I SEMESTER

21EE01 APPLIED MATHEMATICS FOR EMBEDDED SYSTEMS

2 1 0 3

NUMBER THEORY: Divisibility, fundamental theorem of arithmetic, division algorithm, Euclid's algorithm, arithmetical function - Euler totient function and its properties – theory of congruences, linear congruences, Fermat's little theorem, Euler's Theorem, The Chinese remainder theorem, primality testing– Fermat's pseudoprimality test, Miller Rabin test. (7+4)

ALGEBRAIC STRUCTURES: Groups – subgroups, modulo groups - primitive roots - discrete logarithms. Ring, field – finite fields, cryptosystem, elliptic curve cryptosystem (7+3)

GRAPH THEORY: Graphs - subgraphs, graph models, hand-shaking lemma, walk, trail, path, connectedness, distance and diameter. Common classes of graphs – regular, complete Petersen, cycle, path, tree, bi-partite, hypercube, mesh - Isomorphic graphs. Representations of graphs –adjacency matrix, incidence matrix, Eulerian graphs – Chinese postman problem and its solution – Hamiltonian graphs – travelling salesman problem – nearest neighbour algorithm. (8+4)

STOCHASTIC PROCESSES: Introduction – classification, Poisson process, discrete time Markov chain, transition probability matrix, classification of states, Chapman Kolmogorov equations, limiting probabilities. (8+4)

Total L: 30 +T:15 = 45

REFERENCES:

1. Douglas R Stinson, "Cryptography: Theory and practice", Chapman Hall, Boca Raton, 2018.
2. Jonathan L. Gross and Jay Yellen, "Graph Theory and its Applications", CRC press,New York, 2018.
3. Joseph A Gallian, "Contemporary Abstract Algebra", Cengage Learning, 2019.
4. Saeed Ghahramani, "Fundamentals of Probability with Stochastic Processes", CRC press, Taylor &Fransis Group, USA, 2019.
5. Tom M Apostol, "Introduction to analytic Number theory", Narosa Publishing House, New Delhi, 2013.

21EE02 EMBEDDED CONTROLLERS AND APPLICATIONS

3 0 0 3

8051: 8051 microcontroller – Architecture – Instruction sets – Addressing modes – I/O ports – Timer/Counter – Serial Communication – Interrupts – Assembly language programming. (11)

ARM7 : Architecture overview - RISC processor design: ARMArchitecture – Programming Model, Pipelined data path design - Pipeline Hazards,Addressing Modes, -Processor modes – Data types – Registers – Program status registers – Floating Point dataprocessing, Interrupts & Exception Handling–– Simple programs. (11)

ARM Programming: ARM Instruction Set – Thumb Instruction Set - DSP Extensions, MixedC and Assembly programming, AMBA bus system Peripherals, SoC design using ARM core, Debug support, Memory system design- Cache Memory, Memory Management unit – VirtualMemory. ARM advanced CPU cores, Applications development using Keil IDE. (11)

REAL WORLD INTERFACING: Master Synchronous Serial Port ((MSSP) structure - Detail study of UART, SPI, I2C, ADC and Comparators, serial port - ADC using I2C. - RTC using I2C. – Design of data acquisition System - frequency counter with display on LCD - Digital Multimeter - DC motor control using PWM with signal (12)

Total L : 45

REFERENCES:

1. M.A. Mazidi, J.G. Mazidi and R.D. McKinlay, 'The 8051 microcontroller and embedded systems', Prentice Hall India, 2nd Edition, New Delhi, 2013.
2. William Hohl and Christopher Hinds 'ARM Assembly Language Fundamentals and Techniques, CRC Press, second edition, 2015
3. Andrew Sloss Dominic Symes Chris Wright, 'ARM System Developer's Guide, Designing and Optimizing System Software', 1st Edition, 2004
4. David A. Patterson and John L. Hennessy, "Computer Organization and Design – The Hardware/Software Interface", ARM Edition, Morgan Kaufmann Publisher, 2010
5. Steve Furber, "ARM System-on-Chip Architecture", Pearson India, 2015.

