SEMESTER VI

S.No.	CODE	COURSE OF STUDY	L	T	P	C
1.	EE302	Power Electronics	3	0	0	3
2.	EE304	Measurement and Instrumentation	3	0	0	3
4.	EE306	Power System Protection and Switch Gear	3	0	0	3
	EE308	Power System Operation and Control	3	0	0	3
5.	EC332	Communication Systems	3	0	0	3
6.		Elective – I	3	0	0	3
	EE310	Power System Simulation Laboratory	0	0	3	2
7.	EE312	Control and Instrumentation Laboratory	0	0	3	2
8.	EE314	Microprocessor and Microcontroller Laboratory	0	0	3	2
		Total	**18**	**0**	**9**	**24**

LIST OF ELECTIVES FOR VI SEMESTER

1. EE352 MODERN CONTROL THEORY
2. EE354 POWER PLANT ENGINEERING
3. EE356 COMPUTER ARCHITECTURE
4. EC362 VLSI DESIGN AND TECHNOLOGY
5. CS364 OPERATING SYSTEMS

SEMESTER VI

EE302 POWER ELECTRONICS

Course Objectives

The objective of this course is to

- To get an overview of different types of power semi-conductor devices and their switching characteristics.
- To understand the operation, characteristics and performance parameters of controlled rectifiers.
- To study the operation, switching techniques and basic topologics of DC-DC switching regulators.
- To learn the different modulation techniques of pulse width modulated inverters and to understand the harmonic reduction methods.

Unit I: Power Semiconductor Devices –Power diodes -power transistors-SCRs – Triac – GTO – Understanding the parameters from data sheets - Power MOSFETs – IGBTs -

Principles of operation and characteristics, ratings, protection and gate drive circuits.

Unit II: Controlled rectifiers - Introduction. Principle of phase controlled converter operation. Single- phase semi-converters. Full converters. Three-phase half-wave converters. Three-phase full-wave converters.

Unit III: DC choppers - Introduction. Principle of step-down and step-up chopper with R-L load. Performance parameters. Chopper classification. Analysis of impulse commutated thyristor chopper.

Unit IV: Inverters - Introduction. Principle of operation. Performance parameters. Single-phase bridge inverters. Three-phase inverters. Voltage control of single-phase inverters – single pulse width, multiple pulse width, and sinusoidal pulse width modulation. Current source inverters. Variable DC link inverter.

Unit V: Voltage Controllers – Introduction - Principle of ON-OFF and phase control. Single-phase bidirectional controllers with resistive and inductive loads – Single phase Cyclo-converters.

Text Books

1. Rashid.M.H, "Power Electronics", Prentice Hall of India, New Delhi, 2008.
2. Ned Mohan, Tore M. Undeland and William P. Robins, "Power Electronics – Converters, Applications and Design", John Wiley and Sons, 3rd Edition, 2007.
3. Dubey.G.K, Doradla.S.R, Joshi.A and Sinha.R.M.K, "Thyristorised Power Controllers", New Age International Publishers, 2nd Edition, 2010.

Reference Books

1. Singh.M.D and Khanchandani K.B, "Power Electronics", Tata McGraw Hill, 2nd Edition, 2006.
2. Cyril Lander, "Power Electronics", 3rd Edition, McGraw-Hill.
3. Jacob Thomson.J.M, "Power Electronics, Principles and Applications", Vikas Publications.
4. Ananda Murthy.R.S and Nattarasu.V, "Power Electronics, A Simplified Approach", Sanguine Technical Publishers.

