PES UNIVERSITY

Ph.D. / MTech by Research course work syllabus

Electric and Electronics Engineering

List of courses

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UE23EE641A: Microcontrollers and its Applications

Course Objectives:

- Understand the need of microcontroller in development of various projects
- Introduce the outline of the ARM based microcontroller architecture and interfaces
- Get an overview of the system peripherals that cover bus structure, memory map, timers and much more
- Get a hands-on of a microcontroller development tool chain
- How to write programs that interact with other devices and hence build applications

Course Outcomes:

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

- Identify the software and hardware components of the system needed to meet the system needs
- Gain knowledge of architectural aspects, interfacing and programming details for microcontroller
- Interface various I/O devices like stepper motor and other peripherals
- Model in the software implementation with all needed elements and structure with mini-projects
- Gain a good hands-on one of the commercially available development environment to perform the tasks end to end able to analyze real time examples

Course Content:

Unit 1: Arm Embedded Systems : ARM Embedded Systems and Design Philosophy – Processor fundamentals - Understanding specifics of ARM micro-controller: architecture overview, memory and memory map , Introduction to ARM instruction set: Logical, Arithmetic, Data Movement, Load and Store, Branch, Conditional execution, Thumb Instruction set

Unit 2: ARM Cortex Specifics, Debugging tools: . System initialisation and start up code -– High level C constructs - Implications on memory from C variables –- Compiler – Assembler – Linker/Locator – Binary download formats – Debugging - Emulators – Logic Analyser,

GPIO-Interfacing with LEDs and Switches, Polling vs Interrupts, Interrupt controller, HW/SW interrupts Exception handling-

Unit 3: Timers-Watch dog timers- PWM- RTC – Timer application for sensing speed, sinusoidal PWM, motor control. ADC-DAC Study of motors (stepper, DC, servo) – Open & Close loop controls : PWM, Proportional and PID control-Application: Build an application to control motor – simple speed control, PID control etc.

Unit 4: Communication: Protocols, implementation. Serial communication concepts UART, I2C and SPI- CAN Application: Build an application that samples inputs, displays on LCD and has a serial communication Direct Memory Access and DMA controller Study of interfacing Sensors with microcontroller: (Proximity sensor, Sound sensors, ultra-sonic sensors, temperature sensor, accelerometers. Application: Building a system sensing environment inputs to take necessary actions Mini-project presentation/discussions

Prerequisite Course: None

Reference Books:

"ARM System Developer's Guide: Designing and Optimizing System Software", Sloss, A., Symes, D., & Wright, C., Morgan Kaufmann, 2004.

"ARM System-on-chip Architecture", Furber, S. B., Pearson Education, 2000.

"Embedded C", Pont, M. J., Addison-Wesley Longman Publishing Co., Inc., 2002.

"Programming Embedded Systems in C and C++", Barr, M., O'Reilly Media, Inc., 1999.

"Embedded C Programming: Techniques and Applications of C and Pic MCUS", Siegesmund, Imprint Newnes, 2014.

"The C Programming Language (Vol. 2)", Kernighan, B. W., & Ritchie, D. M., Englewood Cliffs: Prentice-Hall, 1988.

UE23EE642A: Artificial Intelligence in Electrical Systems

Course Objectives:

- To familiarize the students to the concepts of artificial intelligence and machine learning.
- To provide knowledge about search algorithms and search metrics and their applications
- To provide adequate knowledge about fuzzy and neuro-fuzzy systems
- To provide comprehensive knowledge of fuzzy logic control to real time systems.
- To understand the role of genetic algorithms in power system control

Course Outcomes:

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

- Use different search algorithms to solve problems at system level
- Apply neural networks for pattern recognition
- Analyze the usage of fuzzy logic and contrast the same with crisp logic
- Apply fuzzy techniques to problems in control systems.
- Use genetic algorithms in solving power system problems

Unit 1: AI Problems and Search: AI problems, Techniques, Problem Spaces and Search, Heuristic Search Techniques- Generate and Test, Hill Climbing, Best First Search Problem reduction, Constraint Satisfaction and Means End Analysis. Approaches to Knowledge Representation- Using Predicate Logic and Rules.

Unit 2: Artificial Neural Networks: Introduction, Basic models of ANN, important terminologies, Supervised Learning Networks, Perceptron Networks, Adaptive Linear Neuron, Back propagation Network. Associative Memory Networks. Training Algorithms for pattern association, BAM and Hopfield Networks.

Unit 3: Unsupervised Learning Network: Introduction, Fixed Weight Competitive Nets, Maxnet, Hamming Network, Kohonen Self-Organizing Feature Maps, Learning Vector Quantization, Counter Propagation Networks, Adaptive Resonance Theory Networks. Applications in electrical engineering

Unit 4: Introduction to Classical Sets Crisp Sets and Fuzzy Sets: Operations and Fuzzy sets. Classical Relations -and Fuzzy Relations- Cardinality, Operations, Properties and composition. Tolerance and equivalence relations. Membership functions- Features, Fuzzification, membership value assignments, Defuzzification.

Unit 5: Fuzzy Arithmetic and Fuzzy Measures: Fuzzy Rule Base and Approximate Reasoning Fuzzy Decision making Fuzzy Logic Control Systems, Genetic Algorithm- Introduction and basic operators and terminology. Applications: Optimization of TSP, Application in power systems.

Prerequisite Course: None

Text Books:

1. “Principles of Soft Computing”, S N Sivanandam, S N Deepa, Wiley India, 2007

2. “Soft Computing and Intelligent System Design”, Fakhreddine O Karray, Clarence D Silva,. Pearson Edition, 2004.