21EE03 REAL-TIME CONCEPTS FOR EMBEDDED SYSTEMS

3 1 0 4

PROGRAMMING LANGUAGE AND TOOLS FOR EMBEDDED SOFTWARE DEVELOPMENT: Fundamentals of Embedded Systems – Embedded Software Development Process: Programming Languages - Embedded C Building Blocks – Mixing of Assembly and C – Preprocessor - Compiler – Assembler - Linker and Loader - Cross Platform Development -Compiler Optimization Techniques – Executable File Formats-Concept of Make Utility - Super Loop based Design Approach (12 + 4)

REAL-TIME OPERATING SYSTEMS: Basic Terminologies of Real-Time Embedded Systems – Concepts of OS-based Software Development – Real-Time Operating Systems: Definition, Characteristics and Structure – Task Management: Definition, Classification, Structure, States, and Scheduling – Concept of Pseudo Multitasking and True Multitasking (11 + 3)

INTER-TASK SYNCHRONIZATION AND COMMUNICATION: Critical Sections – Atomic Operation – Concept of Reentrancy – Semaphores – Event Flag Registers - Inter-task Communication Methods: Shared Memory Technique, Mailbox, Message Queues, and Pipes – Common Design Problems: Premature Task Deletion, CPU Starvation, Deadlocks, and Unbounded Priority Inversion (11 + 4)

INTERRUPT MANAGEMENT, I/O SUBSYSTEMS AND MEMORY MANAGEMENT: Exceptions and Interrupts – Processing of Exceptions and Interrupts – I/O Sub-systems – Memory Management – Dynamic Memory Allocation and Fixed-size Memory Allocation in Embedded Systems - Application Modularization for Concurrency: Outside-In Approach – UML Diagrams- Design Examples (11 + 4)

Total L: 45 T: 15 = 60

REFERENCES:

1. Qing Li, "Real-Time Concepts for Embedded Systems", CMP Books, 2003.
2. Insup Lee, Joseph Leung, and Sang Son, "Handbook of Real-Time Systems", Chapman and Hall, 2008.
3. David E. Simon, "An Embedded Software Primer", Pearson, 2002.
4. Albert Cheng, "Real-Time Systems: Scheduling, Analysis and Verification", Wiley Interscience, 2002.
5. Bernd Bruegge, Allen Dutoit, "Object-oriented Software Engineering – Using UML, Patterns and Java", Prentice Hall, USA, 2010.

21EE04 FPGA BASED SYSTEM DESIGN

3 1 0 4

REVIEW OF DIGITAL LOGIC CIRCUITS: Designing combinational circuit using multiplexer, decoder – Finite State Machines – Mealy Machine- Moore Machine – State Diagram – State table - Design of state machines using Algorithmic State Machines (ASM) chart as a design tool. System Design using PLDs: Basic concepts – Programming technologies - Programmable Logic Element (PLE) - Programmable Array Logic (PLA) - Programmable Array Logic (PAL) – Programmable Logic Architectures – 16L8 – 16R4 – 22V10–Design of combinational and sequential circuits using PLDs. (11+3)

VERILOG: Signals, Identifier , Net and variable types, Operators, Gate instantiations, Modules and ports, data flow, gate level, Behavioral level ,Switch level and state machine modeling , Concurrent and procedural statements, UDP, sub circuit parameters, function and task, timing and delays - test benches-- design of combinational and sequential circuits using Verilog. (12+4)

CPLD and FIELD PROGRAMMABLE GATE ARRAYS: Complex PLDs (CPLDs) –Xilinx cool runner architecture. Types of FPGA - Xilinx XC4000 series - Logic Cell Array (LCA) – Configurable Logic Blocks (CLB) - Input/output Blocks (IOB) - Programmable Interconnection Point(PIP)Implementing Functions in FPGAs Dedicated Memory in FPGAs – Dedicated Multipliers in FPGAs - Mapping, Placement ,and Routing - Verilog based design flow for FPGA. (11+4)

