khanna Publishers, Publications, 2nd Edition, 2001, 1ST Edition, 2002.
5. Earnest, Joshua,, Wind Power Technology, PHI Learning, New Delhi, 2013
6. Daniel, Hunt. V Wind Power, A Hand Book of WECS, Van Nostrend Co., Newyork, 2nd
7. Edition, 1998.
8. Mehmet Kanoglu, Yunus A. Cengel, John M. Cilbala, "Fundamentals and applications of Renewable Energy", McGraw Hill., 2020.
9. Remus Teodorescu, Marco Liserre, Pedro Rodriguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, 2011.
10. Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley and Sons, 2004.
11. Wind Power in Power System, Thomas Ackermann, John Willey &Sons, 2005
12. Online resources:
13. 11. https://www.NPTEL video lectures.
14. 2. https://www.books.askvenkat.com/engineering-textbooks
15. 3. https://www.electrical4u.com.
16. 4. www.energyshouldbe.org/
17. 5. www.power-genindia.com/
18. 6. www.indiastat.com

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Uunderstand concept and working principle of wind energy generation.

CO 2 Appraise about different types of wind turbines and operation

CO 3 Analyze wind energy conversion systems.

CO 4 Application of wind energy sources and case study.

ELECTRICAL ENGINEERING DEPARTMENT

EEMI405B SOLAR ENERGY SYSTEMS

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	**42**

Brief Description about the course

The course provides fundamental concepts of the solar energy sources, design operation of solar power system, solar energy conversion system and power conditioning schemes

Unit - I (10)

Solar constants, Measurement of solar radiations Solar Energy Conversion CSP generators Introduction to Photovoltaic effect, characteristics of photovoltaic cells, conversion efficiency, Types and classification, construction and working principle, Solar Power Generation, construction of a solar PV Systems: Solar cell, Module, Panel and array Types of solar PV.

Unit – II (12)

Solar Photovoltaic Power System: The PV Cell, module and array, equivalent electrical circuit, open circuit voltage and short circuit current, I-V and P-V curves, array design, peak power point operation, PV system components; Solar Thermal System: Energy collection, solar Energy Conversion systems, system i. Stand –Alone Solar PV system ii. Grid-Interactive solar PV system iii. Hybrid Solar PV, system Grid connection issues of solar power plants.

Unit - III (12)

POWER CONDITIONING SCHEMES FOR Solar ENERGY SYSTEMS:

Switching devices for solar energy conversion: DC power conditioning converters, maximum power point tracking algorithms. AC Power conditioners, Line commutated inverters, synchronized operation with grid supply, Harmonic reduction.

Unit – IV (8)

Application, future trend of use, PV water pumping, Application to building envelop. Organic-PV cells, traditional and innovative solar power applications. Concentrator solar-cells, Low, medium and high concentration, reflector and lens based versions., Floating PV systems, Agrovoltaics. Recycling of solar PV modules and methods, Solar power plants in India, case Studies.

References/Textbooks:

17/7/23

1. D.P. Kothari, K.C. Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", 2nd Edition, PHI.
2. Mukund R Patel, "Wind and Solar Power Systems", CRC Press, 1st Edition, 1999.
3. Chetan Singh Solanki , Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall India, 3rd Edition. ISBN 9788120351110
4. Terawatt Solar Photovoltaics, Roadblocks and Opportunities Edited by M. Tao, Springer, 2014 edition. ISBN 978-1- 4471-5643- 7.
5. Daniel, Hunt. V Wind Power, A Hand Book of WECS, Van Nostrend Co., Newyork, 2nd
6. Edition, 1998.
7. Mehmet Kanoglu, Yunus A. Cengel, John M. Cilbala, "Fundamentals and applications of Renewable Energy", McGraw Hill., 2020.
8. A. Luque and S. Hegedus ,Handbook of Photovoltaic Science and Engineering, , John Wiley & Sons, Ltd, 2012 edition. ISBN 978-0- 470-72169- 8
9. D. Mukherjee: Fundamentals of Renewable Energy Systems, New Age International publishers, 2007.
10. Remus Teodorescu, Marco Liserre, Pedro Rodriguez: Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, 2011.
11. Gilbert M. Masters: Renewable and Efficient Electric Power Systems, John Wiley and Sons, 2004.
12. https://www.NPTEL video lectures.

Course Outcomes

On successful completion of the course, students will be able to

- CO 1 Understand components of solar photovoltaic system and working
- CO 2 Appraise about solar power energy conversion system and characteristics
- CO 3 Analyze the switching devices and power conditioning of solar PV systems.
- CO 4 Application of solar PV systems and case study

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEMI406A ROBOTICS & CONTROL

Pre-requisite: MAIC11, EEPC241

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

Aims to give fundamental concepts of kinematics, dynamics and control of industrial Robotic manipulator

Unit-I **(10)**

Definition, Motivation, Historical development, Basic structure, Classification, Workspace, Grippers. Rigid motion and frame Transformations. DH parameters

Unit-II **(10)**

Robot Arm Forward and Inverse Kinematics, Forward and Inverse Kinematics, redundancy resolution, Velocity kinematics and Jacobian, Singular value decomposition, singularity and manipulation ability

Unit-III **(10)**

Lagrange formulation of dynamics.

Trajectory generation: Cartesian Scheme, Joint space scheme

Teaching methods: Manual teaching, Lead through teaching

Sensors and actuators as used in robotics.

Unit-IV **(12)**

Control Scheme: Position Control, Force control, Hybrid position and force control, Industry Multi DOF robotic manipulator case studies.

Design exercises in MATLAB/LABVIEW and case studies.

