I SEMESTER

15EA01/15EE01/15ED01/15EM01

SYSTEMS ENGINEERING MATHEMATICS

2 2 0 3

CALCULUS OF VARIATIONS: Introduction **-** Variational problems of fixed boundaries: Variations and its properties - simplest variational problems – Euler equation – Brachistochrone problem – Variational problems involving several unknown functions – Functional involving first and second order derivatives. (6+6)

VECTOR SPACES: Real vector spaces, subspaces, linear independence – basis and dimension of a vector space – row space, column space and null space - inner product space, orthonormal bases, Gram-Schmidt process. Best approximation: Least squares. (7+7)

LINEAR TRANSFORMATION: Introduction to linear transformations – linear transformations, kernel and range – matrices of linear transformations. (2+2)

STOCHASTIC PROCESSES: Introduction – classification of Stochastic processes. Markov chain: Introduction - transition probability matrices – Chapman Kolmogorov equations - classification of states, limiting probabilities, Poisson process - continuous time Markov chains, Chapman Kolmogorov equations. (6+6)

GRAPH THEORY: Basic concepts**:** Graphs - directed and undirected, subgraphs, graph models, degree of a vertex, degree sequence, Hand-shaking lemma. Walk, trail, path, connectedness, distance, diameter - common classes of graphs, regular, complete, petersen, cycle, path, tree, k-partite, planar, hypercube, mesh - Isomorphic graphs - representation of graphs, adjacency list, incidence list , adjacency matrix and incidence matrix, Spanning trees – Matrix tree theorem (statement only) – Minimum spanning tree using Prim's and Kruskal's algorithms. (6+6)

FINITE ELEMENT METHOD: The Rayleigh-Ritz method, the Collocation and Galerkin method - Finite element method-ordinary differential equations. (3+3)

Total L: 30 + T: 30 = 60

REFERENCES:

1. Elsgolts .L, "Differential Equation and Calculus of Variation", MIR Publication, Moscow, 1977.
2. Howard Anton and Chris Rorres, "Elementary Linear Algebra : Applications Version", Wiley India, New Delhi, 2010.
3. Saeed Ghahramani, "Fundamentals of Probability with Stochastic processes", Pearson, Prentice Hall, New Jersey, 2012.
4. Curtis F, Gerald & Patrick O Wheatly, "Applied Numerical Analysis", Pearson Education, New Delhi, 2011.
5. Narsingh Deo, "Graph Theory with Applications to Engineering and Computer Science", Prentice Hall, New Delhi, 2005.
6. Yellen J and Gross J, "Graph Theory and its Applications", Chapman & Hall, Boca Raton, 2006.

15ED02 FUNDAMENTALS OF POWER SEMICONDUCTOR DEVICES AND ELECTRICAL MACHINES

3 0 0 3

INTRODUCTION: Status of development of power semiconductor devices - Types of static switches - Controlled and uncontrolled - Ideal and real switches – on-state and switching losses- EMI due to switching- Gate circuit requirements - Driver circuit- Protection – selection parameters- Use of heat sinks. (6)

POWER DIODES: Types- Electrical rating- operating principle - Switching and steady state characteristics- Series and parallel operation- Fast recovery diodes. (4)

THYRISTORS: Types- Electrical rating- operating principle - Switching and steady state characteristics of SCR, TRIAC, GTO and IGCT. (7)

POWER TRANSISTORS: Types- Electrical rating- operating principle - Switching and steady state characteristics of Power BJT, Power MOSFET and IGBT- design of basic driver circuit for power MOSFET and IGBT. (8)

EMERGING DEVICES: Power Integrated circuit – Characteristics - Field controlled thyristors - New semiconductor materials for devices - Intelligent power modules. Comparison of Power semiconductor devices- selecting the power semiconductor devices for typical applications. (5)

ELECTRIC MOTORS: DC Motors- principle – types- Characteristics- torque & power equations. AC motors: principle – types- Characteristics- torque & power equations- equivalent circuit (5)

STARTING AND BRAKING: DC and AC motors starters –starting current equations. Electrical braking: methods for DC and AC motors. (5)

SELECTION OF MOTOR POWER RATING: Determination of Motor rating- Classes of Motor Duty -Thermal Model of Motor for Heating & Cooling. (5)

Total L: 45

REFERENCES:
1. Rashid, M.H., "Power Electronics: Circuits, Devices and Applications", Prentice Hall of India, New Delhi, 2003.
2. Ned Mohan, Tore M. Undeland and William P. Robbins., "Power Electronics: Converters, Applications and Design", John Wiley and Sons, 2003.
3. Joseph, Vithayathil, "Power Electronics: Principles and Applications," McGraw Hill, 1995.
4. Williams, B.W., "Power Electronics: Devices, Drivers, Applications and Passive Components", ELBS Oxford University Press, 1992.
5. Umanand L., "Power Electronics Essentials & Applications", Wiley India Pvt. Ltd., 2009.

15ED03 POWER CONVERTERS AND ANALYSIS

3 0 0 3

AC TO DC CONVERTERS: Single phase and three phase bridge rectifiers, half controlled and fully controlled converters with RL, RLE loads, Freewheeling diode, Dual Converter (6)

Evaluation of performance parameter, Input harmonics and output ripple, smoothing inductance, power factor, effect of source inductance, overlap, Design of converter circuits – Snubber circuit design - Control circuit strategies. (5)

DC TO DC CONVERTERS: DC choppers**:** Step down dc chopper with R, RL and RLE loads - Control strategies- Continuous and discontinuous current operations - Two quadrant and four quadrant DC chopper - Multiphase DC chopper - Switching mode regulators: Buck, Boost, Buck-Boost and CUK regulators - Chopper circuit design – Control circuit strategies. (7)

AC TO AC CONVERTERS: Principle of phase control, single-phase bi-directional controllers with R, L and R-L loads, 3-phase bi-directional Controllers, different Configurations, Analysis with pure R and L loads. Principle of operation, - single phase and three phase cyclo converters - Control circuit strategies. (9)

DC TO AC CONVERTERS: Single phase and Three phase bridge inverters - Evaluation of performance parameters –Voltage control and Waveform improvement Techniques – Current source inverters - Inverter circuit design. (9)

RESONANT AND SOFT-SWITCHING CONVERTERS: Introduction-Classification- Resonant Switch - quasi-resonant converters-multi-resonant converters. (9)

Total L : 45

REFERENCES:
1. Rashid M.H., "Power Electronics Circuits, Devices and Applications **"**, Prentice Hall India, 3rd Edition, New Delhi, 2009.
2. Sen PC,"Modern Power Electronics ", Wheeler publishing Co, Tata McGraw Hill, 2004.
3. Ned Mohan, Tore M. Undeland, William P. Robbins, "Power Electronics: Converters, Applications, and Design", John Wiley and Sons, Inc., New York, 2003.
4. Joseph Vithayathil, "Power Electronics - Principles and Applications", McGraw Hill Inc., New York, 1995.
5. VedamSubrahmanyam, "Power Electronics", New Age International (P) Limited, New Delhi, 1996.
6. MD Singh and K B Khanchandani,"Power Electronics" Tata McGraw Hill, 2006.

15ED04 MICROCONTROLLERS AND APPLICATIONS

3 0 0 3

INTEL 8051 : Architecture of 8051 - Memory organization - Register Banks - Bit addressable area - SFR area – Addressing modes – Instruction set - Programming examples. (9)

8051 Interrupt structure -Timer modules - Serial features - Port structure - Power saving modes - MCS51 Family features: 8031/8051/8751. (7)

TYPICAL APPLICATIONS: Stepper Motor Control - DC Motor Control – Servo motor control - AC Power Control. (6)

ARM PROCESSORS: ARM Programmer's Model – Registers – Processor Modes – State of the processor – Condition Flags – ARM Pipelines – Exception Vector Table – ARM Processor Families – Typical 3 stage pipelined ARM organization–Introduction to ARM Memory Management Unit. (9)

ARM Addressing Modes – ARM Instruction Set Overview – Thumb Instruction Set Overview – LPC210X ARM Processor Features. (7)

MICROCONTROLLER DEVELOPMENT TOOLS: Compiler – Assembler – Linker/Locator – Intel Hex file format – Emulators: ROM Emulators – In-circuit Emulators – Logic Analyzer. (7)

Total L: 45

REFERENCES:
1. "8-bit Embedded Controllers", Intel Corporation, 1990.
2. William Hohl "ARM Assembly Language Fundamental and Techniques" CRC Press Taylor & Francis, 2009.
3. Andrew Sloss, "ARM System Developer's Guide", Morgan Kaufmann Publishers, 2005.
4. Steve Furber, "ARM System-on-Chip Architecture", Pearson Education, 2009.
5. "LPC210x ARM Processor Datasheet" Rev. 5, Philips Electronics, 2004.

15ED05 / 15EA07 / 15EE08 OBJECT COMPUTING AND DATA STRUCTURES

3 2 0 4

PRINCIPLES OF OBJECT ORIENTED PROGRAMMING: Software Crisis - Software Evolution - Procedure Oriented Programming, Object Oriented Programming paradigm - Basic concepts and benefits of OOP - Object Oriented Language - Application of OOP - Structure of C++ - Applications of C++ - Operators in C++ - Manipulators. (4+2)

FUNCTIONS IN C++: Call by Reference - Return by reference - Inline functions - Default, Const Arguments - Function Overloading - Friend Functions - Classes and Objects - Member functions - Nesting of Member functions -Private member functions - Memory allocation for Objects - Static data members - Static Member Functions - Arrays of Objects -Objects as Function Arguments - Friend Functions - Pointers to Members. (5+4)

CONSTRUCTORS: Parameterized Constructor-Copy constructor - Multiple Constructors in a Class – Destructors. (4+2)

INHERITANCE: Defining Derived Classes - Single Inheritance - Making a Private Member Inheritable - Multiple Inheritance - Hierarchical Inheritance – Hybrid Inheritance. (4+4)

POLYMORPHISM: Compile and Run Time Polymorphism – Operator Overloading - Virtual function. (4+4)

DATA STRUCTURES: Abstract data Types - Primitive data structures - Analysis of algorithms - Best, worst and average case time complexities – Notation. (4+0)

ARRAYS: Operations - Implementation of one, two, three and multi dimensioned arrays - Sparse and dense matrices - Applications. (4+3)

STACKS: Primitive operations - Sequential implementation - Applications: Subroutine handling, Recursion. (4+3)

QUEUES: Primitive operations - Sequential implementation - Dequeues - Applications: Job Scheduling. (4+3)

LISTS: Primitive Operations - Singly linked lists, Doubly linked lists, Circular lists – Applications: Addition of Polynomials, Sparse Matrix representation and Operations - Linked Stacks - Linked queues. (5+3)

SORTING: Insertion sort - Selection sort - Bubble sort - Radix sort - Algorithms and their time complexities. (3+2)

Total L: 45 + T: 30 = 75

REFERENCES:

1. Stanley B Lippman, Josee Lajoie and Barbara E Moo, “The C++ Primer”, Pearson Education, New Delhi, 2009.
2. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2005.
3. Aaron M Tanenbaum, Moshe J Augenstein and Yedidyah Langsam, "Data structures using C and C++", Pearson Education, New Delhi, 2009.
4. Harvey M Deitel,and Paul J Deitel, “C++ How to Program”, Prentice Hall, New Delhi, 2010.
5. Herbert Schildt, “C++ - The Complete Reference", Tata McGraw Hill, New Delhi, 2012.
6. Nell Dale, “C++ Plus Data Structures”, Jones & Bartlett, Massachusetts, 2011.

