Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

Sem. V

T. Y. B. Tech. (ELECTRICAL) ENGINEERING

R23

Academic Year: 2025-2026

List of Courses

Course Code	Course Name
PC-BTE 501	**Power Electronics**
Course pre-requisites	BEE-I, BEE-II

Course Objectives

1. Explain controlled converters
2. Analyze current and voltage inverters and demonstrate the operation and control of inverter circuits
3. Discuss DC to DC converters and AC voltage controllers
4. Discuss need and application of AC filter

Course Outcomes

1. Demonstrate the behavior of semiconductor devices as a power switch
2. Apply the control techniques of rectifiers and inverters and their filtering requirements
3. Analyze AC to DC, DC to AC, DC to DC and AC to AC converters

Course Content

Module Number	Details	hours
1.	Silicon Controlled Rectifiers: Principle of operation of SCR, Static & Dynamic characteristics, Gate characteristics, pulse firing. Snubber circuits.	2
2.	Controlled Switching Devices: Principle of operation, rating and applications of power transistors, IGBT and MOSFET and power diodes.	4
3.	Rectifiers: Introduction to Half wave uncontrolled and controlled rectifiers with different loads, Full wave controlled rectifiers with different loads (single phase and three phase) Power factor improvements in rectifiers. Effect of load and source inductances	10
4.	Inverters: i. Principle of operation, Performance parameters, single phase bridge Inverters with RL and pure L load. 3 phase bridge Inverters: 180 degree conduction mode. ii. Voltage control of single phase and three phase inverters using PWM techniques, Connection of three phase inverter to grid, concept of active and reactive power flow between inverter and grid	12
5.	Passive Filters: causes of harmonic generation, filter requirement of power electronics converters, selection of inductor and capacitor	4
6.	Switching mode regulators – Buck, Boost, Buck-Boost and Cuk regulators, Bi-directional Chopper	8
7.	AC Voltage Controllers: Principle of Phase Control, Single Phase bidirectional control with R-L load.	2

For Self-study: Study of fully semiconductor switches: Triac, IGCT, GTO, SGTO. Comparison of semiconductor devices. Introduction to requirement of heat sink in semiconductor switches

E resources: http://www.digimat.in/nptel/courses/video/108101038/L01.html

Text Books
1. Mohan, Undeland and Riobbins, 'Power Electronics Converters, Applications and Design'. Wiley student third edition. (2022) 2. Muhammad Rashid, 'Power Electronics, Circuits, Devices and Applications'. Pearson, fourth Edition (2017). 3. Daniel Hart, 'Power Electronics'. McGraw Hill, Indian Edition. (2017) 4. L. Umanand, 'Power electronics essentials and applications' Wiley India (2009) 5. Soumitra Kumar Mandal, Power Electronics. McGraw Hill Education (2014) 6. Bimbra P.S. 'Power Electronics'. Khanna Publishers (2018)
Reference Books and standards
1. B. K. Bose, 'Power Electronics and AC Drives', Pearson (2001) 2. P.C. Sen, ' Principles of electrical machines and power electronics', Wiley India (2013) 3. IEEE-519-2014 Harmonic control standard in Electric power system

Course Code	Course Name
PC-BTE502	**Control System I**
Course pre-requisites	Electrical Networks, Laplace Transform, Signals and System

Course Objectives

1. Introduce control problem and modelling of systems
2. Discuss time response, frequency response
3. Introduce controllers, compensators
4. Design control using root locus and frequency domain

Course Outcomes

Upon successful completion of the course, students should be able to
1. Model linear-time-invariant systems using transfer function and block diagram.
2. Analyze and design Linear Time Invariant system in time domain
3. Analyze and design Linear Time Invariant system in frequency domain

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction to control problem. Industrial Control examples. Mathematical models of physical systems. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems, Benefits of Feedback. Block diagram algebra, Signal Flow graph	06
2	Time Response Analysis Standard test signals, Time response of first and second order systems for standard test inputs, Application of initial and final value theorem, Performance specifications for first and second-order systems, error constants and error calculations, Concept of Stability. Routh-Hurwitz Criteria.	06
3	Root Locus- Construction of Root-loci, Stability Analysis using root locus, design of gain via root locus	08
4	Introduction to Controllers and Compensators P, PI, PD, PID controllers, Lag, Lead, Lead-Lag compensators	05
5	Frequency-response analysis Relationship between time and frequency response, Polar plots, Nyquist Plot, Nyquist stability criterion, Bode plots, Stability margin from Bode Plots.	07
6	Design Specifications: Introduction to design problem and philosophy, Introduction to time domain and frequency domain design specification and its physical relevance. Effect of gain on transient and steady state response, Effect of addition of pole on system performance. Effect of addition of zero on system response.	04
7	Design of Classical Control System in the time domain : Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain. Realization of compensators.	08

	Design of Classical Control System in frequency domain Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using Bode diagram.	

For Self-study:

1) Higher order system analysis

Text Books:

1. Norman Nise, "Control Systems Engineering". Wiley Publication, 4th Edition, 2007
2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt. Ltd, 5th Edition, 2015.

Reference Books:

1. I.G. Nagrath & M. Gopal, "Control Systems Engineering", 5th Edition, New Age, 2007.
2. J.J. D"Azzo, C.H.Houpis and S.N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Marcel Dekker.
3. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education.

E resources (if any):

https://nptel.ac.in/courses/107106081

Course Code	Course Name
PC-BTE503	**Electrical Machines II**

Course pre-requisites	Electrical Machines I

Course Objectives

The objectives of this course are

1. Discuss the principle and operation of generating machine both 1-phase and 3-phase
2. Demonstrate the behavior of generating and motoring machine for different operating conditions.
3. Demonstrate the principle of fractional kilowatt machine
4. Discuss the special types of machines and applications (motors and generators)

Course Outcomes

Upon successful completion of the course, students should be able to

1. Demonstrate the fundamental concept of rotating AC machines.
2. Analyze the operation and behavior of induction and synchronous machine connected to power system
3. Appraise the functionality and applications of fractional kW machine and special purpose machines.

Course Content

Module No.	*Details*	*Hrs.*
1	**Three Phase Induction Machine:** (i) Construction and principle of operation of squirrel cage & slip ring Induction motor (ii) Equivalent circuit, phasor diagram, no load and blocked rotor test, (iii) Steady state analysis: Torque -speed characteristics, maximum torque, starting torque. Starting methods for squirrel cage and slip ring induction machines.	08
2	**Synchronous Generator:** Construction, EMF induced, winding factors, Armature reaction, Phasor diagrams of cylindrical pole synchronous generator at different power factor, Methods of voltage regulation of alternator	08
3	**Synchronous Motor**: principle of operation, various starting methods, power flow and maximum power of synchronous machines, V curves, power angle characteristics, synchronizing power and torque, hunting, synchronous condenser	06
4	Operation on infinite bus for change in excitation for motors and generators, Parallel operation of alternators, Load sharing	04
5	**Salient pole machine**: Blondel's two reaction theory, Measurement of Xd& Xq, Power flow equation.	06

6	**Fractional kW machines**: Construction, principle of operation of single phase induction Motor.	04
7	**Special purpose Machines:** Construction, principle of operation of synchronous reluctance motor, Permanent Magnet Synchronous Motor, BLDC motor and switched reluctance motor.	06

Self-Study: Applications of Single phase induction motor, capacitor start, capacitor run motor, Shaded pole motor. Application of Special purpose machines.

Text Books
1. Sen P. C., "Principles of Electric Machines & Power Electronics". 2. Bimbhra P.S, "Electrical Machinery", Khanna Publisher, VII Edition.
Reference Books
1. Nagrath and Kothari, "Electrical Machines", TMH Publicatio. 2. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publisher. Gross Charles A., "Electrical Machines", CRC Press 3. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.

