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

R22

Academic Year: 2024-2025

List of Courses

Course Code	Course Name
PC-BTE501	**Measurements and Instrumentation**
Course pre-requisites	Basic Electrical Engineering, Electrical networks, Signals and systems

Course Objectives

The objectives of this course are

1. Understanding the basic principles of electrical and electronic measurement, including units of measurement and calibration procedures.
2. Familiarizing students with common types of measurement devices, such as multi-meter, oscilloscopes, signal generators, and frequency counters.
3. Developing skills in the use of measurement equipment, including measurement setup, measurement execution, and data analysis.
4. Developing the ability to analyze and interpret measurement data, and to draw meaningful conclusions from it.

Course Outcomes

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

1. Apply the basics of electrical and electronics for analog signal measurement.
2. Interpret measurement data and identify source of errors in measurement.
3. Apply the knowledge of digital techniques in measuring instruments.
4. Apply calibration techniques and standards of measurements to ensure accuracy of measurement instruments.

Course Content

Module No.	***Details***	***Hrs.***
1	**Basics of Measurements** Analog measuring instruments, General features of indicating, recording and integrating type of instruments, Errors in measurements	04
2	**Measurement of electrical quantities** Measurement of current, voltage and Energy, Measurement of power in balanced and unbalanced electrical systems. **Measurement of electrical parameters** Measurement of low, medium and high resistance, insulation resistance, earth resistance, Wheatstone bridge, Kelvin double bridge, Megger, AC bridges for measurement of inductance and capacitance.	09
3	**Instrument transformer** Theory of Current and potential transformers, Definition, various types, importance and applications, ratings, Definition of ratio and phase angle errors, LEM sensors, CCVT	06

4	**Instruments for generation and analysis of waveforms** Oscillator: Wein bridge oscillator, Phase shift oscillator, Standard signal generator, Function generator, Wave analyzer, Harmonic distortion analyzer, Spectrum analyzer, Cathode ray oscilloscope: time, frequency and phase angle measurement using CRO.	07
5	**Digital Instruments** Analog to digital conversion, sampling theorem, Digital measurement technique, Digital frequency meter, Digital voltmeters (DVM). Digital Storage Oscilloscope, Errors in digital measurement, Data logger, Digital sensors e.g. Sensors in solar PV system,	06
6	**Transducers& basic Instrumentation** Measurement of temperature, vibration, velocity (speed), flow, level, Photoelectric, strain gauge, Characteristics and selection for given Application	05
7	**Calibration of Instruments and Safety in instrumentation** Need of Instrument Calibration, Preparation for calibration, Standard calibration procedure, Five point calibration procedure, Safety in instrumentation, Standards for measurement (IEC 62419)	05

Text Books:

1. Sawhney A.K. "A course in Electrical and electronics measurements and Instrumentation" by Dhanpat Rai and Sons, 17th edition 2007.
2. T.S. Rathore, "Digital measurement techniques" by Narosa Publishing house, 1996

Reference Books:

1. Kalsi H.S. "Electronic Instrumentation", 3rd edition, Tata McGraw Hill, 1997.
2. Doeblin E.O., "Measurement system application and design", 4th edition, Tata McGraw Hill, 1990

Evaluation:

Sr No.	Name of the exam	Total marks	Modules
1	T-I	20	1,2,3
2	T-II	20	3,4
3	End semester examination	100	1-7

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

Course Objectives

1. Introduce control problem.
2. Discuss time response, frequency response
3. Discuss state variable analysis
4. Introduce controllers, compensators and nonlinear control

Course Outcomes

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

1. Model linear-time-invariant systems using transfer function and state-space representations.
2. Analyze Linear Time Invariant system in time domain
3. Analyze Linear Time Invariant system in frequency domain
4. Explain various controllers, compensators and nonlinear control systems.

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-I 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.	06
3	Time Response Analysis-II Concept of Stability. Routh-Hurwitz Criteria. Root-Locus technique. Construction of Root-loci, Stability Analysis using root locus.	08
4	Frequency-response analysis Relationship between time and frequency response, Polar plots, Nyquist Plot, Nyquist stability criterion, Bode plots, Stability margin from Bode Plots.	08
5	Introduction to Controllers and Compensators P, PI, PD, PID controllers Lag, Lead, Lead-Lag compensators	05
6	State variable Analysis Concepts of state variables, State space model, State space solution, Transfer function from State Space, stability analysis.	07

7	Introduction Nonlinear Control Nonlinear system–Basic concepts and analysis.	02

For Self-study:

1) Signals Flow Graph
2) Higher order system analysis
3) Different forms of state space representations

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 synchronous machine connected to power system
3. Demonstrate the operation and application 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 Machine:** 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	Principle of operation of Synchronous Motor, Various starting methods, Power flow and maximum power of synchronous machines, Excitation & power circles, V & O 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. And applications of Single phase induction motor, capacitor start, capacitor run motor, Shaded pole motor.	04
7	**Special purpose Machines:** Construction, principle of operation and applications of Stepper motor and their types, Permanent Magnet Synchronous Motor,	06

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.

Sr. No.	Examination	Module
1	T-I	1, part of 2
2	T-II	Part of 2,3
3	End Sem	1 to 7

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:** Unbalanced system Analysis using symmetrical components, Power in terms of symmetrical components, 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**.** **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.	9
4	**Formation of Y_{bus} & Load Flow Studies:** Nodal admittance matrix, Network incidence matrix, Calculation of Bus Admittance Y_{bus} and Impedance Matrices Z_{bus}, Power Flow Problem, Gauss Seidel (GS) method, Newton Raphson (NR) method Decoupled & Fast Decoupled method, Comparison of different load flow methods.	9
5	**Distribution Load Flow Analysis:** Three phase unbalanced load flow, Backward/forward sweep method, modified Newton Raphson method	5

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 (Telegraphic equations), reflection wave, refraction wave, typical cases of line termination, Bewley Lattice Diagram.	6

For Self-study: Triangular Factorization (LU Decomposition), solution of swing equation using Forward Euler method, Runge-kutta 4^{th} 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. Use source and channel coding appropriately.
3. Compare and select different methods for efficient bandwidth utilization
4. Explain various types of communication and networks with respect to Computer Networking

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, Interne 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”, 10th Edition, 2014

Course Code	Course Name
PC-BTE551	**Measurement and Instrumentation Laboratory**

Course pre-requisites	Electronic Circuits and Digital Electronics

Course Objectives

The objectives of this course are

1. To conduct experiment on calibration of energy meter
2. To understand different in-built Lab view result functions related to signals and system.
3. To validate the theoretical concept

Course Outcomes

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

1. Understand construction and working principle of various analog instruments.
2. Understand various measurement techniques used for measurement of various parameters.
3. Apply theoretical knowledge to convert analog signal into digital signal.

Course Content

Module No.	***Details***	***Hrs.***
1	To measure the energy consumed by load using analog energy meter and compare the measurement with static energy meter. Wattmeter.	02
2	Study of Moving iron, PMMC and Dynamometer type instruments (Basic moving systems).	02
3	To study the working of Megger and carry out measurement of insulation resistance.	02
4	Study of construction of LVDT and measurement of displacement, force and pressure by using it.	02
5	Measurement of R, L and C Using Different Bridges and confirmation with analytical calculations.	02
6	Comparative study of temperature measurement using RTD and thermocouple.	02
7	To measure input voltage signal using Voltage to Frequency Converter using IC 555	02
8	Study of Cathode Ray Oscilloscope	02
9	Speed measurement using photoelectric pick up, magnetic pick up and stroboscope.	02
10	Measurement of power in three phase balanced and unbalanced circuits by conventional two wattmeter method and by power analyzer.	2
11	Demonstration of current transformer and potential transformer	02

Term Work

Term work shall comprise of

Practical Examination/ MCQ examination.

