

Final Year B.Tech. Sem. VII & VIII
Electrical Engineering
Credit System And Course Content
Year 2017-18

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE401	COURSE: Design Management and Auditing of Electrical Systems		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	---	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In semester evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. Introduction to types of electrical projects and electrical systems, energy conservation law, basics of tendering and estimation.
2. Discussion of basic concepts of design of electrical systems like power distribution, switchgear protection and auxiliary system.
3. Learning of management and auditing procedure of electrical systems.
4. Understanding renewable-energy and green building concepts from design perspective.

Course Outcomes: After successfully completing the course, the student will 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.
4. Realize role of renewable-energy and green building concepts in electrical design.

Pre-requisite: Adequate knowledge of power system elements such as cables, machines, transformer, electrical loads, fault calculations, earthing etc.

Course Contents:

Module	Details	Hrs.
1.	Introduction: Types of electrical projects, Types of electrical systems, Review of components of electrical system, Different plans/drawing in electrical system design, Single line diagram in detail, Introduction to Energy Conservation Act 2001	
2.	Design of Power Distribution System: Different types of distribution systems and selection criteria, Electrical load: Size, LF, DF, future estimates, Substation equipment options, Design consideration in: Transformer selection, sizing and specifications. IS standards applicable in above designs. (Substation 'LV' Design)	
3.	Design of Switchgear Protection and Auxiliary System: Selection of HT/LT switchgears, Metering, Switchboards and MCC, Protection systems, cables: selection and sizing, cable installation and management systems, Basics of selection of emergency/backup supplies. UPS, DG set, Batteries, Preliminary design of interior lighting system, IS standards applicable in above designs.	

4.	Tendering Process: Basics of tendering and estimation, Review of economic and financial analysis techniques: Time value of money, Simple payback, IRR.	
5.	Monitoring and Management of Electrical Systems: Energy monitoring and Targeting: Defining monitoring and targeting, Elements of monitoring and targeting, Energy analysis techniques for energy optimization. Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses, Introduction to Energy Efficient Technologies in Electrical systems: Maximum Demand controllers, Automatic Power factor controllers, Energy Efficient motors, Soft starters, Variable speed drives, Energy Efficient Transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology. Energy Management System (EMS) and Building Management System (BMS) systems.	
6.	Energy Audit: Definition, Energy audit-need, types of Energy audit, Energy management (audit) approach- understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments: Audit of installations comprising following with respect to their electrical energy usage: Electric Motors, HVAC systems, Fan and blower systems, Compressed air systems pump, DG sets, Lighting installations etc. Evaluation of energy conservation opportunities, Energy conservation in buildings, Economic and non economic aspects of energy conservation in electrical systems	
7.	Use of Renewable and Green Building Concept: Impact of renewable energy sources in electrical system design. Concept of Green Building and its accreditation.	

Term Work:

1. Design based on following case studies with complete design calculation and diagrams/drawings/layouts (at least two)
 1. Power distribution network: Substation Design
 2. Lighting Design
 3. Cable Selection
 4. Switchgear and Protection System Design
 5. Emergency/backup System Design
2. Preliminary Audit report on observation and analysis of existing electrical installation (at least two)
3. Three Assignments/Case studies based on module 01 and 07

Text Books:-

1. Handbook of Electrical Installation Practice. , By Geoffery Stokes, Wiley Blackwell
2. Designing with light: Lighting Handbook., By Anil Valia, Lighting System
3. Energy Management Handbook. By W.C. Turner, JohnWiley and Sons
4. Handbook on Energy Audits and Management. edited by Amit Kumar Tyagi, Tata Energy Research Institute (TERI).
5. Electrical Design: Estimating and Costing, by K. B. Raina and S. K. Bhattacharya, New Age International Publishers

Reference Books:-

1. Energy Auditing Made Simple, By P. Balasubramanian, Seperation Engineers (P) Limited
2. Energy Management Principles, By C.B.Smith, Pergamon Press
3. Energy Conservation Guidebook, Dale R. Patrick, Stephen Fardo, Ray E. Richardson, Fairmont Press
4. Handbook of Energy Audits., By Albert Thumann, William J. Younger, Terry Niehus, CRC Press
5. Electric Power Distribution Equipment and Systems, by T. A. Short, Taylor and Francis
6. Electrical Power Distribution, A. S. Pabla, Mc-Graw Hill
7. Websites: www.energymanagertraining.com, www.bee-india.nic.in

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS : B.Tech. Electrical		
CODE: BTE402	COURSE: Electronic Instrumentation		
Period per week	Lecture	03	
	Laboratory	--	
	Tutorial	---	
Scheme of Evaluation		Hours	Marks
	In Semester (Test 1 and 2)	01	20*2
	End Semester*	03	100
	Laboratory Work (Journal)	---	-
	TOTAL	---	100

* 60% Weightage for end semester

Course Objectives:

1. Understand signal conditioning and display and recording devices used in Instrumentation.
2. Discuss data acquisition and process control system.
3. Introduce programmable logic controllers.

Course Outcomes:

1. Use signal conditioning for different applications.
2. Choose between different display and recording devices.
3. Understand the features of PLC, SCADA and its application in industries.
4. Implement different data acquisition systems.

Course Contents:

Module	Details	Hrs.
1.	Instrumentation System: Basic Characteristics of Instruments: static and dynamic, Classification of Instruments Response for standard inputs: Unit step Ramp and sinusoidal signals, Specifications of digital meters, resolution, sensitivity, and accuracy.	
2.	Signal Conditioning: Low frequency signal generators, function generator, pulse, RF signals, sweep generators, Frequency synthesizer, and arbitrary waveform generator, Power Analyzer	
3.	Display and Recording Devices: Special purpose oscilloscopes-delayed time-base, analog storage, sampling oscilloscopes. Digital storage oscilloscopes-DSO applications LCD, LED, optical encoders, resistive digital encoders, shaft encoders.	
4.	Data Acquisition System: Introduction of DAS, objective of DAS, signal conditioning of inputs, single and multi-channel DAS, computer based DAS, Overview of sample and hold, multiplexing, D/A, A/D conversion, general description of Data loggers.	

5.	Advances and Applications in Instrumentation systems: Digital transducers, RTD, HMI, SCADA, PLC, telemetry, Virtual Instrumentation: concept and applications, Distributed Control System (DCS), Applications: Biomedical, Automobile etc.	
6.	Principles of Process control and Controller Tuning: Fundamentals of process control, types of control action: discontinuous and continuous. Control elements: controller, final control elements, control systems. Controller tuning: need and different method of controller tuning.	
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.	

Text Books:

1. Instrumentation Devices and Systems By C S Rangan, G R Sharma, V S V Mani, 2nd ed,
2. Process Control System and Instrumentation By Terry Barlett , Delimar Cengage Learning Reprint-2008.

Reference Books:

1. Principles of Industrial Instrumentation and Control System by Chennakesava R. Alavala Delimar Cengage learning Reprint-2008
2. Instrumentation, Measurement and Analysis by B C Nakra, K K Chaudhary, 2nd Ed, Tata
3. Measurement system Applications and Design by E O Doebelin – 4th Ed, Tata McGraw-Hill, 1990
4. Instrumentation for Engineer and Scientist by John D Turner Martyn Hill Oxford University Press.

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS: B.Tech. (Electrical)		
CODE:BTE451	COURSE: Electronics Instrumentation Lab		
Period per week (each of 60 minutes)	Lecture		
	Laboratory	02 hours/batch	
	Tutorial	---	
Scheme of Evaluation		Hours	Marks
	In Semester evaluation	-	
	End Semester*	-	-
	Practical	02	25
	TOTAL	---	25

Course Objectives:

1. Understand and verify the Response of different instruments to various inputs and also different controllers.
2. Introduce programming of PLC.

Course Outcomes:

1. Demonstrate understanding and implementation of various controller modes and their tuning.
2. Implement small automation based experiments on PLC.

List of Experiments

1. To study the Response of different instruments for different test inputs (Unit, Ramp And Sinusoidal signals) Use either MATLAB/LabView
2. Study of controller modes or PID controller (Either on Trainer kit or on LabVIEW)
3. PLC programs
4. Signal generators and CROs
5. Experiment to show calibration of instrument and tuning of controller.

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE403	SUBJECT: Renewable Energy Systems		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	----	
	Tutorial	02 hours/ batch	
Evaluation system		Hours	Marks
	T1	01	20
	T2	01	20
	End Semester*	03	100
	In semester evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. Study of solar, wind, geothermal and tidal energy.
2. Overview of energy storage methods.
3. Introduction to energy from biomass.
4. Study of Hybrid Systems
5. Introduction to design aspects and integration of solar and wind with grid.