15ED51 POWER CONVERTERS LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

1. Study of Characteristics of Power Semiconductor Devices.
2. Performance analysis of AC to DC converter with RL and RLE Load
3. Performance analysis of AC to AC converter with RL and RLE Load
4. Performance analysis of DC to DC converter with RL and RLE Load
5. Single phase SPWM pulse generation using microcontroller.

Total P: 60

15ED61 INDUSTRIAL VISIT & TECHNICAL SEMINAR

0 0 4 2

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits. A quiz covering the above will be held at the end of the semester.

Total P: 60

II SEMESTER

15ED06 LINEAR SYSTEMS

3 0 0 3

MODERN CONTROL THEORY : Limitations of conventional control theory - Concepts of state, State variables and state model – state model for linear time invariant systems: State space representation using physical-Phase and canonical variables- Transfer function from state model. (9)

DISCRETE SYSTEM: State space representation of discrete system - Discretisation of continuous time state equations. (5)

SYSTEM RESPONSE: Solution of state equation - - Characteristic equation - Eigen values and Eigen vectors - State transition matrix computation - Solution of discrete time system - state transition matrix. (5)

SIMILARITY TRANSFORMATION: Diagonalization - Jordan Canonical form - Invariance of Eigen values. (5)

CONTROLLABILITY AND OBSERVABILITY : Definitions - Kalman's and Gilbert's tests - Controllable and observable phase variable forms - Effect of pole-zero cancellation on controllability and observability. (4)

LIAPUNOV STABILITY ANALYSIS: Stability Definitions - Stability in the sense of Liapunov - Definiteness of Scalar Functions – Quadratic forms - Second method of Liapunov - Liapunov stability analysis of linear time invariant systems. (5)

POLE PLACEMENT DESIGN AND STATE OBSERVERS: Stability improvement by state feedback – necessary and sufficient conditions for arbitrary pole placement - State regulator design – Design of state observers. (12)

Total L : 45

REFERENCES:

1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Private Ltd., New Delhi, 2002.
2 Nagrath I.J. and Gopal M., "Control Systems Engineering", New Age International Publisher, New Delhi, 2006.
3. Gopal M, “Digital Control and State Variable Methods”, Tata McGraw-Hill Publishing Company Limited, New Delhi, India, 2003.
4. Nise S. Norman, “Control Systems Engineering”, John Wiley & Sons, Inc, Delhi, 2000.
5. Benjamin C Kuo, ”Automatic Control Systems”, John Wiley & Sons, Inc., Delhi, 2002.

15ED07 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

3 0 0 3

GENERALIZED THEORY: Conversions – Basic two pole machine – Transformer with movable secondary – Transformer voltage and speed voltage - kron’s primitive machine – Analysis of electrical machines. (5)

LINEAR TRANSFORMATION: Invariance of power – Transformation from displaced brush axis three phases to two phases. Rotating axes to stationary axes – Transformed impedance matrix – Torque calculations. (4)

DC MACHINES: Generalized representation - Generator (shunt type only) motor operation - Operation with displaced brushes- Steady state and transient analysis: Sudden short circuit –Sudden application of inertia load. (10)

INDUCTION MACHINES: Generalized representation- Performance equations - Steady state analysis – Transient analysis - Single-phase Induction motor-Transfer function formulation -Double cage machine - Harmonics. (10)

SYNCHRONOUS MACHINES: Generalized representation-Steady state analysis-Transient analysis-Electromechanical transients. (9)

SPECIAL MACHINES: Generalized representation and steady state analysis of Reluctance motor –Brushless DC motor- Variable reluctance motor-single phase series motor. (7)

Total L : 45

REFERENCES:

1. Bimbhra P.S., "Generalised Circuit Theory of Electrical Machines", Khanna Publishers, Delhi, 2002.
2. Adkins B., “The Generalized Theory of Electrical Machines”, Dover Publishers, 1980.
3. Chee- Mun Ong “Dynamic simulation of electrical machinery using MATLAB” Prentice – Hall, Inc, 1998.
4. Krishnan R., “Electric Motor & Drives: Modeling, Analysis and Control”, Prentice Hall of India, 2001.
5. Krause, P.C., O. Wasynczuk, and S.D. Sudhoff, “Analysis of Electric Machinery”, IEEE Press, 1995.

15ED08 ELECTRIC DRIVES AND CONTROL

3 0 0 3

DYNAMICS & CONTROL OF ELECTRICAL DRIVES: Introduction – Parts of Electrical Drives- Fundamental Torque Equations – Speed Torque Conventions and Multiquadrant Operation – Nature & Classification of Load Torques - Modes of Operation – Closed-Loop Control of Drives. (4)

CONVERTER FED DC DRIVES: Single-phase and Three-phase drives - Separately excited and series motor drives - Semiconverter and full Converter fed drives - General analysis - Evaluation of performance parameters - Dual converter fed drives. (5)

CHOPPER FED DC DRIVES: Single- quadrant chopper controlled drives -Evaluation of performance parameters for separately excited and series motor drives - Two quadrant and four quadrant chopper controlled drives. (5)

INDUCTION MOTOR DRIVES: Stator Control: Stator voltage control of 3-Phase induction motors: - control by AC voltage controllers - Variable frequency square wave VSI drives - PWM Drives - CSI drives - closed loop control. (6)

ROTOR CONTROL: Static rotor resistance control - Slip power recovery : Static Kramer drive - Static Scherbius drive. (5)

VECTOR CONTROL OF INDUCTION MOTORS: Principle of vector control -Rotor flux - Oriented control, Stator Flux-oriented control, Magnetizing flux-oriented control of Induction machines. (7)

SENSORLESS VECTOR AND DIRECT TORQUE CONTROLLED DRIVES: Basic types of torque controlled drive scheme: vector drives- direct torque controlled drives. (6)

SPECIAL DRIVES: Synchronous Motor Drives: Scalar control – True synchronous and self control modes - Permanent magnet motor control - Switched reluctance motor and stepper motor drives. (7)

Total L : 45

REFERENCES:

1. Gopal K Dubey, "Fundamentals of Electric Drives", Narosa Publishing House, New Delhi , 2005.
2. Ion Boldea and S.A. Nasar, “Electric Drives”, CRC Press LLC, New York, 1999.
3. Pillai S.K., "Analysis of Thyristor Power Conditioned Motors", University Press, 1992.
4. Bimal K Bose, "Power Electronics and Variable Frequency Drives - Technology and Application", IEEE Press, New York 1997.
5. Peter Vas, "Vector Control of AC Machines", Oxford University Press, 1990.

15ED09 SIMULATION OF POWER ELECTRONIC SYSTEMS

3 0 0 3

INTRODUCTION: Need for Simulation - Challenges in simulation - Classification of simulation programs - Overview of PSPICE, MATLAB and SIMULINK. (6)

MATHEMATICAL MODELLING OF POWER ELECTRONIC SYSTEMS: Static and dynamic models of power electronic switches - Static and dynamic equations and state-space representation of power electronic systems. (6)

PSPICE: File formats - Description of circuit elements - Circuit description – Output variables - Dot commands - SPICE models of Diode, Thyristor, Triac, BJT, Power MOSFET, IGBT, MCT. (7)

MATLAB AND SIMULINK: Toolboxes of MATLAB - Programming and file processing in MATLAB - Model definition and model analysis using SIMULINK - S-Functions - Converting S-Functions to blocks. (6)

SIMULATION USING PSPICE, MATLAB AND SIMULINK: Diode rectifiers -Controlled rectifiers - AC voltage controllers - DC choppers - PWM inverters – Voltage source and current source inverters - Resonant pulse inverters - Zero current switching and zero voltage switching inverters. (10)

Simulation of speed control schemes for DC and AC motors. (10)

Total L : 45

REFERENCES:

1. Muhammad H. Rashid and Hasan M. Rashid., “SPICE for Power Electronics and Electric Power” CRC Press 2006.
2. Ramshaw. E., Schuuram D. C., “PSpice Simulation of Power Electronics Circuits – An Introductory Guide”, Springer, New York, 1996.
3. Chee-Mun Ong, "Dynamic Simulation of Electric Machinery : Using MATLAB/ Simulink", Prentice Hall PTR, New Jersey, 1998.
4. Ned Mohan, "Power Electronics: Computer Simulation Analysis and Education using PSPICE", Minnesota Power Electronics Research and Education, USA, 1992.
5. Randall Shaffer., “Fundamentals of Power Electronics with MATLAB” Charles River Media Boston Massachusetts, 2007.

15ED10 SWITCHED MODE POWER CONVERTERS

3 0 0 3

INTRODUCTION: Switching devices - ideal and real characteristics, control, drive and protection. (3)

REACTIVE CIRCUIT ELEMENTS: Reactive Elements in Power Electronic Systems, Design of inductor, Design of transformer, Capacitors for power electronic applications. (5)

DC-TO-DC CONVERTERS: Basic concepts of Switched Mode power converters. Primitive DC to DC Power Converter-Operating Principle, Exact and Approximate Analysis. (5)

TOPOLOGIES: Non-isolated DC to DC Power Converter- Buck, Boost, Buck-Boost, Cuk, Sepic and Quadratic Converters. Isolated DC to DC Power Converter - Forward, Flyback, Half/Full Bridge Converters. - Steady - state model, dynamic model, analysis, modeling and performance functions of switching power converters. (12)

RESONANT CONVERTERS: Classification of resonant converters-resonant load converters- principal of operation- SMPS using resonant circuit- steady state modeling. Resonant switch converters- Buck converter with ZCS and ZVS-operation and analysis. (10)

CLOSED LOOP CONTROL OF POWER CONVERTERS: Closed Loop Control of Switching Converters- Steady State Error, Control Bandwidth, and Compensator Design- Closed Loop Dynamic Performance Functions- Design of feed- back compensators. Unity power factor rectifiers, resistor emulation principle - applications to rectifiers. (10)

Total L: 45

REFERENCES:

1. Robert W. Erickson, Dragan Maksimovic "Fundamentals of Power Electronics," Springer, 2005.
2. Ramanarayanan V., "Course Material on Switched Mode Power Conversion", Department of Electrical Engineering, Indian Institute of Science, Bangalore, 2007.
3. Issa Batarseh, 'Power Electronic Circuits', John Wiley, 2004.
4. Philip T Krein,' Elements of Power Electronics ', Oxford Press, 1998.
5. L.Umanand, "Power Electronics Essentials & Applications", Wiley India Pvt. Ltd., 2009.