Text Books
1. Sawhney. A.K., "A course in Electrical and electronics measurements and Instrumentation" by Dhanpat Rai and Sons 17th edition 2007. 2. T.S. Rathore, "Digital measurement techniques", by Narosa Publishing house
Reference Books
1. Kalsi H.S. "Electronic Instrumentation", Tata McGraw Hill, 3rd edition 1997. 2. Doeblin E.O, "Measurement system application and design", Tata McGraw Hill, 4^{th} edition 1990

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 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 software and/or hardware tools for the analysis of system and controllers

List of suggested experiments (Simulation / Hardware based)

Module No.	*Suggested topics*	*Hrs.*
1	Mathematical Modeling of a Physical System (Speed Control of a Motor)	02
2	Mathematical Modeling and Analysis of RLC Network	02
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	Block Diagram Reduction	02
9	Root Locus	02
10	Bode Plot	02
11	Nyquist Plot	02
12	Effect of P, I and D in a PID Controller (Simulation)	02
13	State Space analysis	02
14	Non-Linear System Analysis	02
15	Synchro – Transmitter	02
16	Effect of P, I and D in a PID Controller (Hardware)	02
17	Transient analysis of RLC network (Hardware)	02

For Self-study:

Software required for simulation.

Study of any one application where control system is used.

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

1. Analyze the characteristics of induction motor with variation in supply and load parameters.
2. Understand the voltage regulation in cylindrical pole and salient pole synchronous generator and different methods to find it.
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- Curves F-curves of synchronous motor	2
10	Performance characteristics of single phase induction motor	2
11.	Demonstration of stepper motor.	2

12.	Effect of capacitor on the operation of source power factor (for I.M. load/ Transformer load)	2
Term Work: Term work shall comprise of Practical Examination/ MCQ examination/Mini project		
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	**Power System Analysis Laboratory**

Course pre-requisites	Basic knowledge of programming, familiar with Engineering software such as MATLAB, Scilab

Course Objectives

Objectives of this course are

1. Proficiency in using Engineering software such as MATLAB/ Scilab/ETAP/Python (Py-power tool, PANDA power)/ OpenDSS/Gridlab-D
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 power system studies.
2. Evaluate fault current under symmetrical and unsymmetrical fault conditions in power system.
3. Develop algorithm for load flow studies and infer the results.
4. Analyse power system behaviour under small disturbance as well as after large disturbance and interpret the results.

List of Experiments

Expt. No.	***Details***	***Hours***
1	Simulation of typical power system- familiarization with generator, line and load models.	2
2	Simulation and analysis for a symmetrical three phase fault in a power system.	2
3	Study of transient behaviour of synchronous machine under three phase short circuit at the terminal.	2
4	Simulation and analysis of unsymmetrical fault - LL, LG and LLG in a power system.	2
5	Develop a program to calculate Y bus matrix.	2
6	Reduction of Ybus matrix using methods such as Gauss elimination/Kron's elimination /LU decomposition.	2
7	Develop a program to study load flow using Gauss Siedel method	2
8	Validation of Load flow results of Gauss Siedel method with Newton Raphson method using ETAP.	2

9	Unbalanced Load flow analysis in distribution system	2
10	Study of effect of neutral grounding on earth fault current in a power system.	2
11	Study of Power swing equation for a two machines system in ETAP.	2
12	Analysis of small disturbance stability of a single machine connected to infinite bus.	2
13	Develop a program to find numerical solution of power swing equation.	2

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) based on PSA course 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. Also, more examples can be given for practice at home. Students can write program in MATLAB/Scilab or they can convert MATLAB/Scilab code to Python.

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

Text Books

1. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications.
2. Wadhawa C. L., "Electrical Power Systems", New Age International.
3. Stevenson W.D., "Elements of Power System Analysis", TMH Publication.
4. Saadat Hadi, "Power System Analysis, "TMH Publication.
5. MATLAB / Scilab Manual, ETAP Manual
6. Dr. K. Rajamani & Co Authors, "Monograph of IEEMA articles of Dr. K. Rajamani", ieema journal

Reference Books

3. Prabha Kundur, "Power System Stability and Control'', TMH Publication.
4. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication
5. MATLAB/Scilab online Tutorials
6. ETAP webinars

Course Code	Course Name
PE-BTE 501	**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 with minimum EMI and EMC

Course Content

Module 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-BTE502	**Sensors and Actuators**
Course pre-requisites	Basic understanding on 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

Developing skills to select sensors and instrumentation systems for various applications.

Course Outcomes

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

1. Identify the key component of sensor and actuator system.
2. Interpret specifications and characteristics of different sensors and actuators.
3. Select the appropriate sensor for different applications.

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 sensor, 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-sensor, blood-glucose sensor, alcohol sensor.	05
5	**Micro and smart sensors:** Introduction to Microsystems, MEMS, Micro-fabrication, Micro pressure sensor, micro-accelerometer, micro-biosensors, Nano-particle based sensors. **Smart sensors** Characteristic of smart sensor: self-calibration, self-testing, & self-communicating, 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

Text Books:

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 Electro Mechanical System Design", Artech House, 2000.
4. John G. Webster, "Medical Instrumentation Application and Design" , 4th Edition, Wiley publication, 2015

Evaluation:

Sr No.	Name of the exam	Total marks	Modules
1	T-I	20	1,2,3
2	T-II	20	3,4
3	End semester examination	100	1-7

Course Code	
PE-BTE503	**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 using time and frequency domain Analysis to different input signals.
3. 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** 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,	08
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

Environmental Science

Course Code	Course Name
MC-BTE003	Environmental Science

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To sensitize to the ever-increasing environment problems.
2. To acquire knowledge about environmental pollution.
3. To acquire knowledge with respect to renewable energy and its positive impact on environment.
4. To be aware of the national and international concern for environment for protecting the environment.

Course Outcomes

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

1. Understand the requirement of environment science and sustainability and apply it in the field of electrical engineering
2. Propose specifications to comply with norms of environment engineering
3. Describe laws and regulations pertaining to health, safety and environment
4. Apply evaluation tool such as GRIHA to help design, build, operate, and maintain a resource efficient environment management system

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction to Environmental Science and Pollution**: Biotic and Abiotic Environment, Adverse effects of environment, Types of environmental pollution Pollution - Water pollution, Air pollution, Solid waste management, Control Strategies of different environmental problems	05
2	**Introduction to Renewable Energy:** Solar, Wind, Geothermal, Ocean (Tidal), Biomass–Basics, Conservation of natural resources. Environmental and economic impact of each type of renewable energy, Energy Management	07
3	**Sustainability and Sustainable Energy Management**: Introduction to Sustainaility, sustainable strategies, Sustainable technologies, green commodities, Carbon credits, carbon emission monitoring, introduction to energy audit	06
4	**Hazard Assessment, Prevention, and Control:** Stress and Safety, Safety and Health Training, Mechanical Hazards and Machine Safeguarding, Fire Hazards and Life Safety, Ethics and Safety, Hazard Analysis/Prevention and Safety Management, Environmental Safety and ISO 14000 (Environmental Management).	05