Course Outcomes:

1. Recognize current and possible future role of renewable energy sources.
2. Appraise current technologies of utilizing renewable-energy sources and evaluate critically respective R&D activities required.
3. Assess the potential and economic viability of the utilization of a renewable-energy source at a particular location.
4. Continue to advance their knowledge and assimilate new future technologies.

Detailed Syllabus:

Module	Details	Hrs.
1.	Solar energy: The Sun – Production and transfer of solar energy, Sun-Earth angles, Availability and limitations of solar energy, Measuring techniques and estimation of solar radiation, Solar thermal collectors.	
2.	Solar Thermal systems & Energy Storage: Solar Thermal systems-Principle of operation, Flat Plate Collector, Solar Pond, Parabolic Collectors, Parabolic Dish, Central Receiver. Energy Storage systems: Solar thermal systems for residential water heating, industrial heating and power generation. Energy Storage: Sensible heat storage, liquid media storage, solid media storage, dual media storage, phase change energy storage, Storage Capacity – Other storage .	

3.	Direct Energy Conversion- Solar Photovoltaic, I-V characteristics of solar cells, Tracking – Maximum Power Point Tracking, Battery Characteristics, DC Power Conditioning Converters, AC Power Conditioning –Inverters, Testing of PV systems, Applications of DC power systems and AC power systems, Fuel Cells – principle , types, applications .	
4.	Wind Energy : Principles of Wind energy conversion, site selection considerations, Types of wind power conversion systems – operation, maintenance and economics. Generators for Wind Turbines, Control strategies. Different electrical machines for wind generation and their control.	
5.	Geothermal energy: Ocean thermal energy conversion. Tidal Energy: Wave And Tidal energy – scope and economics, Availability, system development and limitations. Introduction to integrated energy systems.	
6.	Biomass Energy Systems:– Types of plants Small Hydro system:-Classification of hydro turbines, Selection and Sizing. Hybrid Systems: Need for Hybrid Systems; Range and type of Hybrid systems.	
7.	Integration of Solar and wind with grid, their design aspects.	

Assignments / Lab work

1. Study of Solar Energy collectors.
2. Study of solar energy storage.
3. Study of Energy from wind.

Text Book

1. Renewable Energy Systems, Kaltschmitt, M.; Themelis, N.J.; Bronicki, L.Y.; Söder, L.; Vega, L.A. (Eds.) 3 volumes, 2013, XXVI, 1898 p.
2. Introduction to Renewable Energy, Vaughn Nelson, West Texas A&M University, Canyon, USA Published: April 25, 2011 by CRC Press – 408 Pages

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE404	COURSE: Elective – I Analysis and Design of Switched Mode Converters		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	----	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	Practical	---	---
	In semester evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. Give an insight into the design and fabrication of switched mode converters.
2. Introduce the applications of switched mode converters.

Course Outcomes:

1. Ability to acquire and apply knowledge of mathematics and converter/ machine dynamics in electrical engineering.
2. Ability to model, analyze and understand power electronic system and equipment using computational software
3. Ability to formulate, design, simulate power converter for generic load and for machine load or for specific application.

Course Contents:

Module	Details	Hrs.
1.	DC-DC Switched Mode Converters: Review of Buck Converters, Boost Converters, Buck-Boost, CUK & SEPIC converter. Duty cycle derivation, Different conduction modes, (CCM & DCM), Voltage and Current waveforms, Calculation of output voltage ripple, Problems.	
2.	Resonant Converters: Switch-mode inductive current switching, Zero Voltage and Zero Current Switching, Resonant Switch converters, Basic resonant circuit concepts, ZCS and ZVS resonant switch converters, Comparison of ZCS and ZVS topologies.	
3.	Switching DC power Supplies: Linear power supplies, Overview of switching power supplies, Switching losses, Fly back and forward converters, duty cycle derivation, waveforms comparison of converters, Problems	
4.	Control Aspects: Voltage feed-forward PWM converter control, Current mode control, Power supply protection, Electrical isolation in the feedback loop, Designing to meet power supply specifications.	

5.	Converter Design (for Buck, Boost, Flyback & Forward converters only) : Selection of output filter capacitor, Selection of energy storage inductor, Design of high frequency inductor and high frequency transformer, Selection of switches, Snubber circuit design, Pulse width modulator circuit, Design of driver circuits, Necessity of EMI filter	
6.	Thermal Model: Thermal resistance, Selection of Heat Sinks, Simple Heat Sink calculations.	
7.	Application: DC/DC converter as Power factor Corrector (active shaping of the line current) Offline computer power supply system, Uninterruptible AC power supplies, Space craft power supply etc. (AC to DC converters with unity power factor, PWM converters.)	

Term Work:

Consists of 3 tutorials, two simulations and fabrication of a switched mode dc-dc converter.

Text Books:

1. Mohan N. Undeland, T & Robbins W, Power Electronics Converters, Application and Design, John Wiley, 3rd Edition 2002
2. .Umanand L. Bhat S.R, Design of magnetic components for switched mode power converters, Wiley Eastern Ltd, 1992
3. Robert w. Erickson, D. Maksimovic, Fundamentals of Power Electronics Springer International Edition, 2005

Reference Books

1. Krein P.T. Elements of Power Electronics, Oxford University Press
2. M.H Rashid, Power Electronics Prentice-Hall India

Sr. No.	Examination	Module
1	T1	1
2	T 2	2, 3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE405	COURSE: Elective I – Illumination		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	---	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In semester Evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. To get detailed insight into illumination system components, its control and design aspect in order to know the requirements of proper and energy efficient lighting.

Course Outcomes:

1. Demonstrate the ability to design illumination systems for desired specifications.
2. Demonstrate the awareness of impact of energy conservation approach to illumination systems.
3. Incorporate technological developments in existing lighting solutions.

Course Contents:

Module	Details	Hrs.
1.	Light, Sight, Color and Photometry: Electromagnetic radiation, Laws of illumination, illumination entities. Photopic and Scotopic vision of human eye. Radiometric and photometric standards, Choice of right detector, detector specification-construction, details of luminous flux, luminance, and luminance and luminous intensity measuring meters. Photometric measurement procedure-preparation of test report. Spectral power distribution data– assessment of lamp efficacy, Color temperature, Colourometry-Different color specification systems and their limitations. Measurement of CRI, CRI of radiation due to multiple sources, Glare.	
2.	Lamps and Luminaries: Lamp development, construction and characteristics Incandescent lamp, Discharge lamps: fluorescent lamps, CFL, mercury vapor, sodium vapor, metal halide and induction lamp.LED and its application in lighting.Lamp testing procedures. Light field, Optical control methods, advanced techniques of using reflection, refraction, polarization, interference, diffraction, diffusion and absorption in optical control. Materials used for Luminaire manufacturing. Controlgear: ballast, standard and electronic type Basics of Mechanical, thermal and electrical design of luminaire Luminaire photometry, Luminaries testing procedures. Introduction to Luminaries for hazardous area application.	

3.	Interior Lighting Design & Calculation: Objectives, quality and quantity of lighting. Lamp/Luminaries selection and placement, design considerations and calculation. Glare consideration and control. Principle of lighting design-Indoor lighting design by lumen method, by point by point method. Designing problems and solution and designing documentation for :applications Like residential, offices, educational institute, industries, religious buildings, art galleries/museums, retail stores, indoor sports centers, eating outlet setc. Applicable standards.	
4.	Exterior Lighting Design & Calculation: Exterior lighting system- Road lighting system, Utility area lighting, Sports lighting, Decorative floodlighting. Design Consideration for Emergency lighting. Applicable IS standards	
5.	Lighting Monitoring and Control: Lighting control strategies, techniques & equipment, sensors and timers, Impact of lighting control, protocols for lighting control.	
6.	Day lighting Design and Analysis: Daylight availability data and analysis. Lighting integration- day lighting /electric lighting integration. Daylight control and distribution.	
7.	Energy Efficient lighting and Lighting Designs tools: Designing techniques for achieving energy efficiency, Concept of Lighting power density, Software design t o o l s f o r interior lighting, road lighting, flood lighting. Advantages and limitations.	

TermWork:

1. Four lab experiments based on study of lamps and luminaries operation and Construction parameters measurements.
2. Group study report on observation and analysis of existing lighting installation (atleast4) at following areas commercial/noncommercial, industries/ offices, indoor/outdoor, sports center etc.
3. Minimum two designs on interior and exterior lighting based on specific applications. Design calculation and computer aided design.