EMBEDDED SYSTEM DESIGN: FPGA -based Embedded Processor - Design Re-use Using On-chip Bus Interface - Creating a Customized Microcontroller - Robot Axis Position Control - FPGA-based Signal Interfacing and Conditioning – Motor Control Using FPGA- Case Studies for Motor Control -Prototype Using FPGA- FPGA Design Test Methodology. (11+4)

Total L:45 + T:15 = 60

REFERENCES:

1. Charles H Roth and Lizy Kurian John "Digital Systems Design Using VHDL," Cengage Learning,2013.
2. Bhaskar J., " A Verilog Primer", Prentice Hall of India learing,2012.
3. Samir Palnitkar" Verilog HDL : A Guide to Digital Design and Synthesis" Pearson Education Asia 2014. .
4. MichealD.Ciletti, " Advance Digital Design with the verilog HDL", Prentice Hall of India learing,2012.
5. Wayne Wolf," FPGA - Based System Design" Prentice Hall, New Jersey,2012.
6. Ming-Bo Lin, —Digital System Designs and Practices: Using Verilog HDL and FPGAsll, Willey Indian Edition, 2012.
7. Rahul Dubey, "Introduction to Embedded System Design Using Field Programmable Gate Arrays" Springer- Verlag London Limited, 2009.

21EE05 EMBEDDED SYSTEM NETWORKS

3 0 0 3

THE CAN BUS: Introduction – Concepts of Bus Access and Arbitration – Error Processing and Management – Definition of the CAN Protocol ISO 11898-1 – Error Properties, Detection and Processing – Framing - The Rest of the Frame - CAN 2.0B (11)

THE CAN PHYSICAL LAYER: Introduction – Signal Propagation – Bit Synchronisation – Network Speed and Range – High Speed CAN – Low Speed CAN – CAN Components – Event-Triggered and Time-Triggered Protocols - CAN Applications**:** Application Layers and Development Tools for CAN. (11)

LIN, MOST and FLEXRAY: LIN: Introduction - Basic Concept of the LIN 2.0 Protocol - Conformity of LIN – MOST: The MOST (Media Oriented Systems Transport) Bus – General - MOST concept – Flexray: Genesis of FlexRay - FlexRay Consortium -

Aim of FlexRay - Physical Time - Local Time - Channels, Cycles, Segments and Slots - Channels and Cycles – Segments - Communication Frames - Symbol Window Segment - Network Idle Time Segment. (11)

USB AND TCP/IP FOR EMBEDDED SYSTEMS: Introduction **–** Types of USB Transfers: Control Transfer – Bulk Transfer – Interrupt Transfer – Isochronous Transfer – Introduction to the Enumeration Process – Introduction to USB Development Tools. TCP/IP for Embedded Systems: Introduction – Embedded SMTP Client – Embedded SMTP Server (12)

Total L: 45

REFERENCES:

1. Dominique Paret, "Multiplexed Networks for Embedded Systems", Wiley, 2007
2. Dominique Paret, "Flexray and Its Applications", A John Wiley & Sons, Ltd., Publication Wiley, 2012.
3. John Hyde, "USB Design by Example", Intel University Press, 2001
4. Jan, Axelson, "USB Complete", Lake View Research, 2005
5. Edward Insam, "TCP/IP Embedded Internet Applications", Elsevier, 2003
6. Tim Jones, "TCP/IP Application Layer Protocols for Embedded Systems", Charles River Media, 2002