5	**Introduction to National Rating System** GRIHA (Green Rating For Integrated Habitat Assessment): An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment. Case studies of GRIHA registered buildings	05

Text Books
1. Jagdish Krishnawamy, R J Ranjit Daniels," Environmental Studies", Wiley India Private Ltd. New Delhi. 4. An Indita Basak, Environmental S
Reference Books
1. GRIHA Manual Volume 1 - Ministry of New and Renewable Energy, Government of India, New Delhi. 2. ISO 14001:2004(E) - Environmental management systems Requirements with guidance for use.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

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: 2024-2025

List of Courses

Course Code	Course Name
PC-BTE601	**Power System Operation & Control**
Course pre-requisites	Power system modelling and Power system Analysis

Course Objectives

The objectives of this course are

1. To make student understand various equipment constraints in operation of power system.
2. To impart knowledge about modelling of controllers required in power system for power and voltage control
3. To make student realize the need of centrally monitoring of large power system with the help of advance techniques such as PMU & WAMS

Course Outcomes

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

1. Describe the equipment & stability constraints in power system operation.
2. Evaluate and/ or Compare and suggest various controlling devices for real and reactive power flow in a power system.
3. Formulate & find optimal generation for given power system.
4. Understand recent trends in centrally monitored grid system as well as distributed generators & Micro-grid.

Course Content

Module No.	***Details***	***Hrs.***
1	**Equipment and Stability Constraints in System Operation:** Generator constraints, generator capability curves, Power transmission capability of transmission line, thermal limit curve & loadability curves of transmission line.	4
2	**Active Power & Frequency Control:** Relationship between generator rotors' speed and 'system frequency' during transients. Calculation of system frequency, Frequency dependence of loads, Load Frequency Control (LFC) of an isolated power system, Automatic Generation Control (AGC) in a single area system, AGC in multi-area system, Tie line bias control,	6
3	**Reactive Power & Voltage control:** Generation and absorption of reactive power, basics of reactive power control, Automatic Voltage Regulator (AVR), brushles AC excitation system, block diagram representation of AVR loop, Excitation system stabilizer with rate feedback & PID controller Synchronous Machine as a condenser for grid stability	6

4	**Power transmission & control in the transmission line**: power transmission in uncompensated transmission line , P-V curve, P-Q curve of transmission line under various loading conditions, real Power flow control using series capacitor, TCSC, phase angle regulator (phase shifting transformer), using embedded HVDC link, methods of reactive power injection – tap changing transformer, SVC (TCR + TSC) and STATCOM for voltage control.	9
5	**Optimal Dispatch of Generation:** Optimal dispatch neglecting generator limits and line losses, Optimal dispatch with generator limits, Optimal dispatch with line losses.	6
6	**Preventive, Emergency & Restorative Control:** Operating states and control actions in a power system, Role of Load Dispatch Center (LDC), system monitoring, data Acquisition and controls using PMU & WAMS, System hardware configurations, SCADA & EMS functions, introduction to state estimation problem. Preventive control: Generation rescheduling, Load tripping, Emergency control: Under-frequency load tripping, generator tripping, system islanding, Restorative control, definition of blackout	8
7	**Modern Trends in Power System Monitoring & Control:** Introduction to Smart Grid, Distributed Generation, Micro-Grid and challenges in Grid Integration, Micro-PMUs for distribution systems.	3

For Self-study: unconstrained, constrained optimization techniques.

Text Books:

6. Saadat Hadi, "Power System Analysis, "TMH Publication.
7. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications.
8. Prabha Kundur, "Power System Stability and Control'', TMH Publication.
9. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication

Reference Books:

1. Chakrabarti .A, Halder.S, "Power System Analysis-Operation and Control", PHI
2. Hingorani N.G., "Understanding of Facts", Wiley Publications.

E resources (if any):

Power Systems Operation and Control, Dr. A.M. Kulkarni, IIT Bombay,
https://nptel.ac.in/courses/108101040

Course Code	Course Name
PC-BTE602	**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), Methods of Voltage control (Ward Leonard scheme, 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 Brush-less DC drives, Introduction to Switched reluctance drives. Solar and Battery 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

Sr. No.	Examination	Module
1	T-I	1, 2
2	T-II	3,4, part of 5
3	End Sem	1 to 7

Course Code	Course Name
PC-BTE603	**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. Understand basics of different components of protection system such as relays, CT, PT etc.
2. Refer and apply various national, international standards such as IEEE, ANSI standards.
3. Select suitable components and co-ordination of protection devices for specific power apparatus protection.
4. Suggest and compare various circuit breakers for specific application.
5. 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. **Introduction to 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 Relay testing: Type tests, commissioning & acceptance tests, Routine maintenance (periodic) tests.	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.	8

3	**Protection of Transforme**r, **Generator and Motor:** -The problems and hazard in transformer, Differential relay for 3 phase transformer winding protection, Magnetizing inrush, Restricted Earth fault protection, Buchholz relay. **Protection of Generator**-The problems and hazard in generator, Differential protection for stator faults, Protection against loss of prime mover and loss of excitation, field suppression, out of step protection. **Motor Protection**- The problems and hazards in Induction motor, Protection against single phasing, Thermal over load and short circuit protection using Type 2 coordination, Under voltage protection, Synchronous motor protection. **Busbar Protection**- Different bus arrangements with breakers, Ring bus arrangement, One and a half breaker arrangement and High impedance bus differential relay	8
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.** Air Break C.B., MCB, MCCB, HRC fuses, Metal Enclosed Switchgear, Control Gear and Contactor: Construction, operation, types, selection and application. **H.V.C.B.** Air break, Air blast, vacuum, minimum oil and bulk oil, SF6 Circuit Breaker: Operation, types, selection and application.	6
6	**Protection against Over Voltage Surges**: Lightening phenomenon, over voltages due to lightning, different types of lighting arresters, Insulation Co-ordination between different devices, BIL.	4
7	**Modern Protection Practices:** Need of 'system' protection, communication based substation monitoring & control, IEC 61850 standard. Idea of situational awareness, WAMS based protection schemes, various Adaptive relaying techniques. Protection Issues in Micro-grids. SF6 Insulated Metal Clad Switchgear – Sub Station (GIS)	4
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

Sr. No.	Examination	Module
1	T-I	1, Part of 2
2	T-II	Part of 2, 3
3	End Sem	1 to 7

Course Code	Course Name
PC-BTE651	**Power System Operation & Control Lab**
Course pre-requisites	Basic knowledge of programming, familiar with Engineering software such as MATLAB or Scilab

Course Objectives

Objectives of this course are

1. Proficiency in using Engineering software.
2. Develop programming skill.
3. To study the power and voltage relation of the transmission line with different receiving end conditions.
4. To study different methods of controlling and monitoring power system parameters.

Course Outcomes

Upon successful completion of the course, students should be able

1. Use suitable Engineering software and Develop complex algorithm to solve power system problems.
2. Analyse effect of variation of load on voltage profile & reactive power requirement of the line.
3. Suggest and compare suitable methods to control power system parameters to enhance stability.
4. Appreciate the importance of central monitoring and control of the power system to maintain stability in the system.