References/Textbooks:

1. J.J. Craig, "Introduction to Robotics – Mechanics A Control", Addison Wesley, 2001.
2. A.J. Koivo, "Fundamentals for Control of Robotic Manipulation", John Wiley Inc. New York, 2001.
3. Spong and Vidyasagar, "Robot Dynamics and Control", John Wiley and Sons, 2005.
4. Sciavicco and Siciliano, "Modeling and Control of Robot Manipulators", McGraw Hill International Edition, 1998.
5. Foundations of Robotics : T. Yoshikawa , PHI India

17/7/23 17/7

COURSE OUTCOMES:

On successful completion of the course, students will be able to

CO1: Understand the basic concept of industrial robotic Manipulator

CO2: Derive direct and inverse kinematic equations of a given robot.

CO3: Derive the dynamic equations of an industrial robot.

CO4: Develop the control algorithm necessary to run the given robot

ELECTRICAL ENGINEERING DEPARTMENT

EEMI406B DRONE TECHNOLOGY

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description:
The course is meant to help students understand and get acquainted with the droning technology currently used and at the same time acquire and develop high-quality skills and competences, including entrepreneurial and digital competencies. The course also provides information on programming, operating, maintaining and using them safely

Course Contents:

Unit-I **(12)**
Introduction to drones and their applications: - Definition of drones, history of drones, India and drones, tinkering and drones.

Structural classification of drones: - fixed wing structure, lighter than air systems, rotary wings aircraft, and applications of drones

Key features of drone regulations:- Notification of final regulations for civil use, operational and procedural requirements, no drone zones, operations through digital platform, enforcement actions, relevant sections of aircraft act-1934

Unit-II **(10)**
Drone mechanics: concepts of engineering mechanics, Free body diagrams types of loads, force analysis in drones, forces and force systems during drone operations, aerodynamics of drones-dynamics of aerial systems, forces of flight, principle axes and rotation of aerial systemsstability and control of drones, force balancing of rotating masses.

Drone flying and operation Flight modes, small drone operations in a controlled environment, Drone controlled Flight operations, management tool ,Sensors, Onboard storage capacity, Removable storage devices

17/7/23

17/7

Unit-III **(10)**

Radio control system: Introduction of radio control system, Controllers, Transmitter and Receiver, Flight Controllers, Electronic Speed Controller, Battery Eliminator Circuit, Universal Battery Eliminator Circuit, OPTO Coupler. Connections and Interfaces of Devices in Drone

Unit-IV **(10)**

Introduction to drone programming: Introduction to programming language used in drone : C and Python. Installation of cards.Auto Pilot software i.e. Ardupilot, Openpilot.

Case studies in the drones' industry

References/Textbooks:

6. Daniel Tal and John Altschuld, Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation, 2021 John Wiley & Sons, Inc.
7. Terry Kilby and Belinda Kilby, Make:Getting Started with Drones ,Maker Media, Inc, 2016
8. John Baichtal, Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs, Que Publishing, 2016
9. Zavrsnik, Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance, Springer, 2018.
10. Robert L. Boylestad / Louis Nashelsky, "Electronic Devices and Circuit Theory", Latest Edition, Pearson Education.

Course outcomes:

On successful completion of the course, students will be able to

CO1 Understand the historical development of unmanned aerial vehicles, guidelines of drone flying in India and structure of unmanned aerial vehicles

CO2 Understand different drone parts and their contribution for successful flight operation and different types of drone circuits /electronic parts

CO3 Understand various communication systems and their up gradation phenomenon.

CO4 Understand the multidisciplinary theory of engineering branches in drone technology viz. mechanical engineering, electrical engineering and electronics engineering

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEMI407A ELECTRIC VEHICLES

Pre-requisite: Electrical Circuits, Basics of Power Electronics, Basics of Electrical Machines

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief Description about the course: This course contains, introduction to Electrical Vehicles, EV Subsystems. Illustrate the various electric drive configurations and their architectures suitable for electric vehicles and Vehicle Dynamics. Various types of electric machines used in electric vehicles and various energy management strategies employed in electric vehicles.

Unit – I (7)

Introduction to EV: Importance and need for electric vehicles (EV), history and evolution of automobile systems, technology and grid infrastructure side barriers in EV adoption, socio-economic barriers. Classification of EVs, types of hybrids and their operating modes, hybridization ratio. BEVs and their key components, FCEVs and their key components, solar EV, EV versus ICE, emissions due to the electrical grid.

Unit – II (10)

Vehicle Dynamics: Vehicle dynamics, vehicle load forces, aerodynamic drag, rolling resistance, climbing resistance. Estimation of BEV range and effect of auxiliary loads on range, downgrade force and regeneration, rated speed. Gradeability, vehicle acceleration, traction motor characteristics, simple drive cycle for vehicle comparisons. Downgrade force and regeneration, simple drive cycle.

Unit - III (12)

Power Electronic Converters and Electrical Machines in EV: Power electronics circuits used for control and distribution of electric power in DC-DC, AC-DC, DC-AC converters used for EV. Fundamental of Drives and Control of EV with DC motor, Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Design and Sizing of Traction Motors.

Unit – IV (13)

Energy Storage Devices and Management in EV: Overview of battery chemistries, EV battery and its required characteristics, cell, modules & pack. Battery terminologies: C-Rate, SOC, DOD, rated voltage, specific energy, specific power, cycle life, self-discharge. BOL, EOL. Charging characteristics of typical Lithium ion battery used in EVs. Hydrogen fuel cell based

17/7/23 12/7

energy storage for EV, balance of plant (BOP), fuel cell polarization curve and power curve, fuel cell and plant efficiencies, sizing the fuel cell plant. Super-capacitor based energy storage and it's importance in BEV. EV charging: EV charging modes, DC fast charger - Operation, types, limitations. SAE J1772 connector, AC Level 1, 2 & 3 charging, Bharat AC-01 charger. EV charging standards: DC fast charging - CHAdeMO, CCS-combo 1, CCS-combo 2, GB/T, Bharat DC-02, GB/T charger, supercharger.