Reference Books:

1. “Fundamentals of Neural Networks, Architecture, Algorithms and Applications”, Laurene V Fausett, Pearson Education, 2011.

2. “Fuzzy Logic with Engineering Applications”, Timothy J Ross, Wiley India Pvt. Ltd, 2011.

3. “Learning and Soft Computing, Support Vector Machines, Neural Networks and Fuzzy Logic Models”, Kecman V, Pearson Education, New Delhi, 2004.

4. “Fuzzy logic intelligence control and information”, Yen J and Langari R, Pearson Education, New Delhi, 2003.

5. “Advanced Fuzzy systems Design & Applications “,Jin Y, Springer, New Delhi, 2010.

UE23EE643A: Power Semiconductor Devices

Course Objectives:

- To understand the material and structural aspects of semiconductor devices
- To understand the influence of device physics on the electrical characteristics
- To understand the importance of parameter values and maximum ratings of different devices
- To understand the need for auxiliary circuits for protection and performance
- To understand thermal design aspects and switch selection choices for different applications

Course Outcomes:

At the end of the course the students will acquire the ability to:

- Predict the behaviour of power semiconductor devices based on their structure and material parameters
- Design optimal control circuits to ensure satisfactory operation of semiconductor switches
- Select the appropriate switch from device datasheets for a given application
- Choose one among the emerging solid state devices for the given application
- Design auxiliary circuits and thermal management systems for safe operation of the devices

Course Content:

Unit1: Semiconductor devices: Classification of Power Semiconductor Device, **Diodes** – structure & I-V characteristics, breakdown voltage – Non-punch through, punch-through, switching characteristics. Schottky Diodes: structure, principle of operation, Ohmic contacts

Unit 2: Thyristors and Bipolar Junction Transistors: Transistor: Structure, static characteristics, dynamic characteristics, second breakdown, safe operating areas, data sheet rating & terminology

BJT base drive circuits – turn on/off control, proportional base control & anti-saturation control and isolation of gate & base drive – *Numericals* **Thyristor**: Basic structure, I-V characteristics, two transistor analogy, switching characteristics, di/dt & dv/dt limitations, methods of improving di/dt & dv/dt ratings, data sheet rating Parameter list for SCRs, TRIACs, AC switches, and DIACS

Unit 3: MOSFET, GTO and IGBTs: MOSFET Operating principle, Static, dynamic characteristics, Voltage breakdown, n-state conduction losses, safe operating area of MOSFET Data sheet ratings

Gate drive circuit for MOSFET & numericals, GTO & IGBT**:** Static, dynamic characteristics, Over-current protection of GTO, IGBT device limits & SOAs' Gate drive requirements for an MOSFET or an IGBT (Gate Drive ICs). Switching power loss calculation & numerical.

Unit 4: Emerging devices, protection; Emerging Devices**:** *In brief* - Field controlled thyristor, MOS controlled thyristor, SiC and GaAs devices. Snubber circuits: for diodes, thyristors, transistors.

Unit 5: Switch realization, Thermal design: Switch Realization: Switch Applications, ngle/two/four quadrant switches, Synchrounous Rectifier (Power MOSFET) Temperature Rise – Use of Heat Sinks and numerics, Heat sinks in BJT, MOSFET, Thermal-electrical equivalents, thermal equivalent circuit.Case studies of thermal design, Course mini-project

Prerequisite Course: None

Text Book:

1. "Power Electronics, Converters, Applications and Design", Ned Mohan, John Wiley and Sons, 2002.

Reference Books:

1. "Fundamentals of power electronics", Erickson, Robert W, and Dragan Maksimovic, Springer Science & Business Media, 2007.
2. "Power electronics: principles and applications", Vithayathil, Joseph, Tata McGraw-Hill Education, 1995.
3. http://www.st.com/content/ccc/resource/technical/document/application_note/ea/24/b1/42/31/ca/4d/66/CD00183570.pdf/files/CD00183570.pdf/jcr:content/translations/en.CD00183570.pdf
4. http://www.swarthmore.edu/NatSci/echeeve1/Class/e12Code/HEAT-NOTE.pdf

UE23EE644A: Electrical Power Quality

Course Objectives:

- To study the production of voltages sags, overvoltage and harmonics and methods of control. To study various methods of power quality monitoring.

Course Outcomes:

At the end of this course students would be able to

- Understand the basic concepts of power quality and various causes of power quality issues in power system.
- Understand the various sources of sag and its mitigation methods
- Understand sources of over voltages and how to implement computer analysis power quality issues
- Understand the effect of harmonics on various loads and its mitigation techniques
- Understand the various power quality monitoring devices

Course Content:

Unit 1:Introduction to Power Quality: Terms and definitions: Overloading – under voltage – over voltage. Concepts of transients – short duration variations such as interruption – long duration variation such as sustained interruption. Sags and swells – voltage sag – voltage swell – voltage imbalance – voltage fluctuation – power frequency variations. International standards of power quality. Computer Business Equipment Manufacturers Associations (CBEMA) curve.

Unit 2: Voltage Sags and Interruptions: Sources of sags and interruptions – estimating voltage sag performance. Thevenin's equivalent source – analysis and calculation of various faulted condition. Voltage sags due to induction motor starting. Estimation of the sag severity – mitigation of voltage sags, active series compensators. Static transfer switches and fast transfer switches.

Unit 3: Overvoltages: Sources of over voltages – Capacitor switching – lightning – Ferro resonance. Mitigation of voltage swells – surge arresters – low pass filters – power conditioners. Lightning protection – shielding – line arresters – protection of transformers and cables. An introduction to computer analysis tools for transients, PSCAD and EMTP.