Course Code	Course Name
PC-BTE504	**Power System Analysis**
Course pre-requisites	Electrical Network, Graph Theory, Numerical Techniques

Course Objectives

The objectives of this course are

1. To make student understand symmetrical component method for fault current calculation under various types of faults in power system
2. To impart knowledge about various load flow analysis techniques.
3. To make student realize the need of stability analysis in case of various types of transient conditions.

Course Outcomes

At the end of the course, students will demonstrate the ability to

1. Model power system components and find fault current in case of symmetrical & unsymmetrical faults.
2. Build the Y_{bus} and determine the line flows using different computational methods for transmission as well as distribution networks.
3. Analyze the concept of steady state stability, its evaluation and its importance.
4. Analyze the power system behavior under various types of transient conditions.

Course Content

Module No.	***Details***	***Hrs.***
1	**Representation of power system components & per unit calculation:** Representation of power system components in Single line diagram, Impedance diagram, Per Unit method and its advantages.	2
2	**Symmetrical Components:** symmetrical component method, Sequence circuits of transmission lines, transformer and Synchronous Machines, Phase shift in star delta transformer, Formation of Sequence Networks	4
3	**Fault Analysis:** **Symmetrical Fault Analysis:** 3 phase fault on a transmission line, Short circuit MVA Capacity of a bus, 3 phase Short circuit of a synchronous machine - steady state, transient and sub- transient equivalent circuits**.**	6
4	**Unsymmetrical Fault Analysis:** Fault analysis using symmetrical components, Single line to ground (SLG) fault, Line to line (LL) fault, Double line to ground (LLG) fault, Open conductor fault.	7
5	**Load Flow Studies:** Formation of Ybus, Power Flow Problem, Gauss Seidel (GS) method, Newton Raphson (NR) method Decoupled & Fast Decoupled method, introduction to unbalanced load flow studies.	12
6	**Power system Stability:** Classification of stability, Dynamics of synchronous machine, power angle equation, swing equation, steady state stability- small disturbances, transient stability- Equal Area Criteria.	7

7	**Power System Transients:** Switching transients, Travelling Wave Phenomena: Travelling wave equations, reflection wave, refraction wave, typical cases of line termination.	6

For Self-study: solution of swing equation using Forward Euler method, Runge-kutta 4th order method

Text Books:

1. Saadat Hadi, “Power System Analysis, “TMH Publication.
2. Kothari D. P Nagrath I. J., “Modern Power System Analysis”, TMH Publications.
3. Wadhawa C. L., “Electrical Power Systems”, New Age International.
4. Grainger John J., Stevenson William D., “Power system Analysis”, MC Graw Hill.
5. A. A. Sallam and O. P. Malik, “Electric Distribution System”, IEEE Press, Piscataway, NJ, 2011.

Reference Books:

1. Olle I. Elgerd, “Electric Energy Systems Theory: an Introduction”, TMH Publication
2. W. H. Kresting, “Distribution System Modeling and Analysis”, CRC Press, New York, 2002.

Course Code	Course Name
PC-BTE505	**Communication Engineering**
Course pre-requisites	Signals and Systems, Electronic and Analog circuits, Digital Electronics

Course Objectives

1. Discuss Analog and Digital Communication systems : Implementation and Comparison
2. Discuss bandwidth utilization methods
3. Introduce Computer Network

Course Outcomes

Students will be able to
1. Compare different analog and digital modulation methods
2. Apply source and channel coding appropriately
3. Compare different bandwidth selection techniques
4. Describe different computer network and adapt appropriately.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction to Analog Communication:** Theory of Amplitude Modulation, Comparison of DSBFC, DSBSC, SSB, ISB systems, Theory of frequency and phase modulation and comparison with amplitude modulation, Introduction to analog receivers	07
2	**Digital Communication** Block diagram of digital communication system Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), BPSK, DPSK, DEPSK,QPSK, Quadrature Amplitude Modulation (QAM)).	07
3	**Pulse Modulation:** Sampling Theorem, Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM) their generation and detection, Pulse Code Modulation, quantization noise, bandwidth, Delta Modulation, Adaptive delta Modulation	06
4	**Bandwidth Utilization:** Guided and unguided media – Twisted pair cable, Coaxial cable, Fiber optic, Radio waves, Microwaves, Infrared waves, Light waves, Multiplexing – FDM, TDM Spreading – DSSS, FHS	05

5	**Source Coding** Information, Entropy, Rate of information, Channel capacity, Shannon theorem, Huffman coding	05
6	**Channel Coding/Decoding** Linear block code, Cyclic code, Convolution code	05
7	**Introduction to Computer Network** Types of communication (simplex, half duplex, full duplex), types of connections, network topology types Types of networks: peer to peer and client server networks, network hardware- transmission technology-broadcast links and point-to-point links and scale–PAN, LAN, MAN, WAN, Internet Network software: protocol hierarchies, protocol, peers, interface, network architecture, protocol stack, Connection oriented and connectionless services, service primitives Reference model: OSI,TCP/IP	07

For Self-study: Electronic/Analog and Digital circuits used in different communication systems

Text Books:

1. G. Kennedy and B. Davis, "Electronic Communication Systems", 4/e, Tata McGraw Hill, 2011
2. Simon Haykin, "Digital Communications", 1/e, John Wiley, India, 2014
3. S. Tanenbaum, "Computer Networks", 4th Edition, Prentice Hall, 2012.

Reference Books

1. Taub and Schilling, "Principles of Communication Systems", McGraw Hill, Fourth reprint 2009. 2.
2. Roddy and Coolen, "Electronic Communication", 4/e, Pearson Education 2008
3. John. G. Proakis, "Digital Communication",5/e, Pearson Education, 2014
4. Herbert Taub and Donald L Schilling," Principles of Communication Systems", Tata McGraw Hill, New Delhi, 2012
5. B. F. Ferouzan, "Data and Computer Communication", 4 th Edition, Tata McGraw Hill, 2010.
6. William Stallings, "Data and Computer Communication", 10^{th} Edition, 2014

Course Code	Course Name
PC-BTE 551	**Power Electronics Lab**
Course pre-requisites	Basic electrical and electronics lab

Course Objectives

1. To simulate various converter circuits.
2. To familiarize the students by introducing software simulation and help them to Simulate and analyze different Converters

Course Outcomes

1. Simulate uncontrolled and controlled converters
2. Observe and analyze various rectifier waveforms for different loads with different firing angles.
3. Demonstrate the variation in magnitude of voltage and frequency in inverter circuits with control techniques

Module No.	*Details*	*Hrs.*	*CO*
1.	Half wave uncontrolled and controlled converter with R and RL load.	2	1,2
2.	Different methods of SCR firing.	2	1,2
3.	Single phase Full wave fully controlled SCR converter with resistive load	2	1,2
4.	Single phase Full wave fully controlled SCR converter with RL load.	2	1,2
5.	Three phase full wave fully controlled SCR converter with resistive load	2	1,2
6.	Single phase Current Source Inverter with R-load.	2	3
7.	Software simulations of three phase inverters with R load	2	1,2
8.	Software simulations of three phase inverters with R-L load	2	1,2
9.	Software simulations of DC to DC converters. Comparison with ideal converter and practical converter (particularly boost converter)	2	1
10.	Mini project		1,2,3

Term work shall comprise of Practical Examination/ MCQ examination/ mini project

Mini project: Use of Power electronics switches in practical applications**.**

Note: The laboratory work will consist of minimum six experiments from the above list and/or any other experiment based on the prescribed syllabus of power electronics. Further, a Mini project or few more experiments (minimum 2) based on power electronics course needs to be completed.