References/Textbooks:

1. John G. Hayes and G. Abas Goodarzi, "Electric Powertrain- Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles" John Wiley & Sons Ltd, 2018
2. Iqbal Husain, Electric and Hybrid Vehicles – Design Fundamentals, 2 ed., CRC Press, 2016.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, 2 ed., Wiley, 2012.
4. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles – Fundamentals, Theory, and Design, CRC Press, 2005.

Course Outcomes

On successful completion of the course, students will be able to

CO 1: Interpret the importance of electric vehicles, barriers in their adoption, and their Impact on power system.

CO 2: Illustrate the various electric drive configurations and their architectures suitable for electric vehicles and Vehicle Dynamics

CO 3: Discuss the various types of electric machines used in electric vehicles and various energy management strategies employed in electric vehicles

CO 4: Describe the different energy storage devices, battery charging-discharging Characteristics, and various AC and DC charging standards.

ELECTRICAL ENGINEERING DEPARTMENT

EEMI407B POWER CONVERTERS FOR RENEWABLE ENERGY

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description: To explore the various DC, AC converters for renewable energy. To study the different types of PV control schemes for solar energy and also analysis the various types of converters for wind energy and wave energy applications.

Unit - I **(11)**

AC-DC converters: Single phase, three phase controlled and uncontrolled Half-wave converter, 2-pulse midpoint converter, half-controlled and fully-controlled bridge converters, input current and output voltage waveforms, effect of load and source impedance, expressions for input power factor, displacement factor, harmonic factor and output voltage, effect of free-wheeling diode, triggering circuits, Dual converter.

Unit – II **(10)**

Power Converters And Analysis Of Solar PV Systems: Power Converters: Line commutated converters (inversion-mode) – Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. Simulation of line commutated converters, buck/boost converters. Analysis: Block diagram of the solar PV systems – Types of Solar PV systems: Stand-alone PV systems, Grid integrated solar PV Systems – Grid Connection Issues.

Unit – III **(11)**

DC to AC converters

Classification; Series and parallel inverters; Single phase voltage source inverter and analysis with various types of loads; Three phase voltage source inverter with 180° and 120° conduction modes; PWM inverters; PWM techniques, Reduction of harmonics; Voltage regulation in single phase inverters; Single phase current source inverter; Application of voltage source inverter in households and industries

Unit – IV **(10)**

Multilevel Converters/Inverters:

17/7

17/7/23

Introduction to Multilevel Converters, Cascaded H-bridge Multilevel Converters, Output Voltage Waveform Synthesis in CHB Converter and Basic of Asymmetrical CHB Converters, Cascaded H-Bridge Converters: Phase-Shifted PWM & Level-Shifted PWM and other types of converters MMC.

References/Textbooks:

1. P.S. Bhimbra, "Power Electronics," Khanna Publishers, 2018.
2. Mohan N., Undeland T. M. and Robbins W. P., "Power Electronics Converters, Applications and Design", 3rd Ed, Wiley India.
3.Bin Wu, Mehdi Narimani "High-Power Converters and AC Drives, 2nd Edition" Wiley-IEEE Press, 2017.
4. Haitham Abu-Rub, Mariusz Malinowski ,Kamal Al-Haddad "Power Electronics For Renewable Energy Systems, Transportation And Industrial Applications, 1st Edition" Wiley-IEEE Press, 2016.
5.Sixing Du, Apparao Dekka, Bin Wu, Navid Zargari "Modular Multilevel Converters: Analysis, Control, and Applications" (IEEE Press Series on Power Engineering) Hardcover – Import, 2018

Course Outcomes

On successful completion of the course, students will be able to

CO 1 Able to describe basic components of the AC-DC conversion system.

CO 2 To apply knowledge of solar energy application.

CO 3 identify the significance of DC to DC and DC to AC converters and their design for PV and wind

CO 4 To understand Multi-level converters and Different Topologies

ELECTRICAL ENGINEERING DEPARTMENT

EEMD408B MODELLING AND SIMULATION

Pre-requisite:

L	T	P	Credits	Total contact hours
3	0	0	3	42

Brief description:

UNIT-I **(10)**

Review of Probability and Random Number generation. Generating continuous and discrete time random variables. Discussions on deterministic and stochastic modeling of engineering systems. Need for stochastic models. Ideas of model validation.

UNIT-II **(10)**

Modeling of systems as discrete event systems(DES). Continuous time and discrete time Markov chains, Properties of DES (observability and controllability), Supervisory control of DES, Queuing models.

UNIT-III **(10)**

Heuristic modeling, Neural, Fuzzy and Neuro-Fuzzy modeling and simulation of dynamical systems.

Modeling of time delays and introduction to networked dynamical systems.

UNIT-IV **(12)**

Dynamical system simulation, Monte Carlo simulations, generation of simulation data and its statistical analysis, Statistical validation techniques, Goodness of fit test $-\chi^2$ and others, Agent based simulation, Numerical issues in simulation of dynamical systems.