List of Experiments

Expt. No.	***Details***	***Hours***
1	Study of complex power flow through a single-phase transmission line with ideal AC voltage sources connected at each end.	2
2	To validate Ferranti effect on an unloaded transmission line.	2
3	Study effect of Tap changing transformer on voltage levels in a power system.	2
4	Study of P-V curve and P-Q curve.	2
5	Study of shunt reactive power compensation with static VAR devices, STATCOM, synchronous condenser etc.	2
6	Study of series compensation and hence the performance of the line.	2
7	Study the effect of load frequency control (LFC) on an isolated power system using SIMULINK/ETAP	2
8	Study the effect of automatic generation control (AGC) on an isolated power system using SIMULINK/ETAP	2
9	Study effect of tie line transmission limit on two area system using SIMULINK/ETAP	2
10	Study of automatic voltage regulator (AVR) using	2

	SIMULINK/ETAP	
11	Program on optimal dispatch of generation	2
12	Study of configuration of Phasor Measurement Units and Wide Area Measurement System.	2
13	Study of Post fault Oscillation Monitoring using WAMS.	2

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 based on NPTEL course or few more experiments (minimum 2) based on PSOC course 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. Also, more examples can be given for practice at home. Students can write program in MATLAB/Scilab or they can convert MATLAB/Scilab code to Python. Resources required: Minimum 20 users License software MATLAB and/ OR ETAP/ Scilab (open source software)
Text Books
1. Kothari D. P Nagrath I. J., "Modern Power System Analysis", TMH Publications. 2. Wadhawa C. L., "Electrical Power Systems", New Age International. 3. Stevenson W.D., "Elements of Power System Analysis", McGRAW-HILL International 4. Saadat Hadi, "Power System Analysis, "TMH Publication. 5. MATLAB / Scilab Manual/ETAP Manual
Reference Books
1. Prabha Kundur, "Power System Stability and Control'', TMH Publication. 2. Olle I. Elgerd, "Electric Energy Systems Theory: an Introduction", TMH Publication 3. MATLAB/Scilab online Tutorials 4. ETAP webinars

Course Code	Course Name
PC-BTE 652	**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.	Chopper 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.	Study of stepper motor drive	2
13.	Harmonic analysis of single phase IM fed by power electronics converter	2

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

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-BTE653	**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. Understand operating characteristics of electromagnetic relays, circuit breaker and other protective devices.
2. Understand various protection scheme used in power system equipments.
3. Analyze performance of electromagnetic, numerical and microprocessor based relay.
4. To develop an ability and skill to design the feasible protection systems needed for each main part of a power system

Course Content

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

Term Work

Term work shall comprise of

1. Practical Examination/MCQ examination
2. 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
PE-BTE601	**Renewable Energy Sources**
Course pre-requisites	Power System –I , Power Electronics

Course Objectives
The objectives of this course are 1.To study the energy scenario and the consequent growth of the power generation from renewable energy sources. 2. To study the basic physics of wind, solar, tidal, and geothermal generation power generation. 3. To study the power electronic interfaces for wind and solar generation. 4. To study social and environmental of various RES 5.To study Life cycle cost of wind and solar.
Course Outcomes
Upon successful completion of the course, students should be able to 1. Understand the energy scenario and the consequent growth of the power generation from renewable energy sources. 2. Estimate the wind, solar and small hydro power generation. 3. Understand the power electronic interfaces for wind and solar generation. 4. Evaluate the socio-environmental impact of various RES 5. Analyse the life cycle cost of wind and solar energy.

Course Content

Module No.	***Details***	***Hrs.***
1	**History of RES and basic concepts**: Graphs - global and Indian statistics, heat transfer, essential of fluid dynamics	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	**Small Hydro**: stream flow, measuring flow, dam, diversion, measuring head calculating power.	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	Requirements of 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. G. N. Tiwari and M. K. Ghosal, "Renewable Energy Applications", Narosa Publications, 2004
4. 1547 IEEE standard

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3, Part of 4
3	End Sem	1 to 7

Course Code	Course Name
PE-BTE602	Design and Management of Electrical Systems
Course pre-requisites	

Course Objectives

The objectives of this course are

1. Introduction to types of electrical projects and electrical systems, basics of tendering and estimation.
2. Discussion of basic concepts of design of electrical systems like power distribution, switchgear protection and auxiliary systems

Course Outcomes

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

1. Work as a team leader or a member in multidisciplinary projects in the role of electrical engineer.
2. Identify the requirement of the project and design electrical systems accordingly as per IS standards.
3. Apply energy efficient ways in design and selection of electrical components

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction:** Types of projects, Roles of Design Engineer in different projects, Types of electrical systems, Review of components of electrical system, Different plans/drawing in electrical system design, Single line diagram in detail.	4
2	**Design of Power Distribution System**: HT connection, industrial substation, Electrical load: Size, LF, DF, future estimates, Industrial loads, motors, starting of motors, selection of motors for various applications, Energy efficient motors. Design consideration in: Transformer selection, sizing and specifications. Lightning Protection, Earthing design, neutral grounding, Power factor correction – kVAR calculations, types of compensation, IS standards applicable in above designs.	9
3	**Design of Switchgear Protection, Cabling Systems & Emergency/Back up Systems:** Selection of HT/LT switchgears, Instrument Transformers, Metering, Switchboards and MCC, PCC panels, Protection system co-ordination, cables: selection and sizing, cable installation and management systems. Types of Emergency supply systems, Design, sizing and selection criteria of DG sets, UPS, Batteries. IS standards applicable in above designs.	9
4	**Traction Systems:** Choice of traction systems for India, Power Supply Systems for Track Electrification, Mechanics of train movement, Types of traction motor best suited for traction duties, Overhead Equipment (OHE), Recent Technology in	6

	locomotives such as Metro, Mono rail, Bullet Train.	
5	**Illumination Systems:** Understanding various terms regarding light, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, design of a lighting scheme for a residential and commercial premises, flood lighting. Energy saving opportunities in illumination.	4
6	**Special Electrical Installations** Computer Installations, Communications – EPABX, internet, video conferencing, Fire Protection & Extinguishing, Security Systems, Elevators, CC/MA TV, PA / Audio systems.	6
7	**Tendering Process:** Basics of tendering and estimation, Databases required for reasonably accurate estimates, underlying assumptions in estimates and sensitivity analysis. Review of economic and financial analysis techniques: Time value of money, Simple payback, IRR.	4

Text Books

Text/Reference Books:

1. Thumann A., *Introduction to Efficient Electrical Systems Design*, Fairmont Press,2nd Ed.1999.
2. Kushare B.E., *Handbook on energy efficient motors,* International Copper Promotion council (India), 1st Ed. 2002.
3. Rajiv Shankar, "*Electrical System Designing made Simple",* Viva Books Pvt.Ltd.2007
4. Dr. K. Rajamani, "Application Guide for Power Engineers Part 1 Earthing & Grounding of Electrical systems", Notion Press.