Unit 4: Harmonics: Harmonic sources from commercial and industrial loads, locating harmonic sources. Power system response characteristics – Harmonics Vs transients. Effect of harmonics – harmonic distortion – voltage and current distortion – harmonic indices – inter harmonics – resonance. Harmonic distortion evaluation – devices for controlling harmonic distortion – passive and active filters. IEEE and IEC standards.

Unit 5: Power Quality Monitoring

Monitoring considerations – monitoring and diagnostic techniques for various power quality problems – modeling of power quality (harmonics and voltage sag) problems by mathematical simulation tools – power line disturbance analyzer – quality measurement equipment – harmonic / spectrum analyzer – flicker meters – disturbance analyzer. Applications of expert systems for power quality monitoring.

Prerequisite Courses: None

Text Book:

1. "Electric Power System Quality", Dugan, R. C., McGranaghan, M. F., Santoso, S., & Beaty, H. W., McGraw Hill Education, 3rd Edition, 2012.

Reference Books:

1. "Electric Power Quality", Heydt, G. T., Stars in Circle Publications, 1991.
2. Bollen, M. H. "Understanding Power Quality Problems (Vol. 3)", IEEE Press, New York, 2000.
3. "Power System Quality Assessment", Arrillaga, J., Watson, N. R., & Chen, S., Wiley, 2000.
4. PSCAD User Manual, Manitoba Research Center, 2005.

UE23EE641BA1: Embedded and Real Time Systems (3-0-2-4-4)

Course Objectives:

- Understand the fundamental building blocks of Embedded System
- Study the role of peripherals in improving system performance
- Understand the challenges posed in real time applications
- Discussion of Application development using appropriate software architecture
- Learn the fundamental RTOS.

Course Outcomes:

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

- Quantify the challenges involving different metrics in arriving at an embedded system design
- Identify the integrated and external peripheral functionalities and hardware required to complete the system design
- Quantify the challenges encountered in real time systems and be able to meet timing constraints imposed
- Chose the appropriate software architecture so that the designed system is the simplest one that can meet real time requirements
- Comprehend the key concepts and challenges in real time systems and be able to use real time operating system software to build application examples

Course Content:

Unit 1: Embedded system concepts : Overview of embedded systems. Embedded system design challenges, Common design metrics and optimizing them. Survey of different embedded systems design methodologies, trade-offs. Custom single purpose processors. Design of custom single purpose processors. RT Level design and optimizing the design.

Unit 2: General & Standard Single Purpose Peripherals : General purpose processors, Timers/counters, UART, PWM, LCD, Keypad controllers, stepper motor control, ADC/DAC. Memory Introduction, Memory write ability and storage performance, common memory types, Composing Memory, Memory Hierarchy, Memory Management Unit, Advanced Memories

Unit 3: Real Time Systems: Basic Model of Real Time Systems, Characteristics, Safety and Reliability, Types of Real Time tasks, Modelling Timing Constrains, Real Time tasks and characteristics, Real Time task scheduling and Classification – Clock Driven, Event Driven, Hybrid

Unit 4: Interrupts and software architecture : Interrupt Basics- Shared Data Problem-Interrupt Latency, Survey of Software Architectures, Round Robin, Round Robin with interrupts – Function Queues, Scheduling- RTOS Architecture. Implementation issues with practical system, balance of system design, interfacing issues. Model Based Design concepts

Unit 5: RTOS Concepts: Tasks – States – Data – Semaphores and shared data – Operating systems Services – Message Queues – Mail Boxes – Timers – Events – Memory Management – Interrupts in an RTOS environment. Examples of real time operating systems and case studies

Reference Books:

1. "Embedded System Design: A Unified Hardware/software Introduction, Vol. 4", Vahid, Frank, and Tony Givargis, Wiley, 2006.
2. "Real Time Systems: Theory and Practice, Mall Rajib, Pearson Education India, 2012
3. "An Embedded Software Primer, Vol. 1", Simon, David E, Addison-Wesley Professional, 1999

UE23EE641BA2: Power Electronic Converter Technologies

Course Objectives:

- To understand and acquire knowledge about various power converters
- To prepare the students to analyze and synthesize different power converter topologies
- To learn about the power quality issues created by power converters
- To understand the utility of multi-level inverters for high power applications

Course Outcomes:

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

- Make use of various power converters in commercial and industrial applications.
- Identify and analyze PWM inverters for various power requirements of consumer applications
- Design and size magnetic and semiconductor devices for converter applications
- Design suitable filter circuits to deal with power quality issues

Course Content:

Unit 1: Line Commutated Converters and AC voltage controllers: Phase control, single phase semi-converter & fully controlled converter, three phase semi controlled & fully controlled converter – R & R-L load. Single-phase dual converters, power factor improvement methods, effect of source inductance, single phase series converters, twelve pulse converter and design of converter circuits with problems. Line side power quality problems and analysis **AC Voltage controllers**: Principle of On-Off Control and Phase control. 1-phase and 3-phase controllers feeding R load & R-L loads with problems. Matrix converters. – Modeling and simulation
– Modeling and simulation

Unit 2: DC-AC Converters: Principle of operation, performance parameters, single phase bridge inverters and three phase two level inverters. Voltage control of single phase and three phase inverters, Generation of gating pulses. Space vector modulation. Current source Inverters and Variable DC link Inverter. Bidirectional converters, active and reactive power control. Space vector diagrams. – Modeling and simulation

