D.N.R. COLLEGE OF ENGINEERING & TECHNOLOGY
AUTONOMOUS
Approved by AICTE, New Delhi & Permanently Affiliated to JNTUK, Kakinada
Accredited with A++ Grade by NAAC & Accredited by NBA (B. TECH – CSE, ECE & EEE)
Ph: 08816-221238 Email: dnrcet@gmail.com website: https://dnrcet.org
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

ANNEXURE-A

B. TECH III YEAR COURSE STRUCTURE
&
SYLLABUS
(DR24 REGULATIONS)

D.N.R COLLEGE OF ENGINEERING & TECHNOLOGY
AUTONOMOUS
ELECTRICALANDELECTRONICSENGINEERING

DR24 -III^nd Year COURSE STRUCTURE &S YLLABUS)

*Honors Engineering Courses offered EEE Branch students Need to Acquire 18 credits

Power Systems

S.No.	Course	Course code	Title	L	T	P	C
1	I	BT24EE0HPS1	Electric Power Quality	3	0	0	3
2	II	BT24EE0HPS2	Smart Grid Technologies	3	0	0	3
3	III	BT24EE0HPS3	Power System Deregulation	3	0	0	3
4	IV	BT24EE0HPS4	Real Time Control of Power Systems	3	0	0	3
5	V	BT24EE0HPS5	Advanced Power Systems Protection	3	0	0	3
6	VI	BT24EE0HPS6	Flexible AC Transmission Systems	3	0	0	3
7	VII	BT24EE0HPS7	AI applications in Power Systems	3	0	0	3
8	VIII	BT24EE0HPS8	Power Systems Lab	0	0	3	1.5
9	IX	BT24EE0HPS9	Advanced Power Systems Simulation Lab	0	0	3	1.5

Power Electronics

S.No.	Course	Course code	Title	L	T	P	C
1	I	BT24EE0HPE1	Special Electrical Machines	3	0	0	3
2	II	BT24EE0HPE2	Machine Modeling and Analysis	3	0	0	3
3	III	BT24EE0HPE3	Power Electronic Converters	3	0	0	3
4	IV	BT24EE0HPE4	Power Quality and Custom Power Devices	3	0	0	3
5	V	BT24EE0HPE5	Power Electronics for Renewable Energy systems	3	0	0	3
6	VI	BT24EE0HPE6	Industrial Applications of Power Electronic Converters	3	0	0	3
7	VII	BT24EE0HPE7	Advanced Electrical Drives	3	0	0	3
8	VIII	BT24EE0HPE8	FACTS Controllers	3	0	0	3
9	IX	BT24EE0HPE9	Power Converters Laboratory	0	0	3	1.5
10	X	BT24EE0HPEX	Electric Drives Laboratory	0	0	3	1.5
11	XI	BT24EE0HPEX1	Renewable Technologies Laboratory	0	0	3	1.5
12	XII	BT24EE0HPEXII	Electric Vehicles Laboratory	0	0	3	1.5

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OPEN ELECTIVES

S.No.	Category	Course code	Title	L	T	P	C
1	Open Elective-I (III-I)	1.BT24EE3101A 2. BT24EE3101B	1. Renewable Energy Sources 2. Concepts of Energy Auditing & Management	3	0	0	3
2	Open Elective–II (III-II)	1 BT24EE3202A 2. BT24EE3202B	1. Fundamentals of Electric Vehicles 2. Electrical Wiring Estimation and Costing	3	0	0	3
3	Open Elective–III (IV-I)	1.BT24EE4103A 2.BT24EE4103B	1. Battery Management Systems and Charging Stations 2. Concepts of Smart Grid Technologies	3	0	0	3
4	Open Elective-IV (IV-I)	1. BT24EE4204A 2.BT24EE4204B	1. Concepts of Power Quality 2. Intelligent Control Systems	3	0	0	3

*Minor Engineering Courses offered by EEE Department for Other Branches (Except EEE Branch)

S.No.	Course	Course code	Title	L	T	P	C
1	I	BT24EE0M01	Concepts of Control Systems	3	0	0	3
2	II	BT24EE0M02	Fundamentals of Electrical Measurements and Instrumentation	3	0	0	3
3	III	BT24EE0M03	Concepts of Power System Engineering	3	0	0	3
4	IV	BT24EE0M04	Fundamentals of Power Electronics	3	0	0	3
5	V	BT24EE0M05	Basics of Electric Drives and applications	3	0	0	3
6	VI	BT24EE0M06	Fundamentals of utilization of Electrical Energy	3	0	0	3
			Total	**18**	**0**	**0**	**18**

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(DR24 -IIInd Year COURSE STRUCTURE &S YLLABUS)

B.Tech. III Year-II Semester

S.No.	Category	Course code	Title	L	T	P	C
1	Professional Core	BT24EE3201	Electrical Measurements and Instrumentation	3	0	0	3
2	Professional Core	BT24EE3202	Microprocessors and Microcontrollers	3	0	0	3
3	Professional Core	BT24EE3203	Power System Analysis	3	0	0	3
4	Professional Elective-II	1. BT24EE32P2A 2. BT24EE32P2B 3. BT24EE32P2C	1. Switch gear and Protection 2. Advanced Control Systems 3. Renewable and Distributed Energy Technologies	3	0	0	3
5	Professional Elective-III	1. BT24EE32P3A 2. BT24EE32P3B 3. BT24EE32P3C	1. Electric Drives 2. Digital Signal Processing 3. High Voltage Engineering	3	0	0	3
6	Open Elective- II			3	0	0	3
7	Professional Core	BT24EE3204	Electrical Measurements and Instrumentation Lab	0	0	3	1.5
8	Professional Core	BT24EE3205	Microprocessors and Microcontrollers Lab	0	0	3	1.5
9	Skill Enhancement course	BT24EE3206	IoT Applications of Electrical Engineering Lab	0	1	2	2
10	Audit Course	BT24HS3201	Research Methodology &IPR	2	0	0	-
			Total	**20**	**1**	**08**	**23**

MC	BT24CS32M1	Student may select from the same minors pool	3	0	4.5
MC	BT24CS32M2	Minor Course (Student may select from the same specialized minors pool)	3	0	3
HC	BT24CS32H1	Student may select from the same honors pool	3	0	3
HC	BT24CS32H2	Honors Course (Student may select from the honors pool)	3	0	3

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DR24 -III[nd] Year COURSE STRUCTURE &S YLLABUS)

B.Tech. III Year-I Semester

S.No	Category	Course code	Title	L	T	P	C
1	Professional Core	BT24EE3101	Power Electronics	3	0	0	3
2	Professional Core	BT24EE3102	Digital Circuits	3	0	0	3
3	Professional Core	BT24EE3103	Power systems -II	3	0	0	3
4	Professional Elective-I	1.BT24EE31P1A 2. BT24EE31P1B 3.BT24EE31P1C	1.Signals and Systems 2.Computer Architecture and Organization 3.Communication systems	3	0	0	3
5	Open Elective-I	BT24HS3101	OR Entrepreneurship Development& Venture Creation	3	0	0	3
6	Professional Core	BT24EE3104	Power Electronics Lab	0	0	3	1.5
7	Professional Core	BT24EE3105	Analog and Digital Circuits Lab	0	0	3	1.5
8	Skill Enhancement course	BT24BS3101	Soft skills	0	1	2	2
9	Engineering Science	BT24EE3106	Tinkering Lab	0	0	2	1
10	Evaluation of Community Service Internship	BT24BS3102		-	-	-	2
		Total		**15**	**1**	**10**	**23**

1	**MC**	BT24CS31M1	Minor Course (Student may select from the same specialized minors pool)	3	0	3	4.5
2	**MC**	BT24CS31M2	Minor Course through SWAYAM/NPTEL(Minimum 12 Week, 3 credit course)	3	0	0	3
3	**HC**	BT24CS31H1	Honors Course (Student may select from the same Honors pool)	3	0	0	3
4	**HC**	BT24CS31H2	Honors Course (Student may select from the same Honors Pool)	3	0	0	3

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III Year–I Semester	PROFESSIONAL CORE POWER ELECTRONICS (BT24EE3101)	L	T	P	C
		3	0	0	3

Pre-requisite:

Electrical Circuit Analysis, Semiconductor Physics, Control Systems

Course Objectives:

- To know the characteristics of various power semi conductor devices.
- To learn the operation of single phase controlled converters and perform harmonic analysis of input current.
- To learn the operation of three phase controlled converters and AC/AC converters.
- To learn the operation of different types of DC-DC converters and control techniques.
- To learn the operation of PWM inverters for voltage control and harmonic mitigation.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the static and dynamic characteristics of SCR, Power-MOSFET and Power-IGBT.
CO2: Analyse the operation of phase-controlled rectifiers.
CO3: Analyse the operation of three-phase full–wave converters
CO4: Analyse the operation of AC Voltage Controllers and Cyclo converters.
CO5: Examine the operation and design of different types of DC-DC converters.
CO6: Analyse the operation of Square wave inverters and PWM inverters for voltage control.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	1	–	–	–	–	–	–	–	1	–
CO2	3	3	–	–	1	–	–	–	–	–	–	–	1	–
CO3	3	3	–	–	1	–	–	–	–	–	–	–	1	–
CO4	3	3	–	–	2	–	–	–	–	–	–	–	1	–
CO5	3	2	3	–	2	–	–	–	–	–	–	–	1	–
CO6	3	3	–	–	2	–	–	–	–	–	–	–	1	–

UNIT–I

Power Semi-Conductor Devices

Silicon controlled rectifier (SCR) – Two transistor analogy - Static and Dynamic characteristics – Turn on and Turn off Methods - Triggering Methods (R, RC and UJT) – Snubber circuit design. Static and Dynamic Characteristics of Power MOSFET and Power IGBT-Numerical problems.

UNIT–II

Single-phase AC-DC Converters

Single-phase half-wave controlled rectifiers - R and RL loads with and without freewheeling diode - Single-phase fully controlled bridge converter with R load, RL load and RLE load - Continuous and Discontinuous conduction - Effect of source inductance in Single-phase fully controlled bridge rectifier – Expression for output voltages – Single-phase Semi-Converter with R load-RL load and RLE load–Continuous and Discontinuous Conduction –Dual converter and its mode of operation-Numerical Problems.

UNIT–III

Three-phase AC-DC Converters &AC–AC Converters

Three-phase half-wave Rectifier with R and RL load - Three-phase fully controlled rectifier with R and RL load - Three-phase semi converter with R and RL load - Expression for Output Voltage - Numerical Problems. Single -phase AC-AC power control by phase control with R and RL loads - Expression for rms output voltage – Single-phase step down and step up Cyclo converter - Numerical Problems.

UNIT–IV

DC–DC Converters

Operation of Basic Chopper – Analysis of Buck, Boost and Buck-Boost converters in Continuous Conduction Mode (CCM) and Discontinuous Conduction Modes (DCM) -Output voltage equations using volt-sec balance in CCM & DCM – Expressions for output voltage ripple and inductor current tripple– control techniques-Numerical Problems.

UNIT–V

DC–AC Converters

Introduction -Single-phase half-bridge and full-bridge inverters with R and RL loads – Phase Displacement Control – PWM with bipolar voltage switching, PWM with unipolar voltage switching - Three-phase square wave inverters - 120^0 conduction and 180^0 conduction modes of operation -Sinusoidal Pulse Width Modulation - Current Source Inverter (CSI) - Numerical Problems.

Text Books:

1. Power Electronics: Converters, Applications and Design by Ned Mohan, Tore M Undeland, William P Robbins, John Wiley & Sons, 2002.
2. Power Electronics: Circuits, Devices and Applications–by M.H. Rashid, Prentice Hall of India, 2nd edition, 2017.
3. Power Electronics: Essentials &Applications by L. Uman and, Wiley, Pvt. Limited, India, 2009.

Reference Books:

1. Elements of Power Electronics–PhilipT.Krein. Oxford University Press ; Second edition, 2014.
2. Power Electronics–by P.S. Bhimbra, Khanna Publishers.
3. Thyristorised Power Controllers – by G. K. Dubey, S. R. Doradla, A. Joshi and R. M. K.Sinha, New Age International (P) Limited Publishers, 1996.
4. Power Electronics: by Daniel W. Hart, McGraw Hill, 2011.

Online Learning Resources:

1. https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007
2. https://archive.nptel.ac.in/courses/108/101/108101126

III Year I Semester	PROFESSIONAL CORE DIGITAL CIRCUITS(BT24EE3102)	L	T	P	C
		3	0	0	3

Pre-requisite:
Knowledge of electronic components and semi conductor devices, number systems, binary arithmetic, Boolean or switching algebra and logic gates.

Course Objectives:

- To know the simplification methods of Boolean functions
- To understand the realization of arithmetic, data routing and memory logic circuits.
- To know the operation and design of various counters and registers.
- To understand the analysis and design of synchronous sequential circuits.
- To understand the basic concepts of digital integrated circuits.

Course Outcomes:
At the end of the course, the student will be able to,
CO1: Use the concepts of Boolean algebra, K-map, and tabulation methods to minimize switching functions and design arithmetic combinational circuits.
CO2: Realize different types of data-routing combinational circuits and programmable logic devices (PLDs).
CO3: Apply knowledge of flip-flops in designing registers and counters.
CO4: Analyze synchronous sequential circuits.
CO5: Apply different methods for the design of synchronous sequential circuits.
CO6: Understand logic families and digital integrated circuits used in digital system design.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	3	2	–	1	–	–	–	–	–	–	–	–	–
CO2	3	2	3	–	2	–	–	–	–	–	–	–	–	1
CO3	3	2	3	–	1	–	–	–	–	–	–	–	–	–
CO4	3	3	–	–	1	–	–	–	–	–	–	–	1	–
CO5	3	2	3	–	2	–	–	–	–	–	–	–	–	–
CO6	3	1	–	–	1	–	–	–	–	–	–	–	–	–

UNIT–I:

Combinational logic circuits –I

Definition of combinational logic, canonical forms, Generation of switching equations from truth tables, simplification of logic functions using Boolean theorems, NAND and NOR implementations, Karnaugh maps – 3,4,5 variables, Incompletely specified functions (Don‘t care terms), Simplifying Max term equations, Quine -Mc Clus key minimization technique, General approach to combinational logic design, Look ahead carry adder, Cascading full adders,4-bitadder-subtractorcircuit,BCDaddercircuit,Excess3 adder, Binary comparators

UNIT–II:

Combinational logic circuits –II

Decoders, BCD decoders, 7 segment decoder, higher order decoder, multiplexer, higher order multiplexing, de-multiplexers, higher order de-multiplexing, realization of Boolean functions using decoders, multiplexers, encoders, priority encoder, Read only and Read/Write Memories, Programmable ROM,PAL,PLA-Basics structures, programming tables of PROM, PAL, PLA, realization of Boolean functions.

Unit–III

Sequential logic circuits

Timing considerations of flip-flops, master-slave flip-flop, edge triggered flip-flops, characteristicequations,flip-flopswithresetandclearterminals,excitationtables, conversion from one flip-flop to another flip-flop, design of asynchronous and synchronous counters, design of modulus-N counters, Johnson counter, ring counter, design of registers - buffer register, control buffer register, shift register, bi-directional shift register, universal shift register.

UNIT–IV

Sequential Circuit Design

Mealy and Moore models, State machine notation, Synchronous Sequential circuit analysis, Construction of state diagrams, Analysis of clocked sequential circuits, realization of sequence detector circuit, state reduction and assignments, design procedure.

UNIT–V

Digital integrated circuits:

Logic levels, propagation delay time, power dissipation, fan-out and fan-in, noise margin, logic families – RTL and DTL Circuits, TTL, Emitter-Coupled Logic, Metal-Oxide Semiconductor, Complementary MOS, CMOS Transmission Gate Circuits.

Textbooks:

1. Switching and finite automata theory Zvi. Kohavi, 3rd edition, Cambridge University Press, 2010.
2. M.Morris Mano andM.D. Ciletti,“Digital Design”, 4thEdition, Pearson Education,2006.

Reference Books:

1. Fundamentals of Logic Design by Charles H.Roth Jr,Jaico Publishers,5thEdition, 1992.
2. Switching Theory and Logic Design by A.Anand Kumar,Prentice Hall India Pvt., Limited, Third Edition, 2016.

Online Learning Resources:

1. https://nptel.ac.in/courses/117106086.
2. https://nptel.ac.in/courses/108105113.

III Year I Semester	PROFESSIONAL CORE POWERSYSTEMS-II(BT24EE3103)	L	T	P	C
		3	0	0	3

Pre-requisite: Power systems-I, Electrical circuit Analysis.

Course Objectives:

- To understand the concepts of GMD & GMR to compute inductance & capacitance of transmission lines.
- To distinguish the models of short, medium and long length transmission lines and analyzes their performance.
- To learn the effect of travelling waves on transmission lines with different terminal conditions.
- To learn the concepts of corona, the factors effecting corona and effects of transmission lines.
- To design the sag and tension of transmission lines as well as to learn the performance of line insulators.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Calculate parameters of transmission lines for different circuit configurations.
CO2: Analyze the performance of short, medium, and long transmission lines.
CO3: Analyze the effects of traveling waves on transmission lines.
CO4: Estimate the effects of corona in transmission lines.
CO5: Calculate sag and tension of transmission lines.
CO6: Analyze the design and performance of line insulators.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	1	–	–	–	–	–	–	–	2	–
CO2	3	3	–	–	1	–	–	–	–	–	–	–	3	–
CO3	3	3	–	–	1	–	–	–	–	–	–	–	3	–
CO4	3	2	–	–	1	–	2	–	–	–	–	–	2	–
CO5	3	2	2	–	1	–	–	–	–	–	–	–	2	2
CO6	3	2	3	–	1	–	–	–	–	–	–	–	2	3

UNIT–I

Transmission Line Parameters Calculations

Conductor materials –Types of conductors – Calculation of resistance for solid conductors – Calculation of inductance for Single-phase and Three-phase single and double circuit lines– Concept of GMR and GMD–Symmetrical and asymmetrical conductor configuration with and without transposition–Bundled conductors, Skin and Proximity effects.

Calculation of capacitance for 2 wire and 3 wire systems – Effect of ground on capacitance – Capacitance calculations for symmetrical and asymmetrical single and Three-phase single and double circuit lines without and with Bundled conductors.

UNIT–II

Performance Analysis of Transmission Lines

Classification of Transmission Lines – Short, medium, long lines and their model representation –Nominal-T, Nominal-π and A, B, C, D Constants for symmetrical Networks.

Rigorous Solution for long line equations –Representation of Long lines – Equivalent T and Equivalent π network models - Surge Impedance and Surge Impedance Loading of Long Lines - Regulation and efficiency for all types of lines – Ferranti effect.

UNIT–III

Power System Transients

Types of System Transients – Propagation of Surges – Attenuation–Distortion–Reflection and Refraction Coefficients. Termination of lines with different types of conditions: Open Circuited Line– Short Circuited Line, Line terminated through a resistance and line connected to a cable. Reflection and Refraction at a T-Junction.

UNIT–IV

Corona & Effects of transmission lines

Description of the phenomenon – Types of Corona - critical voltages and power loss – Advantages and Disadvantages of Corona - Factors affecting corona -Radio Interference.

UNIT–V

Sag and Tension Calculations and Over head Line Insulators:

Sag and Tension calculations with equal and unequal heights of towers–Effect of Wind and Ice weight on conductor – Stringing chart and sag template and its applications.

Types of Insulators – Voltage distribution in suspension insulators–Calculation of string efficiency and Methods for String efficiency improvement – Capacitance grading and Static Shielding.

Text Books:

1. Electrical Power Systems–by C.L.Wadhwa,New Age International (P) Limited, 8th edition,2022.
2. Power System Engineering by I.J.Nagarath and D.P.Kothari, Tata McGraw Hill, 3rd Edition, 2019.

Reference Books:

1. Power system Analysis–by John J Grainger William D Stevenson,

TMC Companies, 4thedition
2. Power System Analysis and Design by B.R.Gupta,Wheeler Publishing.
3. A Text Book on Power System Engineering by M.L.Soni, P.V.Gupta, U.S.Bhatnagar A.Chakrabarthy, Dhanpat Rai Co Pvt. Ltd.2016.
4. Electrical Power Systems by P.S.R.Murthy,B.S.Publications,2017.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105104
2. https://archive.nptel.ac.in/courses/108/102/108102047

III Year–I Semester	PROFESSIONAL ELECTIVE-I SIGNALS AND SYSTEMS (BT24EE31P1A)	L	T	P	C
		3	0	0	3

Course Outcomes:

CO1: Differentiate various classifications of signals and systems.

CO2: Analyze the frequency domain representation of signals using Fourier concepts.

CO3: Classify systems based on their properties and determine the response of LTI systems.

CO4: Explain the sampling process and various types of sampling techniques.

CO5: Apply Laplace transforms to analyze continuous-time signals and systems.

CO6: Apply Z-transforms to analyze discrete-time signals and systems.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	–	2	2
CO2	3	3	–	–	1	–	–	–	–	–	–	–	2	1
CO3	3	3	–	–	1	–	–	–	–	–	–	–	1	1
CO4	3	2	–	–	1	–	–	–	–	–	–	–	1	1
CO5	3	3	–	–	1	–	–	–	–	–	–	–	1	1
CO6	3	3	–	–	1	–	–	–	–	–	–	–	1	1

UNIT- I: INTRODUCTION: Definition of Signals and Systems, Classification of Signals, Classification of Systems, Operations on signals: time-shifting, time-scaling, amplitude- shifting, amplitude-scaling. Problems on classification and characteristics of Signals and Systems, Complex exponential and sinusoidal signals, Singularity functions and related functions: impulse function, step function signum function and ramp function.

UNIT–II : FOURIER SERIES AND FOURIERTRANSFORM:
Fourier series representation of continuous time periodic signals, Dirichlet's conditions, Trigonometric Fourier series and Exponential Fourier series, Relation between Trigonometric and Exponential Fourier series, Complex Fourier spectrum. Deriving Fourier transform from Fourier series, Fourier transform of standard signals, properties of Fourier transforms, Fourier transforms involving impulse function and Signum function. Related problems.

UNIT-III:
CORRELATION: Auto-correlation and cross-correlation of functions, properties of correlation function, Energy density spectrum, Parseval's theorem, Power density spectrum, Relation between Convolution and correlation, Detection of periodic signals in the presence of noise by correlation.

SAMPLING THEOREM: Graphical and analytical proof or Band Limited Signals, impulse sampling, Natural and Flat top Sampling, Reconstruction of signal from its samples, Aliasing, Related problems.

UNIT–IV:

LAPLACE TRANSFORMS: Introduction**,** Concept of region of convergence (ROC) for Laplace transforms, constraints on ROC for various classes of signals, Properties of L.T's, Inverse Laplace transform, Relation between L.T's, and F.T. of a signal. Laplace transform of certain signals using waveform synthesis.

UNIT–V:

Z–TRANSFORMS: Concept of Z-Transform of a discrete sequence. Region of convergence in Z-Transform, constraints on ROC for various classes of signals, Inverse Z- transform, properties of Z-transforms, Distinction between Laplace, Fourier and Z transforms.

TEXT BOOKS:

1. Signals, Systems &Communications -B.P.Lathi, BS Publications,2003.
2. Signals and Systems - A.V.Oppenheim, A.S.Willsky and S.H. Nawab,PHI, 3rd edition,2013.
3. Signals & Systems –Simon Hay kin and VanVeen,Wiley,2nd Edition,2007

REFERENCEBOOKS:

1. Principles of Linear Systems and Signals–BP Lathi,OxfordUniversityPress,2015
2. Signals and Systems–T K Rawat, Oxford University press,2011.

