Dr. B. C. Roy Engineering College, Durgapur
An Autonomous Institute
(approved by AICTE & affiliated to MAKAUT)

Programme Code: 016
Programme : B.Tech in Electrical Engineering
Year (Semester) : 3rd Year (6th Semester)

Sl. No.	Broad Category	Course Category	Course Type	Course Code	Course Name	Contact Hours/Week L	T	P	Total	Credits
					A. Theory					
1	ENGG	Major	PC	EE-601	Power System-II	3	0	0	3	3
2	ENGG	Major	PC	EE-602	Electric Drives	3	0	0	3	3
3	ENGG	Major	PC	EE-603	Non-linear Control and Industrial Automation	3	0	0	3	3
4	ENGG	Minor	PC	EE-604	VLSI and Microelectronics	3	0	0	3	3
5	ENGG	Minor	PC	EE-605	Digital Signal Processing	3	0	0	3	3
6	HUM	Ability Enhancement Courses	HM	EE-606	Design, Technology and Innovation	2	0	0	2	1
7	ENGG	Major	PE	EE-607	Power Quality & FACTS	3	0	0	3	3
				EE-608	Utilization of Electric Power					
				EE-609	Non-Conventional Energy					
				EE-610	Power Generation Economics					
TOTAL Theory						20	0	0	20	**19**
					B. Practical/Sessional					
1	ENGG	Major	PC	EE-691	Power System-II Laboratory	0	0	2	2	1
2	ENGG	Major	PC	EE-692	Electric Drives Laboratory	0	0	2	2	1
3	ENGG	Major	PC	EE-693	Nonlinear Control and Industrial Automation Laboratory	0	0	2	2	1
4	ENGG	Minor	PC	EE-694	VLSI and Microelectronics Laboratory	0	0	2	2	1
5	ENGG	Minor	PC	EE-695	Digital Signal Processing Laboratory	0	0	2	2	1
6	ENGG	Skill Enhancement Courses	PC	EE-696	Modeling, Design and Simulation Laboratory	0	0	2	2	1
TOTAL Practical/Sessional						0	0	12	12	**6**
TOTAL of Semester						20	0	12	32	**25**

Dr. Shibendu Mahata
Chairman, BOS(EE)

POWER SYSTEM-II

Course Code: EE-601

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1. **Course Pre-requisites:**
   1. Basic Electrical Engineering
   2. Network Theory
   3. Power System-I

2. **Course Learning Objectives:**
   This course is designed to introduce students to power electronic devices, converters, and their applications in electrical engineering. The course covers fundamental concepts of analyze large-scale power systems, model components, perform fault analysis, conduct load flow studies, and optimize power flow, while also gaining skills in simulation, communication, and critical thinking.

3. **Course Name: POWER SYSTEM-II**
   Course Code: EE-601
   Hours per Week: 3
   Credits: 3

   Course Contents:

Module	Topics	36L
1.	**Representation of Power system components:** Single-phase representation of balanced three phase networks, the one-line diagram and the impedance or reactance diagram, per unit (PU) system.	02
2.	**Distribution substation:** Types of substations, location of substations, substation equipment and accessories, earthling (system & equipment), feeder and distributors, radial and loop systems.	06
3.	**Load Flow studies:** Network model formulation, formation of Ybus, load flow problem, Gauss-Siedel method, Newton-Raphson method, Decoupled load flow studies, comparison of load flow methods.	07
4.	**Faults in Electrical systems:** Transient on a transmission line, short circuit of a synchronous machine under no load & loaded condition. Symmetrical component transformation, sequence impedance and sequence network of power system, synchronous machine, transmission lines and transformers. Symmetrical component analysis of unsymmetrical faults, single line-to –ground fault, line-to- line fault, double line-to- ground fault.	07
5.	**Power system Stability:** Steady state stability, transient stability, equal area criteria, swing equation, multi machine stability concept	04

6.	**Power system protection:** Basic requirements of protective relaying, Types of protection, Classification of relays, Electromagnetic Relays (construction and operating principle), Induction relays, non-directional overcurrent relay, Directional relay, Distance relays, Mho relay, Reactance relay, Classification of distance relays, Differential relays. Protection of Alternator, Rotor fault protection, AC motor protection, Differential protection of transformer, Overcurrent and unrestricted earth fault protection, Balanced (Restricted) earth fault protection, Generator transformer unit protection. Principle of operation, Types of circuit breaker, Air circuit breaker, Minimum oil circuit breaker, SF_6 circuit breaker, Circuit breaker rating, Testing of circuit breakers, Safety features and interlocking.	10

4. Text Books:

T1: Modern Power System Analysis, D.P. Kothari & I.J. Nagrath, 4th Edition, Tata McGraw Hill.
T2: Modern Electrical Power Systems, Subir Ray, PHI.
T3: Switchgear protection and power systems, Sunil S. Rao, Khanna Publications.
T4: Power system Analysis, operation & control, Chakrabarty & Haldar, 2nd edition, PHI.
T5: Modern power system analysis, D.P. Kothari & I.J. Nagrath, Tata McGraw Hill.

5. References:

R1: Protection & Switchgear, B. Bhalja, R.P. Maheshwari, N.G.Chothani, Oxford.
R2: Power system protection & switchgear, B. Ram & D.N. Vishwakarma, Tata McGraw Hill.
R3: Electric Machinery & Transformer- Bhag S. Guru and H.R. Hiziroglu; Oxford University press.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Ability to analyze of per unit system and distinguish different type of substations.	Define, Explain	Remember, Understand
CO2	Ability to analyze different type of load flow studies.	Analyze, Design	Analyze, Create
CO3	Ability to analyze different faults in electrical system.	Evaluate, Develop	Evaluate, Create
CO4	Ability to analyze power system stability.	Design, Implement	Create, Apply
CO5	Ability to classify, applications of different relays and circuit breakers.	Analyze, Solve	Analyze, Apply

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	1	-
2	3	-	-	-	-
3	1	3	-	-	-
4	-	-	3	-	-
5	-	-	-	3	-
6	-	-	-	-	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	2	2	-	-	1	-	1
CO2	3	3	1	1	2	2	-	-	1	-	1
CO3	3	3	1	1	2	2	-	-	1	-	1
CO4	3	3	1	1	2	2	-	-	1	-	1
CO5	3	3	1	1	2	2	-	-	1	-	1

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3
CO1	3	2	2
CO2	3	3	1
CO3	3	-	1
CO4	3	-	2
CO5	3	2	-

ELECTRIC DRIVES
Course Code: EE-602

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1. Course Prerequisite:

a. Power Electronics
b. Electrical Machine-I & II
c. Control Systems
d. Electrical Measurements
e. Electromagnetic Field Theory

2. Course Learning Objectives:

Course objective is to impart basic concept, classification and principle of operation of Electric Drive. Enabling students to understand methods of starting and braking of Electric Drive, and also to understand methods of control of speed of DC and AC Drives.

3. **Course Name:** ELECTRIC DRIVES
Course Code: EE 602
Hours per Week: 3
Credits: 3
Course Content:

Module	Topics	40L
1.	**Electric Drive:** Concept, classifications, parts and advantages of electrical Drives. Types of loads, Fundamental Torque equations, Equivalent values of drive parameters for loads with rotational and translation motion. Determination of moments of inertia, Steady state stability, Transient stability. Multi-quadrant operation of drives. Load equalizations	05
2.	**Motor Power rating:** Thermal model of motor for heating and cooling, classes of motor duty, determinations of motor rating for continuous, short time and intermittent duty, equivalent current, torque and power methods of determinations of rating for fluctuating and intermittent loads. Effect of loads inertia & environmental factors	05
3.	**Starting of Electric Drives:** Effect of starting on power supply, motor and load. Method of starting of electric motor. Acceleration time Energy relation during starting, methods to reduce the energy loss during starting. **Braking of Electric Drives:** Different Types of braking (Regenerative braking, Dynamic braking and Plugging).	08
4.	**Control of DC motor drives:** Modeling of DC motor, state space modeling, block diagram and transfer function, single phase, three phases fully control and half control DC drives. Dual converter control of DC drives. Power factor, harmonics and ripple in motor current chopper-controlled DC motor drives.	06
5.	**Induction motor drives:** stator voltage variation by three phase controller, speed control using chopper resistance in rotor circuits, slip power recovery scheme. Pulse width modulated inverter fed and current source inverter fed induction motor drive. V/f control, Vector or field oriented control.	05