21EE06 / 21EA06 / 21ED06 / 21EM06 RESEARCH METHODOLOGY AND IPR

vide Automotive Engineering 21AE06

21EE72 AUDIT COURSE I

vide Automotive Engineering 21AE72

21EE51 EMBEDDED SYSTEM DESIGN LABORATORY

0 0 4 2

LIST OF EXPERIMENTS

1. On-chip Peripherals Programming in 8051Microcontroller: GPIO, Timers, Serial Port
2. Interfacing of Sensors and Actuators with 8051 Microcontroller
   a) Sensor Interfacing using External ADC
   b) Actuator Interfacing: Relay, DC Motor, Stepper Motor, and Servo Motor
3. Interrupts and Low Power Modes in 8051 Microcontroller
4. On-chip Peripherals Programming in ARM7 Microcontroller – GPIO, Timers, RTC, ADC, PWM, USART
5. Design and Implementation of simple embedded applications using FPGA

In this course, Students have to complete the given list of experiments to get an exposure to work with all the peripherals of 8051 Microcontroller, ARM Microcontroller and FPGAs. In addition to that, each student is expected to do at-least one mini project by using the facilities available in the laboratory and submit a detailed report with relevant references, proposed methodology and results obtained.

Total P: 60

21EE52 / 21EA51 / 21ED52 OBJECT COMPUTING AND DATA STRUCTURES LABORATORY

0 0 4 2

LIST OF EXPERIMENTS

I. Object Computing using C++

1. Implementation of basic programming concepts like conditionals and loops
2. Implementation of function and operator overloading
3. Creation of classes and objects.
4. Implementation of constructors and destructors
5. Implementation of array of objects and dynamic objects.
6. Implementation of call by value, call by reference and return by reference.
7. Implementation of friend functions, inline functions and default arguments.
8. Implementation of inheritance and its types
9. Implementation of polymorphism and its types.

II. Data Structures using C++

1. Programs using arrays.
2. Implementation of various sorting algorithms.
3. Implementation of Stacks using array.
4. Application of Stack
5. Implementation of queue using array.
6. Implementation of Linked Lists: Singly linked, doubly linked and Circular lists and applications.

Total P: 60

REFERENCES:
1. Herbert Schildt, “C++ - The Complete Reference", Tata McGraw Hill, New Delhi, 2012.
2. Aaron M Tanenbaum, Moshe J Augenstein and YedidyahLangsam, "Data structures using C and C++", Pearson Education, New Delhi, 2009.
3. Harvey M Deitel,andPaul J Deitel, “C++ How to Program”, Prentice Hall, New Delhi, 2010.
4. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C++”, Pearson Education, Fourth Edition, 2014.
5. SahniSartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2016.

II SEMESTER

21EE07 REAL-TIME OPERATING SYSTEMS

3 1 0 4

REAL-TIME SYSTEMS: Basic Terminologies - Limits of Current Real-Time Systems - Desirable Features of Real-Time Systems – Factors affecting Predictability – Types of Task Constraints: Timing Constraints, Precedence Constraints, and Resource Constraints - Classification of Scheduling Algorithms - Metrics for Performance Evaluation - Scheduling Anomalies. (10 + 4)

UNIPROCESSOR SCHEDULING ALGORITHMS: Periodic Tasks Scheduling: Cyclic Schedulers, EDF, RMA, and DMA - Aperiodic Task Scheduling**:** Jackson’s Algorithm, Horn’s Algorithm, Bartley’s Algorithm, Scheduling of Aperiodic Tasks with Precedence Constraints – Hybrid Task Set Scheduling: Foreground and Background Scheduling, Polling Server, Deferrable Server, Priority Exchange Server, Sporadic Server, and Slack Stealing (13 + 5)

RESOURCE ACCESS CONTROL PROTOCOLS: Problems involved in Resource Sharing: Priority Inversion and Deadlock – Deadlock Detection and Avoidance Algorithm - Non-Preemptive Protocol – Highest Locker Priority Protocol – Priority Inheritance Protocol – Priority Ceiling Protocol– Comparison of Resource Access Control Protocols – Handling Task Dependencies (10 + 3)