15ED___ ELECTIVE – 1

15ED52 DRIVES AND CONTROLS LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

1. PWM pulse generation using digital controllers
2. Performance analysis of three phase induction motor
3. Performance analysis of Synchronous reluctance motor
4. Performance analysis of SRM/BLDC motor drive
5. Performance analysis of PMSM drive

Total P: 60

III SEMESTER

15ED___ ELECTIVE – 2
15ED___ ELECTIVE – 3
15ED___ ELECTIVE – 4
15ED___ ELECTIVE – 5
15ED___ ELECTIVE – 6

15ED53 POWER ELECTRONIC SYSTEMS DESIGN LABORATORY

0 0 3 2

LIST OF EXPERIMENTS:

1. Design, development and analysis of DC to DC converters using IGBTs, and Power MOSFETs.
2. Design and development of DC to AC converters using IGBTs, and Power MOSFETs.
3. Design, development and analysis of AC to AC converters of various configurations using SCRs, TRIAC, and IGBTs.
4. Design, development and analysis of AC to DC converters using SCR and Diodes.
5. Interfacing of Power converter simulation circuits using dSPACE.

Total P: 45

15ED71 PROJECT WORK – I

0 0 6 3

- Identification of a problem.
- Literature survey of identified problem.
- Finalization of project specification and requirements
- Presentation / Demonstration of sub block(s) of the Project (Hardware / Software / both)

IV SEMESTER

15ED72 PROJECT WORK – II

0 0 28 14

- Project Implementation (Hardware / Software / both)
- Presentation / Demonstration about the work done
- Consolidated report preparation

PROFESSIONAL ELECTIVES I

15ED21 ROBOTICS AND FACTORY AUTOMATION

3 0 0 3

FUNDAMENTAL CONCEPTS OF ROBOTICS: History, Present status and future trends in Robotics and automation - Laws of Robotics - Robot definitions - Robotics systems and robot anatomy - Specification of Robots - resolution, repeatability and accuracy of a manipulator. Robotic applications. (4)

ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS: Robot drive mechanisms, hydraulic – electric – servomotor-stepper motor - pneumatic drives, Mechanical transmission method - Gear transmission, Belt drives, cables, Roller chains, Link - Rod systems - Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws, End effectors – Types. (8)

SENSORS: Principle of operation, types and selection of Position& velocity sensors, Potentiometers, Encoders, Resolvers, LVDT, Tachogenerators, Proximity sensors. Limit switches – Tactile sensors - Touch sensors - Force and torque sensors. (6)

VISION SYSTEMS FOR ROBOTICS: Robot vision systems, Illumination techniques, Image capture- solid state cameras – Image representation - Gray scale and colour images, image sampling and quantization - Image processing and analysis –, Image data reduction – Segmentation - Feature extraction - Object Recognition- Image capturing and communication - JPEG, MPEGs and H.26x standards, packet video, error concealment- Image texture analysis. (8)

TRANSFORMATIONS AND KINEMATICS: Matrix representation- Homogeneous transformation matrices - The forward and inverse kinematics of robots - D-H representation of forward kinematic equations of robots. (5)

PLC: Building blocks of automation, Controllers – PLC- Role of PLC in Robotics& FA - Architecture of PLC - Advantages - Types of PLC - Types of Programming - Simple process control programs using Relay Ladder Logic and Boolean logic methods - PLC arithmetic functions. (5)

FACTORY AUTOMATION: Flexible Manufacturing Systems concept - Automatic feeding lines, ASRS, transfer lines, automatic inspection - Computer Integrated Manufacture - CNC, intelligent automation. Industrial networking, bus standards, HMI Systems, DCS and SCADA, Wireless controls. (9)

LAB COMPONENT:

1. Simulation of Fanuc Robot using ROBO GUIDE
2. Programming of Fanuc M 710i robot.
3. Programming of Adept SCARA and Parallel kinematic robot.
4. Programming of Differential Mobile Robot
5. Programming and study of Humanoid

Total L : 45 + P:30 = 75

REFERENCES :

1. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy, Prentice Hall of India P Ltd., 2006.
2. Fu KS, Gonzalez RC, Lee C.S.G, "Robotics : Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
3. Mikell P Grooveret. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008.
4. Saeed B Niku,"Introduction to Robotics Analysis,Systems,Applications"'PHI Pvt Ltd, New Delhi,2003.
5. Deh S R., "Robotics Technology and Flexible Automation", Tata McGraw Hill Publishing, Company Ltd., 1994.

15ED22 SCADA AND DCS

3 0 0 3

INTRODUCTION: Factory & Process Automation, PLC - Networking standards. Vertical Integration of Industrial Automation – Field bus and Ethernet. (7)

HMI SYSTEMS: Necessity and Role in Industrial Automation, Text display - operator panels - Touch panels - Panel PCs - Integrated displays (PLC & HMI) (7)

SUPERVISORY CONTROL AND DATA ACQUISITION: SCADA – overview – Developer and runtime packages – architecture – Tools – Tag Internal & External graphics, Alarm logging – Tag logging – structured tags – Trends – history – Report generation, VB & C Scripts for SCADA application. (8)

COMMUNICATION PROTOCOLS OF SCADA: Proprietary and open Protocols-OLE/OPC-DDE-Server/Client Configuration – Messaging – Recipe – User administration – Interfacing of SCADA with PLC, drive, and other field devices. (7)

DISTRIBUTED CONTROL SYSTEMS: Difference between SCADA system and DCS – architecture – local control unit – programming language – communication facilities – operator interface – engineering interfaces. (8)

APPLICATIONS OF SCADA & DCS: Case studies of Process plants using SCADA & DCS – Advanced features / options in SCADA & DCS – Role of PLC in DCS and SCADA – comparison – interfacing field devices (Transducers, drives etc) in DCS/ SCADA. (8)

LAB COMPONENT:

1. Development of Control Logic for various applications using Simatic STEP7 Software
2. Development of SCADA screen using Siemens WINCC/TIA Portal
   a) with internal and external tags
   b) for alarm logging
   c) for Trending
   d) for interfacing with field devices and HMI

Total L : 45 + P:30 = 75

REFERENCES:

1. John W. Webb & Ronald A. Reis, “Programmable Logic Controllers", Prentice Hall Publications, New Delhi, 2010.
2. Michael P Lukas, “Distributed Control Systems”, Van Nostrand Reinfold Company,1995.
3. Hans Berger,” Automating with SIMATIC: Controllers, Software, Programming, Data Communication, Operator Control and Process Monitoring” , Wiley Publications, November 2012.
4. Stuart A. Boyer, “ SCADA - SCADA: Supervisory Control and Data Acquisition”, ISA; 4th Revised edition 2009.
5. Bailey and Wright, “ Practical SCADA for Industry”, Elsevier Publications, 2003.
6. WiNCC Software Manual, Siemens, 2013.

15ED23 COMPUTER NUMERICAL CONTROL

3 0 0 3

INTRODUCTION: History - Advantages and disadvantages of CNC, block diagram of CNC - Principle of operation-Various operating modes of a CNC machine. Features available in CNC systems. DNC, Networking of CNC machines - Ethernet. Electrical cabinet and control panel wiring. Electrical standards. (5)

TYPES OF CNC MACHINES : Types and constructional features of machine tools- Turning centres, machining centres, grinding machines, EDMs, turret punch press, laser and water jet cutting machines, Design considerations – Axis representations. (6)

CONTROL UNITS: Functions of CNC, system hardware, Contouring control - interpolation, software development process. Parameters and diagnosis features. Interfacing with keyboard, monitor, servo drives, field inputs, outputs, MPG and feedback devices. Open architecture systems and PC based controllers. Compensation for machine accuracies- pitch error, backlash and thermal compensation. (8)

PROGRAMMABLE LOGIC CONTROLLERS: Role of PLC in CNC machines.Hardware and I/O configuration. Programming techniques –development of ladder logic using basic functions, Timers, comparator and counters - Programming examples. (6)

DRIVE UNITS: Axis drive arrangements, ball screw, timing belts and couplings, Analog and digital drives. AC&DC servomotors, DC and AC servo drives for axis motors, servo tuning. Stepper motors and drives, spindle motors &drives- DC &AC. Selection criteria, drive optimization and protection. (7)

FEEDBACK DEVICES: Absolute and incremental encoders, resolvers, linear optical encoders, Proximity switches, limit switches –Thermal sensors, pressure and float switches. Transducer placement and measuring schemes using these feed back devices. (5)

NC PART PROGRAMMING PROCESS: Axis notation, EIA and ISO codes, Explanation of basic codes. Tooling concepts, machining methods, part geometry and writing of tool motion statements. Canned cycles. Development of simple manual part programs for turning operations. Simulation of part programmes. Post processors - CNC part programming with CAD/CAM systems. Computer aided part programming. (8)

LAB COMPONENT:

1. Simulation of CNC Configuration using NC Guide
2. Programming and simulation of milling machine in Heidenhain controller
3. Programming of Basic CNC Lathe
4. Programing of different cycles in CNC Machine
5. Trouble shooting techniques of CNC Machine

Total L : 45 + P:30 = 75

REFERENCES :

1. Stenerson and Curran,” Computer Numerical Control- Operation and Programming”, PHI, 2008.
2. HMT Limited, “Mechatronics”, Tata McGraw Hill, New Delhi, 1998.

3. Peter Smid, “CNC Programming Handbook”, Industrial Press Inc, New York 2000.

PROFESSIONAL ELECTIVE

15ED24 POWER ELECTRONICS IN WIND AND SOLAR POWER CONVERSION

3 0 2 4

INTRODUCTION: Trends in energy consumption - World energy scenario – Energy sources and their availability - Conventional and renewable sources - Need to develop new energy technologies. (4)

PHOTOVOLTAIC ENERGY CONVERSION AND APPLICATIONS: Solar radiation and measurement - Solar cells and their characteristics - Influence of insolation and temperature - PV arrays-Introduction to flexible solar cells - Electrical storage with batteries - Solar availability in India - Switching devices for solar energy conversion - Maximum power point tracking. Stand alone inverters - Charge controllers - Water pumping, Street lighting - Analysis of PV Systems. (10)

POWER CONDITIONING SCHEMES: DC Power conditioning Converters - Maximum Power point tracking algorithms - AC Power conditioners - Line commutated inverters - Synchronized operation with grid supply - Harmonic standards, Harmonic problems. (7)

WIND ENERGY SYSTEMS: Basic Principle of wind Energy conversion - Nature of Wind - Wind survey in India (Moved to INTRODUCTION) - Power in the wind - Components of Wind Energy Conversion System (WECS) - Performance of Induction Generators for WECS - Classification of WECS. (7)

SELF EXCITED WECS: Self Excited Induction Generator (SEIG) for isolated Power Generators - Theory of self excitation - Capacitance requirements - Power conditioning schemes - Controllable DC Power from SEIGs - System performance. (7)

GRID CONNECTED WECS: Grid connectors concepts - Wind farm and its accessories (to be moved to WIND ENERGY SYSTEMS) - Grid related problems - Generator control - Performance improvements - Different schemes - AC voltage controllers - Harmonics and PF improvement. (5)

STAND ALONE POWER SUPPLY SYSTEMS: Wind / Solar PV integrated systems - Selection of power conversion ratio - Optimization of system components - Storage - Reliability evolution. (5)
PMSG to be included

Total L : 45

REFERENCES:

1. Mukund R Patel, “Wind and Solar Power Systems”, CRC Press, 2004.
2. Rai, G.D., "Non-conventional Energy Sources", Khanna Publishers, New Delhi, 2002.
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5. Roger A. Messenger, Jerry Ventre,” Photovoltaic System Engineering” CRC Press, 2004.