Module	Topics	40L
6.	**Synchronous motor drives:** variable frequency control, self control, voltage source inverter fed synchronous motor drive, vector control	05
7.	**Industrial applications:** Application of electric drives in textile mills, steel rolling mills, cement mills, Crain & hoist drives with application of AI etc. Introduction to solar and battery powered Drive, stepper motor, switch Reluctance Motor drive.	06

4. **TEXT BOOKS:**

T1: Fundamental of Electrical Drives, G.K. Dubey, Narosa Publishing House
T2: Electric Drive, Vedam Subrahmanyam, TMH
T3: A first course on Electrical drives, S.K. Pillai, New age international Publications
T4: Fundamentals of Power Electronics and Drives, A. Chakraborty, DHANPAT RAI & SONS

5. **REFERENCE BOOKS:**

R1. Electric Motor Drives, R. Krishnan, PHI.
R2. Modern Power Electronics & AC Drives, B.K. Bose, Pearson Education.
R3. Electric Motor & Drives, Austin Hughes, Newnes.
R4. Linear Control System, B.S. Manke, Khanna Publications.

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the concept of Electric Drives and classes of motor duties.	Analyze, Identify	Understand, Remember
CO2	Determine the moment of inertia, stability, equivalent value of drive parameters and Motor power rating for various Drives Systems.	Identify, Select	Understand, Apply, Analyze
CO3	Explain the different types Motor Drives, Various power supply and State space Modeling, Transfer function for D.C. motor drives.	Identify, Select	Understand, Apply
CO4	Illustrate the speed control of the various types of Motors.	Analyze	Understand, Apply, Analyze
CO5	Classify different Types of Starting, Braking of Electric Motors and the Energy Losses.	Identify	Analyze
CO6	Various Drives consideration for the important industries as generated in the real life and solve the numerical of the essential Drive systems.	Implement	Evaluate

7. **Mapping of course outcomes to module / course content**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	2	-	-	-	-
2	1	3	-	-	-	-
3	-	-	-	-	3	-
4	1	-	3	-	-	-
5	-	-	-	3	-	-
6	-	-	-	3	-	-
7	-	-	-	-	-	3

8. **Mapping of the Course outcomes to Program Outcomes**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	1	2	1	-	-	-	1	1
CO2	3	3	2	1	2	1	-	-	-	1	1
CO3	3	3	2	1	2	1	-	-	-	1	1
CO4	3	3	2	1	2	1	-	-	-	1	1
CO5	3	3	2	1	2	1	-	-	-	1	1
CO6	3	3	2	1	2	1	-	-	-	1	1

9. **Mapping to PSO**

	PSO1	PSO2	PSO3
CO1	3	-	1
CO2	3	-	1
CO3	3	-	1
CO4	3	-	1
CO5	3	-	1
CO6	3	-	1

NON-LINEAR CONTROL AND INDUSTRIAL AUTOMATION

Course Code: EE-603

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1. **Course Pre-requisites:**
   Control Systems

2. **Course Learning Objectives:**

   By the end of this course, students will be able to:

1. Understand the architecture of industrial automation systems, key process characteristics, and fundamental concepts of process control and automation.
2. Analyze and implement various control modes, including PID control, and apply controller tuning techniques for effective process regulation.
3. Evaluate advanced industrial control strategies such as feedforward, cascade control, etc., to optimize process performance.
4. Demonstrate knowledge of actuators, PLCs, DCS and SCADA including their architecture, programming, and integration in industrial automation, IoT in Automation and control.

3. **Course Name: NON-LINEAR CONTROL AND INDUSTRIAL AUTOMATION**
   Course Code: EE-603
   Hours per Week: 3
   Credits: 3
   Course Contents:

Module	Topics	40L
1.	**Non-linear control:** State-Space representation of dynamical systems, Features of nonlinear dynamical systems; Lyapunov theory for autonomous and non-autonomous systems, Attractors and Basins, Poincare maps Nonlinear control system design: Sliding control, Basics of Differential geometry, feedback linearization, single input and multi-input cases. Introduction to Chaos, Bifurcations, Hamiltonian Systems. Cases of Mechanisms, Robotics	7
2.	**Introduction to Industrial Automation and Control:** Architecture of Industrial Automation Systems. General review of process, Process control & automation, Servo and regulatory control, Characteristic parameter of a process: Process quality, Process potential, Process resistance, Process capacitance, Process lag, example of Self-regulated processes.	7
3.	**Different control modes and Implementation:** On-off control, Multistep, Time proportional, Proportional, Proportional-integral, Proportional-derivative, Proportional-integral-derivative, integral windup, bump less transfer, Inverse derivative control and tuning methods: Ziegler-Nichols tuning method, Cohen-Coon tuning method, Implementation of PID controllers (digital and analog).	9

4.	**Advance Industrial control strategies:** Feedforward control, Cascade control, Ratio control, Adaptive control, Selective Control, Split Range Control	5
5.	**Actuators and final control elements:** Classification of Actuators: pneumatic, hydraulic, electro pneumatic, and stepper motor operated actuators; Pumps and motors	3
6.	**Programmable Logic Controller:** Block diagram, Classification, Basic Architecture and Functions; Input-Output Modules, power supply. PLC Programming: Relay logic and ladder logic, PLC ladder diagram realization, PLC Timer, PLC Counter, PLC programming examples for Industrial maintenance and control **Distributed Control System (DCS):** Basic concept and overview of DCS, DCS System Architecture, configuration, operation and features. HMI and SCADA, OSI Communication Standard and Fieldbus, IoT based process automation. **Industry 4.0:** IoT in automation for smart manufacturing, predictive maintenance, and remote monitoring and control.	9

4. Text Books:

T1: Industrial Instrumentation and Control, *S. K. Singh*, Tata-McGraw, 2010.
T2: Industrial Instrumentation, Control and Automation, *S. Mukhopadhyay, S. Sen and A. K. Deb*, Jaico Publishing House, 2012.
T3: Process Control, *K. Krishnaswamy*, New Age International Publishers, 2009.
T4: Programmable Logic Controllers with Control Logix, *Jon Stenerson*, Delmar Cengage learning, 2009.

5. Reference Books:

R1: Automatic Process Control, *D.P. Eckman*, John Wiley and Sons.
R2: Process Control Instrumentation Technology, *C.D. Johnson*, PHI, 2005.
R3: Khalil, H.K., Nonlinear Systems, Prentice Hall Englewood Cliffs, New Jersey, 3rd Edition, 2002.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Differentiate between linear and nonlinear systems and their behaviour. Design of nonlinear control system, Understand Lyapunov theory.	Understand	Analyze
CO2	Explain the architecture of industrial automation systems, key process characteristics, and fundamental concepts of process control and automation.	Explain	Understand
CO3	Apply different control modes, including PID control and tuning techniques, to regulate industrial processes effectively.	Apply	Apply
CO4	Analyze advanced industrial control strategies such as feedforward, cascade, and adaptive control to optimize system performance.	Analyze	Analyze
CO5	Classify different types of actuators and final control elements, including pneumatic, hydraulic, and electromechanical systems.	Classify	Understand

CO6	Develop PLC programs using ladder logic, timers, counters, and advanced instructions for industrial automation applications. Evaluate the architecture, configuration, and functionalities of Distributed Control Systems (DCS), including their integration with HMI, SCADA and IoT in Automation.	Develop	Create

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	-	-	-	3	-
6	-	-	-	-	-	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2	-	2	-	-	1	-	1
CO2	3	2	2	2	1	2	-	-	1	-	1
CO3	3	2	2	2	1	2	-	-	1	-	1
CO4	3	2	2	2	-	1	-	-	1	-	1
CO5	3	2	2	2	-	1	-	-	1	-	1
CO6	3	2	2	2	3	2	-	-	1	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3
CO1	3	-	1
CO2	3	-	-
CO3	3	-	-
CO4	3	1	-
CO5	3	1	-
CO6	3	1	1

VLSI and Microelectronics

Course Code: EE-604

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1. **Course Prerequisite:**
   1. Digital Electronics
   2. Analog Electronics

2. **Course Learning Objectives:**
   The objective is to gain a deep understanding of VLSI design concepts, exploring the fundamentals of MOS structures and their significance in the design process. It also aims to provide insight into the functioning of CMOS VLSI circuits and their applications. Additionally, the goal is to comprehend the various stages and processes involved in VLSI fabrication, shedding light on the intricate techniques used to build integrated circuits.