Course Outcomes

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

1. Understand the importance of power electronics and its applications in industry
2. Constructional features and switching characteristics of SCR and BJT.
3. Constructional features and switching characteristics of MOSFET and IGBT

4. Determine the performance (efficiency, steady-state and transient currents and voltages, power factor, ripples, transformer utilization factor, and harmonics) of single phase controlled rectifier at different load conditions (R, L, C, E)
5. Determine the performance (efficiency, steady-state and transient currents and voltages, power factor, ripples, transformer utilization factor, and harmonics) of three- phase controlled rectifier at different load conditions (R, L, C, E) and dual converters
6. Determine the performance (efficiency, steady-state and transient currents and voltages, power factor, and harmonics) of single phase bridge inverter at different load conditions (R, L, C)
7. Determine the performance (efficiency, steady-state and transient currents and voltages, power factor, and harmonics) of three phase bridge inverter at different load conditions (R, L, C).
8. Understand the operation of voltage commutated, load commutated and current commutated choppers.
9. Understand the performance of AC voltage regulators operating under different loads.

EE304 MEASUREMENT AND INSTRUMENTATION

Course Objectives

The objective of this course is

- To make the student have a clear knowledge of the basic laws governing the operation of the instruments, relevant circuits and their working.
- To introduce general instrument system, error, calibration etc.
- To Emphasis analog and digital techniques used to measure voltage, current, energy and power etc.
- To have an adequate knowledge of comparison methods of measurement.
- To expose various transducers and data acquisition system.

Unit I: SI units – Analog indicating instruments – PMMC – moving iron – ammeters and voltmeters - Electrodynamic wattmeters – Induction type energy meter.

Unit II: Null balance method of measurements: wheatstone bridge, kelvin bridge, meg ohm bridge, megger – measurement of L and C – Maxwell bridge – Max – Wien bridge – Anderson bridge – Schering bridge – Wien bridge.

Unit III: Graphical methods – YT and XY recorders – oscilloscope : CRT – deflection sensitivity – block diagram – modes of operation – Z modulation – modes of trigger – single channel and multiple channels – alternate and chopped mode of operation – dual time base – sampling

Unit IV: Digital methods of measurement – timer –counter – frequency, time period, phase measurements – digital voltmeter – digital multimeter – data acquisition systems – digital storage oscilloscope.

Unit V: Instrumentation: Block diagram – sensors – signal conditioning and control – Transducers and their characteristics - classification & selection of transducers, strain gauges, inductive & capacitive transducers, piezoelectric and Hall-effect transducers, thermistors, thermocouples.

Text Books

1. Sawhney.A.K, "Electrical and Electronics Measurements and Instrumentation", Dhanpat Rai, 2003.
2. Cooper.W.D and Helfric.A.P, "Modern Electronic Instrumentation and Measurement Techniques", Prentice Hall of India, 1st Edition, 1992.
3. Bentley.J.P, "Principles of Measurement Systems", Longman Group Limited (Pearson Education), 3rd Edition, 2008.

Reference Books

1. Doeblin, "Measurement Systems", Tata McGraw Hill Publication, 2nd Edition, 1990.
2. Gupta.J.B, "A Course in Electrical and Electronic Measurements and Instrumentation", S.K Kataria & Sons, Reprint, 2013.

Course Outcomes

On completion of this course, students will be able to

1. Illustrate the circuit parameters, characteristic, standards and calibration.
2. Understand the principles and instruments adopted for measurement of current, voltage, power, energy.
3. Understand the principles and instruments adopted for measurement of Iron loss, phase, frequency and magnetic Measurement.
4. Understand the different methods for measurement of resistance, inductance and capacitance, potentiometers, interference and grounding techniques.
5. Understand the different display devices, LED, LCD, Printers and Plotters.
6. Illustrate how to store digital signal and provide meaningful information and explain data loggers.
7. Illustrate the different types of transducers and elements of data acquisition systems.

EE306 POWER SYSTEM PROTECTION AND SWITCH GEAR

Course Objectives

The objective of this course is

- To provide introduction to power system protection and switchgear
- To gain detailed knowledge about the various components used in power system protection.
- To gain knowledge about protection systems used for electric machines, transformers, bus bars, overhead and underground feeders.
- To understand the theory, construction, and applications of main types of circuit breakers.