III Year–I Semester	PROFESSIONAL ELECTIVE-I COMPUTER ARCHITECTURE AND ORGANIZATION (BT24EE31P1B)	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in digital electronics, fundamentals of computers.

Course Objectives:

- To explain the basic working of a digital computer.
- To understand the register transfer language and micro operators.
- To learn various addressing modes supported by the processors.
- To be familiar with peripheral interfacing with processors.
- To understand memory hierarchy in computers.

Course Outcomes:

At the end of this course, student will be able to:

CO1: Demonstrate the instruction cycle of a computer system.
CO2: Understand various micro-operations and Register Transfer Language (RTL).
CO3: Understand the various addressing modes supported by processors.
CO4: Describe parallel processing and pipelining techniques.
CO5: Interface different peripherals with processors.
CO6: Explain the advantages of cache memory and virtual memory.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P010	P011	PO12	PS01	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	3	2	-	2	-	-	-	-	-	-	-	-	-
CO6	3	2	-	-	-	-	-	-	-	-	-	-	-	-

UNIT-I

Basic Computer Organization and Design: Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Memory-Reference Instructions, Input- Output and Interrupt, Complete Computer Description, Design of Basic Computer, Design of Accumulator Logic.

UNIT-II

Register Transfer and Micro operations: Register Transfer Language, Register Transfer, Bus and Memory Transfers, Arithmetic Micro operations, Logic Micro operations, Shift Micro operations, Arithmetic Logic Shift Unit. Micro programmed Control: Control Memory, Address Sequencing, Micro program Example, Design of Control Unit.

UNIT-III

Central Processing Unit: Introduction, General Register Organization, Stack Organization, Instruction Formats, Addressing Modes, Data Transfer and Manipulation, Program Control, Reduced Instruction Set Computer (RISC) Pipe line and Vector

Processing: Parallel Processing, Pipelining, Arithmetic Pipeline, Instruction Pipeline, RISK Pipeline, Vector Processing, Array Processors.

UNIT-IV

Input/output Organization: Peripheral Devices, I/O interface, Asynchronous data transfer, Modes of transfer, priority Interrupt, Direct memory access, Input-Output Processor (IOP), Serial Communication.

UNIT-V

Memory Organization: Memory Hierarchy, Main memory, Auxiliary memory, Associate Memory, Cache Memory, and Virtual memory, Memory Management Hardware.

Text Books:

1. Computer System Architecture, M. Morris Mano, Prentice Hall of India Pvt. Ltd., kerned 3rd Edition, June 2017.

References Books:

1. Computer Architecture and Organization, William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, 11th Edition, 2019.
2. Computer Organization and Architecture, Linda Null, Julia Lobur, Narosa Publications ISBN 81-7319-609-5,5th edition,2018
3. Computer System Organization by John. P. Hayes. McGrath Hill 3rd edition 2017.

III Year I Semester	RENEWABLE ENERGY SOURCES (BT24EE3101A)	L	T	P	C
		3	0	0	3

Pre-requisite: Basic Electrical Engineering

Objectives:

- To study the solar radiation data, equivalent circuit of PV cell and its I-V& P-V characteristics.
- To understand the concept of Wind Energy Conversion &its applications.
- To study the principles of biomass, hydel and geothermal energy.
- To understand the principles of ocean Thermal Energy Conversion, waves and power associated with it.
- To study the various chemical energy sources such as fuel cell and hydrogen energy along with their operation and equivalent circuit.

Course Outcomes:

After the completion of the course the student should be able to:
CO1: Analyze solar radiation data, extra-terrestrial radiation, radiation on the earth's surface, and methods of solar energy storage.
CO2: Illustrate the components and working principles of wind energy systems.
CO3: Explain the working of biomass, hydel, and geothermal power plants.
CO4: Demonstrate the principle of energy production from Ocean Thermal Energy Conversion (OTEC).
CO5: Demonstrate the principle of energy production from tidal and wave energy systems.
CO6: Evaluate the concept, working, and applications of fuel cells and MHD power generation.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	3	–	–	–	–	3	–	–	–	–	–	3	–
CO2	3	2	–	–	–	–	3	–	–	–	–	–	2	–
CO3	3	2	–	–	–	–	3	–	–	–	–	–	2	–
CO4	3	2	–	–	–	–	3	–	–	–	–	–	2	–
CO5	3	2	–	–	–	–	3	–	–	–	–	–	2	–
CO6	3	3	–	–	–	–	2	–	–	–	–	–	3	–

UNIT–I

Solar Energy

Introduction-Renewable Sources –prospects, solar radiation at the Earth Surface - Equivalent circuit of a Photovoltaic (PV) Cell - I-V & P-V Characteristics -Solar Energy Collectors: Flat plate Collectors, concentrating collectors - Solar Energy storage systems and Applications: Solar Pond –Solar water heating -Solar Green house.

UNIT–II

Wind Energy

Introduction - basic Principles of Wind Energy Conversion, the nature of Wind - the power in the wind - Wind Energy Conversion - Site selection considerations - basic components of Wind Energy Conversion Systems (WECS) - Classification - Applications.

UNIT–III
Biomass, Hydel and Geo thermal Energy
Biomass: Introduction-Bio mass conversion technologies-Photosynthesis. Factors affecting Bio digestion.
Hydro plants: Basic working principle – Classification of hydro systems**:** Large, small, micro hydel plants.
Geo thermal Energy: Introduction, Geothermal Sources–Applications- operational and Environmental problems.

UNIT–IV
Energy from oceans, Waves &Tides:
Oceans: Introduction - Ocean Thermal Electric Conversion (OTEC) – methods - prospects of OTEC in India.
Waves: Introduction-Energy and Power from the waves-Wave Energy conversion devices.
Tides: Basic principle of Tide Energy –Components of Tidal Energy.

UNIT–V
Chemical Energy Sources:
Fuel Cells: Introduction - Fuel Cell Equivalent Circuit - operation of Fuel cell -types of Fuel Cells - Applications.
Hydrogen Energy: Introduction-Methods of Hydrogen production –Storage and Applications
Magneto Hydro Dynamic (MHD) Power generation: Principle of Operation - Types.

Text Books:
1. G.D. Rai, Non-Conventional Energy Sources, Khanna Publications,2011.
2. John Twidell& Tony Weir, Renewable Energy Sources, Taylor & Francis, 2013.

Reference Books:
1. S.P.Sukhatme&J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2011.
2. John Andrews & Nick Jelly, Energy Science- principles, Technologies and Impacts, Oxford, 2nd edition, 2013.
3. ShobaNath Singh, Non-Conventional EnergyResources, Pearson Publications, 2015.

Online Learning Resources:
1. https://archive.nptel.ac.in/courses/103/103/103103206
2. https://archive.nptel.ac.in/courses/103/107/103107157

III Year I Semester	CONCEPTS OF ENERGY AUDITING & MANAGEMENT(BT24EE3101B)	L	T	P	C
		3	0	0	3

Pre-requisite:

Basics of Conservation of Electrical Energy

Course Objectives:

- To understand basic concepts of Energy Audit & various Energy conservation schemes.
- To design energy an energy management program.
- To understand concept of Energy Efficient Motors and lighting control efficiencies.
- To estimate/calculate power factor of systems and propose suitable compensation techniques.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Understand the principles of energy audit along with various energy-related terminologies.
CO2: Assess the role of an energy manager and the components of an energy management program.
CO3: Design energy-efficient motors and effective lighting systems.
CO4: Analyze methods to improve power factor in electrical systems.
CO5: Identify and select energy instruments for various real-time applications.
CO6: Evaluate computational techniques related to energy efficiency considering economic aspects.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	–	–	2	–	–	–	–	–	2	–
CO2	2	2	–	–	–	2	3	2	–	–	2	–	2	–
CO3	3	3	3	–	2	–	3	–	–	–	–	–	2	2
CO4	3	3	2	–	–	–	2	–	–	–	–	–	2	2
CO5	2	2	–	2	3	–	–	–	–	–	–	–	2	2
CO6	3	3	2	–	–	2	2	–	–	–	3	–	–	–

UNIT–I

Basic Principles of Energy Audit

Energy audit- definitions - concept - types of **Energy** audit - energy index - cost index - pie charts – San key diagrams and load profiles - Energy conservation schemes- Energy audit of industries- energysavingpotential-energyauditofprocessindustry,thermal power station building energy audit - Conservation of Energy Building Codes (ECBC-2017)

UNIT–II:

Energy Management

Principles of energy management - organizing energy management program - initiating - planning-controlling-promoting-monitoring-reporting.Energymanager-qualitiesand functions - language - Questionnaire – check list for top management.

UNIT–III:

Energy Efficient Motors and Lighting

Energy efficient motors - factors affecting efficiency - loss distribution - constructional details - characteristics – variable speed - RMS - voltage variation-voltage unbalance-over motoring-motor energy audit. Lighting system design and practice- lighting control-lighting energy audit.

UNIT–IV

Power Factor Improvement and Energy Instruments

Power factor – methods of improvement - location of capacitors - Power factor with non- linear loads-effect of harmonics on Power factor –power factor motor controllers–Energy Instruments-watt meter - data loggers – thermocouple s - pyrometers - lux meters - tongue testers.

UNIT–V

Economic Aspects and their Computation

Economics Analysis depreciation Methods - time value of money - rate of return - present worth method - replacement analysis - lifecycle costing analysis – Energy efficient motors.

Text Books:

1. Energy management by W.R.Murphy & G.Mckay Butterworth-Heinemann publications Elsarer,India -2003
2. Energy management hand book by W.CTurner-John wiley and sons -2007 3rd edition.

Reference Books:

1. Energy efficient electric motors byJohn.C.Andreas-MarcelDekkerIncLtd-2nd edition - 1995
2. Energy management by Paul o' Callaghan -Mc-graw Hill Book company-1st edition -1998
3. Energy management and good lighting practice: fuel efficiency-booklet12-EEO

Online Learning Resources:

1. https://nptel.ac.in/courses/108106022
2. https://archive.nptel.ac.in/courses/108/106/108106022

III Year I Semester	POWERE LECTRONICS LAB (BT24EE3104)	L	T	P	C
		0	0	3	1.5

Course objectives:

- To learn the characteristics of various power electronic devices and analyze firing circuits and commutation circuits of SCR.
- To analyze the performance of single–phase and three–phase full–wave bridge converters with both resistive and inductive loads.
- To understand the operation of AC voltage regulator with resistive and inductive loads.
- To understand the working of Buck converter and Boost converter.
- To understand the working of single-phase & three-phase inverters.

Course outcomes:

After the completion of the course the student should be able to:

CO1: Analyze characteristics of various power electronic devices and design firing circuits for SCR.

CO2: Analyze the performance of single-phase dual converter, three-phase full-wave bridge converter, and dual converter with resistive and inductive loads.

CO3: Examine the operation of single-phase AC voltage regulators with resistive and inductive loads.

CO4: Differentiate the working principles and control methods of Buck and Boost converters.

CO5: Differentiate the working principles and control methods of square-wave and PWM inverters.

CO6: Examine the operation of single-phase cyclo converters with resistive and inductive loads.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	3	2	–	2	–	–	–	–	–	–	–	3	2
CO2	3	3	2	–	–	–	–	–	–	–	–	–	3	2
CO3	3	2	–	–	–	–	–	–	–	–	–	–	2	2
CO4	3	3	2	–	–	–	–	–	–	–	–	–	2	2
CO5	3	3	2	–	–	–	–	–	–	–	–	–	2	2
CO6	3	2	–	–	–	–	–	–	–	–	–	–	2	2

Any 10 of the Following Experiments are to be conducted

1. Characteristics of SCR-Power MOSFET & Power IGBT.
2. R, RC & UJT firing circuits for SCR.
3. Single-Phase semi-converter with R & RL loads.
4. Single-Phase full-converter with R &RL loads.
5. Three-Phase full-converter with R&RL loads.
6. Single-phase dual converter in circulating current & non circulating current mode of operation.
7. Single-Phase AC Voltage Regulator with R &RL Loads.
8. Single-phase step down Cyclo converter with R &RL Loads.
9. Boost converter in Continuous Conduction Mode operation.
10. Buck converter in Continuous Conduction Mode operation.
11. Single-Phase square wave bridge inverter with R& RL Loads.
12. Single-Phase Uni polar and bi-Polar PWM inverter.
13. Three-phase bridge inverter with 180^0 conduction mode.
14. SPWM control of Three-phase bridge inverter

III Year I Semester	ANALOG AND DIGITAL CIRCUITS LAB (BT24EE3105)	L	T	P	C
		0	0	3	1.5

Course Objectives:

To impart knowledge on

- Analysis of transistor amplifiers
- Analysis of feedback amplifiers and oscillators
- Realization of digital circuits such data routing, registers and counters.

Course Outcomes:

At the end of the course, the student will be able to,

CO1: Analyze the operation of diode clipper and clamper circuits and transistor biasing techniques.
CO2: Illustrate the operation and applications of feedback amplifiers.
CO3: Illustrate the operation and design of oscillator circuits.
CO4: Analyze the applications and working of linear ICs.
CO5: Demonstrate the operation of arithmetic and data routing digital circuits.
CO6: Demonstrate the operation of digital circuits such as registers and counters.

CO-PO/PSO MATRIX (Level of Mapping-3: High; 2: Modarate: 1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	3	2	–	–	–	–	–	–	–	–	–	3	2
CO2	3	2	2	–	–	–	–	–	–	–	–	–	3	2
CO3	3	2	2	–	–	–	–	–	–	–	–	–	2	2
CO4	3	3	2	–	2	–	–	–	–	–	–	–	2	2
CO5	3	2	2	–	–	–	–	–	–	–	–	–	2	1
CO6	3	2	2	–	–	–	–	–	–	–	–	–	1	2

Any 5 of the Following Experiments are to be conducted from each

PART-A.

1. Analysis of clipper and clamper circuits.
2. Analysis of self-bias to a transistor.
3. Analysis of voltage series and current series feedback amplifiers.
4. Analysis of Wien Bridge oscillator and RC-phase shift oscillator.
5. Analysis of Integrator and Differentiator Circuits using IC741.
6. Analysis of Mono stable and Astable multi vibrator operation using IC555 Timer.
7. Analysis of Schmitt Trigger Circuits using IC741 and IC555.
8. Verify the PLL characteristics using IC565.
9. Analysis of 8 bit A to D and D to A circuits

PART-B

1. Design of Full adder and Full Sub tractor using logic gates.
2. Realization of parallel adder/sub tractor using IC 7483.
3. Implementation of 3 to 8 line decoder using logic gates and IC7445.
4. Implementation of 8to 1 multiplexer using logic gates and IC74151.
5. Verify the operation of master-slave JK flip-flop using IC7476.

6. Realization of the following shift registers using IC7495.
    a) SISO
    b) SIPO
    c) PISO
    d) PIPO
7. Implementation of Mod-10 ripples counter using flip-flops and IC 7490.
8. Implementation of Mod-8 synchronous up/down counters using flip-flops.
9. Implementation of 4 bit Ring Counter and John son Counter using D flip-flops/J-K flip-flops.

Course Objectives:

III Year-I Semester	Course Code: BT24HS3101	L	T	P	C
		3	0	0	3
ENTRPRENEURSHIP DEVELOPMENT&VENTURE CREATION (Open Elective - 1)					

By the end of the program, students will be/able to:

1. Inspired; develop entrepreneurial mind-set and attributes; entrepreneurial skill sets for venture creation and entrepreneurial leadership
2. Apply process of problem-opportunity identification and feasibility assessment through developing a macro perspective of the real market, industries, domains and customers while using design thinking principles to refine and pivot their venture idea.
3. Analyze Customer and Market segmentation, estimate Market size, develop and validate Customer Persona.
4. Initiate Solution design, Prototype for Proof of Concept. Understand MVP development and validation techniques to determine Product-Market fit
5. Craft initial Business and Revenue models, financial planning and pricing strategy for profitability and financial feasibility of a venture. Understand relevance and viability of informal and formal funding with respect to different business models.
6. UnderstandanddevelopGo-to-Marketstrategieswithafocusondigitalmarketingchannels.

Course Outcomes

At the end of the course, students will be able to

1. Develop an entrepreneurial mindset and appreciate the concepts of entrepreneurship, cultivate essential attributes to become an entrepreneur or Entrepreneur and demonstrate skills such as problem solving, team building, creativity and leadership
2. Comprehendtheprocessofproblem-opportunityidentificationthroughdesignthinking, identify market potential and customers while developing a compelling value proposition solution
3. Analyse and refine business models to ensure sustainability and profitability
4. Build Proto type for Proof of Concept and validate MVP of their practice venture idea
5. Create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture
6. Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

Course Content

Twelve learning modules organized over 14weeks in the following logical flow of units

Unit I: Entrepreneurship Fundamentals & Context

Meaning and concept, attributes and mindset of entrepreneurial and entrepreneurial leadership, role models in each and their role in economic development. An understanding of how to build entrepreneurial mindset, skillets, attributes and networks while on campus.

Core Teaching Tool: Simulation, Game, Industry Case Studies (Personalized for students – 16 industries to choose from), Venture Activity

Unit II: Problem &Customer Identification

Understanding and analyzing the macro-Problem and Industry perspective, technological, socio economic and urbanization trends and their implication on new opportunities. Identifying passion, identifying and defining problem using Design thinking principles. Analyzing problem and validating with the potential customer. Iterating problem-customer fit. Understanding customer segmentation, creating and validating customer personas. Competition and Industry trends mapping and assessing initial opportunity.

Core Teaching Tool: Several types of activities including Class, game, Gen AI, 'Get out of the Building'And Venture Activity.

Unit III: Solution design, Prototyping & Opportunity Assessment and Sizing

Understanding Customer Jobs-to-be-done and crafting innovative solution design to map to customer's needs and create a strong value proposition. Developing Problem-solution fit in an iterative manner. Understanding prototyping and MVP. Developing a feasibility prototype with differentiating value, features and benefits. Initial testing for proof-of-concept and iterate on the prototype. Assess relative market position via competition analysis, sizing the market and assess scope and potential scale of the opportunity.

Core Teaching Tool: Venture Activity, no-code Innovation tools, Class activity

Unit IV: Business & Financial Model, Go-to-Market Plan

Introduction to Business model and types, Lean approach,9block lean canvas model, riskiest assumptions to Business models. Importance of Build - Measure – Lean approach.

Business planning: components of Business plan- Sales plan, People plan and financial plan.

Financial Planning: Types of costs, preparing a financial plan for profitability using financial template, understanding basics of Unit economics and analyzing financial performance.

Introduction to Marketing and Sales, Selecting the Right Channel, creating digital presence, building customer acquisition strategy.

Choosing a form of business organization specific to your venture, identifying sources of funds: Debt & Equity, Map the Start-up Lifecycle to Funding Options.

Core Teaching Tool: Founder Case Studies–Sama and Securely Share; Class activity and discussions; Venture Activities

Unit V: Scale Outlook and Venture Pitch readiness

Understand and identify potential and aspiration for scale visa is your venture idea. Persuasive Story telling and its key components. Build an Investor ready pitch deck.

Core Teaching Tool: Expert talks; Cases; Class activity and discussions; Venture Activities.

Suggested Reading:

- RobertD.Hisrich, MichaelP.Peters, DeanA.Shepherd,SabyasachiSinha(2020). Entrepreneurship, McGrawHill, 11th Edition.
- Ries,E.(2011).TheLeanStartup:HowToday'sEntrepreneursUseContinuous Innovation to Create Radically Successful Businesses. Crown Business
- Osterwalder,A.,&Pigneur,Y.(2010).BusinessModelGeneration:AHandbookfor Visionaries, Game Changers, and Challengers. John Wiley & Sons.
- SimonSinek(2011)StartwithWhy,PenguinBookslimited
- BrownTim(2019)ChangebyDesignRevised&Updated:HowDesignThinking Transforms Organizations and Inspires Innovation, Harper Business
- NamitaThapar(2022)TheDolphinandtheShark:StoriesonEntrepreneurship,Penguin Books Limited
- SarasD.Sarasvathy,(2008)Effectuation:ElementsofEntrepreneurialExpertise,Elgar Publishing Ltd

Web Resources

• Learning resource-Ignite 5.0 Course Wadhwani platform (Includes200+componentsof custom created modular content +500+components of the most relevant curated content)

Supported Evaluation

Evaluation is designed to measure individual and group work.

Ongoing Assessment components:
Enable remedial action in the classroom by the faculty and additional assistance by AI Tutor.

1. Three System-assessed, randomized short answer type assessments during the 14 weeks to assess Individual learner's understanding and internalization of core concepts-includes questions of
    a. Multiple choice
    b. Fill in the blanks
    c. Match the options
    d. 'true and false'

2. Two interim assessments of the Venture application milestones submission via the platform (teamwork). Simple and easy way for the faculty to assess the milestones and the team's work.

Final Assessment component:

Assessment that provides an overall assessment of learning and application. Evaluated by faculty against an assessment rubric.

1. Final Venture Idea Pitch submission and presentation (team application work) (Students build a Practice Venture with Venture activities progressively leading to the development of a pitch presentation deck with various milestones to mark advancement. It is reflection of their learning as well as a practical application of concepts to identifying, building and validating a venture idea.)
Additional evaluation mechanisms: In Addition to this, mandatory individual exercises are embedded in the course, faculty can use those for any additional evaluation that they May need to score the students

Teaching Learning Process (Pedagogy), Tools, Student Experience

I. Program Facilitation and Learning Tools

a. **Dynamic Facilitation**: Led by expert facilitators utilizing a comprehensive suite of micro-learning materials.

- Audio-visual content, written materials and info graphics.
- Real-world examples enhancing the learning experience.

b. **Interactive Learning**: Engaging case studies, games, simulations, and kinesthetic classroom activities.

- Focus on current Indian startups to provide context-relevant learning.
- Aimed at GenZ learners for informative, immersive and authentic learning experience.

II. Venture Development Activities

a. **Innovation and Strategic Application**: Fostering innovative thinking and strategic problem-solving.

- Students create Venture Ideas Pitch and feasibility proto types addressing real- world scalable problem-opportunities.

b. **Practical Experience**: Combining academic rigor with practical, hands-on entrepreneurial activities.

- Functions as an incubator for aspiring entrepreneurs and entrepreneurial leaders.

III. Anytime, anywhere Gen AI Supported Digital Learning

a. **Multi-Modal Digital Tools** :A range of digital resources available for students.

- Comprehensive concept and reference guides and hand books.
- AI Tutor and AI Assistant to enhance learning and application via development of a feasible Venture Idea Pitch.

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IV. Ongoing Inspiration and Learning with Practitioners

1. **Seminars, Workshops and Master classes**: Access to live talks and specialized classes running through each semester.
    - Founder stories, including social entrepreneurs.
    - Technology Trend and Industry Opportunity sessions
    - Innovation and IPR Management session
    - Startup Ecosystem overview

V. Certification and Community Engagement

a. **Recognition and Networking**: Opportunities available upon course completion.