Text Books
1. Mohan, Undeland and Riobbins, ‘Power Electronics Converters, Applications and Design’. Wiley student third edition. (2022) 2. Muhammad Rashid, ‘Power Electronics, Circuits, Devices and Applications’. Pearson, fourth Edition (2017). 3. Daniel Hart, ‘Power Electronics’. McGraw Hill, Indian Edition. (2017) 4. L. Umanand, ‘Power electronics essentials and applications’ Wiley India (2009) 5. Soumitra Kumar Mandal, Power Electronics. McGraw Hill Education (2014) 6. Bimbra P.S. ‘Power Electronics’. Khanna Publishers (2018)
Reference Books and Standards
1. B. K. Bose, ‘Power Electronics and AC Drives’, Pearson (2001) 2. P.C. Sen, ‘ Principles of electrical machines and power electronics’, Wiley India (2013) 3. IEEE-519-2014 Harmonic control standard in Electric power system

Course Code	Course Name
PC-BTE 552	**Control System Laboratory**
Course pre-requisites	

Course Objectives

1 Model linear-time-invariant systems using transfer function and state- space representations.
2. Carry out analysis of Linear Time Invariant system in time domain and in frequency domain
3. Use of software tools for system analysis

Course Outcomes

Upon successful completion of the course, students should be able to

1. Model linear-time-invariant systems in transfer function form using simulation software.
2. Analyze and design Linear Time Invariant system in time domain and in frequency domain using simulation software.
3. Evaluate performance of physical systems and controllers experimentally.
4. Write experimental procedures, observe output and interpret the results.

List of suggested experiments (Simulation / Hardware based)

Module No.	***Suggested topics***	***Hrs.***
1	Mathematical Modeling of a Physical System (DC Motor / RLC Network	02
2	Synchro – Transmitter	01
3	Potentiometer as error detector	01
3	First order system analysis	02
4	Second order system analysis	02
5	Higher order system approximation with second order system	02
6	Analysis of Under-damped systems	02
7	Effect of zero location on the performance of second order system	02
8	Analysis and Design using Root Locus	02
9	Analysis and Design using Bode Plot	02
10	Nyquist Plot	02
11	Effect of P, I and D in a PID Controller (Simulation)	02
12	Effect of P, I and D in a PID Controller (Hardware)	02
13	Effect of compensating networks	02
14	Study of frequency Response of closed loop control system	02

For Self-study: Software required for simulation.
Text Books:

1. Norman Nise, "Control Systems Engineering". Wiley Publication, 4th Edition, 2007
2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt.Ltd, 5th Edition, 2015.

Reference Books:

1. I.G. Nagrath & M. Gopal, "Control Systems Engineering", 5th Edition, New Age, 2007.
2. J.J. D"Azzo, C.H.Houpis and S.N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Marcel Dekker.
3. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education.

E resources (if any):

https://matlabacademy.mathworks.com/details/matlab-fundamentals/mlbe

https://github.com/MathWorks-Teaching-Resources/Virtual-Controls-Laboratory

https://ee32-iitb.vlabs.ac.in/#

https://asnm-iitkgp.vlabs.ac.in/exp/rlc-series-circuit/procedure.html

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp1/

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp2/

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp4/

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp5/

Course Code	Course Name
PC-BTE553	**Electrical Machines II Laboratory**

Course pre-requisites	Electrical Machines I

Course Objectives

The objectives of this course are

1. To perform load test on three phase induction motor
2. To observe the effect of rotor resistance and supply voltage on torque speed characteristic of induction motor
3. To study and evaluation of Voltage Regulation for synchronous generator volt
4. To conduct experiment to draw V and inverted V curves for synchronous motors.
5. To calculate Xd and Xq of a salient pole synchronous machine

Course Outcomes

Upon successful completion of the course, students should be able to use experimental data to

1. Validate the characteristics of induction motor.
2. Compare different methods of the voltage regulation in synchronous generator.
3. Analyze the V curve and inverted V-curve for synchronous motor under various load conditions.

Course Content

Module No.	***Details***	***Hrs.***
1	To perform load test on 3 Phase Induction Motor.	2
2	To study the effect of rotor resistance on torque speed characteristic of 3 Phase Induction Motor.	2
3	To study the effect of supply voltage on torque speed characteristic of 3 Phase Induction Motor.	2
4	Voltage Regulation of synchronous generator by EMF/MMF method	2
5	Voltage Regulation of synchronous generator by ZPF method	2
6	Voltage Regulation of synchronous generator ASA Method	2
7	Voltage regulation of synchronous generator by direct loading	2
8	Slip Test on salient pole synchronous generator	2
9	V-curves and inverted V- curve of synchronous motor	2
10	Performance characteristics of single phase induction motor	2
11.	Effect of capacitor on the operation of source power factor (for I.M. load/ Transformer load)	2

Term Work: The laboratory work will consist of minimum six experiments from the above list and/or any other experiment based on the prescribed syllabus. Further, a Mini project or few more experiments (minimum 2) based on the course content needs to be completed. The Instructor is expected to ask the students to manually verify the results wherever possible.

End semester examination shall comprise of Practical Examination & / MCQ examination/Mini project/ presentations

Text Books

1. Sen P. C., “Principles of Electric Machines & Power Electronics”.
2. Bimbhra P.S, “Electrical Machinery”, Khanna Publisher, VII Edition.

Reference Books

1. Nagrath and Kothari, “Electrical Machines”, TMH Publicatio. 5.
2. Bimbhra P.S., “Generalized Theory of Electrical Machines”, Khanna Publisher.
3. Gross Charles A., “Electrical Machines”, CRC Press
4. M.G. Say, “Theory & Performance & Design of A.C. Machines”, ELBS London.

Course Code	Course Name
PC-BTE554	**Electrical Simulation Laboratory**

Course pre-requisites	Basic knowledge of programming

Course Objectives

Objectives of this course are

1. Proficiency in using Engineering software
2. Develop programming skill.
3. Understand the behaviour of the power system under symmetrical and unsymmetrical fault condition using symmetrical components.
4. Use different numerical techniques to study load flow as well as transient stability.

Course Outcomes

Upon successful completion of the course, students should be able

1. Use various Engineering software for Electrical system studies.
2. Evaluate fault current under symmetrical and unsymmetrical fault conditions in power system.
3. Develop algorithm for load flow studies, power system stability studies and infer the results.
4. Analyse the performance of electrical machines & power electronic devices using software tools.

List of Experiments

Expt. No.	***Details***	***Hours***	
1	Simulation of typical power system- familiarization with generator, line and load models.	2	1
2	Develop a program to calculate Y bus matrix.	2	1,2
3	Develop program to study load flow using Gauss Siedel/Newton Raphson method & validate results manually/ using various software tools.	2	1,4
4	Simulation and analysis for symmetrical, unsymmetrical faults in a power system.	2	1,2
5	Study of transient behavior of synchronous machine under three phase short circuit at the terminal.	2	1,3
6	Study of effect of neutral grounding on earth fault current in a power system.	2	1,3
7	Study of Power swing equation for a two machines system. Or develop a program to find numerical solution of power swing equation.	2	1,3
8	Analysis of small disturbance stability of a single machine connected to infinite bus.	2	1,3
9	Study the effect of turns ratio of an ideal transformer on maximum power transfer.	2	1,3

10	Study of Buck converter / Boost converter	2	1,4
11	Simulation three phase VSI using sine-triangular PWM technique	2	1,4
12	Study the performance of synchronous generator	2	1,4
13	Study the performance of Induction motor	2	1,4
14	Study of vector group of a transformer.		
15	Unbalanced Load flow analysis in distribution system.	2	1,4

Term work

Note: The laboratory work will consist of **minimum six** experiments from the above list and/or any other experiment based on the prescribed syllabus of power system Analysis. Further, a Mini project or few more experiments (minimum 2) needs to be completed. The Instructor is expected to ask the students to manually verify the results wherever possible, so that students can have practice of solving examples. Students can write program in any programming language suitable for them.