3. **Course Name:** VLSI and Microelectronics
   Course Code: EE-604
   Hours per Week: 3
   Credits: 3

   Course Content:

Module	Topics	42L
1.	VLSI Design Concepts, Moor's Law, Scale of Integration (SSI, MSI, LSI, VLSI, ULSI– basic idea only), Types of VLSI Chips (Analog & Digital VLSI chips, General purpose, ASIC, PLA, FPGA), Design Domains (Behavioural, Structural, Physical), Y-Chart, Digital VLSI Design Steps.	5
2.	E-MOS & D-MOS, Charge inversion in E-MOS, Threshold voltage, Flat band voltage, Potential balance & Charge balance, Inversion, MOS capacitances. Three Terminal MOS Structure: Body effect Four Terminal MOS Transistor: Drain current, I-V characteristics. Current-voltage equations (simple derivation), Scaling in MOSFET: Short Channel Effects, General scaling, Constant Voltage & Field scaling.	9
3.	Steps in fabricating CMOS, Basic n-well CMOS process, p-well CMOS process, Twin tub process,	5
4.	CMOS inverter, Different Combinational Gates- NAND, NOR, AND, OR, X-OR, X-NOR Gate using CMOS, Layout Design Rule: Stick diagram with examples, Layout rules.	8
5.	VLSI Fabrication: Silicon Semiconductor Technology- An Overview, Wafer processing, Oxidation, Epitaxial deposition, Ion-implantation & Diffusion, Cleaning, Etching, Photo-lithography– Positive & Negative photoresist.	8
6.	Hardware Description Language – VHDL/Verilog based Combinational & Sequential Logic circuit Design.	7

4. Text Books:

1. Digital Integrated Circuit, J.M. Rabaey, Chandrasan, Nicolic, Pearson Education.
2. CMOS Digital Integrated Circuit, S.M. Kang & Y. Leblebici, TMH.
3. Modern VLSI Design, Wayne Wolf, Pearson Education.

5. Reference Books:

1. Modern VLSI Design: System on silicon, Wayne Wolf; Addison Wesley Longman Publisher.
2. Basic VLSI Design, Douglas A. Pucknell & Kamran Eshranghian, PHI.
3. CMOS Circuit Design, Layout & Simulation, R.J. Baker, H.W. Lee, D.E. Boyee, PHI.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	To explain the principle of design of VLSI circuits	Analyze, Identify	Understand, Remember
CO2	To explain different MOS structure with characteristics	Identify, Select	Understand, Remember
CO3	To design different types of logic circuits in CMOS technology.	Analyze, Implement	Understand, Apply, Analyze
CO4	To draw the stick diagram and layout for simple CMOS circuits	Analyze, Identify, Implement	Understand, Apply, Analyze
CO5	To apply different processes for VLSI fabrication	Analyze, Identify	Analyze, Apply
CO6	Apply VHDL/Verilog for designing digital systems	Apply	Apply

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	1	3	-	-	-	-
3	2	2	3	3	-	-
4	2	2	3	3	-	-
5	2	-	2	3	3	-
6	-	-	-	-	-	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	1	1	-	-	-	-	-	-
CO2	3	3	3	2	2	-	-	-	-	-	-
CO3	3	3	3	3	2	-	-	-	-	-	-
CO4	3	3	3	3	2	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-

9. Mapping to PSO:

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	3	1
CO3	3	2	1
CO4	3	2	1
CO5	3	2	1
CO5	3	2	1

DIGITAL SIGNAL PROCESSING

Course Code: EE-605

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1. **Course Prerequisite:**
   1. Network Theory
   2. Digital Electronics
   3. Control Systems

2. **Course Learning Objectives:**
   This course is designed to review the fundamentals and practices of discrete signal processing methods and their applications in Electrical and Electronics Engineering such as Discrete Fourier Transform, Z-transform, Linear and Circular convolution method, etc., for the analysis and processing of various discrete time signals. This course also aims to design digital filters for numerous signal processing applications.

3. **Course Name: DIGITAL SIGNAL PROCESSING**
   Course Code: EE-605
   Hours per Week: 3
   Credits: 3
   Course Content:

Module	Topics	40L
1.	**Discrete time signals and LTI Systems:** Concept of discrete time signal, basic idea of sampling and reconstruction of signal, Sampling Theorem sequences–periodic, energy, power, unit sample, unit step, unit ramp, real & complex exponentials, arithmetic operations on sequences. Definition, representation, impulse response, derivation for the output sequence, Concept of convolution, graphical, analytical and overlap add methods to compute convolution supported with examples and exercises, properties of convolution, interconnections of LTI systems with physical interpretations, stability and causality conditions.	06
2.	**Discrete Time Fourier Transform (DTFT):** Concept of frequency in discrete and continuous domain and their relationship (radian and radian/sec), freq. response in the discrete domain. Discrete system's response to sinusoidal/complex inputs (DTFT), Representation of LTI systems in complex frequency domain. **Z-transform:** Definition, mapping between s-plane and z-plane, unit circle, convergence and ROC, properties of z-transform, z-transform on sequences with examples and exercises, characteristic families of signals along with ROCs, convolution, correlation and multiplication using z-transform, initial value theorem, Parseval's relation, Inverse z-transform by contour integration, power series & partial fraction expansions with examples and exercises.	08

Module	Topics	40L
3.	**Discrete Fourier Transform (DFT) :** Concept and relations for DFT/IDFT, Relation between DTFT & DFT. Twiddle factors and their properties, computational burden on direct DFT, DFT/DFT as linear transformation, DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circulation convolution, computation of circular convolution by graphical, DFT/IDFT and matrix methods, linear filtering using DFT, aliasing error, filtering of long data sequences Overlap-Save and Overlap-Add methods with examples and exercises.	08
4.	**Fast Fourier Transform (FFT):** Radix2 algorithm, decimation–in-time and decimation-in-frequency algorithms, signal flowgraphs, Butterflies, computation in one place, bit-reversal, examples and exercises.	06
5.	**Design of Digital filters:** Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Bandstop and Highpass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation.	08
6.	**Digital Signal Processor:** Elementary idea about the architecture and important instruction sets of TMS320C5416/6713 processor, writing of small programs in Assembly Language.	04

4. Text Books:

T1: Digital Signal Processing: Principles, Algorithms & Application, J.C. Proakis & M.G. Manslakis, PHI.
T2: Digital Signal Processing: Signals, Systems and Filters– A. Antoniou, TMH Publishing Co.
T3: Digital Signal Processing, A.V. Oppenhein & R.W. Shaffer, PHI.
T4: Digital Signal Processing – P.Rameshbabu, Scitech Publications (India).