15ED25 SPECIAL MACHINES AND CONTROLLERS

3 1 0 3.5

STEPPER MOTORS: Types **-**Constructional features, principle of operation, modes of excitation - torque production in Variable Reluctance (VR) stepper motor, dynamic characteristics, Drive systems and circuit for open loop and closed loop control of stepper motor. (6)

SWITCHED RELUCTANCE MOTORS: Constructional features, principle of operation, Torque equation, characteristics, Control Techniques, Drive concept – Applications- **Introduction to SynRM**. (9)

PERMANENT MAGNET BRUSHLESS DC MOTORS: Commutation in DC motor, Electronic commutation, Hal sensors, Optical sensors, Magnetic circuit model, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller. (8)

PERMANENT MAGNET SYNCHRONOUS MOTORS: Introduction -Motor Morphologies -Principle of operation, EMF, power input and torque expressions, Phasor diagram, Torque -speed characteristics -Parameter Estimation Power controllers, Torque Controllers, , Self-control, Vector control, Current control schemes. (9)

LINEAR MOTORS: Linear Induction motor (LIM) classification - construction - Principle of operation - concept of current sheet - goodness factor - DC Linear motor (DCLM) types - circuit equation - DCLM control applications. (8)

SERVOMOTORS: Types – Constructional features, principle of operation - control applications (5)

Total L: 45

REFERENCES:

1. Miller T.J.E,"Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
2. KenjoT and Naganori, S., “Permanent Magnet and Brushless DC Motors", Clarendon Press, Oxford, 1989.
3. Kenjo T, "Stepping Motors and their Microprocessor Control", Clarendon Press, Oxford, 1989.

4. Naser A and Boldeal., “Linear Electric Motors: Theory, Design and Practical Applications”, Prentice Hall Inc., New Jersy, 1987.
5. Floyd E Saner,” Servo Motor Applications“, Pittman USA, 1993.

15ED26 DIGITAL CONTROLLERS IN POWER ELECTRONIC APPLICATIONS

3 0 0 3

INTRODUCTION TO DSP PROCESSOR: Introduction to the C2xx DSP core and code generation. The components of the C2xx DSP core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface, System configuration registers, Memory , Types of Physical Memory , memory Addressing Modes , Code Composer Studio for C2xx DSP. (8)

I/O AND INTERRUPTS: Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers, Programming I/O. Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software, Programming Interrupts (8)

ADC AND EVENT MANAGERS: ADC Overview , Operation of the ADC in the DSP , Overview of the Event manager (EV), Event Manager Interrupts , General Purpose (GP) Timers , Compare Units, Capture Units And Quadrature Enclosed Pulse (QEP) Circuitry, General Event Manager Information, Programming of ADC and Event Managers (9)

FPGA: Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA, Xilinx XC3000 series - case study. (7)

DESIGN OF CONTROLLER IN POWER ELECTRONICS: Typical applications: DSP-based implementation of DC-DC buck-boost converter- DSP-based control of permanent magnet brushless DC machines- DSP-based Implementation of clarkes’s and park’s transformations- DSP-Based implementation of SPWM, SVPWM inverter pulse generation. (13)

Total L: 45

REFERENCES:

1. 2833x Digital Signal Controller (DSC) Data Manual
   a. TMS320C28x CPU and Instruction Set Reference Guide - SPRU430
   b. TMS320x28xx, 28xxx Peripheral Reference Guide - SPRU566
   c. TMS320x2833x System Control and Interrupts Reference Guide - SPRUFB0
   d. TMS320x2833x Analog-to-Digital Converter (ADC) Reference Guide - SPRU812
   e. TMS320x28xx, 28xxx Enhanced Pulse Width Modulator (ePWM) & High-Resolution Pulse Width Modulator (HRPWM) Module Reference Guide - SPRU791 & - SPRU924
2. Hamid.A.Toliyat and Steven G.Campbell “DSP Based Electro Mechanical Motion Control“ CRC Press New York, 2004.
3. Wayne Wolf,” FPGA based System Design“, Prentice hall, 2004.

15ED27 ADVANCED CONTROL OF ELECTRIC DRIVES

3 0 0 3

ADVANCED CONTROL METHODS : Introduction - Power Converter Control using State-Space Averaged Models - Sliding-Mode Control of Power Converters - Fuzzy Logic Control of Power Converters (7)

MOTOR DRIVES : – Review - DC Motor Drives - Induction Motor Drives - Synchronous Motor Drives - Reluctance motor Drives – Servo Motor Drives (8)

HIGH PERFORMANCE DRIVES: Types of Torque-Controlled Drive Schemes - Vector Drives, Direct-Torque-Controlled Drives – DSP Controlled Drives – DC Drive, AC Drive, Synchronous motor Drive, and Special Motor drive (11)

ARTIFICIAL-INTELLIGENCE BASED DRIVES: AI-Based Techniques - Applications in Electrical Machines and Drives - Neural-Network-Based Drives -commercial AI based Drives (10)

FUZZY LOGIC ELECTRIC DRIVES: The Fuzzy Logic Concept- Applications of Fuzzy Logic to Electric Drives - Hardware System Description (9)

Total L: 45

REFERENCES:

1. Marcian Cirstea, Andrei Dinu, Malcolm Mc Cormick, Jeen Ghee Khor, “Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes Publications, 2002.
2. Bimal K Bose, "Power Electronics and Variable Frequency Drives - Technology and Application", IEEE Press, 1997.
3. Grafame Holmes D and Thomas A Lipo, “Pulse Width Modulation for Power Converters- Principles and Practice”- IEEE Press, 2003.
4. Peter Vas, "Vector Control of AC Machines", Oxford University Press, 1990.
5. Hamid A Toliyat and Steven G. Campbell, “DSP Based Electromechanical Motion Control”, CRC Press, 2004.
6. Ned Mohan, “Advanced Electric Drives: Analysis, Control and Modeling using Simulink”, John Wiley and Sons Ltd, 2001.

15ED28 SOFT COMPUTING TECHNIQUES FOR RENEWABLE ENERGY SYSTEM

3 0 0 3

INTRODUCTION TO SOFT COMPUTING TECHNIQUES: Fundamentals – Biological neural network – Artificial neuron – Activation function – Learning rules **-** Single Layer Feedback Networks - Unsupervised Learning Networks - Membership Functions - Features of membership function - Standard forms and Boundaries - fuzzification - membership value assignments. (5)

INTRODUCTION TO MATLAB AND SIMULINK: Toolboxes of MATLAB - Programming and file processing in MATLAB - Model definition and model analysis using SIMULINK - S-Functions - Converting S-Functions to blocks. (4)

PHOTOVOLTAIC ENERGY CONVERSION: Basics of Solar PV, Parameter Identification of Solar cell Prediction of Solar radiation - Optimization of Solar Array Systems - PV Module Performance Measurements. Types of PV Systems, MATLAB Model of Solar PV - Charge Controller MATLAB Model of SOC - MATLAB Model of Charge Controller Maximum Power Point Tracking, MATLAB/SIMULINK Models of MPPT Techniques, MATLAB/SIMULINK Model of Inverter (9)

WIND ENERGY CONVERSION SYSTEMS: Basics of WECS, Components of WECS - Wind Turbine Generators-MATLAB/SIMULINK model of Wind turbine and Wind Turbine Generators. Prediction of Wind Turbine Power Factor, Pitch Angle Control, MPPT Algorithms, for WECS, Economic Dispatch For Wind Power System – Related MATLAB/SIMULINK models-FLC based STATCOM - Prediction of Wind Speed based on FLC - Fuzzy Logic Controlled SPWM Converter for WECS. (9)

GRID INTEGRATION: Integration of small scale generation into distribution grids, Different types of grid interfaces, Issues related to grid Integration systems - Phase Locked Loop for Grid Connected Power System, Grid Connected Inverters, Current Controllers for PWM inverters, MATLAB/SIMULINK model of Grid Integration, and PLL grid connected power system. (9)

HYBRID ENERGY SYSTEMS: Need for hybrid energy system, MATLAB/SIMULINK models of Hybrid Solar PV and Wind Energy System- - CUK-SEPIC converter, Boost Converter, Hybrid model of Solar PV and Diesel Energy System,– Hybrid Solar PV and Wind Energy Conversion Systems (9)

Total L: 45

REFERENCES:

1. Laurene Fausett, “Fundamentals of Neural Networks”, Pearson Education India, New Delhi, 2004.
2. Randall Shaffer., “Fundamentals of Power Electronics with MATLAB” Charles River Media Boston Massachusetts, 2007.
3. Rao S S., "Optimization Theory and Applications", Wiley Eastern Limited, New Delhi, 2003.
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5. H.P.Garg and J.Prakash, “Solar Energy, Fundamentals and Applications”, Tata McGraw Hill Publishing Company Ltd., New Delh, 1997.

15ED29 FLEXIBLE AC TRANSMISSION SYSTEM

3 0 0 3

INTRODUCTION: Fundamentals of AC power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers. (7)

SHUNT COMPENSATOR: Principle of operation - types - Variable Impedance type & switching converter type - Static Synchronous Compensator (STATCOM) - configuration, characteristics and control-applications. (10)

SERIES COMPENSATOR: Principles of operation- types - static series compensation using GCSC, TCSC and TSSC, Static Synchronous Series Compensator (SSSC) – characteristics and control-applications. (9)

VOLTAGE REGULATORS AND PHASE SHIFTERS: Principles of operation-types -Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations-applications. (9)

UNIFIED POWER FLOW CONTROLLER: Principles of operation – characteristics- independent active and reactive power flow control-applications. Comparison of UPFC with the controlled series compensators and phase shifters. Coordinated control of FACTS Devices. Use of FACTS devices under deregulated environment. (10)

Total L: 45

REFERENCES:

1. Song, Y.H. and Allan T. Johns, ‘Flexible AC Transmission Systems (FACTS)’, Institution of Electrical Engineers Press, London, 1999.
2. Hingorani ,L.Gyugyi, ‘Understanding FACTS - Concepts and Technology of Flexible AC Transmission Systems’, IEEE Press New York, 2000.
3. Mohan R .Mathur and Rajiv Varma K. , ‘Thyristor - based FACTS Controllers for Electrical Transmission Systems’, IEEE Press, Wiley Inter science , 2002.
4. Padiyar K.R., ‘FACTS Controllers for Transmission and Distribution Systems’ New Age international Publishers, 2007.
5. Loi Lei Lai, ‘Power System Restructuring and Deregulation’, John Wiley & Sons Ltd. 2003.

