SEMESTER VII

S.No.	CODE	COURSE OF STUDY	L	T	P	C
1.	HM401	Management Concepts and Practices	3	0	0	3
2.	EE401	High Voltage Engineering	3	0	0	3
4.	EE403	Solid State Drives	3	0	0	3
5.	EE405	Electrical Machine Design	3	1	0	4
6.		Elective – II	3	0	0	3
7.		Elective – III	3	0	0	3
8	EE407	Power Electronics and Drives Laboratory	0	0	3	2
9.	EE481	Comprehensive Viva Voce	0	0	0	1
10.	EE483	Project Work – Phase I	0	0	6	2
		Total	**18**	**1**	**9**	**24**

LIST OF ELECTIVES FOR VII SEMESTER

1. EE451 ADVANCED POWER SYSTEM PROTECTION
2. EE453 FLEXIBLE AC TRANSMISSION SYSTEMS
3. EE455 EHVAC AND HVDC TRANSMISSION SYSTEMS
4. EE457 SPECIAL MACHINES AND CONTROLLERS
5. EE459 EMBEDDED SYSTEM DESIGN
6. EE461 BIOMEDICAL INSTRUMENTATION
7. EE463 ENERGY SCIENCE AND ENGINEERING
8. EE465 FRACTIONAL ORDER SYSTEMS AND CONTROLS

EE451 ADVANCED POWER SYSTEM PROTECTION

Course Objectives

To provide an in-depth view of the methods and devices used in electric power system protection; protection systems, relay types, protection of machines, transformers, buses and lines; instrument transformers; and modern trends in protection including digital techniques

Unit I: Introduction to Static Relays - General – Basic construction of static protective relays – characteristic functions of protective relays. Comparators and associated elements - Phase and amplitude comparators – Zener diode phase comparators – dynamic design of static comparators.

Unit II: Solid State Directional and Over current Relays - Phase comparator directional units – Amplitude comparator directional units – polyphase directional relays. Instantaneous over current relays - time over current relays – applications of different types of time current characteristics – basic principles of time over current relays – practical circuits for time over current relays.

Unit III: Solid State Differential Relays - Operating characteristics – restraining characteristics – types of differential relays – requirement of current transformers for differential protection (static schemes).

Unit IV: Solid state Distance Relays - Standard 3-zones protection – distance protection requirements – relay characteristics - types of distance relays – reach of distance relays – polarized mho distance relays – performance specifications of distance relays – static distance relay schemes.

Unit V: Computer Applications to Protective Relaying - Introduction – digital computer applications – microprocessor applications to power system protection – under frequency protection – protection against loss of excitation.

Text Books

1. Madhava Rao.T.S, "Power System Protection Static Relays",2nd Edition, Tata McGraw Hill, 2nd Edition, 2001.
2. Ravindranath.B and Chander.M, "Power System Protection and Switch Gear", New Age International Private Limited Publishers.
3. Ram.B and Visswakarma.D.N, "Power System Protection and Switchgear", Tata McGraw Hill Publishing Company Limited, New Delhi, 1st Edition, 2011.

Reference Books

1. Christopoulos.C and Kluwer.W. A., "Electrical Power System Protection," Academic Publishers, 2 Edition, 1999.
2. Singh.L.P, "Digital Protection: Protective Relaying from Electromechanical to Microprocessor", New Age Publishers, 1997.
3. Paithankar.Y.G and Bhide. S.R, "Fundamentals of Power System Protection", Prentice-Hall of India, 2nd Edition, 2010.

Course Outcomes

On completion of this course students will be able to:

1. Specify current and voltage transformers for transient operation
2. Calculate settings for differential protection schemes and recognise blind spots in the protection

3. Design and specify protection schemes
4. Analyze protection operation using sequence component methods
5. Understand trends in protection technology.