Unit I: Review of Fault Analysis, Importance of protective schemes, Concept of Protective zones, Relays – General classification, Principle of operation, types, characteristics, Torque equation, Relaying Schemes, Relay Co- ordination.

Unit II: Apparatus and line protection – Line Protection – Distance, Differential protection and Carrier current protection. Generator protection – protection against abnormal condition, stator and Rotor protection - Transformer Protection – Incipient fault – Differential protection, Feeder and Bus bar protection.

Unit III: Protection against over voltages – Causes of over voltage Ground wires, Surge absorbers and diverters. Earthling types – Neutral Grounding. Insulation coordination.

Unit IV: Theory of arcing and arc quenching circuit breakers types – rating and comparison, RRRV, Resistor switching and capacitor switching, Current Chopping and Capacitive current Breaking, Recent developments in Circuit breaker Design and its operation-static circuit breaker.

Unit V: Static relays – Digital relays - Microprocessor based relays – Apparatus and line protection – Basics of Numerical relays.

Text Books

1. Badri Ram and Vishwakarma.D.N, "Power System Protection and Switchgear", Tata McGraw Hill publishing company Limited, 2nd Edition, 2011.
2. Sunil S.Rao, "Protective Switch Gear", Khanna Publishers, New Delhi, 1999.
3. Ravindranath.B and Chander.N, "Power Systems Protection and Switch Gear", Wiley Eastern Limited, 1977.
4. Paithangar.Y.G, "Fundamentals of Power System Protection", Prentice Hall of India.

Reference Books

1. Soni.M.L, Gupta.P.V, Bhatnagar.U.S and Chakrabarti.A, "A Text Book on Power System Engineering", Dhanpat Rai and Co., 2008.
2. Wadhwa.C.L, "Electrical Power Systems", New Age International (P)

Limited, 6th Edition, 2010.
3. Ravindra P.Singh, "Switchgear and Power System Protection", PHI Learning Private Limited, New Delhi 2009.

Course Outcomes

Students would be able to:

1. Classify various relaying schemes and identify and implement an appropriate relaying schemes for different power apparatus
2. Suggest the protective relay settings for a specific operational scenario
3. Illustrate the arc quenching phenomenon in CBs and the relative advantages and disadvantages of various types of CBs.

EE308 POWER SYSTEM OPERATION AND CONTROL

Course Objectives

The objective of this course is

- To have an overview of power system operation and control.
- To model power-frequency dynamics and to design power-frequency controller.
- To model reactive power-voltage interaction and the control actions to be implemented for maintaining the voltage profile against varying system load.

Unit I: Introduction - System load – variation – load characteristics – load curves and load-duration curve (daily, weekly and annual) – load factor – diversity factor. Importance of load forecasting and simple techniques of forecasting. An overview of power system operation and control and the role of computers in the implementation. (Qualitative treatment with block diagram).

Unit II: Real Power – frequency control - Basics of speed governing mechanism and modeling – speed-load characteristics – load sharing between two synchronous machines in parallel. Control area concept LFC control of a single-area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC.

Unit III: Reactive Power voltage Control - Basics of reactive power control. Excitation systems – modeling. Static and dynamic analysis – stability compensation – generation and absorption of reactive power. Relation between voltage, power and reactive power at a node – methods of voltage control.

Unit IV: Unit Commitment and Economic Dispatch - Statement of economic dispatch problem – cost of generation – incremental cost curve – co-ordination equations without loss and with loss, solution by direct method and λ- iteration method. Statement of Unit

Commitment problem – constraints; spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints. Solution methods – Priority-list methods – forward dynamic programming approach. Numerical problems only in priority-list method using full-load average production cost.

