KAMARAJ COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)

S.P.G.Chidambara Nadar - C.Nagammal Campus

S.P.G.C. Nagar, K.Vellakulam – 625 701 (Near VIRUDHUNAGAR).

Department of Electrical and Electronics Engineering

B.E. Electrical and Electronics Engineering

(Regulations 2020 – Autonomous)

Vision of the Department:

To make the Department of Electrical and Electronics Engineering of this Institution the unique of its kind in the field of Research and Development activities in this part of the world.

Mission of the Department:

Department of Electrical and Electronics Engineering is committed to

1. Inculcate technical knowledge by providing well-balanced curriculum to the urban and unreachable rural student community through "Total Quality Education"
2. Induce leadership and entrepreneurial skills with high standard of ethics and moral values to the student community.
3. Impart innovative skills to the student community by effectively involving them in research activities.
4. Create a wholesome environment to promote effective interaction of students with the industry experts

Program Educational Objectives (PEOs):

Graduates of the programme will be able to

1. Technical Knowledge:

Apply Technical knowledge acquired in the field of Electrical and Electronics Engineering and allied areas for practical or industrial problems for a successful professional career

2. Problem Solving:

Develop and envisage appropriate solutions for real time technological problems faced by the industries and society.

3. Personality Development

Demonstrate interpersonal skills, soft skills and leadership quality blended with ethical and social responsibility for a prospective career

4. Life Long Learning:

Habituate life-long learning so as to adapt to the emerging needs of the profession

Program Specific Outcomes (PSOs):

PSO 1: Ability to design and solve engineering problems by applying the fundamental knowledge of Engineering Mathematics, Basic Sciences, Electrical and Electronics Engineering.

PSO 2: Ability to understand the recent technological developments in Electrical & Electronics Engineering and develop products / software to cater the Societal & Industrial needs.

SEMESTER V

S. No.	Course Code	Course Name	Category	Contact Periods	Credits			
					L	T	P	C
Theory								
1.	EE1501	Power System Analysis	PC	3	3	0	0	3
2.	EE1571	Control Systems	PC	4	3	1	0	4
3.	EE1572	Microprocessors and Microcontrollers	PC	3	3	0	0	3
4.		Professional Elective I	PE	3	3	0	0	3
5.		Open Elective I	OE	3	3	0	0	3
6.		Audit Course II	AU	3	3	0	0	0
Practical								
7.	EE1511	Control and Instrumentation Laboratory	PC	4	0	0	4	2
8.	EE1581	Microprocessors and Microcontrollers Laboratory	PC	4	0	0	4	2
9.	EE1521	Presentation Skills and Technical Seminar	EEC	2	0	0	2	1
			Total	**29**	**18**	**1**	**10**	**21**

SEMESTER VI

S. No.	Course Code	Course Name	Category	Contact Periods	Credits			
					L	T	P	C
Theory								
1.	EE1601	Power Electronics and Drives	PC	3	3	0	0	3
2.	EE1602	Protection and Switchgear	PC	3	3	0	0	3
3.	EE1603	Renewable Energy Systems	PC	3	3	0	0	3
4.	EE1671	Digital Signal Processing	PC	3	3	0	0	3
5.		Professional Elective II	PE	3	3	0	0	3
6.		Online Course I*	OL	3	3	0	0	3
Practical								
7.	EE1611	Power Electronics and Drives Laboratory	PC	4	0	0	4	2
8.	EE1612	Renewable Energy Systems Laboratory	PC	4	0	0	4	2
9.	HS1621	Verbal Reasoning and Aptitude	EEC	2	0	0	2	1
			Total	**28**	**18**	**0**	**10**	**23**

*Total of 3 credits to be earned before the end of 7th Semester

Professional Elective Courses (PE)

S. No.	Course Code	Course Name	Category	Contact Periods	Credits			
					L	T	P	C
Professional Elective I (5th Semester)								
1.	EE1531	Design of Electrical Apparatus	PE	3	3	0	0	3
2.	EE1532	Internet of Things and Its Applications	PE	3	3	0	0	3
3.	EE1533	Machine Learning Applications for Electrical Engineering	PE	3	3	0	0	3
4.	EE1534	Power System Transients	PE	3	3	0	0	3
5.	EE1535	Special Electrical Machines	PE	3	3	0	0	3
Professional Elective II (6th Semester)								
1.	EE1631	Advanced Control Systems	PE	3	3	0	0	3
2.	EE1632	Electric Vehicles and Energy Management	PE	3	3	0	0	3
3.	EE1633	Energy Storage Technology	PE	3	3	0	0	3
4.	EE1634	Power Quality	PE	3	3	0	0	3
5.	EE1635	Principles of Robotics	PE	3	3	0	0	3

Open Electives offered by Department of EEE

S. No.	Course Code	Course Name	Category	Contact Periods	Credits				Offered to Dept.
					L	T	P	C	
Open Elective I (5th Semester)									
1.	OEE151	Bio Electronics	OE	3	3	0	0	3	BT
2.	OEE152	Control System Analysis	OE	3	3	0	0	3	AD, CSE, IT
3.	OEE153	Green Building	OE	3	3	0	0	3	MECH, MTR, CIVIL
4.	OEE154	Renewable Energy Sources	OE	3	3	0	0	3	ALL
5.	OEE155	Soft Computing Techniques and Applications	OE	3	3	0	0	3	ALL

EE1501	POWER SYSTEM ANALYSIS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To model the power system under steady state operating condition
- To apply numerical iterative techniques for load flow studies.
- To model and carry out short circuit studies on power system
- To model and analyze stability problems in power system

UNIT I INTRODUCTION TO POWER SYSTEM 9

Power scenario in India - Power system components (Synchronous generator, Synchronous motor, Transmission line, off-nominal transformer & load) – Representation - Single line diagram - per unit quantities - p.u. impedance diagram and reactance diagram - Network graph, Bus incidence matrix, Primitive parameters- Formation of bus admittance matrix using Two rule method and Singular Transformation method.

UNIT II POWER FLOW ANALYSIS 9

Significance of power flow analysis- Bus classification (PV, PQ and SB) - Power Flow equations in polar coordinates - Power flow solution using Gauss Seidel method - Handling of Voltage controlled buses - Power Flow Solution by Newton Raphson method.

UNIT III SYMMETRICAL FAULT ANALYSIS 9

Importance of short circuit studies- Assumptions in short circuit analysis - Symmetrical short circuit analysis using Thevenin's theorem – Formation of Bus Impedance matrix using bus building algorithm (without mutual coupling) - Symmetrical fault analysis using bus impedance matrix - Current limiting reactors.

UNIT IV UNSYMMETRICAL FAULT ANALYSIS 9

Symmetrical components - Sequence impedances - Sequence networks - Analysis of unsymmetrical faults at generator terminals: LG, LL and LLG faults - computation of post fault currents in symmetrical components and phasor domain.

UNIT V STABILITY ANALYSIS 9

Importance of stability studies-Classification of power system stability – Rotor angle stability - Swing equation - Swing curve - Power-Angle equation - SMIB system - Equal area criterion - Critical clearing angle and time - Classical step-by-step solution of the swing equation – fourth order Runge Kutta method (Simple numerical problems).

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Model and develop the per unit equivalent circuit of power system network and to determine the various network matrices by suitable method.

CO2: Formulate the power flow problem and solve using numerical iterative methods

CO3: Solve the given power system network under symmetrical faults using appropriate technique

CO4: Determine the fault current and post fault voltage when subjected to unsymmetrical faults.
CO5: Classify power system stability and derive the swing equation for SMIB system and to assess the transient stability of given SMIB system by appropriate technique

TEXT BOOKS:

1. Stevenson Jr, W. and Grainger, J., 2015. *Power system analysis*. McGraw-Hill Education.
2. Kothari, D.P. and Nagrath, I.J., 2019. *Power System Engineering, 3e*. McGraw-Hill Education.

REFERENCES:

1. Saadat, H., 2015. 'Power System Analysis', Tata McGraw Hill Publishing Company, New Delhi, 2010.
2. Pai, M.A. and Chatterjee, D., 2014. *Computer techniques in power system analysis*. McGraw-Hill Education (India).
3. Glover, J.D., Sarma, M.S. and Overbye, T., 2012. *Power system analysis & design, SI version*. Cengage Learning.
4. Gupta, B.R., 2008. *Power System*. S. Chand publishing.
5. Kundur, P., 2010. Power system stability. *Power system stability and control*, pp.7-1.

EE1571 CONTROL SYSTEMS

L	T	P	C
3	1	0	4

OBJECTIVES:

- To introduce the basic control system components for the analysis of physical systems.
- To provide adequate knowledge on the time response analysis and steady state error analysis of linear systems.
- To accord basic knowledge in obtaining the open loop and closed–loop frequency response analysis of linear systems.
- To introduce the concepts of stability analysis and design of various types of compensators.
- To introduce state variable representation of physical systems.

UNIT I SYSTEMS AND REPRESENTATION 12

Basic elements in control systems: Open and closed loop systems – Mathematical Models – Differential Equations - Electrical analogy of mechanical and thermal systems – Transfer function – Block diagram reduction techniques – Signal flow graphs- Case Study: AC and DC servomotors

UNIT II TIME RESPONSE ANALYSIS 12

Time response: Time domain specifications – Standard Test Signals – Time domain analysis of I and II order system – Error coefficients – Generalized error series – Steady state error – Root locus construction- Effect of addition of poles and Zeros - Effects of P, PI, PID modes of feedback control

UNIT III FREQUENCY RESPONSE ANALYSIS 12

Frequency response: Bode plot – Polar plot – Determination of closed loop response from open loop response (M and N circles) - Correlation between frequency domain and time domain specifications

UNIT IV STABILITY AND COMPENSATOR DESIGN 12

Characteristic equation – Routh Hurwitz criterion – Nyquist stability criterion- Performance criteria –Effect of Lag, lead and lag-lead compensation on frequency response-Design of Lag, Lead and Lag Lead compensator using bode plots**.**

UNIT V STATE VARIABLE ANALYSIS 12

Concepts of state variables – State models for linear and time invariant Systems (Controllable, Observable and Jordan Models) – Equivalence between transfer function and state variable representations - Solution of state and output equation – Concepts of controllability and observability

TOTAL: 60 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to
CO1: Develop mathematical model for various physical systems.
CO2: Determine time-domain specifications of given linear system and discuss on applications of various types of conventional controllers (P, PI and PID)
CO3: Obtain the frequency response analysis of given linear system using bode and polar plot.
CO4: Analyze the stability of control system using suitable methods and design compensator s for the given specifications.
CO5: Frame various types of state space model for a system and obtains its solution.