References/Textbooks:

1. Sheldom Ross, "Simulation", Academic Press, Elsevier Imprint, 2006.
2. Sankar Sen Gupta. "System Simulation and Modeling", Pearson Education, 2013.
3. J. Banks, J. S. Carson, B. Nelson and D. M. Nicol, "Discrete Event system simulation", Pearson Education, 5th Edition, 2014.
4. J. R. Jang and C. Sun, "Neuro-Fuzzy Modeling and Control", Proceedings of IEEE, Vol. 83, No. 3, March 1995.

Course Outcome

17/7/23

17/7/23

On successful completion of the course, students will be able to

CO1: Look engineering system from the point of view of stochastic framework

CO2: Model various systems from multiple domains e.g. electrical engineering, bio-informatics, financial systems etc.

CO3 Undertake further industrial and research assignments.

1/7/17

Program Core Labs (Semester III)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC207 COMPUTATIONAL TECHNIQUES LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course CSIC13, EEPC101. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Understand the MATLAB software syntax and will be able to use it for solving various Engineering problems.

CO2 Understand the numerical methods to compute the roots of nonlinear algebraic equations.

CO3 Solve the differential equations using various numerical methods.

CO4 Able to simulate linear systems and implement various kinds of operational amplifiers.

17/7/23

17/7

Program Core Labs (Semester IV)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC213 ANALOG AND DIGITAL ELECTRONICS LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC202. Updated list of experiments will be floated by the course cocrdinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Have a thorough understanding and identification of the components and devices used in analog and digital electronics.

CO2 The ability to verify, analyze and design of the fundamental device characteristics used in analog and digital electronics.

CO3 To understand and examine the structure of various mathematical operation using OPAMP and its application in design.

CO4 The ability to understand, analyze and design various combinational and sequential circuits.

ELECTRICAL ENGINEERING DEPARTMENT

EEPC214 ELECTRICAL MACHINES LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC201. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Parameter evaluation and performance analysis of transformer.

CO2 Parameter evaluation and performance analysis of induction motor 3.

CO3 Parallel operation of transformers.

CO4 Working of Induction machine as induction generator.

17/7

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC215 MEASUREMENT AND INSTRUMENTATION LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC212. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Parameter evaluation and performance analysis of measuring devices.
CO2 Analysis of static measuring devices.
CO3 Understand the operation of measuring transformers.
CO4 Working of different types of bridges.

17/12

Program Core Labs (Semester V)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC305 ELECTRICAL MACHINES LAB-II

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC211. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Performance analysis of DC machine.
CO2 Calculate the efficiency of DC machine.
CO3 Voltage regulation of Synchronous machine.
CO4 Measurement of various reactance of synchronous machine.

17/7/23

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPC306 CONTROL SYSTEMS LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC208. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Understand the time response of various control systems.
CO 2 Describe the transfer function of different control systems.
CO 3 Analyse the closed loop operation of different types of controllers.
CO 4 Understand the frequency response of control operations.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPC307 POWER ENGINEERING LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC209. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1: Evaluate the operation and design of the transmission lines.

CO 2: Apply numerical techniques for load flow calculations.

CO 3: Analyze different faults using Z bus building algorithm and stability of power system,

CO 4: Understand the operation of circuit breakers and high voltage generation techniques.

17/7

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC308 POWER ELECTRONICS LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC210. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Understand characteristics of various power devices.
CO 2 Analyze various power device operations based on experiments.
CO 3 Understand performance analysis of the various power converters.
CO 4 Understand the operation of DC drives.

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPC314 MICROPROCESSORS AND MICROCONTROLLERS LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC302. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Understand the basic hardware knowledge of working using 8085 microprocessor and its applications.

CO 2 Describe the operation and basic hardware knowledge of working using 8051 microcontroller and its applications.

CO 3 Analyse the generation of different waves.

CO 4 Understand the A/D conversion and bit numbers mathematical operations.

17/7/23

17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPC315 POWER ENGINEERING LAB-II

Pre-requisite: EEPC233, EEPC242, EEPC351

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC301. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Apply the economic dispatch and load frequency control for multi area power systems.

CO 2 Understand different protection schemes and plot their operating characteristics.

CO 3 Understand the impact of reactive power compensation of transmission line performance.

CO 4 Analyze the operation of solar and wind energy systems.

17/2

ELECTRICAL ENGINEERING DEPARTMENT

EEPC316 POWER ELECTRONICS LAB-II

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC304. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Understand the operation of various power converters.
CO 2 Describe the operation of different types of tube light chokes.
CO 3 Analyse the performance of a power electronic converters and drives.
CO 4 Understand the operation of solar voltaic system.

17/7/23 17/7

ELECTRICAL ENGINEERING DEPARTMENT

EEPC317 CONTROL SYSTEMS LAB-II

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC303. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Design the controller parameters for different systems.
CO 2 Describe the performance of feedback controller.
CO 3 Analyse the stability of non-linear systems.
CO 4 Understand the feedback controller of control operations.

Program Core Labs (Semester VII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC402 DRIVES LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

Laboratory experiments will be based upon the corresponding theory course EEPC401. Updated list of experiments will be floated by the course coordinator before the beginning of each semester.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO 1 Evaluate the operation Thyristor/ MOSFET/IGBT based dc and ac drives.

CO 2 Apply knowledge of power electronics to AC drive systems.

CO 3 Analyze different Scalar, Vector Control, and Direct Torque Control for EV based motor drive systems

CO 4 Understand the operation of different Intelligent Controllers for DC and AC Machines Drives.

17/7/23 17/7

Program Core Internships (Semester V)
EEPC309 SUMMER INTERNSHIP

Program Core Internships (Semester VII)
EEPC403 SUMMER INTERNSHIP

Course Objectives: The internship is aimed at developing the undergraduate education program in Electrical Engineering to include a practical training in a professional engineering set up (a company, top educational institution, research institute etc.) hereafter referred to as host "organization" as deemed appropriate.