Unit 3: Non – isolated DC-DC Converters: Principle of operation of step-down, step-up converters, and Buck-Boost converter Analysis and design. Four quadrant chopper, Derived converters, Cuk Converter and SEPIC converter. Design of converters. – Modeling and simulation

Unit 4: Isolated DC-DC converters and Offline switched mode power supplies: Need for isolation, transformer design, effect of leakage inductance, Resonant converters, LLC converter half and full bridge. Design analysis and modeling. Control of converters. Commercial Integrated circuits for converter. Offline converters and multi-output power supplies

Unit 5: Multilevel Inverter: Multilevel concepts, types of multilevel inverter, diode clamped, flying-capacitor, Cascaded multilevel Inverter, Applications, Features and comparison of multilevel converters. Space vector diagrams of Multilevel inverters. Five phase two-level inverter, space vector diagram. Generation of gating pulses. – Modeling and simulation

Reference Books:

1. "Power Electronics: Converters, Applications, and Design", Mohan, N., & Undeland, T. M., John Wiley & Sons, 2007.
2. "Power Electronics: Circuits, Devices, and Applications", Rashid, M. H., Pearson Education India, 2003.
3. "Power Electronics Essentials and Applications", Umanand, L., 1st Edition, New York, NY, Wiley Publishers, 2009.
4. "Fundamentals of Power Electronics", Erickson, R. W., & Maksimovic, D., Springer Science & Business Media, 2007.

UE23EE641BA3: Renewable Energy Systems

Course Objectives:

- To understand the different types of renewable energy sources
- To have a knowledge on the applications of renewable energy sources
- To comprehend the environmental impacts of renewable energy systems

Course Outcomes:

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

- Understand the principles of solar PV systems and the applications
- Understand the dynamics of WECS and applications of wind energy
- Appreciate the resources from biomass and their classification
- Realize the concept of Biophotolysis and fuel cells
- Understand the concept of energy generation from Ocean, and geothermal energy.

Course Content:

Unit 1: Solar Energy: Solar radiation its measurements and prediction – solar thermal flat plate collectors concentrating collectors – applications – heating, cooling, desalination, power generation, drying, cooking etc – principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, and water pumping, power generation schemes.

Unit 2: Wind Energy: Atmospheric circulations – classification – factors influencing wind – wind shear – turbulence – wind speed monitoring – Betz limit – Aerodynamics of wind turbine rotor site selection – wind resource assessment – wind energy conversion devices – classification, characteristics, applications. Hybrid systems – safety and environmental aspects.

Unit 3: Bio-energy: Biomass resources and their classification – chemical constituents and physicochemical characteristics of biomass – Biomass conversion processes – Thermo chemical conversion: direct combustion, gasification, pyrolysis and liquefaction – biochemical conversion: anaerobic digestion, alcohol production from biomass – chemical conversion process: hydrolysis and hydrogenation. Biogas – generation – types of biogas Plants- applications

Unit 4: Hydrogen and Fuel Cells : Thermodynamics and electrochemical principles – basic design, types, and applications – production methods – Biophotolysis: Hydrogen generation from algae biological pathways – Storage gaseous, cryogenic and metal hydride and transportation. Fuel cell – principle of working- various types – construction and applications.

Unit 5: Other Sources of Energy: Ocean energy resources – principles of ocean thermal energy conversion systems – ocean thermal power plants – principles of ocean wave energy conversion and tidal energy conversion – hydropower – site selection, construction, environmental issues – geothermal energy – types of geothermal energy sites, site selection, and geothermal power plants.

Reference Books:

1. "Solar Energy: Principles of Thermal Collection and Storage", Sukhatme, K., & Sukhatme, S. P., Tata McGraw-Hill Education, 1996.
2. "Renewable Energy Resources", Twidell, J., & Weir, T. Routledge, 2015.
3. "Principles of Solar Engineering", Kreith, F., & Kreider, J. F., Hemisphere Publishing Corporation,Washington, DC,1978
4. "Renewable Energy: Power for a Sustainable Future. Energy", Kaygusuz, K., Exploration & Exploitation, 19(6), 603-626, 2001
5. "Alternative Energy Sources", Veziroglu, T.N., Vol 5 and 6, McGraw-Hill, 1990.
6. "Biochemical and Photosynthetic Aspects of Energy Production", San Pietro, A. (Ed.), Elsevier, 2012
7. "Thermochemical Processing of Biomass In Thermochemical Processing of Biomass", Bridgewater, A. V., Butterworths, 1984
8. "Fuel Cells: Theory and Application", Hart, A. B., & Womack, G. J., Chapman & Hall, 1967.
9. "Biogas Technology: A Practical Handbook", Khandelwal, K. C., & Mahdi, S. S., Tata McGraw-Hill, 1988.

UE23EE642BB1: Design for Internet of Things

Course Objectives:

- The objective of the course is to introduce students to design concept for IoTecho system. The course will
- Introduce general concepts and methodologies to design, build and deploy IoT solution
- Learn about sensors, microcontrollers and communication interfaces to design and build IoT devices
- Discussion on various technologies and protocols used for communication
- Gain an understanding of commonly used IoT frameworks
- Discussion on cloud servers available

Course Outcome:

By the end of the course, the student will be able to:

- Able to evaluate, select and design sensor and actuator interfaces for IoT end Devices
- Able to identify the software and hardware components, integrate and describe the interaction needed for IoT use cases
- Get the knowledge and skills to design and build a network to publish/subscribe to connect, collect data, monitor and manage data
- Able to work on commonly used frameworks on the popular boards