TEXT BOOKS:

1. Nagrath, I.J., 2018. *Control systems engineering*. New Age International
2. Kuo, B.C., 2018. *Automatic control systems*. Wiley.

REFERENCES:

1. Gopal, M., 2012. *Control systems: principles and design*. Tata McGraw-Hill Education.
2. Ogata, K. and Yang, Y., 2002. *Modern control engineering* (Vol. 4). India: Prentice hall.
3. Dorf, R.C. and Bishop, R.H., 2011. *Modern control systems*. Pearson.
4. Dutton, K., 1997. *The art of control engineering*. Addison-Wesley Longman Publishing Co., Inc..
5. Houpis, C.H. and Sheldon, S.N., 2013. *Linear Control System Analysis and Design with MATLAB®*. CRC Press.
6. NPTEL Video Lecture Notes on "Control Engineering"

EE1572 MICROPROCESSORS AND MICROCONTROLLERS **L T P C**

3 0 0 3

OBJECTIVES:

- To learn the programming concepts in 8085 Processor
- To understand the features of 8051
- To deliver the introduction in PIC
- To learn basic concepts of Embedded C Programming
- To study the interfacing of different sensors with Arduino

UNIT I: MICROPROCESSOR 8085 **9**

Pin out and Architecture of 8085-Instruction format- Classifications of Instructions- size, operations and addressing modes-Data transfer and manipulation instructions-Branching and Machine related instructions-Timing Diagram

UNIT II: MICROCONTROLLER 8051 **9**

Hardware Architecture, pin outs of 8051- -RAM addressing- Ports in 8051- SFRs- Addressing mode- Instruction set- Stepper and Servo motor control

UNIT III: PIC MICROCONTROLLER **9**

CPU Architecture-Instruction set- Timers-UART-A/D Converter- PWM - Introduction to C compiler.

UNIT IV: EMBEDDED C PROGRAMMING **9**

Introduction to Embedded C - Data types, programming for time delay - I/O programming - Logical operations - Control statements and loops - Timer/Counter and Interrupt Techniques.

UNIT V: ARDUINO AND ITS APPLICATIONS **9**

I/O Port Capability of Arduino UNO- Variables –Looping statement-Operators- Simple Programming: Temperature Monitoring- Distance Measurement- Obstacle detection.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Describe the architecture, different operations and interfacing concept of 8085

CO2: Understand the special features and programming concepts in 8051

CO3: Comprehend the architecture and functionality of PIC microcontroller

CO4: Develop programs using embedded C

CO5: Develop a high level programming knowledge in Arduino

TEXT BOOKS:

1. Ramesh Gaonkar 2013. *Microprocessor Architecture Programming and Applications with 8085*, Penram Intl. Publishing, 6th Edition.
2. Kenneth Ayala 2007. *The 8051 Microcontroller*, Cengage Learning Publications, 3rd Edition.

REFERENCE BOOKS:

1. Muhammad Ali Mazidi, Janice GillispieMazidi & RolinMcKinlay 2012. *The 8051 Microcontroller and Embedded Systems using Assembly and C*, Prentice Hall Publications, 2nd Edition.
2. Ray,A.K., & Bhurchandi , K.M., 2013. *Advanced Microprocessor and Peripherals*, Tata McGraw-Hill Publications, 3 rd Edition.
3. Sencer Yeralan& Helen Emery 2000. *Programming and interfacing the 8051 Microcontroller*, Addison-Wesley Publications, 1st Edition.
4. Massimo Banzi, 2014. *Getting Started with Arduino: The Open Source*, Shroff Publishers and Distributors pvt.ltd.
5. Simon monk, 2016. Programming Arduino: Getting Started with Sketches, Mc-Graw Hill Educations, second edition.

		L	T	P	C
EE1511	**CONTROL AND INSTRUMENTATION LABORATORY**	**0**	**0**	**4**	**2**

OBJECTIVES:

To impart knowledge on the analysis and design of control system concepts along with basics of instrumentation.

LIST OF EXPERIMENTS

Control Systems

1. Estimate the effects of P, PI, PD and PID controllers on the Second-order linear system using suitable software package.
2. Perform stability analysis of linear systems using Bode, Root locus & Nyquist plots method using suitable software package.
3. Derive the mathematical modelling of a DC machine and Thermistor
4. Design of Lag, Lead and Lag-Lead Compensators using suitable software package.
5. DC Position Control Systems
6. AC Synchro: Transmitter- Receiver and Characteristics

Instrumentation

7. AC bridges (Anderson bridge) and (Schering bridge), DC bridges (Wheat stone bridge)
8. Study of Displacement Transducer – LVDT, Study of Pressure Transducer, Study of Flow sensor, Study of RDT
9. Calibration of Three Phase Energy meter by direct loading, Measurement of Three Phase power and power factor, Calibration of Single-Phase energy meter
10. Instrumentation Amplifier
11. D/A and A/D converters
12. Real time interfacing of Sensors with Microcontrollers

TOTAL: 60 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to

CO1: Demonstrate the concepts of control theory to perform stability analysis on linear systems

CO2: Design simulation models for controllers/compensators for simple electrical applications.

CO3: Implement bridge circuits to measure various electrical quantities

CO4: Calibrate energy meter and perform signal conditioning of instruments

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No.	Description of Equipment	Quantity Required
Control System		
1.	Digital storage Oscilloscope	1 No.

S. No.	Description of Equipment	Quantity Required
2.	Personal Computer with control system simulation packages (MATLAB)	10 Nos
3.	DC motor –Generator test set-up for evaluation of motor parameters	1 No.
4.	CRO 30MHz	1 No.
5.	Position Control Systems Kit (with manual) –Tacho Generator Coupling set	1 No.
6.	AC Synchro transmitter& receiver	1No.
7.	Sufficient number of Digital multi meters, speed and torque sensors	
8.	Arudino sensor	5 No.
Instrumentation		
9.	R, L, C Bridge kit (with manual)	
10.	Thermistor (silicon type) RTD nickel type	1No.
11.	30 psi Pressure chamber (complete set) – 1No. Current generator (0 – 20mA) Air foot pump – (with necessary connecting tubes)	1No.
12.	LVDT20mm core length movability type – 1No. CRO 30MHz	1No.
13.	Single phase Auto transformer Watt-hour meter (energy meter) Ammeter Voltmeter Rheostat Stop watch Connecting wires	1No
14.	IC Transistor kit	1No
15.	Instrumentation Amplifier kit	1No
16.	Analog – Digital and Digital –Analog converters (ADC and DACs)	1 No

EE1581 MICROPROCESSORS AND MICROCONTROLLERS LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVES:

- To develop the programming skills in 8085 microprocessor and 8051 microcontroller
- To interface sensors with Arduino
- To develop the programming skills in Embedded C

LIST OF EXPERIMENTS

8085 – Based Experiments

1. Simple arithmetic operations: addition / subtraction / multiplication / division.
2. Programming with control instructions:
   (i) Ascending / Descending order, Maximum / Minimum of numbers.
   (ii) Programs using Rotate instructions.

8051-Based Experiments

3. Demonstration of basic instructions with 8051 Micro controller execution, including:
   (i) Arithmetic instructions
   (ii) Conditional jumps & looping
4. Stepper motor control

EMBEDDED C – Based Experiments

5. Programming with timer to generate a Square Waveform
6. Programming with Interrupt Handling Techniques

ARDUINO Based Experiments

7. Display letters in Arduino IDE environment
8. Interfacing Ultrasonic Sensor to measure the distance of an object
9. Interfacing IR sensor to detect the obstacles
10. Closed loop control of stepper and servo motor
11. Mini project using any microcontrollers

TOTAL: 60 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Develop and Execute simple programming in 8085

CO2: Demonstrate the interface concepts in 8085

CO3: Implement the control program using 8051

CO4: Develop and Execute programming in Embedded C.

CO5: Interface different sensors with Arduino

Requirements for a batch of 30 students (3 students per batch)

1	8085 Microprocessor Trainer with Power supply	10
2	8051 Trainer with Power supply	10
3	DAC Interfacing Board	5
4	Stepper Motor	5
5	Stepper Motor Interfacing Board	5
6	Keil Software	10
7	Arduino Uno	10
8	ULN 2003 Module	5

9	Stepper motor - 28 BY J-48 - 5V	5
10	Servo motor - SG90-Microservo motor	5
11	Ultrasonic sensor - HC SR 04	5
12	IR transmitter module	5
13	L293D Module	5
14	PIR Motion sensor	5
15	LDR	10
16	LM35 Sensor	5

EE1521 PRESENTATION SKILLS AND TECHNICAL SEMINAR L T P C

0 0 2 1

OBJECTIVES:

- To encourage the students to study advanced engineering developments.
- To prepare and present technical reports.
- To encourage the students to use various teaching aids such as overhead projectors, power point presentation and demonstrative models.