5. Reference Book:

R1: Digital Signal Processing, A. Nagoor Kani.
R2: Understanding Digital Signal Processing, Richard G. Lyons.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Represent signals mathematically in continuous and discrete-time and in the frequency domain.	Represent, Identify	Understand, Remember
CO2	Analyze discrete-time systems using z-transform.	Analyze, Select	Understand, Apply, Analyze
CO3	Explain the Discrete-Fourier Transform (DFT) and the FFT algorithms.	Identify, Select	Understand, Apply
CO4	Design digital filters for various applications.	Design	Understand, Apply, Analyze
CO5	Implement digital filters in Direct form-I, Direct Form-II, parallel and cascade realizations.	Identify	Evaluate, Create
CO6	Apply digital signal processing for the analysis of real-life signals.	Implement	Create

7. **Mapping of course outcomes to module / course content:**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	1	-	-
2	2	3	-	-	-	-
3	2	-	3	-	-	-
4	-	-	3	3	-	1
5	-	-	-	3	3	-
6	1	-	-	-	-	3

8. **Mapping of the Course outcomes to Program Outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	2	2	-	1	-	-	-	2
CO2	3	2	2	3	2	1	-	-	-	-	-
CO3	3	3	3	2	2	-	1	-	-	-	-
CO4	3	3	3	3	2	1	1	-	-	-	1
CO5	3	3	3	3	2	1	2	-	-	-	-
CO6	3	2	3	2	1	-	2	1	-	-	1

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3
CO1	3	3	2
CO2	3	-	1
CO3	3	2	2
CO4	3	-	2
CO5	3	-	1
CO6	3	2	3

DESIGN, TECHNOLOGY AND INNOVATION
Course Code: EE-606

1. **Course Pre-requisites:**
NIL

2. **Course Learning Objectives:**
This course aims to equip students with a foundational understanding of the interrelationship between design, technology, and innovation. Students will learn to apply design thinking methodologies to solve real-world problems, analyze the role of emerging technologies in driving innovation, and adopt human-centered design approaches for product and service development. The course fosters critical thinking about sustainable and social innovation, enabling learners to develop inclusive and impactful solutions. Students will gain practical experience in prototyping, user research, and business model design, preparing them to manage innovation processes effectively in multidisciplinary and dynamic environments.

3. **Course Name:** DESIGN, TECHNOLOGY AND INNOVATION
Course Code: EE-606
Hours per Week: 2
Credits: 1
Course Contents:

Module	Topics	28L
1.	**Introduction to Design Thinking and Innovation:** Definitions: Design, Technology, and Innovation; Types of Innovation: Incremental, Radical, Disruptive, Open Phases of Innovation; Design Thinking: Empathize, Define, Ideate, Prototype, Test; Innovation Ecosystem and Stakeholders; Real-world innovation case studies (Apple, IDEO, Tata Nano, Tesla) Activities: 1. Mind-mapping session on "What is Innovation?" 2. Group exercise: Design thinking challenge using a common problem (e.g., campus navigation)	**04**
2.	**Technology as a Driver of Innovation:** Role of Science and Technology in Innovation; Technology Push vs Market Pull Models; Technological Change: Moore's Law, S-curves; Disruptive Technologies: AI, IoT, Blockchain, AR/VR, 3D Printing; Technology Adoption Life Cycle and Crossing the Chasm; Technology Readiness Levels (TRL) **Activities:** 1. Case discussion: Uber, Netflix, SpaceX 2. Mini research assignment: Choose one emerging technology and map its innovation potential.	**04**
3.	**Human-Centered Design and User Experience:** Principles of Human-Centered Design (HCD); Ethnographic Research: Interviews, Observation, Shadowing; Creating Personas and Journey Maps; User Experience Design: Usability, Accessibility, Inclusivity; UX Evaluation Tools and Methods (A/B Testing, Heuristics)	**05**

Module	Topics	28L
	Activities: 1. Field research: Interview 3 users to understand a daily challenge. 2. Create a persona and customer journey map for a specific user group.	
4.	**Innovation Management and Strategy:** Innovation in Organizations: Structures and Cultures; Open vs Closed Innovation; The Innovation Funnel & Stage-Gate Models; Business Model Canvas (BMC); Value Proposition Design; Intellectual Property Rights (Patents, Copyrights, Trademarks) **Suggested Activities:** 1. Workshop: Create a Business Model Canvas for an idea. 2. Discussion: Compare open vs. closed innovation strategies using company examples.	**05**
5.	**Prototyping, Experimentation, and Product Development:** Types of Prototypes: Paper, Digital, Physical; Rapid Prototyping Tools (CAD, Figma, 3D printers, Arduino); Lean Startup Methodology and MVPs; Iterative Design: Feedback Loops and A/B Testing; Pilot Testing and Metrics for Evaluation. Assignment: Build and present an MVP (can be digital or physical)	**05**
6.	**Sustainable and Social Innovation:** Sustainability and Systems Thinking; Eco-design and Circular Economy; Frugal Innovation and Jugaad; Innovation for Social Good (Healthcare, Education, Energy) Case Studies: Aravind Eye Care, Jaipur Foot, SELCO, M-KOPA **Activities:** • Case study analysis: Pick a social innovation project and critique its impact. • Design challenge: Create a sustainable solution for a local issue.	**05**

4. Text Books:

1. Navi Radjou, Jaideep Prabhu, and Ramesh Srinivasan *"Jugaad Innovation"*, Harper Business.

2. Rishikesha T. Krishnan, *"From Jugaad to Systematic Innovation: The Challenge for India"*, Sage Publications.

3. Pavan Soni, *"Innovation by Design: How Design Thinking Creates Better Business Solutions"*, Penguin Random House India

4. Sameer Kochhar, *"The New Age Organisation: How Indian Leaders are Revolutionising Business"*, Skoch Media

5. Porus Munshi, *"Making Breakthrough Innovation Happen: How 11 Indians Pulled off the Impossible"*, Collins Business

6. U. C. Jindal, "*Product Design and Development"*, Pearson Education (Indian adaptation).

5. Reference Books:

1. ***The Design of Everyday Things*** – Don Norman

2. ***Change by Design*** – Tim Brown

3. ***The Lean Startup*** – Eric Ries

4. ***Ten Types of Innovation*** – Doblin

5. Harvard Business Review articles on innovation.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the fundamental concepts of design, innovation, and technology and their interrelations.	Explain	Understand
CO2	Analyze the impact of emerging technologies on product, service, and process innovation.	Analyze	Analyze
CO3	Apply design thinking and human-centered design principles to real-world problem-solving.	Apply	Apply
CO4	Create prototypes and MVPs using digital and physical tools for innovative solutions.	Create	Create
CO5	Evaluate business models and strategies for managing innovation in organizations.	Evaluate	Evaluate
CO6	Design sustainable and socially impactful innovations using frugal and inclusive approaches.	Design	Create

7. Mapping of course outcomes to module / course content:

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	-	-	-	-	-
2	-	3	-	-	-	-
3	-	-	3	-	-	-
4	-	-	-	3	-	-
5	-	-	-	-	3	-
6	-	-	-	-	-	3

8. Mapping of the Course outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	1	1	2	2	1	2	2	2	2	2	2
CO2	1	1	2	2	1	2	2	2	2	2	2
CO3	1	1	2	2	1	2	2	2	2	2	2
CO4	1	1	2	2	1	2	2	2	2	2	2
CO5	1	1	2	2	1	2	2	2	2	2	2
CO6	1	1	2	2	1	2	2	2	2	2	2

9. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	2	-	2
CO2	2	-	2
CO3	2	-	2
CO4	2	-	2
CO5	2	-	2
CO6	2	-	2

POWER QUALITY AND FACTS

Course Code: EE-607

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1. **Course Pre-requisites:**
   1. Power System
   2. Control System
   3. Power Electronics

2. **Course Learning Objectives:**
   1. To understand the characteristics of ac transmission and the effect of shunt and series reactive compensation. 2. To understand the working principles of FACTS devices and their operating characteristics. 3. To understand the basic concepts of power quality. 4. To understand the working principles of devices to improve power quality. 5. To solve numerical problems on the topics studied

3. **Course Name: POWER QUALITY AND FACTS**
   Course Code: EE607
   Hours per Week: 3
   Credits: 3
   Course Contents:

Module	Topics	36L
1	Introduction: Transmission Lines and Series/Shunt Reactive Power Compensation: Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation	05
2	Thyristor-based Flexible AC Transmission Controllers (FACTS): Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.	07
3	Voltage Source Converter based (FACTS) controllers: Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.	06
4	Application of FACTS: Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using a STATCOM.	06
5	Power Quality Problems in Distribution Systems: Power Quality problems in distribution systems. Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve. Effects in distribution system due to power system harmonics and load.	06
6	Dynamic Voltage Restorer and Unified Power Quality Conditioner: Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies. Major goal/application of PLCC, Main components of PLCC. Signal-to-Noise ratio calculation.	06

4. Text Books:

T1: FACTS Controllers in Power Transmission and Distribution, N K. R. Padiyar, New Age International (P) Ltd. 2007.