Unit V: Computer Control of Power Systems - Need of computer control of power systems. Concept of energy control centre (or) load dispatch centre and the functions – system monitoring – data acquisition and control. System hardware configuration – SCADA and EMS functions. Network topology – state estimation – security analysis and control. Various operating states (Normal, alert, emergency, in-extremis and restorative). State transition diagram showing various state transitions and control strategies – concept of smart grid.

Text Books

1. Allen J. Wood and Bruce F. Wollenberg, "Power Generation, Operation and Control, John Wiley and Sons Inc., 2nd Edition, 2006.
2. Chakrabarti and Halder, "Power System Analysis: Operation and Control", Prentice Hall of India, 3rd Edition, 2010.
3. Kothari.D.P and Nagrath.I.J, "Modern Power System Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 4th Edition, 2011.

Reference Books

1. Grigsby.L.L, "The Electric Power Engineering, Hand Book", CRC Press and IeeE Press, 2001.
2. Hadi Saadat, "Power System Analysis", 11th Reprint, 2007.
3. Kundur.P, "Power System Stability and Control", Tata McGraw Hill Publisher, USA, 2006.
4. Olle.I.Elgerd, "Electric Energy Systems theory - An introduction", Tata McGraw Hill Publishing Company Ltd. New Delhi, Second Edition 2003.

Course Outcomes

At the end of the course the student should be able to

1. Recall the basic over view of power system operation and control, Loads and their characteristics.
2. Design a LFC model for both single and two area power system, analyze its static and dynamic response.
3. Design of Tie line power flow and the Development of state variable model for both single and two area system.
4. Design a model of AVR and analyze its static and dynamic response and to study about the reactive power components.
5. Explain various methods of voltage control.
6. Explain the methods of optimum dispatch of generation with minimum cost-Unit commitment.

7. Explain the methods of optimum dispatch of generation with minimum cost- Economic dispatch.

EC332 COMMUNICATION SYSTEMS

Course Objectives

The objective of this course is

- To introduce different methods of analog communication and their significance
- To introduce Digital Communication methods for high bit rate transmission
- To introduce the concepts of source and line coding techniques for enhancing rating of transmission of minimizing the errors in transmission.
- To introduce various media for digital communication

Unit I: Analog Modulation: Principles of Amplitude Modulation, single and double side band - suppressed carrier system and frequency modulation - varactor diode and reactance modulator - AM detectors - FM discriminators - AM and FM transmitters and receivers.

Unit II: Digital communication : Sampling theorem - pulse modulation techniques - PAM, PWM and PPM concepts - PCM encoder and decoder - Data transmission using analog carriers (FSK, PSK, QPSK, MSK and QAM).

Unit III: Synchronous and Asynchronous transmission: transmission - error control techniques - data communication protocols link oriented protocols - asynchronous protocols – computer communication networks .

Unit IV: Modern Communication Systems: Microwaves and optical communication system, Satellite communication system, Mobile communication system.

Unit V: Principles of television engineering: Requirements and standards - need for scanning - types of camera tubes and picture tubes - B/W and colour systems - PAL - CCTV -Cable TV – Introduction to analog television engineering – Digital television – fundamentals – HDTV

Text Books

1. Kennedy.G, "Electronic Communication System", Tata McGraw Hill, 1987.
2. Roddy.D and Coolen.J, "Electronic Communications", Prentice Hall of India, 4th Edition.
3. Simon Haykins, "Electronic Communications", John Wiley, 3rd Edition, 1995.

Reference Books

1. Taub and Schiling "Principles of communication systems" Tata McGraw Hill 2007.
2. Das.J, "Principles of Digital Communication", New Age International, 2011.
3. Theodore S. Rappaport, "Wireless Communications - Principles and Practice", Pearson, 2nd Edition, 2010
4. Bernard Sklar, "Digital communication fundamentals and applications", Pearson Education, 2nd edition, 2009.