Text Books:

1. “Designing with light: Lighting Handbook”, Anil Valia; Lighting System2002
2. “LED lighting system”, Anil Valia
3. “Lamps and Lighting”, M .A. Cayless and A.M. Marsden; Edward Arnold
4. “Interior Lighting for Designers”, Gary Gorden, John Wiley & Sons Inc.
5. “Applied Illumination Engineering”, Jack L. Lindsey Fairmont Pr; 2nd edition

Reference Book:

1. “IESNA lighting Handbook: Illuminating Engineering Society of North America 9th edition 2000.
2. “Simplified Design for Building Lighting”, M.Schiler; John Wiley & Sons Inc.
3. IS3646: Part I: 1992, Code of practice for interior illumination.

Sr. No.	Examination	Module
1	T1	1,2
2	T 2	3,4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE 406	COURSE: Elective – I Embedded System		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	---	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In semester Evaluation	---	25
	TOTAL	---	125

- 60% Weightage for end semester

Course Objectives:

1. Introduction to embedded system design.
2. Study of ARM processor.
3. Study of serial communication, analog interfacing and hardware interrupts.
4. Understand the concept of RTOS.

Course Outcomes:

After completion of this course student will be able to:

1. Define the unique characteristics of embedded systems.
2. Discuss the interfacing challenges of embedded processors and peripherals.
3. Demonstrates the basics of an embedded system, program an embedded system, design, implement and test an embedded system.
4. Distinguish between real time embedded system and embedded system with applications.

Course Contents:

Module	Details	Hrs.
1.	Introduction to Embedded systems, Design Metrics, Examples of embedded systems, hardware/software co-design, Embedded micro controller cores (ARM, RISC, CISC, and SOC), embedded memories, sensors and interfacing techniques, Architecture of Embedded Systems.	
2.	Introduction to MSP 430 RISC Controllers, parallel I/O, external interrupts. Introduction to ARM 7 instruction set, addressing modes, operating modes with ARM core, ARM7 TDMI modes, ADC, Timers, Interrupt structure. Byte ordering (LE, BE), Thumb mode normal mode instructions changes, Pipeline utilization with all register allocations, Floating to fixed point conversion fundamentals. System design with ARM as key processor. DSP features of ARM Core Digital Signal Controllers-DSC differences with conventional micro controllers.	
3.	Serial communications: SCI, SPI, Timing generation and measurements. Analog interfacing and data acquisition. Hardware Interrupts: - Various C ISR Declaration syntaxes - Interrupt Vectors, Priorities and Nesting - Tick Timer Interrupt as heart-beat of embedded system 7-Seg LED, Segment-LCD, Alphanumeric LCD, Graphic LCD displays	

	<p>Communications and Networks</p> <ul style="list-style-type: none"> - RS485 (2 and3 wire)and Modbus Protocol (Intro only) - Ethernet and TCPIP Stack (Features and Usage only) - CAN features and protocol 	
4.	<p>Software Programming in Assembly Language (ALP) and in High Level Language ‘C’, ‘C’ Program Elements: Header and Source Files and Preprocessor Directives, Program Elements: Macros and Functions, Program Elements: Data Types, Data Structures, Modifiers, Statements, Loops and Pointers, Queues, Stacks, Lists and Ordered Lists, Embedded Programming in C++, ‘C’ Program Compiler and Cross-Compiler, Source Code Engineering Tools for Embedded C/C++, Optimization of Memory Needs.</p>	
5.	<p>Real-time concepts, real-time operating systems, Required RTOS services/capabilities (in contrast with traditional OS). Real-world issues: blocking, unpredictability, interrupts, caching, Benefits of using RTOS</p> <ul style="list-style-type: none"> - Concepts of Tasks/Threads/Process - Multitasking - Task Scheduling - Task management - Inter-task communication and Synchronization: - Device Drivers - How to choose an RTOS 	
6.	<p>Fundamentals of Design and Development, Program Modeling tools Testing and Debugging methodologies.</p>	
7.	<p>Applications of Embedded Systems: case studies</p> <ul style="list-style-type: none"> - Industrial and Automation - Medical - Robotics - Access Control Systems (Smart Cards, RFIDs, Finger Scan) 	

Term work: Term work will consist of minimum six experiments, Assignments.

Text Books:

1. Rajkamal, Embedded Systems – Architecture, Programming and Design, Tata McGraw Hill, Second edition, 2009.
2. Shibu K V , Introduction to Embedded Systems , Tata Mc Graw Hill, 2009.
3. SriramIyer and Pankaj Gupta, Embedded Realtime Systems Programming, Tata McGraw Hill, first edition, 2003.

References

1. Jonathan W. Valvano ,Thomson, Embedded Microcomputer Systems
2. David E. Simon,Pearson Education, An Embedded Software Primer
3. Dr. K.V.K.Prasad, Dreamtech Press, Embedded real time system.

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS : B. Tech. Electrical		
CODE: BTE 407	COURSE: Elective – I: Image Processing		
Period per week (each of 60 minutes)	Lectures	03	
	Laboratory	----	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In semester Tests	01	20*2
	End Semester*	03	100
	In semester Evaluation	--	25
	Total	--	125

- 60% Weightage for end semester

Course Objectives:

1. To develop an overview of the field of image processing
2. To learn the fundamental concepts of Digital Image Processing
3. To understand basic image enhancement and segmentation techniques
4. To illustrate Image Transform calculations mathematically and develop fast transform algorithm
5. To learn Image Compression and Decompression Techniques.

Course Outcomes:

After successful completion of the course student will be able to

1. Understand the concept of Digital Image processing.
2. Explain image enhancement and Segmentation technique
3. Understand Digital Image compression and decompression techniques
4. Perform Binary Image Processing

Module	Details	Hrs
1	Introduction: Background, Digital Image Representation, Fundamental Steps in Image Processing, Elements of a Digital Image Processing System	
2	Digital Image Fundamentals: Elements of Visual Perception, A Simple Image Model, Sampling and Quantization, Some Basic Relationships between Pixels, Imaging Geometry. Image File Formats: BMP, TIFF and JPEG. Color Models (RGB, HSI, YUV)	
3	Image Enhancement: Spatial Domain Methods, Frequency Domain Methods, Some Simple Intensity Transformations, Histogram Processing, Image Subtraction, Image Averaging, Background Smoothing Filters, Sharpening Filters, Low pass Filtering, High pass Filtering, Generation of Spatial Masks from Frequency Domain Specifications. Homomorphic Filtering	

4	<p>Image Segmentation and Representation:</p> <p>(i) Detection of Discontinuities, Edge Linking using Hough Transform, Thresholding, Region based Segmentation, Split and Merge Technique,</p> <p>(ii) Image Representation and Description, Chain Code, Polygonal, Representation, Shape Number, Moments.</p>	
5	<p>Binary Image Processing:</p> <p>Binary Morphological Operators, Hit-or-Miss Transformation, Boundary Extraction, Region Filling, Thinning and Thickening, Connected Component Labeling, Iterative Algorithm and Classical Algorithm</p>	
6	<p>Image Transform:</p> <p>(i) Introduction to the Fourier Transform, The Discrete Fourier Transform, Some Properties of the Two-Dimensional Fourier Transform Fast Fourier Transform(FFT),</p> <p>(ii) Discrete Hadamard Transform(DHT), Fast Hadamard Transform(FHT), Discrete Cosine Transform(DCT), Discrete Wavelet Transform(DWT),</p>	
7	<p>Image Compression:</p> <p>Fundamentals – Coding Redundancy, Interpixel Redundancy, Psycho visual Redundancy, Fidelity Criteria.</p> <p>Image Compression Models – The Source Encoder and Decoder, Lossless Compression Techniques : Run Length Coding, Arithmetic Coding, Huffman Coding, Differential PCM</p> <p>Lossy Compression Techniques: Improved Gray Scale Quantization, Vector Quantization, JPEG, MPEG-1.</p>	

Recommended Books:

1. Rafael C. Gonzalez and Richard E. Woods, ‘Digital Image Processing’, Pearson Education Asia, Third Edition, 2009,
2. S. Jayaraman, E. Esakkirajan and T. Veerkumar, “Digital Image Processing” Tata McGraw Hill Education Private Ltd, 2009,
3. Anil K. Jain, “Fundamentals and Digital Image Processing”, Prentice Hall of India Private Ltd, Third Edition

Sr. No.	Examination	Module
1	Test I	1, 2, 3, 4(i)
2	Test II	4(ii), 5, 6(i)
3	End Semester	6(ii), 7

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE408	COURSE: Elective –II High Voltage Engineering		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	---	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In semester Evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. Know the fundamentals of high voltage laboratory techniques.
2. Understand high-voltage phenomenon.
3. Present the basic of high-voltage insulation design and testing.
4. Understand the analytical and modern numerical tool available to high-voltage equipment designers.