EE453 FLEXIBLE AC TRANSMISSION SYSTEMS

Course Objectives

The objective of this course is

- To provide the basic concepts of controlling the power system parameters using FACTS devices.
- To study various types of FACTS devices that can be incorporated in the power system.

Unit I: Fundamental of AC transmission system, transmission problem and needs, emergence of FACTS-Basic types of FACTS controllers –benefits from FACTS technology – Comparison of HVDC and FACTS

Unit II: Objectives of Shunt Compensation – Methods of Controllable Var Generation – Static Var compensators – SVC, STATCOM – Compensator Control – Comparison Between SVC & STATCOM.

Unit III: Objectives of Series Compensation – Variable Impedance type series compensators – GCSC, TSSC and TCSC – basic control schemes –Switching converter type Series compensator: SSSC –internal and external control.

Unit IV: Principles of operation – Steady state model and characteristic of a static voltage regulators and phase shifters – power circuit configuration.

Unit V: UPFC – Operating principles, conventional transmission control capabilities, independent real and reactive power flow control, comparison. IPFC –operating principles, characteristics and control structure.

Text Books

1. N.G Hingorani , L.Gyugyi, " Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems", Wiley India Pvt Ltd.2011
2. Y.-H. Song and A.T. Johns, " Flexible A.C. Transmission Systems (FACTS)", IEE Book series,1999
3. P.Kundur, " Power System Stability and Control", McGraw Hill ,2006.
4. J. Arrillaga and N.R. Watson, " Computer modeling of Electric Power Systems", John Wiley & sons, 2001

Reference Books:

1. John.A.T, "Flexible AC Transmission System", Institution of Electrical and Electronic Engineers (IEEE), 1999.
2. Mohan Mathur.R and Varma Rajiv. K, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley and Sons Incorporation, 2011.
3. Sood.V. K, "HVDC and FACTS controllers - Applications of Static Converters in Power System", Kluwer Academic Publishers, 2004.

Course Outcomes

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

1. Understand the importance of reactive power control and compensation methods
2. Understand the basics of important FACTS devices
3. Understand the operating principle, characteristics and applications of SVC, TCSC
4. Understand the operating principle, characteristics, implementation and applications of STATCOM and UPFC
5. Understand the concepts of controller interactions and coordination

EE455 EHVAC AND HVDC TRANSMISSION SYSTEMS

Course Objectives

To impart knowledge on the basic concepts of HVDC with existing HVDC projects

Unit I: HVAC Power Transmission - Introduction – Standard Transmission Voltages – Problems in HV Transmission – Resistance of conductors – Properties of Bundled conductors –Line inductance and capacitance.

Unit II: Effects on EHVAC Transmission Lines - Calculation of EHV line configuration – Sequence Inductances and Capacitances – Charge potential relations for multi conductor lines – Surface voltage gradients on conductors (single and bundled conductor) Corona effects – Power loss and audible noise – High phase order transmission- harmonics-filters.

Unit III: HVDC Power Transmission - Introduction – Development of HVDC technology – Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system – Types of DC links – Static power conversion principle – Rectifier operation – Inverter operation - analysis of Graetz circuit – Twelve pulse converter.

Unit IV: Converter Control and Harmonics - Basic Philosophy – Principles of DC link control – Converter control characteristics – System control hierarchy – Firing angle

control – Current and Extinction angle control – Starting and Stopping of DC link – Converter harmonics – Characteristic and non-characteristic harmonics-filters.

Unit V: EHVAC Cable Transmission - Introduction – Typical construction and cross section of cables – Power rating – Electrical characteristics of EHV cables – Electrical stress – Capacitance, insulation resistance and loss factor – Design basis of Cable Insulation – Tests on cable characteristics.

Text Books

1. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", New Age International Limited, Publishers, 4th Edition, 2011.
2. Kundur.P, "Power System Stability and Control", Tata McGraw Hill Incorparation, 2006.
3. Padiyar.K.R, "HVDC Power Transmission System", Wiley Eastern Ltd., New Delhi, 2nd Edition, 2011.
4. Arrillaga.J, " High Voltage Direct Current Transmission", Peter Pregrinus, London, 2nd Edition, 1998.
5. Kimbark.E.W, "Direct current Transmission", 1972.