The participating organizations are selected that are either already visiting NIT Kurukshetra for placement or are forming new relationships of mutual benefit. The internship gives the student the opportunity to translate engineering theory into practice in a professional engineering environment. The technical activity in the project should be related to both the student's engineering studies and to the host organization's activities and it should constitute a significant body of engineering work at the appropriate level. It should involve tasks and methods that are more appropriately completed in a professional engineering environment and should, where possible, make use of human and technology resources provided by the organization. It consolidates the student's prior learning and provides a context for later research studies. The student remains a full time registered student at Thapar University during the project semester and this activity is therefore wholly distinct from any industrial interactions which may occur over vacation periods.

Assessment Details:
Each student is assigned a faculty supervisor who is responsible for managing and assessment of the internship semester.
The faculty supervisor monitors the student's progress in a semester and interacts with the industry mentor during his/her visit to the host organization twice.
This includes a Reflective Diary which is updated throughout the project semester, an Interim internship Report, a Final Report with Learning Agreement/Outcomes and a Final Presentation & Viva which involves the faculty Supervisor and some other members from the department.
The mentor from the host organization is asked to provide his assessment on the designated form.
The faculty supervisor is responsible for managing and performing the assessment of the project semester experience.

Course Outcomes:
Upon completion of internship, the students will be able to:

17/7/23

17/7/23

CO1: Acquire knowledge and experience of software and hardware practices in the area of project.

CO2: Carry out design calculations and implementations in the area of project.

CO3: Associate with the implementation of the internship requiring individual and teamwork skills.

CO4: Communicate their work effectively through writing and presentation.

CO5: Demonstrate the knowledge of professional responsibilities and respect for ethics.

17/7

17/7/23

Electrical Engineering Department

Program Core Seminar (Semester VIII)
EEPC408 Seminar

Course Objectives:

Students learn how to search the journals papers, prepare the report and present as seminars. Seminar enhances their knowledge in the new technology domain, develop writing skills, and understand professional skills, team work, ethics, and communication skills in them.

Seminar Evaluation:

The Seminar is evaluated on the basis of presentation cum viva-voce examination and the report submitted by the candidate.

Course Outcomes:

Upon completion of seminar, the students will be able to:

- CO1 Develop interest towards research oriented field with ability to search the literature and brief report preparation.
- CO2 Develop the skills, competencies and points of view needed by professionals in the field most closely related to the Electrical Engineering.
- CO3 Discussion and critical thinking about topics of current intellectual importance.
- CO4 Develop presentation and communication skills.

17/7/23

Electrical Engineering Department

Program Core Project (Semester VII)
EEPC404 Design Project

Program Core Project (Semester VIII)
EEPC409 Major Project

Pre-requisite:
Idea of subjects related to electrical engineering and simulations/experimental setups

Project Allotment:
The students are assigned to a faculty advisor who may follow any one of the following procedure for project identification and allotment:

- Project proposals are invited from students and critically assessed based on previously mentioned quality standards.
- In case the students are willing, topics already identified by the faculty advisor are assigned directly.
- The students are instructed to perform a literature survey pertaining to a specific topic, identify limitations and draft a project proposal

Assessment Details:

- Introduction: Descriptions related to recent topics of research in respective fields, brief knowledge about different authenticated publishers for study materials/literature available on related topics, Selection of topics and selection of good papers.
- Literature Review: Review process of good papers related to the topic, thorough reading of literature, point out the important findings and the opportunities in the related field, selection of the problems, carry out the literature survey in the area of selected problem.
- Problem Formulations: Selection of a particular problem to carry out the further research work.
- Solution Findings: Formulate the solution of the defined problem.
- Simulation/hardware implementation.
- Conclusions and documentation.

Project Monitoring:
The progress of the project is monitored continuously by the faculty supervisors throughout the semester.

Project Evaluation:

17/7/23

The project outcomes are evaluated on the basis of presentation cum viva-voce examination and the report submitted by the candidate

Course Outcomes:

Upon completion of the project, the students will be able to:

CO1: Carry out the literature survey of the particular topic related to electrical system.

CO2: Identify the recent problems/constraints are faced by the research community.

CO3: Investigate the solution to minimize/mitigate the existing problem.

CO4: Validate the proposed solution with the help of simulation/hardware setup.

17/7/23

Annexure

Electrical Engineering Department

EEPC Laboratory Courses

Laboratory experiments will be based upon the corresponding theory courses.

The Tentative lists of Experiments for each of the Laboratory class are attached herewith.

Updated List of experiments will be floated by the course coordinator before the beginning of each Semester.

ELECTRICAL ENGINEERING DEPARTMENT

EEPC 207 Computational Techniques Lab

Pre-requisite

1. Electric Circuit theory
2. Mathematics I & II

L	T	P	Credits	Total contact hours
0	0	3	1	42

List of Experiments

Exp 1 (a) Familiarization with MATLAB software, mathematical operations, programming and Simulink.

(b) Study of Continuous and Discrete time signals.

Exp 2 Study of the time properties of signals.

Exp 3 Study of the frequency properties of the signals.

Exp 4 Study of the basic properties of static and dynamic linear systems.

Exp 5 Solution of DC circuits using

(a) Node analysis
(b) Mesh Analysis

Exp 6 Verification of the following DC circuits theorems:

(a) Maximum Power Transfer Theorem
(b) Superposition Theorem

Exp 7 Solving root-finding problems in one dimension using any numerical method technique.

Exp 8 Implementing and visualizing the response of the linear system to an impulse input.

Exp 9 Nonlinear curve fitting using Artificial Neural Network Toolbox in MATLAB.