Course Outcomes:

1. Understand the concept of high voltage engineering and the basics of high voltage insulation and testing.
2. Able to know the modern numerical tool available for high voltage equipment designers.
3. Analyze behavior of high voltage equipment in the presence of impurities, unexpected outages and/or load variations using numerical and computerized tools.
4. Design layout of high voltage laboratory with various high voltage equipments and tools.

Course Contents:

Module	Details	Hrs.
1.	Electrostatic Fields, their control and estimation: Electric field stress, its control and estimation, Analysis of electrical field intensity in homogenous isotropic Single dielectric and multi-dielectric systems, Introduction to Numerical methods for the estimation of electrical field intensity.	
2.	Conduction and breakdown in air and other gaseous Dielectrics in electric fields: Ionization processes, Townsend's current growth equation (Primary and Secondary processes), Townsend's criterion for breakdown in electronegative gases, Paschen's law, Breakdown in non-uniform fields and Corona discharges, Post breakdown phenomenon and application, practical considerations in using gas for insulation purposes.	
3.	Conduction and breakdown in liquid dielectrics: Conduction and breakdown in pure liquids, Conduction and breakdown in commercial liquids.	

4.	Breakdown in solid dielectrics: Intrinsic, Electromechanical and Thermal breakdown, Breakdown of solid dielectrics in practice, Breakdown of composite insulation, Solid dielectrics used in practice, Application of insulating materials in electrical power apparatus, electronic equipments. HV fault testing (cable fault testing, impulse current testing, partial discharge, break down of gases, NDT)	
5.	Generation and Measurement of High-voltage and Currents : Generation of HV DC and HV AC and impulse voltage, Generation of impulse current, Tripping and control of impulse generators, Measurement	
6.	Testing and Evaluation of dielectric material and power apparatus: Non-destructive testing of dielectric materials, DC resistivity measurement, dielectric and loss factor measurement, partial discharge measurement, testing of insulators, brushing, isolators, circuit breakers, cable, transformers, high voltage motors and surge diverters, Radio interference measurement.	
7.	High-voltage laboratory Designplanning and layout : Size and dimensions of the equipment and their layout, Earthling and its importance.	

Term Work: At least 6 experiments / assignments and a report on visit to a high-voltage laboratory covering the topics mentioned in the above syllabus.

Text Books:

1. Naidu M.S and Kamaraju V, High-voltage Engineering TMH publications 2nd Edition 1995.
2. Wadhwa C.L, High-voltage Engineering Wiley Eastern Ltd 1st Edition 1994.
3. Kuffel E and Abdullah M, Introduction to High-voltage Engineering Pergamon 1970.
4. Kuffel E, High-voltage Engineering Pergamon 1984.

Reference Books:

1. E. Kuffel, W.S. Zaengl, and J. Kuffel, High-voltage Engineering Fundamentals 2nd edition Elsevier publications.
2. Dieter Kind and Kurt Feser, High-voltage test techniques (SBA Electrical Engineering series) by Shankars Book agency Pvt. Ltd.

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE409	COURSE: Elective – II Restructuring and Deregulation of Power System		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	---	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In Semester Evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. Overview of power system in India.
2. Understand power sector economics and regulation.
3. Introduction to power system restructuring and market reforms.
4. Overview of transmission planning and pricing.

Course outcomes:

1. Able to understand power sector economics and regulation, power system restructuring and market reforms.
2. Analyzing the competition in electricity markets and understands the concept of different trading models
3. Demonstrate transmission planning and pricing.
Pre-requisite : Basic knowledge of economics is expected.

Course Contents:

Module	Details	Hrs.
1.	Power Sector in India: Evolution of integrated, monopoly state electricity board (SEB's), Introduction to various institutions in Indian power sector such as CEA, Planning Commission, PFC, Ministry of Power, State and Central Governments, REC, Financials Institutions, PTC utilities and their roles, challenges before Indian power sector, Electricity act 2003 and various National policies and guidelines under the act, Introduction to Indian Energy Exchange and it's working.	
2.	Power Sector Economics: Introduction to various concepts such as capital cost, debt and equity, depreciation, fixed and variable costs, working capital, profitability indices, net profit value, life cycle cost etc. Typical cost components of utilities such as return in equity, depreciation, interest and financial charges, O and M expenses etc, and their determinants, Introduction to average, marginal and avoided costs, Tariff setting principles and choice of rate structure, Concepts of subsidy and cross-subsidy.	
3.	Power Sector Regulation: Role of regulation and evolution of regulatory commission in India, Types and methods of regulation (rate of return regulation, performance based regulation, incentive regulation, benchmarking or yardstick regulation), The regulatory process in India (composition of RC's, selection, authority regulatory decision making	

	process), Non price issues in regulation such as externalities (environment etc) Service quality, Consumer service, Social equity, transparency and public participation in regulatory process.	
4.	Introduction to Power Sector Restructuring: Introduction, models based on energy trading or structural models- Monopoly, single buyer, wholesale competition etc. Ring fencing and accounting separations, models based on contractual arrangements – pool model, bilateral dispatch.	
5.	Introduction to Power Sector Market Reforms: Pool and bilateral trades, multilateral trades, ownership models (Public sector – state owned and municipal utilities, cooperatives, private sector, public-private partnership), rationale behind reforms, competition for the market v/s competition in the market, International experience with electricity reform – Latin America, The Nordic Pool, UK, USA, China, and India(Oriassa, AP and Maharashtra), The California Energy Crisis.	
6.	Competitive Electricity Market: Trading – Electricity market places, rules that govern the electricity markets, peculiarity of electricity as commodity, various models of trading arrangements – integrated trading model, wheeling trading model, decentralized trading model. Retail Competition – retail access framework, competing retailers, metering and accounting issues, technological aspects of competition, Impact of market reform on regulation and externalities (environment social equity etc).	
7.	Transmission Planning and Pricing: Transmission planning in the era of market structure, transmission rights and pricing, different methods of transmission pricing, different transmission services (ancillary services etc), congestion issues and management, grid codes, transmission ownership and control – Transco and ISO, Transmission pricing and model in India – availability based tariff (ABT), role and load dispatch centers (LDC's), open access.	

Text Books

1. Deregulation in Power Industry Proceedings of a course under continuing education program held by Dept of Electrical Engineering IIT Mumbai.
2. Know your Power, A citizen primer on the electricity sector, Prayas Energy group Pune.

Reference Books:

1. Bhanu Bhushan, ABC of ABT – A primer on Availability Tariff
2. Central Electricity Regulatory Commission, Regulation and Orders
3. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy.
4. Electricity Acts and National Policies
5. Maharashtra Electricity Regulatory Commission, Regulations and Orders
6. Paper The Real Challenges in Power Sector Restructuring: Instilling Public control through TAP, Prayas Energy Group, Energy for Sustainable development Sept 2001
7. Privatization or Democratization, The Key to the Crisis in the Electricity Sector ,

The case of Maharashtra 2002

8. Regulation in Infrastructure Services, Progress and the way forward, TERI 2001
9. Sally Hunt, Making Competition work in Electricity, 2002, John Wiley Inc.
- 10 Various Publications, reports and presentations by Prayas Energy Group, Pune

Website:

1. www.cercind.com
2. www.powermin.nic.in
3. www.ixindia.com
4. www.mercindia.com
5. www.prayaspune.org

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VII	CLASS: B.Tech. Electrical		
CODE: BTE410	COURSE: Elective – II DSP Applications in Power System		
Period per week (each of 60 minutes)	Lecture	03	
	Laboratory	02 hours/batch	
	Tutorial	---	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In semester evaluation	---	25
	TOTAL	---	125

* 60% Weightage for end semester

Course Objectives:

1. To make students aware of need and advantages of DSP techniques.
2. Appreciation of state of the art approach to digital solutions.

Course Outcomes:

1. Ability to apply various numerical relaying algorithms.
2. Ability to use DFT and FFT techniques.
3. Design of FIR and IIR filters.