- Venture Ideas Pitch Deck evaluation for certification by organizations like the Wadhwa Foundation.
- Access to a global community fostering connections and support for competitions. Group mentoring and individual mentorship sessions to further guide students

III Year-I Semester	SOFT SKILLS- (BT24BS3101) (Skill Enhancement course)	L	T	P	C
		0	1	2	2

Course Objectives:

- To equip the students with the skills to effectively communicate in English
- To train the students in interview skills, group discussions and presentation skills
- To motivate the students to develop confidence
- To enhance the students' interpersonal skills
- To improve the students' writing skills

Course Outcomes:

COs	Statements	Blooms Level
CO1	**Demonstrate** analytical thinking and active listening skills to make informed decisions and effectively solve real-world problems.	K5
CO2	**Implement** self-management strategies to develop resilience, and goal-oriented behavior in academic and professional environments.	K3
CO3	**Use** standard grammar structures accurately in both speaking and writing to ensure clear and effective communication in global contexts.	K3
CO4	**Develop** job-oriented communication and presentation skills that align with current industry standards and digital tools.	K6
CO5	**Build** and sustain effective interpersonal relationships through empathy, teamwork in diverse professional settings.	K4
CO6	**Integrate** critical thinking, workplace readiness, and social intelligence to succeed in today's competitive job market.	K6

UNIT – I: Analytical Thinking & Listening Skills: Self-Introduction, Shaping Young Minds - A Talk by Azim Premji (Listening Activity), Self – Analysis, Developing Positive Attitude, Perception.
Communication Skills: Verbal Communication; Non Verbal Communication (Body Language)
UNIT – II: Self-Management Skills: Anger Management, Stress Management, Time Management, Six Thinking Hats, Team Building, Leadership Qualities Etiquette: Social Etiquette, Business Etiquette, Telephone Etiquette, Dining Etiquette

UNIT – III: Standard Operation Methods: Basic Grammars, Tenses, Prepositions, Pronunciation, Letter Writing; Note Making, Note Taking, Minutes Preparation, Email & Letter Writing

UNIT-IV: Job-Oriented Skills: Group Discussion, Mock Group Discussions, Resume Preparation, Interview Skills, Mock Interviews

UNIT-V: Interpersonal relationships: Introduction, Importance, Types, Uses, Factors affecting interpersonal relationships, Accommodating different styles, Consequences of interpersonal relationships

Text books:

1. Barun K. Mitra, Personality Development and Soft Skills, Oxford University Press, 2011.
2. S.P. Dhanavel, English and Soft Skills, Orient Blackswan, 2010.

Reference books:

1. R.S.Aggarwal, A Modern Approach to Verbal & Non-Verbal Reasoning, S.Chand& Company Ltd., 2018.
2. Raman, Meenakshi& Sharma, Sangeeta, Technical Communication Principles and Practice, Oxford University Press, 2011.

E-resources:
https://swayam-plus.swayam2.ac.in/courses/course-details?id=P_CAMBR_01

III Year I Semester	ENGINEERING SCIENCE TINKERING LAB(BT24EE3106)	L	T	P	C
		0	0	2	1

The aim of tinkering lab for engineering students is to provide a hands-on learning environment where students can explore, experiment, and innovate by building and testing prototypes. These labs are designed to demonstrate practical skills that complement theoretical knowledge.

Course Objectives: To

1. Encourage Innovation and Creativity
2. Provide Hands-on Learning
3. Impart Skill Development
4. Foster Collaboration and Team work
5. Enable Inter disciplinary Learning
6. Impart Problem-Solving mind-set
7. Prepare for Industry and Entrepreneurship

Course Outcomes: The students will be able to experiment, innovate, and solve real-world challenges.

CO1: Construct and demonstrate basic electrical circuits such as series and parallel circuits using a breadboard for practical applications.

CO2: Design and demonstrate a traffic light control circuit using a breadboard.

CO3: Build and demonstrate an automatic street lighting system using an LDR sensor.

CO4: Simulate Arduino-based LED control applications using Tinker cad.

CO5: Develop and demonstrate Arduino programs for LED blinking using the Arduino IDE.

CO6: Interface sensors and actuators such as IR sensors and servo motors with Arduino and demonstrate their operation.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	2	–	–	–	–	–	2	–	–	–	2	2
CO2	3	2	3	–	–	–	–	–	2	–	–	–	3	2
CO3	3	3	3	–	–	–	3	–	2	–	–	–	3	2
CO4	2	2	2	–	3	–	–	–	–	–	–	–	2	3
CO5	2	2	2	–	3	–	–	–	–	–	–	–	3	3
CO6	3	3	3	–	3	–	–	–	2	–	–	–	3	3

These labs bridge the gap between academia and industry, providing students with the practical experience. Some students may also develop entrepreneurial skills, potentially leading to start-ups or innovation-driven careers. Tinkering labs aim to cultivate the next generation of engineers by giving them the tools, space, and mind-set to experiment, innovate, and solve real-world challenges.

List of experiments:

1) Make your own parallel and series circuits using breadboard for any application of your choice.
2) Demonstrate a traffic light circuit using bread board.
3) Build and demonstrate automatic Street Light using LDR.
4) Simulate the Arduino LED blinking activity in Tinker cad.
5) Build and demonstrate an Arduino LED blinking activity using Arduino IDE.
6) Interfacing IR Sensor and Servo Motor with Arduino.
7) Blink LED using ESP32.
8) LDR Interfacing with ESP32.

9) Control an LED using Mobile App.
10) Design and 3D print a Walking Robot
11) Design and 3D Print a Rocket.

12) Build a live soil moisture monitoring project, and monitor soil moisture levels of a remote plan in your computer dashboard.
13) Demonstrate all the steps in design thinking to re design a motorbike.

Students need to refer to the following links:

1) https://aim.gov.in/pdf/equipment-manual-pdf.pdf
2) https://atl.aim.gov.in/ATL-Equipment-Manual/
3) https://aim.gov.in/pdf/Level-1.pdf
4) https://aim.gov.in/pdf/Level-2.pdf
5) https://aim.gov.in/pdf/Level-3.pdf

		L	T	P	C
III Year I Semester	**EVALUATIONOFCOMMUNITY SERVICE INTERNSHIP(BT24BS3102)**	-	-	-	2

III Year II Semester	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION (BT24EE3201)	L	T	P	C
		3	0	0	3

Pre-requisite:

Basics of Electrical and Electronics Engineering.

Course Objectives:

- To understand and analyze the factors that affects the various measuring units.
- To choose the appropriate meters for measuring of voltage, current, power, power factor and energy qualities and understand the concept of standardization.
- Describe the operating principle of AC & DC bridges for measurement of resistance, inductance and capacitance.
- To understand the concept of the transducer and their effectiveness in converting from one form to the other form for the ease of calculating and measuring purposes.
- To understand the operating principles of basic building blocks of digital systems, record and display units.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Understand the construction and working principles of various types of analog instruments.
CO2: Describe the construction and working of watt meters and power factor meters.
CO3: Understand the construction and working of various bridge circuits for measurement of resistance.
CO4: Understand the construction and working of various bridge circuits for measurement of inductance and capacitance.
CO5: Understand the operational principles and applications of various transducers.
CO6: Understand the construction and working principles of digital meters.

CO-PO/PSO MATRIX (Level of Mapping-3: High; 2: Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	–	3	–
CO2	3	2	–	–	–	–	–	–	–	–	–	–	3	–
CO3	3	2	–	–	–	–	–	–	–	–	–	–	3	–
CO4	3	2	–	–	–	–	–	–	–	–	–	–	3	–
CO5	3	2	–	–	2	–	–	–	–	–	–	–	2	2
CO6	3	2	–	–	3	–	–	–	–	–	–	–	2	–

UNIT-I

Analog Ammeter and Voltmeters

Classification – deflecting, control and damping torques – PMMC, moving iron type and electrostatic instruments –Construction –Torque equation –Range extension –Errors and compensations –advantages and disadvantages. Instrument transformers: Current Transformer and Potential Transformer – theory –Ratio and phase angle errors–Numerical Problems.

UNIT-II

Analog Watt meters and Power Factor Meters

Electrodynamometer type wattmeter (LPF and UPF) – Power factor meters: Dynamometer and M.I type (Single phase and Three phase) – Construction – torque equation – advantages and disadvantages. Potentiometers: Principle and operation of D.C Crompton's potentiometer –

Standardization –Applications –AC Potentiometer (Polar and coordinate types) –Standardization – Applications – Numerical Problems.

UNIT-III

Measurements of Electrical parameters

DC Bridges: Method of measuring low, medium and high resistance –Wheat stone's bridge for measuring medium resistance– Kelvin's double bridge for measuring low resistance – Loss of charge method for measurement of high resistance –Megger – measurement of earth resistance – Numerical Problems.

AC Bridges: Measurement of inductance and quality factor – Maxwell's bridge – Hay's bridge – Anderson's bridge. Measurement of capacitance and loss angle – Desauty's bridge – Schering Bridge – Wien's bridge –Numerical Problems.

UNIT-IV

Transducers

Definition –Classification –Resistive, Inductive and Capacitive Transducer – LVDT –Strain Gauge –Thermistors –Thermocouples – Piezo electric and Photo Diode Transducers –Hall effect sensors – Numerical Problems.

UNIT-V

Digital meters

Digital Voltmeters – Successive approximation DVM – Ramp type DVM and integrating type DVM – Digital frequency meter – Digital multi meter – Digital tachometer – Digital Energy Meter – Q meter. CRO – measurement of phase difference and Frequency using lissajious patterns – Numerical Problems.

Text Books:

1. Electrical Measurements and measuring Instruments by E.W. Golding and F.C.Widdis - 6th Edition - Wheeler Publishing 2019.
2. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper - PHI – 1st Edition - 2015.

Reference Books:

1. Electrical & Electronic Measurement & Instruments by A.K. Sawhney Dhanpat Rai & Co. Publications -19th revised edition -2012.
2. Electrical and Electronic Measurements and instrumentation by R.K.Rajput

-S.Chand-3rdedition 2013.

3. Principles of Electrical Measurements by Bucking ham and Price -Prentice–Hall 1955
4. Electrical Measurements by Forest K. Harris. John Wiley and Sons,1968.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105153

III Year II Semester	MICRO PROCESSORS AND MICRO CONTROLLERS (BT24EE3202)	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in digital electronics, fundamentals of computers.

Course objectives:

- To understand the organization and architecture of Microprocessor
- To understand addressing modes to access memory
- To understand 8051micro controller architecture
- To understand the programming principles for 8086 and 8051
- To understand the interfacing of Microprocessor with I/O as well as other devices
- To understand how to develop cyber physical systems

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Explain the general concepts, functions, and capabilities of microprocessors.
CO2: Compare and evaluate the performance and features of different microprocessors.
CO3: Analyze the instruction set, addressing modes, and minimum/maximum mode operations of the 8086 microprocessor.
CO4: Analyze microcontroller architecture and interfacing capabilities.
CO5: Describe the architecture, programming, and interfacing of the 8051 microcontroller.
CO6: Understand the concepts of PIC microcontrollers and their programming.

CO-PO/PSO MATRIX (Level of Mapping-3: High; 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	–	3	2
CO2	3	3	2	–	–	–	–	–	–	–	–	–	3	2
CO3	3	3	3	–	–	–	–	–	–	–	–	–	3	2
CO4	3	3	3	–	2	–	–	–	–	–	–	–	3	2
CO5	3	3	3	–	2	–	–	–	–	–	–	–	2	2
CO6	3	2	2	–	2	–	–	–	–	–	–	–	2	2

UNIT-I

Introduction to Microprocessor Architecture

Introduction and evolution of Microprocessors – Architecture of 8086 – Memory Organization of 8086 – Register Organization of 8086– Introduction to 80286 -80386 - 80486 and Pentium (brief description about architectural advancements only).

UNIT-II

Minimum and Maximum Mode Operations

Instruction sets of 8086 - Addressing modes – Assembler directives –Simple Programs- General bus operation of 8086 – Minimum and Maximum mode operations of 8086 – 8086 Control signal interfacing – Read and write cycle timing diagrams.

UNIT-III

Microprocessors I/O interfacing

8255 PPI– Architecture of 8255–Modes of operation– Interfacing I/O devices to 8086 using 8255–Interfacing A to D converters– Interfacing D to A converters– Stepper motor interfacing– Static memory interfacing with 8086–Architecture and interfacing of DMA Controller (8257).

UNIT-IV

8051 Microcontroller

Overview of 8051 Microcontroller – Architecture– Memory Organization – Register set – Instruction set – Simple Programs - I/O ports and Interrupts – Timers and Counters – Serial Communication – Interfacing of peripherals.

UNIT-V

PIC Architecture

BlockdiagramofbasicPIC18microcontroller– registers I/O ports–Programming in C for PIC: Data types - I/O programming -logical operations -data conversion.

Text Books:

1. Ray and Burchandi - “Advanced Microprocessors and Interfacing”- Tata McGraw–Hill -3rd edition -2006.
2. Kenneth J Ayala-“The8051MicrocontrollerArchitecture-Programmingand Applications”-Thomson Publishers-2nd Edition.
3. PIC Microcontroller and Embedded Systems using Assembly and C for PIC 18 -- Muhammad Ali Mazidi –Rolind D.Mckinay-Danny causey -Pearson Publisher 21stImpression.

Reference Books:

1. Microprocessors and Interfacing –Douglas V Hall -Mc–GrawHill-2ndEdition.
2. R.S.Kaler-“A Text book of Micro processors and Micro Controllers”-I.K. International Publishing House Pvt. Ltd.
3. Ajay V.Deshmukh -“Microcontrollers–Theory and Applications”-Tata McGraw– Hill Companies –2005.
4. Ajit Pal -“Microcontrollers – Principles and Applications” -PHI Learning Pvt Ltd - 2011.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105102
2. https://archive.nptel.ac.in/courses/108/103/108103157
3. https://nptel.ac.in/courses/106108100

III Year II Semester	POWER SYSTEM ANALYSIS (BT24EE3203)	L	T	P	C
		3	0	0	3

Pre-requisite:

Concepts of electrical circuits and power systems-II

Course Objectives:

- To develop the impedance diagram (p.u) and formation of Y_{bus}
- To learn the different load flow methods.
- To learn the Z_{bus} building algorithm.
- To learn short circuit calculation for symmetrical faults
- To learn the effect of unsymmetrical faults and their effects.
- To learn the stability of power systems and method to improve stability.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Draw the impedance diagram for a power system network.

CO2: Calculate per-unit quantities for power system components.

CO3: Apply load flow solution techniques to analyze power system performance using different methods.

CO4: Form the Z-bus matrix for power system networks and analyze the effects of symmetrical faults.

CO5: Determine sequence components for power system components and analyze the effects of unsymmetrical faults.

CO6: Analyze the stability concepts and criteria of power systems.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	3	–	–	–	–	–	–	–	–	–	3	2
CO2	3	3	3	–	–	–	–	–	–	–	–	–	3	2
CO3	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO4	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO5	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO6	3	3	3	2	–	–	–	–	–	–	–	–	3	3

UNIT-I
Circuit Topology

Graph theory definitions – Formation of element node incidence and bus incidence matrices–Primitive network representation–Formation of Y_{bus}matrix by singular transformation and direct inspection methods.

Per Unit Representation

Per Unit Quantities–Single line diagram –Impedance diagram of a power system–Numerical Problems.

UNIT-II
Power Flow Studies

Necessity of power flow studies – Derivation of static power flow equations – Power flow solution using Gauss-Seidel Method – Newton Raphson Method (Rectangular and polar coordinates form) – Decoupled and Fast Decoupled methods–Algorithmicapproach–NumericalProblemson3–bussystemonly.

UNIT-III

Z-Bus Algorithm

Formation of Z_{bus}**:** Algorithm for the Modification of Z_{bus} Matrix (with out mutual impedance) – Numerical Problems.

Symmetrical Fault Analysis

Reactance's of Synchronous Machine–Three Phase Short Circuit Currents- Short circuit MVA calculations for Power Systems – Numerical Problems.

UNIT-IV

Symmetrical Components

Definition of symmetrical components – symmetrical components of unbalanced three phase systems – Power in symmetrical components – Sequence impedances and Sequence networks of Synchronous generator , Transformers and Transmission line-Numerical Problems.

Unsymmetrical Fault analysis

Various types of faults: LG– LL– LLG and LLL on unloaded alternator- Numerical problems.

UNIT-V

Power System Stability Analysis

Elementary concepts of Steady state – Dynamic and Transient Stabilities – Swing equation – Steady state stability – Equal area criterion of stability – Applications of Equal area criterion –Factors affecting transient stability –Methods to improve steady state and transient stability –Numerical problems.

Text Books:

1. Power System Analysis by Grainger and Stevenson-Tata McGraw Hill.1st edition 2017.
2. Modern Power system Analysis–by I.J.Nagrath & D.P.Kothari: Tata McGraw–Hill Publishing Company – 5th edition - 2022.

Reference Books:

1. PowerSystemAnalysis–byA.R.Bergen-PrenticeHall-2ndedition- 2009.
2. Power System Analysis by Hadi Saadat– Tata McGraw–Hill 3rd edition -2010.
3. Power System Analysis by B.R.Gupta –AH S Chand Company Limited - 2005.
4. Power System Analysis and Design by J.Duncan Glover-M.S.Sarma- T.J.Overbye – Cengage Learning publications -5th edition -2011.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/117/105/117105140
2. https://archive.nptel.ac.in/courses/108/105/108105104

III Year II Semester	SWITCH GEAR AND PROTECTION (BT24EE32P2A)	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic concepts of Electrical Machines and Power Systems.

Course Objectives:

- To explain the working principles and applications of circuit breakers in power systems, including MCBs, oil, SF6, and vacuum breakers.
- To provide an understanding of electromagnetic protection mechanisms, particularly relays used in fault detection and system protection (over current, under- voltage, directional, differential).
- To analyze protection techniques for generators and transformers, including fault protection schemes like percentage differential protection and Buchholz relays.
- To explore feeder and bus bar protection methods using advanced relay systems such as distance and static relays.
- To study over-voltage protection systems including lightning arresters and neutral grounding methods to safeguard the power system.

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the operation, ratings, and types of circuit breakers, including the principles of arc interruption.

CO2: Analyze relay-based protection systems and explain their functions in over-current, under-voltage, and fault detection.

CO3: Design protection schemes for generators and transformers, including protection against restricted earth faults and inter-turn faults.

CO4: Apply and solve numerical problems related to restricted earth fault (REF) and inter-turn fault protection schemes for generators.

CO5: Implement feeder and bus bar protection using advanced relays such as distance, impedance, and static relays.

CO6: Evaluate over-voltage protection strategies including lightning arresters and various neutral grounding techniques.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	–	3	-
CO2	3	3	2	–	–	–	–	–	–	–	–	–	3	3
CO3	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO4	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO5	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO6	3	2	2	2	–	–	–	–	–	–	–	–	3	2

UNIT–I

Circuit Breakers

Miniature Circuit Breaker(MCB)– Elementary principles of arc interruption– Restriking Voltage and Recovery voltages– Restriking phenomenon - RRRV– Average and Max. RRRV– Current chopping and Resistance switching– Concept of oil circuit breakers– Description and operation of Air Blast–Vacuum and SF_6 circuit breakers–Circuit Breaker ratings and specifications– Concept of Auto reclosing.

UNIT–II

Electromagnetic Protection

Relay connection–Balanced beam type attracted armature relay-induction disc and Induction cup relays–Torque equation - Relays classification–Instantaneous– DMT and IDMT types–Applications of relays: Over current and under voltage relays– Directional relays–Differential relays and percentage differential relays–Universal torque equation– Distance relays: Impedance– Reactance– Mho and offset mho relays– Characteristics of distance relays and comparison.

UNIT–III

Generator Protection

Protection of generators against stator faults–Rotor faults and abnormal conditions– restricted earth fault and inter turn fault protection– Numerical examples.

Transformer Protection

Percentage differential protection–Design of CT's ratio–Buchholz relay protection– Numerical examples.

UNIT– IV

Feeder and Bus bar Protection & Static Relays:

Over current Protection schemes–PSM-TMS–Numerical examples–Carrier current and three zone distance relay using impedance relays. Protection of bus bars by using Differential protection. Static relays: Introduction – Classification of Static Relays – Basic Components of Static Relays.

UNIT–V

Protection against over voltage and grounding

Generation of over voltages in power systems–Protection against lightning over voltages– Valve type and zinc oxide lighting arresters. Grounded and ungrounded neutral systems – Effects of ungrounded neutral on system performance – Methods of neutral grounding: Solid–resistance–Reactance–Arcing grounds and grounding Practices.

Text Books:

1. Power System Protection and Switchgear by Badri Ram and D.N Viswakarma –Tata McGraw Hill Publications -3rd edition -2022.
2. Power system protection- Static Relays with microprocessor applications by T.S.Madhava Rao - Tata McGraw Hill -2nd edition 2008

Reference Books:

1. Fundamentals of Power System Protection by PaithankarandS.R.Bhide.-PHI-2nd edition 2010.
2. Art & Science of Protective Relaying– by CR Mason-Wiley Eastern Ltd 2021.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/107/108107167
2. https://archive.nptel.ac.in/courses/108/105/108105167

III Year II Semester	ADVANCED CONTROL SYSTEMS (BT24EE32P2B)	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic concepts of Control Systems.

Course Objectives:

- To understand the concept of controllability, observability, and their tests for continuous-time systems, as well as the principle of duality in state-space analysis.
- To understand the state-space methods to assess controllability, observability, and design state feedback controllers via pole placement.
- To know the stability of nonlinear systems using phase-plane analysis, describing functions and Lyapunov's stability theorems.
- To learn optimal control strategies using the calculus of variations, including constrained minimization and the minimum principle.
- To learn Optimal control and state regulator problems.

Course Out comes: At the end of the course, student will be able to

CO1: Explain the concepts of controllability, observability, and the principle of duality in state-space Systems.

CO2: Apply state-space methods to analyze controllability and observability, and design state feedback Controllers.

CO3: Apply phase-plane analysis techniques to assess the stability and dynamic behavior of nonlinear Systems.

CO4: Evaluate system stability using Lyapunov's direct and indirect methods.

CO5: Examine the minimization of performance indices and control variables under equality constraints.

CO6: Formulate and solve optimal regulator problems using modern optimal control techniques.

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CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	2	–	–	–	–	–	–	–	–	–	3	2
CO2	3	3	3	2	–	–	–	–	–	–	–	–	3	3
CO3	3	3	2	2	–	–	–	–	–	–	–	–	3	3
CO4	3	3	3	3	–	–	–	–	–	–	–	–	3	3
CO5	3	3	3	3	3	–	–	–	–	–	–	–	3	3
CO6	3	3	3	3	3	2	–	–	–	–	–	–	3	3

UNIT–I

Controllability-Observability and Design of Pole Placement

General concepts of controllability and observability -Tests for controllability and observability for continuous time systems - Principle of duality - Effect of state feedback on controllability and observability - Design of state feedback control through pole placement, full order and reduced order observers.

UNIT–II

Nonlinear Systems

Introduction to nonlinear systems - Types of nonlinearities. Introduction to phase plane analysis, construction of phase trajectories-Analytical and Isocline method, Describing function - Describing functions of on-off nonlinearity, on-off nonlinearity with hysteresis, and relay with dead zone.

UNIT–III

Stability analysis by Lyapunov Method

Stability in the sense of Lyapunov – Lyapunov's stability and Lyapunov's instability theorems – Direct method of Lyapunov for the linear and nonlinear continuous time autonomous systems.

UNIT–IV

Calculus of Variations

Minimization of functional - functional of single function – Constrained minimization – Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints.

UNIT–V

Optimal Control

Necessary conditions for optimal control, Formulation of the optimal control problem, minimum time problem, minimum energy problem, minimum fuel problem, state regulator problem, output regulator problem.