METHOD OF EVALUATION

During the seminar session each student is expected to prepare and present a topic on engineering/ technology, for duration of about 8 to 10 minutes. In a session of two periods per week, 15 students are expected to present the seminar. Each student is expected to present at least twice during the semester and the student is evaluated based on that. At the end of the semester, he / she can submit a report on his / her topic of seminar and marks are given based on the report. A course instructor is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also. Evaluation is 100% internal.

TOTAL: 30 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1 : Comprehend the various technological developments in domain area of specialization.

CO2: Prepare a documentation report on the chosen topic of interest.

CO3: Give a formal technical presentation on the topic chosen.

EE1601 POWER ELECTRONICS AND DRIVES L T P C

3 0 0 3

OBJECTIVES:

- To impart knowledge on operation, characteristics and performance analysis of power semiconductor devices, converters and inverters.
- To impart knowledge on operation, and performance analysis of AC and DC motor drives.

UNIT I POWR SEMICONDUCTOR DEVICES 9

Study of switching devices – Power - DIODE, SCR, GTO, MOSFET, IGBT, IGCT, Triggering and commutation circuit for SCR, Driver and snubber circuit, Gate pulse generation circuit

UNIT II DC CONVERTERS 9

2-pulse converter, 3-pulse converter, 6-pulse converter, Dual Converters, Performance Parameters of converters, Effect of source inductance.

Introduction to types of choppers – Type A, Type B Choppers. Switched mode Regulators - Buck converter, Boost converter, Buck-Boost converter, Control Strategy, Introduction to Resonant Converters.

UNIT III AC CONVERTERS 9

Single phase voltage source inverters (120^o&180^o mode), Current source inverter, Applications. Single Phase AC Voltage controllers, Single phase cycloelectric -converter, Introduction to Matrix converters.

UNIT IV DC DRIVES 9

Electric drive – Equations governing motor load dynamics – steady state stability – multi quadrant Dynamics: acceleration, deceleration, starting & stopping – typical load torque characteristics – Selection of motor. Steady state analysis of the single and three phase converter fed separately excited DC motor drive –continuous conduction –4 quadrant operation of converter /chopper fed drive-Applications.

UNIT V AC DRIVES 9

Stator voltage control–energy efficient drive–v/f control–constant airgap flux–field weakening mode – voltage – closed loop control. PWM techniques: Sinusoidal PWM, Modified sinusoidal PWM, Multiple PWM, Introduction to Space vector Modulation, Vector control of Induction Motors (Block Diagram). Introduction to BLDC motor drive.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Explain the concept of different types of power semiconductor devices and its gating and triggering circuits.

CO2: Describe the various types of DC – DC converters.

CO3: Illustrate the concept of various types of AC converters.

CO4: Outline the characteristics of DC Drives

CO5: Classify different PWM techniques and outline the characteristics of AC Drives.

TEXT BOOKS:

1. Rashid, M.H., 2004. *Power Electronics Circuits, Devices, and Applications* 3'd Edition. Pearson education–2004.
2. Bimbhra, P.S. and Kaur, S., 2012. *Power electronics* (Vol. 2). Khanna publishers.

REFERENCES:

1. Krishnan, R., 2001. *Electric motor drives: modeling, analysis, and control*. Pearson.
2. Bose, B.K., 2002. *Modern power electronics and AC drives* (Vol. 123). Upper Saddle River, NJ: Prentice hall.

EE1602	PROTECTION AND SWITCHGEAR	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To discuss on the principles and need for protection schemes for different faults.
- To discuss on basic principles, construction and characteristics of different Electromagnetic relays.
- To discuss on protection schemes of different power equipment.
- To discuss on different aspects of static relays and numerical protection schemes.
- To discuss on the principles & construction of different types of circuit breaker.

UNIT I PROTECTION SCHEMES 9

Principles and need for protection schemes – causes and Types of faults – Methods of Grounding - Zones of protection and essential qualities of protection – Protection scheme - Current transformers and Potential transformers and their applications in protection schemes

UNIT II ELECTROMAGNETIC RELAYS 9

Operating principles of relays - the Universal relay – Torque equation – R-X diagram – Electromagnetic Relays – Over current, Directional, Distance, Differential, Negative sequence and Under frequency relays.

UNIT III APPARATUS PROTECTION 9

Transformer protection: Differential Protection - Buchholz Relay - Protection against Over-fluxing – Generator protection: Stator and Rotor protection – loss of excitation and prime mover - Motor protection: Electrical faults - Bus bar protection: Differential protection - Transmission line – Three stepped protection.

UNIT IV STATIC RELAYS AND NUMERICAL PROTECTION 9

Static relays – Phase, Amplitude Comparators – Synthesis of various relays using Static comparators – Block diagram of Numerical relays – Over current protection, transformer differential protection, distance protection of transmission lines.

UNIT V CIRCUIT BREAKERS 9

Physics of arcing phenomenon and arc interruption - DC and AC circuit breaking – re-striking voltage and recovery voltage - rate of rise of recovery voltage - resistance switching – current chopping - interruption of capacitive current - Types of circuit breakers – air blast, air break, oil, SF6, MCBs, MCCBs and vacuum circuit breakers – comparison of different circuit breakers – Rating and selection of Circuit breakers.

Case Study: Air Circuit Breaker and Over Current relay in power house of college campus.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Analyze different types of faults and their effects on the power system and understand the practical significance of protection zones.

CO2: Explain the basic principle, construction and characteristics of different electromagnetic relays.

CO3: Discuss on protection schemes for different power equipment such as transformer, generator etc. against various electrical faults.

CO4: Elucidate static relays and various numerical protection schemes.

CO5: Describe the principle, construction, selection and problems associated with different types of circuit breaker.

TEXT BOOKS:

1. Paithankar, Y.G. and Bhide, S.R., 2011. *Fundamentals of power system protection*. PHI Learning Pvt. Ltd.
2. Rao, S.S., 1982. *Switchgear and Protection: Theory, Practice and Solved Problems*. Khanna publishers.

REFERENCES:

1. Ram, B., 2011. *Power system protection and switchgear*. Tata McGraw-Hill Education.
2. Ravindranath, B. and Chander, M., 1977. *Power system protection and switchgear*. New Age International.
3. Chakrabarti, A., Soni, M.L., Gupta, P.V. and Bhatnagar, U.S., 2000. A text book on Power System Engineering. *Dhanpar Rai and Co.(P) Ltd*.
4. Singh, R.P., 2009. *Switchgear and power system protection*. PHI Learning Pvt. Ltd.
5. Mehta, V.K. and Mehta, R., 2011. Principles of power systems, S. *Chand, New Delhi, India*.
6. Wadhwa, C.L., 2006. *Electrical power systems*. New Age International.

EE1603 RENEWABLE ENERGY SYSTEMS L T P C

3 0 0 3

OBJECTIVES:

- To analyze topology of the stand-alone and grid connected photo-voltaic systems.
- To outline the various forms of wind energy conversion systems.
- To outline the concept of other non-conventional energy sources such as bio mass, hydro,

ocean, geothermal etc.

UNIT I RENEWABLE ENERGY (RE) SOURCES 9

Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources(solar, wind, biomass, ocean and geothermal), Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources.

UNIT II WIND ENERGY 9

Basics of wind energy- Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine-Power in the Wind – Types of Wind Power Plants(WPPs)–Components of WPPs-Working of WPPs(DFIG,PMSG & SCIG based WPPs)- Siting of WPPs-Grid Connected and Stand alone WPPs

UNIT III SOLAR PV AND THERMAL SYSTEMS 9

Solar Radiation, Radiation Measurement, Solar Thermal Power Plant, Central Receiver Power Plants, Solar Ponds.- Thermal Energy storage system with PCM- Solar Photovoltaic systems : Basic Principle of SPV conversion – Types of PV Systems- Types of Solar Cells, Photovoltaic cell concepts: Cell, module, array ,PV Module I-V Characteristics, Efficiency & Quality of the Cell, series and parallel connections, maximum power point tracking (P&O and Incremental conductance algorithm), Applications.

UNIT IV BIOMASS & OTHER RE SOURCES 9

Introduction-Bio mass resources –Energy from Bio mass: conversion processes-Biomass Cogeneration-Environmental Benefits. Geothermal Energy: Basics, Direct Use, Geothermal Electricity. Mini/micro hydro power: Classification of hydropower schemes, Essential components of hydroelectric system, Pumped Storage in Hydro power plants.

UNIT V OCEAN & MODERN ENERGY SOURCES 9

Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems. Wave Energy: Energy from waves, wave power devices. Ocean Thermal Energy Conversion (OTEC)- Hydrogen Production and Storage- Fuel cell : Principle of working- various types - construction and applications. Energy Storage System- Hybrid Energy Systems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able

CO1: To explain the importance of various renewable energy sources and its existing scenario in world.

CO2: To Analyze the different configurations of the wind energy conversion systems.

CO3: To Develop a stand-alone photo voltaic system with MPPT algorithm.

CO4: To Discuss the basic concepts of Biomass Energy and other renewable energy sources such as hydro, geothermal etc.

CO5: To elucidate the concepts of Ocean and modern energy sources such as fuel cell, batteries etc.

TEXT BOOKS:

1. Khan, B.H., 2006. *Non-conventional energy resources*. Tata McGraw-Hill Education.

REFERENCES:

1. Joshua Earnest, Tore Wizeliu, 'Wind Power Plants and Project Development', PHI Learning Pvt.Ltd, New Delhi, 2011.
2. D.P.Kothari, K.C Singal, Rakesh Ranjan "Renewable Energy Sources and Emerging Technologies", PHI Learning Pvt.Ltd, New Delhi, 2013.
3. Scott Grinnell, "Renewable Energy & Sustainable Design", CENGAGE Learning, USA, 2016.
4. Bradley A. Striebig,Adebayo A.Ogundipe and Maria Papadakis," Engineering Applications in Sustainable Design and Development", Cengage Learning India Private Limited, Delhi, 2016.
5. Solanki, C.S., 2015. *Solar photovoltaics: fundamentals, technologies and applications*. Phi learning pvt. Ltd..