Reference Books

1. E.Kuffel, "High Voltage Engineering Fundamentals," Butterworth-Hienman Press, Oxford, 2nd Edition, 2000.
2. Naidu M.S and Kamaraju V.B, "High Voltage Engineering", Tata McGraw Hill, 5th Editioon, 2013.

Course Outcomes

Students will be able to

1. Demonstrate the modern trends and planning of HVDC system.
2. Analyze various converters and associated control strategy.
3. design of AC and DC filter to eliminate Harmonics
4. Model of HVDC systems for Digital Dynamic Simulation.

EE457 SPECIAL MACHINES AND CONTROLLERS

Course Objectives

The objective of this course is

- To provide knowledge about the constructional features and operating principles of various types of special electrical machines.
- To compare and analyze the static and dynamic characteristics of special electrical machines.
- To provide the knowledge about the different types of drive systems and controllers used in special electrical machines.

Unit I: Synchronous Reluctance motors - Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – phasor diagram, motor characteristics – Linear induction machines.

Unit II: Stepping motors - Constructional features, principle of operation, modes of excitation torque production in Variable Reluctance (VR) stepping motor, dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor-Applications.

Unit III: Switched reluctance motors - Constructional features-principle of operation-Torque equation-Power Controllers-Characteristics and control Microprocessor based controller.

Unit IV: Permanent Magnet Synchronous motors - Permanent Magnet and characteristics-Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes- Sensorless control.

Unit V: Permanent magnet Brushless DC motors - Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave, Sine wave permanent magnet brushless motor drives, Torque and EMF equation, Torque-speed characteristics, Controllers-Microprocessor based controller.

Text Books

1. Miller.T.J.E, "Brushless Permanent Magnet and Reluctance motor drives", Clarendon Press, Oxford University, 1989.
2. Kenjo.T, "Stepping motors and their microprocessor control", Clarendon Press, Oxford University,2nd Edition, 1994.
3. Kenjo.T and Naganori.S, "Permanent Magnet and brushless DC motors", Clarendon Press, Oxford University, 1990.
4. Kenjo.T, "Power Electronics for the Microprocessor Age", Oxford University Press, 1990.

Reference Books

1. Bose.B.K, "Modern Power Electronics and AC drives", Prentice Hall Publisher, 2002.
2. Krishnan.R, "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India Private Limited, New Delhi, 2010
3. Venkataratnam, "Special Electrical Machines", Tayler and Francis, 2009.

Course Outcomes

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

1. Understand the construction and operating principles of special electrical machines.
2. Analyze the characteristics and performance of special electrical machines.
3. Understand the different types of controllers and control techniques.

EE459 EMBEDDED SYSTEM DESIGN

Course Objectives

The objective of this course is

- To provide the basic concepts of embedded system design and its applications to various fields.
- To introduce embedded software Tools.
- To study various scheduling algorithms for process.
- To provide basics of Real time operating system.
- Demo with example tutorials to discuss on one real-time operating system tool.

Unit I: Introduction to Embedded Systems – Build process for embedded systems- Structural units for a Embedded microcontroller , selection of processor and memory devices- DMA – Memory management methods- Timer and Counting devices, Watchdog Timer, Real Time Clock- IDE, assembler, compiler, linker, simulator, debugger, Incircuit Emulator, Target Hardware Debugging, Boundary Scan

Unit II: Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols -RS232 standard – RS485 – CAN Bus -Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I^2C) – PC Parallel port communication- ISA, PCI.

Unit III: Programmed-I/O busy-wait approach without interrupt service mechanism-ISR concept interrupt sources – multiple interrupts – context and periods for context switching, interrupt latency and deadline – Introduction to Device Drivers

Unit IV: Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication-shared memory, message passing-, Interprocess Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, comparison of Real time Operating systems: VxWorks, μC/OS-II, RT Linux.