Course Content

Unit 1: Introduction to IoT: IoT Device side –Sensors, Sensor Characteristics and Interfaces, IoT Application Examples, Overview of System Design, Power of Low power nodes, Power and Battery Management. Introduction to boards that needs to be used for developing application (Eg: Arduino/Raspberry Pi/ LoRA WAN sensor nodes/), Prototyping Embedded device software, Programming Embedded Device using IDE, Interfacing sensors and actuators Hands-on component: Development of Sensor interfaces and actuator controls, Design for low power node and measurements

Unit 2: Interfaces/Communication Protocols: I2C, UART, SPI, CAN, Basics of IoT Networking, Communication: BTLE, ZigBee, LoRaWan Hands-on component: Setup and development for the application/s for making use of MQTT Setting up gateway and establishing connections by developing components

Unit 3: Data Protocols: MQTT, CoAP, AMQP. Basics of RFID and NFC, Wireless Sensor Networks and challenges, Machine to Machine Communication. Hands-on component: Setting up device making use of NFC/RFID and establish communication with gateway and establishing connections by integrating different software components as appropriate

Unit 4: Internet connectivity: Internet-based communication, REST APIs. Cloud computing paradigm for data collection, storage and computing, Cloud service models, IoT Cloud- based data collection, storage and computing services Hands-on: Set up the needed cloud related infrastructure, Upload of data to cloud server using REST APIs

Unit 5: Case Studies: Study of Application Use cases for Agriculture, Healthcare, Activity monitoring

Text Books

1. "Internet of Things, A Hands-On Approach", Arshdeep Bahga and Vijay Madisetti.
2. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases"Pethuru Raj and Anupama C. Raman (CRC Press)
3. Case Studies using Published papers

UE23EE642BB2: Electric Vehicle Systems

Electric vehicles are the future of transportation, and this course covers the essential concepts of electric vehicle drive-trains, motor performance parameters and battery management. Hybrid vehicles are also covered due to their relevance in this transitory period. Modeling and simulation of electric vehicle systems is also done.

Course Objectives

- Familiarize students with the environmental impact of fossil fuel powered vehicles and the advantages of electric
- Study the different drive-train options and motors that can be used, along with their characteristics
- Learn about different energy storage options and design storage controllers and battery management systems

Course Outcomes

Upon completion of the course the students would be able to:

- Design electric vehicle components like motors, batteries and safety systems
- Model and simulate the behaviour of an electric vehicle and size drive-train and battery pack
- Design electrical systems conforming to safety standards relating ti high voltage isolation and necessary safe shutdown procedures

Course Content

Unit 1: Electric Vehicles – Perspective: History of IC engine, hybrid and electric vehicles, social and environmental impact of modern drive-trains. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, steering. Mathematical models to describe vehicle performance. Configuration and control of DC Motor drives, fuel efficiency analysis.

Unit 2: Induction motors and PMSM drive model: Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives. Modeling and simulation of EV drive-train. Implementation of control algorithm on controller.

Unit 3: BLDC and SRM drive model: Configuration and control of Switch Reluctance Motor drives and BLDC drives, Implementation of control algorithm on controller. Drive system efficiency. Sizing the drive system, Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology. Multi- motor drives, coupling torque and speed. Dynamics of single and multi motor drive-trains

Unit 4: Energy Storage: Introduction to Energy Storage Requirements in Electric Vehicles, Battery based energy storage and its analysis, battery chemistries. Charging and charge controllers. Fuel Cell, Super Capacitor and Flywheel based energy storage and analysis, Hybridization of different energy storage devices. Plug in hybrid and electric vehicles. EV integration to grid, V2G. Influence of large scale EV penetration on grid.

Unit 5: Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Battery Management systems and Regenerative braking systems. Communications, supporting subsystems. Mechanical and Electrical Safety issues. High voltage isolation, standards. Self driving vehicles

Text Book:

1.“Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, 3rd ed. Mehrdad Ehsani, Yimin Gao & Ali Emadi:

References Books:

“Electric and Hybrid Vehicles”, Denton, Tom, 1st Edition, Routledge; April 1, 2016, ISBN-10: 1138842370, ISBN-13: 978-1138842373

“Electric and Hybrid Vehicles: Design Fundamentals”, Iqbal Husain , 2ndEdition 2011, CRC Press

UE23EE642BB3: Smart Grid

Course Objectives:

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications

Course Outcomes:

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

- Understand the need for smart grid, concept of self healing grid
- Understand the technology involved in smart grid
- Have a knowledge on Smart Meters, Advanced Metering infrastructure drivers and protocols, Phasor Measurement Unit, and Intelligent Electronic Devices
- Manage power quality issues in Smart Grid
- Appreciate smart grid applications namely Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols

Course Content:

Unit 1: Introduction to Smart Grid: 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.

Unit 2: Smart Grid Technologies: 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).

Unit 3: Smart meters and 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.

Unit 4: Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit 5: High Performance Computing For Smart Grid Applications: 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.

Reference Books:

1. "Smart Grid Technologies: Communication Technologies and Standards, Vol. 7, No. 4", Vehbi C. Güngör, DilanSahin, TaskinKocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, IEEE Transactions on Industrial Informatics, 2011.
2. "Smart Grid : Infrastructure, Technology and Solutions", Stuart Borlase, CRC Press. 2012.
3. "Smart Grid: Technology and Applications", Wiley Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, 2012.

UE23EE643BC1: General Processor Architecture

Course Objectives:

- To describe computer architecture concepts and mechanisms related to the design of modern processors, memories, and networks and explain how these concepts and mechanisms interact.
- To Apply this understanding to new computer architecture design problems within the context of balancing application requirements against technology constraints; more specifically, quantitatively assess a design's execution time in cycles and qualitatively assess a design's cycle time, area, and energy.
- To Evaluate various design alternatives and make a compelling quantitative and/or qualitative argument for why one design is superior to the other approaches

Course Outcomes:

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

- Suggest alternate processor architectures for specific applications
- Do comparative analysis of different architectures & choose right architecture for specific applications
- Architect a solution for a given problem.