EE1671	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the concept of analyzing discrete time signals & systems in the time and frequency domain through mathematical representation.
- To study various time to frequency domain transformation techniques
- To understand the computation algorithmic steps for Fourier Transform
- To study about filters and their design for digital implementation.
- To introduce the programmable digital signal processor & its application.

UNIT I INTRODUCTION 9

Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect.

UNIT II DISCRETE TIME SYSTEM ANALYSIS 9

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z-transform, application to discrete systems - Stability analysis, frequency response – Linear and Circular Convolution.

UNIT III DISCRETE FOURIER TRANSFORM & COMPUTATION 9

DFT properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT & DIF - FFT using radix 2 – Butterfly structure

UNIT IV DESIGN OF DIGITAL FILTERS 9

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. IIR design: Analog filter design –

Butterworth and Chebyshev approximations; digital design using impulse invariant and bilinear transformation - Warping, prewarping - Gibbs Phenomenon

UNIT V DIGITAL SIGNAL PROCESSORS 9

Introduction – Architecture of TMSC5X DSP processor– Features – Addressing Formats – Functional modes - Introduction to Commercial DSP Processors

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Classify the given signal or system based on its mathematical representation and explains the various sampling and quantization techniques in digital signal representation.

CO2: Solve the given discrete time system using Z-transform and analyze its stability using frequency response and determine the DTFT of a given discrete sequence.

CO3: Compute DFT and Inverse DFT using Radix-2 FFT algorithm.

CO4: Design FIR filter using Windowing Technique and IIR filter using Bilinear Transformation and Impulse Invariant Techniques and also to design Analog filters for Butterworth and Chebyshev approximations.

CO5: Discuss the architecture and functional modes of commercial digital signal processors

TEXT BOOKS:

1. Proakis J.G. & Manolakis D.G., 2009, *Digital Signal Processing Principles, Algorithms and Applications*, Pearson Education.
2. Robert J.Schilling & Sandra L.Harris, 2014, *Introduction to Digital Signal Processing using MATLAB*, Cengage Learning.

REFERENCES:

1. Emmanuel C Ifeachor & Barrie W Jervis, 2009, Digital Signal Processing – A Practical approach, Pearson Education.
2. Alan V. Oppenheim, Ronald W. Schafer & John R. Buck., 2010, Discrete – Time Signal Processing, Pearson Education.
3. SenM.kuo, Woonsengs.gan, 2013, Digital Signal Processors, Architecture, Implementations & Applications, Pearson.
4. Mitra S. K., 2011, Digital Signal Processing – A Computer Based Approach, Tata McGraw Hill.
5. Venkataramani, B & Bhaskar, M., 2010, Digital Signal Processors, Architecture, Programming and Applications, Tata McGraw Hill.

EE1611 POWER ELECTRONICS AND DRIVES LABORATORY L T P C

0 0 4 2

OBJECTIVES:

- To study the characteristics of various Power Electronic Devices.
- To impart knowledge in design of Power Converters

- To provide hands on experience in Motor Drives.

LIST OF EXPERIMENTS

1. Gate Pulse Generation using R, RC and UJT triggering circuit.
2. Characteristics of SCR and TRIAC
3. Characteristics of MOSFET and IGBT
4. Speed control of PMBLDC motor.
5. Performance Analysis of Half and Fully controlled Converter with R, RL and RLE load.
6. Performance Analysis of Step down and step up MOSFET based choppers
7. Performance Analysis of IGBT based single phase PWM inverter
8. Performance Analysis of IGBT based three phase PWM inverter
9. Performance Analysis of AC Voltage controller
10. Speed control of Induction motor.
11. Simulation of Power Electronic circuits (1Φ & 3Φ semi converters, 1Φ & 3Φ full converters, DC - DC Converters, AC voltage controllers).
12. Sped control of AC and DC drives.

TOTAL: 60 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Obtain the characteristics of various power semiconductor devices.

CO2: Design and analyze half controlled / fully controlled converter circuits with various loads.

CO3: Illustrate PWM technique used in inverters.

CO4: Simulate and experiment various power electronic converter circuits.

CO5: Obtain the performance characteristics motor drives.

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

1. Device characteristics (for SCR, MOSFET, TRIAC, GTO, IGCT and IGBT kit with built-in /discrete power supply and meters) - 2 each
2. Single phase SCR based half controlled converter and fully controlled converter along with built-in /separate/firing circuit/module and meter – 2 each
3. MOSFET based step up and step down choppers (Built in/ Discrete) – 1 each
4. IGBT based single phase PWM inverter module/Discrete Component – 2
5. IGBT based three phase PWM inverter module/Discrete Component – 2
6. Switched mode power converter module/Discrete Component – 2
7. SCR &TRIAC based 1 phase AC controller along with lamp or rheostat load – 2
8. Cyclo converter kit with firing module – 1
9. Dual regulated DC power supply with common ground
10. Cathode ray Oscilloscope –10
11. Isolation Transformer – 5
12. Single phase Auto transformer –3
13. Components (Inductance, Capacitance) 3 set for each
14. Multi meter – 5
15. LCR meter – 3

16. Rheostats of various ranges – 2 sets of 10 value
17. Work tables – 10
18. DC and AC meters of required ranges – 20
19. Component data sheets to be provided
20. PMBLDC motor – 1

EE1612	RENEWABLE ENERGY SYSTEMS LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To impart knowledge in design of Renewable Energy Sources and technologies.
- To provide adequate inputs on a variety of issues in harnessing Renewable Energy.
- To recognize current and possible future role of Renewable energy sources.

LIST OF EXPERIMENTS

1. Simulation study on Solar PV Energy System.
2. Experiment on "IV & PV Characteristics of Solar PV System".
3. Experiment on "Shadowing effect & diode based solution in Solar PV System".
4. Experiment on Performance assessment of Grid connected Solar Power System.
5. Experiment on Performance assessment of Standalone Solar Power System.
6. Simulation study on Wind Energy Generator.
7. Experiment on Performance assessment of micro Wind Energy Generator.
8. Simulation study on Hybrid (Solar-Wind) Power System.
9. Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.
10. Experiment on Performance Assessment of Fuel Cell.
11. Simulation study of Energy storage technologies for RE Applications.

TOTAL: 60 PERIODS

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

S. No.	Description of Equipment	Quantity Required	Quantity Required
1.	Personal Computers (Intel Core i3, 80 GB, 2 GB RAM)	15	-
2.	CRO	9	30 MHZ
3.	Digital Multimeter	10	Digital
4.	PV panels - 100W, 24V	1	-
5.	Battery storage system with charge and discharge control 40Ah	1	-
6.	PV Emulator	1	-

7.	Micro Wind Energy Generator module	1	-
Consumables (Minimum of 5 Nos. each)			
8.	Potentiometer	5	-
9.	Step-down transformer	5	230V/12-0-12V
10.	Component data sheets to be provided		

HS1621 VERBAL REASONING AND APTITUDE L T P C

0 0 2 1

OBJECTIVES:

- To improve their problem-solving skill.
- To give the basic idea about aptitude and reasoning for their GATE exam.
- Make them Employable Graduates
- Develop their confidence and help them attend interviews successfully.

UNIT I NUMERICAL COMPUTATION 6

Percentages - Ratios – powers – exponents and logarithms – Permutation and combination

UNIT II ANALYTICAL APTITUDE 6

Logical Induction and Deduction – Analogy – Word analogy, Numerical Analogy, Mixed analogy, Image analogy.

UNIT III DATA INTERPRETATION 6

Table charts- Pie Charts- Bar Charts- Line Charts – Maps

UNIT IV VERBAL 6

Reading Comprehension- Sentence Rearrangement- Error Detection- Antonyms and Synonyms - Subject verb agreement - One word substitution

UNIT V INTERVIEW SKILLS 6

Self-Introduction- Individual presentation practice - Participating in group discussions - GD strategies - Interview etiquette - FAQs related to job interviews

TOTAL: 30 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to
CO1: Apply speed math tricks.
CO2: Develop their thinking ability.
CO3: Interpret data from various types of chart.
CO4: Apply their verbal skills to participate effectively in competitive exams.
CO5: Participate confidently in Group Discussions and Job interviews.

TEXT BOOKS:

1. Raman, Meenakshi and Sangeeta Sharma. Professional Communication. Oxford University

Press: Oxford, 2014.

REFERENCES:

1. Agarwal.R.S, "Quantitative Aptitude for Competitive Examinations", S.Chand Limited 2011.
2. Abhijit Guha, "Quantitative Aptitude for Competitive Examinations", Tata McGraw Hill, 3rd Edition, 2011.
3. Dr. R.S. Agarwal, "A modern approach to Verbal & Non-Verbal Reasoning", S. Chand Limited, 2nd Edition, 2018.
4. Edgar Thorpe, "Course in Mental ability and Quantitative Aptitude for Competitive Examinations", Tata McGraw Hill, 2nd Edition, 2001.
5. E. Suresh Kumar et al. Communication for Professional Success. Orient Blackswan: Hyderabad, 2015.

EE1531 DESIGN OF ELECTRICAL APPARATUS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To describe the magnetic circuit parameters and design of lap and wave windings
- To design the core, yoke, windings and cooling systems of transformers.
- To design the armature and field systems for D.C. machines.
- To design the stator and rotor of induction machines and synchronous machines.
- To implement the computer aided design method for electrical apparatus provided

UNIT I DESIGN OF FIELD SYSTEM AND ARMATURE 9

Major considerations in Electrical Machine Design – Materials for Electrical apparatus – Design of Magnetic circuits – Magnetizing current – Flux leakage – Leakage in Armature- Design of lap winding and wave winding.