Unit V: Case Study : Washing Machine- Automotive Application- RFID- System, Application, RFIDTag, Reader-Embedded Product Development Life Cycle, Objective, Need, and different Phases and Modelling of the EDLC.

Text Books

1. Rajkamal, "Embedded system - Architecture, Programming, Design", Tata McGraw Hill, 2nd Edition, 2008.
2. Peckol, "Embedded system Design", JohnWiley and Sons, 2010.

Reference Books

1. Shibu.K.V, "Introduction to Embedded Systems", Tata Mcgraw Hill,2009.
2. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2010.
3. Rajib Mall, "Real Time systems Theory and Practice", Pearson Education, 1st edition, 2012.
4. Han Way Huang, "Embedded system Design using 8051", Cengage Learning, 2009.

Course Outcomes

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

1. Understand the basics of Embedded system and RTOS
2. Design an embedded system for the real time problem.

EE461 BIOMEDICAL INSTRUMENTATION

Course Objectives

The course is designed to make the student acquire an adequate knowledge of the physiological systems of the human body and relate them to the parameters that have clinical importance. The fundamental principles of equipment that are actually in use at the present day in the health centre are introduced.

Unit I: Electro physiology: Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, cardiovascular dynamics, electrode theory, bipolar and uni-polar electrodes, surface electrodes, physiological transducers. Systems approach to biological systems.

Unit II: Bioelectric potential and cardiovascular measurements: EMG - Evoked potential response, EEG, foetal monitor. ECG phonocardiography, vector cardiograph, BP, blood flow cardiac output, plethysmography, impedance cardiology, cardiac arrhythmia's, pace makers, defibrillators.

Unit III: Respirator and pulmonary measurements and rehabilitation: Physiology of respiratory system, respiratory rate measurement, artificial respirator, oximeter, hearing aids, functional neuromuscular simulation, physiotheraphy, diathermy, nerve stimulator, artificial kidney machine.

Unit IV: Patient monitoring systems: Intensive cardiac care, bedside and central

monitoring systems, patient monitoring through bio-telemetry, implanted transmitters, telemetering multiple information. Sources of electrical hazards and safety techniques.

Unit V: Recent trends: Medical imaging, X-rays, laser applications, ultrasound scanner, echo cardiography, CT Scan MRI/NMR, cine angiogram, colour doppler systems, Holter monitoring, endoscopy.

Text Books

1. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, "Biomedical Instrumentation and Measurements", 2nd Edition, Prentice Hall, New Delhi, 1998.
2. John G.Webster, biomedical Instrumentation, John Wiley & Sons, 2008).

Reference Books:

1. Geddes L. A. and Baker L. E., "Principles of Applied Biomedical Instrumentation", 3rd Edition, John Wiley, New York, 2008.
2. Richard Aston, "Principles of Bio-medical Instrumentation and Measurement", Merril Publishing Company, New York, 1990.
3. Kandpur R. S, "Handbook of Biomedical Instrumentation", Tata McGraw Hill, New Delhi, 2009.

Course Outcomes

Students will be able to:

1. Acquaintance of the physiology of the heart, lung, blood circulations, respirations, patient monitoring and electrical safety in clinical environment.
2. Obtain the in-depth knowledge in various electrical origins of recording methods of ECG, EEG, EMG and ERG.
3. Know how to use the latest medical equipments available for measurement of non-electrical parameters in the physiological systems of the human body and also the modern methods of imaging techniques used for diagnostic purpose in the health care centre.
4. Know the latest procedure adopted for providing Medical assistance through Telemedicine and the Therapeutic equipments used for diagnostic and surgery purposes.