Exp 10 Design a model for the tipping problem using the Fuzzy-Logic toolbox in MATLAB.

Text Books / Reference:

1. Gilat, A., 2004. *MATLAB:* An Introduction with Applications. John Wiley & Sons.
2. Sadiku, Matthew NO, and Charles K. Alexander. Fundamentals of electric circuits. McGraw-Hill Higher Education, 2007.

17/7/23

3. Alan V. Oppenheim, Alan S. Willsky, S. Hamid Nawab. Signals and systems, 2nd edition, Prentice-Hall
4. Yang, W.Y., Cao, W., Kim, J., Park, K.W., Park, H.H., Joung, J., Ro, J.S., Lee, H.L., Hong, C.H. and Im, T., 2020. Applied numerical methods using MATLAB. John Wiley & Sons.

Course Outcomes:

Upon successful completion of the course, the students will be able to

1. Understand the MATLAB software syntax and will be able to use it for solving various Engineering problems.
2. Understand the numerical methods to compute the roots of nonlinear algebraic equations.
3. Solve the electric circuits using mesh and nodal analysis.
4. Understand the working of the ANN & Fuzzy logic toolbox in MATLAB and how to use it for curve-fitting problems.
5. Understand the responses and properties of linear systems.
6. Understand the time & frequency domain properties of the signals.

17/7/23

Program Core Labs (Semester IV)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC~~246~~213 ANALOG AND DIGITAL ELECTRONICS LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

List of Experiments

1. To observe the performance of
   a. Common emitter b. Common base c. Common collector amplifiers
2. To study the characteristic of BJT (NPN, PNP), JEET (N-Channel, P-Channel), MOSFET(n-Channel, P- Channel).
3. To study the following mathematical operations using Op-amps:-
   a. Addition b. Subtraction
   c. Multiplication d. Division
   e. Integration f. Differentiation
4. To study the Op-amp as:
   a. Astable multivibrator
   b. Mono-stable multivibrator
   c. Schmitt Trigger circuit
5. To study OP-AMP as non-inverting voltage amplifier, low pass filter, high-pass filter and band-pass filter.
6. To study NOT, AND , OR NOR, XOR, XNOR gates.
7. To study and verify the truth table of R-S,D, J-K and T filp flop.
8. To verify the operation of a 4bit UP and DOWN serial/parallel counter.
9. Study of a combinational circuit of half adder, full adder, subtractor, encoder, decoder, multiplexer and 4 bit digital comparator.
10. Study of shift register SISO, SIPO, PISO, PIPO using shift register.

Course Outcomes:

Upon successful completion of the course, the students will be able to

12/7/23

CO1 Have a thorough understanding and identification of the components and devices used in analog and digital electronics.

CO2 The ability to verify, analyze and design of the fundamental device characteristics used in analog and digital electronics.

CO3 To understand and examine the structure of various mathematical operation using OPAMP and its application in design.

CO4 The ability to understand, analyze and design various combinational and sequential circuits.

ELECTRICAL ENGINEERING DEPARTMENT

EEPC215 Measurement & Instrumentation Lab

Pre-requisite

1. **PHIC11**
2. **PHIC12**

L	T	P	Credits	Total Contact Hours
0	0	2	1	28

Course Description:

The Measurement & Instrumentation Lab is very essential to identify the procedures for different measuring instruments for the measurement of various electrical and non-electrical parameters like power, resistance, inductance, of different ranges and displacement, etc... It will also provide to acquire the knowledge for various measuring instruments.

List of Experiments:

1. To calibrate AC energy meter for different loads.
2. To study the error in Wattmeter at various Power factors.
3. Measurement of the low/medium Resistance by using Kelvin Double Bridge and Wheatstone bridge.
4. To study the basic functions of CRO and measurement of voltage, phase and frequency using CRO
5. Measurement of unknown inductance by using **Maxwell Bridge and Hay' Bridge**
6. Measurement of 3 – Ø power with Two-Wattmeter method for Balanced and Unbalanced loads.
7. To determine the output characteristics of LVDT and measurement of displacement using LVDT.
8. Measurement of strain using Strain Gauge.
9. To study the characteristics of temperature transducer like thermocouple, thermistor and RTD.
10. Study and understanding of "LabVIEW" software and programming.

Course Outcomes:

On successful completion of the course, student can learn

CO 1. Identify different measuring instruments for the measurement of various electrical and non-electrical parameters.

CO 2. Select various transducers for the measurement of physical quantities like temperature, Strain, and displacement etc.

CO 3. Compute the errors present in measuring instruments and calibrate them.

CO 4. Examine the bridges for the measurement of resistance and inductance.

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC214 ELECTRICAL MACHINES LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	3	1	42

List of Experiments

1. Separation of Hysteresis and Eddy current losses of a single phase Transformer.
2. Parallel operation of two single phase transformer of different KVA rating and find the variation of current shared by each transformer vs load current
3. Sumpner's test on two identical single phase Transformers
4. Scott connection of Two Single Phase Transformers
5. To conduct open and short circuit test on three-phase transformer and determine the equivalent circuit parameters in per unit
6. Running light test and Blocked Rotor Test of Three-Phase Squirrel Cage Induction Motor
7. To conduct direct load test on a three phase squirrel cage induction motor and plot input current, torque, power factor, speed and efficiency V/s output power.
8. To determine the rotor resistance of a three phase squirrel cage induction motor by performing variable frequency blocked rotor test.
9. No-Load and Blocked Rotor Test of Capacitor Start Single-Phase Induction Motor
10. To run the induction machine as a self-excited induction generator and plot the variation of terminal voltage and frequency vs speed for different excitation capacitances.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Parameter evaluation and performance analysis of transformer.
CO2 Parameter evaluation and performance analysis of induction motor 3.
CO3 Parallel operation of transformers.
CO4 Working of Induction machine as induction generator.