15ED30 POWER QUALITY MANAGEMENT

3 0 0 3

INTRODUCTION : Definition of power quality – Power quality, Voltage quality – Power quality issues : Short duration voltage variations, Long duration voltage variations, Transients, Waveform distortion, Voltage imbalance, Voltage fluctuation, Power frequency variations – Sources and Effects of power quality problems – Power quality terms – voltage and current harmonics – standards - Power quality and Electro Magnetic Compatibility (EMC) Standards. (7)

SHORT INTERRUPTIONS : Introduction – Origin of short interruptions : Voltage magnitude events due to reclosing, Voltage during the interruption – Monitoring of short interruptions – End user issues : Influence on induction motors, Synchronous motors, Adjustable speed drives, Electronic equipments – Utility system fault clearing issues – Single phase tripping : Voltage during fault and post fault period, Current during fault period – Prediction of short Interruptions. (7)

LONG INTERRUPTIONS : Definition – Terminology : Failure, Outage, Interruption – Origin of interruptions – Causes of long interruptions – Principles of regulating the voltage – Voltage regulating devices, Applications : Utility side, End-User side – Limits for the interruption frequency, Interruption duration – Reliability evaluation – Cost of interruptions. (7)

VOLTAGE SAG : Introduction – Definition – Characterization : Magnitude, Duration – Causes of Voltage Sag – Three Phase Unbalance – Phase angle jumps – Load influence on voltage sags – Equipment behavior : Adjustable speed drives, Power electronics loads, Sensitive loads - Stochastic assessment of voltage sags - Overview of mitigation methods. (7)

WAVEFORM DISTORTION & TRANSIENTS : Voltage Vs Current distortion – Harmonics Vs Transients – Sources and effects of harmonic distortion – System response characteristics – Principles of controlling harmonics - Types and causes of transients – Devices for over voltage protection - Utility capacitor switching transients – Utility lightning protection – Transients from load switching. (6)

WIRING AND GROUNDING: Definitions and terms – Reasons for grounding –Typical Wiring and Grounding Problems- Solutions to Wiring and Grounding Problems (5)

POWER QUALITY SOLUTIONS : Introduction – Power quality monitoring : Need for power quality monitoring, Evolution of power quality monitoring, Deregulation effect on power quality monitoring – Brief introduction to power quality measurement equipment's and power conditioning equipment's –Introduction to harmonic filters- Planning, Conducting and Analyzing power quality survey. (6)

Total L: 45

REFERENCES:

1. Roger C. Dugan, Mark F. McGranaghan and H.WayneBeaty, "Electrical Power Systems Quality", McGraw-Hill,New York, 2002.
2. Barry WKennedy, "Power Quality Primer", McGraw-Hill, New York , 2000.
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15ED31 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS

3 0 0 3

HIGH POWER DEVICES AND THREE PHASE CONVERTERS: High power devices for power system controllers – characteristics – Converters configuration for large power control. Properties of three phase converters – Current and voltage harmonics – Effects of source and load impedance – Choice of best circuit for power systems. (8)

CONVERTER CONTROL : Gate control – Basic means of control – Control characteristics – Stability of control –Reactive power control. (6)

HVDC SYSTEM : Application of converters in HVDC system – Static VAR control – Sources of reactive power – Harmonics and filters. (7)

WIND ENERGY AND PV ENERGY CONVERSION SYSTEM: Basic components – Generator control –– Power factor improvement - Different schemes for PV energy conversion – DC and AC power conditioners –Synchronized operation with grid supply – Harmonic problems. (9)

POWER FLOW AND STABILITY ANALYSIS: Component models – Converter control – Analysis of converter for power flow analysis– Transient and Dynamic stability analysis – Protection. (8)

FACTS: Concepts of flexible AC Transmission system – static VAR compensators – Thyristor controller reactor- Thyristor switched capacitor – Static condenser – controllable series compensation – UPFC – Static Voltage and phase angle regulators. (7)

Total L: 45

REFERENCES:

1. Acha E and Agilidis VG, "Power Electronic Control in Electrical Systems",Elsevier India Pvt. Ltd., 2006.
2. Arrillaga and Watson, "Computer Modelling of Electrical Power Systems", John Wiley, London, 2001.

3. Padiyar KR, “HVDC Power Transmission System- – Technology and System Interaction”, New Age International Publication, 2006.
4. Mukund R Patel, “Wind and Solar Power Systems – Design, Analysis and Operation”, CRC Press, London, 2006.
5. Rai GD, “Solar Energy Utilization”, Khanna Publishers, Newdelhi, 2004.
6. Rakesh Das Bagamudre, “Extra High Voltage AC Transmission Engineering”, New Age International Publishers Pvt. Ltd., 2005.

15ED32 ADVANCED TOPICS IN POWER ELECTRONICS

3 0 0 3

RESONANT CONVERTERS: Zero voltage and Zero current switching – Classification of resonant converters - Basic resonant circuit concepts - Load resonant converters - Resonant switch converters - Zero voltage switching, clamped voltage topologies - Resonant DC link Inverters and Zero voltage switching - High frequency link integral half cycle converters - Applications in SMPS and lighting. (11)

IMPROVED UTILITY INTERFACE: Generation of current harmonics – Current harmonics and power factor - Harmonic standards and recommended practices - Need for improved utility interface - Improved single phase utility interface - Improved three phase utility interface - Electromagnetic interference. (13)

FACTS AND CUSTOM POWER: Introduction - Principles of reactive power control in load and transmission line compensation - Series and shunt reactive power compensation - Concepts of Flexible AC Transmission System (FACTS) - Static var compensators (SVC) - Thyristor controlled reactor - Thyristor switched capacitor - Solid state power control - Static condensers - Controllable series compensation - Thyristor controlled phase-angle regulator and unified power flow control - Modeling and methods of analysis of SVC and FACTS controllers - System control and protection - Harmonics and filters – Simulation and study of SVC and FACTS under dynamic conditions. (15)

EMERGING DEVICES AND CIRCUITS: Power Junction Field Effect Transistors - Field Controlled Thyristors - JFET based devices Vs other power devices - MOS controlled thyristors - Power integrated circuits - New semiconductor materials for power devices. (6)

Total L: 45

REFERENCES:

1. Ned Mohan., Undeland, and Robbins, " Power Electronics: Converters, Applications and Design ", John Wiley and Sons (Asia) Pte Ltd, Singapore, 2003.
2. Rashid, M.H., “Power Electronics – Circuits, Devices and Applications”, Pearson Education (Singapore) Pte. Ltd, New Delhi, 2004. Prentice Hall of India, New Delhi.
3. Joseph Vithayathil., ”Power Electronics”, Mc-Graw Hill Series in Electrical and Computer Engineering, USA, 1995.
4. Las Zlo Gyugyi, Narain G Hingorani, “Understanding Facts: Concepts & Technology of Flexible AC Transmission System”, The Institute of Electrical and Electronics Engineers. Inc., New York, 2000.
5. Mohan Mathur P, Rajiv K Varma, “ Thyristor – Based Facts Controllers for Electrical Transmission Systems”, John Wiley and Sons Inc., IEEE Press,USA, 2002.

15ED33 HVDC TRANSMISSION

3 0 0 3

GENERAL ASPECTS: Historical development - HVAC and HVDC links – Structure of HVDC Transmission – Principles of HVDC Control – Reactive power demand –Economic considerations – Applications- Advantages and Disadvantages. (6)

ANALYSIS OFCONVERTER AND INVERTER CIRCUITS: Choice of Converter configuration - Properties of Thyristor converter circuits – Three phase converters - Analysis with gate control with and without overlaps - Characteristics of twelve pulse converter-Deciding factors for best circuit of HVDC converters – Operation of Inverter – Transformer connections. (10)

CONTROL: Basic means of control – Gate Control - Power reversal - Constant current versus constant voltage - Control characteristics - Stability of control - Frequency control - Multi terminal lines. (9)

MISOPERATION OF CONVERTERS and PROTECTION: Converter disturbance – By pass action in bridge – Short circuit on a rectifier – Commutation failure- Basics of protection - DC reactors - Voltage and current oscillations - Clearing line faults and re-energizing - Circuit breakers - Overvoltage protection. (9)

HARMONICS and FILTERS: Characteristics and uncharacteristic harmonics –Effects of harmonics and its mitigation - Harmonic filters. (6)

LOSSES AND GROUNDING: Corona loss in HVDC lines - Radio interference due to corona- Grounding –advantages and problems- Design of earth electrodes. (5)

Total L: 45

REFERENCES:

1. Kimbark, E.W., ‘Direct Current Transmission-Vol.1’, Wiley Interscience, New York, 1971.
2. Padiyar K.R., “HVDC Power Transmission System – Technology and System Interaction”, New Age International (P) Limited, 2006.
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5. Arrillaga J, Liu Y.H, Watson NR, “Flexible Power Transmission: The HVDC Options” John-Wiley & Sons INC publication, 2007.

15ED34 OPTIMIZATION TECHNIQUES

3 0 0 3

INTRODUCTION TO OPTIMIZATION: Statement of Optimization problems - Classical optimization techniques - Single variable and multi variable optimization - Method of direct substitution constraint variation - Lagrange multipliers multivariable optimization with equality constraints - Kuhn Tucker conditions. (7)

LINEAR PROGRAMMING: Linear programming definition - Pivotal reduction of general system of equations - Simplex algorithms - Two phases of the simplex method - Revised simplex method - Duality in linear programming. (6)

NONLINEAR PROGRAMMING (ONE DIMENSIONAL): Unimodal function – Elimination methods - Unrestricted and exhaustive search, Dichotomous search, Fibonacci method - Interpolation methods - Direct root method. (5)

NONLINEAR PROGRAMMING (UNCONSTRAINED OPTIMIZATION) : Direct search methods - Univariate method, Pattern search methods - Rosenbrock's method – The simplex method - Descent method - Conjucate gradient method - Quasi Newton methods. (7)

NONLINEAR PROGRAMMING (CONSTRAINED OPTIMIZATION) : Direct methods - The Complex method - Cutting plane method - Methods of feasible directions and determination of step length - Termination criteria, determination of step length (8)

DYNAMIC PROGRAMMING: Multistage decision process - Computational procedure - Final value problem to initial value problem -Continuous dynamic programming - Discrete dynamic programming. (7)

HEURISTIC TECHNIQUES FOR OPTIMIZATION - Neural Networks - Genetic algorithm – Adaptive genetic algorithm – particle swarm optimization - Ant Colony Optimization - Typical applications. (5)

Total L: 45

REFERENCES:

1. Nash S G and Ariela Sofer, "Linear and Nonlinear Programming", McGraw Hill Book Com Inc, New York, 1996.
2. David E Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison Wesley Publishing Company, 1999.
3. Rao S S., "Optimization Theory and Applications", Wiley Eastern Limited, New Delhi, 2003.
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15ED35 DIGITAL SIGNAL PROCESSING