Reference Books

1. IEEE 80 – IEEE guide for safety in substation grounding
2. Upadhayay J. and Mahindra S. N. Electric Traction, Allied Publishers Ltd, 1st edition
3. "Best Practice Manual on Lighting" by Bureau of Energy Efficiency, Ministry of Power, Government of India

Course Code	Course Name
PE-BTE603	**Electrical Machine Design**
Course pre-requisites	Electrical Machines I and II

Course Objectives

The objectives of this course are

1. Discuss the design of transformers, induction motors and synchronous machines
2. Introduction to computer aided design

Course Outcomes

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

1. Understand the construction and performance characteristics of electrical machines.
2. Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines
3. Understand the principles of electrical machine design and carry out a basic design of an ac machine

Course Content

Module No.	*Details*	*Hrs.*
1	**Fundamental aspects of Electrical Machine Design:** Design of machines: Design factors - Limitations in design - modern trends in Design of Electrical machines - Modern machine manufacturing techniques. Materials used in Transformers and Rotating Machines: Electrical conducting materials – High conductivity materials. Magnetic materials: Soft magnetic materials – Solid core materials – Sheet steels – Special purpose alloys. Insulating Materials: Electrical properties of insulating material – Temperature rise of insulating material – classification of insulating material - Insulating materials used in Modern Electric machines.	06
2	**Thermal Design aspects of Electrical machines:** Thermal state in electrical machines – Theory of Solid Body Heating – Heating – Cooling. Cooling of Rotating machines: Methods of cooling - cooling system -quantity of Cooling medium (coolant).	06
3	**Design of Transformers: (Core Type Transformers).** Sizing of a transformer. Design Details: Output for single & three-phase transformers – Output Equation – Volt per Turn. Optimum Designs. Design of Core – Rectangular core – Square and stepped cores – Variation of core diameter. Selection of Core area and Type of Core. Choice of flux density. Design of windings – Selection of Type winding – Position of winding relative to core. Window space factor – Window dimensions – Width of window for optimum	08

	output. Design of Yoke. Overall Dimensions. Simplified Steps for Transformer Design.	
4	**Transformer Design Operating Characteristics:** Resistance of Winding – Leakage reactance of winding – Regulation – No-load current. Temperature Rise of Transformers - Methods for cooling of transformers – Transformer oil as cooling medium – Temperature rise in plain walled Tanks. Design of Tank - with Tubes with Radiators.	04
5	**Design of Induction Motors:** Introduction - Sizing of an induction motor. Relation between Rating and Dimensions of Induction Motor – Specifications - Output Equation – Main Dimensions - Factors affecting the size of the machine – Specific electrical Loading – Specific Magnetic loading – Choice of specific electrical and magnetic loadings – Efficiency and Power Factor.	04
6	**Induction motor Design Details**: Calculation of Main Dimensions – Separation of D and L – Peripheral velocity – Ventilating Ducts. Design of Stator Core - Stator winding Design - Stator slot design – Stator Teeth Design – Depth of Stator Core. Determination of Air gap length. Design Rotor: Design of Squirrel cage Rotor - Rules for selecting rotor slots - Design of rotor bars and slots - design of end rings. Design of wound rotor – Number of Slots - Number of Turns – Rotor current and conductor section. Design of rotor core.	10
7	**Estimation of Operating Characteristics of Induction Motor**: No-load current – Short circuit current – Stator and Rotor Resistance – Leakage Reactance – Circle diagram – Starting Torque – Losses and Efficiency.	04

Text Books

2. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 1970.
3. S. K. Sen, "Principles of Electrical Machine Design with computer programs", Oxford and IBH Publishing, 2006

Reference Books

1. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.

Sr. No.	Examination	Module
1	T-I	1, Part of 2
2	T-II	Part of 2, 3
3	End Sem	1 to 7

Course Code	Course Name
PE-BTE604	**Control System Design**
Course pre-requisites	Control System

Course Objectives

1. Discuss design specifications
2. Design of controllers and compensators n time and frequency domain
3. Design of controllers and observers using state space
4. Introduce non linearity and its effect on system performance

Course Outcomes

Students will be able to
1. Use time and frequency domain design specifications.
2. Design controllers/ compensators time domain and frequency domain methods.
3. Design controllers and observers using the state-space approach.
4. Explain various nonlinearities and phase plot analysis

Course Content

Module No.	***Details***	***Hrs.***
1	**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.	06
2	**Design of PID controllers** Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems.	06
3	**Design of Classical Control System in the time domain :** Introduction to compensator. Design of Lag, lead lag-lead compensator in time domain. Feedback and Feed forward compensator design. Feedback compensation. Realization of compensators	07
4	**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.	06
5	**Control System Design in state space** Review of state space representation, Realization: Canonical form, Diagonal form, Concept of controllability & observability, effect of pole zero cancellation on the controllability & observability of the system.	06
6	**Controller and Observer Design** Pole placement design through state feedback. Ackerman's Formula for feedback gain design. Design of Observer. Reduced order observer. Separation Principle	06
7	Nonlinearities and its effect on system performance Various types of non-linearity. Effect of various nonlinearities on system performance. Singular points. Phase plot 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
3. R. T. Stefani and G. H. Hostetter, “Design of feedback Control Systems”, 4/e, Oxford University Press, 2002

Course Code	Course Name
PE-BTE 611	**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 learner will be able:

1. To Illustrate the general configuration and working principles of different types of Automotive Powertrains
2. To understand the working of various automotive transmission systems and the various hybrid electric powertrains and their different modes of operations
3. To explain the basic and state of the art of Electric vehicles and to compare with ICE vehicles, HEVs and EVs.

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	6

	efficiency, volumetric efficiency. Cooling systems for ICE based vehicles. Few basic topic of thermodynamic to understand ICE. RC Snubber Design, RCD Snubbers,	
5	**Electric Vehicles:** Basics of Electric Vehicles, Current Status and Trends for EVs, Battery 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
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

Website Reference / Video Courses:

1. NPTEL Web course: Fundamentals of Automotive Systems, by Prof. C.S. Shankar Ram, IIT Madras, https://nptel.ac.in/courses/107/106/107106088/

Course Code	Course Name
PE-BTE612	**Micro-grid and Distributed generation**
Course pre-requisites	Power System

Course Objectives

The objectives of this course are

1. To illustrate the concept of distributed generation.
2. To analyse the impact of grid integration.
3. To study concept of Micro grid and its configuration

Course Outcomes

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

1. Review the conventional power generation
2. Analyse the concept of distributed generation and installation
3. Design the grid integration system with conventional and non-conventional energy sources

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction:** Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro- turbines, biomass, and tidal sources. Distributed vs Central Station Generation Sources of Energy **Distributed generations:** Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547, DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra- capacitors, flywheels. Captive power plants	6
2	**Impact of grid integration:** Requirements for grid interconnection, limits on operational parameters, voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.	06
3	**Basics of a micro grid:** Concept and definition of micro grid, micro grid drivers and benefits, review of sources of micro grids, typical structure and configuration of a micro grid, AC and DC micro grids, Power Electronics interfaces in DC & AC micro grids.	06
4	**Control and operation of micro grid:** Modes of operation and control of micro grid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, micro grid communication infrastructure	06

5	Impact of Distributed Generation on the Power System. Power Quality Disturbances. Power quality issues in micro grids, regulatory standards, Micro grid economics	4
6	Control of DG inverters, phase locked loops, current control and DC voltage control for standalone and grid parallel operations. Protection of the converter Relaying and protection: distributed generation interconnection relaying, sensing using CTs and PTs.	6
7	DG planning cost implications of power quality, cost of energy and net present value calculations and implications on power converter design. Economics of Distributed Generation-Case Studies	8

Reference Books:

1. Technical literature-papers published in power electronics related journals and IEEE standards.
2. Ned Mohan, Tore M. Undeland, William P Robbins, “Power Electronics: Converters, Application, and Design”. Wiley, 2002.
3. Ranjan Rakesh, Kothari D.P, Singal K.C, “Renewable Energy Sources and Emerging Technologies”,2nd Ed. Prentice Hall of India ,2011
4. Math H. Bollen, Fainan Hassan,“ Integration of Distributed Generation in the Power System”, July 2011, Wiley –IEEE Press
5. Loi Lei Lai, Tze Fun Chan, “Distributed Generation: Induction and Permanent Magnet Generators”, October 2007, Wiley-IEEE Press.
6. Roger A. Messenger, Jerry Ventre, “Photovoltaic System Engineering”, 3rd Ed, 201

Course Code	Course Name
PE-BTE613	**Digital Control Design**
Course pre-requisites	Control System, Digital Signal Processing

Course Objectives

1. Obtain discrete representation of LTI systems.
2. Analyze stability of open loop and closed loop discrete-time systems.
3. Design and analyze digital controllers.
4. Design state feedback and output feedback controllers

Course Outcomes

Students will be able to

1. Obtain discrete representation of LTI systems.
2. Analyze stability of discrete-time systems.
3. Design and analyze digital controllers.
4. Design state feedback and output feedback controllers.