Course Outcomes

The students will be able

1. To have an overview of various analog modulation schemes.
2. Understand the principle operation of various modulator and demodulator circuits.
3. Illustrate the different types of digital modulation techniques.
4. To have an overview of various communication systems.
5. Explain the basic operation of B/W and colour TV systems.
6. Understand the various data communication protocols.

EE310 POWER SYSTEM SIMULATION LABORATORY

1. Real and reactive power computation
2. Transmission Line parameter calculation
3. Power Circle diagrams
4. Bus admittance matrix formulation
5. Graph theory matrices
6. Load flow analysis
7. Z bus formulation
8. Short circuit analysis
9. Simulation of AC DC Converters
10. Power Electronic applications in Power Systems

EE312 CONTROL AND INSTRUMENTATION LABORATORY

1. Time and frequency response characteristics of a second order system.
2. Constant gain compensation in time and frequency domain.
3. Design of compensation networks – Lead, Lag, Lead-lag
4. Design of state feedback controller.
5. P, PI and PID controllers
6. Modeling of Systems – Machines, Sensors and Transducers
7. Displacement measurement using LVDT
8. Design of V-F converter and F-V converter

9. Instrumentation amplifier
10. Thermocouple Compensation.
11. Thermistor Linearization transmitter design.
12. Signal conditioning circuit for any resistive pressure, transducer.
13. Signal conditioning circuit for optical encoder.

EE314 MICROPROCESSOR AND MICROCONTROLLER LABORATORY

1. Simple arithmetic operations with 8 bit data:
   Addition / subtraction / multiplication/ division
2. Programming with control instructions
3. Simple arithmetic operations with 8 bit data:
   Addition / subtraction / multiplication/ division
4. Interface Experiments:
   A/D interfacing
   D/A interfacing
   Traffic light controller
   Stepper motor interfacing
   Segment LED Display.
5. Generation of firing pulses for single phase full converter
6. Demonstration of basic instructions with 8051 Micro controller execution, including: Conditional jumps, looping, Calling subroutines, Stack parameter testing
7. Programming exercise on RAM Direct Addressing, Bit Addressing

ELECTIVES

EE352 MODERN CONTROL THEORY

Course Objectives

To impart knowledge on

- Stability of the linear and non linear systems using state variable techniques.
- Phase plane analysis, describing function analysis.
- Basic concepts about optimal control.

Unit I: Systems in state space: Concept of states and state model, State equation from transfer function, Modeling of dynamical systems, State space representation of multivariable systems, Building blocks of state space models. Modeling through energy approach of electrical, mechanical and electromechanical systems – Introduction to fractional order systems.

Unit II: Canonical forms, Solution to state-space equations, state transition matrix, properties of state transition matrix, computation of state transition matrix.

Unit III: Equilibrium points and stability concepts, stability definitions, Modeling energy of the system in terms of quadratic functions, Direct method of Lyapunov criterion for LTI systems.

Unit IV: Definition of controllability, observability, stabilizability and detectability. State feedback control for controllable canonical form, State feedback control in general, Output feedback controller. Full-order and reduced-order observers, Introduction to Linear Quadratic problems.

Unit V: Introduction to Discrete time systems , analogies with continuous-time systems, mathematical models for LTI discrete- time systems, Z- transformation of difference equation, analysis of first, second order and higher order systems. State space modelling of discrete-time dynamical systems.

Text Books

1. Nagrath.I.J and Gopal.M, "Control System Engineering", New Age International (P) Limited Publishers, 5th Edition, 2012.
2. Richard Dorf and Robert Bishop, "Modern control system", Pearson Education, 12th Edition, 2014.

Reference Books

1. Dingyu Xue, YangQuan Chen, Derek P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB"', Society for Industrial and Applied Mathematics, 1st Edition, 2007.
2. Norman S. Nise, "Control System Engineering", Wiley Student Edition, 6th Edition, 2012.
3. B.C Kuo, "Automatic control systems", Prentice Hall, New Delhi, 7th Edition, 2002.