UNIT II DESIGN OF TRANSFORMERS 9

Construction - kVA output for single and three phase transformers – Overall dimensions – Design of yoke, core and winding for core and shell type transformers Estimation of No-load current- Temperature rise in Transformers – Design of Tank and Cooling tubes of Transformers - Computer program: Complete Design of single-phase core transformer

UNIT III DESIGN OF DC MACHINES 9

Construction - Output Equations – Main Dimensions – Choice of specific loadings – Carter's Coefficient - Selection of number of poles – Design of Armature – Design of commutator and brushes – Design of field - Computer program: Design of Armature main dimensions

UNIT IV DESIGN OF INDUCTION MOTORS 9

Construction - Output equation of Induction motor – Main dimensions – choice of specific loadings – Design of squirrel cage rotor and wound rotor – Design of rotor bars and slots – Design of end rings - short circuit current Circle diagram, Operating characteristics: Magnetizing current - Computer program: Design of slip-ring rotor

UNIT V DESIGN OF SYNCHRONOUS MACHINES 9

Output equations – choice of specific loadings – Design of salient pole machines – Short circuit ratio – Armature design – Estimation of air gap length – Determination of full load field MMF - Design of rotor –Design of damper winding — Design of field winding – -Computer program: Design of Stator main dimensions-Brushless DC Machines

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Explain the design considerations for rotating and static electrical machines and its field system

CO2: Design various parts of single and three phase transformers using suitable equations.

CO3: Design armature and field circuit of DC machines using output equations.

CO4: Design different types of induction motor (squirrel cage and wound rotor) using its output equations.

CO5: Design and analyze the stator and rotors parts of synchronous machines using its output

equation.

TEXTBOOKS:

1. Sawhney, A.K., 1976. *A course in electrical machine design*. Dhanpat Rai and Sons.
2. V Rajini, V.S Nagarajan, 2017. *Electrical Machine Design*, Pearson.

REFERENCES:

1. Sen, S.K., 2009. *Principles of Electrical Machine Designs with Computer Programmes*. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
2. M V Deshpande, 2011. *Design and Testing of Electrical Machines*. PHI learning Pvt Lt.
3. A.Shanmugasundaram, G.Gangadharan, R.Palani, 2007. *Electrical Machine Design Data Book*, New Age International Pvt. Ltd., Reprint.

EE1532	INTERNET OF THINGS AND ITS APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

UNIT I INTRODUCTION TO IoT **9**

Evolution of Internet of Things - Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and connecting Smart Objects.

UNIT II IoT PROTOCOLS **9**

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT.

UNIT III DESIGN AND DEVELOPMENT **9**

Design Methodology - Embedded computing logic - Microcontroller, System on Chips - IoT system building blocks - Arduino - Board details, IDE programming - Raspberry Pi - Interfaces and Raspberry Pi with Python Programming.

UNIT IV DATA ANALYTICS AND SUPPORTING SERVICES **9**

Structured Vs Unstructured Data and Data in Motion Vs Data in Rest – Role of Machine Learning – No SQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework –

Django – AWS for IoT – System Management with NETCONF-YANG.

UNIT V ELECTRICAL DOMAIN APPLICATIONS 9

Real world design constraints - Applications - Battery management system, Inverter power quality investigation, Industrial automation, smart grid, Home automation, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT, Electric vehicle and intelligent transportation systems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1 : Interpolate the evolution and simple architecture of Internet of Things.
CO2 : Analyze various protocols in different layers for IoT.
CO3: Design a portable IoT using Rasperry Pi/Ardiuno.
CO4 : Discuss the concept of data analytics and cloud environment in IoT.
CO5 : Examine applications of IoT in electrical and its allied fields.

TEXT BOOKS:

1. Bahga, A. and Madisetti, V., 2018. *Internet of Things: A hands-on approach*. Vpt.
2. Uckelmann, D., Harrison, M. and Michahelles, F. eds., 2017. *Architecting the internet of things*. Springer Science & Business Media.

REFERENCES:

1. Zhou, H., 2012. *The internet of things in the cloud*. Boca Raton, FL: CRC press.
2. Holler, J., Tsiatsis, V., Mulligan, C., Karnouskos, S., Avesand, S. and Boyle, D., 2014. *Internet of Things*. Academic Press.
3. Hersent, O., Boswarthick, D. and Elloumi, O., 2012. *The internet of things: Key applications and protocols*. John Wiley & Sons.

EE1533 MACHINE LEARNING APPLICATIONS FOR ELECTRICAL ENGINEERING

L	T	P	C
3	0	0	3

OBJECTIVES:

- Analyze and identify significant characteristics of data sets.
- Develop an understanding of training a learning algorithm including over-fitting, noise, convergence and stopping criteria.
- Match a data set with the most promising inductive learning algorithms.
- Understand and implement the training, testing, and validation phases of learning algorithms development and deployment.
- Determine the computational complexity associated with development and execution of learning algorithms for a given data set.

UNIT I INTRODUCTION TO MACHINE LEARNING 9

Introduction to Machine Learning, supervised, unsupervised, reinforcement and semi-supervised modelling / learning -Machine Learning pipeline.

UNIT II SUPERVISED LEARNING 9

Linear Models for Regression –Linear Basis Function Models –The Bias-Variance Decomposition –Bayesian Linear Regression –Common Regression Algorithms –Simple Linear Regression – Multiple Linear Regression –Linear Models for Classification –Discriminant Functions – Probabilistic Generative Models –Probabilistic Discriminative Models –Laplace Approximation – Bayesian Logistic Regression –Common Classification.

Applications of Supervised learning in Load forecasting, Solar forecasting, Wind Prediction and Electricity Price forecasting,

UNIT III UNSUPERVISED LEARNING 9

Mixture Models and EM–K-Means Clustering –Dirichlet Process Mixture Models –Spectral Clustering –Hierarchical Clustering –The Curse of Dimensionality –Dimensionality Reduction – Principal Component Analysis –Latent Variable Models(LVM) –Latent Dirichlet Allocation (LDA). Applications of Unsupervised learning in dynamic security assessment.

UNIT IV ADVANCED LEARNING 9

Reinforcement Learning –Representation Learning –Neural Networks –Active Learning – Ensemble Learning, Bootstrap Aggregation –Boosting –Gradient Boosting Machines –Deep Learning Applications of Unsupervised learning in transient stability assessment of power systems.

UNIT V WEKA TOOL 9

Datasets – Introduction, Iris plants database, Breast cancer database, Auto imports database – Introduction to WEKA, The Explorer – Getting started, Exploring the explorer, Learning algorithms, Clustering algorithms, Association–rule learners.

Applications of WEKA tool in data analytics of Energy consumption

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Define fundamental machine learning models (linear regression, logistic regression, polynomial regression, decision trees, support vector machines, PCA).

CO2: Describe, design, and optimize a regression model.

CO3: Describe, design, and optimize a clustering model.

CO4: Estimate the pricing for reinforcement learning by applying various methods.

CO5: Apply simple machine learning models to engineering applications using WEKA.

TEXT BOOKS:

1. Géron, A., 2019. *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems*. O'Reilly Media.
2. Ayodele, T.O., 2010. Introduction to machine learning. *New Advances in Machine Learning*, pp.1-9.

REFERENCES:

1. Chen, Chong, et al. "Energy consumption modelling using deep learning embedded semi-supervised learning." *Computers & Industrial Engineering* 135 (2019): 757-765.
2. Zhang, R., Wu, J., Xu, Y., Li, B. and Shao, M., 2019. A hierarchical self-adaptive method for post-disturbance transient stability assessment of power systems using an integrated CNN-based ensemble classifier. *Energies*, *12*(17), p.3217.
3. Fenner, M., 2019. *Machine learning with Python for everyone*. Addison-Wesley

Professional- Pearson Education.

EE1534	POWER SYSTEM TRANSIENTS	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge about the following topics:

- Generation of switching transients and their control using circuit – theoretical concept.
- Mechanism of lighting strokes and the production of lighting surges.
- Propagation, reflection and refraction of travelling waves.
- Voltage transients caused by faults, circuit breaker action, load rejection on integrated power system.

UNIT I INTRODUCTION AND SURVEY 9

Review and importance of the study of transients - causes for transients. - double frequency transients -. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning. Case Study: Simulation model of switching of a RL/RLC circuits

UNIT II SWITCHING TRANSIENTS 9

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of source regulation - capacitance switching with a restrike, with multiple restrikes. Illustration for multiple restriking transients - ferro resonance.

UNIT III LIGHTNING TRANSIENTS 9

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes– model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

UNIT IV TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS 9

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling
waves.

UNIT V TRANSIENTS IN INTEGRATED POWER SYSTEM 9

The short line and kilometric fault - distribution of voltages in a power system – Line dropping and load rejection - voltage transients on closing and reclosing lines – over voltage induced by faults - switching surges on integrated system Qualitative application of EMTP for transient computation using PSCAD/EMTDC.

TOTAL: 45 PERIODS

OUTCOMES:

After the completion of the course, student will be able to

- Explain the causes, effects and different types of power system transients
- Describe the concept of switching transients and their control circuit.
- Understand the mechanism of lighting strokes and their associated theories.
- Illustrate the importance of propagation, reflection and refraction of travelling waves.
- Explain voltage transients caused by faults. circuit breaker action and load rejection on integrated power system.

REFERENCES:

1. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Inter Science, New York, 2ndEdition, 1991.
2. Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009.
3. C.S. Indulkar, D.P.Kothari, K. Ramalingam, 'Power System Transients – A statistical approach', PHI Learning Private Limited, Second Edition, 2010.