Course Content:

Unit 1: Fundamental Processors: Instruction set architecture; Single-cycle processors; hardwired vs. microcoded FSM processors; pipelined processors; resolving structural, data and control hazards; analyzing processor performance.

Unit 2: Fundamental Memories: Memory technology; direct-mapped vs. associative caches; write-through vs write-back caches; single-cycle, FSM, pipelined caches; analyzing memory performance

Unit 3: Fundamental Networks: Single-cycle global crossbars; arbitration; traffic patterns; torus and butterfly topologies; routing algorithms; channel and router micro-architecture; analyzing network performance

Unit 4: Advanced Processors: Superscalar execution, out-of-order execution, register renaming, memory disambiguation, branch prediction, speculative execution; multithreaded, VLIW, and SIMD processors

Unit 5: Advanced Memories: Non-blocking cache memories; memory protection, translation, and virtualization; and memory synchronization, consistency, and coherence

Reference Books:

1. "Computer Architecture: A Quantitative Approach", J. L. Hennessy and D. A. Patterson, 5th Edition, Morgan Kaufmann, 2012.
2. "Digital Design and Computer Architecture", D. M. Harris and S. L. Harris, 2nd Edition, Morgan Kaufmann, 2012.

UE23EE643BC2: Drives and Utility Interactive Systems

Course Objectives:

- To design a closed loop controller for DC motor
- To design a closed loop controller for induction motors
- To design a utility interactive converter for power electronic interface to the grid

Course Outcomes:

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

- Design a simple open loop control for DC and induction motors
- Control a motor drive by designing a closed loop controller
- Enable power transfer to grid from a variety of renewable energy sources

Course Content:

Unit 1: DC Drive: Three-phase controlled converter, control circuit, control modeling of three phase converter – Concept of decoupled control. Steady state analysis of three phase converter control DC motor drive – Two quadrant, Three phase converter controlled DC motor drive – DC motor and load, converter. Current and speed controllers – Current and speed feedback – Design of controllers – Current and speed controllers .Harmonics and associated problems – sixth harmonics torque.

Unit 2: Brushless DC and PMSM Drives: Steady state analysis of BLDC motor drives – rating of the devices – Pulsating torque. Closed loop operation: Speed controlled drive system – current control loop – pulse width modulated current controller – hysteresis current controller –Simulation of BLDC Motor Drives: Dynamic Simulations of the speed controlled BLDC motor drives – Speed feedback speed controller – Commutation, PMSM modeling and control of PMSM drive

Unit 3: Stator Side Control of Induction Motor Drive: Scalar control – Voltage fed inverter control – Open loop volts/Hz control – speed control slip regulation – speed control with torque and flux control – current controlled voltage fed inverter drive – current – fed inverter control – Independent current and frequency control – Speed and flux control in Current –Fed inverter drive – Volts/Hz control of inverter drive – Efficiency optimization control by flux program. Rotor Side Control of Induction Drives: Slip power recovery drives – Static Kramer Drive – Phasor diagram – Torque expression – speed control of Kramer Drive – Static Scheribus Drive – modes of operation.

Unit 4: Vector control of Induction Motor Drive: Principles of Vector control – Vector control methods Field oriented control - Direct methods of vector control – Indirect methods of vector control – Adaptive control principles – Self tuning regulator Model referencing control. Direct torque control

Unit 5: Utility interactive Systems: Grid connected renewable energy systems. Synchronizing of inverters. PLL types. Vector control of grid connected single phase and three phase inverters. Reference signal generation, control of power flow. Modeling and simulation of grid connected converters

Reference Books:

- "Fundamentals of Electrical Drives", Dubey, G. K., CRC Press, 2002.
- "Power Electronics and Motor Drives: Advances and Trends", Bose B. K., Academic Press, 2010.
- "Power Electronics and Motor Control", Shepherd W., Hulley, L. N., & Liang, D. T. W, Cambridge University Press, 1995.
- "Power Electronics: Circuits, Devices, and Applications", Rashid M. H., Pearson Education India, 2003.
- "Power Semiconductor Drives", Dewan S. B., Slemon G. R., & Straughen A., Wiley-Interscience, 1984.

UE23EE644BD1: VLSI Architecture and Design Methodologies

Course Objectives:

- To understand the basic construction, design, synthesis and simulation of logic devices using VLSI design methodologies.

Course Outcomes:

- To give an insight to the students about the significance of CMOS technology and fabrication process.
- To teach the importance and architectural features of programmable logic devices.
- To introduce the ASIC construction and design algorithms
- To teach the basic analog VLSI design techniques.
- To study the Logic synthesis and simulation of digital system with Verilog HDL.

Course Content:

Unit 1: CMOS Design: Overview of digital VLSI design Methodologies- Logic design with CMOS-transmission gate circuits-Clocked CMOS-dynamic CMOS circuits, Bi-CMOS circuits- Layout diagram, Stick diagram-IC fabrications – Trends in IC technology.

Unit 2: Programmable Logic Devices: Programming Techniques-Anti fuse-SRAM-EPROM and EEPROM technology – Re- Programmable Devices Architecture- Function blocks, I/O blocks, Interconnects, Xilinx- XC9500,Cool Runner – XC-4000,XC5200, SPARTAN, Virtex – Altera MAX 7000-Flex 10Kstratix.Basic Construction, Floor Planning, Placement and Routing: System partition – FPGA partitioning – Partitioning methods- floor planning – placement physical design flow – global routing – detailed routing – special routing- circuit extraction – DRC.