Resources required: Minimum 20 users License software MATLAB and/ OR ETAP/ Scilab/ Python (Py-power tool, PANDA power)/ OpenDSS/Gridlab-D

Text Books

1. Stevenson W.D., “Elements of Power System Analysis”, TMH Publication.
2. Saadat Hadi, “Power System Analysis, “TMH Publication.
3. MATLAB / Scilab Manual, ETAP Manual
4. Mohan, Undeland and Riobbins, ‘Power Electronics Converters, Applications and Design’. Wiley student third edition. (2022)
5. Sen P. C., “Principles of Electric Machines & Power Electronics”.

Reference Books

1. Prabha Kundur, “Power System Stability and Control’’, TMH Publication.
2. MATLAB/Scilab online Tutorials
3. ETAP webinars

Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

Sem. VI

T. Y. B.Tech. (ELECTRICAL) ENGINEERING

Academic Year: 2025-2026

List of Courses

Course Code	Course Name
PC-BTE601	**Electric Drives**
Course pre-requisites	Power Electronics and Electrical Machines

Course Objectives

1. Understand fundamentals of electric drives and their control through knowledge of electrical machines and power electronics
2. Discuss basics, dynamics, selection, braking and control of AC/DC drives.
3. Discuss applications of drives in industry
4. Understand the selection of motor as per the torque-speed characteristics of load.

Course Outcomes

1. Analyze the fundamental concept of electrical drives system.
2. Select and analyze the control of electrical drive for the particular application based on the mechanical characteristics of load
3. Evaluate the Control performance of DC and AC drives using conventional and solid state drive

Module No.	***Details***	***Hrs.***
1	**Introduction:** Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives	04
2	**Dynamics of Electrical Drives:** Fundamental torque equations, Speed torque conventions and multi quadrant operation, Equivalent values of Drive parameter, Measurement of moment of Inertia, Components of load torque, Nature and Classification of load torques, Calculation of Time and Energy-Loss in transient operation, Steady state stability, Load equalization.	08
3	**Selection of Motor Power Rating:** Thermal Model of motor for heating and cooling, Classes of motor rating, Determination of motor rating.	04
4	**Control of Electrical Drives:** Modes of operation, Speed control drive classification, Closed loop control of drives. Speed sensing, current sensing, Phase locked loop control	04
5	**DC Drives:** Speed torque relations for shunt, series, and separately excited motors, Starting, Braking (Regenerative, Dynamic and Plugging), Speed Control (Armature voltage, Field flux, Armature resistance), Controlled rectifiers, Controlled rectifier fed DC drives (separately excited only)), Single phase fully-controlled rectifier, Single phase half- controlled rectifier, three phase fully-controlled rectifier, three phase half controlled rectifier, dual converter control, Chopper control (motoring and braking of separately excited)	08

6	**AC Drives:** Induction motor drives, Review of speed-torque relations, Review of starting methods, Braking (Regenerative, Plugging, AC/DC Dynamic braking), Speed control: Stator voltage control variable frequency control from voltage Source (V/F Control),Wound rotor induction motor control, rotor resistance control, Slip power recovery scheme, State Kramer and Scherbius drive, Vector control (elementary treatment only), Introduction to Synchronous Motor variable speed drive	08
7	**Special Motor Drives:** Stepper motor drives, Types, Torque v/s stepping rate characteristics, Drive circuits, Introduction to PM motor drives, Brush- less DC drives, Switched reluctance drives. Recent trends in Electric Drives.	06

For Self-study: Three phase rectifier (half control and full control), Separately excited DC motor speed control using chopper, Stepper motor drives, Types, Torque v/s stepping rate characteristics

E resources:

Text Books
1. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall.. 2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall.
Reference Books
1. G. K. Dubey, "Fundamentals of Electrical Drives", CRC Press. 2. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media. 3. Subrahmanyam V, Electrical Drives: Concepts and Applications TMH 4. Pillai S.K, A First course on Electrical Drives Wiley Eastern PH

Course Code	Course Name
PC-BTE602	**Switchgear and Protection**
Course pre-requisites	Basics of power system, fault analysis

Course Objectives

1. Understand Art & Science of Relaying Technology
2. Explore design and working principles of various Circuit Breakers
3. Study different types of protection philosophies and their applications for various power apparatus protection.
4. Get familiar with modern protection techniques.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Identify different components of protection system such as relays, CT, PT etc.
2. Select suitable components and co-ordination of protection devices for specific power apparatus protection and human safety.
3. Compare various circuit breakers and select for specific application.
4. Appreciate the need for new trends in switchgear technologies.

Course Content

Module No.	*Details*	*Hrs.*
1	**Basics of protection** Protective zones. Attributes of relays, Primary and back up protection, remote and local back up, Desirable qualities. Introduction to CT and VT Typical relays: Electromagnetic type, static type and Numerical Relay Architecture. **Principle and characteristics of:** Over current Relays - Time setting, plug setting, Different characteristics like IDMT, very Inverse etc., Directional Relay, Distance Relay- Reactance, Impedance, MHO relay, Differential Relay, Earth Fault Protection.	8
2	**Protection of Transmission lines & feeders**- over current protection and relay coordination, application of directional relays for various feeder arrangements. Distance relay application, Distance relays under load encroachment and power swing, Pilot protection.	9
3	**Protection of Transformer, Generator and Motor:** Differential relay for 3 phase transformer winding protection, Magnetizing inrush, Restricted Earth fault protection, Buchholz relay. **Protection of Generator**- Differential protection for stator faults, Protection against loss of prime mover and loss of excitation, field suppression, out of step protection. **Motor Protection**- Protection against single phasing, Thermal over load and short circuit protection using Type 2 coordination, overvoltage, under voltage protection.	9

	Busbar Protection- concept of bus bar differential protection, High impedance bus differential protection.	
4	**Principles of Circuit Braking:** D.C and A.C. circuit breaking, arc voltage and current waveforms in an A.C. circuit., Definition of transient recovery voltage, rate of rise of TRV, ratings and specifications of circuit breakers, making and breaking capacity **Basics of Arc Extinction**: Ionization of Gases, Deionization, Arc Formation in AC Circuit Breakers, Modes of Arc Extinction, Arc Interruption Theories	4
5	**Low Voltage & High Voltage Circuit Breakers** **L.V. C.B. (more emphasis on lab practices)** Air Break C.B., MCB, MCCB, HRC fuses, Metal Enclosed Switchgear, Contactor: Construction, operation, types, selection and application. **H.V.C.B.** Air break, Air blast, vacuum, SF6 Circuit Breaker: Operation, types, selection and application.	6
6	**Protection against over voltage Surges in transmission system**: Lightening phenomena, Different types of lighting arresters, role of ground wire, concept of Insulation coordination.	3
7	**Modern Protection Practices:** Need of 'system' protection, communication based substation monitoring & control, IEC 61850 standard. WAMS based protection schemes, Protection Issues in Micro-grids. SF6 Insulated Metal Clad Switchgear – Sub Station (GIS)	3

Self-study – Buchholz relay, Synchronous motor protection

Various IEEE Standards and Testing Practices:

IEEE 242-2001: IEEE recommended Practice for protection and coordination of Industrial and commercial power systems.

ANSI/IEEE standard C37.2 : ANSI standard Device Numbers

Text Books

1. Badri Ram, D.N. Vishwakarma. Power system protection and Switchgear. McGraw Hill Education, Second Edition
2. Y.G. Paithankar. Transmission Network Protection. Marcel Dekker, Inc
3. Bhuvanesh Oza, Nirmal Kumar Nair, Ramesh Mehta and Vijay Makwana. Power system protection and switchgear. MacGraw Hill.
4. B. Ravindarnath, M. Chandar. Power system Protection and switchgear. New age Int. Ltd.

Reference Books

1. Blackburn, J.L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982.
2. Phadke, A.G. and J.S. Thorp, Computer Relaying for Power Systems, Research Study Press Ltd, John Wiley & Sons, Taunton, UK, 1988

E resources (if any):

Power System Protection, Dr. S. A. Soman, IIT Bombay
https://nptel.ac.in/courses/108101039

Course Code	Course Name
PE-BTE603	**Control System II**
Course pre-requisites	Control System I

Course Objectives

1. Introduce state space modelling and analysis
2. Design of controllers and observers using state space
3. Introduce non linearity and its effect on system performance

Course Outcomes

Students will be able to
1. Model and analyze linear-time-invariant systems using state-space representation.
2. Design state feedback controllers and observers
3. Analyze nonlinear system behavior using phase plane analysis.