Course Content

Module No.	***Details***	***Hrs.***
1	**Discrete Representation of Continuous Systems** Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modeling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent, state space system	07
2	**Discrete System Analysis** Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.	07
3	**Stability of Discrete Time System** Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design	06
4	**State Space Approach for discrete time systems** State space models of discrete systems, solution to state space equations, State space analysis. Lyapunov Stability	05
5	**State Space Approach for discrete time systems** Controllability and observability analysis. Effect of pole zero cancellation on the controllability & observability.	05
6	**Design of Digital Control System** Nyquist plot for controller design,	05

	Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator	
7	**Discrete output feedback control** Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.	07

For Self-study:

Text Books:

1. M. Gopal, "Digital Control and State Variable Methods", 3/e Mcgraw Hill Higher Education,2010

Reference Books

1. K. Ogata, "Discrete Time Control Systems", 2/e, PHI, 2005
2. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", 3/e, Addison-Wesley, 1998.
3. B.C. Kuo, "Digital Control System", 2/e, Holt, Rinehart and Winston, 1987

Course Code	Course Name
OE-BTE601	**Power Plant Engineering**
Course pre-requisites	

Course Objectives

The objectives of this course is

To provide an overview of power plants and the associated energy conversion issues

Course Outcomes

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

Understand the principles of operation for different power plants and their economics

Course Content

Module No.	*Details*	*Hrs.*
1	Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates	06
2	Subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems	06
3	Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) Systems	06
4	Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.	06
5	Hydroelectric power plants, classification, typical layout geothermal, biogas and fuel cell power systems	06
6	Energy, economic issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies	06
7	Energy environmental issues including waste disposal options for coal and nuclear plants.	06

Text Books

1. Nag P.K., Power Plant Engineering, 3rd ed., Tata McGraw Hill, 2008.

Reference Books

1. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010.
2. Elliot T.C., Chen K and Swanekamp R.C., Power Plant Engineering, MGH2nd ed., McGraw Hill, 1998.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Course Code	Course Name
OE-BTE602	**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

1. Demonstrate a clear understanding of choice of technology and technology scaling.
2. Design MOS based circuits and draw layout.
3. Realize logic circuits with different design styles.
4. Demonstrate a clear understanding of system level design issues such as timing and power dissipation

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. **Logic Circuit Design**: Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter.	**06**
3	**MOS Circuit Design Styles:** **Design Styles:** Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS. **Circuit Realization:** 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	**Hardware Description Languages for VLSI Design:** Managing concurrency and time in Hardware Description	**08**

	Languages, Introduction to VHDL, Basic Components in VHDL, Structural Description in VHDL, Behavioral Description in VHDL, and Introduction to Verilog.	
7	**VLSI Clocking:** CMOS clocking styles, Clock generation, stabilization and distribution.	**04**

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.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Course Code	Course Name
OE-BTE603	**Linear Algebra and Matrix Computation**

Course pre-requisites	

Course Objectives

The objectives of this course are

1. To make student conversant with fundamentals of Linear Algebra.
2. To impart knowledge about various concepts of matrix computation.
3. To learn the complexity in solving least square problem
4. To understand concepts of Eigen Value and Eigen vectors

Course Outcomes

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

1. To apply theoretical concepts of vector spaces to solve linear equations.
2. To analyse various properties such as rank, subspaces, norm, condition number, eigen value etc. of a given matrix.
3. To compare complexity of various matrix decomposition methods.
4. To solve least square problem with different matrix computation techniques
5. To suitably select various matrix computation tools to solve real life complex problems

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction:** Over-view of the course, applications in various engineering fields, **Vector-spaces:** Fields, definition of a vector-space, examples, subspaces, sums and intersections of subspaces, span, linear independence, bases, dimension, basis extension, coordinates, calculations of bases concerning solutions of linear equations.	4
2	**Linear maps:** Definition, examples, null/kernel space, range/image space, matrix representations of linear maps, row-rank, column-rank, rank-nullity theorem, algebra of linear maps, linear functionals	4
3	**Gaussian elimination:** Basic Gaussian elimination without pivoting, LU decomposition, Gaussian elimination with pivoting. Positive definite matrices, A brief discussion on sparsity.	6
4	**Sensitivity and round-off errors:** Vector norms, matrix norms. Condition number. Perturbation, residual, round-off errors. Error propagation in Gaussian elimination.	6
5	**Least Squares Problem:** Orthogonal matrices, rotators and reflectors. Solution of the least squares problem, the full-rank case. Gram-Schmidt process. Singular value Decomposition (SVD): Introduction, Some basic applications, least squares problem	8
6	**Eigenvalues and Eigenvectors:** The power method. Unitary similarity transform, Schur's theorem, normal matrices, spectral theorem of normal matrices. Hessenberg and tri-diagonal matrices,	8

	reduction to these forms. The QR algorithm. A brief discussion on sparsity.	
7	**Applications:** a) Graphs, KCL and KVL b) Solving linear ODEs c) The geometry of gradient descent d) Best approximation e) Multi-agent systems.	6

Text Books
1. K. Hoffman and R. Kunze, Linear Algebra, Pearson, 2015. 2. G. Strang, Linear algebra and its applications (4th Edition).
Reference Books
1. David S. Watkins, Fundamentals of Matrix Computations, 3rd Edition, Willey-Inter science, 2010. 2. Gene H. Golub and Charles F. Van Loan, Matrix Computations, 4th Edition, The Johns Hopkins University Press, 2013.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Course Code	Course Name
OE-BTE604	**Computer Architecture**

Course pre-requisites	Microprocessor and Microcontroller

Course Objectives
The objectives of this course are 1. Introduction to computer, memory and input-output organization 2. Discuss pipelining 3. Explain different architectures
Course Outcomes
Upon successful completion of the course, students should be able to 1. Explain the concepts of microprocessors, their principles and practices. 2. Solve integer and floating point arithmetic. 3. Explain CPU operation and implementation 4. Compare and contrast various architectures and microprocessors.

Course Content

Module No.	***Details***	***Hrs.***
1	**Introduction to computer organization** Architecture and function of general computer system, CISC Vs RISC,	02
2	**Data types, Integer Arithmetic** - Multiplication, Division, Fixed and Floating point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.	06
3	**Memory organization** System memory, Cache memory - types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optical Disks	08
4	**Input – output Organization** Accessing I/O devices, Direct Memory Access and DMA controller, Interrupts and Interrupt Controllers, Arbitration, Multilevel Bus Architecture, Interface circuits - Parallel and serial port. Features of PCI and PCI Express bus.	08
5	16 and 32 microprocessors 80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real and Protected mode.	06

6	**Pipelining** Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set.	06
7	**Different Architectures** VLIW Architecture, DSP Architecture, SoC architecture, Processor and programming	06

Term Work

Term work shall comprise of

1. Assignments on the above topics which include some numerical calculations.
2. Examination (MCQ) based on topics mentioned in latest GATE syllabus
3. Mini Project*

*Mini Project: :There will be a course project in the form of case study where the students will be able to analyze and integrate the knowledge gained during the course. The case study will be done by teams of Two to Four students.