MULTIPROCESSOR SCHEDULING and REAL-TIME KERNEL DESIGN ISSUES: Multiprocessor Task Partitioning and Scheduling Algorithms - Structure of a typical Real-Time Kernel - Data Structures –List Management – Kernel Primitives - Standards for Real-Time Operating Systems – Survey of Commercial Real-Time Operating Systems – Development Tools – Performance Anlayzers (12 + 3)

Total L: 45 T:15 = 60

REFERENCES:
1.Giorgio C. Buttazzo, “Hard Real-Time Computing Systems”, Springer, New York, 2011.
2.Jean J. Labrosse, “ µC/OS-III, The Real-Time Kernel”, Micrium Press, 2009.
3.Jane W. Liu, “Real-Time Systems”, Pearson, New Delhi, 2006.

21EE08 LINUX ARCHITECTURE AND DEVICE DRIVERS

3 1 0 4

BASIC ARCHITECTURE: Evolution of Linux OS – Main characteristics of Linux – Typical Linux distributions – Linux directory structure – User and super/root users – access rights – Home directory – Vi editior - Commands – Overview of shell and GUI. (11+3)

LINUX KERNAL ARCHITECTURE: Layer diagram of OS - Hardware Abstraction Layer (HAL) – Memory manager – scheduler – file system – I/O subsystem – Networking subsystem – IPC – user space. (11+4)

LINUX FILE SYSTEM: Layers of Linux file system – structure of inode – process file system – The Ext2 File system –System programming concepts – API & ABIs – C library and compiler. (11+4)

DEVICE DRIVER: System start up (Booting) Methods **-** PC I/O architecture – classification of Linux devices: character and block devices – port I/O – PCI and ISA bus – polling, interrupt, and waiting queue – Device Files - Device driver Registration – Device driver initialization – I/O operation - typical Linux driver – dynamic and static drivers - kernel modules – Linking and unlinking of modules – On Demand modules linking. (12+4)

Total L: 45 + T: 15 = 60

REFERENCES:
1. Michael beck, Harald bohme, Mirko dziadzka, Ulrich Kunitz "Linux Kernel Programming", Pearson Education, Reprint 2009.
2. Raghavan P., Amol Lad, Sriram Neelakandan “Embedded Linux System Design and Development”, Tailor & Francis Group, reprint 2019
3. Daniel P.Bovet, Marco Cesati “Understanding the Linux kernel”, Shroff publishers & distributors Pvt Ltd, 2019,
4. Robert Love “ LINUX System Programming” Shroff publishers & distributors Pvt Ltd,2013.

5. Tim jones M. " GNU/Linux Application Programming", Wiley Dreamtech India Pvt. Ltd, New Delhi, 2008.

21EE82 AUDIT COURSE II

vide Automotive Engineering 21AE82

21EE61 REAL-TIME SYSTEMS LABORATORY

0 0 4 2

LIST OF EXPERIMENTS

1. Creating a Makefile for an Embedded Application
2. Task Management and Resource Management using Open Source Real-Time Kernel
3. Inter-task Communication in Open Source Real-Time Kernel
4. Interrupt Management and Memory Management using Open Source Real-Time Kernel
5. Performance Evaluation of Single-core and Multi-core Scheduling Algorithms

In this course, Students have to complete the given list of experiments to get an exposure to work with all Kernel Objects of an Open Source Real-Time Kernel. In addition to that, each student is expected to do at-least one mini project by using the facilities available in the laboratory and submit a detailed report with relevant references, proposed methodology and results obtained.

Total P: 60

21EE62 EMBEDDED NETWORKING AND DEVICE DRIVERS LABORATORY

0 0 4 2

LIST OF EXPERIMENTS

1. Implementation of I^2C and SPI Protocols
2. Implementation of Controller Area Network Protocol
3. Development of USB based Driver for an External Storage Device
4. Development of SPI based Driver for Micro SD Card
5. Development of Drivers for Wi-Fi and Bluetooth Devices

In this course, Students have to complete the given list of experiments to get some exposure on Networking Protocol Implementation and Device Driver Development Process. In addition to that, each student is expected to do at-least one mini project that involves all the concepts learnt in this course and submit a detailed report with relevant references, proposed methodology and results obtained.