Text Books:

1. Modern Control Engineering – by K. Ogata - Prentice Hall of India - 3rd edition -2009.
2. Automatic Control Systems by B.C.Kuo –Prentice Hall Publication 9th edition 2014.

Reference Books:

1. Modern Control System Theory–by M.Gopal-New Age International Publishers -3rd edition – 2014.
2. Optimal control theory: an Introduction by Donald E.Kirk by Dover publications,2004.
3. Control Systems Engineering by I.J. Nagarath and M.Gopal-New Age International (P) Ltd 6th edition 2020.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/103/108103007
2. https://archive.nptel.ac.in/courses/108/107/108107115

III Year II semester	RENEWABLEAND DISTRIBUTED ENERGYTECHNOLOGIES(BT24EE32P2C)	L	T	P	C
		3	0	0	3

Pre-requisite: Power system I

Course Objectives:

- To understand the basic concepts on wind energy systems.
- To understand the various relations between speed, power and energy in the wind systems.
- To analyze the solar energy systems, various components of solar thermal systems, applications in the relevant fields and design of PV systems.
- To design the Hydel system components and to get an idea on different other sources like tidal, geothermal and gas based units.
- To understand the concepts of hybrid renewable energy systems.

Course Outcomes:

After the completion of the course the student should be able to:

O1: Illustrate the basic concepts of renewable energy and distributed wind energy sources.
CO2: Demonstrate the components and working of wind energy conversion systems (WECS).
CO3: Model solar PV systems and analyze Maximum Power Point Tracking (MPPT) techniques.
CO4: Illustrate the principles of energy production from hydro, tidal, and geothermal resources.
CO5: Compare hydro, tidal, and geothermal power generation systems in terms of efficiency, capacity, environmental impact, and sustainability.
CO6: Explain the configuration, operation, and benefits of hybrid renewable energy systems.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	–	–	–	–	–	–	–	–	3	2
CO2	3	3	2	–	–	–	–	–	–	–	–	–	3	3
CO3	3	3	2	2	–	–	–	–	–	–	–	–	3	3
CO4	3	3	2	2	–	–	–	–	–	–	–	–	3	3
CO5	3	3	3	3	–	–	–	–	–	–	–	–	3	3
CO6	3	3	3	3	2	–	–	–	–	–	–	–	3	3

UNIT–I

Introduction and Wind energy systems

Brief idea on renewable and distributed sources - their usefulness and advantages. Wind Energy Systems: Estimates of wind energy potential-wind maps- Aerodynamic and mechanical aspects of wind machine design - Conversion to electrical energy - Aspects of location of wind farms.

UNIT–II

Wind power and energy

Wind speed and energy -Speed and power relations -Power extraction from wind -Tip speed ratio (TSR) - TSR characteristics- Functional structure of wind energy conversion systems -Pitch and speed control - Power vs speed characteristics -Fixed speed and variable speed wind turbine control - Power optimization -Electrical generators -Self-Excited and Doubly-Fed Induction Generators operation and control.

UNIT–III

Solar PV Systems

Present and new technological developments in photovoltaic -estimation of solar irradiance -

components of solar energy systems –solar thermal system- applications- Modeling of PV cell -current-voltage and power-voltage characteristics -Effects of temperature and irradiance -Solar array simulator -Sun tracking -Peak power operations -PV system -MPPT techniques: Perturb and observe method, hill climbing and incremental conductance methods-Effects of partial shading on the characteristic curves and associated MPPT techniques - Solar park design outline-Solar Pond-Types of PV systems.

UNIT–IV

Small Hydro and other sources

Hydel :Small-Mini-Medium -Plant layouts Water power estimates -use of hydrographs -hydraulic turbine - characteristics and part load performance -design of wheels - draft tubes and pens tocks. Other sources **:** Tidal-geothermal-gas-based generations.

UNIT–V

Hybrid Renewable systems

Requirements of hybrid/combined use of different renewable and distributed sources -Need of energy storage- Control of frequency and voltage of distributed generation in Stand-alone and Grid-connected mode - use of energy storage and power electronics interfaces for the connection to grid and loads -Design and optimization of size of renewable sources and their storages.

Text Books:

1. Math J. Bollen - Fainan Hassan ‘Integration of Distributed Generation in the Power System’ - IEEE Press - 2011.
2. G.D.Rai‘Non-Conventional Energy Sources’ KHANNA PUBLISHERS.

Reference Books

1. Studies ‘Craig Anderson and RudolfI.Howard‘Wind and Hydropower Integration: Concepts –Considerations and Case- Nova Publisher- 2012.
2. Amanda E.Niemi and Cory M.Fincher ‘Hydro power from Small and Low- Head Hydro Technologies’ - Nova Publisher - 2011.
3. D.Yogi Go swami- Frank Kreith and Jan F.Kreider‘Principles of Solar Engineering’ - Taylor & Francis 2000.
4. Math J. Bollen - Fainan Hassan ‘Integration of Distributed Generation in the Power System’ - IEEE Press - 2011.
5. S. Heier and R. Waddington ‘Grid Integration of Wind Energy Conversion Systems’ – Wiley - 2006.
6. LoiLeiLai and Tze Fun Chan‘Distributed Generation: Induction and Permanent Magnet Generators’ - Wiley-IEEE Press - 2007.
7. G.N.Tiwari‘Solar Energy Technology’ – Nova Science Publishers- 6th edition 2017.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103206
2. https://archive.nptel.ac.in/courses/103/107/103107157

III Year II Semester	ELECTRIC DRIVES (BT24EE32P3A)	L	T	P	C
		3	0	0	3

Pre-requisite: Electrical Circuit Analysis, Power electronics, Electrical Machines and Control Systems.

Course Objectives:

- To learn the fundamentals of electric drive and different electric braking methods.
- To analyze the operation of three phase converter controlled dc motors and four quadrant operation of dc motors using dual converters.
- To discuss the DC-DC converter control of dc motors.
- To understand the concept of speed control of induction motor by using AC voltage controllers, voltage source inverters and slip power recovery scheme.
- To learn the speed control mechanism of synchronous motors.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Explain the fundamentals of electric drives and various electric braking methods.
CO2: Analyze the operation of three-phase converter-fed DC motors and the four-quadrant operation of DC motors using dual converters.
CO3: Explain the control of DC motors using DC–DC converters across different quadrants of operation.
CO4: Understand and analyze speed control of induction motors using AC voltage controllers and voltage source inverters (VSI).
CO5: Differentiate between stator-side and rotor-side speed control methods of induction motors based on operating principles and performance.
CO6: Explain the principles and methods of speed control of synchronous motors.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	2	–	–	–	–	–	–	–	–	–	2	–
CO2	3	3	3	2	–	–	–	–	–	–	–	–	3	2
CO3	3	3	3	2	–	–	–	–	–	–	–	–	3	2
CO4	3	3	3	2	–	–	–	–	–	–	–	–	3	2
CO5	3	3	3	2	–	–	–	–	–	–	–	–	3	2
CO6	3	3	3	2	–	–	–	–	–	–	–	–	3	2

UNIT-I

Fundamentals of Electric Drives

Electric drive and its components– Fundamental torque equation – Load torque components – Nature and classification of load torques – Steady state stability – Load equalization– Four quadrant operation of drive (hoist control) – Braking methods**:** Dynamic Braking, Plugging and Regenerative Braking –Numerical problems.

UNIT-II

Converter Fed DC Motor Drives

3-phase half and fully-controlled converter fed separately and self- excited DC motor drive – Output voltage and current waveforms – Speed-torque characteristics and expressions – 3-phase Dual converter fed DC motor drives – Numerical problems.

UNIT-III

DC–DC Converter Fed DC Motor Drives

Single quadrant, two quadrant and four quadrant DC-DC converter fed separately excited and self-excited DC motors – Continuous Current Mode of operation - Output voltage and current waveforms – Speed-torque characteristics and expressions – Closed loop operation (qualitative treatment only) – Numerical problems.

UNIT-IV

Control of 3-phase Induction motor Drives

Stator voltage control using 3-phase AC voltage regulators – Waveforms –Speed torque characteristics– Variable Voltage Variable Frequency control of induction motor by PWM voltage source inverter – Closed loop V/f control of induction motor drives (qualitative treatment only). Static rotor resistance control – Slip power recovery schemes – Static Scherbius drive – Static Kramer drive – Performance and speed torque characteristics– Numerical problems.

UNIT-V

Control of Synchronous Motor Drives

Separate control of synchronous motor – self-control of synchronous motor employing load commutated thyristor inverter - closed loop control of synchronous motor drive (qualitative treatment only)– PMSM: Basic operation and advantages – Numerical problems.

Text Books:

1. Fundamentals of Electric Drives– G K Dubey- Narosa Publications- 2nd edition – 2002.
2. Power Semi conductor Drives-S.B. Dewan-G.R.Slemon-A.Straughen -Wiley India-1984.

Reference Books:

1. Electric Motors and Drives Fundamentals - Types and Applications -by Austin Hughes and Bill Drury -Newnes.4th edition -2013.
2. Thyristor Control of Electric drives–Vedam Subrahmanyam Tata McGraw Hill Publications -2011.
3. Power Electronic Circuits-Devices and applications by M.H. Rashid- PHI -3rd edition -2009.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108104011

III Year II Semester	DIGITAL SIGNAL PROCESSING (BT24EE32P3B)	L	T	P	C
		3	0	0	3

Pre-requisite:

Laplace Transforms, Z-Transforms, Fourier series and transforms.

Course Objectives:

- To explore the basic concepts of digital signal processing.
- To connect the time domain signal to frequency domain signals using Fourier transform.
- To understand the basic structures of IRR systems.
- To understand and design FIR Digital filters.
- To explore the concepts of multiple sampling rates for DSP.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Understand the fundamentals of Digital Signal Processing (DSP) and the frequency-domain representation of discrete-time signals.
CO2: Explain the concept, properties, and applications of the Z-transform in DSP.
CO3: Compute Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) for various Sequences.
CO4: Design IIR filters using analog filter approximation techniques and analyze their basic structures.
CO5: Design FIR filters using windowing techniques and analyze their basic structures.
CO6: Understand and apply the concepts of Multirate Signal Processing, including decimation and Interpolation.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	1	–	–	–	–	–	–	2	–	–
CO2	3	2	–	–	1	–	–	–	–	–	–	2	–	–
CO3	3	3	–	2	2	–	–	–	–	–	–	2	–	–
CO4	3	3	3	2	2	–	–	–	–	–	–	2	–	–
CO5	3	3	3	2	2	–	–	–	–	–	–	2	–	–
CO6	3	2	–	–	1	–	–	–	–	–	–	2	–	–

UNIT-I

Introduction to Digital Signal Processing

Discrete time signals & sequences - Classification of Discrete time systems - stability of LTI systems - Invert ability - Response of LTI systems to arbitrary inputs. Solution of Linear constant coefficient difference equations. Frequency domain representation of discrete time signals and systems. Review of Z-transforms - solution of difference equations using Z-transforms - System function.

UNIT-II

Discrete Fourier Transforms and FFT Algorithms

Discrete Fourier series representation of periodic sequences -Properties of Discrete Fourier Series - Discrete Fourier transforms: Properties of DFT - linear filtering methods based on DFT - Fast Fourier transforms (FFT) - Radix-2 decimation in time and decimation in frequency FFT Algorithms - Inverse FFT.

UNIT-III

Design and Realizations of IIR Digital Filters

Analog filter approximations–Butter worth and Chebyshev filters-Design of IIR Digital filters from analog filters with examples. Analog and Digital frequency transformations. Basic structures of IIR systems – Direct-Form Structures - Transposed Structures - Cascade- Form Structures - Parallel-Form Structures Lattice and Lattice-Ladder Structures.

UNIT-IV

Design and Realizations of FIR Digital Filters

Characteristics of FIR Filters with Linear Phase -Frequency Response of Linear Phase FIR Filters -Design of FIR Digital Filters using Window Techniques and Frequency Sampling technique -Comparison of IIR & FIR filters. Basic structures of FIR systems – Direct-Form Structure - Cascade-Form Structures Linear Phase Realizations - Lattice structures.

UNIT-V

Multirate Digital Signal Processing

Decimation –Interpolation-Sampling Rate Conversion by a Rational Factor–Implementation of sampling rate converters–Applications of Multirate Signal Processing-Digital Filter Banks.

Text Books:

1. Digital Signal Processing –Principles Algorithms and Applications: John G.Proakis - Dimitris G.Manolakis -4th Edition -Pearson Education / PHI -2007.
2. Discrete Time Signal Processing –A.V. Oppenheim and R.W.Schaffer-PHI.
3. Digital Signal Processing: A Computer based approach. Sanjit K Mitra -4th Edition - TMH -2014.

Reference Books:

1. Digital Signal Processing: Andreas Antoniou-TATAMcGrawHill-2006.
2. Digital Signal Processing: MH Hayes -Schaum’s Outlines -TATA Mc-Graw Hill - 2007.
3. DSP Primer-C.BrittonRorabaugh-TataMcGrawHill-2005.
4. FundamentalsofDigitalSignalProcessingusingMatlab–RobertJ.Schilling-Sandra L.Harris - Thomson -2007.
5. Digital Signal Processing–AlanV.Oppenheim-Ronald W.Schafer- PHIEd. - 2006.
6. DigitalSignalProcessing–KRajaRajeswari-1stedition-I.K.International Publishing -House -2014.

Online Learning Resources:

1. https://nptel.ac.in/courses/117102060
2. https://archive.nptel.ac.in/courses/108/101/108101174

III Year II Semester	HIGH VOLTAG EENGINEERING (BT24EE32P3C)	L	T	P	C
		3	0	0	3

Pre-requisite:

Material Science, Electromagnetic Fields and Basics of Transient Circuits.

Course Objectives:

- To understand HV break down phenomena in gases.
- To understand the break down phenomenon of liquids and solid dielectrics.
- To acquaint with the generating principle of operation and design of HVDC, AC voltages.
- To understand the generating principles of Impulse voltages & currents.
- To understand various techniques for AC, DC and Impulse measurements of high voltages and currents.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Recognize the fundamental dielectric properties of gaseous insulating materials.
CO2: Understand the role and applications of gaseous dielectrics in high-voltage equipment.
CO3: Differentiate the breakdown phenomena in liquid and solid dielectric materials.
CO4: Explain techniques for generating high AC and DC voltages.
CO5: Explain techniques for generating high impulse voltages and currents.
CO6: Understand the measurement methods for high AC, DC, and impulse voltages and currents.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1:	3	2	–	–	–	–	–	–	–	–	–	1	–	–
CO2:	3	2	1	–	–	–	–	–	–	–	–	1	–	–
CO3:	3	3	1	–	–	–	–	–	–	–	–	1	–	–
CO4:	3	2	2	1	1	–	–	–	–	–	–	1	1	–
CO5:	3	2	2	1	1	–	–	–	–	–	–	1	1	–
CO6:	3	3	2	2	1	–	–	–	–	–	–	2	1	–

UNIT-I

Break down phenomenon in Gaseous and Vacuum:

Insulating Materials: Types, properties and its applications. Gases as insulating media – Collision process – Ionization process – Townsend's criteria of breakdown in gases and its limitations – Streamers Theory of break down – time lag – Paschen's law- Paschen's curve, Penning Effect. Break down mechanisms in Vacuum.

UNIT-II

Break down phenomenon in Liquids:

Liquid as Insulator–Pure and commercial liquids–Break down in pure and commercial liquids-Mechanisms.

Break down phenomenon in Solids:

Intrinsic breakdown–Electro mechanical breakdown–Thermal break down–Break down of composite solid dielectrics.

UNIT-III

Generation of High DC voltages: Voltage Doubler Circuit-Voltage Multiplier Circuit–Van de-Graaff Generator.

Generation of High AC voltages: Cascaded Transformers–Resonant Transformers–Tesla Coil.

UNIT-IV

Generation of Impulse voltages: Specifications of impulse wave–Analysis of RLC circuits-Marx Circuit.

Generation of Impulse currents: Definitions–Circuits for producing Impulse current waves Wave shape control-Tripping and control of impulse generators.

UNIT-V

Measurement of High DC&AC Voltages:

Resistance potential divider - Generating Voltmeter - Capacitor Voltage Transformer (CVT) - Electrostatic Voltmeters – Sphere Gaps.

Measurement of Impulse Voltages &Currents:

Potential dividers with CRO-Hall Generator-Ro go w ski Coils.

Text Books:

1. High Voltage Engineering: Fundamentals by E.Kuffel -W.S.Zaengl -J.Kuffel by Elsevier -2nd Edition,2014.
2. High Voltage Engineering by M.S.Naidu and V.Kamaraju–TMH Publications 2020 -6th Edition.

Reference Books:

1. High Voltage Engineering and Technology by Ryan –IET Publishers -2nd edition 2013.
2. High Voltage Engineering by C.L. Wadhwa-New Age Internationals(P) Limited – 2024 4th edition.
3. High Voltage Insulation Engineering by Ravindra Arora –Wolf gang Mosch- New Age International (P) Limited -2021..

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104048
2. https://bharatsrajpurohit.weebly.com/high-voltage-engineering-course.html

III Year II Semester	FUNDAMENTALS OF ELECTRIC VEHICLES (BT24EE3202A)	L	T	P	C
		3	0	0	3

Pre-requisite: Basic knowledge in Physics, Chemistry and Basics of Electrical and Electronics.

Course Objectives:

- To familiarize the students with the need and advantages of electric and hybrid electric vehicles.
- To understand various power converters used in electric vehicles.
- To be familiar all the different types of motors suitable for electric vehicles.
- To know various architecture of hybrid electric vehicles.
- To have knowledge on latest developments in batteries and other storage systems.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the use, benefits, and advantages of different types of electric vehicles (EVs).
CO2: Select and apply suitable power converters for EV applications.
CO3: Choose appropriate electric motors for EV power train design based on performance requirements.
CO4: Design hybrid electric vehicle (HEV) configurations for specific applications.
CO5: Analyze various energy storage systems used in electric vehicles, including batteries and super capacitors.
CO6: Analyze the functions and operation of Battery Management Systems (BMS) in electric vehicles.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

(CO/PO)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1:	3	2	–	–	–	–	2	–	–	–	–	1	2	1
CO2:	3	2	2	1	3	–	–	–	–	–	–	1	3	2
CO3:	3	3	2	1	2	–	–	–	–	–	–	1	3	2
CO4:	3	3	3	2	2	–	1	–	–	–	1	2	3	3
CO5:	3	3	2	1	2	–	2	–	–	–	–	2	3	2
CO6:	3	3	2	2	3	–	1	–	–	–	–	2	3	3

UNIT–I

Introduction

Fundamentals of vehicles – Vehicle model – Calculation road load and tractive force –Components of conventional vehicles – Drawbacks of conventional vehicles – Need for electric vehicles– Advantages and applications of Electric Vehicles – History of Electric Vehicles – EV Market in India and outside India – Types of Electric Vehicles.

UNIT–II

Components of Electric Vehicles

Main components of Electric Vehicles – Electric Traction Motor and Controller– Power Converters – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters – PWM inverters used in EVs.

UNIT–III

Motors for Electric Vehicles

Characteristics of traction drive – requirements of electric machines for EVs – Comparison of Different motors for Electric and Hybrid Vehicles – Induction Motors – Synchronous Motors – Permanent Magnetic Synchronous Motors – Brushless DC Motors – Switched Reluctance Motors (Construction details and working only).

UNIT–IV

Hybrid Electric Vehicles

Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs – Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples –Merits and Demerits.

UNIT–V

Energy Sources for Electric Vehicles

Batteries– Types of Batteries – Lithium-ion – Nickel-metal hydride – Lead-acid – Comparison of Batteries – Battery Charging – Fast Charging –Battery Management System – Ultra capacitors – Flywheels – Compressed air energy storage (CAES)– Fuel Cell – it's working.

Text Books

1. Iqbal Hussein -Electric and Hybrid Vehicles: Design Fundamentals - CRC Press -2021.
2. Tom Denton, Hayley Pells-Electric and hybrid vehicles, Third Edition, 2024

Reference Books:

1. Kumar - L. Ashok –and S. Albert Alexander. Power Converters for Electric Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

Online Learning Resources:

1. MOOCathttps://www.edx.org/learn/electric-cars
2. https://archive.nptel.ac.in/courses/108/106/108106170

III Year II Semester	ELECTRICAL WIRING ESTIMATION ANDCOSTING(BT24EE3202B)	L	T	P	C
		3	0	0	3

Pre-requisite:

Electrical Circuits, Basics of Power Systems and Electrical Machines.

Course Objectives:

- Introduce the electrical symbols and simple electrical circuits
- Able to learn the design of electrical installations.
- Able to learn the design of electrical installation for different types of buildings and small industries.
- Learn the basic components of electrical substations.
- Familiarize with the motor control circuits

Course Outcomes:

After the completion of the course, the student should be able to:

CO1: Demonstrate various electrical apparatus and their interconnections in installations.
CO2: Examine and identify various components used in electrical installations.
CO3: Estimate the cost and material requirements for wiring installations in different types of buildings and small industries.
CO4: Illustrate the components and layout of electrical substations.
CO5: Design suitable control circuits for starting three-phase induction motors and synchronous motors.
CO6: Design and analyze protection and control circuits for synchronous motor starting and operation.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1:	3	2	–	2	1	–	–	–	–	–	–	1	3	2
CO2:	3	3	–	2	1	–	–	–	–	–	–	1	3	2
CO3:	3	2	2	–	–	–	–	–	–	–	3	2	2	2
CO4:	3	2	–	2	1	–	–	–	–	–	–	1	3	2
CO5:	3	3	3	2	2	–	–	–	–	–	1	2	3	3
CO6:	3	3	3	2	2	–	–	–	–	–	1	2	3	3

UNIT-I

Electrical Symbols and Simple Electrical Circuits

Identification of electrical symbols -Electrical wiring Diagrams -Methods of representation of wiring diagrams -introduction to simple light and fan circuits - system of connection of appliances and accessories.

UNIT-II

Design Considerations of Electrical Installations

Electric supply system -Three-phase four wire distribution system -protection of electric installation against overload -short circuit and earth fault -earthing - neutral and earth wire -types of loads -systems of wiring -permissible of voltage drops and sizes of wires-estimating and costing of electrical installations.

UNIT-III

Electrical Installation for Different Types of Buildings and Small Industries

Electrical installations for electrical buildings-estimating and costing of material-simple examples on electrical installation for residential buildings -electrical installations for commercial buildings -electrical installation for small industries- case study.

UNIT-IV

Substations

Introduction - types of substations - outdoor substations-pole mounted type - indoor substations-floor mounted type - simple examples on quantity estimation- case study.

UNIT-V

Motor control circuits

Introduction to AC motors-starting of three phase squirrel cage induction motors-starting of wound rotor motors -starting of synchronous motors -contractor control circuit components -basic control circuits -motor protection –Schematic and wiring diagrams for motor control circuits.

Text Books:

1. Electrical Design and Estimation Costing - K. B. Raina and S.K.Bhattacharya New Age International Publishers-2017.

References Books:

1. Electrical wiring estimating and costing–S.L.Uppal and G.C.Garg– Khanna Publishers-6th edition -2024
2. A course in electrical installation estimating and costing–J.B.Gupta– Kataria SK & Sons-2013.