Course Outcomes

The students will be able to

1. Analyze state variable concepts in continuous time format for linear and non linear systems.
2. Achieve desired system characteristics by pole-placement using complete state variable feedback.
3. Optimize the gain matrix of state feedback control law.

EE354 POWER PLANT ENGINEERING

Course Objectives

The objective of this course is to familiarize with operation of various power plants.

Unit I: Thermal Stations- layout- main components- boiler- economizer- air preheater- super heater- reheater- condenser- feed heater- cooling powers- FD and ID fans- Coal handling plant- water treatment plant- Ash handling plant- Types of boilers and theirs characteristics- Steam turbines- and their characteristics- governing system for thermal stations.

Unit II: Hydro Electric Stations- Selection of site- layout- classification of hydro plants- general arrangement and operation of a hydro-plant- governing system for hydel plant- types of turbines-pumped storage plants.

Unit III: Economic operation of steam-hydro plants- inter connected operations- division of load in inter-connected system, economic loading of steam and hydro power plants.

Unit IV: Nuclear power plants - principle of power generation, location, advantages and disadvantages of nuclear power plants; Reactor control- reactor safety waste disposal.

Unit V: Non-conventional power plants - basic concepts, principles of working and Fuel cells, OTEC, solar, wind, tidal, biomass and geothermal power generation.

Text Books

1. Soni Gupta, Bhatnagar and Chakrabarti, "A text book on Power Systems Engineering", Dhanpat Rai and Sons, New Delhi, 1997.
2. Wadhwa.C.L, "Generation, Distribution and Utilization of Electrical Energy", Wiley Eastern Limited, 3rd Edition, 2011.

Reference Book

1. Deshpande.M.V, "Elements of Electrical Power station Design", Pitman, New Delhi, Tata McGraw Hill, 2008.

Course Outcomes

On completion of this course, the students will be able to

1. Innovatively apply design, planning and expansion process to power system generation, transmission & Distribution.
2. Ability to do research on important scientific and technical problem related to the field of electrical and electronics engineering and to disseminate knowledge and publish research findings.
3. Ability to function effectively in multidisciplinary research and development teams.

EE356 COMPUTER ARCHITECTURE

Course Objectives

To impart knowledge on

- the basic concepts of computer organization.
- instruction formats and various addressing modes.
- arithmetic processing in computers
- memory organization in computers.

Unit I: Computer -Functional units, Addressing modes, Instruction formats, Stacks and Subroutines. Processing Unit - Execution of instructions - Control step sequence.

Unit II: Control Design - Hardwired control-design - multiplier control unit – CPU control unit and Microprogrammed control - micro instructions - Sequencing - prefetching.

Unit III: Arithmetic and Logic Unit-Fixed point and floating point numbers and operations. Design of arithmetic units.

Unit IV: Memories - cache memories - virtual memories. Input-Output Organization-Data transfer-synchronization-Interrupt handling-I/O interfaces.

Unit V: Introduction to parallel processing-Generation of computer systems – Parallelism in uniprocessor system-Parallel computer structures-architectural classification schemes.

Text Books:

1. Morris Mano.M., 'Computer system Architecture',Third Edition, PHI, New Delhi 2008.
2. Stalling, W.,'Computer Organisation and Architecture', Pearson Education , 2003
3. Tanenbaum, A.S. 'Structured Computer Organisation', Third Edition, Prentice Hall of India, 2000.

Reference Books:

1. Hayes John P, "Computer Architecture and Organization", McGraw Hill, 3rd Edition, 2012.
2. 2.William Stallings, "Computer Organization and Architecture: Designing for Performance", Pearson Education, 2010.

Course Outcomes

Students will be able to

1. Understand the organization of basic computer
2. Analyze the operation of Central Processing and Arithmetic Logic Units
3. Know the concept of Memory organization
4. Know the basics Parallel processing