3 0 0 3

DISCRETE TIME SYSTEMS: Properties – Linearity – Shift Invariance – Causality & Stability – Z-Transform – Inverse Z - Transform – Difference equations – Transfer function of linear discrete systems - Frequency Response of Discrete Time Systems. (5)

DESIGN OF DIGITAL FILTERS: Review of design techniques for analog low pass filters – Frequency transformation – IIR filters– Properties – Design –Bilinear transformation and Impulse Invariant design - FIR filters – Characteristics of FIR filters with linear phase – Frequency response of linear phase FIR filters – Design of FIR filters using Window functions (12)

REALIZATION OF DIGITAL FILTERS: Recursive and Non-Recursive Filter realization – Direct, Cascade, Parallel and Ladder realizations. (5)

DISCRETE TRANSFORMS: Discrete Fourier Transform (DFT) – Definition – Properties – Digital filtering using the DFT – Linear and Circular Convolution, Overlap add method, Overlap save method – Fast Fourier Transform – Properties - Radix-2 FFT – Decimation in time – Decimation in frequency – Computing Inverse DFT by doing a direct DFT (10)

EFFECTS OF FINITE REGISTER LENGTH: Effect of number representation on Quantization – Product Quantization – Coefficient Quantization – Signal Scaling – Finite register length effects in realization of IIR digital filters - Finite register length effects in realization of FIR digital filters - Finite register length effects in DFT computations. (6)

MULTIRATE SIGNAL PROCESSING : Concepts of Multirate signal processing –Decimation and Interpolation by an integer factor-Sampling rate conversion by non-integer factors-Multistage approach to sampling rate Conversion (7)

Total L: 45

REFERENCES:

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2. Mitra S K, “Digital Signal Processing – A Computer based Approach”, Tata McGraw Hill, New Delhi, 2005.
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5. Vinay K Ingle & John G Proakis, “ Digital signal processing using MATLAB, Brooks / Cole, 2006.

15ED36 ADVANCED VIRTUAL INSTRUMENTATION

3 0 0 3

FUNDAMENTALS OF VIRTUAL INSTRUMENTATION: Concept of Virtual Instrumentation-Block diagram and Architecture of a virtual instrument-Role of Hardware and Software in virtual instrumentation-Comparison of Graphical programming technique with conventional programming technique. (4)

GRAPHICAL PROGRAMMING ENVIRONMENT: Introduction to LabVIEW- Advantages of using LabVIEW in Virtual Instrumentation - Graphical Data Flow programming- Menus and Palettes-Front Panel Controls and Indicators-Block Diagram Functions-Data types in LabVIEW -Developing simple VI's- sub-VI creation-formula nodes – Debugging techniques in LabVIEW. (9)

PROGRAMMING STRUCTURE IN LabVIEW: loops - case and sequence structures –arrays and clusters-graphs and charts-local and global variables- string & file I/O-examples. (10)

DATA ACQUISITION BASICS: ADC, DAC, DIO -counters & timers - PC Hardware structure-timing- Interrupts DMA- software and hardware installation. (4)

COMMON INSTRUMENT INTERFACES: Motion Control- Image Acquisition and Processing- Serial Communication: RS 232C/ RS485- GPIB – system interface buses: USB, PXI and VISA. (8)

ADVANCED LabVIEW FEATURES: Sound VI's**-** VI server-Web server -Web publishing tool- Multithreading in LabVIEW – LabVIEW Interface for Arduino. (5)

OBJECT ORIENTED PROGRAMMING IN LabVIEW: Object Oriented Programming Concepts- LabVIEW classes and objects-Methods: members VI's-Special methods: Constructors and Destructors- Encapsulation- inheritance-Dynamic dispatch. (5)

Total L : 45

REFERENCES:

1. Garry W Johnson, "LabView Graphical Programming", Tata McGraw Hill, 2001.
2. Sanjay Gupta and Joseph John, "Virtual Instrumentation Using LabVIEW", Tata McGraw-Hill, 2008.
3. Rick Bitter, Taqi Mohiuddin and Matt Nawrocki, "LABVIEW Advanced Programming Techniques", CRC Press, 2009.
4. Barry Paron, "Sensors, Transducers and LabVIEW", Prentice Hall , 2000.

15ED37 WAVELETS AND APPLICATIONS

3 0 0 3

INTRODUCTION: Vector spaces-properties-dot product-basis-dimension, orthogonality and orthonormality-relationship between vectors and signals-signal spaces-concept of convergence-Hilbert spaces for energy signals-Generalized Fourier expansion. (8)

FOURIER ANALYSIS: Fourier Transform-drawbacks of Fourier analysis-Short-time Fourier Transform (STFT) analysis-spectrogram plot-phase-space plot in time-frequency plane-Time and frequency limitations-uncertainty principle-Tilling of the time-frequency plane for STFT. (8)

CONTINUOUS WAVELET TRANSFORM: Wavelet transform-properties-concept of scale and its relation with frequency-Continuous Wavelet Transform (CWT)-scaling function and wavelet functions: Daubechies, Haar, Coiflet, Mexican hat, Sine, Gaussian, Tilling of time scale plane for CWT. (7)

DISCRETE WAVELET TRANSFORM: Discrete Wavelet Transform (DWT)-Filter bank and sub-band coding principles-Multi-resolution analysis-Time scale difference equations for wavelets and scaling functions-Wavelet filters-scale variation in discrete domain-Mallet's algorithm for DWT-Inverse DWT computation by filter banks-multi-band wavelet transform. (9)

ADVANCED TOPICS: Wavelet packets, Bi-orthogonal basis, Lifting scheme of wavelet generation, Multiwavelets, Ridgelets, Curvelets. (6)

APPLICATIONS OF WAVELETS : Sub-band coding of images-Image compression-Image de-noising-Detection of sag, tilt, swells and surge in power signal-Fractal signal analysis. (7)

Total L: 45

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5. Mallat S., "A Tour on Wavelet Signal Processing", Elsevier, New Delhi, December, 2008.

15ED38 PERSONAL COMPUTER SYSTEMS

3 0 0 3

ARCHITECTURE: AT architecture - DMAC - Interrupt controllers - Timers -Memory map - I/O map - AT BUS (ISA BUS) specifications –Extended and expanded memory - PCI Bus concepts. (6)

PERIPHERAL ADAPTERS: Keyboard Interfacing - Functional description of keyboard processing - Display Adapters: VGA and SVGA adapter – Functional configurations – AGP basics. (6)

FLOPPY DISKETTE TYPES: Hard disk structure - IDE Bus-SATA - CD-ROM structure – Printers - Centronics parallel interface - Features of EPP and ECP modes of printers - USB Bus. (9)

ASSEMBLY LANGUAGE PROGRAMMING: Program development stages -Macro assembler: Directives - Macros - Linker - Debugger in real mode of the processor. (9)

STRUCTURE OF MS-DOS: BIOS - DOS Kernel - Command processor – Boot record - File allocation table - File directory - Booting process of DOS-COM and EXE files - BIOS and DOS interrupts - Structure of device drivers. (7)

MULTIUSER/ MULTI-TASKING OPERATING SYSTEM CONCEPTS: Scheduling - Protection - Memory management – Windows system architecture : Virtual hardware and device drivers - Windows virtual address space memory map - Comparison of WIN 16 and WIN 32 applications structure. (8)

Total L: 45

REFERENCES:

1. Mathivanan N., “Microprocessors, PC Hardware Interfacing”, Prentice Hall of India, Reprint 2007.
2. Douglas V Hall, "Microprocessors and Interfacing: Programming and Hardware", McGraw Hill, 2006.
3. Barry B Brey, "The Intel Microprocessor 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium Pro Processor, Pentium II ,III and IV Architecture, Programming and Interfacing", Prentice Hall of India, 2005.
4. Ray Duncan, "Advanced MSDOS Programming", Microsoft Press, USA, 2002.
5. Walter Oney, ”Systems Programming for Windows 95”, Microsoft Press, USA, 1996.
6. IBM PC/AT Technical Reference Manual,1985.

15ED39 SMART GRID TECHNOLOGIES

3 0 0 3

SMART GRID ARCHITECTURE AND INITIATIVES: Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives. (10)

DISTRIBUTION AUTOMATION SYSTEMS: Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV). (10)

ADVANCED METERING INFRASTRUCTURE: Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU), Intelligent Electronic Devices(IED) & their application for monitoring & protection. (8)

POWER QUALITY & EMC IN SMART GRID: Power Quality issues of Grid connected Renewable Energy Sources, Web based Power Quality monitoring, Power Quality Audit. (8)

SMART GRID NETWORKING AND COMMUNICATIONS: Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid. (9)

Total L : 45

REFERENCES:

1. Stuart Borlase, “Smart Grid: Infrastructure, Technology and Solutions”, CRC Press, 2012.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu and Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley, 2012.
3. Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, “Smart Grid Technologies: Communication Technologies and Standards”, IEEE Transactions on Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang ‘Smart Grid – The New and Improved Power Grid: A Survey’, IEEE Transaction on Smart Grids.
5. IEEE Transactions on Smart Grid.

15ED40 DISTRIBUTED GENERATION AND MICROGRIDS

3 0 0 3

INTRODUCTION : Trends in Energy Consumption – World Energy Scenario – Energy Sources and their availability – Conventional Energy Sources – Advantages and Disadvantages – Non-conventional Energy Sources – Review of Solar Photovoltaic – Wind Energy Systems – Fuel Cells – Micro turbines – biomass and tidal energy conversion systems. Energy storage systems: Batteries – ultra capacitors – fly wheels – captive power power plants. (9)

DISTRIBUTED GENERATION : Distributed Generation – Concept and topologies, Role of Renewable Energy in Distributed Generation. Standards – IEEE 1547 Standard for Interconnecting Distributed Generation to Electric Power Systems – DG Installations – Siting and sizing of DGs – optimal placement – Regulatory issues. (9)

ISSUES IN GRID INTEGRATION OF RENEWABLES : Basic requirements of Grid Interconnections – operational Parameters – Voltage, Frequency and THD limits – Grid Interfaces – Inverter based DGs and rotary machines based DGs – Reliability, Stability and Power Quality issues on Grid Integration – Impact of DGs on Protective Relaying and islanding issues in existing distribution Grid. (9)

MICROGRIDS : Introduction to Microgrids – types – Structure and configuration of Microgrids – AC and DC Microgrids – Power Electronic Intefaces for Microgrids – Energy Management and Protection Control Strategies of a Microgrid - Case Studies. (9)

CONTROL AND OPERATION OF MICROGRID : Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids. (9)

Total L : 45

REFERENCES:

1. Gregory W. Massey, “Essentials of Distributed Generation Systems”, Jones & Bartlett Publishers, 2011.
2. Math H. Bollen, “Integration of Distributed Generation in the Power System”, John Wiley & Sons, 2011.
3. N. Jenkins, Nicholas Jenkins, “Distributed Generation” Institution of Engineering and Technology (IET Press), 2010.
4. S. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks”, Institution of Engineering and Technology (IET Press), 2010.
5. Ali Keyhani, “Design of Smart Power Grid Renewable Energy Systems”, John Wiley & Sons, 2011.