T2: Understanding FACTS: Concepts and Technology of FACTS Systems, N. G. Hingorani and L. Gyugyi Wiley-IEEE Press, 1999.

5. References:

R1: Reactive Power Control in Electric Systems, T. J. E. Miller, John Wiley and Sons, New York, 1983.

R2: Electrical Power Systems Quality", R. C. Dugan, McGraw Hill Education, 2012.

R3: Electric Power Quality, G. T. Heydt, Stars in a Circle Publications, 1991

6. Course Outcomes:

Course Outcomes	**Details/Statement**	**Action Verb**	**Knowledge Level**
CO1	Explain the fundamentals of AC transmission and the need for reactive power compensation.	Represent, Identify	Understand, Analyze
CO2	Describe and analyze the operation and control of Thyristor-based FACTS devices	Analyze, Evaluating	Understand, Analyze
CO3	Understand and apply the principles of Voltage Source Converter (VSC)-based FACTS controllers.	Understand Analyze	Understand, Apply
CO4	Evaluate the application of FACTS devices for improving power flow and system stability.	Analyze, Evaluating	Analyze, Evaluate
CO5	Identify and analyze various power quality problems in distribution systems.	Understand Remember	Analyze, Evaluate
CO6	Explain and implement methods for power quality improvement using DVR and UPQC.	Apply	Understand, Apply, Evaluate

7. Mapping of course outcomes to module/course content:

Module	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
1	3	-	-	1	-	-
2	1	3	2	-	-	-
3	1	-	3	1	-	-
4	-	-	2	3	-	-
5	-	-	1	2	3	-
6	-	-	2	1	-	3

8. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	-	2	1	-	-	-	1
CO2	3	3	1	1	-	2	2	-	-	-	1
CO3	3	3	1	1	-	1	2	-	-	-	1
CO4	3	3	1	1	-	1	2	-	-	-	1
CO5	3	3	1	1	-	2	1	-	-	-	1
CO6	3	3	1	1	-	2	2	-	-	-	1

9. **Mapping to PSO:**

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	1	1
CO3	3	2	1
CO4	3	1	2
CO5	3	1	1
CO6	3	2	2

UTILIZATION OF ELECTRIC POWER

Course Code: EE-608

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1. **Course Pre-requisites:**
   1. Basic Electrical Engineering
   2. Power System-I
   3. Electrical and Electronics Measurements

2. **Course Learning Objectives:**
   The usage of electric power comprises the many different ways in which electricity is utilized to accomplish beneficial work, such as lighting, heating, and cooling, as well as driving machinery, both in homes and industries and propulsion of electric traction.

3. **Course Name: UTILIZATION OF ELECTRIC POWER**
   Course Code: EE-608
   Hours per Week: 3
   Credits: 3

   Course Content:

Module	Topics	36L
1	**Electric Traction:** Requirement of an ideal traction system, Supply system for electric traction, Train movement (speed time curve, simplified speed time curve, average speed and schedule speed), Mechanism of train movement (energy consumption, tractive effort during acceleration, tractive effort on a gradient, tractive effort for resistance, power & energy output for the driving axles, factors affecting specific energy consumption, coefficient of adhesion). Electric traction motor & their control: Parallel and series operation of Series and Shunt motor with equal and unequal wheel diameter, effect of sudden change of in supply voltage, Temporary interruption of supply, Tractive effort and horse power. Use of AC series motor and Induction motor for traction. Traction motor control: DC series motor control, multiple unit control, Braking of electric motors, Power electronic controllers in traction system.	14
2	**Illumination:** The nature of radiation, Polar curve, Law of illumination, Photometry (Photovoltaic cell, distribution photometry, integrating sphere, brightness measurement), Types of Lamps: Conventional and energy efficient, Basic principle of light control, Different lighting scheme & their design methods.	08
3	**Electric Heating welding:** Types of heating, Resistance heating, Induction heating, Arc furnace, Dielectric heating, Microwave heating. DC welding, Resistive welding, Arc welding, TIG, MIG, Laser and ultrasonic welding.	08

4	**Electrolytic processes:** Basic principles, Faraday's law of Electrolysis, Electro deposition, Extraction and refining of metals, Power supply of Electrolytic processes.	06

4. **Textbook:**

T1: Art And Science of Utilisation of Electrical Energy, H. Partap, Dhanpat Rai and Co. Publisher.
T2. Utilization of electric power, R.K Rajput, Laxmi Publication Ltd.
T3. Generation, Distribution and Utilization of Electrical Energy, C.L. Wadhwa, New Age International Publication Ltd.
T4: Utilization of electric power, J.B. Gupta, Kataria Publication Ltd.

5. **References:**

R1: Utilization of electric power, N.V. Suryanarayana, New Age International Publication Ltd.
R2: Utilization of electric power, part-3, Thereja, Thereja, S.Chand Publisher

6. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Compare various traction drives and power supply systems used in Indian Railways.	Analyze, Identify	Understand, Remember
CO2	Calculate tractive effort, specific energy consumption for electric traction used in a particular terrain.	Identify, Select	Understand, Apply, Analyze
CO3	Monitor speed of electric trains using various speed control methods.	Identify, Select	Understand, Apply
CO4	Select suitable Power electronic controllers for electric trains.	Analyze	Evaluate, Apply, Analyze
CO5	Measure proper light at proper location, understand different characteristics of various lamps and choose appropriate fittings for real life requirement.	Identify	Understand, Apply, Analyze
CO6	Identify heating, welding and electrolytic schemes for a given application.	Implement	Understand, Apply, Analyze

7. **Mapping of course outcomes to module / course content:**

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	3	3	3	-	-
2	-	-	-	-	3	-
3	-	-	-	-	-	3
4	-	-	-	-	-	3

8. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	3	1	1	3	1	2	-	1	2
CO2	2	3	3	2	1	3	-	1	-	1	2
CO3	3	3	2	-	-	1	2	-	-	1	1
CO4	3	3	3	2	-	1	1	-	-	1	1
CO5	3	3	3	2	-	1	2	-	-	1	1
CO6	3	3	3	1	2	2	1	-	-	1	2

9. Mapping to PSO:

	PSO1	PSO2	PSO3
CO1	3	1	2
CO2	3	1	2
CO3	3	1	2
CO4	3	1	1
CO5	3	1	1
CO6	3	3	2

NON-CONVENTIONAL ENERGY

Course Code: EE-609

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1. **Course Pre-requisites:**
   1. Power System-I
   2. Power System-II
   3. Power Plant Engineering

2. **Course Learning Objectives:**
   This course is designed to provide brief introduction to non-conventional energy sources. Finite, non-renewable energy sources like coal, oil, and gas are consumed quicker than they are replaced. Long-term energy security, shortages, and price volatility are issues. Greenhouse gasses from fossil fuel burning cause climate change and air pollution. Renewable energy sources like solar, wind, and hydro power produce fewer emissions and are more sustainable. Natural replenishment makes non-conventional energy sources renewable and infinite. For future generations' energy sustainability, this is essential.

3. **Course Name: NON-CONVENTIONAL ENERGY**
   Course Code: EE-609
   Hours per Week: 3
   Credits: 3

   Course Contents:

Module	Topics	36L
1	**Introduction to Energy sources:** Renewable and non-renewable energy sources, energy consumption as a measure of Nation's development; strategy for meeting the future energy requirements Global and National scenarios, Prospects of renewable energy sources. Impact of renewable energy generation on environment, Kyoto Protocol.	02
2	**Solar Energy:** Solar radiation - beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solar radiation, local solar time, derived solar angles, sunrise, sunset and day length. flat plate collectors, concentrating collectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating & cooling of buildings, Solar photo voltaic cells: different types of PV Cells, Mono-poly Crystalline and amorphous Silicon solar cells. Equivalent circuit of solar cell, I-V and P-V characteristics, partial shedding effect, efficiency calculation, Design of PV array. cost and rating of PV array for standalone and grid connected systems.	11
3	**Wind Energy:** Principle of wind energy conversion; Basic components of wind energy conversion systems; wind mill components, various types and their constructional features; design considerations of horizontal and vertical axis wind turbines: analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations. Types of generators used and their characteristics.	09
4	**Energy from Biomass:** Biomass conversion technologies, Biogas generation plants, classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas.	06

5	**Hydel energy:** Introduction to hydro power. Brief description of Mini, micro and pico hydel plant. Fundamental concepts of converting water's energy into electricity and the different types of hydro power plants, including storage, run-of-river, and pumped-storage. Different types of turbines and generator used in hydel power plant.	08

4. Text Books:

T1: Non-conventional Energy sources, G.D. Rai, Khanna Publishers.
T2: Non-conventional Energy Resources, B. H. Khan, Tata McGraw Hill.
T3: Renewable energy sources and conversion technology, Bansal, Keemann and Meliss, Tata McGraw Hill.
T4: Energy Technology, O.P. Gupta, Khanna Publishing House.
T5: Renewable energy resources and emerging technologies, D.P. Kothari, PHI.