For Self-Study: Instruction set of 80x86, I/O addressing in 80x86

Text Books

1. W. Stallings, "Computer organization", PHI, 1987.
2. V. Carl, G. Zvonko and S. G. Zaky, "Computer organization", McGraw Hill, 1978.
3. Y. C. Lieu and G. A. Gibson, "Microcomputer Systems: The 8086/8088 Family",Prentice Hall India, 1986

Reference Books

1. J. L. Hennessy and D. A. Patterson, "Computer Architecture A Quantitative Approach", Morgan Kauffman, 2011.
2. P. Barry and P. Crowley, "Modern Embedded Computing", Morgan Kaufmann, 2012. 6. N. Mathivanan, "Microprocessors, PC Hardware and Interfacing", Prentice Hall, 2004.
3. P. Able, "8086 Assembly Language Programming", Prentice Hall India.
4. B. Brey and C. R. Sarma, "The Intel microprocessors", Pearson Education, 2000.

Sr. No.	Examination	Module
1	T-I	1,2,3
2	T-II	4,5
3	End Sem	1 to 7

Course Code	Course Name
OE-BTE605	**Project Management**

Course pre-requisites	Basics of Electrical Engineering, Basics of statistics and mathematics, general knowledge about working of organizations

Course Objectives

The objectives of this course are

1. Get familiarized with basics of project management, its organization and project management framework.
2. Learn five important project management process groups, namely: initiating, planning, executing, monitoring & control, closing and ten important project management knowledge areas.
3. Understand the relationship between project management process groups and knowledge areas.

Course Outcomes

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

1. Explain basics of Project Management, its organization and project management framework.
2. Perform project management process group and knowledge area mapping.
3. Solve a case study using step-by-step process of managing projects and explain why each step is necessary.

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction** • Basics of project management, operations management and organizational strategy, • Project management framework, organizational structures, • Project Management Processes – Initiating, Planning, Executing, Monitoring & Control, Closing.	03
2	**Project Integration Management** • Integrated change control, Developing project management plan and project charter, • Project selection, corrective action, preventive action, defect repair, change control board, • Cost benefit analysis, Net present value, internal rate of return, payback period, present value, economic value added, • Opportunity costs, sunk costs, law of diminishing returns, working capital, depreciation. **Project Scope Management** • Scope baseline, WBS, Project scope statement, WBS dictionary, benefits and uses of WBS • Requirement documentation, requirements traceability matrix, requirements management plan	04
3	**Project Time Management** • Schedule baseline, schedule compression, Network diagram, • Precedence Diagramming Method (PDM), Three point estimating,	09

	analogous estimating, parametric estimating, • Schedule management plan, resource optimization, Critical path method, Program Evaluation Review Technique (PERT). **Project Cost Management** • Earned value measurement, Earned value monitoring, cost baseline, cost budget, Cost management plan, • Reserve analysis, contingency reserve, management reserves, cost risk, • Variable / fixed costs, direct / indirect costs, life cycle costing, value analysis, control thresholds, cost of quality, Return of Interest (RoI), and discounted cash flow. **Project Quality Management** • Seven basic quality improvement tools – control chart, Pareto diagram, Cause and effect diagram, flow chart, scatter diagram, histogram. Use of s-curve in project monitoring. • Quality assurance tools and techniques – Affinity diagram, tree diagrams, process decision program charts, matrix diagrams, prioritization matrices, network diagrams.	
4	**Project Human Resource Management** • Role of PM, sponsor, stakeholders, functional manager, portfolio manager, program manager, • HR management plan, recognition and reward systems, team building, stages of team formation and development, team types. • Conflict Management, • Responsibility Assignment Matrix (RAM), RACI Chart, • Motivation theory, Management and Leadership styles, **Project Communication Management** • Communication models, channels, method, communication blockers.	04
5	**Project Risk Management** • Risk management plan, risk response strategies, threats, opportunities, risk register, contingency plans, fallback plans, residual risks, secondary risks, • Risk types and categories, SWOT analysis, **Project Procurement Management** • Procurement management plan, types of agreements and contract types, advantages and disadvantages of each contract type, • PM's role in procurement, procurement documents : RFP, IFB, RFQ, RFI, • Types of procurement, procurement negotiations, centralized / decentralized contracting, contract interpretation, price, profit, cost, target price, sharing ratio, ceiling price	06
6	**Project Stakeholder Management** • Stakeholder analysis, stakeholder register, stakeholder expectations, stakeholder engagement, • Power and interest grid, stakeholders engagement assessment matrix	03
7	**Professional and Social Responsibility** • Project management traits in professional and social responsibility, • Code of Ethics and Professional conduct w. r. t. responsibility, respect, fairness, honesty. **Project Management Case Study / Activity**	05

Text Books
1. Rita Mulcahy, "PMP Exam Prep", Eight Edition, RMC Publications, Inc., 2013. 2. Kalpesh Ashar, "Project Management – Essentials You Always Wanted to Know", Vibrant Publishers, 2012. 3. Prasanna Chandra, "Projects: Planning, Analysis, Selection, Financing, Implementation and Review", McGraw Hill India, 2014.
Reference Books
1. Dennis Lock and Lindsay Scott, "Gower Handbook of People in Project Management", Routledge Publishers, NY, USA, 2016. 2. "A Guide to the Project Management Body of Knowledge (PMBOK Guide)", 5th Edition, Project Management Institute, USA. 3. David Cleland, "Project Management Handbook", 2nd Edition, Wiley, 1988.

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

Appendix -I

Skill Based Courses

Sr No.	Name of the course	Course code
1	Electrical Simulation Lab	SK-BTE001
2	Electronics Design Laboratory	SK-BTE002
3	DSP Processor and applications to electrical engineering	SK-BTE003
4	Programmable Logic Controllers	SK-BTE004

1. Electrical Simulation Lab (SK-BTE001)

Course Code	Course Name
SK-BTE001	Electrical Simulation Lab

Course pre-requisites	Courses in Electrical Network, Machines I, II, Power Electronics, Power system and basic knowledge of programming, familiar with Engineering software such as MATLAB or Scilab

Course Objectives

Objectives of this course are

1. To demonstrate theoretical knowledge.
2. To conduct simulations for analysis of different concepts in Electrical Engineering

Course Outcomes

Upon successful completion of the course, students should be able

1. Acquire skills of using software for Electrical Engineering studies.
2. Analyze different theories studied in electrical networks, power electronics, control system, power system and electrical machines.