15ED41 HYBRID ELECTRIC VEHICLES

3 0 0 3

Introduction to Hybrid Electric Vehicles: Impact of different transportation technologies on environment and energy supply - Air pollution and global warming- History of hybrid electric, electric and fuel cell vehicles- Vehicle motion and the dynamic equations for the vehicle- Vehicle power plant and transmission characteristics and vehicle performance including braking performance- Fuel economy characteristics of internal combustion engine. (9)

Hybrid Power Train Topology and Dynamics: Basic architecture - Analysis of drive trains and power flows - Drive cycle implications and fuel efficiency estimations- Sizing of components for different hybrid drive train topologies- Topologies for electric drive-train - Fuel efficiency estimations and wheel to wheel fuel efficiency analysis- Sizing of components for different electric drive train topologies. (9)

Electric Propulsion Unit: Electric drives used in HEV/EVs, classifications and characteristics – Induction motor, permanent magnet motors, switch reluctance motors, their configurations and optimization for EV/HEVs. Induction motor drives, Permanent Magnetic Motor drives, switch reluctance motor drives - their control and applications in EV/HEVs - Losses in traction motors, inverters and efficiency maps. (9)

Sizing of Drives: Sizing the power electronics based on Switch Technology - Switching Frequency and Ripple capacitor design – Selection of energy storage technology - Matching the electric drive and ICE, Transmission selection and gear step selection - Sizing the propulsion motor, its torque, constant power speed ratio and machine dimensions. (9)

Vehicle Power Management and Energy Storage Systems: Energy storage, battery based energy storage and simplified models of battery - Fuel cells, Super capacitor ,Flywheels and their modeling for energy storage in HEV/BEV - Energy management strategies and its general architecture - Rule and optimization based energy management strategies (EMS) - Case study of design of a HEV and BEV. (9)

Total L: 45

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2010.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2009.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Total L : 45

15ED42 INTERNET OF THINGS

3 0 0 3

FUNDAMENTALS OF IoT: Introduction to Internet of Things (IoT) – Machine to Machine (M2M) – Functional Characteristics – Recent Trends in the Adoption of IoT – Societal Benefits of IoT (6)

IoT ARCHITECTURE: Functional Requirements - Components of IoT: Sensors – Actuators – Embedded Computation Units – Communication Interfaces – Software Development. (9)

COMMUNICATION PRINCIPLES: RFID – ZigBEE – Bluetooth – Internet Communication- IP Addresses - MAC Addresses - TCP and UDP – IEEE 802 Family of Protocols – Cellular-Introduction to EtherCAT. (12)

SECURITY IN IoT: IEEE 802.11 Wireless Networks Attacks: Basic Types, WEP Key Recovery Attacks, Keystream Recovery Attacks against WEP – RFID Security – Security Issues in ZigBEE: Eavesdropping Attacks, Encryption Attacks – Bluetooth Security: Threats to Bluetooth Devices and Networks. (10)

OVERVIEW OF IoT APPLICATIONS: Health Care – Smart Transportation – Smart Living – Smart Cities- Smart Gri. (8)

Total L:45

REFERENCES

1. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley and Sons Ltd, UK, 2014.
2. Olivier Hersent, David Boswarthick and Omar Elloumi, “The Internet of Things: Key Applications and Protocols”, John Wiley and Sons Ltd., UK 2012.
3. Dieter Uckelmann, Mark Harrison, Florian Michahelles, “Architecting the Internet of Things”, Springer, New York, 2011.
4. Johnny Cache, Joshua Wright and Vincent Liu, “Hacking Exposed Wireless: Wireless Security Secrets and Solutions”, Tata McGraw Hill, New Delhi, 2010.
5. Himanshu Dwivedi, Chris Clark and David Thiel, “Mobile Application Security”, Tata McGraw Hill, Nw Delhi, 2010.
6. Vijay Madisetti, Arshdeep Bahga, “Internet of Things (A Hands-on Approach), Universities Press, 2015.

ONE CREDIT COURSES

15EK03 LOW – VOLTAGE SWITCHGEAR

1 0 0 1

CONTRACTORS: Introduction to LV Switchgear – Typical industrial electrical layout. Introduction to contractors – Difference between switch and contractor – Types of contactors – Utilization category – Selection of contactors – Nameplate details – Limits of operation – Special types of contactors. (3)

RELAYS AND FUSES : Introduction to overload relay – Types of overload relay – Types of motor failures – Utilization category and trip class – Selection of overload relay – Introduction to Fuses. HRC fuse – Types and Utilization category. Introduction to digital protection techniques. (2)

SWITCHES AND STARTERS : Introduction to switch – Types of switches – Utilization category – Selection of switches. Introduction to motor starters – Types of starters – Control and Power wiring circuits – Selection of starters – Types of timers.(2)

CIRUIT BREAKER : Introduction to circuit breaker – Types of circuit breaker – Selection of Air circuit breaker – Introduction to MCCB and MCB – Difference between relay and release. (2)

LABORATORY COMPONENT: (6)

- Assembling and maintenance of contactors.
- Testing the pick-up and drop-off voltages in contactors.
- Testing of thermal overload relay.
- Control wiring practice on DOL and Star Delta Starter.

Total : L:9 + P: 6 = 15

TEXT BOOK:

1. Sunil S Rao, “Switch Gear and Protection”, Khanna Publishers – 2008.

REFERENCES:

1. Wadhwa C L, “Electrical Power Systems”, New Age Internationa – 2005.
2. Madhava Rao T S, “Power Systems Protection : Static Relay with Microprocessors Application” , Tata Mcgraw-Hill-2004.

15EK04 ENERGY AUDITING AND CONSERVATION TECHNIQUES

1 0 0 1

INTRODUCTION: Mandatory Auditing requirements – Audit purpose, scope and frequency - Energy auditing Conservation concepts and its Importance – Energy conservation opportunities in electrical power supply sector -The Energy Conservation Act, 2001 and its features. (2)

ENERGY AUDIT METHODOLOGY AND MANAGEMENT SYSTEM: Electrical energy audit, tools for electrical energy audit, billing elements, tariff systems, electrical demand and load factor improvement, power factor correction, power demand control and demand shifting- Duties and responsibilities of energy systems auditors (3)

ENERGY CONSERVATION IN ELECTRICAL SYSTEMS: Electrical energy requirements in pumps and fans and lighting, different types of Variable Speed Drives, electrical energy conservation in industrial motors, air conditioning and refrigeration systems, DG Sets, Cabling Techniques for energy conservation. (3)

GREEN BUILDINGS: Barriers to green buildings, green building rating tools, material selection, operating energy, façade systems, ventilation systems, transportation, water treatment systems, water efficiency, building economics, Leed and IGBC codes (3)

ENERGY AUDITING IN INDUSTRIAL LIGHTING: Choice of lighting, energy saving, control of lighting, lighting standards, lighting audit, use of different lighting technologies, electronic ballast. (1)

LABORATORY COMPONENT:

- Power factor Measurement & Compensation Techniques (1)
- Energy Saving Techniques - Lighting, air conditioning, pumps & fans (1)
- Case studies and exercises (1)

Total L: 15

REFERENCES:

1. Donald R Wulfinghoff, “Energy Efficiency Manual”, Energy Institute Press, 1999.
2. “Electrical Energy Conservation”, Proceedings of National Productivity Council, 1997.
3. Tripathy S C, “Electrical Energy Utilization and Conservation”, Tata McGraw Hill, 1991.
4. John L Fetters, Handbook of Lighting Surveys and Audits, CRC Press, 1998.
5. Rao VVL, Openshaw Taylor E., "Utilization of Electric Energy", Orient Longman Ltd, 2006.
6. Michael E., Brumbach, “Electronic Variable Speed Drives” Thomson Asia (P) ltd., 2002.
7. Donald R. Wulfinghoff, “Energy Efficiency Manual”, Energy Institute Press, 1999.

15EK05 IGBT IN POWER ELECTRONIC CIRCUITS

1 0 0 1

SEMICONDUCTOR PHYSICS: Current Flow – Conductivity – Ionization - Thermal Equilibrium - Recombination of Charges - Carrier Life Time - Saturation Current. (2)

INTERNAL STRUCTURE AND CHARACTERISTICS : Multi cell structure of IGBT (Cross Section) - IGBT vs MOSFET (Drift Region) - Different Types of IGBTs and its Cell Structures (NPT, TRENCH GATE, PUNCH THRO, NON PUNCH THRO) - VI characteristics - Circuit Symbol. (3)

Two Transistor Analogy of IGBT - Latch up Behavior of IGBTs - Internal Capacitances (C_{ies}, C_{oes}, C_{res}) - Turn ON Behaviour - Turn OFF Behaviour - Lead Inductance and Gate Resistance - Safe Operating Area - Typical Datasheet Parameter Explanation. (3)

SELECTION FOR INVERTER AND DESIGN CRITERIA : Module Ratings, f_{sw} Determination - Gate Resistance - Conduction loss, Switching Loss and Blocking Loss - Derations - Thermal design (Thermal Resistance, Junction to Case, Selection of Heat Sink, Cooling Methods, Thermal Compound and its properties) (3)

DRIVERS AND PROTECTIONS: Gate Driver Selection and Design (gate Charge Curve, Gate Charge Measurement, Driver Output Power, Gate Current, Peak Gate Current, Gate Driver IC Selection, Gate Resistance Selection, Market Available Gate Drivers)

Protection Schemes (Active Clamping, Active Miller Clamping, dv/dt Protection, IGBT Double Pulse Testing and Bus Bar Design Considerations, RC Snubber Principles, Snubber Design-Turn ON, Turn OFF, Overshoot) (3)

ADVANCED POWER SEMICONDUCTORS: Trends on semiconductors in IGBT and semiconductor (SiC, GaNi , GaAs and Diamond) - Intelligent Power Modules (Packages and Features) - Advantages of Emerging Technologies. (1)

LABORATORY COMPONENT: (3)

Simulation

Simulation (Device Level – Manufacturer Modelling w.r.t Internal Parameters)
Simulation (System Level – Inverter Working Model w.r.t Current, Voltage Waveform, and Behaviour)

Total : L:12 + P: 6 = 18

REFERENCES:

1. William B. W., “Power Electronics: Devices, Drivers, Applications and Passive Components”, McGraw-Hill, 1992.
2. Ned Mohan, Tore M. Undeland and William P. Robbins., "Power Electronics: Converters, Applications and Design", John Wiley and Sons, 2003.
3. IGBTs Loss Calculation Manual by Infineon.
4. “Application Notes on IGBT Modules”, by Fuji electric.
5. “Application Notes on IGBT Modules”, by Semikron.