Online Learning Resources:

1. https://onlinecourses.swayam2.ac.in/nou25_ec07/preview

III Year II Semester	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LAB (BT24EE3204)	L	T	P	C
		0	0	3	1.5

Course Objectives:

- To understand students how different types of meters work and their construction.
- To make the students understand how to measure resistance, inductance, and capacitance by AC & DC bridges.
- To understand the testing of CT and PT.
- To Understand and the characteristics of Thermo couples, LVDT, Capacitive transducer, piezoelectric transducer and measurement of strain and choke coil parameters.
- To study the procedure for standardization and calibration of various methods.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Understand the concepts of phantom loading and calibration procedures for electrical instruments.
CO2: Measure electrical parameters such as voltage, current, power, and energy using appropriate Measuring instruments.
CO3: Measure and analyze the electrical characteristics of passive components, including resistance, Inductance and capacitance.
CO4: Understand the working principles and applications of various bridge circuits for measurement.
CO5: Learn the usage and application of Current Transformers (CTs) and Potential Transformers (PTs) for measurement purposes.
CO6: Understand the characteristics of transducers and measure strain, frequency, and phase difference using appropriate instruments.

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	2	1	–	–	–	–	–	–	–	–	–
CO2	3	3	–	2	2	–	–	–	–	–	–	–	–	–
CO3	3	3	–	2	2	–	–	–	–	–	–	–	–	–
CO4	3	2	2	2	1	–	–	–	–	–	–	–	–	–
CO5	3	2	–	2	2	–	–	–	–	–	–	–	–	–
CO6	3	3	–	2	2	–	–	–	–	–	–	–	–	–

Any 10 of the following experiments are to be conducted:

1. Calibration of dynamometer wattmeter using phantom loading.
2. Measurement of resistance using Kelvin's Double Bridge and determination of its tolerance.
3. Measurement of capacitance using Schering Bridge.
4. Measurement of inductance using Anderson Bridge.
5. Calibration of LPF wattmeter by direct loading.
6. Measurement of three-phase reactive power using single wattmeter method for a balanced load.
7. Testing of C.T. using mutual inductor – measurement of percentage ratio error and phase angle of the given C.T. by null deflection method.
8. P.T. testing by comparison using V.G. as null detector – measurement of percentage ratio error and phase angle of the given P.T.
9. Determination of the characteristics of a thermocouple.
10. Determination of the characteristics of an LVDT.
11. Determination of the characteristics of a capacitive transducer.
12. Measurement of strain using a bridge strain gauge.

13. Measurement of choke coil parameters and single-phase power using three voltmeter and three ammeter methods.
14. Calibration of single-phase induction type energy meter.
15. Calibration of DC ammeter and voltmeter using Crompton DC potentiometer.
16. AC potentiometer (Polar form / Cartesian form) – calibration of AC voltmeter and determination of parameters of choke.

III Year II Semester	MICRO PROCESSORS AND MICRO CONTROLLERS LAB (BT24EE3205)	L	T	P	C
		0	0	3	1.5

Pre-requisite: Concepts of Microprocessors and Microcontrollers

Course Objectives

- To study programming based on **8086 microprocessor** and **8051 microcontroller**.
- To study **8086 microprocessor–based ALP** using arithmetic, logical, and shift operations.
- To study interfacing of **8086 with I/O and other devices**.
- To study **parallel and serial communication** using **8051 and PIC18 microcontrollers**.

Course Outcomes

After the completion of the course, the student should be able to:

CO1: Write assembly language programs using the 8086 microprocessor based on arithmetic, logical, number system, and shift operations.

CO2: Write assembly language programs for numeric operations and array handling problems.

CO3: Write assembly language programs on string operations**.**

CO4: Interface 8086 with I/O and other devices**.**

CO5: Perform parallel and serial communication using 8051 and PIC18 microcontrollers.

CO6: Program microprocessors and microcontrollers for real-world applications**.**

CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	3	–	–	1	–	–	–	–	–	–	2	–	–
CO2	3	3	–	–	1	–	–	–	–	–	–	2	–	–
CO3	3	3	–	–	1	–	–	–	–	–	–	2	–	–
CO4	3	2	3	2	2	–	–	–	–	–	–	2	–	–
CO5	3	2	3	2	2	–	–	–	–	–	–	2	–	–
CO6	3	3	3	2	2	–	–	–	–	–	–	2	–	–

List of Experiments

Any 10 of the following experiments are to be conducted:

8086 Microprocessor Programs

1. Arithmetic operations on two 16-bit and multi-byte numbers:
   addition, subtraction, multiplication, and division (signed and unsigned), ASCII arithmetic operations.
2. Logic operations:
   shift and rotate operations, conversion of packed BCD to unpacked BCD, BCD to ASCII conversion, and BCD number addition.

3. Arrange a given array in ascending and descending order**.**
4. Determine the factorial of a given number**.**
5. String operations using instruction prefix:
   block move, reverse string, sorting, insertion, deletion, length of string, and string comparison.
6. Find the first and nth number of Fibonacci series for given *n*.
7. Find the number and sum of even and odd numbers in a given array.
8. Find the sum of 'n' natural numbers and sum of squares of 'n' natural numbers.
9. Arithmetic operations using 8051 microcontroller**.**
10. Conversion of decimal to hexadecimal and hexadecimal to decimal numbers.
11. Find the sum of elements, and identify the largest and smallest elements of a given array using 8051

Programs on Interfacing

12. Interfacing 8255 PPI with 8086**.**
13. Stepper motor control using 8253 / 8255**.**
14. Reading and writing on a parallel port using 8051.
15. Timer programming in different modes using 8051**.**
16. Implementation of serial communication using 8051**.**
17. Understanding three memory areas (00–FF) using 8051 external interrupts**.**
18. Traffic Light Controller using 8051**.**

III Year II Semester	IOT APPLICATIONS OF ELECTRICAL ENGINEERINGLAB(BT24EE3206)	L	T	P	C
		0	1	2	2

Pre-requisite: Concepts of Computer Organization and Computer Networks
Course Objectives

- To understand the working of Arduino**.**
- To learn the programming of Raspberry Pi**.**
- To know various sensors used with Arduino / Raspberry Pi.
- To interface various displays with Arduino / Raspberry Pi.
- To connect with various wireless communication devices**.**

Course Outcomes
At the end of the course, students will be able to:
CO1: Operate the Arduino Integrated Development Environment (IDE) and develop embedded applications using Arduino.
CO2: Program embedded Python applications on Raspberry Pi OS.
CO3: Interface various sensors with Arduino and Raspberry Pi in IoT environments.
CO4: Connect and program different display modules with Arduino and Raspberry Pi.
CO5: Understand the fundamentals of wireless communication technologies used in IoT.
CO6: Apply wireless communication techniques to interconnect electronic and communication systems in IoT applications.
CO-PO/PSO MATRIX (Level of Mapping-3: High;, 2:Modarate:1-Low;-Not mapped)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PSO2
CO1	3	2	–	–	3	–	–	–	–	–	–	2	–	–
CO2	3	2	–	–	3	–	–	–	–	–	–	2	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	2	–	–
CO4	3	2	3	2	3	–	–	–	–	–	–	2	–	–
CO5	3	2	–	–	1	–	–	–	–	–	–	2	–	–
CO6	3	3	3	2	2	–	–	–	–	–	–	2	–	–

Topics to be Covered in Tutorials

Module–1: Programming Arduino (3 Hours)

Arduino – Classification of Arduino Boards – Pin diagrams – Arduino Integrated Development Environment (IDE) – Programming Arduino.

Module–2: Sensors (5 Hours)

Working of temperature sensor, proximity sensor, IR sensor, light sensor, ultrasonic sensor, PIR sensor, color sensor, soil sensor, heartbeat sensor, fire alarm, etc.

Actuators: Stepper motor, servo motor, and their integration with Arduino / Raspberry Pi.

Module–3: Raspberry Pi (2 Hours)

Introduction – Classification of Raspberry Pi series – Pin diagrams – Programming Raspberry Pi.

Module–4: Displays (2 Hours)

Working of LEDs, OLED display, LCDs, seven-segment display, touch screen, analog input and digital output converters, and their integration with Arduino / Raspberry Pi.

Module–5: Wireless Communication Devices (4 Hours)

Working of Bluetooth, Wi-Fi, Radio Frequency Identification (RFID), GPRS / GSM technology, ZigBee, etc., and their integration with Arduino / Raspberry Pi.Features of Alexa**.**

List of Experiments

Any 10 of the following experiments are to be conducted:

1. Familiarization with Arduino / Raspberry Pi and performing necessary software installation.
2. Interfacing LED / buzzer with Arduino / Raspberry Pi and writing a program to turn ON the LED for 1 second after every 2 seconds.
3. Interfacing push button / digital sensor (IR / LDR) with Arduino / Raspberry Pi and writing a program to turn ON the LED when the push button is pressed or when the sensor is activated.
4. Interfacing temperature sensor with Arduino / Raspberry Pi and writing a program to display temperature and humidity readings.
5. Interfacing Organic Light Emitting Diode (OLED) with Arduino / Raspberry Pi.
6. Interfacing Bluetooth with Arduino / Raspberry Pi and writing a program to send sensor data to a smart phone using Bluetooth.
7. Interfacing Bluetooth with Arduino / Raspberry Pi and writing a program to turn LED ON / OFF when ‘1’ / ‘0’ is received from a smart phone.
8. Writing a program using Arduino / Raspberry Pi to upload and retrieve temperature and humidity data to Thing Speak cloud.
9. Interfacing 7-segment display with Arduino / Raspberry Pi.
10. Interfacing joystick with Arduino / Raspberry Pi.
11. Interfacing analog input and digital output with Arduino / Raspberry Pi.
12. Night light controlled and monitoring system.
13. Interfacing fire alarm using Arduino / Raspberry Pi.
14. IR remote control for home appliances.
15. Heart rate monitoring system.
16. Alexa-based home automation system.

III Year-II Semester	RESEARCH METHODOLOGY & IPR (BT24HS3201) (AUDIT COURSE)	L	T	P	C
		2	0	0	-

COURSE OBJECTIVES:

1. To understand the knowledge on basics of research and its types.
2. To familiarize students with research design and methods, including data collection, sampling techniques, and measurement tools.
3. To impart the concept of Literature Review, Technical Reading, Attributions and Citations.
4. To know the Ethics in Engineering Research.
5. To know the concepts of Intellectual Property Rights in Engineering
6. To understand the importance of IPR protection and management for innovation, commercialization, and technology transfer in business and industry.

COURSE OUTCOMES:

1. Understand research problem formulation.
2. Analyze research related information, Follow research ethics
3. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Understanding that when IPR would take such important place in growth of individuals& nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R&D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
6. Identify procedure to protect different forms of IPRs national and international level

Unit1:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit2:

Effective literature studies approaches, analyze is Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit3:

Nature of Intellectual Property: Patents, Designs, Trademarks and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT

Unit4:

Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.

Unit5:

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc, Traditional knowledge Case Studies, IPR and IITs

TEXT BOOKS

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'".
2. Wayne Goddard and Stuart Melville, "Research Methodology :An Introduction"

REFERENCE BOOKS

1. RanjitKumar,2nd Edition, "Research Methodology: Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
3. Mayall,"Industrial Design", McGraw Hill,1992

Minor Engineering Courses offered by EEE Department for Other Branches (Except EEE Branch)

		L	T	P	C
I	CONCEPTS OF CONTROL SYSTEMS (BT24EE0M01)	3	0	0	3

Pre-requisite:

Basic Engineering Mathematics

Course Objectives:

- To learn the mathematical modeling of physical systems and to use block diagram algebra and signal flow graph to determine overall transfer function
- To analyze the time response of first and second order systems and improvement of performance using PI, PD, PID controllers.
- ToinvestigatethestabilityofclosedloopsystemsusingRouth'sstability Criterion and root locus method.
- To learn Frequency Response approaches for the analysis of LTI systems using Bode plots, polar plots and Nyquist stability criterion.
- To learn state space approach for analysis of LTI systems and understand the concepts of controllability and observability.

Course Outcomes:

After the completion of the course, the student should be able to:

CO1: Derive the transfer function of physical systems and determine the overall transfer function using Block diagram reduction and signal flow graph methods.

CO2: Determine the time response specifications of second-order systems and evaluate steady-state error Constants.

CO3: Analyze the absolute and relative stability of LTI systems using Routh–Hurwitz criterion and root Locus techniques.

CO4: Analyze the stability of LTI systems using frequency response methods (Bode, Nyquist, and Nichols plots).

CO5: Represent physical systems using state-space models and determine their time responses.

CO6: Understand and analyze the concepts of controllability and observability in control systems.

UNIT–I Mathematical Modeling of Control Systems

Classification of control systems – open loop and closed loop control systems and their differences – transfer function of linear systems – differential equations of electrical networks – translational and rotational mechanical systems – block diagram algebra – feedback characteristics.

UNIT–II Time Response Analysis

Standard test signals – time response of first- and second-order systems – time domain specifications – steady-state errors and error constants – **P, PI, PD, and PID controllers**.

UNIT–III Stability and Root Locus Technique

Concept of stability – Routh–Hurwitz criterion – limitations of Routh–Hurwitz criterion – root locus concept – construction of root loci (simple problems).

UNIT–IV Frequency Response Analysis

Introduction to frequency domain specifications – Bode diagrams – determination of transfer function from Bode diagrams – phase margin and gain margin**.**

UNIT–V State Space Analysis of Linear Time-Invariant (LTI) Systems

Concepts of state, state variables, and state models – state space representation of transfer function – state transition matrix and its properties.

Text Books

1. **Modern Control Engineering** – Katsuhiko Ogata, Prentice Hall of India.
2. **Automatic Control Systems** – Benjamin C. Kuo, Prentice Hall of India, 2nd Edition.

Reference Books

1. **Control Systems: Principles and Design** – M. Gopal, Tata McGraw-Hill Education Pvt. Ltd., 4th Edition.
2. **Control Systems** – Manik Dhanesh N., Cengage Publications.
3. **Control Systems Engineering** – I. J. Nagarath and M. Gopal, New Age International Publications, 5th Edition.
4. **Control Systems Engineering** – S. Palani, Tata McGraw-Hill Publications.

Online Learning Resources

1. https://archive.nptel.ac.in/courses/107/106/107106081
2. https://archive.nptel.ac.in/courses/108/106/108106098
3. https://nptelvideos.com/video.php?id=1423&c=14

II	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
FUNDAMENTALS OF ELECTRICAL MEASUREMENTS AND INSTRUMENTATION(BT24EE0M02)					

Pre-requisite: Basics of Electrical and Electronics Engineering
Course Objectives

- Interpret the working principles of various **analog measuring instruments**.
- Understand the concepts behind **power and energy measurement** procedures.
- Calculate **resistance, inductance, and capacitance** using various bridges.
- Evaluate the importance of and understand the concepts of various **transducers**.
- Comprehend the types of **digital meters** and their functionalities.

Course Outcomes: After completing the course, the student will be able to:

CO1: Select appropriate instruments for measuring AC and DC voltage and current.
CO2: Analyze the operation and working principles of wattcmeters and energy meters.
CO3: Differentiate between AC and DC bridge circuits and their applications.
CO4: Explain the working principles and applications of various transducers.
CO5: Recognize the importance and applications of digital meters in electrical and electronic measurements.
CO6: Explain the working principles and operation of digital meters.

UNIT–I: Fundamentals of Analog Measurement
Analog Ammeter and Voltmeter: Classification of instruments – deflecting, controlling, and damping torques.
Types of Instruments:
PMMC and moving iron types – construction, working principle, advantages, and disadvantages. Applications and simple numerical problems.

UNIT–II: Measurement of Power and Energy
Analog Wattmeter:
Electrodynamometer type wattmeter's – low power factor (LPF) and unity power factor (UPF) – construction, advantages, and disadvantages.
Energy Meters:
Induction type energy meter – construction and working principle – simple numerical problems.

UNIT–III: Measurement of Electrical Parameters

DC Bridges: Measurement of resistance –Low resistance: Kelvin's double bridge**,** Medium resistance: Wheatstone bridge**, High** resistance**:** Loss of charge method

AC Bridges:
Measurement of inductance (**Maxwell's bridge**) and capacitance (**Schering bridge**) – numerical problems.

UNIT–IV: Transducers and Sensors

Classification of transducers – basics and applications.

- **Resistive:** Strain gauge

- **Inductive:** Linear Variable Differential Transformer (LVDT)
- **Capacitive:** Piezoelectric -Applications.

UNIT–V: Introduction to Digital Measurement

Digital Instruments:
Digital voltmeters (successive approximation type), digital frequency meters and multi meters, digital tachometers, and digital energy meters – overview and applications.

Text Books

1. **Electrical & Electronic Measurement & Instruments** – A. K. Sawhney, Dhanpat Rai & Co. Publications, 19th Revised Edition, 2011.
2. **Electronic Instrumentation** – H. S. Kalsi, TMH

Reference Books

1. **Electrical Measurements and Measuring Instruments** – E. W. Golding and F. C. Widdis, Wheeler Publishing, 5th Edition.
2. **Modern Electronic Instrumentation and Measurement Techniques** – A. D. Helfrick and W. D. Cooper, PHI, 5th Edition, 2002.
3. **Electrical and Electronic Measurements and Instrumentation** – R. K. Rajput, S. Chand, 3rd Edition.

Online Learning Resources

1. https://archive.nptel.ac.in/courses/108/105/108105153

III	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
CONCEPTS OF POWER SYSTEM ENGINEERING(BT24EE0M03)					

Pre-requisite: Basic Electrical Engineering

Course Objectives:

- To understand the types of **electric power plants** and their working principles.
- To understand the concepts of **electric power transmission and distribution**.
- To gain knowledge of **protection and grounding** of power system components.
- To learn the **economic aspects of electrical energy**.
- To understand the importance of **power factor improvement and voltage control**.

Course Outcomes

After the completion of the course, the student should be able to:

CO1: Understand the concepts and methods of power generation using various types of power plants.
CO2: Analyze short transmission line parameters and understand different distribution system schemes.
CO3: Explain protection equipment and grounding methods used in power systems.
CO4: Apply economic principles to calculate tariffs and evaluate the cost of electrical energy.
CO5: Understand the importance and methods of power factor improvement in power systems.
CO6: Understand the importance and techniques of voltage control in power systems.

UNIT–I Electrical Power Generation: Concepts and Types

Sources for generation of electrical energy – working principles and schematic diagram approach of thermal power plant, hydro power plant, nuclear power plant, and gas power plant – comparison between different power plants – importance of renewable energy sources.

UNIT–II Transmission and Distribution Concepts

Types of conductor materials – parameters of transmission line – classification of overhead transmission lines – performance of **short transmission lines** – simple numerical problems.
Basic concepts of **substations** – distribution systems – connection schemes of distribution systems – structure of cables – differences between **overhead and underground systems**.

UNIT–III Protection and Grounding

List of faults – basic concepts of **fuses** – circuit breakers – relays – **SF_6 circuit breakers** – **vacuum circuit breakers** – operation of lightning arresters – grounding and its advantages – methods of neutral grounding: **resistance, reactance, and resonant grounding** – numerical problems.

UNIT–IV Economic Aspects

Definitions of load – load curves and load duration curves – load factor – demand factor – utilization factor – types of tariff – cost of electrical energy – expression for cost of electrical energy – numerical problems.

UNIT–V Power Factor Improvement and Voltage Control

Power factor – effects and causes of low power factor – shunt and series capacitor compensation – numerical problems – need for voltage control – types of voltage regulating devices.

Text Book

1. **Principles of Power System** – V. K. Mehta and Rohit Mehta, S. Chand Publishers, 2022.

Reference Book

1. **Electrical Power Systems** – C. L. Wadhwa, New Age International Publishers, 2012.

Online Learning Resources

1. https://nptel.ac.in/courses/108102047

IV	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
FUNDAMENTALS OF POWER ELECTRONICS (BT24EE0M04)					

Pre-requisite: Basic concepts of Electrical and Electronic Circuits **and** Semiconductor Physics

Course Objectives

- To know the characteristics of various power semiconductor devices**.**
- To learn the operation of single-phase full-wave converters**.**
- To learn the operation of three-phase full-wave converters and AC–AC converters**.**
- To learn the operation of different types of DC–DC converters**.**
- To learn the operation of PWM inverters for voltage control.

Course Outcomes
After the completion of the course, the student should be able to:
CO1: Illustrate the static and dynamic characteristics of SCR, power MOSFET, and power IGBT.
CO2: Analyze the operation of phase-controlled rectifiers.
CO3: Analyze the operation of three-phase full-wave converters and AC voltage controllers.
CO4: Examine the operation and design of different types of DC–DC converters.
CO5: Analyze the operating principles of Pulse Width Modulation (PWM) inverters.
CO6: Analyze the role of PWM inverters for voltage control applications.

UNIT–I Power Semiconductor Devices

Power diode – characteristics – silicon controlled rectifier (SCR) – two-transistor analogy – static and dynamic characteristics – turn-on methods. Static and dynamic characteristics of power MOSFET and power IGBT**.**

UNIT–II Single-Phase AC–DC Converters

Single-phase half-wave controlled rectifiers with R load and RL load, with and without free-wheeling diode – single-phase fully controlled bridge converter with R and RL loads – continuous conduction – expressions for output voltages – single-phase semi-converter with R and RL loads – continuous conduction.

UNIT–III Three-Phase AC–DC Converters and AC–AC Converters

Three-phase fully controlled rectifier with R and RL loads – three-phase semi-converter with R and RL loads – expressions for output voltage.AC power control by phase control with R and RL loads – expression for RMS output voltage.

UNIT–IV DC–DC Converters

Basic chopper operation with R and RL loads – step-up chopper – classification of choppers – time ratio control – current limit control.

UNIT–V DC–AC Converters

Introduction – single-phase half-bridge and full-bridge inverters with R and RL loads – voltage control of single-phase inverters – PWM inverters – sinusoidal pulse-width modulation.

Text Books

1. **Power Electronics** – P. S. Bhimbra, Khanna Publishers.
2. **Power Electronics: Essentials & Applications** – L. Umanand, Wiley Pvt. Ltd., India, 2009.

Reference Books

1. **Power Electronics: Converters, Applications and Design** – Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley & Sons.
2. **Power Electronics: Circuits, Devices and Applications** – M. H. Rashid, Prentice Hall of India, 2nd Edition, 1998.
3. **Power Electronics** – Daniel W. Hart, McGraw-Hill.

Online Learning Resources

1. https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007
2. https://archive.nptel.ac.in/courses/108/101/108101126

VI	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
FUNDAMENTALS OF UTILIZATION OF ELECTRICAL ENERGY (BT24EE0M06)					

Pre-requisites: Electrical Machines, Power Electronics and Drives, and Power Systems – II

Course Objectives

To make the students learn about:

- Maintenance of **electric drives** used in industries.
- Identification of suitable **electric heating and welding schemes** for given applications.
- Maintenance and troubleshooting of various **lamps and lighting fittings** in use.
- Understanding different **traction schemes** and their main components.
- Designing suitable **speed control schemes** for traction systems.

Course Outcomes

After learning the course, the students should be able to:

CO1: Understand the principles and industrial applications of electric drives.
CO2: Explain the principles of electric heating and welding, along with their practical applications.
CO3: Design simple resistance furnaces based on electric heating principles.
CO4: Design residential illumination schemes using appropriate lighting concepts.
CO5: Understand electric braking methods and the control of traction motors.
CO6: Calculate tractive effort, power, acceleration, and velocity in traction systems.

UNIT–I Electric Drives

Types of electric drives – choice of motor – starting and running characteristics – speed control – temperature rise – cooling and heating time constants – applications of electric drives – types of industrial loads: continuous, intermittent, and variable loads – load equalization.