EE463 ENERGY SCIENCE AND ENGINEERING

Course Objectives

The objective of this course is

- Prepare students for careers in renewable energy advanced research and management.
- Train the researchers and engineers who will help to prepare and implement

energy strategies and policies for leading manufacturers, innovative start-ups and public organizations.

Unit I: Energy resources: terminology, major energy resources in use: resource, reserve and availability of Oil, gas and coal in global and national context.

Unit II: Hydro-electricity and nuclear-electricity: availability and developmental constraints. Energy consumption demand: consumption sectors; growth rate in industrial, commercial & residential, agriculture and transportation sector of total energy and electricity national and international trends.

Unit III: Renewable Energy: need for accelerated growth, availability and environmental constraints of traditional non-renewable sources. Demerits of solar sources. Technologies for electricity generation: wind, PV and biomass; tidal and geothermal power plants. Ocean thermal and wave electricity generation. Fuel cells.

Unit IV: Energy storage: role of storage in electricity supply, hydrogen energy.

Unit V: Energy management and audit: demand side and supply side of management (DSM & SSM): conservation of electrical energy, conservation act, 2001. Energy audit: Preliminary detailed audit.

Text Books

1. Khan.B.H, "Non Conventional Energy Resources", Tata McGraw Hill, 2nd Edition, 2009.
2. Andrews.J and Jelley.N, "Energy Science Principles, Technologies and Impact", Oxford University Press, 2007.

Reference Books

1. Chauhan.D.S and Srivastava.S.K, "Non Conventional Energy Resources", New Age International Private Limited.
2. Gevorkian.P, "Sustainable Energy Systems Engineering", Tata McGraw Hill, 2006.

Course Outcomes

Students will be able to:

1. Understand the volatile nature of the renewable energy resources.
2. Model the size of the battery for hybrid power system
3. Understand the demand side management concept.

EE465 FRACTIONAL ORDER SYSTEMS AND CONTROLS

Course Objectives

To impart knowledge on

- Fractional order systems and controllers
- Implementation of fractional order systems and controllers
- Fractional order PID controller

Unit I : Fundamentals of fractional order systems - fractional order integrals - fractional order derivatives - Laplace and Fourier Transforms – fractional order differential equations - numerical solutions – fractional order systems - models and representations – stability - analysis of time and frequency domain responses.

Unit II : Continuous time LTI state space models stability analysis – State space realizations - solution of the state equation of continuous LTI commensurate order systems – controllability and observability – discrete time LTI state space models - solution of the discrete time LTI commensurate order - controllability and observability of discrete time LTI commensurate order systems.

Unit III: Implementations of fractional order controllers - continuous and discrete time implementations of fractional order operators - frequency response fitting of fractional order controllers – sub optimal approximation of fractional order transfer function – Implementation in MATLAB.

Unit IV: Fractional order control - generalized fractional order control actions – fractional order lead lag compensator - classical and fractional order PID controller – tuning - stability regions with fractional PID controller.

Unit V: Case studies - position control of a single link flexible robot -automatic control of a hydraulic canal – fractional order control strategies for power electronic buck converters.

Text Books

1. Monje.C.A, Chen.Y.Q, Vinagre.B.M, Xue.D and Feliu.V, "Fractional order systems and controls - fundamentals and applications", Springer, 1st Edition. 2010.
2. Caponetto.R, Dongola.G and Fortuna.L, "Fractional order systems - Modeling and Control Applications", World Scientific Publishing, 1st Edition. 2010.

Reference Books

1. I.Podluby, "Fractional differential equations", Academic Press, 1st Edition, 1999.

2. Dingyu Xue, YangQuan Chen, Derek P. Atherton, "Linear Feedback Control Analysis and Design with MATLAB", Society for Industrial and Applied Mathematics, 1st Edition, 2008.

Course Outcomes

The students will be able to

1. Compare the classical and fractional order PID controller
2. Estimate the time domain and frequency domain response of fractional order systems
3. Achieve desired system characteristics by tuning the fractional order controller