5. References:

R1: Non-conventional Energy, Ashok V. Desai, New Age International Publishers Ltd.

R2: Non-Conventional Energy Resources, Chandra and Chandra, Khanna Publishing House.

6. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	To understand the difference between Renewable and non-renewable energy sources	Analyze, Identify	Understand, Remember
CO2	To understand methods of conversion of solar energy to other form of energy	Identify, Select	Understand, Apply, Analyze
CO3	To understand methods of conversion of wind energy	Identify, Select	Understand, Apply
CO4	To understand methods harnessing energy from Biomass	Analyze	Understand, Apply, Analyze
CO5	To understand the principle of operation of hydel sources	Analyze	Understand, Apply, Analyze

7. Mapping of course outcomes to module/course content:

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	-	-
2	2	3	-	-	-
3	2	-	3	-	-
4	2	-		3	-
5	2	-	-	3	-

8. Mapping of CO to PO:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	-	-	-	-	-	-	1
CO2	3	3	3	2	2	-	-	-	-	-	1
CO3	3	3	3	3	2	-	-	-	-	-	1
CO4	3	3	3	3	2	-	-	-	-	-	1
CO5	3	3	3	3	2	-	-	-	-	-	1

9. Mapping to PSO:

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	3	1
CO3	3	2	1
CO4	3	2	1
CO5	3	2	1
CO6	3	3	1

POWER GENERATION ECONOMICS

Course Code: EE-610

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1. Course Pre-requisites:

1. Basic Electrical Engineering
2. Engineering Mathematics-I
3. Engineering Mathematics-II
4. Power System

3. **Course Learning Objectives:**

Explain the different terms e.g. load factor, etc., for economics of generation. Apply different types of tariffs for electricity pricing. Optimize the operation of power system with unit commitment. Determine generation levels such that the total cost of generation becomes minimum for a defined level of load. Determine the state of the system given by the voltage magnitudes and phase angles at all the busses.

4. **Course Name: POWER GENERATION ECONOMICS**
Course Code: EE610
Hours per Week: 3
Credits: 3

Course Contents:

Module	Topics	36 L
1.	**Economics of Generation:** Cost of power generation- Thermal, Hydro and Nuclear. Types of Consumers in a distribution system-Domestic, Commercial, Industrial etc. Concept of load factor, plant capacity factor, plant use factor, diversity factor, demand factor. Choice of size and number of generation's units.	06
2.	**Tariff:** Block rate, flat rate, two-part, maximum demand, Power factor and three- part tariffs. Subsidization and Cross subsidization Availability, tariff of generation companies. Pool tariff of transmission companies. Availability based tariff (ABT).	08
3.	**Unit Commitment:** Constraints in Unit Commitment, Spinning reserve, Thermal unit constraints, Hydro constraints, Must run, Fuel constraints. Unit commitment solution methods.	07
4.	**Economic Dispatch**: Transmission loss formulae and its application in economic load scheduling. Computational methods in economic load scheduling. Active and reactive power optimization.	08
5.	**State Estimation and load forecasting in power system:** Introduction, state estimation methods, concept of load forecasting, load forecasting technique and application in power system.	07

5. **Text Books:**

T1: Electrical Power Systems – Ashfaq Husain.
T2: Power System Analysis Operation and Control – Abhijit Chakrabarti, Sunita Halder, PHI.
T3: Modern Power System Analysis (fourth edition) – D.P.Kothari, I J Nagrath, McGraw Hill.
T4: Electrical Power System- D. Das, New Age Publishers.

6. **References:**

R1: Fundamentals of Power System Economics, Kirschen D, Wiley.

R2: Generation And Economics Consideration, J.B. Gupta, S.K.Kataria & Sons.

R3: Power Generation & Economics, Dr. Pawan Khetrapal, Technical Publication.

7. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Explain the different terms e.g. load factor etc., for economics of generation.	Represent, Identify	Understand, Remember
CO2	Apply different types of tariff or electricity pricing.	Analyze, Evaluating	Understand, Apply, Evaluating
CO3	Optimize the operation of power system with unit commitment.	Understand, Analyze	Understand, Apply
CO4	Determine generation levels such that the total cost of generation becomes minimum for a defined level of load.	Analyze, Evaluating	Understand, Apply, Analyze
CO5	Determine the state of the system given by the voltage magnitudes and phase angles at all buses.	Understand, Remember	Evaluate

8. **Mapping of course out comes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	1	-
2	1	3	-	3	-
3	1	-	3	2	-
4	-	-	3	3	-
5	-	-	3	3	2

9. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	1	-	2	-	-	-	-	1
CO2	3	3	2	1	-	2	-	-	-	-	1
CO3	3	3	1	1	2	2	-	-	-	-	1
CO4	3	3	1	1	-	2	-	-	-	-	1
CO5	3	3	1	1	1	2	-	-	-	-	1

10. **Mapping to PSO:**

	PSO1	**PSO2**	**PSO3**
CO1	3	3	2
CO2	3	-	1
CO3	3	2	2
CO4	3	-	2
CO5	3	-	1

POWER SYSTEM-II LABORATORY

Course Code: EE-691

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1. **Course Pre-requisites:**
   1. Basic Electrical Engineering
   2. Network Theory
   3. Power System-I

2. **Course Learning Objectives:**
   The course equips students to analyze faults, apply symmetrical components, understand stability concepts, and design protective schemes, enabling reliable, safe, and economical operation of power systems under normal and faulted conditions.

3. **Course Name: POWER SYSTEM-II LABORATORY**
   Course Code: EE-691
   Hours per Week: 2
   Credits: 1

   Course Contents:

	Topics
1	Study on the characteristics of on load time delay relay and off load time delay relay.
2	Test to determine polarity, ratio and magnetization characteristics of CT.
3	Test to determine polarity, ratio and magnetization characteristics of PT.
4	Study of different characteristics of over current relay.
5	Testing on (i) Under Voltage Relay and (ii) Earth Fault Relay.
6	Study on Economic load dispatch (without constraint).
7	Study on Economic load dispatch (with constraint).
8	Study on AC load flow using Gauss-seidel method.
9	Study on AC load flow using Newton Raphson method.
10	Study on DC load flow.

4. **Text Books:**

T1: Modern Power System Analysis, D.P. Kothari & I.J. Nagrath, 4th Edition, Tata McGraw Hill.
T2: Power system Analysis, operation & control, Chakrabarty & Haldar, 2nd edition, PHI.
T3: Modern power system analysis, D.P. Kothari & I.J. Nagrath, Tata McGraw Hill.

5. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Understand the operating principles and characteristics of protective relays (overcurrent, under-voltage, earth fault, time-delay relays).	Analyze, Calculate	Remember, Understand
CO2	Determine the polarity, ratio, and magnetization characteristics of current and potential transformers used in protection schemes.	Identify, Evaluate	Analyze, Create
CO3	Analyze and simulate power system load flow using Gauss-Seidel, Newton-Raphson, and DC load flow methods.	Measure, Assess	Evaluate, Create
CO4	Evaluate economic load dispatch solutions both with and without constraints for optimal power system operation.	Determine, Calculate	Create, Apply
CO5	Conduct protection-related experiments using software/hardware tools, interpret the results through graphs/tables, and document findings effectively.	Simulate, Analyze	Analyze, Apply

6. **Mapping of course outcomes to module/course content:**

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	-	-
2	1	3	-	-	3
3	-	3	-	-	3
4	3	-	-	-	-
5	3	-	-	-	-
6	-	-	-	3	-
7	-	-	-	3	-
8	-	-	3	-	-
9	-	-	3	-	-
10	-	-	3	-	-

7. **Mapping of CO to PO:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	2	2	-	-	1	-	1
CO2	3	3	1	1	2	2	-	-	1	-	1
CO3	3	3	1	1	2	2	-	-	1	-	1
CO4	3	3	1	1	2	2	-	-	1	-	1
CO5	3	3	1	1	2	2	-	-	1	-	1

8. **Mapping to PSO:**

	PSO1	PSO2	PSO3
CO1	3	2	2
CO2	3	3	1
CO3	3	-	1
CO4	3	-	2
CO5	3	2	-

Electric Drives Laboratory
Course Code: EE-692

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1. **Course Pre-requisites:**
   1. Power Electronics
   2. Electrical Machine

2. **Course Learning Objectives:**
   The Electric Drive Laboratory aims to provide students with practical knowledge and hands- on experience in analysing, designing, and implementing. The key learning objectives are to control the speed of DC motor using SCR and Chopper, control the speed of 1phase IM using TRIAC and performance of V/f control operation of a 3phase IM, speed control and braking of a 3-phase IM using commander SE and PLC.

3. **Course Name: Electric Drives Lab**
   Course Code: EE-692
   Hours per Week: 2
   Credits: 1
   Course Content:

Exp. No.	Experiment
1	Speed control of a D.C separately excited motor by single phase fully control rectifier
2	Speed control of a D.C separately excited motor by three phase fully control rectifier
3	Speed control of a D.C separately excited motor by chopper control
4	Speed control of a three-phase induction motor by VSI control
5	V/f control operation of a three phase induction motor drives
6	Speed control of a D.C shunt motor using fully control SCR drive
7	Study of a A.C single phase induction motor speed control using TRIAC
8	Speed control and braking of a three-phase induction motor using commander SE and PLC

4. **Text Books:**
    1. Fundamentals of Electrical Drives, G.K. Dubey, New Age International Publication.

5. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Identify appropriate equipment and instruments for the experiment.	Analyze, Identify	Understand, Remember
CO2	Test the instrument for application to the experiment.	Identify, Select	Understand, Apply, Analyze
CO3	Construct circuits with appropriate instruments and safety precautions.	Identify, Select	Understand, Apply
CO4	Apply different methods of control of Electric Drive in the laboratory.	Analyze	Understand, Apply, Analyze
CO5	Analyze experimental data	Analyze	Analyze

6. **Mapping of course outcomes to module / course content:**

Exp. No	CO1	CO2	CO3	CO4	CO5
1	3	-	-	3	-
2	-	-	-	3	-
3	-	3	-	-	-
4	-	-	-	3	-
5	-	-	-	3	-
6	-	-	3	3	-
7	-	-	-	-	3
8	-	-	-	3	-

7. **Mapping of the Course outcomes to Program Outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	-	-	1	-	-	-	-	1
CO2	3	3	3	2	2	1	-	-	-	-	1
CO3	3	3	3	3	2	2	-	-	-	-	1
CO4	3	3	3	3	2	1	-	-	-	-	1
CO5	3	3	3	3	2	1	-	-	-	-	1

8. **Mapping to PSO:**

	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	3	1
CO3	3	2	1
CO4	3	2	1
CO5	3	2	1

Nonlinear Control and Industrial Automation Laboratory
Course Code: EE-693

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1. **Course Pre-requisites:**

   i. Control Systems
   ii. Electrical and Electronic Measurements

2. **Course Learning Objectives:** At end of this course students will be able to understand and develop PLC ladder diagrams. Able to analyze and implement various control modes, including PID control, and apply controller tuning techniques for effective process regulation.

3. **Course Name: NONLINEAR CONTROL AND INDUSTRIAL AUTOMATION LABORATORY**
   Course Code: EE-693
   Hours per Week:2
   Credits: 1
   Course Content:

Exp. No.	Experiment
1	Study of PLC field device interface modules (AI, AO, DI, DO modules)
2	Programming Logic Gates Function in PLC
3	Implementing Mathematical Operations in PLC
4	a. Traffic Light Control by PLC. b. Reversal of DC Motor Direction by PLC c. ON/OFF Controller for Thermal Process by PLC.
5	Tuning of Controller and control of Thermal Process
6	Tuning of Conventional Controller for different process loops.
7	State Space-based Modeling and Control
8	On-line Monitoring and Control of different control loops

4. **Text Books**

T1: Programmable Logic Controllers with Control Logix, *Jon Stenerson*, Delmar Cengage learning, 2009.
T2: Automatic Process Control, *D.P. Eckman*, John Wiley and Sons.
T3: Process Control Instrumentation Technology, *C.D. Johnson*, PHI, 2005.
T4: Instrument Engineers Handbook - Vols. I, II, III, *B.G. Liptak*, CRC Press, 2003.
T5: Principles of Process Control – D. Patranabis

5. Course Outcomes:

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Knowledge of the PLC hardware module.	Analyze, Identify	Understand, Analyze
CO2	Demonstrate knowledge of actuators, and develop PLC ladder diagram.	Analyze, Identify	Understand, Analyze,
CO3	Analyze and implement various control modes, including PID control, and apply controller tuning techniques for effective process regulation.	Analyze, Apply	Understand, Analyze, Apply.
CO4	Application of State space Equation for different process models.	Analyze, Apply	Understand, Analyze, Apply.

6. Mapping of course outcomes to module / course content:

Exp. No.	CO1	CO2	CO3	CO4
1	3	2	2	-
2	2	3	-	-
3	2	3	2	-
4	2	3	1	-
5	1	-	3	-
6	-	-	3	-
7	--	-	-	3
8	-	-	1	-

7. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	1	2	2	2	3	2	-	2	1	1	1
CO2	1	2	2	2	3	2	-	2	1	1	1
CO3	1	2	2	2	3	2	-	2	1	-	1
CO4	1	2	2	2	3	1	-	1	1	-	1

8. Mapping to PSO:

	PSO1	PSO2	PSO3
CO1	3	-	1
CO2	3	-	1
CO3	3	-	1
CO4	3	1	1
CO5	3	1	-

VLSI and Microelectronics Laboratory

Course Code: EE-694

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1. **Course Pre-requisites:**
   (i) Digital Electronics Lab
   (ii) Analog Electronics Lab

2. **Course Learning Objectives**

The objective of this laboratory course is to provide hands-on experience in analysing MOS device characteristics, designing and simulating CMOS logic circuits, and implementing combinational and sequential systems. It also aims to familiarize students with layout design, design rule checks, and introduce the fundamental processes of VLSI fabrication through process simulations. This lab bridges theoretical concepts with practical applications in microelectronics and VLSI design.

3. **Course Name: VLSI and Microelectronics Laboratory**
   Course Code: EE-694
   Hours per Week: 2
   Credits: 1
   Course Contents:

Module	Topics
1	Study of I–V characteristics of NMOS and PMOS transistors.
	Determination of threshold voltage (Vth) and mobility parameter
	Observation of body effect on MOS transistor characteristics.
2	Design and simulation of CMOS inverter; analysis of rise time, fall time, and noise margin.
	Design and simulation of CMOS NAND and NOR gates.
	Implementation of XOR and XNOR circuits using CMOS logic.
3	Design and simulation of CMOS SR latch and D flip-flop.
	Design of a 4-bit ripple carry adder using CMOS logic.
4	Layout design of CMOS inverter using stick diagram and design rules.
	Layout design and simulation of 2-input NAND/NOR gates.
5	VHDL/Verilog programming to design combinational circuits on FPGA
	VHDL/Verilog programming to design sequential circuits on FPGA

4. **Text Books:**
   1. Digital Integrated Circuits: A Design Perspective – J.M. Rabaey, A. Chandrakasan, B. Nikolić, Pearson Education.
   2. CMOS Digital Integrated Circuits: Analysis and Design – Sung-Mo Kang & Yusuf Leblebici, Tata McGraw Hill.
   3. Modern VLSI Design – Wayne Wolf, Pearson Education.