Detailed Syllabus:

Module	Details	Hrs.
1.	Overview of the Application of DSP in Power System. Need For Numerical (Digital / Computer Based) Controllers. Basic Structure of DSP Based Systems.	
2.	Power System & DSP System Interface: Signal Transducers, Signal Conditioning: .Data Conversion System Analysis And Design: (Sampling: Shannon’s Sampling Theorem, Phenomenon Of Aliasing, Anti-Aliasing Filter Design, Sampling Process, Necessity Of Sample & Hold , Choice Of Sampling Frequency, A/D & D/A Conversion And Quantization Noise, Techniques Of Reducing Quantization Noise, Over-Sampling ADC , Sigma Delta Modulator)	
3.	Introduction To General Purpose Digital Signal Processors: Computer Architecture for Signal Processing, Special Purpose DSP Hardware, DSP Arithmetic, ADC Quantization Noise and Signal Quality, Finite World Length Effects, Correlation & Discrete Transform (DFT , Wavelet, Etc) Techniques for Extraction of Fundamental and Harmonic Components Form the Voltage and Current Waveform Samples.	
4.	DSP Based Relays; Discrete Time FIR and IIR Filters For Implementations of Numerical Relay Algorithms. Power Electronics System Controllers, Some	

	Simple Schemes	
5.	Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs. Implementing digital processor based control systems for power electronics.	
6.	Reference frame transformations, PLL implementations, machine models, harmonic and reactive power compensation, space vector PWM.	
7.	Numerical integration methods. Comparison in terms of time step, stability	

Assignments / Lab work

1. Generation of sine waves
2. Estimation of single phase power
3. Estimation of three phase power
4. Generation of space vector of voltage and currents
5. Generation of Harmonics

Text Book

1. A.T. Johns, S.K. Salman, Peter Peregrinus, Digital protection for Power Systems, IEE–U.K. 1995
2. Emmanuel C., Ifeachor, Barrie W Jervis, Digital Signal Processing (A Practical Approach), Pearson Education Asia, Second Edition
3. Alan V Oppenheim, Ronald W Schafer, Discrete time signal Processing, Prentice Hall of India (private)Limited, New Delhi, 1994
4. Vinay K Ingle, John G Proakis, Digital Signal Processing Using MATLAB Brooks/Cole Publishing Company
5. Prabhakar S Naidu, Modern Digital Signal Processing, Narosa Publishing house New Delhi, second edition 2006
6. A.G. Phadke , J.S. Thorp, Computer Relaying for Power Systems , Wiley Research Studies Press (2006)

Sr. No.	Examination	Module
1	T1	1, 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VIII	CLASS: B.Tech. (Electrical)		
CODE: BTE411	COURSE: Modern Control Theory		
Period per week (each of 60minutes)	Lecture	03	
	Practical	--	
	Tutorial	02 per batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester*	03	100
	In semester Evaluation	---	25
	TOTAL		125

*60% Weightage for End semester

Course Objective

The purpose of the course is

1. To introduce the nature of nonlinearities found in systems and control
2. To learn standard methods of analysis and design in linear systems
3. To learn standard methods of analysis and design in nonlinear system.

Course Outcome:

Upon successful completion, a student should able to:

1. Understand and apply concepts of linear algebra for system analysis.
2. Understand and develop mathematical models of various systems.
3. Linearize a nonlinear system and analyze the linear system from control perspective.
4. Perform stability analysis of linear and nonlinear systems
5. Use software tools to demonstrate analysis.

Module	Details	Hrs.
1.	Linear Algebra: Introduction, Basis Representation and Ortho-normalization, Linear Algebraic Equations, Similarity Transformation, Diagonal Form, Jordan form, norms of vectors and matrices, Quadratic Forms and Positive Definiteness.	
2.	Non-linear systems: Introduction, behavior of non-linear system, common physical non linearity-saturation, friction, backlash, dead zone, relay, multi variable non-linearity.	

3.	Phase Plane Analysis: Concept of phase plane, constructing phase portrait, Phase plane analysis of linear systems, Phase plane analysis of nonlinear systems, Existence of limit cycles.	
4.	Fundamentals of Lyapunove theory: equilibrium points, concept of stability, linearization of nonlinear systems, Local stability, Lyapunov Equation, Liapunov's direct method, Stability and instability theorems.	
5.	System analysis based on Liapunov's direct method and Control Design based on Liapunov's direct method.	
6.	Describing Functions: Stability analysis and limit cycles, Linear compensation methods, General describing functions of common nonlinearities, Relative stability.	
7.	Feedback linearization: feedback linearization and canonical form, Input-state linearization, Input- output linearization.	

Term work: The term work shall consist of at least six tutorials covering the whole syllabus and two computer simulations using software such as MATLAB / SCILAB.

Reference Books:

1. Slotine, J. E. & Weiping Li, Applied Nonlinear Control, Prentice-Hall, [1991]
2. Khalil, Hasan K., Nonlinear Systems, Macmillan Publishing, [1992]
3. Chi-Tsong Chen, "Linear Systems Theory and Design", Oxford University Press New York, 1999.
4. T. Kailath, "Linear Systems", Prentice-Hall, New Jersey, 1980, Science and Business Media 2008.
5. Gilbert Strang, "Linear Algebra and its Application", Fourth Edition CENGAGE Learning
6. Ogata, K., Modern Control Engineering, Prentice-Hall, [2002]
7. Gopal, M., Modern Control System Theory, John Wiley Eastern Ltd. New Delhi, [1984]
8. Friedland, B., Control System Design, McGraw-Hill, [1986]
9. Ogata, K., State Space Analysis of Control Systems, Prentice-Hall, [1967]
10. Kuo, B. C., Automatic Control Systems, Prentice-Hall, [1987]

Final Year B.Tech.Sem. VIII
Electrical Engineering
Credit System And Course Content
Year 2017-18

EM VIII	Class: B. Tech. Electrical		
CODE: BTE426	COURSE: Electrical Drives and Controls		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	--	
Scheme of Evaluation		Duration (Hrs)	Marks
	In Semester Tests	01	20
	End Semester Exam*	03	100
	Total		100

*60% weightage for end semester exam.

Course Objectives:-

1. This course is designed to understand fundamentals of electric drives and their control through Knowledge of electrical machines and power electronics.
2. The scope of this course covers basics, dynamics, selection, braking and control of AC/DC drives.
3. Students are expected to learn more by studying application of drives in industry.
4. Ability for the selection of motor as per the torque-speed characteristics of load.

Course Outcomes:

After learning the course the student should be able to:

1. Understand the fundamental concept of electrical drives system.
2. Select an electrical drive for a particular application and based on mechanical characteristics of load
3. Control of DC motor using conventional and solid state drives.
4. Control of AC motor using conventional and solid state drives.

Course Contents:

Module	Details	Hrs.
1.	Introduction: Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives	
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.	
3.	Selection of Motor Power Rating: Thermal Model of motor for heating and cooling, Classes of motor rating, Determination of motor rattling.	

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.	
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 and series motor).	
6.	AC Drives: (i) Induction motor drives, Review of speed-torque relations, Review of starting methods, Braking (Regenerative, Plugging, AC/DC Dynamic braking), (ii) 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 drives.	
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.	

Term Work: Term work will consist of at least 6 experiments / assignments performed, properly recorded.

Text Books:

1. Dubey G.K, Fundamentals of Electric Drives, Narosa
2. Subrahmanyam V, Electrical Drives: Concepts and Applications TMH
3. Krishnan R, Electric Motor Drives: Modeling, Analysis and Control PHI
4. Pillai S.K, A First course on Electrical Drives Wiley Eastern PH

Reference Books:

1. Bose B.K, Modern Power Electronics and AC Drives, Pearson Education Asia
2. Rashid M.H, Power Electronics: Circuits, Devices and Application PHI

Sr. No.	Examination	Module
1	T1	1, 2, 3
2	T 2	4, 5, 6
3	END SEMESTER	1 to 7

SEMESTER-VIII	CLASS: B.Tech. (Electrical)		
CODE:BTE476	COURSE: Electrical Drives and Control Lab		
Period per week (each of 60 minutes)	Lecture		
	Laboratory	02 hours/batch	
	Tutorial	---	
Scheme of Evaluation		Hours	Marks
	In Semester	-	25
	End Semester*	-	-
	Practical	02	--
	TOTAL	---	25

Course Objectives:

1. To handles the lab apparatus and develop confidence in operating the machine.
2. Able to develop the different experiment on AC-DC drives.
3. Understand the operating characteristics of machines under different operating conditions from the collected data.