Course Content

Module No.	***Details***	***Hrs.***
1	State Space Model: Concepts of state variables, State space model.	04
2	Realization: Canonical form, eigen values and eigen vectors, Diagonal form.	04
3	State variable Analysis: State space solution, Transfer function from State Space, stability analysis.	04
4	Concept of controllability & observability, controllability & observability of the system.	03
5	**Controller Design** Pole placement design through state feedback. Ackerman's Formula for feedback gain design.	05
6	**Observer Design** Design of Observer, Reduced order observer. Separation Principle	03
7	Nonlinearities and its effect on system performance Various types of non-linearity. Effect of various nonlinearities on system performance. Singular points. Phase plane analysis.	05

For Self-study: Application where the design of controller/ compensator/observer is used.

Text Books:
1. N. Nise, "Control system Engineering", 4/e,John Wiley, 2007.
2. I. J. Nagrath and M. Gopal, "Control system engineering", 5/e, New Age, 2007.
3. M. Gopal, "Control Systems Principles and Design", 2/e, McgrawHill,2006

Reference Books
1. K. Ogata, "Modern Control Engineering", 5/e, Pearson, 2015
2. J. J. D'Azzo and C. H. Houpis, "Linear control system analysis and design (conventional and modern)", 3/e, McGraw Hill, 1988

R. T. Stefani and G. H. Hostetter, "Design of feedback Control Systems", 4/e, Oxford University Press,

Course Code	Course Name
PC-BTE 651	**Electric Drives Laboratory**
Course pre-requisites	Power Electronics, Electrical Machines

Course Objectives

The objectives of this course are
1. Perform simulations of electrical drives
2. Perform experiments on Plugging. Braking of DC and Induction motors
3. Perform experiments to understand different types of electrical drives

Course Outcomes

Upon successful completion of the course, students should be able to
1. Compare the braking methods of dc drives through performing the practical and software simulation.
2. Analyze the power electronics control for ac and dc drives.
3. Analyze the braking methods of ac drives.
4. Analyze the V/F control of three phase induction motor.

Course Content

	Details	***Hrs.***
1.	Simulation of Electrical drives.	2
2.	Simulation of starting of DC motor (soft start).	2
3.	Dynamic braking of DC motor	2
4.	Plugging of DC motor/Plugging while lowering the load.	2
5.	Regenerative braking of DC motor (by making V<Eb) for high inertia load.	2
6.	DC Dynamic braking of 3 phase induction motor.	2
7.	DC motor control using DC Drive	2
8.	Plugging of induction motor	2
9.	Single phase full wave controlled DC motor drive.	2
10.	V/F control of Induction motor using PWM inverter	2
11.	Measurement of moment of inertia by retardation test	2
12.	Torque –speed characteristic of BLDC/PMSM motor	2
13.	Harmonic analysis of single phase IM fed by power electronics converter	2

Term Work: The laboratory work will consist of minimum six experiments from the above list and/or any other experiment based on the prescribed syllabus. Further, a Mini project or few more experiments (minimum 2) based on the course content needs to be completed.

End semester examination shall comprise of Practical Examination & / MCQ examination/Mini project/presentations

Text Books

1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall..
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall.

Reference Books

1. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press.
2. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media.
3. Subrahmanyam V, Electrical Drives: Concepts and Applications TMH
4. Pillai S.K, A First course on Electrical Drives Wiley Eastern PH

Course Code	Course Name
PC-BTE652	**Switchgear and Protection Laboratory**
Course pre-requisites	

Course Objectives

The objectives of this course are
1. To demonstrate theoretical knowledge.
2. To conduct experiment based on overcurrent protection scheme.
3. To conduct experiment based on generator protection, earth fault protection

Course Outcomes

Upon successful completion of the course, students should be able to
1. Verify operating characteristics of electromagnetic relays, circuit breaker and other protective devices.
2. Design and test various protection scheme used in power system.
3. Analyze performance of electromagnetic, numerical and microprocessor based relay.

Course Content

Module No.	*Details*	*Hrs.*	*CO*
1	IDMT characteristic of non-directional over voltage relay	02	1,3
2	Study of Miniature Circuit Breaker HRC fuse, MCCB: components identification and Applications	02	1
3	Study of Power Contactor	02	1
4	Air Circuit Breaker: components identification and Applications.	02	1
5	Simulation of 2O/C+ 1E/F protection scheme.	02	2
6	Numerical Relay: Study and Application	02	3
7	Generator protection	02	2,3
8	Differential protection using static relay	02	2,3
9	Microprocessor based distance protection	02	2,3

Term Work

Term work shall comprise of

4. Practical Examination/MCQ examination/mini project/presentations
5. Visit to any Industrial switchyard/ Receiving station / substation for which students will submit report

Text Books

1. Badri Ram, D.N. Vishwakarma. Power system protection and Switchgear. McGraw Hill Education, Y.G. Paithankar. Transmission Network Protection.Marcel Dekker, Inc
2. Bhuvanesh Oza,. Power system protection and switchgear. MacGraw Hill.
3. B. Ravindarnath, M. Chandar. Power system Protection and switchgear. New age Int. Limited.

Reference Books

1. Blackburn, J.L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982.

Course Code	Course Name
PC-BTE653	**System Analysis and Design Laboratory**
Course pre-requisites	Control System I

Course Objectives

1 Model linear-time-invariant systems using state- space representations.
2. Carry out analysis of Linear Time Invariant system in time domain and in frequency domain
3. Use of software tools for system analysis

Course Outcomes

Upon successful completion of the course, students should be able to
1. Model and analyze linear-time-invariant systems using state-space representations.
2. Evaluate performance of physical systems and controllers experimentally.
3. Use software and hardware tools for the analysis and design of systems
4. Work in a team and document experimental procedures, record observations, and interpret results

List of suggested experiments (Simulation / Hardware based)

Module No.	***Suggested topics***	***Hrs.***
1	Mathematical Modeling of a Physical System (State Space)	02
2	Analyze system using State Space analysis	02
3	DC Voltage regulator using closed loop control	02
4	D.C. Motor position control	02
5	Design of a controller	02
6	Design of an Observer	02
7	Analyze a Non-Linear System	02
8	Micro-controller based on-off control	02
9	Mini Project – Design and implement a control mechanism for a system (preferably using idea Lab)	06

For Self-study:
Software required for simulation.
Study of any one application where control system is used.
Mini-Project- Design of controller for any one industrial application

Text Books:

3. Norman Nise, “Control Systems Engineering”. Wiley Publication, 4th Edition, 2007
4. Katsuhiko Ogata, “Modern Control Engineering”, Prentice Hall of India Pvt.Ltd, 5th Edition, 2015.

Reference Books:

4. I.G. Nagrath & M. Gopal, “Control Systems Engineering”, 5th Edition, New Age, 2007.

5. J.J. D"Azzo, C.H.Houpis and S.N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Marcel Dekker.

Course Code	Course Name

6. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education.

E resources (if any):

https://matlabacademy.mathworks.com/details/matlab-fundamentals/mlbe

https://github.com/MathWorks-Teaching-Resources/Virtual-Controls-Laboratory

https://ee32-iitb.vlabs.ac.in/#

https://asnm-iitkgp.vlabs.ac.in/exp/rlc-series-circuit/procedure.html

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp1/

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp2/

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp4/

http://ebootathon.com/labs/beta/ec/ControlSystem-I/exp5/

PE-BTE 601	**Basics of Automotive Systems**
Course pre-requisites	Basic Machines, Applied Mechanics

Course Objectives

1. To study different automotive components and subsystems.
2. To explore and compare the transition of automotive domain from ICE to electric vehicles.