		L	T	P	C
EE1535	**SPECIAL ELECTRICAL MACHINES**	**3**	**0**	**0**	**3**

OBJECTIVES:

To impart knowledge on the following topics

- Construction, principle of operation, control and performance of stepping motors.
- Construction, principle of operation, control and performance of switched reluctance motors.
- Construction, principle of operation, control and performance of permanent magnet brushless D.C. motors.
- Construction, principle of operation and performance of permanent magnet synchronous motors.
- Construction, principle of operation and performance of other special machines

UNIT I STEPPER MOTORS 9

Constructional features –Principle of operation –Types – Torque predictions – Linear Analysis – Characteristics – Drive circuits and current suppression schemes for stepper motor – Closed loop control – Concept of lead angle – Applications of stepper motors in computer peripherals, robotics and 3D printers.

UNIT II SWITCHED RELUCTANCE MOTORS (SRM) 9

Constructional features –Principle of operation- Torque prediction–Characteristics - Steady state performance prediction – Analytical Method – Current control schemes- Hysteresis and PWM-Power controllers – Control of SRM drive- Sensor less operation of SRM – Applications.

UNIT III PERMANENT MAGNET BRUSHLESS D.C. MOTORS 9

Disadvantages of BLDC motor-Fundamentals of Permanent Magnets- Types- Principle of operation- Magnetic circuit analysis- EMF and Torque equations- Power Converter Circuits and

their controllers - Characteristics and control- Applications.

UNIT IV PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM) 9

Constructional features -Principle of operation – EMF and Torque equations - Sine wave motor with practical windings - Phasor diagram - Power controllers – performance characteristics - Digital controllers – Comparison of PMSM and PMBLDC -Applications.

UNIT V OTHER SPECIAL MACHINES 9

Constructional features – Principle of operation and Characteristics of Hysteresis motor- Synchronous Reluctance Motor–Linear Induction motor-Repulsion motor- AC series motor- Universal motor- Applications.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Interpret the various modes of excitations, drive circuits and control techniques of stepper motor.

CO2: Explicate the Construction, working and Performance of Switched Reluctance Motor

CO3: Analyze the various applications of PMBLDC Motor based on its performance.

CO4: Apply Permanent Magnet Synchronous Motor Drive in an appropriate application based on its performance.

CO5: Explicate the Construction, working and Performance of Hysteresis Motor, Synchronous Reluctance motor, Linear Induction Motor, AC series motor, Universal motor & Repulsion motor.

TEXT BOOKS:

1. Veṅkaṭaratnam, K., 2009. *Special electrical machines*.
2. Kenjo, T., 1984. Stepping Motors and Their Microprocessor Controls, Clarendon. *Oxford, UK*, *4*, pp.620-625.

REFERENCES:

3. Janardanan, E.G., 2014. *Special electrical machines*. PHI Learning Pvt. Ltd.
4. Krishnan, R., 2017. *Switched reluctance motor drives: modeling, simulation, analysis, design, and applications*. CRC press.
5. Kenjō, T. and Nagamori, S., 1985. *Permanent-magnet and brushless DC motors* (Vol. 18). Clarendon Press.
6. Miller, T.J., 1989. Brushless permanent-magnet and reluctance motor drives.

EE1631	ADVANCED CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

To impart knowledge on

- On the design of state feedback control and state observer.
- On phase plane analysis.
- Basics of Digital Control system
- Use of describing function analysis for Non Linear Systems
- Design of optimal controller and estimators

UNIT I STATE VARIABLE ANALYSIS 9

Introduction- concepts of state variables and state model-State model for linear continuous time systems, Diagonalisation- solution of state equations, State Transition matrix, Concepts of controllability and observability.

UNIT II STATE VARIABLE DESIGN 9

Introduction to state model: Effect of state feedback - Pole placement design: Necessary and sufficient condition for arbitrary pole placement, State regulator design - Design of state observers- Separation principle- Design of servo systems: State feedback with integral control.

UNIT III SAMPLED DATA ANALYSIS 9

Introduction spectrum analysis of sampling process signal reconstruction difference equations The Z transform function, the inverse Z transform function, response of Linear discrete system, the Z transform analysis of sampled data control systems, response between sampling instants, the Z and S domain relationship. Stability analysis and compensation techniques.

UNIT IV NON LINEAR SYSTEMS 9

Introduction, common physical non linearity's, The phase plane method: concepts, singular points, stability of non linear systems, construction of phase trajectories system analysis by phase plane method. The describing function method, stability analysis by describing function method, Jump resonance.

UNIT V OPTIMAL CONTROL 9

Introduction: Classical control - P, PI, PID Controllers & Basic Tuning Methods - Optimization, formulation of optimal control problem, Typical optimal control performance measures - Optimal state regulator design: Lyapunov equation, Matrix Riccati equation - LQR steady state optimal control – Application examples.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Interpret a given linear system in State Space Model

CO2: Apply the concepts of State Space Analysis for designing state feedback controller and state observer.

CO3: Interpret a given Digital Control system and test its Stability

CO4: Apply describing function method for interpreting Non Linear Systems

CO5: Design and analyze an optimal controller for any specific application

TEXT BOOKS:

1. M.Gopal, "Digital Control and State Variable Methods", 4th edition, Mc Graw Hill India, 2012

REFERENCES

1. Ogata, K. and Yang, Y., 2002. Modern control engineering, Edition 4, India: Prentice hall.
2. Mohandas, K.P., 2006. Modern Control Engineering. Sanguine, India.
3. Gopal, M., 2014. Modern control system theory. New Age International.

EE1632 ELECTRIC VEHICLES AND ENERGY MANAGEMENT L T P C

3 0 0 3

OBJECTIVES:

- To understand the working of Electric Vehicles and its energy management.
- To apply the concept of different Power Converter topologies in Electric Vehicle applications.

UNIT I INTRODUCTION TO ELECTRIC VEHICLES 9

Introduction to conventional vehicles, electric drive – trains: Basic concepts of Electric traction, Introduction to various electric drive – train topologies, Power flow control in electric drive – efficiency analysis.

UNIT II ELECTRIC PROPULSION UNIT 9

Introduction to electric drives , DC/DC chopper based four quadrant operations of DC drives, Inverter based V/f Operation (motoring and braking) of induction motor drive system, Induction motor based vector control operation Configuration and control of Permanent magnet motor drives, Configuration and control of switched reluctance motor drives, BLDC drives.

UNIT III ENERGY STORAGE 9

Introduction to energy storage requirement in electric vehicles, Battery, Fuel cell, Super capacitor and flywheel based energy storage and its analysis. Introduction to Batteries, Different types, Battery Parameters, Battery modeling, Battery Management system for Lithium ion Batteries.

UNIT IV DRIVE SYSTEM 9

Sizing of propulsion motor, Sizing of Power Electronic converters, Selection of energy storage technology, communications, and supporting sub systems.

UNIT V ENERGY MANAGEMENT STRATEGIES 9

Introduction to Energy Management Strategies used for electric vehicles - Classification, comparison, Implementation issues. Case study: Battery Electric Vehicle (BEV). Introduction to V2G and G2V technology.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to
CO1: Discuss on basic concept of electric traction and various train topologies.
CO2: Choose a suitable drive scheme for developing a hybrid electric vehicle depending on available resources.
CO3: Identify the appropriate energy storage system for electric vehicle applications.
CO4: Explicate the sizing and selection of various sub systems in electric vehicle Application.
CO5: Illustrate the various strategies of energy Management system used in Electric vehicle application.

TEXT BOOKS:

1. Husain, I., 2011. *Electric and hybrid vehicles: design fundamentals*. CRC press.
2. Ehsani, M., Gao, Y., Longo, S. and Ebrahimi, K., 2018. *Modern electric, hybrid electric, and fuel cell vehicles*. CRC press.
3. Onori, S., Serrao, L. and Rizzoni, G., 2016. Hybrid electric vehicles: Energy management strategies.

REFERENCES:

1. Soylu, S. ed., 2011. *Electric vehicles: modelling and simulations*. BoD–Books on Demand
2. Williamson, S.S., 2013. *Energy management strategies for electric and plug-in hybrid electric vehicles*. New York: Springer.

EE1633	**ENERGY STORAGE TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

To impart knowledge about the following topics:

- To Study details of various energy storage systems along with their applications
- Enabling to identify the optimal solutions to a particular energy storage applications/ utility

UNIT I Introduction to Energy Storage Systems 9

Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal and Compressed air storage technology, comparison of energy storage technologies

UNIT II Thermal Energy Storage Systems 9

Thermal Energy storage, sensible and latent heat, phase change materials, Energy and exergy analysis of thermal energy storage, Mechanical-Pumped hydro, flywheels and pressurized air energy storage

UNIT III Electric and Magnetic Energy Storage Systems 9

Electrical Energy storage-super-capacitors, Magnetic Energy Storage-Superconducting systems,

UNIT IV Electrochemical Energy Storage Systems 9

Principle of direct energy conversion using fuel cells, thermodynamics of fuel cells, Types of fuel cells, AFC, PEMFC, MCFC, SOFC, Microbial fuel cell, Fuel cell performance, Electrochemical

Energy Storage- Battery, primary, secondary and flow batteries,

UNIT V Design and Applications of Energy Storage Systems 9

Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices, Mobile storage Applications- Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to
CO1: Outline the basic concepts and need of different energy storage systems
CO2: Relate the various types of thermal energy storage systems
CO3: Summarize the different types related to electric and magnetic energy storage systems
CO4: Explain principle of operation and types of various electrochemical storage systems such as fuel cells, battery
CO5: Illustrate the design and applications of energy storage systems

TEXT BOOKS:

1. Ahmed Faheem Zobaa ,Energy *Storage - Technologies and Applications* , InTech.

REFERENCES:

1. J. Jensen and B. Sorenson ,*Fundamentals of Energy Storage*, *Wiley-Interscience*, New York,
2. C. Daniel, J. O. Besenhard ,*Handbook of battery materials* ,Wiley VCH Verlag GmbH & Co. KgaA.
3. G. Pistoia ,*Electric & Hybrid Vehicles* , Elsevier B. V.
4. Dincer I. and Rosen M. A ,*Thermal energy storage: Systems and Applications* , Wiley pub.
5. Huggins R. A., ,*Energy Storage: Fundamentals, Materials and Applications*, Springer

EE1634 POWER QUALITY

L	T	P	C
3	0	0	3

OBJECTIVES:

- To realize the various power quality issues.
- To instruct on production of voltages sags, over voltages and harmonics and methods of control.
- To decide the passive compensation techniques used for power factor correction and load voltage regulation
- To impart knowledge on various methods of power quality monitoring

UNIT I INTRODUCTION TO POWER QUALITY 9

Terms and Definitions of Power Quality- Need for a quality power - General Classes of Power Quality Problems- Transients - Long-Duration Voltage Variations - Short-Duration Voltage Variations - Voltage Imbalance - Waveform Distortion - Voltage Fluctuation- Power Frequency

Variations- Power Quality Terms- CBEMA Curves

UNIT II VOLTAGE SAG AND SWELL 9

Estimating voltage sag performance - Analysis and calculation of various faulted condition - Estimation of the sag severity - Mitigation of voltage sag, Static transfer switches and fast transfer switches. - Capacitor switching – Lightning - Ferro resonance - Mitigation of voltage swell.

UNIT III HARMONICS 9

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 IV CUSTOM POWER DEVICES 9

Construction, Working and limitation: Distribution STATCOM (D- STATCOM), Dynamic Voltage Restorer (DVR), Unified Power Quality Conditioner (UPQC).

UNIT V POWER QUALITY MONITORING 9

Monitoring considerations – Power Quality measurement equipment: Multimeters, Oscilloscopes, Harmonic / spectrum analyzer, Flicker meters, Disturbance analyzer, Combination disturbance and harmonic analyzers - Applications of expert systems - Power Quality Monitoring Standards: IEEE 1159 and IEC (61000-4-30).

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Describe various sources, causes and effects of power quality issues, electrical systems and their measures and mitigation.

CO2: Explore the causes & Mitigation techniques of various PQ events.

CO3: Illustrate the concept of various Active & Passive power filters used for harmonic mitigation.

CO4: Describe the construction working & limitation of custom power devices (D- STATCOM DVR & UPQC).

CO5: Discuss on various methods of power quality monitoring & their standards.

TEXT BOOKS:

1. Dugan, R.C., McGranaghan, M.F. and Beaty, H.W., 1996. *Electrical power systems quality*. *epsq*.

REFERENCES:

1. Singh, B., Chandra, A. and Al-Haddad, K., 2014. *Power quality: problems and mitigation techniques*. John Wiley & Sons.
2. Heydt, G.T., 1991. *Electric power quality* (pp. 1985-1993). West Lafayette, IN: Stars in a circle publications.

EE1635	PRINCIPLES OF ROBOTICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the functional elements of Robotics
- To impart knowledge on the direct and inverse kinematics
- To introduce the manipulator differential motion and control
- To educate on various path planning techniques
- To introduce the dynamics and control of manipulators

UNIT I BASIC CONCEPTS 9

Brief history-Types of Robot–Technology-Robot classifications and specifications-Design and control issues- Various manipulators – Sensors - work cell - Programming languages.

UNIT II DIRECT AND INVERSE KINEMATICS 9

Mathematical representation of Robots - Position and orientation – Homogeneous transformation-Various joints- Representation using the Denavit Hattenberg parameters -Degrees of freedom-Direct kinematics-Inverse kinematics- SCARA robots- Solvability – Solution methods-Closed form solution.

UNIT III MANIPULATOR DIFFERENTIAL MOTION AND STATICS 9

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance.

UNIT IV PATH PLANNING 9

Definition-Joint space technique-Use of p-degree polynomial-Cubic polynomial-Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning.

UNITV DYNAMICS AND CONTROL 9

Lagrangian mechanics-2DOF Manipulator-Lagrange Euler formulation-Dynamic model – Manipulator control problem-Linear control schemes-PID control scheme-Force control of robotic manipulator.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Explain the types of robots and design of controllers/manipulators

CO2: Explain the basic representations of robots and degrees of freedom

CO3: Describe the differential motion of manipulators and its static analysis.

CO4: Illustrate the concept of various path planning techniques for robot movement.

CO5: Develop dynamic model and describe the various control schemes incorporated in robotics.

TEXT BOOKS:

1. R.K.Mittal and I.J.Nagrath, *Robotics and Control*, Tata McGraw Hill, New Delhi,4th Reprint, 2005.

REFERENCES:

1. JohnJ.Craig , *Introduction to Robotics Mechanics and Control*, Third edition, Pearson Education, 2009.

2. M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, *Industrial Robotics*, McGraw-Hill Singapore, 1996.

OEE151	BIO ELECTRONICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To explain the fundamental principles of electronics.
- To learn about basics of digital and logic circuits.
- To discuss basic biological materials and motion in solution.
- To describe the concepts of electrolyte.
- To develop knowledge on bio inspired real time systems.

UNIT I BASIC ELECTRONICS 9

Semiconductor Materials, chemical and physical bonds, Intrinsic and extrinsic semiconductors, carrier motion in semiconductors – Drift, Diffusion and Recombination – Generation process, Boltzmann Transport equation, P-N junction diode, Bipolar Junction Transistor (BJT), Field Effect Transistor (FET), Operational Amplifier (OPAMP).

UNIT II DIGITAL LOGIC CIRCUITS 9

Boolean algebra and logic gates, Combinational logic circuit, sequential logic circuit – flip flops.

UNIT III BIOLOGICAL MATERIALS AND CHEMICAL REACTION 9

Analogy between semiconductor and biological materials, water and electrolyte solutions; biological molecules - Proteins, Nucleic acids, Phospholipids, cell membrane, Eucaryotic cell, Diffusion, Brownian motion, electrophoresis, enzyme kinetics. Introduction to bio sensors.

UNIT IV SOLID ELECTROLYTE JUNCTION 9

Electrode-electrolyte interfaces, Poisson – Boltzmann equation, Membrane transport, Nernst-Plank equation and solution.

UNIT V BIO INSPIRED SYSTEMS 9

Artificial heart and circulatory assist devices, artificial lungs, artificial kidney, artificial cell, artificial muscle, Robotic systems and devices, acoustical systems, computing system such as neural network, bio inspired exploration, bio inspired computer architectures.

TOTAL: 45 PERIODS

OUTCOMES:

Upon successful completion of this course, the students will be able to

CO1 : Interpolate the fundamentals of electronics.
CO2 : Explain the elements of power semiconductor devices and digital logic circuits.
CO3 : Infer various biological materials and its motion .
CO4 : Discuss about chemical reaction of various electrolytes.
CO5 : Examine artificial and real time bio inspired systems.

TEXT BOOKS:

1. Grattarola, M. and Massobrio, G., 1998. *Bioelectronics handbook*. McGraw-Hill.
2. E. A. Hall, *Biosensors*, Publisher : Wiley.
3. Ruddy Ratner, *Biomaterial Science* Publisher: Academic Press.
4. S. Bone, B. Zabba, *Bioelectronics*, Publisher : Wiley.
5. Malvino, A.P., Bates, D.J. and Hoppe, P.E., 1993. *Electronic principles.* Glencoe.

REFERENCES:

1. M Farkas; *Dynamical Model in Biology*; Publisher: Academic Press.
2. B Webb, T R Consi *Biorobotics*; Publisher: AAAI Press
3. Williams, K., 2003. *Insectronics: build your own walking robot.* TAB/Electronics.
4. *Amphoibionics: Built Your own biologically Inspired Reptilian Robot*; *Bioinspired Nanoscale Hybrid System :* Conference Proceeding Held on Nov'02, Editor : Author: G. Schmid, Online Book Store: Amazon

		L	T	P	C
OEE152	**CONTROL SYSTEMS ANALYSIS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To introduce the basic control system components for the analysis of physical systems.
- To provide adequate knowledge on the time response analysis and steady state error analysis of linear systems.
- To accord basic knowledge in obtaining the open loop and closed–loop frequency response analysis of linear systems.
- To introduce the concepts of stability analysis and design of various types of compensators.
- To introduce state variable representation of physical systems and to convert the state space models into transfer function models and vice versa

UNIT I SYSTEMS COMPONENTS AND THEIR REPRESENTATION 9

Control System: Terminology and Basic Structure-Feed forward and Feedback control theory-Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs models- Multivariable control system – Case Study: DC and AC servo Systems-Synchros

UNIT II TIME REPONSE ANALYSIS 9

Transient response - Steady state response- Measure of performance of the standard first order and second order systems - Effect of an additional zero and an additional pole - Steady state error constant and system- Type number- PID control -Analytical design for PD,PI,PID control systems.

UNIT III FREQUENCY RESPONSE ANALYSIS 9

Closed loop frequency response- Performance specifications in frequency domain- Frequency response of standard second order system- Bode Plot - Polar Plot- Design of compensators using Bode plots- Cascade lead compensation- Cascade lag compensation- Cascade lag-lead compensation

UNIT IV CONCEPTS OF STABILITY ANALYSIS 9

Concept of stability- Bounded - Input Bounded - Output stability-Routh stability criterion-Relative stability- Root locus concept- Guidelines for sketching root locus- Nyquist stability criterion.

UNIT V CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS 9

State variable representation- Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models- Solution of state equations- Concepts of Controllability and Observability- Stability of linear systems- Equivalence between transfer

function and state variable representations- State variable analysis of digital control system- Digital control design using state feedback.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Develop mathematical models for various physical systems.