Total P: 60

21EE63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR

vide Automotive Engineering 21AE63

III SEMESTER

21EE71 PROJECT WORK I

vide Automotive Engineering 21AE71

IV SEMESTER

21EE81 PROJECT WORK II

Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVES

21EE21 / 21ED23 / 21EM23 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 – Consumer IoT vs Industrial Functional Components of a typical IoT System: Sensors, Actuators, Embedded Computation Units, Communication Interfaces , Software Development (9)

IoT PROTOCOLS: Physical and Data Link Layer Protocols: RFID: NFC, FFC, ZigBEE, Bluetooth Low Energy, Z-Wave, Wi-Fi, LoRA - Network Layer Protocols: IPv4, IPv6, TCP & UDP, 6LoWPAN - Application Layer Protocols: COAP, MQTT (13)

CLOUD COMPUTING: NIST Visual Model – Essential Characteristics –Components of Cloud Computing - Service Models – Deployment Models – Service Management and Security – Examples – Basics of Fog Computing (12)

IoT SECURITY AND APPLICATIONS: IEEE 802.11 Wireless Networks Attacks: Basic Types, RFID Security – Security Issues in ZigBEE: Bluetooth Security: Threats to Bluetooth Devices and Networks - IoT Applications**:** Health Care, Connected Vehicles, Smart Grid, Smart Home, and Smart City (11)

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. HimanshuDwivedi, Chris Clark and David Thiel, “Mobile Application Security”, Tata McGraw Hill, Nw Delhi, 2010.
6. Vijay Madisetti, ArshdeepBahga, “Internet of Things (A Hands-on Approach), Universities Press, 2015.

21EE22 / 21ED24 TOTALLY INTEGRATED AUTOMATION

3 0 0 3

INTRODUCTION TO FACTORY & PROCESS AUTOMATION: Evolution of Industrial Versions - Control elements of Industrial Automation- IEC/ ISA Standards for Control Elements – Selection criteria for control elements –Utilisation Category with IEC standards- Construction of Relay Ladder logic with different control elements- Need for PLC - PLC evolution. (6)

PROGRAMMABLE LOGIC CONTROLLERS: Architecture of PLC - Types of PLC – PLC modules, PLC Configuration -Scan cycle - Capabilities of PLC- Selection criteria for PLC – PLC Communication - PLC Wiring- Installation of PLC and its Modules. Types of Programming – Bit Instructions -Timers and counters– PLC arithmetic functions PTO / PWM generation- High Speed Counter – Analog Scaling – Encoder Interfacing- Servo drive control – Stepper Motor Control. (12)

HMI SYSTEMS & NETWORKING: Need for HMI in Industrial Automation, Types of HMI – Configuration of HMI, Screen development and navigation, Configuration of HMI elements / objects and Interfacing with PLC - PLC Networking- Networking standards & IEEE Standard - Protocols - Field bus - Process bus and Ethernet –EttherCAT (13)

SUPERVISORY CONTROL AND DATA ACQUISITION: Architecture – Tools – Tag Configuration - Internal & External graphics, Alarm logging – Tag logging – structured tags – Trends – history – Report generation (14)

Total L:45

REFERENCES:

1. W. Bolton, Programmable logic controllers, Elsevier Ltd, 2015.
2. Frank D Petruzella, Programmable logic controllersǁ, McGraw-Hill, 2011.
3. John R Hackworth and Fredrick D Hackworth Jr., —Programmable Logic Controllers: Programming Methods and Applicationsǁ, Pearson Education, 2006.
4. Working with WinCC, Software manual, Siemens, 2015.
5. CIMPLICITY SCADA Packages Manual, Fanuc India Ltd 2004.