Unit 3: Analog VLSI Design: Introduction to analog VLSI- Design of CMOS 2stage-3 stage Op-Amp – High Speed and High frequency op-amps-Super MOS-Analog primitive cells-realization of neural networks.

Unit 4: Logic Synthesis and Simulation: Overview of digital design with Verilog HDL, hierarchical modeling concepts, modules and port definitions, gate level modeling, data flow modeling, behavioural modeling, task & functions,

Unit 5: Verilog and logic synthesis: Simulation-Design examples, Ripple carry Adders, Carry Look ahead adders, Multiplier, ALU, Shift Registers, Multiplexer, Comparator, Test Bench.

Reference Books:

1. "Application Specific Integrated Circuits", M.J.S Smith, Addition Wesley Longman Inc., 1997.
2. "Essentials of VLSI Circuits and System", Kamran Eshraghian, Douglas A. Pucknell and Sholeh Eshraghian, Prentice Hall India, 2005.
3. "Modern VLSI Design", Wayne Wolf, Prentice Hall India, 2006.
4. "Analog VLSI Signal and Information Processing", Mohamed Ismail, Terri Fiez, McGraw Hill International,1994.
5. "VeriLog HDL, A Design Guide to Digital and Synthesis", Samir Palnitkar, 2nd Edition,Pearson, 2005.
6. "Chip Design for Submicron VLSI cmos Layout and Simulation",John P. Uyemera, Cengage Learning India Edition, 2011.

UE23EE644BD2: HVDC Transmission

Course Objectives:

- To know modern transmission systems using HVDC
- To study converters, and the control of converters used in HVDC
- To understand the concept of harmonics and reduction using filters
- To study power flow analysis and stability analysis

Course Outcomes:

At the end of the course the student will be able to Learn the planning of HVDC transmission, and understand the modern trends in DC transmission

- Appreciate the choice of converter and study the configuration
- Analyse the converter in two and three, and three and four valve conduction modes, along with the LCC bridge characteristics
- Analyse the operation of Capacitor Commutated and voltage source converters.Learn the strategies used to Control Converters such as, firing angle control, current and extinction angle control, Starting and stopping of Dc link, Power control, Frequency control, Reactive power control, and Tap changer control
- Understand the faults that occur in converters and adapt suitable methods to protect them
- Gain a knowledge on reactive power control
- Learn the concept of harmonics generation and design AC and DC filters to eliminate the harmonics
- Analyze the concept of power flow with VSC based HVDC system.
- Analyze the voltage stability in asynchronous AC/DC system

Course Content:

Unit 1: DC Power Transmission Technology: Introduction – comparison of AC and DC transmission – application of DC transmission – classifications of DC transmission system – Planning for HVDC transmission – modern trends in DC transmission – DC breakers – cables, VSC based HVDC. Comparison of line commutated converter (LCC) link and voltage source converter (VSC) link.

Unit 2: Analysis of HVDC converters and HVDC system control: Pulse number, choice of converter configuration – simplified analysis of Graetz circuit – converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters. General principles of DC link control – converter control characteristics – System control hierarchy – firing angle control – Current and extinction angle control – generation of harmonics and filtering – power control – higher level controllers.

Unit 3: Multi-terminal DC systems and harmonics: Introduction – potential applications of MTDC systems – types of MTDC systems – control and protection of MTDC systems – study of MTDC systems- parallel operation of AC and DC transmission. Harmonics on AC and DC sides – filters

Unit 4: Power flow analysis in AC/DC systems: Per unit system for DC quantities – modeling of DC links – solution of DC load flow – solution of AC-DC power flow – case studies.

Unit 5: Stability analysis of HVDC systems: Introduction – system simulation tools – modeling of HVDC systems for digital dynamic simulation – dynamic interaction between DC and AC systems.– inclusion of HVDC model in small signal stability (SSS) algorithm – inclusion of HVDC model in transient stability algorithm and voltage stability analysis.

Reference Books:

1. "HVDC Power Transmission Systems: Technology and System Interactions", Padiyar, K. R., New Age International, 1990.
2. "High Voltage Direct Current Transmission (No. 29)", Arrillaga, J., IET – Technology and Engineering, 1998.
3. "Power System Stability and Control (Vol. 7)", Kundur, P. N. J. Balu, & M. G. Lauby (Eds.), McGraw-Hill, New York 1994.
4. "Power Transmission by Direct Current", Uhlmann, E., Springer Science & Business Media, 2012.
5. "HVDC Transmission: Power Conversion Applications in Power Systems", Kim, C. K., Sood, V. K., Jang, G. S., Lim, S. J., & Lee, S. J., John Wiley & Sons, 2009.
6. "Flexible Power Transmission: The HVDC Options", Arrillaga, J., Liu, Y. H., & Watson, N. R., John Wiley & Sons, 2007.

UE23EE645BE1: Digital Image Processing

Course Objectives:

- To introduce techniques and tools for digital image processing.
- To introduce image analysis techniques in the form of image segmentation.
- To develop on-hand experience in applying tools to process images.
- To develop engineering skills and intuitive understanding of the tools used in Image Processing.