17/7/23

Program Core Labs (Semester V)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC305 ELECTRICAL MACHINES LAB-II

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	2	1	32

List of Experiments

1. To perform Swinburne's test on a DC Shunt motor
2. To perform Direct load test on DC Compound generator
3. To perform Speed control of DC shunt motor using armature and field control
4. To perform direct load test on Dc shunt motor and plot variation of input current, speed, torque and efficiency against output power.
5. To perform Magnetization characteristics of a DC Machine
6. To measure quadrature axis reactance of a synchronous machine
7. To measure synchronous impedance of a synchronous machine
8. To measure zero power factor characteristics of Synchronous Machine
9. To plot V – Curves for Synchronous Machines
10. To perform slip-test on Salient-Pole Machine

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1 Performance analysis of DC machine.
CO2 Calculate the efficiency of DC machine.
CO3 Voltage regulation of Synchronous machine.
CO4 Measurement of various reactance of synchronous machine.

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC306 CONTROL SYSTEMS LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	2	1	32

List of Experiments

1. Obtain the Step response of the 'First and Second order systems'. Determine the time-domain specifications from their transfer functions.
2. Determine the characteristics of following Error Detectors for the control applications: (i) LVDT, (ii) Potentiometer.
3. Obtain the response of 'P, PI, PD, PID and Relay' control actions on various processes:
   (i) One time constant with and without delay,
   (ii) Two time constant with and without delay
4. Study of a Thermal System and its temperature control:
   (i) Find the transfer function of the Thermal System by obtaining open-loop time response.
   (ii) Determine the closed-loop response by applying PID and Relay control actions;
   (iii) Compare the obtained results.
5. Study the performance of:
   (i) Magnetic Levitation System using P and PD control action.
   (ii) DC Motor position control.
6. (i) Obtain the speed-torque characteristics of AC servomotor.
   (ii) Determine the speed control characteristics of DC motor with control parameter.
7. Design the Lag/Lead compensator of a given system. Obtain the frequency response and analyze.
8. For the given system (TF/SS), perform the simulation exercises in MATLAB environment and obtain the:
   (i) Time-domain specifications,
   (ii) Frequency-domain specifications,
   (iii) Stability.

ELECTRICAL ENGINEERING DEPARTMENT

EEPC357 POWER ENGINEERING LAB-I

Pre-requisite: EEPC233, EEPC242

L	T	P	Credits	Total contact hours
0	0	2	1	32

Brief Description

To perform the experiments on transmission system understand the basic concepts of energy systems with basics of power generation, concepts of transmission and distribution systems, electrical machines fundamentals, and basics of power electronics and drives

Names of the Experiments:

1. To determine ABCD parameters of transmission line and calculate the regulation and efficiency.
2. Bus Admittance Matrix Formulation using graph theory and direct building algorithm considering the impact of phase shifter and transformer.
3. Load Flow Analysis using Gauss-Siedel Method
4. Load Flow Analysis using Newton Raphson Method and Fast Decoupled technique
5. Z-bus Formation and Symmetrical fault analysis
6. Unsymmetrical Fault Analysis using Z-bus technique
7. Simulation of E-Marx circuit for impulse generation.
8. Demonstration of E-marx circuit for switching and lightening impulse generation.
9. Study of breakdown of air using high voltage AC with different geometries.
10. To study the operation of MCCB and Air Circuit Breaker in SCOE.
11. Stability analysis using RungeKutta Method.
12. Dielectric test on Transformer oil
13. Design of Transmission line using given specifications. (Individual Design Project for the lab, mandatory for all students).

Course Outcomes:

CO 1: Evaluate the operation and design of the transmission lines.
CO 2: Apply numerical techniques for load flow calculations.
CO 3: Analyze different faults using Z bus building algorithm and stability of power system,
CO 4: Understand the operation of circuit breakers and high voltage generation techniques.

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9. Study the performance of an Industrial Process for (i) Level control, and (ii) Flow control.

Course Outcomes:

CO 1. Understand the time response of various control systems.
CO 2. Describe the transfer function of different control systems.
CO 3. Analyse the closed loop operation of different types of controllers.
CO 4. Understand the frequency response of control operations.

17/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC3[illegible]5 POWER ENGINEERING LAB-II

Pre-requisite: EEPC233, EEPC242, EEPC351

L	T	P	Credits	Total contact hours
0	0	2	1	32

Brief Description

The main objective of the course is to 1. Understand the different concepts in power systems by performing various experiments and tests in the laboratory.

List of Experiments

1. Load frequency control using SIMULINK considering different controllers
2. Economic load dispatch study using GAMS software
3. Study and experimentally plot the operating characteristics of Overcurrent relay
4. Study and experimentally plot the operating characteristics of Differential Relay
5. Study and experimentally plot the operating characteristics of Overvoltage and under voltage relay
6. Study and experimentally plot the operating characteristics of Under frequency and over frequency relay
7. Study and experimentally plot the operating characteristics of Buchholz relay
8. Study and experimentally plot the operating characteristics of microprocessor based over current relay
9. Study and experimentally plot the operating characteristics of negative sequence relay
10. Study and experimentally plot the operating characteristics of Reverse Power Relay
11. To study the behavior of transmission line using reactive power compensators.
12. Solar PV simulator using PV emulator
13. Wind power simulator using wind emulator
14. A hardware based design project based on the above experiments

Course Outcomes:

CO 1. Apply the economic dispatch and load frequency control for multi area power systems.
CO 2. Understand different protection schemes and plot their operating characteristics.
CO 3. Understand the impact of reactive power compensation of transmission line performance.
CO 4. Analyze the operation of solar and wind energy systems.