Course Outcomes

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

1. Illustrate the general configuration and working principle of different types of Automotive system.
2. Compare various automotive transmission systems and various hybrid electric powertrains and their different modes of operations.
3. Compare and contrast Electric vehicles, ICE vehicles, & HEVs.
4. Analysis of Green House Gas emission in EV, ICE vehicles, & HEVs.

Course Content

Module No.	***Details***	***Hrs.***
1	**Vehicle Mechanics:** History of Vehicle Development, General Configuration of Automobile, Body and Chassis Fundamentals: General Packaging, Types of Structural System, Backbone Construction; Body and Chassis Materials. Automotive Powertrain, Mechanical Suspensions system, Steering System, Noise –vibration and harshness (NVH), Control System Integration and Implementation. Front-Wheel Drive (FWD) Powertrains, Rear-Wheel Drive Powertrains (RWD), Multi-Wheel Drive Powertrains (AWD and 4WD)	10
2	**Transmission Systems:** Transmission gears, Manual Transmission (MT), Automatic Transmission (AT), Automated Manual Transmissions (AMT) and Continuously Variable Transmissions (CVT); Manual Transmissions Powertrain Layout and Manual Transmission Structure, Power Flows and Gear Ratios, Manual Transmission Clutch and its structure. Drivetrain and Differential structure.	6
3	**Automotive Subsystems:** Automotive Aero-dynamics, Vehicle Power Demand Analysis, Torque-speed characteristics of vehicular load.Types of suspension and drive, Braking systems; Tyre Mechanics: Tyres and wheels, Tyre characteristics, Vehicle handling & stability	6
4	**ICE Performance Characteristics:** Power and torque generation, specific fuel consumption, specific emissions, Efficiencies- fuel conversion efficiency, mechanical efficiency, volumetric efficiency. Cooling systems for ICE based vehicles. Few basic topic of thermodynamic to understand ICE.	6
5	**Electric Vehicles:** Basics of Electric Vehicles, Current Status and Trends for EVs, Battery	6

	Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs), Electric Machines for EV applications (brief introduction), EV Transmission: Single-Speed EV Transmission, Multiple Ratio EV Transmissions. Cooling systems for Electric Vehicles	
6	**Hybrid Powertrain:** Series HEVs, Parallel HEVs, Series–Parallel HEVs, Complex HEVs, Operating Modes, Degree of Hybridization, Comparison of HEVs, Plug-in Hybrid Electric Vehicles (PHEVs) Real Life examples of HEVs.	4
7	**Impact analysis of Green House Gas (GHS)** Comparison of ICE vehicle with HEVs and EVs. National Policy for adoption of EVs.	4

Text Books:-
1. Vehicle Powertrain Systems by Behrooz Mashadi and David Crolla, Wiley, 2012
2. Automotive Aerodynamics by Joseph Katz, Wiley, 2016
3. Automotive Chassis Engineering, by David C. Barton and John D. Fieldhouse, Springer, 2018
4. Automotive Engineering Powertrain, Chassis System and Vehicle Body Edited by David A. Crolla, Elsevier, 2009
5. Automotive Power Transmission Systems by Yi Zhang and Chris Mi, Wiley, 2018
6. Linear Electric Machines, Drives, and MAGLEVs Handbook, by Ion Boldea, CRC Press. 2013
7. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, and Ali Emadi, CRC Press 2005
8. Electric Vehicle Technology Explained by James Larminie and John Lowry, John Wiley, 2003
9. Electric And Hybrid Vehicles- Design Fundamentals by Iqbal Husain, CRC Press, 2005

Reference Books:-
1. Encyclopaedia of Automotive Engineering edited by David Crolla et al, Wiley, 2014
2. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
3. The Automotive Transmission Book by Robert Fischer, Ferit Küçükay, Gunter Jürgens , Rolf Najork, and Burkhard Pollak, Springer, 2015
4. Noise and Vibration Control in Automotive Bodies by Jian Pang, Wiley, 2019

Course Code	Course Name	
PE-BTE 602	**Design of Power Electronics Converters**	
Course pre-requisites	Power Electronics	
Course Objectives		
1. Learn the important concepts needed to design proper power electronic hardware. 2. Understand Simulation tools, proper designing of power PCB. 3. Design of power electronics converter components		
Course Outcomes		
1. Analyze different power electronics converters and Demonstrate selection of power electronics devices and gate driver circuits 2. Design magnetics, snubber and heat sink circuits for converters **3.** Design of power electronic converters **4.** Summarize effect of EMI and EMC on power electronics converters design.		
Course Content		
Mo. No.	***Details***	***Hrs.***
1	**Analysis of power electronic converters** Analysis of Buck Converter, Choosing L and C, Design Example of Buck Converter, Analysis of H Bridge, Bipolar PWM, Unipolar PWM, Bipolar vs Unipolar PWM	6
2	**Power semiconductor devices** Different types of power diode, Diode characteristics, Diode Datasheets, Diode Datasheet Examples, MOSFET, Switching characteristics of MOSFET, MOSFET Datasheets-I, MOSFET Datasheet example, IGBT, IGBT Datasheets, IGBT Datasheet Example	6
3	**Gate drivers** Introduction to Gate Drivers, Gate Driver Requirements, Opto-couplers based Gate Drivers, Desat Protection, Bootstrapping, Pulse Transformer based Gate Drivers, Gate Drivers - Few Other Requirements	7
4	**Snubber design** Introduction to Snubbers, RC Snubber Analysis, Underdamped Case, Overdamped and Critically Damped Case RC Snubber Design, RCD Snubbers,	6
5	**Thermal Design** Power Loss, Thermal Modelling, Choosing Heat Sink	5
6	**Magnetics Design** Fundamentals, Magnetic losses, conductors, Magnetic Materials, Magnetic Core, Inductor design, Transformer Design, Inductor Design Example, Example of Transformer design, design of particular converter for the given ratings	7
7	**Electromagnetic interference in power electronic converters** Introduction to EMI, EMI Measurements, EMI in Power Electronics, CM and DM noise, Design Solutions of EMI, EMI Filter	5

E resources: https://onlinecourses.nptel.ac.in/noc23_ee38

Text Books
1. Mohan, Undeland and Riobbins, 'Power Electronics Converters, Applications and Design'. Wiley student third edition. (2022) 2. Muhammad Rashid, 'Power Electronics, Circuits, Devices and Applications'. Pearson, fourth Edition (2017). 3. Daniel Hart, 'Power Electronics'. McGraw Hill, Indian Edition. (2017) 4. L. Umanand, 'Power electronics essentials and applications' Wiley India (2009) 5. Soumitra Kumar Mandal, Power Electronics. McGraw Hill Education (2014) 6. Bimbra P.S. 'Power Electronics'. Khanna Publishers (2018)
Reference Books and Standards
1. B. K. Bose, 'Power Electronics and AC Drives', Pearson (2001) 2. P.C. Sen, ' Principles of electrical machines and power electronics', Wiley India (2013) 3. IEEE-519-2014 Harmonic control standard in Electric power

Course Code	Course Name
PE-BTE603	**Sensors and Actuators**
Course pre-requisites	Basic understanding of measurements, measuring instruments, analog and digital electronics.

Course Objectives

The objectives of this course are

1. Understanding the fundamental concepts of sensors and instrumentation, including their types, working principles and applications
2. Familiarizing with different types of sensors, such as temperature sensors, pressure sensors, flow sensors, level sensors, and position sensors, and their applications in various industries
3. Understanding the calibration of sensors and instrumentation and the significance of proper calibration for accurate measurements
4. Developing skills to select sensors and instrumentation systems for various applications.