5. **Reference Books:**
   1. Basic VLSI Design – Douglas A. Pucknell & Kamran Eshraghian, PHI.
   2. CMOS Circuit Design, Layout and Simulation – R.J. Baker, H.W. Li, D.E. Boyce, PHI.
   3. Principles of CMOS VLSI Design – Neil H.E. Weste & David Harris, Pearson Education.

6. **Course Outcomes**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Analyze MOS transistor characteristics through experiments.	Analyze, Identify	Understand, Apply
CO2	Design and simulate basic CMOS logic gates.	Design, Implement	Apply, Analyze
CO3	Implement sequential and combinational circuits using CMOS.	Design, Implement	Apply, Analyze
CO4	Prepare stick diagrams and layouts following VLSI design rules.	Draw, Implement	Apply, Analyze
CO5	Program FPGAs using Verilog/VHDL	Demonstrate	Apply

7. **Mapping of Course Outcomes to Module/course content**

Module	CO1	CO2	CO3	CO4	CO5
1	3	-	-	-	-
2	-	3	-	-	-
3	-	2	3	2	-
4	-	-	2	3	-
5	-	-	-	-	3

8. **Mapping of the Course Outcomes to Program Outcomes**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	2	1	-	-	-	-	-	1
CO2	3	3	3	2	2	-	-	-	-	-	1
CO3	3	3	3	3	2	-	-	-	-	-	1
CO4	3	3	2	3	2	-	-	-	-	-	1
CO5	3	2	2	2	2	-	-	-	-	-	1

9. **Mapping to PSO**

CO	PSO1	PSO2	PSO3
CO1	3	2	1
CO2	3	3	2
CO3	3	3	2
CO4	3	2	2
CO5	3	2	1

Digital Signal Processing Laboratory
Course Code: EE-695

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1. Course Pre-requisites

- Signals and Systems fundamentals

2. Course Learning Objectives

The goal of the Digital Signal Processing Laboratory is to provide students with basic practical knowledge in signal analysis, processing, and filter design. Students will implement DSP algorithms, visualize results, and understand their applications in real-world problems.

3. Course Name: Digital Signal Processing Laboratory
Course Code: EE-695
Hours per Week: 2
Credits: 1
Course Content:

Exp. No.	Experiment
1	Generation and plotting of basic discrete-time signals (unit impulse, step, ramp, sinusoidal, exponential)
2	Time shifting, time reversal, and scaling operations on discrete signals
3	Convolution and correlation of two discrete signals (linear and circular convolution)
4	Z-Transform and Inverse Z-Transform
5	Discrete Fourier Transform (DFT) and Inverse DFT
6	Fast Fourier Transform (FFT) implementation and verification with DFT
7	Design and frequency response of FIR filters using window methods (Hamming, Hanning, Rectangular)
8	Design and frequency response of IIR filters (Butterworth and Chebyshev)
9	Noise addition and removal in signals using digital filtering
10	Sampling and reconstruction of signals (aliasing demonstration)

4. Text Books

T1: Proakis, J.G., & Manolakis, D.G., *Digital Signal Processing: Principles, Algorithms, and Applications*, Pearson.
T2: Mitra, S.K., *Digital Signal Processing: A Computer-Based Approach*, McGraw Hill.

5. Course Outcomes

Course Outcome	Statement	Action Verb	Knowledge Level
CO1	Generate and manipulate discrete-time signals	Generate	Understand, Apply
CO2	Perform convolution and correlation of signals	Implement	Apply
CO3	Compute and interpret DFT/FFT of signals	Analyze	Apply, Analyze
CO4	Design FIR and IIR filters	Design	Apply, Analyze
CO5	Apply DSP techniques for noise removal and signal reconstruction	Apply	Apply, Analyze

6. Mapping of course outcomes/course content

Exp. No.	CO1	CO2	CO3	CO4	CO5
1	3	-	-	1	1
2	1	3	-	2	-
3	1	-	3	-	-
4	-	2	1	3	-
5	-	-	1	2	3
6	1	-	-	-	-
7	-	3	1	2	1
8	-	1	1		2
9	-	1	-	-	2
10	1	-	-	1	3

7. Mapping of the Course Outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	1	1	-	1	-	-	-	-
CO2	3	2	2	3	1	1	-	-	-	-	-
CO3	3	3	3	1	1	-	1	-	-	-	-
CO4	3	3	3	3	3	1	1	-	-	-	-
CO5	3	3	3	3	1	1	3	-	-	-	-

8. Mapping to PSO

	PSO1	PSO2	PSO3
CO1	3	3	1
CO2	3	-	1
CO3	3	1	3
CO4	3	-	3
CO5	3	-	1

MODELLING, DESIGN AND SIMULATION LABORATORY
Course Code: EE-696

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1. **Course Pre-requisites:**
   1. Electrical Machine
   2. Power System
   3. Control System

2. **Course Learning Objectives:**
   The goal involves the **design of electrical machines, power systems, and control systems.**

3. **Course Name:Modelling, Design and Simulation Laboratory**
   Course Code: EE-696
   Hours per Week: 2
   Credits: 1
   Course Content:

Sl. No	Laboratory Experiment
1	Design of small transformer.
2	Design of overall dimension of distribution transformer.
3	Design of cooling system of transformer.
4	Design of main dimensions of synchronous machine.
5	Design of field winding of a turbo generator.
6	Design of damper winding of a synchronous machine.
7	Design of main dimensions of DC machine.
8	Stator design of three -phase induction motor.
9	Wiring and installation design of a multi-storied residential building.
10	Designing the power distribution system for a small township.
11	Design of a controller for speed control of DC machine.

4. **Text Books:**
   1. Electrical Machine design: A.K. Sawhney (Dhanpat Rai & Co.).
   2. Design of Electrical Machines: V.N. Mittle & A. Mittle.
   3. Electrical wiring design: M.K. Giridharan (I.K. International).

5. **Course Outcomes:**

Course Outcomes	Details/Statement	Action Verb	Knowledge Level
CO1	Analyze and calculate the core, windings, and magnetic circuit parameters of transformers, DC machines, synchronous machines, and induction motors	Analyze, Understand	Knowledge
CO2	Design the main dimensions and performance parameters of small transformers, DC machines, synchronous machines, and induction motors using output equations and standard design techniques	Design, Calculate	Application
CO3	Create design algorithms for transformers, rotating machines, and controllers.	Implement, Develop	Application
CO4	Estimate load requirements and design power distribution systems and internal wiring for multi-storied buildings and small townships.	Design, Estimate	Application
CO5	Develop and simulate control strategies for speed control of DC machines using programming.	Simulate, Control	Analysis/Synthesis
CO6	Analyze and design the cooling systems of electrical machines based on heat dissipation and surface area calculations.	Analyze, Evaluate	Analysis

6. **Mapping of course outcomes to module / course content:**

Exp. No.	CO1	CO2	CO3	CO4	CO5	CO6
1	3	2	2	-	-	-
2	3	2	2	-	-	-
3	3	-	2	-	-	3
4	2	2	3	-	-	-
5	2	2	3	-	-	-
6	3	2	2	-	-	-
7	3	2	2	-	-	-
8	3	2	2	-	-	-
9	-	-	-	3	-	-
10	-	-	-	3	-	-
11	-	-	2	-	3	-

7. Mapping of the Course outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11
CO1	3	2	3	-	-	-	-	2	-	-	-
CO2	3	2	2	-	-	-	-	2	-	-	-
CO3	2	2	2	1	-	-	-	2	-	-	-
CO4	3	3	1	2	-	-	-	2	-	-	-
CO5	3	3	1	2	-	-	-	2	-	-	-
CO6	3	2	2	2				2			

8. Mapping to PSO:

	PSO1	PSO2	PSO3
CO1	3	-	1
CO2	2	3	1
CO3	2	3	1
CO4	3	3	1
CO5	3	3	1
CO6	3	2	2