12/7/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC358 POWER ELECTRONICS LAB-I

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	2	1	32

List of Experiments

1. To study characteristics of MOSFET, IGBT, SCR TRIAC, DIAC.
2. To study UJT as relaxation oscillator.
3. To study commutation circuits of SCR.
4. To study performance of single phase half controlled and fully controlled bridge rectifier.
5. To simulate in PSIM and MATLAB experiment No. 4.
6. To study the operation of three phase full wave rectifier circuit.
7. To study the single phase AC Motor speed control using TRIAC.
8. To study SCR based Cycloconverter.
9. To study single phase Dual converter and Cycloconverter using MATLAB.
10. To study speed control of DC motor using Three phase fully controlled rectifier circuit using PSIM.

Course Outcomes:

CO 1. Understand characteristics of various power devices.
CO 2. Analyze various power device operations based on experiments.
CO 3. Understand performance analysis of the various power converters.
CO 4. Understand the operation of DC drives.

17/7/23 17-7

ELECTRICAL ENGINEERING DEPARTMENT

EEPC306 POWER ELECTRONICS LAB-II

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	2	1	32

List of Experiments

1. To study performance of unity power factor and law power factor choke based tube-right.
2. To study buck, boost and buck-boost chopper.
3. To study single phase inverter.
4. To simulate in PSIM expt. 2&3.
5. To simulate in MATLAB expt. 2&3.
6. To study three phase inverter.
7. To study V-I and V-P curve of solar PV modules in different combinations in the field.
8. To simulate experiment 6 in MATLAB
9. To study Solar simulation of Dark & illuminated current voltage characteristics of solar cell.
10. To simulate CUK converter using PSIM

Course Outcomes:

CO 1. Understand the operation of various power converter.
CO 2. Describe the operation of different types of tube light chokes.
CO 3. Analyse the performance of a power electronic converters and drives.
CO 4. Understand the operation of solar voltaic system.

12/3/23

ELECTRICAL ENGINEERING DEPARTMENT

EEPC307 CONTROL SYSTEMS LAB-II

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	2	1	32

List of Experiments

1. (a) Study the model of Magnetic levitation system and check its response for stabilization.

   (b) Design a controller and implement for the maglev systems.
2. (a) Study the model of twin rotor twin rotor aero-dynamical system.

   (b) Design a controller to control pitch and yaw angles of the model.
3. Design and implement a state feedback controller for the rotary flexible link.
4. (a) Analyze the performance of single rotary inverted pendulum through experimental study by applying a feedback controller.

   (b) Determine the stability of closed- loop systems in the presence of uncertainty.
5. (a) Analyze the stability of nonlinear systems having nonlinearities (Relay, Dead - zone, Hysteresis of their combination) using phase plane analysis.

   (b) Describe the function method of non-linear systems.
6. (a) Analyze the performance of double rotary inverted pendulum through experimental study by applying a feedback controller.

   (c) Determine the stability of closed- loop systems in the presence of uncertainty.
7. Study of Micro-Controller kit with interfacing to ADC of Stepper Motor.
8. To design a feedback controller for reducing the vibrations in the Torsional System.
9. To design a controller for the level and flow control in the Coupled-Tank system.

Course Outcomes:

CO 1. Design the controller parameters for different systems.
CO 2. Describe the performance of feedback controller.
CO 3. Analyse the stability of non-linear systems.
CO 4. Understand the feedback controller of control operations.

17/7/23

Program Core Labs (Semester VII)

ELECTRICAL ENGINEERING DEPARTMENT

EEPC402 DRIVES LAB

Pre-requisite:

L	T	P	Credits	Total contact hours
0	0	2	1	32

List of Experiments

1. Speed Control of separately excited DC motor using Full Controlled Converter and Chopper using MATLAB.
2. Speed Control of separately excited DC motor using Three-Phase Full and Semi-Controlled Rectifier using PSIM.
3. Speed Control of three-phase Slip Ring Induction Motor using Static Rotor Resistance control.
4. Control speed of a 3 phase induction motor in variable stator voltage mode using 3-phase AC voltage regulator Using PSIM.
5. Control of 3-Phase Induction Motor in variable frequency V/f constant mode using 3-phase inverter Using MATLAB.
6. Vector Control of Three Phase Induction Motor Using MATLAB .
7. Vector Control of Three Phase Permanent Magnet Synchronous Machine Using MATLAB.
8. Vector Control of Three Phase Permanent Magnet Synchronous Machine Using Real-Time Simulator.
9. Direct Torque Control of Three Phase Induction Motor Using MATLAB.
10. Direct Torque Control of Three Phase Permanent Magnet Synchronous Machine Using MATLAB
11. Intelligent Controllers for Speed control of DC Drives using MATLAB.
12. Intelligent Controllers for DTC control of 3-Phase Induction Motor Drives using MATLAB.
13. Intelligent Controllers for DTC control of 3-Phase Permanent Magnet Synchronous Machine Drives using MATLAB

Course Outcomes:

CO 1: Evaluate the operation Thyristor/ MOSFET/IGBT based dc and ac drives.

12/7/23

CO 2: Apply knowledge of power electronics to AC drive systems.
CO 3: Analyze different Scalar, Vector Control, and Direct Torque Control for EV based motor drive systems
CO 4: Understand the operation of different Intelligent Controllers for DC and AC Machines Drives.

12/7/23