Course Outcomes:

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

- Describe different modalities and current techniques in image acquisition
- Describe how digital images are represented and stored efficiently depending on the desired quality, color depth, dynamics
- Use the mathematical principles of digital image enhancement
- Describe and apply the concepts of feature detection and contour finding algorithms.
- Analyze the constraints in image processing when dealing with larger data sets (efficient storage and compression schemes)

Course Content:

Unit 1: Introduction: Examples of fields that use digital image processing, fundamental steps in digital image processing, components of image processing system. Digital Image Fundamentals: Light and the Electromagnetic Spectrum, Image sensing and Acquisition, A simple image formation model, Image sampling and Quantization, basic relationships between pixels.

Unit 2: Image enhancement : Image enhancement in the spatial domain: Basic gray-level transformation, histogram processing, enhancement using arithmetic and logic operations, basics of spatial filtering, smoothing and sharpening spatial filters, combining the spatial enhancement methods. Image enhancement in the frequency domain Introduction to the Fourier transform and the frequency domain, Smoothing and sharpening frequency-domain filters, homomorphic filtering, Implementation.

Unit 3: Image restoration: A model of the image degradation/restoration process, noise models, restoration in the presence of noise–only spatial filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear, Position-Invariant Degradations, Estimating the degradation function, Inverse Filtering, Weiner filtering, Constrained least squares filtering. Image Compression Types of redundancies, Encoder-Decoder model, Lossy and Lossless compression, Entropy of an information source, Variable Length Coding, Huffman Coding, Arithmetic Coding, LZW coding, Transform coding, Sub-image size selection, blocking artifacts, DCT implementation using FFT, Run length coding, Bit-plane encoding, Bit-allocation, Zonal Coding, Threshold Coding, JPEG, Lossless predictive coding, Lossy predictive coding, Motion Compensation.

Unit 4: Wavelet based Image Compression: Expansion of functions, Multi-resolution analysis, Scaling functions, MRA refinement equation, Wavelet series expansion, Discrete Wavelet Transform (DWT), Continuous Wavelet Transform, Fast Wavelet Transform, 2-D wavelet Transform, JPEG-2000 encoding, Digital Image Watermarking.

Unit 5: Morphological Image Processing: Preliminaries, Dilation and Erosion, Opening and closing, hit or miss transformation, basic morphologic algorithms. Image Segmentation Detection of discontinuous, edge linking and boundary detection, thresholding, region–based segmentation, segmentation by Morphological Watersheds.

Reference Book:

1. "Digital Image Processing", Gonzalez, R. C.,Pearson Education India, 2009.

UE23EE645BE2: Modeling and Design of FACTS Controllers

Course Objectives:

- To understand the issues in power system and objectives of compensation
- To educate on Shunt FACTS controllers and their applications
- To educate on Series FACTS controllers and their applications
- To understand the operation of voltage source converter-based series-series and series shunt FACTS controllers
- To analyze the performance of various FACTS controllers

Course Outcomes:

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

- Explain the various issues in power system and compensation techniques
- Develop the model of Static VAR compensator for stability studies
- Explain the importance of controlled series capacitor compensation and to develop the model of TCSC
- Understand the performance of variable reactance-based FACTS controllers and Voltage source converter-based FACTS controllers
- Understand the design procedure of controller and compare the performance of FACTS controller

Course Content:

Unit 1: Power System Compensation: Objectives of power system compensation, Reactive power control, Voltage Stability, Load compensation, Transmission Line compensation, Analysis of uncompensated AC Transmission line, Voltage regulation in a transmission line, Profile of voltage vs. power, Relative power requirement of an uncompensated line, Need for FACTS Devices, Classification of FACTS controllers

Unit 2: Shunt FACTS Controllers: Effect of Shunt compensation at the mid-point of the line on power transfer capability Configuration of Static VAR Compensator (SVC),Voltage regulation by SVC, performance characteristics of static VAR compensator ,Modeling of SVC for load flow analysis-Modeling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications of static VAR compensator

Unit 3: Series FACTS Controllers: Effect of series compensation on power transfer capability, Concepts of Controlled Series Compensation, Operation of thyristor-controlled series capacitor (TCSC), Various modes of Operation of TCSC and GCSC, Analysis of TCSC, Modeling of TCSC for load flow studies, open loop and closed loop control of TCSC, Applications of thyristor-controlled series capacitor

Unit 4: Series-Series and Series Shunt FACTS controllers: Operation of STATCOM and SSSC-Power flow control with STATCOM and SSSC- , Steady state solution of STATCOM, Modeling of STATCOM and SSSC for power flow and transient stability studies, Comparison between STATCOM and SVC, operation of Unified and Interline power flow controllers (UPFC and IPFC)- Modeling of UPFC and IPFC , Application of STATCOM , SSSC , UPFC and IPFC

Unit 5: FACTS Controllers and their Co-Ordination: Capability of different FACTS controllers, FACTS Controller interactions – SVC–SVC interaction – The Basic Procedure for Controller Design, co-ordination of multiple controllers using linear control techniques – Quantitative treatment of control coordination, Case studies

Text Book

1. “FACTS Controllers in Power Transmission and Distribution”, K.R. Padiyar, New Age International (P) Ltd., Publishers, New Delhi, 2008

Reference Books

1. “Thyristor-based FACTS Controllers for Electrical Transmission Systems”, Mathur, R. M., & Varma, R. K., John Wiley & Sons, 2002.

2. “Flexible AC Transmission System”, A.T. John, Institution of Electrical and Electronic Engineers (IEEE), 1999.
3. “Understanding FACTS Concepts and Technology of Flexible AC Transmission System”, NarainG.Hingorani, Laszio. Gyugyl, IEEE Press, NY, 2000.
4. “HVDC and FACTS Controllers: Applications of Static Converters in Power Systems”, Sood, V. K., Springer Science & Business Media, 2004.