Course Outcomes:

1. Demonstrates very good knowledge of the lab procedures and helps other students to follow procedures along with safety measures.
2. Implementation and verification of the basic characteristics AC-DC machines under starting and braking conditions
3. Compare the Conventional Control and Higher level control of electrical drives.
4. Evaluation of the performance of the drives using graphical analysis based on the collected data.

List of Experiments

1. Simulation of Electrical drive.
2. Simulation of starting of DC motor (soft start).
3. Dynamic braking of DC motor.
4. Plugging of DC motor/Plugging while lowering the load.
5. Regenerative braking of DC motor (by making $V < E_b$) for high inertia load.
6. DC or AC Dynamic braking of 3 phase induction motor.
7. Plugging of induction motor.
8. Single phase full wave controlled DC motor drive.
9. Chopper Drive.
10. V/F control of Induction motor using PWM inverter.
11. Measurement of moment of inertia by retardation test.
12. Study of stepper motor drive.

SEMESTER-VIII	Class: B. Tech. Electrical		
CODE: BTE427	COURSE: Power Electronics applications in Power System		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20*2
	End Semester	03	100
	In semester Evaluation	--	25
	Total		125

*60% weightage for end semester exam.

Course Objectives:-

1. To study the operation of power system components that improves the power system performance.
2. Introduction of series & shunt compensation for transmission lines.
3. Discuss reactive power support & elimination of harmonics using Voltage Source Inverters.
4. To study the operation & control of HVDC transmission system.

Course Outcomes:

1. Understand the various methods of improving power system performance.
2. Able to analyze the existing system for performance improvement
3. Able to create the system performance improvement using advanced technology

Detailed Syllabus

Module	Details	Hrs.
1.	Introduction: Brief discussion on Transmission line theory, use of Voltage source inverters (VSI) for reactive power support, mid-point series and shunt compensation and HVDC, Discussion on voltage profile at the point of common coupling (PCC), need for load compensation, load balancing using passive elements, Limitations of load balancing using passive elements.	
2.	Use of VSI as a Var generator, Indirect current controlled Synchronous link converter Var Compensator (SLCVC), Various PWM techniques, Harmonic elimination and space vector PWM techniques, theory and implementation issues, Expression for active and reactive powers in terms of d-q components, stationary to rotating frame transformation,	
3.	Shunt Compensation Introduction, methods of Var generation, Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC), Fixed capacitor-thyristor controlled reactor (FC-TCR), STATCOM.	
4.	Series Compensation Introduction, comparison between series and shunt compensation, various equipments: GTO controlled series capacitor (GCSC), comparison of TCR and GCSC, Thyristor switched series capacitor (TSSC), Thyristor controlled series capacitor (TCSC), Static Synchronous Series compensator (SSSC), modes of operation, voltage regulator, and Phase angle regulator (PAR), Multi-function FACTS controller, Unified power flow controller (UPFC), control capabilities of UPFC,	

5.	HVDC: Introduction, various possible HVDC configurations, unipolar and bipolar links, components of HVDC systems – converter, transformer, smoothing reactor, harmonic filter, Reactive power support.	
6.	HVDC Operation of 6-pulse controlled rectifier in inverting mode of operation, effect of source inductance, equivalent circuit representation of 6-pulse converter considering effect of source inductance, operation of 12-pulse converter.	
7.	Control of HVDC systems: Rectifier and inverter characteristics, mode stabilization, current control, voltage dependent current order limit, combined rectifier-inverter characteristics, wave blocking and by-passing, limitation of HVDC system using line commutated converters, modern HVDC systems – HVDC light.	

Term work contains 7-8 simulations/ tutorials based on the above syllabus

Text Books

1. Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS: Concepts and technology of flexible AC transmission systems, IEEE Press, 2000

References

1. K. R. Padiyaar , HVDC Power transmission and system
2. K R Padiyaar , Facts controllers in power transmission and distribution

Sr. No.	Examination	Module
1	T 1	1 , 2 , 3
2	T 2	4 , 5 , 6
3	END SEMESTER	1 to 7

SEMESTER-VIII	Class: B. Tech. Electrical		
CODE: BTE428	COURSE:- Elective II–Traction		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 per batch	
Scheme of Evaluation		Duration (Hrs)	Marks
	In Semester	01	20*2
	End Semester	03	100
	Term-work	--	25
	Seminar	--	--
	Total		

*60% weightage for end semester exam.

Course Objectives:-

1. Classify basic systems of traction related to the Indian scenario.
2. Compare the application and control of different types of motors for traction application.
3. Describe and sketch parameters of Overhead Equipment (OHE).
4. To examine and study Railway signaling, Communication and safety.

Course Outcomes:

1. Able to differentiate and justify systems of traction and types as per Indian scenario.
2. Able to justify the application of motors and their control relevant to electric traction.
3. Compare OHE, signaling, and protection in electric traction.
4. Design simplified electric traction for daily usage. **Prerequisite:** Electrical Machines, Power Electronics, Drives.

Course Contents:

Module	Details	Hrs.
1.	Traction system : Principle, History and introduction to systems of traction, Steam engine drive – Internal combustion engine drive – Electric drive – Diesel Electric traction – Electric transmission, Choice of traction systems for India, Power Supply Systems for Track Electrification, Booster transformer , Rail connected booster transformer, Booster transformer with return feeder, Comparison between pure a.c and d.c systems, Urban traction ,metros, monorails , high speed magnetic levitation etc.	
2.	Mechanics of train movement: Speed-time curve for train movement, tractive effort and T-N curve of a typical train load, specific energy consumption (SEC), & factors affecting SEC, Adhesion and coefficient of adhesion, suspension and mechanism of torque transmission, concept of weight transfer & effect of unstrung mass and wheel diameter.	
3.	Traction motor drives and control Types of traction motor best suited for traction duties, available motor characteristics and their suitability for traction duties, organization of design and construction features for improved power to weight ratio, DC/AC traction employing poly phase motors, Traction control of DC locomotives and EMU's, traction control system of AC locomotives, control gear, PWM control of induction motors, vector control of IM, power and auxiliary circuit equipment (other than traction motors).	
4.	Overhead Equipment (OHE): Principles of design of OHE , Sectionalizing, bonding of Rails AND Masts, materials employed in OHE, Current Collection Systems Conductor rail equipment , Current collection gear for OHE , Cable collector, Pole collector, Bow collector, Pantograph collector, Quality of current collection	

5.	Electric Traction sub-system(Power supply installations): Layout design of 137/25KV 07 traction substation, dual phase 2x25kv AC system, Feeding post, Feeding and sectioning arrangements, Sectioning and paralleling post, Subsectioning and paralleling post , Subsectioning post , Elementary section, Miscellaneous equipment at control posts or switching stations ,Major equipment at substation, Transformer, Circuit breaker, Interruptor, protection system for a.c system, Remote control centre.	
6.	Protection of electric locomotive equipments and circuits (safety consideration and 07 Monitoring) Broad strategy for protection, surge protection, overload protection of main power circuits, Earth fault protection of power of auxiliary circuits, protection from over voltage and under voltage, differential protection of traction circuits, protection against high and low air pressure in the compressed air circuit, temperature monitoring, protection of transformer by Bucholz relay, protection against accidental contact with HT equipment, protection against fires	
7.	Railway Signalling and Communication: Block section concepts, track circuits, interlocking principle, train speed and signalling, solid state interlocking, automatic warning systems , Cab signalling, signalling level crossing, underground tunneling , ventilation system, SCADA control, Remote control system equipment and network.	

Term work: Term work will consists of at least 6 experiments / assignments and an industrial visit report.

Text Books:

1. Upadhayay J. and Mahindra S. N. Electric Traction, Allied Publishers Ltd, 1st edition
2. Rao P. S. Principles of 25 KV Overhead Equipments, R(Nasik) Printpack Pvt. Ltd. 1st Edition
3. Fundamentals of Electric Drives, Gopal K. Dubey, Narosa Publishing
4. Modern Electric Traction, Partap, Dhanpat Rai and Sons

Websites:

1. www.irieen.com (Indian Railway Institute of Electrical Engineering, Nasik Road)
2. www.wr.railnet.gov.in/bctweb/ELECTRICAL.html
3. www.irfca.org
4. www.scrailway.gov.in

Sr. No.	Examination	Module
1	T 1	1 , 2
2	T 2	3, 4
3	END SEMESTER	1 to 7

SEMESTER-VIII	Class: B. Tech. Electrical		
CODE: BTE429	COURSE: Elective II- Smart Grid		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Hours	Marks
	In Semester Tests	01	20
	End Semester Exam*	03	100
	In Semester Evaluation	--	25
	Total		125

*60% weightage for end semester exam

Course Objectives:-

1. To understand the concepts and need of smart grid.
2. To study and understand the requirements of Smart Meters, real time pricing, Smart appliances, Automatic Meter Reading.
3. To understand concepts of micro grid, need and applications of micro grid.
4. To study the integration of various renewable power sources and its security system.
5. To understand the concept of Power Quality Management in Smart Grid.