Course Outcomes

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

1. Explain the principles, classification, and characteristics of various sensors, and actuators.
2. Analyze real-world applications of sensor technologies.
3. Evaluate the performance of smart sensing and actuation systems.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction** Introduction sensors and transducers, various primary sensing elements, active and passive transducers, Input-output configuration of Instruments and measurement system, choice and economics of sensors.	04
2	**Measurement of Temperature and motion** Measurement of temperature using Thermistor, Thermocouple & RTD, Concept of thermal imaging. Introduction to motion sensors, Motion and dimensional measurement by resistive potentiometer, strain gauge, LVDT, Piezoelectric transducer and Synchros. Measurement of translational and rotational velocity by tachometer and stroboscopic method.	07
3	**Measurement of flow and pressure** Introduction to flow measurement, Measurement of flow by electromagnetic flow meter, hot-wire anemometer, Doppler flow meter, water flow measurement, blood flow measurement, gas flow measurement. Introduction to pressure sensor, measurement of pressure using diaphragm Gauge, McLeod Gauge and ionization gauge.	07
4	**Biosensors and Bio-Chemical Sensors** Introduction to biosensors, introduction to chemical sensors, pH-sensors, blood-glucose sensors, alcohol sensor.	05

5	**Micro and smart sensors:** Introduction to Microsystems, MEMS, Micro-fabrication, Micro pressure sensor, micro-accelerometer, micro-biosensors, Nanoparticle based sensors. **Smart sensors** Characteristics of smart sensors: self-calibration, self-testing, & self-communication, Application of smart sensors: Automatic robot and automobile engine controls. Introduction to sensor-less systems.	08
6	**Actuators:** Electric actuators: Motors (DC, AC, stepper), solenoids, Electromagnetic actuators: Relays, contactors, Piezoelectric actuators, Hydraulic and pneumatic actuators.	06
7	**Application of sensors and Instrumentation** Case study of any process industry e.g. Power industry, automation industry, Sensor networks.	05

Self-Study:

Textbooks:

1. E.O. Doebelin, "Measurement System: Application and Design", 4th Edition, McGraw- Hill publication, 1990.
2. D. Patranabis, "Sensors and Transducers", 2nd Edition, PHI publication, 2003.
3. Clarence W. de Silva, "Sensors and Actuators: Engineering System Instrumentation", 2nd Edition, CRC Press, 2015.
4. Douglas A. Skoog, F. James Holler, and Stanley R. Crouch "Principles of Instrumental Analysis" 7th Edition, Cengage India Pvt. Ltd., 2020.

Reference Books:

1. R.P. Areny and J.G. Webster, "Sensors and Signal Conditioning", 2nd Edition, Wiley-Inter Science, 2000.
2. Ian Sinclair, "Sensors and Transducers", 3rd Edition, Elsevier Publication, 2011.
3. Nadim Maluf, "An Introduction to Micro Electromechanical System Design", Artech House, 2000.
4. John G. Webster, "Medical Instrumentation Application and Design", 4th Edition, Wiley publication, 2015

E resources (if any):

https://nptel.ac.in/courses/108108147

Course Code	Course Name
PE-BTE604	**Renewable Energy Sources & Grid Integration**
Course pre-requisites	Power System –I , Power Electronics

Course Objectives

The objectives of this course are

1. **To understand** the principles and characteristics of various renewable energy technologies and their role in sustainable development.
2. **To explore** the physical, technical, and economic aspects of energy generation from renewable sources.
3. **To apply** engineering concepts to assess the performance and integration of renewable energy systems with electrical grids.
4. **To analyze** operational challenges, environmental impacts, and regulatory requirements related to renewable energy deployment.

Course Outcomes

Upon successful completion of the course, students should be able to

1. **Explain** the fundamental working principles and key components of various renewable energy technologies.
2. **Analyze** the technical and operational behavior of renewable energy systems under both standalone and grid-connected conditions.
3. **Apply** relevant engineering methods to evaluate energy output, efficiency, and performance characteristics of renewable energy systems.
4. **Interpret** grid integration requirements, power quality issues, and regulatory aspects related to large-scale deployment of renewable energy sources.

Course Content

Module No.	***Details***	***Hrs.***
1	Renewable Energy technologies, Energy Usage by Humans - Estimate of Impact on Atmosphere, Indian and global Scenario	4
2	**Wind Energy**: Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics- probability distributions, Wind speed and power-cumulative distribution functions. Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent- Magnet Synchronous Generators, Social and environmental aspects. Life cycle cost	8
3	**Solar Energy**: Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability. **Solar photovoltaic:** Technologies-Amorphous, mono crystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Maximum Power Point Tracking (MPPT) algorithms. **Solar thermal Electric System**: Concentrating solar power system, low temperature solar thermal, non-grid solar thermal applications. Life cycle cost	10

4	**Bulk solar and Wind farms**: Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behaviour during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.	6
5	**Hydro Power Generation:** Introduction to hydro power plant, overview of micro, mini and small hydro power plants, hydraulic turbines, Selection and design criteria of pumps and turbines, Brief theory, design and analysis of hydro power plants	4
6	**Tidal power**: Power from a tidal barrage, tidal resonance, kinetic energy of tidal currents, generation of tidal energy, advantages and disadvantages of tidal energy. **Geothermal power generation:** Introduction to Geophysics, dry rock and hot aquifer analysis, harnessing geothermal resources, social and environmental aspects	6
7	**Grid integration of renewable energy sources:** Grid integration issues, principles of grid code integration. Calculation of hosting capacity of the transmission and distribution system. Description of the different network topologies where distributed renewable generation can be connected.	4

Term Work

Term work shall comprise of

1. Tutorials 2. MCQ examination.

Text Books

1.John Twidell,Tony Weir, “Renewable energy resources”, Routledge; 4th edition (November 30, 2021).
2. T. Ackermann, “Wind Power in Power Systems”, John Wiley and Sons Ltd., 2005.
3.P. Sukhatme, “Solar Energy: Principles of Thermal Collection and Storage”, McGraw Hill,1984.
. 4.G. M. Masters, “Renewable and Efficient Electric Power Systems**”,** John Wiley and Sons 2004.
5. William Shepherd, “Electricity Generation using wind power”, World Scietific

Reference Books

1. S. C. Bhatia, “Advanced Renewable Energy Systems”, CRC Press, 2014
2. J.F. Manwel,J G Mcgowan., “Wind Energy Explained: Theory, design and application”, Wiley Publications.
3. 1547 IEEE standard

NPTEL online courses

1. Sustainable Power Generation Systems by Dr. Pankaj Kalita | IIT Guwahati

Link : Sustainable Power Generation Systems - Course

2. Non-conventional Energy resources, Dr. Prathap Haridoss, IIT Madras

Link : nptel.ac.in/courses/121106014

Course Code	
PE-BTE605	**Digital Signal Processing**
Course pre-requisites	Signals and Systems

Course Objectives

1. Discuss time domain and frequency domain analysis of discrete time systems
2. Explain Fast Fourier Transform algorithms to evaluate Discrete Fourier Transform
3. Discuss design of IIR and FIR systems

Course Outcomes

Students will be able to
1. Classify Discrete Time signals and systems
2. Evaluate system response to different inputs using time and frequency domain methods
3. Analyze DFT and Compute DFT using FFT
4. Design of IIR and FIR filters

Course Content

Module No.	***Details***	***Hrs.***
1	**Digital Signals and Systems:** Sequences; representation of signals on orthogonal basis; Signal Classification, Representation of discrete systems using difference equations, System Classification, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate, Linear convolution concept	06
2	**Z Transform** z-Transform, Region of Convergence, Analysis of Linear Time Invariant systems using z transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms	06
3	**Discrete Fourier Transform** Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Circulation convolution, comparison between linear and circulation convolution,, Circulation convolution using DFT / IDFT, Response of LTI system (linear convolution or linear filtering) using circulation Convolution, using DFT / IDFT	06
4	**Fast Fourier Transform** Comparison of computation complexity of direct computation of DFT and FFT., Radix-2 Decimation in Time and Decimation in Frequency algorithms, IDFT using FFT algorithms	06
5	**IIR Filter Design** Introduction, Designing of analog IIR filters using Butterworth and Chebyshev approximations, Analog to analog spectral transformations, Designing of IIR digital filters using impulse invariance, bilinear transformation and matched Z transform methods, stability properties.	07
6	**FIR Filter Design**	08