UNIT–II Electric Heating and Welding

Advantages and methods of electric heating – resistance heating – induction heating – dielectric heating – electric welding – resistance welding and arc welding – electric welding equipment – comparison between **AC and DC welding**.

UNIT–III Fundamentals of Illumination

Introduction – terms used in illumination – laws of illumination – polar curves – photometry – integrating sphere – sources of light – discharge lamps – mercury vapor (MV) and sodium vapor (SV) lamps – comparison between **tungsten filament lamps** and **fluorescent tubes** – basic principles of light control – types and design of lighting and flood lighting.

UNIT–IV Electric Traction – I

Systems of electric traction and track electrification – review of existing electric traction systems in India – special features of traction motors – methods of electric braking: plugging, rheostatic braking, and regenerative braking.

UNIT–V Electric Traction – II

Mechanics of train movement – speed–time curves for different services: trapezoidal and quadrilateral curves – calculation of tractive effort, power, and specific energy consumption for a given run – effect of varying acceleration and braking retardation – adhesive weight – braking retardation – coefficient of adhesion.

Text Books

1. **Utilization of Electric Energy** – E. Openshaw Taylor and V. V. L. Rao, Universities Press, 2009.
2. **Art and Science of Utilization of Electrical Energy** – Partab, Dhanpat Rai & Co., 2004.
3. **Utilization of Electrical Power Including Electric Drives and Electric Traction** – J. B. Gupta, S. K. Kataria & Sons.

Reference Books

1. **Generation, Distribution and Utilization of Electrical Energy** – C. L. Wadhwa, Wiley Eastern Limited, 1993.
2. **Electrical Power** – S. L. Uppal, Khanna Publishers, 1988.

Online Learning Resources

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108105060

V	MINOR ENGINEERING COURSES	L	T	P	C
		3	0	0	3
BASICS OF ELECTRIC DRIVES AND APPLICATIONS(BT24EE0M05)					

Pre-requisite:

Electrical Machines, Control Systems and Fundamentals of Power Electronics.

Course Objectives:

To make the students learn about:

- To learn the fundamentals of electric drive and different electric braking methods.
- To analyze the operation of single phase converter controlled dc motors and four quadrant operation of dc motors using dual converters.
- To discuss the DC-DC converter control of dc motors in various quadrants.
- To understand the concept of speed control of induction motor by using AC voltage controllers and voltage source inverters.
- To understand the speed control mechanism of synchronous motors

Course Outcomes: After the completion of the course the student should be able to:

CO1: Explain the fundamentals of electric drive..

CO2: Understand the different types of electric braking methods

CO3: Analyze the operation of single-phase converter fed dc motors and four quadrant operations of dc motors using dual converters.

CO4: Describe the converter control of DC motors in various quadrants of operation

CO5: Know the concept of speed control of induction motor by using AC voltage controllers.

CO6: Explains the speed control mechanism of synchronous motors.

UNIT-1

Fundamentals of Electric Drives

Electricdriveanditscomponents–Fundamentaltorqueequation–Loadtorquecomponents– Classification of load torques –Load equalization– Four quadrant operation of drive (hoist control).

UNIT-2

Controlled Converter Fed DC Motor Drives

1-Phase half and fully-controlled converter fed separately and self-excited DC motor drive – Output voltage and current wave forms and their expressions–Speed-torque characteristics.

UNIT-3

DC–DC Converters Fed DC Motor Drives

Single quadrant–Two quadrant and four quadrant DC-DC converter fed separately excited and self-excited DC motors – Continuous current operation -Output voltage and current waveforms – Speed–torque characteristics.

UNIT-4

Control of 3-phase Induction motor Drives

Stator voltage control using 3-phase AC voltage regulators – Waveforms –Speed torque characteristics–Variable Voltage Variable Frequency control. Static rotor resistance control– Static Scherbius drive – Static Kramer drive – Performance and speed torque characteristics.

UNIT-5

Control of Synchronous Motor Drives

Separate control of synchronous motor–self-control of synchronous motor employing load commutated thyristor inverter- closed loop control of synchronous motor drive(qualitative treatment only).

Text Books:

1. Fundamentals of Electric Drives, G.K. Dubey, Narosa Publications, 2002.
2. Power Semiconductor Drives, S.B.Dewan, G.R.Slemon, A.Straughen,WileyIndia, 2009.

Reference Books:

1. Electric Motors and Drives Fundamentals- Types and Applications- by Austin Hughes and Bill Drury -Newnes.4th edition -2013.
2. ThyristorControlofElectricdrives–VedamSubramanyamTataMcGrawHillPublications-1987.
3. PowerElectronicCircuits-DevicesandapplicationsbyM.H.Rashid-PHI-3rd edition -2009.
4. Power Electronics handbook by Muhammad H.Rashid-Elsevier -2nd edition -2010.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108104011

***Honors Engineering Courses offered EEE Branch students Power Systems**

I	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
ELECTRIC POWER QUALITY(BT24EE0HPS1)					

Pre-requisite: Power Systems, Power Electronics

Course Objectives

The course aims to enable students to:

- Learn the effects responsible for power quality phenomena.
- Understand transient over voltages and overvoltage protection methods.
- Identify sources of long-duration over voltages and understand the working of voltage-regulating equipment.
- Learn the effects of harmonic distortion on different electrical equipment.
- Explain the relationship between distributed generation and power quality, and the importance of monitoring.

Course Outcomes

After completion of the course, the student will be able to:
CO1: Differentiate between various types of power quality problems.
CO2: Explain the sources and characteristics of transient over voltages.
CO3: Describe the methods of overvoltage protection used in power systems.
CO4: Explain the principles of long-duration over voltages and voltage regulation improvement methods.
CO5: Analyze voltage distortion and current distortion along with their power quality indices.
CO6: Understand the concepts of interfacing distributed generation technologies and power quality monitoring systems.

UNIT–I: Introduction

Overview of power quality – Concern about power quality – General classes of power quality and voltage quality problems – Transients – Long-duration voltage variations – Short-duration voltage variations – Voltage unbalance – Waveform distortion – Voltage fluctuation – Power frequency variations – Voltage sag – Voltage swell.

UNIT–II: Transient Over voltages and Overvoltage Protection

Sources of transient over voltages – Principles of overvoltage protection – Devices for overvoltage protection – Utility capacitor switching transients – Utility system lightning protection – Managing ferro resonance – Switching transient problems with loads.

UNIT–III: Long-Duration Voltage Variations and Voltage Regulation

Principles of voltage regulation – Devices for voltage regulation – Utility voltage regulator applications – Capacitors for voltage regulation – End-user capacitor applications – Regulating utility voltage with distributed resources – Voltage flicker.

UNIT–IV: Harmonic Distortion and Solutions

Voltage distortion versus current distortion – Harmonic indices: THD, TDD, and true power factor – Sources of harmonics – Effects of harmonic distortion – Impact on capacitors, transformers, motors, and meters – Concept of point of common coupling – Passive and active filtering – Numerical problems.

UNIT–V: Distributed Generation and Monitoring

Distributed Generation

Resurgence of distributed generation – DG technologies – Interface to the utility system – Power quality issues and operating conflicts – DG on low-voltage distribution networks.

Monitoring

Power quality monitoring and considerations – Historical perspective of PQ measuring instruments – Power quality measurement equipment – Assessment of PQ measuring data.

Text books

1. Dugan, R. C., Mc Granaghan, M. F., Santoso, S., & Beaty, H. W., *Electrical Power Systems Quality*, McGraw-Hill, 2nd Edition, 2012 / 3rd Edition.
2. Bollen, M. H. J., *Electric Power Quality Problems*, IEEE Series, Wiley India Publications, 2011.
3. Kennedy, B. W., *Power Quality Primer*, McGraw-Hill, First Edition, 2000.

Reference Books

1. Bollen, M. H. J., *Understanding Power Quality Problems: Voltage Sags and Interruptions*, IEEE Press, First Edition, 2000.
2. Arrillaga, J., & Watson, N. R., *Power System Harmonics*, John Wiley & Sons, Second Edition, 2003.
3. Kazibwe, W. E., & Sendaula, M. H., *Electric Power Quality Control Techniques*, Van Nostrand Reinhold, New York.
4. Shankaran, C., *Power Quality*, CRC Press, 2001.
5. De La Rosa, F. C., *Harmonics and Power Systems*, CRC Press (Taylor & Francis).
6. Fuchs, E. F., & Masoum, M. A. S., *Power Quality in Power Systems and Electrical Machines*, Elsevier.

Online Learning Resources

1. https://nptel.ac.in/courses/108102179
2. https://nptel.ac.in/courses/108107157

II	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
SMART GRID TECHNOLOGIES(BT24EE0HPS2)					

Pre-requisite: Basic Electrical Engineering, Power Systems, Signals & Systems

Course Objectives

The course aims to enable students to:

• Introduce the architecture, functions, and components of smart grids.
• Explore communication and control technologies integral to smart grids.
• Examine the integration of renewable energy and distributed generation.
• Understand demand-side management and smart grid applications.
• Highlight challenges related to security, privacy, and regulation in smart grid implementation.

Course Outcomes: At the end of the course, the student will be able to:
CO1: Understand the structure, architecture, and benefits of smart grids.
CO2: Analyze communication technologies and protocols used in smart grid systems.
CO3: Evaluate smart grid components such as smart meters, energy storage systems, and distributed generation.
CO4: Apply demand response strategies and load management techniques in smart grid environments.
CO5: Identify cyber security threats and vulnerabilities in smart grid infrastructure.
CO6: Explain mitigation techniques and protection mechanisms to enhance cyber security in smart grids.

UNIT–I: Introduction to Smart Grids

Evolution of power grids: traditional grids vs. smart grids – Key characteristics of smart grids: efficiency, reliability, and flexibility – Smart grid architecture: components and functions – Generation, transmission, distribution, and consumption sectors – Smart grid vision, goals, and benefits – Economic, environmental, and operational benefits – Role of ICT in smart grids: data management and communication infrastructure.

UNIT–II: Smart Grid Communication and Networking

Communication technologies for smart grids: wired (Ethernet, fiber optics) and wireless (Zigbee, Wi-Fi, cellular) – Power line communication (PLC) for smart metering and control – Smart metering systems: functionality and communication protocols – Advanced Metering Infrastructure (AMI) – Protocols in smart grids: IEC 61850, Mod bus, DNP3, and others – Data acquisition and control systems in smart grids – Integration of Internet of Things (IoT) in smart grid communication.

UNIT–III: Smart Grid Components and Technologies

Smart meters: role, functionality, and types – Energy storage systems: batteries, super capacitors, flywheels, and their role in grid stability – Distributed generation and renewable energy integration: solar, wind, and micro grids – Energy management systems (EMS): load flow analysis and optimization techniques – Smart grid automation: SCADA systems, automated metering, and fault detection – Real-time monitoring and control techniques and technologies.

UNIT–IV: Integration of Renewable Energy and Demand-Side Management

Challenges in integrating renewable energy into the grid: variability, intermittency, and storage solutions – Role of smart grids in renewable energy integration: grid stability and power quality – Wind and solar power forecasting techniques – Demand-side management (DSM) and smart appliances: load shifting, load shedding, and peak demand reduction – Role of consumers in grid optimization (smart home technologies) – Electric vehicle (EV) integration and smart charging infrastructure.

UNIT–V: Security, Privacy, and Policy Issues in Smart Grids

Cyber security in smart grids: threats, vulnerabilities, and risks – Cyber attacks on critical infrastructure – Privacy concerns and data protection in smart grid systems: consumer data, smart meters, and privacy regulations – Authentication, authorization, and secure communication protocols – IEC 62351 security standards – Smart grid regulations and policies: global standards and frameworks (NIST, IEC, IEEE) – Policy challenges in grid modernization and renewable energy adoption – Future trends and challenges in smart grid development.

Text books

1. *Borlase, S.*, Smart Grids: Infrastructure, Technology, and Solutions.
2. *Momoh, J. A.*, Smart Grid: Fundamentals of Design and Analysis.
3. *Boyle, G.*, Renewable Energy: Power for a Sustainable Future.
4. *Flick, T., & Morehouse, J.*, Smart Grid Security: An End-to-End View of Security in the New Electric Grid.

Reference Books

1. Ekanayake, J., Liyanage, K., Wang, J., Jenkins, N., & Zhang, X., *Smart Grid: Technology and Applications*.
2. Galvin, G., & Shapiro, P. L. P., *The Smart Grid: Enabling Energy Efficiency and Demand Response*.
3. Gellings, C. W., *The Smart Grid: Enabling Energy Efficiency and Demand Response*.

Online Learning Resources

1. https://archive.nptel.ac.in/courses/108/107/108107113

III	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
POWER SYSTEM DE REGULATION(BT24EE0HPS3)					

Pre-requisite:
Power System Analysis, Power System Operation and Control

Course Objectives

The course aims to enable students to:

- Familiarize students with the concepts and need for deregulated power systems.
- Impart knowledge of power market development in India and across the world.
- Understand key factors in equipment specification and system design in deregulated environments.
- Learn about ancillary services management.
- Become familiar with electric energy trading mechanisms.

Course Outcomes

At the end of the course, the student will be able to:

CO1: Illustrate the operation of deregulated electricity market systems.
CO2: Identify typical issues and challenges in deregulated electricity markets.
CO3: Analyze electricity market operational and control issues using modern mathematical models.
CO4: Summarize power wheeling transactions and explain congestion management methods.
CO5: Analyze the role and impact of ancillary services in deregulated power systems.
CO6: Understand global power market scenarios and electric energy trading practices.

UNIT–I: Deregulation of the Electric Supply Industry

Introduction – Concept of deregulation – Different entities in deregulated electricity markets: Independent System Operator (ISO), Market Operator – Background to deregulation and the current situation around the world – Benefits of a competitive electricity market – After-effects of deregulation.

Market Structure and Operation

Objectives of market operations – Electricity market models: pool company, bilateral contracts, and hybrid models – Power market types: energy services, ancillary services, and transmission markets – Forward and real-time markets – Market power.

UNIT–II: Power System Operation in Competitive Environment

Introduction – Role of the Independent System Operator – Operational Planning activities of ISO in pool and bilateral markets – Operational planning activities of a GENCO in pool markets and bilateral markets – Market participation issues – Unit commitment in a deregulated environment – Competitive bidding.

UNIT–III: Transmission Open Access and Pricing Issues

Introduction – Power wheeling – Transmission open access – Cost components in transmission – Pricing of power transactions: embedded cost-based and incremental cost-based transmission pricing – Security management in deregulated environments – Congestion management under deregulation.

UNIT–IV: Ancillary Services Management

General description of ancillary services – Ancillary service management practices in various countries – Checklist of ancillary services recognized by different electricity markets – Reactive power as an ancillary service.

UNIT–V: Electric Energy Trading

Introduction – Essence of electric energy trading – Energy trading framework – Derivative instruments in energy trading – Portfolio management – Energy trading hubs – Brokers in electricity trading – Green power trading.

Text books

1. Bhattacharya, K., Bollen, M. H. J., & Daalder, J. E., *Operation of Restructured Power Systems*, Springer (Units I–IV).
2. Shahideh pour, M., Yamin, H., & Li, Z., *Market Operations in Electric Power Systems*, Wiley (Units I and V)

Reference Books

1. Stoft, S., *Power System Economics: Designing Markets for Electricity*, Wiley.
2. Lai, L. L., *Power System Restructuring and Deregulation*, 1st Edition, John Wiley & Sons Ltd., 2012.

Online Learning Resources

1. https://nptel.ac.in/courses/108101005

IV	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
REALTIME CONTROL OF POWER SYSTEMS(BT24EE0HPS4)					

Pre-requisite: Power Systems, Power System Analysis and Protection

Course Objectives

The course aims to enable students to:

• Understand the importance of state estimation in power systems.
• Learn the significance of security analysis and contingency evaluation.
• Understand SCADA, its objectives, and its importance in power system operation.
• Recognize the significance of voltage stability analysis.
• Gain an in-depth understanding of the operation of deregulated electricity market systems.

Course Outcomes

At the end of the course, students will be able to:

CO1: Illustrate different types of state estimation techniques used in power systems.
CO2: Describe security analysis methods in power system operation.
CO3: Explain contingency evaluation techniques for reliable power system operation.
CO4: Demonstrate computer-based monitoring and control of power systems.
CO5: Classify and compare voltage stability issues and phenomena in power systems.
CO6: Describe the conditions, concepts, and framework of power system deregulation

UNIT–I: State Estimation

Different types of state estimation – Theory of weighted least squares (WLS) state estimation – Sequential and non-sequential methods for processing measurements – Observability analysis – Pseudo-measurements – Bad data detection, identification, and elimination.

UNIT–II: Security and Contingency Evaluation

Security concept – Security analysis and monitoring – Contingency analysis for generator and transmission line outages using iterative linear power flow method – Fast decoupled power flow model – Network sensitivity methods.

UNIT–III: Computer Control of Power Systems

Need for real-time and computer control of power systems – Operating states of a power system – Supervisory Control and Data Acquisition (SCADA) systems – Implementation considerations – Energy control centers – Software requirements for implementing monitoring, control, and optimization functions.

UNIT–IV: Voltage Stability and Security

Voltage stability, voltage collapse, and voltage security – Relationship between voltage stability and rotor angle stability – Introduction to voltage stability analysis – P–V curves and Q–V curves – Voltage stability in mature power systems – Long-term voltage stability – Power flow analysis for voltage stability – Static voltage stability indices – Research areas in voltage stability.

UNIT–V: Deregulation and Power System Operation

Need and conditions for deregulation – Introduction to market structure and market architecture – Spot markets, forward markets, and settlements – Review of concepts: marginal cost of generation, least-cost operation, and incremental cost of generation – Power system operation in deregulated environments.

Text books

1. Wood, A. J., & Wollenberg, B. F., *Power Generation, Operation and Control*, John Wiley & Sons, 1984.
2. Grainger, J. J., & Stevenson, W. D., *Power System Analysis*, McGraw-Hill, 1994 (International Edition).
3. Kundur, P., *Power System Stability and Control*, McGraw-Hill, 1994.
4. Stoft, S., *Power System Economics: Designing Markets for Electricity*, IEEE Press and Wiley–Interscience, 2002.

Reference Books

1. Dhar, R. N., *Computer-Aided Power Systems Operation and Analysis*, Tata McGraw-Hill, 1982.
2. Singh, L. P., *Advanced Power System Analysis and Dynamics*, Wiley Eastern Ltd., 1986.

Online Learning Resources

1. https://nptel.ac.in/courses/108104191

V	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
ADVANCED POWER SYSTEMS PROTECTION(BT24EE0HPS5)					

Pre-requisit: Basic Concepts of Power Electronics, Electronic Circuits, and Power Systems

Course Objectives

The course aims to enable students to:

• Analyze static relay components and understand the role of each component in static relay operation.
• Understand the fundamentals of amplitude and phase comparators, study different types of comparators, and apply comparator techniques in static relays.
• Explore different types of static relays and understand their working mechanisms in power system protection.
• Explain the importance and working principles of pilot relaying schemes and study various pilot relaying methods.
• Study the working of microprocessor-based and numerical relays and analyze the architecture and components of numerical relays.

Course Outcomes

At the end of the course, the student will be able to:

CO1: Understand the fundamentals of static relays and analyze the working of static relay components.
CO2: Analyze the operation of different types of comparators used in protection systems.
CO3: Compare various comparator techniques and select suitable comparator methods for power system protection schemes.
CO4: Explain the principles of static over current relays and apply them in power system protection.
CO5: Apply pilot relaying schemes in power system protection and evaluate their performance.
CO6: Illustrate the operation and applications of microprocessor-based and numerical relays used in power system protection.

UNIT–I: Static Relays – Classification and Tools

Comparison of static relays with electromagnetic relays – Basic classification – Level detectors – Amplitude and phase comparators – Duality concept – Basic tools: Schmitt trigger circuits, multi vibrators, square wave generation – Polarity detector – Zero crossing detector – Thyristor and UJT triggering circuits – Phase sequence filters – Speed and reliability of static relays.

UNIT–II: Amplitude and Phase Comparators

Generalized equations for amplitude and phase comparison – Derivation of relay characteristics – Rectifier bridge circulating and opposed voltage type amplitude comparators – Averaging and phase splitting type amplitude comparators – Principle of sampling comparators.

Phase comparison techniques: Block spike and phase splitting techniques – Transistor integrating type phase comparison – Rectifier bridge type comparison – Vector product devices.

UNIT–III: Static Relays for Power System Protection

Static over current relays: instantaneous, definite time, and inverse time characteristics – Static distance relays – Static directional relays – Static differential relays – Measurement of sequence impedances in distance relays – Multi-input comparators – Elliptic and hyperbolic characteristics – Switched distance schemes – Impedance characteristics during faults and power swings.

UNIT–IV: Pilot Relaying Schemes

Wire pilot protection: circulating current scheme – Balanced voltage scheme – Transley scheme – Half-wave comparison scheme – Carrier current protection schemes – Relative merits and demerits – Phase comparison protection – Carrier-aided distance protection – Transfer scheme, blocking scheme, and acceleration scheme.

UNIT–V: Microprocessor-Based Relays and Numerical Protection
Microprocessor-based relays: over current relay, impedance relay, directional relay, reactance relay. Numerical protection: numerical relays – Numerical relaying algorithms – Mann–Morrison technique – Differential equation technique – Discrete Fourier transform (DFT) technique – Numerical overcurrent protection – Numerical distance protection.

Text books

1. Rao, T. S. M., *Power System Protection with Static Relays*, Tata McGraw-Hill.
2. Badri Ram & D. N. Vishwakarma, *Power System Protection and Switchgear*, Tata McGraw-Hill.

Reference Books

1. Warrington, A. R. van C., *Protective Relaying*, Vol. II, Springer.
2. Mason, C. R., *The Art and Science of Protective Relaying*, Wiley.
3. Kimbark, E. W., *Power System Stability*, Vol. II, Wiley.
4. Christopoulos, C., & Wright, A., *Electrical Power System Protection*, Springer.
5. Bhalja, B., Maheshwari, R. P., & Chothani, N. G., *Protection and Switchgear*, Oxford University Press.

Online Learning Resources

1. https://nptel.ac.in/courses/108104191

VI	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
FLEXIBLE AC TRANSMISSION SYSTEMS(BT24EE0HPS6)					

Pre-requisites: Fundamentals of Electrical Engineering, Power Systems, Power Electronics

Course Objectives

• To understand the role of FACTS controllers and their impact on improving the performance, stability, and efficiency of transmission systems.
• To analyze compensation techniques and explore the effects of static shunt and series compensation on voltage regulation, power flow control, and system stability.
• To study shunt compensation devices by investigating the working principles and applications of Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) for reactive power compensation.
• To select appropriate FACTS devices by assessing various power system scenarios and determining the most suitable FACTS device to enhance power transfer capability.
• To examine advanced controllers by understanding the principles of operation, control strategies, and applications of Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC).

Course Outcomes

After the completion of the course, the student should be able to:

CO1: Understand the need for FACTS controllers and their role in improving the performance of transmission systems.
CO2: Demonstrate the effects of static shunt compensation techniques on power system performance.
CO3: Demonstrate the effects of static series compensation techniques on power system performance.
CO4: Illustrate the use and operating characteristics of SVC and STATCOM for shunt compensation.
CO5: Determine and justify appropriate FACTS devices for different power system applications.
CO6: Understand the principle of operation and control strategies of advanced FACTS controllers such as UPFC and IPFC.

UNIT–I: FACTS Concepts

FACTS concepts, transmission interconnections, power flow in AC systems, loading capability limits, dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits of FACTS controllers.