15EK06 POWER ELECTRONICS IN MORE-ELECTRIC AIRCRAFT

1 0 0 1

INTRODUCTION TO AIRCRAFT ELECTRICAL SYSTEM– Power sources: Aircraft Batteries – Lead Acid Batteries, VRLA Batteries, NiCd Batteries, Generators, Main Engine, Auxiliary Power Unit; Primary and Secondary Power Distribution System. (3)

MORE ELECTRIC AIRCRAFT ARCHITECTURE – Migration from conventional fixed frequency electrical system to variable frequency electrical system, Advantages of More Electric Aircraft. Introduction to working principle of various Electrical Loads in Conventional and More Electric Aircraft. Electrical Loads in conventional aircraft – Avionics, Cabin Lighting, In-Flight Entertainment, Pumps and Fans. New Electrical Loads in More Electric Aircraft – Cabin Pressurisation Compressor, Air Conditioning, Ice Protection, Flight Control Actuator, Landing Gear, Electrical Taxi System, Braking System, Fuel Pumping. (4)

RECTIFIERS, INVERTERS AND MOTOR CONTROLLERS IN AIRCRAFT – Starter Generator System in Aircraft: Main Engine and APU start System. Multipulse Rectifiers – Autotransformer Rectifier Units as front end converter. How design of Inverters for motor controllers in Aircraft is different from that for conventional industrial application. 2-Level and 3-Level inverters for motor control – Brushless DC motor control and Sensorless Vector control. (4)

CASE STUDIES & PROJECT: Introduction to DO-160 standard and how that influences the design of power converter in aircraft. Practical Design of Power Electronic converters for real life Aero application: Case Study: Design of Exciter Power Supply – Design for space and weight optimization while meeting DO-160 standard. (4)

Total L: 15 + P: 0 = 15

REFERENCES:

1. Aircraft Electrical Systems, 3rd Edition (1997) by E.H.J. Pallett, ISBN-13: 978-0582988194.
2. Aircraft Electricity and Electronics, Sixth Edition (2013), by Thomas Eismin, ISBN-13: 978-0071799157.
3. Recent Advances in Aircraft Technology, (2012), Chapter 13, 14 & 15; Edited by Ramesh K. Agarwal, ISBN 978-953-51-0150-5.
4. M. J. J. Cronin, "The all-electric aircraft," IEE Review, Vol. 36,1990, pp. 309-311.
5. R. I. Jones, "The More Electric Aircraft: the past and the future?" IEE Colloquium on Electrical Machines and Systems for the More Electric Aircraft, 1999, pp. 1/1-1/4.

15EK07 POWER QUALITY IN INDUSTRIES

1 0 0 1

POWER QUALITY : History, concern about power quality, Definition - categories and characteristics of power system - electromagnetic phenomenon. (3)

SOURCES OF POWER QUALITY PROBLEM : Source of Power Supply & its saturation, Transformer & DG Environment, Sags, Dips & Interruptions & its effect on equipments, Capacitors & Resonance, Case Study – Ill effects of Capacitors. Switching, Non – Linear Loads & Harmonics, Case Study. (3)

EFFECTS OF POWER QUALITY PROBLEMS: On Maximum Demand, Contract Demand, Power Factor & Over all operation - Case studies. (4)

POWER QUALITY STANDARDS : IEEE 519 1991 STDS, EMC & ESD & IEC (2)

HANDLING OF POWER QUALITY PROBLEMS : Principles of mitigation of harmonics **-**Passive & Active filter, Dynamic Voltage Regulator & STATCOM. (2)

PRACTICAL CONTENT :
Case Study using Power Quality Analyser (1)

Total L: 14 + P: 1 = 15

REFERENCES:

1. Roger .C. Dugan, Mark F.Mcgranaghan & H.Wayne Beaty, “Electrical power system Quality” McGraw-Hill Newyork Second edition 2003.
2. Math.H.J.Bollen, Understanding Power Quality Problems” Voltage sags & Interruptions” IEEE Press, Newyork 2000.
3. Snakaran C, “Power Quality”, CRC press Washington DC 2002.

15EK09 SOLAR PV SYSTEMS – DESIGN, SIMULATION AND MONITORING AND CONTROL

1 0 0 1

INTRODUCTION TO PV SYSTEM DEISGN: Solar PV Fundamentals - PV Modules, PV Inverters, DC & AC Configurations, and Parameters & Datasheet approach, MET Parameters, Weather Monitoring stations, Modems & Protocols. (2)

SOLAR PRO USER INTERFAC: Setting up of a Solar PV system using Simulation Wizard, 3D CAD interface, File formats, Export / Import capabilities, System requirements, Shortcut keys. Choosing the Data Source - Meteorological data, PV database, Inverter database. (2)

CONFIGURATION OF PV SYSTEM: Assessment of loads to be connected, Selection of right Inverters & PV modules. Creating a string, Creating an Array, PV Array configuration, PV Inverter configuration, PV Electrical Assembly configuration, PV Module mounting configuration & PV Module Tracking configuration, Electrical BOM preparation. (4)

3D DESIGN FEATURES: Building and Surrounding Objects - Setting up of building parameters, setting up of surrounding buildings or interfering structures, setting up of plants, trees and vegetation. (2)

SIMULATION & REPORT GENERATION: Time Trackers, I-V curve simulation, Shadow analysis, Power generation, PV system cost & Financial analysis, PV Array layout, Power generation and loss diagram, Performance Ratio Analysis. Economic viability and Cost effectiveness of project, Print options and export options of variable parameters. (2)

MONITORING OF SOLAR PV POWER PLANT: Remote Monitoring, Real – Time Monitoring, Multiple Inverter Monitoring, Interfacing of Hardware- Solar Link Zero- Modem, Routers, Modbus – Internet Gateway, Cloud Data, RS-485, RS-232 Serial, USB, Ethernet and DVI-D ports. (3)

Total L : 15

REFERENCES:

1. SolarPro:Photovoltaic System Simulation Software Manual, Laplace Systems, 2012.
2. Solar Link Monitoring Solutions Manual, Laplace Systems, 2014.
3. Roger A. Messenger, Jerry Ventre," Photovoltaic System Engineering" CRC Press, 2004

15EK10 INDUSTRIAL DRIVES FOR AUTOMATION

1 0 0 1

INTRODUCTION: Construction and Principle of operation of PMSM and SynRM – AC drive Hardware Blocks – Control Blocks – Automatic Motor Adaptation – Parameterization of Drives (Local and Remote). (4)

CONFIGURATIONS OF DIFFERENT I/O CONTROL: Digital Input and output – Analog Input and output Control-word access – Motion control - Sequential Logic Control (SLC) - Parameterization for different communication protocol: RS 485 – MODBUS - PROFIBUS. (6)

CONFIGURATION FOR DIFFERENT APPLICATIONS: AQUA – HVAC – Automation – Master/ Slave control. (4)

PRACTICAL: Performance characterization of PMSM and SynRM - Conveyor control – Cascaded Pump Control – Synchronization of Drives with Master Slave Control. (4)

Total L: 14 +P: 4=18

REFERENCES:

1. Programming Guide for FC Drives by Danfoss Industries pvt. Ltd.

2. Monograph prepared by PSG-DanfossCoE for Climate and Energy.

15EK11 FIELD PROGRAMMABLE ANALOG ARRAY FOR ANALOG SYSTEM DESIGN

1 0 0 1

INTRODUCTION: Overview of Analog Design - Introduction to Field Programmable Analog Array (FPAA) and its advantages - Role of EDA tool in Analog Design process. (2)

CONFIGURABLE ANALOG MODULES: Introduction to Anadigm`s inbuilt Analog Functions (CAM) - Generation of Clock Signals - Signal Delay - Performance of CAM. (3)

SIMULATION and PHYSICAL REALIZATION: Features of ANADIGMDESIGNER2 EDA tool for simulating the analog design- Configuring the FPAA with analog design - Real time verification. (2)

FPAA IO INTERFACING: Interfacing of input and output signals to the FPAA - Rauch Filter - Output Buffer. (2)

STATIC CONFIGURATION: Full Wave Rectifier - Tone Generation and Notch filter - Voltage Controlled Oscillator - Pulse Width Modulation - Phase Detector. (3)

DYNAMIC RECONFIGURATION: Reconfigurable Analog design using FPAA, Various methods of Reconfiguration - Real time verification. (3)

REFERENCES:

1. Thomas L. Floyd "Electronic devices Conventional Current Version" Pearson Education Ltd, Ninth Edition, 2012.
2. Thomas L. Floyd "Instructor's Resource Manual to Accompany Electronic Devices" Pearson Education Ltd, Eighth Edition, 2008.
3. Thomas L. Floyd "Electronic Devices" Pearson Education Ltd, Eighth Edition, 2008.
4. www.anadigm.com **–** Anadigm's official website.

15EK12 AUTOMOTIVE SOFTWARE TESTING

1 0 0 1

BASICS OF AUTOMOTIVE SOFTWARE TESTING: Introduction – Conventional Software Testing Vs Automotive Software Testing - Need for Automotive Software Testing - Major recalls and impact of recalls – Case study. (3)

FUNDAMENTALS OF SOFTWARE TESTING: Basics of Software Development Life Cycle – Model Based - Modular - Reusable Design - Static Analysis, Dynamic Analysis - Code Coverage including MC/DC (Modified Condition/Decision Coverage) and LCSAJ (Linear Code Sequence and Jump) - Data Flow and Control Flow analysis- Unit/System/Integration Testing - Code Quality - Software Quality metrics - test management - Importance of using qualified software for software testing. (6)

CODING STANDARDS: Coding Standards - important - Coding Standard for Automotive Industry – MISRA C: 2012 with Security Amendments - Top 10 secure coding best practices - Advantages of adhering to coding standards. (3)

PROCESS STANDARD: Introduction to ISO 26262 – Functional Safety Standard - Details about ASIL (Automotive Safety Integrity Level) - Details about Part 4 and Part 6 of ISO 26262 – Failure Mode Effective analysis (FMEA). (3)

Lab Session (along with Theory Class)

- Practical Implementation of Fundamentals of software testing using LDRA Software.
- Adhering to MISRA C coding guidelines using LDRA Software.
- Achieving compliance to ISO 26262 using LDRA Software.
- In case of non-availability of MISRA C document, students may refer to CERT C standard.
- Example of Code Coverage and Executing Test Cases on Raspberry Pi or Arduino.

REFERENCES:

1. Pradeep Oak and Renu Rajani , "Software Testing – Effective Methods, Tools and Techniques" Tata McGraw Hill Publications, 2004.
2. MISRA Online Resources available at https://www.misra.org.uk/
3. MISRA C:2012 Amendments
   URL: https://www.misra.org.uk/Publications/tabid/57/Default.aspx
4. CERT C Programming Language Secure Coding Standard
   URL: http://www.open-std.org/jtc1/sc22/wg14/www/docs/n1255.pdf
5. White papers and Technical Videos on MISRA C & ISO 26262 available at www.ldra.com

ONE CREDIT COURSES

For the detailed syllabi of the electives and one credit courses offered by other departments refer to the syllabi of M.E- Automotive Engineering offered by Automobile Engineering Department.