List of Experiments (Minimum Ten)

Expt. No.	*Details*	*Hours*
1	Study of power flow in a Star connected load and Delta connected load parallel to each other and fed from 3 phase AC source through a transmission line.	2
2	Study of vector group of a transformer.	2
3	Concept of balanced and unbalanced loads in a 3-phase system.	2
4	Simulation of Hysteresis loss in a transformer in MATLAB	2
5	Comparison of linear and non-linear inductor in MATLAB	2
6	Supercapacitor charging and discharging behavior in MATLAB	2
7	Study of Analog anti-aliasing filter in MATLAB	2
8	Study of customized synchronous Machine in MATLAB	2
9	Modelling of Frequency dependent transmission line in MATLAB	2
10	Study of Induction motor starting current with DOL starter and Star-Delta starter	2
11	Load flow study in any IEEE standard multimachine system using Load flow analyzer or ETAP.	2
12	Development of overcurrent relay using Simulink	2

13	Development differential protection of transformer using Simulink	2
14	Detection of fault location on a transmission line using voltage, current measurements.	2
15	Study of Capacitor bank switching transient	2
16	Study of inductive load switching transient	2
17	Study of relay co-ordination using ETAP	2
18	Study of Type 2 Co-ordination for an Induction motor using ETAP	2
19	Study of circuit breaker short circuit ratings adequacy using ETAP	2
20	Estimation of phasors using DFT Algorithm	2
21	Study vulnerability of distance relay (VADR) using WAMS software.	2
21	Transient stability analysis of a simple power system using ETAP under different contingencies.	2

Text Books
1. MATLAB / Scilab Manual 2. ATP/PSCAD manual 3. ETAP Manual
Reference Books
1. MATLAB/Scilab online Tutorials 2. ETAP webinar

2. Electronics Design Laboratory (SK-BTE002)

Course Code	**Course Name**
SK-BTE002	Electronic Design Laboratory

Course pre-requisites	Electronic circuit, Analog Electronics,

Course Objectives
The objectives of this course are 1. To introduce the fundamental principles of electronics system design. 1. To highlight the circuit design issues in the context of electronic system design.
Course Outcomes
Upon successful completion of the course, students should be able to 1. Understand the practical issues related to practical implementation of applications using electronic circuits. 2. Choose appropriate components, software and hardware platforms. 3. Design a Printed Circuit Board, get it made and populate/solder it with components. 4. Work as a team with other students to implement an application.

Course Content

Module No.	***Details***	***Hrs.***
1	Basic concepts on measurements; Noise in electronic systems; Sensors and signal conditioning circuits;	4+4
2	Introduction to electronic instrumentation and PC	4+4

	based data acquisition;	
3	Electronic system design, Analog system design, Interfacing of analog and digital systems	4+4
4	Embedded systems, Electronic system design employing microcontrollers, CPLDs, and FPGAs	4+4
5	PCB design and layout;.	4+4
6	System assembly considerations	4+4
7	Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application	4+4

Term Work

Term work shall comprise of

1. Assignments on above topics.
2. Lab assignments consist of design problems based on electronics/electrical system design.
3. Mini Project*

*Mini Project: There will be a course mini project where the students will be able to apply and integrate the knowledge gained during the course. The projects will be developed by teams of Four to Five students. The group has to present the project and submit the project report

Text Books

1. P. Horowitz and W. Hill, “The Art of Electronics”, Cambridge University Press, 1997.
2. H.W.Ott, “Noise Reduction Techniques in Electronic Systems”, Wiley, 1989.
3. W.C. Bosshart, “Printed Circuit Boards: Design and Technology”, Tata McGraw Hill,1983

Reference Books

1. A. S. Sedra and K. C. Smith, “Microelectronic circuits”, Oxford University Press, 2007.
2. G.L. Ginsberg, “Printed Circuit Design”, McGraw Hill, 1991.

3. DSP Processor and applications to electrical engineering (SK-BTE003)

Course Code	Course Name
SK-BTE003	DSP Processor and applications to electrical engineering

Course pre-requisites	

Course Objectives

Objectives of this course are

1. To understand comparison of microcontrollers and digital signal processors.
2. To learn and implement DSP programming
3. To understand internal details of DSP architecture, peripheral, addressing modes, interrupt structure, hardware multiplier

Course Outcomes

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

1. Understand and use new /advanced DSP
2. Implement the basic power electronics control algorithm such as PWM techniques using DSPs

Course Contents

Mod. No.	*Details*	*Hours*
1	Review of microcontrollers and digital signal processors, architecture, peripheral modules.	04
2	Typical processors for control implementation, memory organization, CPU details	04
3	Addressing modes interrupt structure, hardware multiplier, pipelining, Fixed and floating-point data representations, Assemblers, linkers and loaders.	04
4	Binary file formats for processor executable files, Typical structure of timer interrupt driven programs, Implementing digital processor based control systems for power electronics.	04
5	Reference frame transformations, PLL implementations, machine models harmonic and reactive power compensation, space vector PWM.	04
6	Numerical integration methods. Comparison in terms of time step, stability	04
7	Multitasking concepts for power electronics implementations, The need for multitasking, various multitasking method	06

Text Books

1.N. Mohan, “Power Electronics”, third edition, John Wiley and Sons.

Reference Books

K. Ogata, “Discrete-Time Control Systems”, second edition, Pearson Education Asia.

4. Programmable Logic Controllers (SK-BTE004)

Course Objective:

1. Discuss the purpose, functions, and operations of a PLC
2. Explain basic components of the PLC and how they function

Course Outcome: Students will be able to

1. Generate and print out a ladder logic report using PLC software
2. Create a PLC project using PLC
3. Configure the I/O for a PLC project using PLC

Course content: 1. Introductions to the purpose, functions, and operations of the PLC, Identification of various components of the PLC, 2. Introduction to PLC ladder logic and basic programming concepts, Establishing communications with the PLC, 3. Definitions of conditional inputs and outputs, Electrical continuity versus logical continuity, 4. PLC timer and counter concepts and programming applications, 5. Programming applications using sequencers.

Appendix -I

Value Added Courses

1. **Soft -Computing I (VA-BTE001)**

   Course Objective: Provide knowledge of MATLAB/ SCILAB.

   Course Outcome: Students will be able to develop good applications using MATLAB/ SCILAB

   Course content: 1. Basic Introduction and Overview, 2.Variables and Data types, 3.Operation,. Control Structure, 4.Function, Introduction to different tool boxes available, 5. Introduction to MATLAB simulink

2. **Open source operating systems and Software (Linux, python/ SciLab/octave/ R) (VA-BTE003)**

3. **Finite Element Methods for Electrical Engineering (VA-BTE005)**

   Course objective: Introduce how the finite element method can be used as a numerical tool to solve differential equations.

   Course Objective: Students will be able to solve Electrical engineering problems using finite element methods

   Course content: 1. Introduction to the mathematical description of Electrical engineering problems, 2. Revision of numerical solutions to differential and algebraic equations, Overview of the finite element method - Variational approach, 3. Ritz technique, Galerkin method, Approximation functions for one, two and three-dimensional elements, 4. Application of the FEM to Analyzing electrical circuits 5. Programming FEM in open source

4. **ETAP and WAMS (VA-BTE009)**
   Course Objective:

   - Introduce ETAP software
   - Discuss the synchro phasor measurement techniques in a Wide Area Control through the basic building blocks of GPS satellite synchronized clocks, the architecture of the Phasor Measurement Units (PMUs), and The communications equipment.

   Course Outcome: Students will be able to

   1. Use ETAP as an analysis platform for the designing, simulating, operating and automation of generation and distribution of power systems.

2. Understand the synchro phasor measurement techniques in a Wide Area Control

Course content: 1. Build power systems and simulate the power, current and voltage flow, Single Line diagram creation and analysis, run and Analyze AC power circuits, 2. Run load flow analysis on one line diagram, run Short Circuit analysis. 3. Introduction to Synchro Phasor & WAMS Technologies, Synchro Phasor needs and benefits for Operations, 4. Planning and Control Vision for Synchro Phasor & Online Stability Solutions Fundamental building blocks for WAMS and Synchro Phasor Platform Architecture, 5. PMU standard and communication.