UNIT–II: Static Shunt Compensation

Objectives of shunt compensation, midpoint voltage regulation, voltage instability prevention, improvement of transient stability, power oscillation damping, methods of controllable VAr generation, variable impedance type static VAr generation, switching converter type VAr generation, hybrid VAr generation. Basic concepts of voltage source converters (VSC) and current source converters (CSC), comparison of current source converters with voltage source converters.

UNIT–III: SVC and STATCOM

Regulation slope, transfer function and dynamic performance, transient stability enhancement, power oscillation damping, operating point control, and summary of compensation control techniques.

UNIT–IV: Static Series Compensation

Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC, and TCSC.

UNIT–V: Advanced FACTS Controllers

Unified Power Flow Controller (UPFC): Basic operating principle, conventional transmission control capabilities, independent real and reactive power flow control, comparison of UPFC with series compensators and phase angle regulators.
Interline Power Flow Controller (IPFC): Introduction, operating principle, and applications.

Text Books

1. N. G. Hingorani and L. Gyugyi, *Understanding FACTS Devices*, IEEE Press. Indian Edition: Standard Publications.

Reference Books

1. Y. H. Song and A. T. Johns, *Flexible AC Transmission Systems*, IEEE Press, 2006.
2. Vijay K. Sood, *HVDC and FACTS Controllers: Applications of Static Converters in Power Systems*, Springer Publishers.

Online Learning Resources

1. https://nptel.ac.in/courses/108107114
2. https://nptel.ac.in/courses/117103488

VII	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		3	0	0	3
AIAPPLICATIONS IN POWER SYSTEMS(BT24EE0HPS7)					

Pre-requisites:
Fundamentals of Power Systems, Artificial Intelligence, Optimization Techniques

Course Objectives

- Understand the fundamentals of Artificial Neural Networks (ANN), including key terminologies, neuron models, activation functions, and learning strategies.
- Explore and apply advanced ANN paradigms such as Back Propagation, Radial Basis Function (RBF) networks, and Kohonen's Self-Organizing Maps.
- Study classical and fuzzy sets, their properties, operations, and applications in handling uncertainty and decision-making.
- Design and implement Fuzzy Logic Controllers (FLC) using fuzzification, inference, and defuzzification techniques.
- Apply AI techniques such as back propagation and fuzzy logic to real-world power system applications including load forecasting and load frequency control.

Course Outcomes

At the end of the course, the student will be able to:

CO1: Describe the fundamental concepts, architecture, and components involved in the functioning of ANN and fuzzy logic systems.
CO2: Explain the functionality of different ANN models such as perceptron and back-propagation networks.
CO3: Explain fuzzy set theory, membership functions, and fuzzy inference operations.
CO4: Apply ANN algorithms and fuzzy logic techniques to solve practical engineering problems such as load forecasting and control systems.
CO5: Analyze the performance, advantages, and limitations of various ANN models and fuzzy logic controllers in different applications.
CO6: Design and implement ANN-based solutions and fuzzy logic controllers for engineering applications such as power system control and frequency regulation.

UNIT–I: Introduction to Artificial Neural Networks

Artificial Neural Networks (ANN): Humans and computers, biological neural networks, ANN terminology, models of artificial neurons, activation functions, typical architectures, biases and thresholds. Learning strategies: supervised, unsupervised, and reinforcement learning. Learning rules, perceptron training and classification using discrete and continuous perceptron algorithms, limitations and applications of perceptron training algorithm, linear separability and non-separability with examples.

UNIT–II: ANN Paradigms

Generalized delta rule, back propagation algorithm, radial basis function (RBF) networks, Kohonen's self-organizing feature map (KSOFM), learning vector quantization (LVQ), functional link networks (FLN), bidirectional associative memory (BAM), Hopfield neural network.

UNIT–III: Classical and Fuzzy Sets

Introduction to classical sets: properties, operations, and relations. Fuzzy sets: membership functions, uncertainty, operations, properties, fuzzy relations, cardinality of fuzzy sets.

UNIT–IV: Fuzzy Logic Controller (FLC)

Components of fuzzy logic systems: fuzzification, inference engine (development of rule base and decision-making system), defuzzification to crisp sets, defuzzification methods.

UNIT–V: Applications of AI Techniques

Load forecasting using back propagation algorithm, load flow studies using back propagation algorithm, single-area and two-area load frequency control using fuzzy logic.

Text Books

1. Jacek M. Zurada, *Introduction to Artificial Neural Systems*, Jaico Publishing House, 1997.
2. T. J. Ross, *Fuzzy Logic with Engineering Applications*, McGraw-Hill Inc., 1997.

Reference Books

1. Rajasekharan and Pai, *Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*, PHI Publications.
2. S. N. Sivanandam, S. Sumathi, and S. N. Deepa, *Introduction to Neural Networks using MATLAB 6.0*, Tata McGraw-Hill.
3. S. N. Sivanandam, S. Sumathi, and S. N. Deepa, *Introduction to Fuzzy Logic using MATLAB*, Springer, 2007.

Online Learning Resources

1. https://nptel.ac.in/courses/127105006

VIII	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		0	0	3	1.5
POWER SYSTEMS LAB(BT24EE0HPS8)					

Course Objectives

• To understand and determine sequence impedances of an alternator using direct methods and fault analysis techniques, including the application of sequence voltages.
• To measure sequence impedances of three-phase transformers, analyze poly-phase connections of single-phase transformers, and determine the equivalent circuit of a three-winding transformer.
• To study the Ferranti effect, measure ABCD parameters, and evaluate the performance of long transmission lines with and without compensation, including shunt and reactor compensation techniques.
• To determine differential and percentage bias relay operations, analyze over current relay characteristics, and understand relay-based protection schemes for generators and transformers.
• To apply theoretical concepts to practical scenarios, conduct experiments to measure system parameters, and analyze the impact of different protection and compensation techniques on power system performance.

Course Outcomes

After the completion of the course, the student should be able to:

CO1: Calculate the positive, negative, and zero sequence impedances of a synchronous machine.
CO2: Calculate the sequence impedances of transformers and explain various transformer connections.
CO3: Describe the Ferranti effect in transmission lines and explain compensation techniques.
CO4: Analyze transmission line parameters and evaluate their impact on system performance.
CO5: Explain the principles and operating characteristics of various protection relays.
CO6: Analyze the application and coordination of protection relays in power system protection schemes.

List of Experiments

Any ten of the following experiments are to be conducted:

1. Determination of sequence impedances of an alternator by direct method.
2. Determination of sequence impedances of an alternator by fault analysis.
3. Measurement of sequence impedance of a three-phase transformer:
   a) By application of sequence voltage.
   b) Using fault analysis.
4. Poly-phase connection on three single-phase transformers and measurement of phase angle.
5. Determination of equivalent circuit of a three-winding transformer.
6. Study of Ferranti effect in a long transmission line.
7. Measurement of ABCD parameters of a transmission line.
8. Performance of a long transmission line without compensation.
9. Determination and verification of reactor compensation of a transmission line.
10. Performance of a long transmission line with shunt compensation.
11. Study of differential and percentage bias integrated relay operations.
12. Performance characteristics of over current relay.
13. Study of protection of generator and transformer.

IX	HONORS ENGINEERING COURSES (POWER SYSTEMS)	L	T	P	C
		0	0	3	1.5
ADVANCED POWER SYSTEMS SIMULATION LAB(BT24EE0HPS9)					

Course Objectives

The objectives of this course are to:

• Utilize advanced analytical and computational techniques to evaluate and enhance the stability of multi-machine power systems.
• Apply optimal power flow techniques to improve system efficiency and analyze unit commitment strategies for cost-effective power generation.
• Conduct load flow studies and assess contingency scenarios to ensure the reliability and resilience of power systems.
• Implement state estimation techniques and power quality improvement strategies to maintain system reliability and performance.
• Analyze the stability of Single Machine Infinite Bus (SMIB) systems under different operating conditions, with and without controllers, to improve system dynamics.

Course Outcomes
After the completion of the course, the student will be able to:

CO1: Analyze the stability of multi-machine power systems using advanced analytical and numerical approaches.

CO2: Compute optimal power flow solutions using modern optimization techniques.

CO3: Analyze unit commitment problems and scheduling of generating units using optimal methods.

CO4: Analyze load flow solutions and evaluate contingency cases in power systems.

CO5: Explain and implement state estimation techniques and power quality improvement methods.

CO6: Analyze the stability of Single Machine Infinite Bus (SMIB) systems with and without controllers

List of Experiments

(Any 10 of the following experiments are to be conducted)

1. Multi-machine transient stability analysis using Modified Euler's Method.
2. Multi-machine transient stability analysis using Runge–Kutta (2nd Order) Method.
3. Optimal Power Flow analysis using Newton's Method.
4. Unit Commitment problem solution using Dynamic Programming.
5. Optimal Power Flow analysis using Genetic Algorithm.
6. Distribution system load flow solution using Forward–Backward Sweep Method.
7. Contingency analysis of a power system.

8. State estimation of a power system using Weighted Least Squares (WLS) Method.
9. Stability analysis of SMIB system using State-Space approach without PSS controller.
10. Stability analysis of SMIB system using State-Space approach with PSS controller.
11. Power quality improvement using D-STATCOM

Power Electronics

I	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
SPECIAL ELECTRICAL MACHINES(BT24EE0HPE1)					

Pre-requisite: Basic knowledge of magnetic circuits and electrical machines.

Course Objectives

The objectives of this course are to:

- Describe the operation and characteristics of Permanent Magnet DC (PMDC) motors.
- Understand the performance and control of stepper motors and their applications.
- Explain the operation and control of switched reluctance motors.
- Distinguish between brushed DC motors and brushless DC motors.
- Explain the theory of travelling magnetic fields and applications of linear motors.

Course Outcomes

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

CO1: Demonstrate the merits, advantages, and applications of permanent magnet motors.

CO2: Explain the construction and operating principles of stepper motors.

CO3: Select appropriate control schemes for stepper motors based on specific application requirements.

CO4: Design and construct suitable converter circuits for switched reluctance motors.

CO5: Analyze the characteristics, performance, and control aspects of brushless DC motors.

CO6: Explain the operation, characteristics, and applications of Linear Induction Motors.

UNIT–I Permanent Magnet Materials and PMDC Motors

Introduction – Classification of permanent magnet materials used in electrical machines – Minor hysteresis loop and recoil line – Stator frames of conventional DC machines – Development of electronically commutated DC motor from conventional DC motor – Permanent magnet materials and characteristics – B–H loop and demagnetization characteristics – High temperature effects – Reversible and irreversible losses – Mechanical properties – Handling and magnetization – Applications of permanent magnets in motors – Power density – Operating temperature range – Severity of operating duty – Hysteresis motors – Eddy current motors.

UNIT–II Stepper Motors

Principle of operation of stepper motors – Constructional details – Classification of stepper motors – Different configurations for switching phase windings – Control circuits for stepper motors – Open-loop and closed-loop control of two-phase hybrid stepper motors.

UNIT–III Switched Reluctance Motors

Construction and principle of operation of switched reluctance motors – Comparison of conventional and switched reluctance motors – Design of stator and rotor pole arcs – Torque production principle and torque equation – Converter configurations for SRM – Drive and power circuits – Rotor position sensing methods – Applications of SRM.

UNIT–IV Permanent Magnet Brushless DC Motors

Principle of operation of BLDC motors – Types of construction – Surface-mounted and interior permanent magnet BLDC motors – Torque and EMF equations for square-wave and sine-wave BLDC motors – Torque–speed characteristics – Merits and demerits of square-wave and sine-wave BLDC motors – Performance and efficiency – Applications.

UNIT–V Linear Induction Motors (LIM)

Construction – Principle of operation – Development of double-sided LIM from rotating induction motor – One-sided LIM with back iron – Schematic of LIM drive for traction – Equivalent circuit of LIM – Applications.

Text Books

1. Miller, T.J.E., *Brushless Permanent Magnet and Reluctance Motor Drives*, Clarendon Press, Oxford, 1989.
2. Venkata Ratnam, K., *Special Electrical Machines*, University Press, New Delhi, 2009.

Reference Books

1. Janardhanan, E.G., *Special Electrical Machines*, PHI Learning Private Limited.
2. Krishnan, Ramu, *Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications*, CRC Press, 2017.
3. Krishnan, Ramu, *Permanent Magnet Synchronous and Brushless DC Motor Drives*, CRC Press, 2017.

Online Learning Resources

1. NPTEL Course: https://nptel.ac.in/courses/108102156

		L	T	P	C
II	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	3	0	0	3
MACHINE MODELING AND ANALYSIS(BT24EE0HPE2)					

Pre-requisites: Electrical Circuits and Electrical Machines

Course Objectives

The objectives of this course are to:

• Analyze the performance of electrical machines under both steady-state and transient conditions.
• Apply reference frame transformations and derive mathematical models of three-phase induction and synchronous motors.
• Learn the dynamic modeling of special electrical machines for performance analysis.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Develop mathematical models of DC machines for steady-state and transient analysis.
CO2: Explain phase and reference frame transformations used in electric machine modeling.
CO3: Develop mathematical models of three-phase induction motors using reference frame theory.
CO4: Apply reference frame theory to obtain d–q axis models of induction motors in different reference frames.
CO5: Distinguish various inductances of asynchronous motors and develop synchronous motor models in the rotor's dq0 reference frame.
CO6: Develop mathematical models of special electrical machines for performance and dynamic analysis.

UNIT–I DC Motor Modeling

Importance of mathematical modeling of electrical machines – Mathematical model of separately excited DC motor and DC series motor in state-variable form – Mathematical model of DC shunt motor and DC compound motor in state-variable form – Steady-state analysis – Transient state analysis – Transfer function of DC motor – Sudden application of inertia load.

UNIT–II Reference Frame Theory and 3-Phase Induction Motor dq Model

Linear transformations – Phase transformation (abc to αβ0) – Power equivalence – Active transformation (αβ0 to dq0) – Transformations in the complex plane – Commonly used reference frames and transformations between reference frames – Circuit model of three-phase induction motor – Flux linkage equations – dq transformation of flux linkages in the complex plane – Voltage equations.

UNIT–III Modeling of 3-Phase Induction Motor in Various Reference Frames

Voltage equation transformation to synchronous reference frame – dq model of induction motor in stator reference frame, rotor reference frame, and arbitrary reference frame – Power equation – Electromagnetic torque equation – State-space model of induction motor with flux linkage variables and current–flux variables.

UNIT–IV Modeling of 3-Phase Synchronous Motor

Synchronous machine inductances – Circuit model of three-phase synchronous motor – Derivation of voltage equations in the rotor dq0 reference frame – Electromagnetic torque equation – State-space model with flux linkages as state variables.

UNIT–V Special Machines

Modeling of Permanent Magnet Synchronous Motors (PMSM) – Modeling of Brushless DC Motors (BLDC) – Analysis of Switched Reluctance Motors (SRM).

Text Books

1. Bimbhra, P.S., *Generalized Theory of Electrical Machines*, 5th Edition, Khanna Publishers, 1985.
2. Nam, Kwang Hee, *AC Motor Control and Electric Vehicle Applications*, CRC Press, Taylor & Francis Group, 2010.

Reference Books

1. Krishnan, R., *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson Publications, 1st Edition, 2002.
2. Krishnan, R., *Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications*, CRC Press, 2001.
3. Krause, P., Wasynczuk, O., Sudhoff, S.D., Pekarek, S., *Analysis of Electric Machinery and Drive Systems*, 3rd Edition, Wiley–IEEE Press, 2013.

Online Learning Resources

1. NPTEL Course: https://archive.nptel.ac.in/courses/108/106/108106023/

<table>
<tr><td rowspan="2">III</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">POWER ELECTRONIC CONVERTERS(BT24EE0HPE3)</td></tr>
</table>

Pre-requisite: Power Electronics

Course Objectives

The objectives of this course are to:

• Learn the characteristics of power switching devices and the use of gate driver circuits.
• Understand the need for isolation and analyze the performance of different isolated switch-mode converters.
• Learn the working principles of multilevel inverters and understand their merits and demerits.
• Apply PWM techniques to control fundamental voltage and mitigate harmonics in inverter systems.

Course Outcomes

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

CO1: Explain the characteristics of power switching devices and implement suitable gate driver circuits.
CO2: Analyze the operating principles and performance of isolated switch-mode DC–DC converters.
CO3: Investigate PWM control techniques for single-phase inverters and evaluate their performance.
CO4: Investigate PWM control techniques for three-phase inverters and compare their performance.
CO5: Analyze and compare PWM control strategies for cascaded H-bridge and diode-clamped multilevel inverters.
CO6: Evaluate the harmonic performance, switching losses, and application suitability of inverter and converter topologies in power electronic systems.

UNIT–I Overview of Switching Devices

Power MOSFET, IGBT, GTO, and GaN devices – Static and dynamic characteristics – Gate drive circuits for power switching devices.

UNIT–II Isolated DC–DC Converters

Need for isolated converters – Forward converter – Forward converter with demagnetizing winding – Flyback converter – Push–pull converter – Half-bridge converter – Full-bridge converter – Flux walking and balancing capacitors in half-bridge and full-bridge converters.

UNIT–III PWM Inverters

Voltage control of single-phase inverters using phase displacement control – Bipolar PWM – Unipolar PWM – Three-phase voltage source inverters: Six-step VSI operation – Voltage control using Sinusoidal PWM, Third Harmonic Injection PWM, and Space Vector Modulation – Comparison of PWM techniques – Three-phase current source inverters.

UNIT–IV Multilevel Inverters

Introduction and multilevel concept – Types of multilevel inverters – Diode-clamped multilevel inverter: principle of operation and features – Improved diode-clamped inverter – Cascaded H-bridge multilevel inverter: principle of operation and features – Fault-tolerant operation of CHB inverter – Comparison of diode-clamped and cascaded H-bridge inverters – Modular Multilevel Converters (MMC): principle of operation.

UNIT–V PWM Techniques for Multilevel Inverters

Cascaded H-Bridge multilevel inverter: Staircase modulation – Selective Harmonic Elimination (SHE-PWM) – Phase-shifted multicarrier PWM – Level-shifted PWM – Diode-clamped multilevel inverter: SHE-PWM – Sinusoidal PWM – Space Vector PWM – Capacitor voltage balancing techniques.

Text Books

1. Mohan, N., Undeland, T.M., Robbins, W.P., *Power Electronics: Converters, Applications, and Design*, 2nd Edition, John Wiley & Sons, 2003.
2. Rashid, M.H., *Power Electronics*, 3rd Edition, Pearson Education, 2008.
3. Wu, Bin, and Mehdi Narimani, *High-Power Converters and AC Drives*, John Wiley & Sons, 2017.

Reference Books

1. Krein, P.T., *Elements of Power Electronics*, Oxford University Press, 2014.
2. Hart, D.W., *Power Electronics*, McGraw-Hill, 2011.

Online Learning Resources

1. NPTEL: https://nptel.ac.in/courses/108105066
2. NPTEL: https://nptel.ac.in/courses/108102584
3. NPTEL: https://nptel.ac.in/courses/108101126

<table>
<tr><td rowspan="2">IV</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">POWER QUALITY AND CUSTOM POWER DEVICES(BT24EE0HPE4)</td></tr>
</table>

Pre-requisite: Basic knowledge in power systems and power electronics.

Course Objectives

The objectives of this course are to:

• Become familiar with the causes and effects of power quality issues in electrical power systems.
• Understand techniques for mitigation of power quality problems.
• Study the effects of harmonics and design suitable harmonic filters.
• Understand the working principles of custom power devices.
• Select and apply appropriate devices for power quality improvement.

Course Outcomes
At the end of the course, the student will be able to:
CO1: Identify and describe various power quality issues in electrical power systems.
CO2: Classify short-duration and long-duration voltage variations occurring in power systems.
CO3: Analyze the causes and effects of harmonics in power systems.
CO4: Evaluate different harmonic mitigation techniques used for power quality improvement.
CO5: Explain the importance, operating principles, and applications of custom power devices.
CO6: Compare and select appropriate compensation techniques to minimize power quality disturbances in electrical networks.

UNIT–I Introduction to Power Quality

Overview of power quality – Concerns about power quality – General classes of power quality problems – Voltage unbalance – Waveform distortion – Voltage fluctuations – Power frequency variations – Power quality terminology – Voltage sags, swells, flicker, and interruptions – Sources of voltage and current interruptions – Nonlinear loads.

UNIT–II Transient and Long-Duration Voltage Variations

Sources of transient over-voltages – Principles of over-voltage protection – Devices for over-voltage protection – Utility capacitor switching transients – Utility lightning protection – Load switching transient problems – Principles of voltage regulation – Devices for voltage regulation – Utility voltage regulator applications – Capacitors for voltage regulation – End-user capacitor applications – Voltage regulation with distributed generation.

UNIT–III Harmonic Distortion and Solutions

Voltage versus current distortion – Harmonics versus transients – Power system quantities under non-sinusoidal conditions – Harmonic indices – Sources and location of harmonics – System response characteristics – Effects of harmonic distortion – Inter-harmonics – Harmonic distortion evaluation – Devices for controlling harmonic distortion – Harmonic filter design – Harmonic standards.

UNIT–IV Custom Power Devices

Concept of custom power – Custom power devices – Voltage source inverters – Reactive power and harmonic compensation devices – Compensation of voltage and current interruptions – Static series and shunt compensators – Compensation in distribution systems – Interaction with distribution equipment – Installation considerations.

UNIT–V Applications of Custom Power Devices in Power Systems

Static and hybrid source transfer switches – Solid-state current limiters – Solid-state circuit breakers – p–q theory and control of active and reactive power – Dynamic Voltage Restorer (DVR): operation and control – Distribution Static Compensator (D-STATCOM): operation and control – Unified Power Quality Conditioner (UPQC): operation and control.

Text Books

1. Dugan, R.C., McGranaghan, M.F., Santoso, S., Beaty, H.W., *Electrical Power Systems Quality*, 2nd Edition, McGraw-Hill, 2002.
2. Bollen, M.H.J., *Understanding Power Quality Problems: Voltage Sags and Interruptions*, IEEE Press, 2000.
3. *Guidebook on Custom Power Devices*, EPRI Technical Report, November 2000.
4. Ghosh, A., Ledwich, G., *Power Quality Enhancement Using Custom Power Devices*, Kluwer Academic Publishers, 2002.

Reference Books

1. Kennedy, B.W., *Power Quality Primer*, McGraw-Hill, 2000.
2. Arrillaga, J., Watson, N.R., *Power System Harmonics*, 2nd Edition, John Wiley & Sons, 2003.
3. Kazibwe, W.E., Sendaula, M.H., *Electric Power Quality Control Techniques*, Van Nostrand Reinhold.
4. Shankaran, C., *Power Quality*, CRC Press, 2001.
5. De La Rosa, F.C., *Harmonics and Power Systems*, CRC Press.
6. Fuchs, E.F., Masoum, M.A.S., *Power Quality in Power Systems and Electrical Machines*, Elsevier.
7. Akagi, H. et al., *Instantaneous Power Theory and Applications to Power Conditioning*, IEEE Press, 2007.
8. Ghosh, A., Ledwich, G., *Custom Power Devices – An Introduction*, Springer, 2002.
9. Yash Pal et al., “A Review of Compensating Type Custom Power Devices for Power Quality Improvement,” POWERCON 2008.