	Introduction: Linear Phase FIR Filters, Frequency response of different types of linear phase FIR Filters, Locations of definite zeros of different types of FIR Filters. Designing of FIR filters using windowing technique, Gibbs Phenomenon (Hamming, Hanning, Rectangular, Bartlett, Kaiser window functions), Designing of FIR filters using frequency sampling technique,	
7	**Applications of Digital Signal Processing** Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using, ARMA Model, Linear Mean-Square Estimation, Wiener Filter.	03

For Self-study Quantization and realization structures

Text Books:

1. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4/e, PHI, 2000
2. Alan Oppenheim and Ronald Schafer, Discrete Time Signal Processing, 3/e, Prentice Hall

Reference Books

1. Richard G. Lyones, Understanding Digital Signal Processing, 1/e, Prentice Hall, 1996
2. Antoniou, Andreas, Digital Filters: Analysis, Design And Signal Processing Applications, Mc GrawHill

Course Code	Course Name
PE-BTE606	**Artificial Intelligence**
Course pre-requisites	

Course Objectives

The objectives of this course are

1. Introduce to Artificial Intelligence
2. Understand problem solving methods
3. Discuss applications of AI

Course Outcomes

Upon successful completion of the course, students should be able TO

1. Explain basic understanding of AI building blocks presented in intelligent agents
2. Choose an appropriate problem solving method and knowledge representation technique, analyze the strength and weaknesses of AI approaches to knowledge – intensive problem solving
3. Design models for reasoning with uncertainty as well as the use of unreliable information

Course Content

Module No.	***Details***	***Hrs.***
1	Introduction to Artificial Intelligence (AI) History of Artificial Intelligence, Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Sub- areas of AI, Applications of AI, Current trends in AI	04
2	Intelligent Agents Agents and Environments, The concept of rationality, The nature of environment, The structure of Agents, Types of Agents, Learning Agent	04
3	Problem solving 1 Solving problem by Searching: Problem Solving Agent, Formulating Problems, Example Problems. Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening(DFID), Informed Search Methods: Greedy best first Search A* Search , Memory bound heuristic Search.	07
4	Problem solving 2 Local Search Algorithms and Optimization Problems: Hill-climbing search Simulated annealing, Local beam search, Genetic algorithms. Adversarial Search: Games, Optimal strategies, The minimax algorithm, Alpha-Beta Pruning.	07
5	Knowledge based Agents, The Wumpus World, Forward chaining, backward Chaining, Knowledge Engineering	10

	in First-Order Logic, Unification, Resolution, Introduction to logic programming (PROLOG). Uncertain Knowledge and Reasoning: Uncertainty, Representing knowledge in an uncertain domain, The semantics of belief network, Inference in belief network.	
6	Planning and Learning The planning problem, Planning with state space search, Partial order planning, Hierarchical planning, Conditional Planning, Learning: Forms of Learning, Inductive Learning, Learning Decision Tree, Expert System: Introduction, Phases in building Expert Systems, ES Architecture, ES vs Traditional System.	06
7	Applications Natural Language Processing (NLP), Expert Systems.	04

For Self-Study : Propositional logic, First Order Logic: Syntax and Semantic, Inference in FOL

Term work shall include assignments and develop programs to verify different algorithms.

Text Books
1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach “Fourth Edition" Pearson Education. 2. Saroj Kaushik “Artificial Intelligence” ,Cengage Learning.
Reference Books
1. George F Luger “Artificial Intelligence” Low Price Edition, Sixth edition, Pearson Education. 2. Ivan Bratko “PROLOG Programming for Artificial Intelligence”, Fourth Edition, Pearson Education. 3. Elaine Rich and Kevin Knight “Artificial Intelligence” Third Edition, Mc Graw Hill. 4. Davis E.Goldberg, “Genetic Algorithms: Search, Optimization and Machine Learning”, Addison Wesley, N.Y., 1989. 5. Hagan, Demuth, Beale, “Neural Network Design” CENGAGE Learning, India Edition

Course Code	Course Name
PE-BTE607	**VLSI Circuits**
Course pre-requisites	Digital Electronics

Course Objectives

The objectives of this course are

1. To introduce the fundamental principles of VLSI circuit design and layout techniques.
2. To highlight the circuit design issues in the context of VLSI technology.
3. To examine the basic building blocks of large-scale digital integrated circuits

Course Outcomes

Upon successful completion of the course, students should be able to

4. Explain the fundamental principles and fabrication techniques of CMOS technology.
5. Analyse digital circuits and memory components, including strategies for low power consumption.
6. Explore the design and simulation using Hardware Description Languages, with a focus on clocking and timing mechanisms.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction and overview:** History, basic transistor technology, NMOS and CMOS technology. **Fabrication process and layout:** NMOS, LOCOS, CMOS, CMOS Design rules, MOSFET Scaling: Types of scaling, MOSFET capacitances.	**06**
2	**MOSFET Inverters:** **Circuit Analysis**: Static and dynamic analysis (Noise, propagation delay and power dissipation) of resistive load and CMOS inverter, comparison of all types of MOS inverters, design of CMOS inverters, CMOS Latch- up.	**06**
3	**MOS Circuit Design Styles:** Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter. Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS. SR Latch, JK FF, D FF.	**06**
4	**Semiconductor Memories:** ROM Array**,** SRAM (operation, design strategy, leakage currents, read/write circuits), DRAM (Operation 3T, 1T, operation modes, leakage currents, refresh operation, Input-Output circuits).	**08**
5	**Low Power CMOS Circuits:** Various components of power dissipation. CMOS, Limits on low power design, low power design through voltage Scaling.	**04**
6	**VLSI Clocking:** CMOS clocking styles, Clock generation, stabilization and distribution.	**04**

7	**Hardware Description Languages for VLSI Design:** Managing concurrency and time in Hardware Description Languages, Introduction to VHDL, Basic Components in VHDL, Structural Description in VHDL, Behavioral Description in VHDL, and Introduction to Verilog.	**08**

Text Books

1. Sung-Mo Kang and Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", Tata McGraw Hill.
2. Neil H. E. Weste, David Harris and Ayan Banerjee, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson Education

Reference Books

1. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, "Digital Integrated Circuits: A Design Perspective", Pearson Education.
2. Etienne Sicard and Sonia Delmas Bendhia, "Basics of CMOS Cell Design", Tata McGraw Hill.
3. Debaprasad Das, "VLSI Design", Oxford.
4. Kaushik Roy and Sharat C. Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, Student Edition.

E resources (if any):

https://nptel.ac.in/courses/117106092

Field Project

Course Code	Course Name
FP-BTE601	**Field Project**
Course pre-requisites	All courses till semester V

Course Objectives

1. Expose students to real-life societal challenges by engaging with local communities, industries, or institutions.
2. Foster empathy, social responsibility, and sustainable thinking through direct involvement in grassroots-level problem identification and solution.
3. Apply technical knowledge and problem-solving skills to design or suggest practical interventions addressing local issues.
4. Develop teamwork, communication, and documentation skills through field-based collaborative activities.

Course Outcomes

Upon successful completion of the course, students should be able to

1. Identify and analyze community or field-based problems using structured observation and data collection techniques.
2. Propose viable technical or social solutions using interdisciplinary knowledge aligned with community needs and sustainable development.
3. Work effectively in teams and interact with stakeholders (such as local authorities, NGOs, industries, or residents) in a respectful and productive manner.
4. Prepare and present detailed reports and reflections that showcase field findings, solutions proposed, challenges faced, and learning gained.