CO2: Determine time-domain specifications of given linear system and discuss on applications of various types of conventional controllers (P, PI and PID)

CO3: Obtain the frequency response analysis of given linear system using bode and polar plot.

CO4: Analyze the stability of control system using suitable methods and design compensators for the given specifications.

CO5: Design various transfer functions of digital control system using state variable models.

TEXT BOOKS:

1. Nagrath, I.J., 2018. *Control systems engineering*. New Age International
2. Kuo, B.C., 2018. *Automatic control systems*. Wiley.

REFERENCES:

1. Gopal, M., 2012. *Control systems: principles and design*. Tata McGraw-Hill Education.
2. Ogata, K. and Yang, Y., 2002. *Modern control engineering* (Vol. 4). India: Prentice hall.
3. Dorf, R.C. and Bishop, R.H., 2011. *Modern control systems*. Pearson.
4. Dutton, K., 1997. *The art of control engineering*. Addison-Wesley Longman Publishing Co., Inc..
5. Houpis, C.H. and Sheldon, S.N., 2013. *Linear Control System Analysis and Design with MATLAB®*. CRC Press.
6. NPTEL Video Lecture Notes on "Control Engineering"

		L	T	P	C
OEE153	**GREEN BUILDING**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To understand the effects on environment, by buildings
- To acquire knowledge on the utilization of natural energy while constructing buildings
- To understand about the concept of passive solar cooling and heating.
- To impart knowledge about the various energy efficient technologies in buildings
- To comprehend various techniques that are used in Indian Green Buildings.

UNIT I ENVIRONMENTAL IMPLICATIONS OF BUILDINGS 10

Energy use, carbon emissions, water use, waste disposal - Building materials: sources, methods of production and environmental Implications - Embodied Energy in Building Materials - Transportation Energy for Building Materials - Maintenance Energy for Buildings. Green Buildings and its necessity.

UNIT II PRINCIPLES OF GREEN BUILDING DESIGN 9

Energy conservation in buildings – Day lighting – Water heating and photovoltaic systems – Advances in thermal insulation – Heat gain/loss through building components – Solar architecture - Green Buildings – Indian Green Building council ratings for New and Existing buildings.

UNIT III UTILITY OF SOLAR ENERGY IN BUILDINGS 9

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings. Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

UNIT IV EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS 9

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors and soft starters - Energy efficient Transformers, Energy Efficient Lighting systems – Occupancy sensors- Energy Performance index

UNIT V GREEN BUILDINGS IN INDIA – CASE STUDIES 8

Rajiv Gandhi International Airport, Hyderabad – Suzlon one earth campus, Pune – Infinity Benchmark, Pune – The ITC green centre, Gurgaon - CII-Sohrabji Godrej Green Business Centre, Hyderabad - Infosys, Mysore – T-Zed Homes, Bengaluru – Raintree hotel, Chennai.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Demonstrate the energy spent in rising a building and carbon emission.

CO2: Explain the principles to be adopted in construction of Green buildings

CO3: Describe the ways in which solar energy can be utilized in building.

CO4: Apply energy efficient technologies in the electrical systems of buildings.

CO5: Analyse the technology adopted in various Green buildings.

TEXTBOOKS:

1. Clarke J. A., 2001. *Energy Simulation in Building Design*, 2nd Edition, Butterworth.
2. Nayak J. K. and Prajapati J. A. 2006. *Handbook on Energy Conscious Buildings*, Pilot edition, Solar Energy centre, MNES.
3. Jagadish K.S., Venkataramareddy B. U. and Nanjundarao K. S. 2017. *Alternative Building Materials and Technologies*. 2nd Edition, New Age International.
4. Ursula Eicker, 2009. *Low Energy Cooling For Sustainable Buildings.* 1st Edition, Wiley. 2004. *Sustainable Building Design Manual. Volume 1 and 2*, TERI.

REFERENCES:

1. Osman Attmann, 2010. *Green Architecture Advanced Technologies and Materials*. 1st Edition McGraw Hill.
2. Jerry Yudelson, 2009. *Green building Through Integrated Design.* 1st Edition. McGraw Hill, 2009.
3. Marian Keeler and Bill Burke, 2009. *Fundamentals of Integrated Design for Sustainable Building.* 1st Edition, John Wiley & sons.
4. Sodha M. S., Bansal N. K, Bansal P. K., Kumar A. and Malik. M. A. S., 1986. *Solar Passive Building: Science and Design*, 1st Edition, Pergamon Press.

5. Albert Thumann and Paul Mehta, 2013. *Handbook of Energy Engineering,* 7th Edition, River Publishers.

		L	T	P	C
OEE154	**RENEWABLE ENERGY SOURCES**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To know the significance of renewable energy resources.
- To get exposure on various renewable energy sources and its environmental impact.
- To learn about the solar, wind and biomass energy and its economic aspects.
- To know the various types and its function of geothermal energy ocean energy & fuel cell.

UNIT I INTRODUCTION TO RENEWABLE ENERGY SOURCES 9

Classification of Energy Sources- Importance of Non-Conventional Energy Sources- Energy Chain- Common Forms of Energy - Advantages and Disadvantages of Conventional Energy Sources - Salient Features of Non-Conventional Energy Sources - Environmental Aspects of Energy – Introduction to Energy Conservation - important aspects of energy conservation - Energy Storage: Necessity of Energy Storage, Energy Storage Devices and Energy Storage Methods.

UNIT II SOLAR PV AND THERMAL ENERGY 9

Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance - solar thermal power plants - Thermal energy storage for solar heating and cooling - limitations. Solar PV Cells: Theory of solar PV cells. Solar PV cell materials, solar PV array, solar PV power plant, limitations of solar PV. Types of PV power plants (Stand alone & Grid connected)

UNIT III FUEL CELLS AND WIND ENERGY 9

Fuel Cells: Principle of working of various types of fuel cells, performance and limitations. Wind power and its sources, site selection, Types of WECS, Based on turbine VAT Turbine, HAT Turbine, Based on Power Delivery: Stand alone & Grid connected. Performance and limitations of energy conversion systems.

UNIT IV GEOTHERMAL ENERGY & HYDRO POWER PLANT 9

Geothermal Energy: Sources of geothermal energy, geothermal Power plant, environmental considerations. Essential components of Hydroelectric Systems, Classification of Hydro power schemes, Turbine theory, classification of water turbine.

UNIT V BIO-MASS AND OCEAN ENERGY 9

Bio-mass: Availability of bio-mass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations. Wave and Tidal Energy: Principle of working, performance and limitations.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Describe the significance of various renewable energy resources and Energy storage technology.

CO2: Discuss on materials, types and applications of solar PV and Thermal energy storage system.

CO3: Describe the principle of working & types of fuel cells & WECS.

CO4: Discuss on geothermal energy and hydro power plant.

CO5: Illustrate the utilization of other energy sources such as biogas and Ocean energy.

TEXT BOOKS:

1. Khan, B.H., 2006. *Non-conventional energy resources*. Tata McGraw-Hill Education.

REFERENCES:

1. Rai, G.D., 2011. A Text book of Non-conventional energy Sources.
2. Twidell, J. and Weir, T., 2015. *Renewable energy resources*. Routledge.

OEE155	SOFT COMPUTING TECHNIQUES AND APPLICATIONS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basics of soft computing techniques
- To describe the artificial neural network and its applications
- To explain the basics of fuzzy logic and its applications.
- To solve single objective optimisation problems using GAs.
- To analyse the features of hybrid control schemes.

UNIT I INTRODUCTION TO SOFT COMPUTING 9

Concept of computing systems – Soft computing vs Hard computing – Characteristics of soft computing – Some applications of soft computing techniques.

UNIT II ARTIFICIAL NEURAL NETWORK 9

Review of fundamentals – Biological neuron, artificial neuron, activation function, single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network – online learning algorithms, BP through time – Real Time Recurrent Learning algorithms – Reinforcement learning - Neural Network based controller.

UNIT III FUZZY LOGIC 9

Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Fuzzy membership functions - Defuzzification – Fuzzy logic controller – Familiarization with fuzzy logic toolbox – Fuzzy logic application – A typical case study.

UNIT IV GENETIC ALGORITHMS 9

Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques – Basic GA framework and different GA architectures – GA operators: Encoding, Crossover, Selection, Mutation, etc. – Solving single-objective optimization problems using GAs.

UNIT V HYBRID CONTROL SCHEMES 9

Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy neuron– GA – Optimization of membership function and rule base using Genetic Algorithm – Introduction to other evolutionary optimization techniques, support vector machine– Case study – Familiarization with ANFIS toolbox – Applications of hybrid systems to engineering problems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Successful Completion of this course, the students will be able to

CO1: Differentiate between soft and hard computing techniques.

CO2: Understand the basics of artificial neural network.

CO3: Interpret fuzzy logic model for a given system.

CO4: Construct genetic algorithm for single objective optimisation problem.

CO5: Acquire knowledge on hybrid control

REFERENCES:

1. Laurence Fausett, *"Fundamentals of Neural Networks",* Prentice Hall, Englewood Cliffs, N.J., 1992
2. Timothy J. Ross, "*Fuzzy Logic with Engineering Applications",* McGraw Hill Inc., 2000.
3. Goldberg, "*Genetic Algorithm in Search, Optimization and Machine learning*", Addison Wesley Publishing Company Inc. 1989
4. Millon W.T., Sutton R.S. and Webrose P.J., "*Neural Networks for Control*", MIT press, 1992
5. Ethem Alpaydin, "*Introduction to Machine learning (Adaptive Computation and Machine Learning series)*', MIT Press, Second Edition, 2010.
6. Zhang Huaguang and Liu Derong, "*Fuzzy Modeling and Fuzzy Control Series: Control Engineering*", 2006