Online Learning Resources

1. NPTEL: https://nptel.ac.in/courses/108107157
2. NPTEL: https://nptel.ac.in/courses/108102179
3. NPTEL: https://nptel.ac.in/courses/108106025

V	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS (BT24EE0HPE5)					

Pre-requisites: Power Electronics, Electrical Machines, Control Systems

Course Objectives

The objectives of this course are to:

• Illustrate the I–V characteristics of solar PV modules and the use of blocking and bypass diodes for shade mitigation.
• Understand Maximum Power Point Tracking (MPPT) techniques and the use of power converters for PV systems and battery charging.
• Understand different wind turbine technologies and power electronic converters used for wind energy generation.
• Analyze integrated solar PV and wind energy systems.

Course Outcomes

At the end of the course, the student will be able to:
CO1: Illustrate the I–V and P–V characteristics of solar PV modules and apply blocking and bypass diodes for shade mitigation.
CO2: Explain the working principles of maximum power point tracking (MPPT) techniques used in solar PV systems.
CO3: Analyze power electronic converters used for PV systems and battery charging applications.
CO4: Explain wind turbine technologies and classify various wind energy conversion systems.
CO5: Analyze the role and operation of power electronic converters in wind energy generation systems.
CO6: Analyze the configuration, operation, and performance of integrated PV and wind energy systems.

UNIT–I Solar Photovoltaic Fundamentals

Solar spectrum – PV materials – Equivalent circuit of a PV cell – Effects of series and shunt resistances – Fill factor – Cells, modules, and arrays – I–V characteristics under standard test conditions – Effects of temperature and insolation on I–V curves – Series and parallel connections of PV modules – Shading effects on I–V characteristics – Bypass and blocking diodes for shade mitigation – I–V characteristics for different load conditions.

UNIT–II Power Converters for Solar PV and Battery Charging

Perturb and Observe (P&O) MPPT method for solar PV inverters – Central, string, and micro inverters – Leakage current issues – Use of transformers for leakage current elimination – Transformer-less PV inverters – Battery chargers – Battery characteristics – Charge control methods – Battery charging using DC–DC converters – Dual Active Bridge (DAB) converter for battery charging.

UNIT–III Wind Energy Conversion Systems

Wind turbine technologies: Horizontal-axis and vertical-axis turbines – Power available in wind – Wind turbine power curves – Betz limit – Advantages and disadvantages of wind energy systems – Review of modern wind turbine technologies – Fixed-speed and variable-speed wind turbines – Doubly Fed

Induction Generators (DFIG) – Permanent Magnet Synchronous Generators (PMSG) and their characteristics.

UNIT–IV Power Electronic Converters for Wind Energy

Converters for wind generators – AC–DC–AC converters – Matrix converters – Multilevel converters – Maximum power point tracking for wind turbines – Fault ride-through capability of wind energy systems.

UNIT–V Grid Integration of Renewable Energy Systems

Grid connection principles – Clarke and Park transformations – Grid-connected photovoltaic systems – Grid-connected wind energy systems – Filters – Grid synchronization and Phase-Locked Loop (PLL) – Operation and control of hybrid renewable energy systems – IEEE and IEC codes and standards for renewable energy grid integration.

Text Books

1. Masters, G., *Renewable and Efficient Electric Power Systems*, 2nd Edition, IEEE–John Wiley & Sons, 2013.
2. Teodorescu, R., Liserre, M., Rodriguez, P., *Grid Converters for Photovoltaic and Wind Power Systems*, 2nd Edition, Wiley, 2011.
3. Keyhani, A., Marwali, M., Dai, M., *Integration and Control of Renewable Energy in Electric Power Systems*, 2nd Edition, John Wiley, 2010.

Reference Books

1. Solanki, C.S., *Solar Photovoltaic: Fundamentals, Technologies and Applications*, PHI Learning, 2019.
2. Farret, F.A., Simoes, M.G., *Integration of Renewable Sources of Energy*, 2nd Edition, Wiley, 2017.

Online Learning Resources

1. NPTEL: https://onlinecourses.nptel.ac.in/noc22_ee71/preview
2. NPTEL: https://nptel.ac.in/courses/103103206

<table>
<tr><td rowspan="2">VI</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="6">INDUSTRIAL APPLICATIONS OF POWER ELECTRONIC CONVERTERS
(BT24EE0HPE6)</td></tr>
</table>

Course Educational Objective: This course enables students to understand various power converters and their operation, with applications in LED lighting systems, uninterruptible power supplies (UPS), electric drives, and micro-grid systems**.**

Course Outcomes: At the end of the course, student will be able to

At the end of the course, the student will be able to:

CO1: Design and analyze converters and drivers for efficient LED lighting systems.

CO2: Illustrate the operation and applications of UPS, SMPS, and bi-directional DC–DC (BDC) converters.

CO3: Explain the applications of inverters and rectifiers for both high-power and low-power systems.

CO4: Analyze the operation and performance of various power converters.

CO5: Design power converters for grid-connected applications and evaluate their performance.

CO6: Implement and validate power converter solutions using simulation tools and experimental setups.

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT– 1	**Power Converters for LED Driving:** LED Characteristics, Driving LEDs, Converters (Buck, Boost & Buck-Boost) for LED lightning systems, PFC based LED drivers, Selecting Components for LED Drives, Applications of LEDs.	
UNIT– 2	**UPS and SMPS:** Components of UPS, operation and applications of UPS, Basic operation and applications of SMPS, Difference between UPS and SMPS. **Bi-directional DC-DC(BDC) converters:** Electric traction, Automotive Electronics, Battery charging converters, Line Conditioners and Solar	

	Charge Controllers.	
UNIT– 3	**High Voltage Power Supplies -** Power supplies for X-ray applications, Power supplies for radar applications, Power supplies for space applications. **Low Voltage High Current Power Supplies:** Power converters for modern Micro processor and Computer loads.	
UNIT– 4	**Power converters for AC Drives:** Two-Level VSI-Based Medium Voltage (MV) drives, NPC/H-Bridge inverter fed drive, ANPC inverter fed drive, Modular Multilevel inverter fed drive, and Multi-Module Cascaded Matrix Converter fed MV drive, power converters for PMSM & BLDC motors.	
UNIT– 5	**Power converters for micro-grid and grid connection of renewable energy sources:** Design, control of converters, grid synchronization and filtering requirements, Solid State Transformers technologies in Distribution System.	

Text Books:

1. Steve Winder, Power Supplies for LED Driving, Newnes, 2016,2nd Edition.
2. Abraham I. Pressman,Keith Billings &Taylor Morey, Switching Power Supply Design, McGraw Hill International, 2009, 3rd Edition.
3. Ali Emadi, A. Nasiri, and S. B. Bekiarov, Uninterruptible Power Supplies and Active Filters, CRCPress, 2004, 1stEdition.
4. AliKeyhani Mohammad Marwali,Min Dai,Integration and Control of Renewable Energy in Electric Power System,,JohnWileypublishingcompany,2010,2ndEdition.

Reference Books:

1. Muhammad H. Rashid ,Power Electronics Handbook, Butterworth-Heinemann, 2023, 5thEdition
2. MSingh, KKhanchandani, Power Electronics,McGraw-HillEducation,2006,2ndEdition.
3. B.L.Theraja,A Textbook of Electrical Technology-Volume III,2007,1stEdition.
4. William Ribbens, Understanding Automotive Electronics: An Engineering Perspective, Butter worth Heinemann, 2017, 8th Edition.
5. PaulC. Krause, Oleg W, Scott D. Sudhoff, Analysis of Electric Machinery &Drive systems, IEEE Press, 2013, 3rd Edition.
6. High-powerConvertersandACDrives, Bin-Wu, Wiley-Blackwell, 2017,2nd Edition.

VII	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
ADVANCED ELECTRICAL DRIVES(BT24EE0HPE7)					

Pre-requisites: Knowledge of Power Electronics, Electrical Machines, and Control Systems
Course Objectives

The objectives of this course are to:

• Provide a comprehensive understanding of advanced control schemes for induction motor drives.
• Familiarize students with control strategies for Permanent Magnet Synchronous Motors (PMSM), Brushless DC (BLDC), and Switched Reluctance Motor (SRM) drives.
• Impart knowledge on minimizing torque ripple and improving overall performance in motor drives.

Course Outcomes
After the completion of the course, the student will be able to:
CO1: Understand the concepts and principles of scalar control methods used in drive systems.
CO2: Understand the concepts and principles of vector control methods used in drive systems.
CO3: Select and implement suitable control techniques for induction motor drives based on application requirements.
CO4: Select and implement suitable control techniques for synchronous motor drives based on application requirements.
CO5: Analyze and design control techniques and converter topologies for Switched Reluctance Motor (SRM) drives.
CO6: Analyze and design controllers and converter circuits for Brushless DC (BLDC) motor drives.

UNIT–I Vector Control of Induction Motor Drives

Principles of scalar and vector control – Direct vector control – Indirect vector control – Implementation block diagrams – Estimation of flux – Flux weakening operation.

UNIT–II Direct Torque Control of Induction Motor Drives

Principle of Direct Torque Control (DTC) – Concept of space vectors – DTC control strategy of induction motors – Comparison between vector control and DTC – Applications – Space vector modulation-based DTC of induction motors.

UNIT–III Control of Synchronous Motor Drives

Synchronous motor and its characteristics – Control strategies: constant torque-angle control, power factor control, constant flux control, flux weakening operation – Load-commutated inverter-fed synchronous motor drive – Motoring and regeneration – Phasor diagrams.

UNIT–IV Control of Switched Reluctance Motor Drives

SRM structure – Stator excitation – Techniques for sensorless operation – Converter topologies – SRM waveforms – SRM drive design factors – Torque-controlled SRM – Torque ripple reduction – Instantaneous torque control using current and flux controllers

UNIT–V Control of BLDC Motor Drives

Principle of operation of BLDC machine – Sensing and logic switching schemes – BLDC as variable-speed synchronous motor – Methods to reduce torque pulsations – Three-phase full-wave BLDC motor – Sinusoidal BLDC motor – Current-controlled BLDC motor servo drives.

Text Books

1. Bose, B.K., *Power Electronics and Variable Frequency Drives*, IEEE Press, Standard Publisher Distributors, 2001.
2. Krishnan, R., *Electric Motor Drives: Modelling, Analysis and Control*, Prentice Hall of India Private Limited.

Reference Books

1. Miller, T.J.E., *Switched Reluctance Motors and Their Control*, Magna Physics, 1993.
2. Mohan, Undeland, Robbins, *Power Electronic Converters: Applications and Design*, Wiley Publications.
3. De Doncker, R.W., Pulle, D.W.J., Veltman, A., *Advanced Electrical Drives*, Springer, 2020.
4. Mohan, N., *Advanced Electric Drives: Analysis, Control, and Modeling Using MATLAB/Simulink*®, John Wiley & Sons, 2014.

Online Learning Resources

1. NPTEL: https://nptel.ac.in/courses/108104011
2. NPTEL: https://nptel.ac.in/courses/108102046

VIII	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		3	0	0	3
FACTS CONTROLLERS (BT24EE0HPE8)					

Pre-requisites

Fundamentals of Electrical Engineering, Power Systems, Power Electronics

Course Objectives

The objectives of this course are to:

- Understand the role of FACTS controllers and their impact on improving the performance, stability, and efficiency of transmission systems.
- Analyze compensation techniques and explore the effects of static shunt and series compensation on voltage regulation, power flow control, and system stability.
- Study shunt compensation devices and investigate the working principles and applications of Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) for reactive power compensation.
- Select appropriate FACTS devices by assessing various power system scenarios to enhance power transfer capability.
- Examine advanced controllers by understanding the principles, control strategies, and applications of Unified Power Flow Controller (UPFC) and Interline Power Flow Controller (IPFC) for comprehensive power flow management

Course Outcomes

At the end of the course, the student will be able to:

CO1: Understand how FACTS devices improve the performance of transmission systems.

CO2: Demonstrate the effects of static shunt compensation on system stability and power flow.

CO3: Demonstrate the effects of static series compensation on system stability and power flow.

CO4: Illustrate the use of SVC and STATCOM for shunt compensation.

CO5: Determine appropriate FACTS devices for different types of power system applications.

CO6: Explain the principles of operation and control strategies of UPFC and IPFC.

UNIT–I FACTS Concepts

FACTS concepts – Transmission interconnections – Power flow in an AC system – Loading capability limits – Dynamic stability considerations – Importance of controllable parameters – Basic types of FACTS controllers – Benefits of FACTS controllers.

UNIT–II Static Shunt Compensation

Objectives of shunt compensation – Midpoint voltage regulation – Voltage instability prevention – Improvement of transient stability – Power oscillation damping – Methods of controllable VAR generation: variable impedance type, switching-converter type, hybrid VAR generation – Basic concepts of voltage and current source converters – Comparison of current source converters and voltage source converters.

UNIT–III SVC and STATCOM

Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) – Regulation slope – Transfer function and dynamic performance – Enhancement of transient stability and power oscillation damping – Operating point control – Summary of compensation control.

UNIT–IV Static Series Compensation

Concept of series capacitive compensation – Improvement of transient stability – Power oscillation damping – Functional requirements – GTO thyristor controlled series capacitor (GSC) – Thyristor switched series capacitor (TSSC) – Thyristor controlled series capacitor (TCSC) – Control schemes for GSC, TSSC, and TCSC.

UNIT–V Advanced FACTS Controllers

Unified Power Flow Controller (UPFC): Basic operating principle – Conventional transmission control capabilities – Independent real and reactive power flow control – Comparison with series compensators and phase angle regulators. Interline Power Flow Controller (IPFC): Introduction, operation, and applications.

Text Books

1. Hingorani, N.G., and Gyugyi, L., *Understanding FACTS Devices*, IEEE Press, Indian Edition available: Standard Publications.

Reference Books

1. Hand, S.Y., and John, A.T., *Flexible AC Transmission Systems*, IEEE Press, 2006.
2. Sood, V.K., *HVDC & FACTS Controllers: Applications of Static Converters in Power Systems*, Springer Publishers.

Online Learning Resources

1. NPTEL: https://nptel.ac.in/courses/108107114
2. NPTEL: https://nptel.ac.in/courses/117103488

IX	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		0	0	3	1.5
POWER CONVERTERS LABORATORY(BT24EE0HPE9)					

Course Objectives

The objectives of this laboratory course are to:

• Illustrate the working of single-phase and three-phase full converters and semi-converters.
• Analyze the performance of square-wave inverters and PWM inverters.
• Analyze the performance of DC–DC converters.
• Analyze the performance of three-level NPC and five-level CHB inverters.

Course Outcomes

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

CO1: Illustrate the working principles and operation of single-phase full converters and semi-converters.
CO2: Illustrate the working principles and operation of three-phase full converters and semi-converters.
CO3: Analyze the performance of square-wave inverters and PWM inverters.
CO4: Analyze the performance of DC–DC converters used in power electronic applications.
CO5: Analyze the operation and performance of three-level Neutral Point Clamped (NPC) inverters.
CO6: Analyze the operation and performance of five-level cascaded H-bridge (CHB) inverters.
.

List of Experiments

Any 10 of the following experiments are to be conducted:

1. Analysis of single-phase half-controlled bridge rectifier.
2. Analysis of three-phase fully-controlled rectifier.
3. Analysis of single-phase square-wave inverter.
4. Analysis of three-phase inverter for 180° mode of conduction.
5. Analysis of single-phase inverter with unipolar and bipolar PWM switching.
6. Analysis of three-phase inverter using Sine-PWM method.
7. Analysis of three-phase inverter using Space Vector PWM (SVPWM) method.
8. Analysis of Buck DC–DC converter.
9. Analysis of Boost DC–DC converter.
10. Analysis of Buck–Boost DC–DC converter.
11. Analysis of Sine-PWM technique for 3-phase, 3-level NPC inverter.
12. Analysis of single-phase, 5-level cascaded H-bridge inverter with staircase modulation.
13. Analysis of phase-shift PWM technique for 3-phase, 5-level cascaded H-bridge inverter.
14. Analysis of level-shift PWM technique for 3-phase, 5-level cascaded H-bridge inverter.

<table>
<tr><td rowspan="2">X</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>0</td><td>0</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="6">ELECTRIC DRIVES LABORATORY(BT24EE0HPEX)</td></tr>
</table>

Course Objectives

This course enables students to gain hands-on experience in understanding different control methods of DC drives and advanced electric drives through practical experimentation.

Course Outcomes

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

CO1: Analyze the speed control of DC drives using various converter circuits.

CO2: Select appropriate converter circuits for DC drive speed control based on application requirements.

CO3: Examine regenerative braking methods and energy recovery techniques used in DC drives.

CO4: Analyze the performance and control strategies of V/f (scalar) control methods for AC drives.

CO5: Analyze the performance and control strategies of vector control methods for AC drives.

CO6: Compare and evaluate different control techniques used in DC and AC drive systems for industrial Applications.

List of Experiments

Any 10 of the following experiments are to be conducted:

1. Armature-controlled speed control of separately excited DC drive using single-phase full converter.
2. Armature-controlled speed control of separately excited DC drive using three-phase full converter.
3. Study of regenerative braking of DC drive.
4. Soft starting of three-phase induction motor.
5. Performance characteristics of three-phase induction motor using V/f control.
6. Vector control-based speed control of three-phase induction motor drive.
7. Study of direct torque control (DTC) of three-phase induction motor.
8. Speed control of PMSM motor using voltage control method.
9. Speed control of BLDC motor using voltage control method.
10. Vector control-based speed control of PMSM drive.
11. Vector control-based speed control of BLDC motor drive.
12. Speed control of Switched Reluctance Motor (SRM) with eddy current loads.

XI	HONORS ENGINEERING COURSES (POWER ELECTRONICS)	L	T	P	C
		0	0	3	1.5
RENEWABLE TECHNOLOGIES LABORATORY(BT24EE0HPEX1)					

Course Objectives:

- To understand Solar PV Characteristics by developing and analyzing the mathematical model of a solar PV cell and study its characteristics under different operating conditions.
- To evaluate PV Cell Combinations by investigating the performance of solar PV modules in series and parallel configurations by analyzing their I-V and P-V characteristics.
- To explore Power Electronic Converters by examining the role of different power electronic converters in optimizing the performance of PV systems and improving energy conversion efficiency.
- To implement MPPT Algorithms by demonstrating the significance of Maximum Power Point Tracking (MPPT) algorithms to enhance the efficiency of solar PV systems.
- To analyze Wind Energy Generation – Study the working principles of wind turbines, analyze wind turbine performance curves, and evaluate power generation characteristics.
- To model Uninterrupted Power Supply (UPS) by designing and analyzing of an Uninterrupted Power Supply (UPS) system to ensure continuous power delivery in renewable energy applications.

Course Outcomes

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

CO1: Analyze the mathematical model and understand the characteristics of a solar PV cell.

CO2: Demonstrate the effect of series and parallel combination of PV cells using I–V and P–V curves.

CO3: Analyze the effect of suitable power electronic converters for PV systems.

CO4: Demonstrate the significance of various Maximum Power Point Tracking (MPPT) algorithms on PV systems.

CO5: Demonstrate wind power generation and study wind turbine power curves.

CO6: Analyze the model and performance of Uninterruptible Power Supply (UPS) systems.

List of Experiments

Any 10 of the following experiments are to be conducted:

Software-Based Experiments

1. Simulate the mathematical model of a PV cell using single-diode and two-diode equivalent circuits.
2. Simulate I–V and P–V curves of a solar cell and analyze variations with temperature and irradiation.
3. Simulate I–V and P–V curves for PV modules connected in series and study the effect of temperature and irradiation.
4. Simulate I–V and P–V curves for PV modules connected in parallel and study the effect of temperature and irradiation.
5. Simulate the effect of varying series resistance on the fill factor of a PV cell.
6. Simulate Buck–Boost converter operation with closed-loop control for PV applications.
7. Simulate MPPT of a PV module using the Incremental Conductance (INC) algorithm.
8. Simulate MPPT of a PV module using the Perturb & Observe (P&O) algorithm.
9. Simulate a wind power plant model.
10. Simulate an Uninterruptible Power Supply (UPS) system model.

Hardware-Based Experiments

Using Solar PV Training System:

11. Measure I–V and P–V characteristics of a single PV module under varying radiation and temperature.
12. Study I–V and P–V characteristics of PV modules in series and parallel combinations.
13. Investigate the effect of shading on a PV module.
14. Study the effect of tilt angle on PV module performance.
15. Demonstrate the role of bypass and blocking diodes in a PV module.

Using Wind Energy Training System:

16. Determine the cut-in speed of a wind turbine.
17. Evaluate the Tip Speed Ratio (TSR) at different wind speeds.
18. Determine the coefficient of performance (Cp) of the wind turbine.
19. Study turbine characteristics: power variation with wind speed.
20. Determine the turbine power curve with respect to rotor speed at fixed wind speeds.
21. Analyze turbine output power with AC load in a wind energy system.

<table>
<tr><td rowspan="2">XII</td><td rowspan="2">HONORS ENGINEERING COURSES
(POWER ELECTRONICS)</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
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<tr><td colspan="6">ELECTRIC VEHICLES LABORATORY(BT24EE0HPEXII)</td></tr>
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Course Objectives:

- To simulate Power Converters for EVs by analyzing and implementing isolated and non-isolated DC-DC converters for electric vehicle applications using simulation tools.
- To evaluate Motor Control Strategies by Studying and simulating advanced motor control techniques such as Field-Oriented Control (FOC), Direct Torque Control (DTC), and closed-loop control for different EV propulsion motors.
- To design and analyze EV Battery Systems by developing and fabricating a Li-ion battery pack for EV applications and perform controlled charging and discharging experiments.
- To implement Hardware-Based Motor Control with Operation of induction motor and analyze its performance using V/F control and four-quadrant operation modes for EV applications.
- To assess EV System Performance by measuring and analyzing key parameters such as voltage, current, speed, torque, and power flow in propulsion systems under different operating conditions.

Course Outcomes

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

CO1: Simulate and analyze the performance of isolated and non-isolated DC–DC converters for electric vehicle (EV) applications.

CO2: Implement and evaluate Field-Oriented Control (FOC) and Direct Torque Control (DTC) strategies for induction motor drives in EVs.

CO3: Design and simulate closed-loop control systems for Switched Reluctance Motor (SRM) and BLDC motor drives for EV applications.

CO4: Construct and analyze a Li-ion battery pack (48V/72V, 3/5 kWh) and study its charging and discharging characteristics.

CO5: Perform real-time analysis of propulsion motor speed, voltage, current, and power using throttle control.

CO6: Demonstrate V/F control of induction motors and study four-quadrant operation of propulsion motors, including motoring and braking modes.

List of Experiments

Any 10 of the following experiments are to be conducted:

Software-Based Experiments

1. Simulation of isolated and non-isolated DC–DC converters for EV applications.
2. Simulation of Field-Oriented Control (FOC) / DTC-controlled induction motor drive for EV applications.
3. Simulation of closed-loop control of SRM drives for electric vehicle applications.
4. Simulation of Field-Oriented Control of PMSM for electric vehicle applications.
5. Simulation of closed-loop control of BLDC motor drive for electric vehicle applications.

Hardware-Based Experiments

6. Run the propulsion motor using throttle paddle and analyze speed, voltage, current, and power of the system.
7. Design and fabricate a 48V/72V, 3/5 kWh Li-ion battery pack.
8. Perform constant-current mode charging and discharging of EV battery.
9. V/F control of induction motor drive for electric vehicle application.
10. Study four-quadrant operation of propulsion motor and analyze all parameters (voltage, current, speed, torque, and power flow):
    a) Forward motoring mode
    b) Forward braking mode
    c) Reverse motoring mode
    d) Reverse braking mode