Course Outcomes:

4. To bring awareness of current and possible future role of smart grid and microgrid.
5. Understand the role of information and communication technology for smart grid
6. Understand the importance of cyber security for smart grid.
7. To evaluate power quality management in smart grid.

Detailed Syllabus

Module	Details	Hrs.
1.	Introduction to Smart Grid Evolution of Electric Grid, concept of Smart Grid, definitions, need of Smart Grid, functions of Smart Grid, opportunities and barriers of Smart Grid, difference between conventional and Smart Grid, concept of resilient and self healing Grid, present development and international policies in Smart Grid, Case studies of Smart Grid, CDM opportunities in Smart Grid.	
2.	Smart Grid Technologies Part I Introduction to Smart Meters, real time pricing, Smart appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicle (PHEV), Vehicle to Grid, Smart sensors, Home and building automation, Phase shifting transformers.	
3.	Smart Grid Technologies Part II Smart substations, substation automation, feeder automation, Geographic Information Systems (GIS), Intelligent Electronic Devices (IED) & their application in monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase measurement unit (PMU).	
4.	Micro grids and Distributed Energy Resources Concepts of micro grid, need and applications of micro grid, formation of micro grid, issues of	

	interconnection, protection and control of micro grid, Plastic and organic solar cells, thin film solar cells, variable speed wind generators, fuel cells, micro turbines, captive power plants, integration of renewable energy sources.	
5.	Power Quality Management in Smart Grid Power quality & EMC in Smart Grid, power quality issues of grid connected renewable energy sources, power quality conditioners for Smart Grid, Web based Power Quality monitoring, Power quality Audit.	
6.	Information & Communication Technology for Smart Grid Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, Zigbee, GPS, Wi-Fi, Wi-Max based communication, Wireless mesh network.	
7.	Security for Smart Grid Basics of CLOUD computing and cyber security for Smart Grid, Broadband over Power Line (BPL), IP based protocols.	

Teamwork contains 7-8 simulations/ tutorials based on the above syllabus

Text Books:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai, Integration of Green and Renewable Energy in Electric Power Systems, Wiley.
2. Clark C. Gellings, The Smart Grid – Enabling Energy Efficiency and Demand Response CRC press.
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, Smart Grid – Technology and Applications, Wiley.
4. Jean Claude Sabonnadière, NouredineHadjsaid, Smart Grids, Wiley Blackwell.
5. Peter S. Fox, Penner, Smart Power – Climate Changes, the Smart Grid and the Future of Electric Utilities, Island Press, 1st Edition 8th June 2010.
6. Stuart Borlase, Smart Grids (Power Engineering) CRC Press.
7. S.Chowdhury, S. P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, Institution of Engineering and Technology, 30th June 2009.

Reference Books:

1. Andres Carvallo, John Cooper, The Advanced Smart Grid – Edge Power Driving Sustainability, Artech house Publishers, July 2011.
2. James Northcote, Green, Robert G. Wilson, Control and Automation of Electric Power Distribution Systems (Power Engineering), CRC Press.
3. MladenKezunovic, Mark G. Adamiak, Alexxander P. Apostolov, Jeffery George Gilbert, Substation Automation (Power Electronics and Power Systems), Springer
4. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, Electrical Power System Quality, 2nd Edition McGraw Hill Publication.
5. Yang Xiao, Communication and Networking in Smart Grids, CRC Press

Sr. No.	Examination	Module
1	T 1	1, 2
2	T 2	3, 4
3	End Semester	1 to 7

SEMESTER-VIII	Class: B. Tech. Electrical		
CODE: BTE430	COURSE: Elecive – II Power System Dynamics		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Duration (Hrs)	Marks
	In Semester	01	20*2
	End Semester Exam*	03	100
	In semester evaluation	--	25
	Total		125

*60% Weightage for end semester exam

Course Objectives:

1. Study the stability considerations in power system.
2. Understanding the different stability of power system and multi-machine stability concept
3. Study of voltage stability, PV, QV and PQ curves
4. Study of improving the stability of power system

Course Outcomes:

1. Students should be able to understand and appreciate the stability concept in the power network.
2. Student should understand the effects of various electrical parameter on the the stability

Detailed Syllabus:

Sr. No.	Description	Hrs
1	Power system stability considerations – definitions-classification of stability-rotor angle and voltage stability-synchronous machine representation –classical model-load modeling concepts modeling of excitation systems-modeling of prime movers.	
2	Transient stability-swing equation-equal area criterion-solution of swing equation-Numerical methods-Euler method-Runge-Kutta method-critical clearing time and angle-effect of excitation system and governors	
3	Multi machine stability –extended equal area criterion-transient energy function approach.	
4	Small signal stability – state space representation – eigen values- modal matrices-small signal stability of single machine infinite bus system	
5	Synchronous machine classical model representation-effect of field circuit dynamics-effect of excitation system-small signal stability of multi machine system.	

6	Voltage stability – generation aspects - transmission system aspects – load aspects – PV curve – QV curve – PQ curve – analysis with static loads – load ability limit – sensitivity analysis-continuation power flow analysis - instability mechanisms- examples.	
7	Methods of improving stability – transient stability enhancement – high speed fault clearing – steam turbine fast valving-high speed excitation systems- small signal stability enhancement power system stabilizers – voltage stability enhancement – reactive power control.	

Termwork: Contains 7-8 simulations/ tutorials based on the above syllabus

Recommended Books:

1. Kundur, P., “Power System Stability and Control”, McGraw-Hill International Editions, 1994.
2. Anderson, P. M. and Fouad, A. A., “Power System Control and Stability”, John Wiley, second edition 2003.
3. Van Cutsem, T. and Vournas, C., “Voltage Stability of Electric Power Systems”, Springer

Tentative syllabus for Examinations:

Sr. No.	Examination	Module
1	Test I	1, 2, 3
2	Test II	3, 4, 5
3	Final Examination	1 to 7

SEMESTER-VIII	Class: B. Tech. Electrical		
CODE: BTE431	COURSE: Elecive – I Robotics		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Duration (Hrs)	Marks
	In semester Tests	01	20*2
	End Semester Exam*	03	100
	In semester evaluation	--	25
	Total		125

*60% weightage for end semester exam.

Course Objectives:-

1. This course familiarizes students with the concepts and techniques in robot manipulator control.
2. Its main objective is to make students familiar with the Kinematics and Dynamics involved in robotic manipulator used in automation industry.
3. To study and appreciate the need of control theory to control such a complex nonlinear.

Course Outcomes: Students will be

1. Able to appreciate the importance of robotic arm and its applications in automation industry.
2. Able to appreciate the importance of control system theory to control such a complex nonlinear robotic arm.
3. Able to describe the kinematic and dynamic model of robotic arm.
4. Able to appreciate the importance of path, task and trajectory planning

Course Contents:

Module	Details	Hrs.
1.	Introduction to Robotics Automation and Robots, Classification, Application, Specification, Notations.	
2.	Direct Kinematics Dot and Cross Products, Co-ordinate frames, Rotations, Homogeneous Co-ordinates, Link Co-ordinates, Arm Equation (Three axis, Four axis and Five axis robots).	
3.	Inverse Kinematics General properties of solutions, Tool configuration, Inverse Kinematics of Three axis, Four axis and Five axis robots.	
4.	Workspace Analysis Workspace analysis of four axis and Five axis robots, Work envelope, Workspace fixtures.	
5.	Trajectory Planning Trajectory Planning, Pick and Place operations, Continuous path motion, Interpolated motion, Straight-Line motion.	
6.	Task Planning Task level programming, Uncertainty, Configuration space, Gross motion Planning, Grasp planning, Fine-motion Planning, Simulation of Planer motion, Source and goal scenes, Task planner simulation.	

7.	<p>Robot Arm Dynamics Lagrange-Euler Formulation, Newton-Euler Formulation, Computational Algorithm, A two-Link Manipulator Example, control Techniques applied to Robotic Arm.</p>	
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Term work

Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books:

1. Robert Shilling, Fundamentals of Robotics-Analysis and Control, Prentice Hall of India.
2. Fu, Gonzales and Lee, Robotics, McGraw Hill.
3. J.J. Craig, Introduction to Robotics, Pearson Education.
4. Curtis D. Johnson, Process Control Instrumentation Technology, PHI publication, Eighth Edition.

Reference Books:

1. Staughard, Robotics and AI, Prentice Hall of India.
2. Grover, Wiess, Nagel, Oderey, "Industrial Robotics", McGraw Hill.
3. WalframStdder, Robotics and Mechatronics .
4. Niku, Introduction to Robotics, Pearson Education.
5. Klafter ,Chmielewski, Negin, Robot Engineering, Prentice Hall of India.
6. Mittal, Nagrath, Robotics and Control, Tata McGraw Hill Publication.
7. George L Balten Jr., Programmable Controllers, Tata McGraw Hill Publication.

Sr. No.	Examination	Module
1	T 1	1 , 2
2	T 2	3, 4 , 5
3	END SEMESTER	1 to 7

SEMESTER-VIII	Class: B.Tech. Electrical		
CODE: BTE432	COURSE: Elective – I Power Quality		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Duration (Hrs)	Marks
	In semester Tests	01	20*2
	End Semester Exam*	03	100
	In semester Evaluation	--	25
	Total		125

*60% weightage for end semester exam

Course Objectives:-

1. To understand the effect of power quality issues.
2. To study the methodology to improve the power quality in the power network.
3. To study the effects of monitoring of power quality from load side as well as from source side.

Course Outcomes:

1. Able to understand and study power quality issues in power network.
2. To evaluate power quality management in power network
3. Able to analyze the power quality issues in communication system and LAN system in smart grid.
4. To understand various techniques to monitor the power quality in power network.

Course Contents:

Module	Details	Hrs.
1.	Introduction Importance of power quality, terms and definitions of power quality as per IEEE Std 1159, such as transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, symptoms of poor power quality, good grounding practices and problems due to poor grounding.	
2.	Voltage Variations RMS voltage variations in power system and voltage regulation, per unit system, complex power, subdivision of voltage variation in power system, Long and short duration voltage variation, Over voltage, under voltage, voltage sags, swells, imbalance, transient and flicker, Principles of regulating the voltage, basic power flow and voltage drop, various devices used for voltage regulation and impact of reactive power management, various causes of voltage flicker and their effects, short term (Pst) and long term (Plt) flicker, various means to reduce flicker.	
3.	Voltage Sag and Interruptions-I Definitions of Voltage sag and interruptions, voltage sag v/s interruptions, economic impact of voltage sag, major causes and consequences of voltage sags, voltage sag characteristics i.e. magnitude, duration, phase angle jump, point on wave initiation, and point on wave recovery, missing voltage, voltage sag assessment.	
4.	Voltage Sag and Interruptions-II Influence of fault location and fault level on voltage sag, Area of vulnerability, assessment of equipment sensitivity to voltage sags, voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI, F47 curves, representation of the results of voltage sag analysis, voltage sag indices, mitigation measures for voltage sags, such as UPS, DVR, SMES, CVT, etc, utility solutions and end user solutions.	

5.	<p>Waveform Distribution</p> <p>Definition of harmonics, inter harmonics, sub-harmonics, causes and effects of harmonics on all equipments, voltage v/s current distortion, overview of Fourier analysis, harmonic indices, A.C. Quantities under non-sinusoidal conditions, Triplen harmonics, characteristics and non characteristics harmonics, harmonics series and parallel resonances, consequences of harmonic resonance, K-rated transformer, principles for controlling harmonics, reducing harmonic current in loads, study of different types of tuned and de-tuned filters, active filter topologies, harmonic study procedure, computer tools for harmonic analysis, locating sources of harmonics, harmonic filtering, passive and active filters, modifying the system frequency response, IEEE 519-1992 harmonic standard.</p>	
6.	<p>Transient Over Voltages</p> <p>What are transients, their sources and effects, impulsive transients due to lightening, transient velocity, surge impedance and the effect of line terminations, capacitor switching transients, magnification of capacitor switching transients, basic principles of over voltage protection, various devices used for over voltage protection, load switching related transient problems, computer tools for transient analysis, study of transient voltage surge suppressor and types based on their application for electrical distribution systems of sensitive electronic equipments, communication systems and LAN systems.</p>	
7.	<p>Power Quality Monitoring</p> <p>Need of power quality monitoring and approaches followed in power quality monitoring (reactive and proactive approach), power quality monitoring objectives and requirements, initial site survey, selection of monitoring equipments and use of various equipments required for power quality monitoring, study of connection of power quality monitor, selection of monitoring location and period, requirement of power quality monitor to monitor various power quality parameters, system wide and discrete power quality monitoring, setting thresholds on monitors, various techniques of data collection and analysis, selection of transducers.</p>	

Term work Contains 7-8 simulations/ tutorials based on the above syllabus

Text Books:

1. J. Arrillaga, M. R. Watson, S. Chan, Power System Quality Assessment, John Wiley and Sons.
2. M. H. J. Bollen, Understanding Power Quality Problems, Voltage Sag and Interruptions, New York IEEE press, 2000 Series on Power Engineering.
3. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, Electrical Power System Quality, 2nd Edition McGraw Hill Publication.

Reference Books:

1. EnriquesAcha, Manuel Madrigal, Power System Harmonics – Computer Modeling and Analysis, John Wiley and Sons Ltd.
2. Ewald F. Fuchs, Mohammad A. S. Masoum, Power Quality in Power Systems and Electrical Machines.
3. G. J. Heydt, Electric Power Quality, Stars in Circule publications.
4. IEEE Std. 519-1992, IEEE recommended practices and requirements for harmonics control in electrical power system.

Sr. No.	Examination	Module
1	T 1	1 , 2
2	T 2	3, 4, 5
3	END SEMESTER	1 to 7

SEMESTER-VIII	Class: B. Tech. Electrical		
CODE: BTE433	COURSE: Elective – I Industrial Automation		
Period per week (Each of 60 minutes)	Lecture	03	
	Laboratory	--	
	Tutorial	02 hours/batch	
Scheme of Evaluation		Duration (Hrs)	Marks
	In Semester	01	20*2
	End Semester	03	100
	Termwork	--	25
	Seminar	--	--
	Total		125

*60% weightage for end semester exam

Course Objectives:-

1. Understand architecture of Industrial Automation system.
2. Overview of industrial control system.
3. Overview of elements of automation system.
4. Understand performance objectives of process automation.

Course Outcomes:

1. Able to understand Architecture of Industrial Automation Systems.
2. Able to understand the process of tuning and draw P & I diagrams.
3. Able to understand elements of industrial automation.
4. Get knowledge of design methodology for industrial automation systems.

Detailed Syllabus

Module	Details	Hrs.
1.	Introduction Industrial Automation and Control and Architecture of Industrial Automation Systems.	
2.	Industrial Control System: P, I, D & Tuning with reference to Process Control & Drives Control	
3.	Process representation: P & I Diagrams and Interpretation, block diagrams	
4.	Design methodology User Requirement Specifications (URS) System (Or Software) Requirement Specifications (SRS) Factory & Site Acceptance Tests (FAT & SAT) Quality Assurance System	
5.	Elements Industrial Automation (a) Five tier concept (Sensors to Boardroom) Field Devices (Instruments, IEDs, Lab Equipment etc, Smart & Conventional) Controllers (PLC, DCS, RTU, DDCs) SCADA/HMI & Database Elements Industrial Automation (b) Higher level applications (MIS/MES/Optimization / ERP etc) IT Infrastructure (Servers, Work Stations, Engineering Stations, Gateways, FEP,	

	Communication Networks etc...) Protocols: 7 layer model, TCP/IP Ethernet, Modbus TCP/IP & RTU, -Profibus, IEC61850, BACNet , OPC etc	
6.	Performance objectives: Response times (At various levels) Availability Calculation for the System (MTBF & MTTR) Resolution, Linearity, Accuracy	
7.	Case Study(Any one) <ul style="list-style-type: none"> - Electric Drives : Introduction, Energy Saving with Adjustable Speed Drives - Introduction to Production Control Systems - Introduction to CNC Machines 	

Term work: Term work will consists of at least 6 experiments/Simulations.

Text Books:

1. John Webb: Programmable Logic Controllers Principles and applications, PHI.
2. T. A. Hughes: Programmable Controllers.
3. C.D. Johnson: Process Control Instrumentation.

Sr. No.	Examination	Module
1	T 1	1 to 3
2	T 2	4,5
3	END SEMESTER	1 to 7