21EE23 / 21EA39 / 21EM39 INDUSTRAIL DRIVES FOR AUTOMATION

3 0 0 3

DYNAMICS OF ELECTRIC DRIVES: Fundamental torque equation- multi-quadrant operation- nature and classification of load torques- modes of operation. **Induction Motor Drives**: Construction-Principle – performance characteristics – stator voltage control, frequency control, v/f control, rotor resistance control, static rotor resistance control, slip power recovery: Static Krammer drive, Static Scherbius drive. (12)

VECTOR CONTROL OF INDUCTION MOTOR DRIVES: Introduction to Park's and Clarke's transformation- Principle of vector control-Direct vector control-indirect vector control- stator flux oriented vector control- rotor flux oriented vector control– sensorless control- Direct torque control. (12)

SPECIAL DRIVES: BLDC-principle, controllers; PMSM-principle-PMSM flux density distribution-Controller– SynRM-principle-magnetic flux density and operating point- converter VA requirements. (10)

CONFIGURATIONS OF I/O CONTROL: AC drive Hardware Blocks – Control Blocks – Automatic Motor Adaptation – Parameterization of Drives (Local and Remote).Digital input and output- Analog input and Output control- word access- motion control- sequential logic control(SLC)- parameterization of different communication protocol: RS 485 – MODBUS – PROFIBUS. (11)

Total L : 45

REFERENCES:

1. Gopal K Dubey, "Fundamentals of Electric Drives", Narosa Publishing House, New Delhi, 2005
2. Bimal K Bose, "Power Electronics and Variable Frequency Drives - Technology and Application", Wiley, 2010.
3. Peter Vas, "Vector Control of AC Machines", Oxford University Press, 1990
4. John Park, Steve Mackey and Edwin Wright, "Data Communications for Instrumentation and Control", Elsevier 2003
5. Ned Mohan, "Advanced Electric Drives: Analysis, Control and Modeling using Simulink", John Wiley and Sons Ltd, 2001.

21EE24 / 21EA26 COMPUTER ARCHITECTURE AND PARALLEL PROCESSING

3 0 0 3

FUNDAMENTALS OF COMPUTER DESIGN: Register transfer language –Micro-operations- Control unit implementation - Arithmetic for computers: Binary arithmetic unit – BCD arithmetic unit – Floating point arithmetic unit-Memory Hierarchy - Main memory –Interleaved memory – Associative memory - Virtual memory systems – Structure – Paging – TLB – Segmentation – Replacement strategies – Cache memory: Basic cache structure – Replacement policies – Multiple caches – Memory management hardware. (12)

INSTRUCTION-LEVEL PARALLELISM: Trends towards parallel processing- Parallelism in uniprocessor systems- Parallel processing mechanisms- Parallel computer structure- Architectural classification schemes –Instruction level parallelism: Pipelining and Handling Hazards - Instruction Scheduling - Static and Dynamic Branch Prediction - Hardware Based Speculation – Multi-threading- Limitations of ILP. (11)

VECTOR, SIMD AND GPU ARCHITECTURES: Basics of vector processing Architecture -Issues in vector processing - SIMD architecture- SIMD Instruction Set -GPU Architecture - Detecting and Enhancing Loop Level Parallelism. (11)

MULTIPROCESSOR AND MUTLICORE ARCHITECTURES: Functional structures: Loosely and Tightly coupled Multiprocessors – Processor characteristics for multiprocessing – Symmetric Multiprocessors (SMP) – Non-Uniform Memory Access (NUMA) – Interconnection structures for multiprocessors – Cache coherence – Symmetric and distributed shared memory architecture – Homogeneous and Heterogeneous Multi-core architectures-INTEL Multi-core architecture. (11)

Total L: 45

REFERENCES:

1. Mano, M.M., "Computer System Architecture", Pearson Publishers, 3rd Edition, 2013.
2. Stallings W., "Computer Organisation and Architecture – Designing for performance", Pearson Publishers, 9th Edition, 2014.
3. Kai Hwang and Faye A Briggs., "Computer Architecture and Parallel Processing", McGraw Hill Book Company, 2016.
4. John Hennessy and David Patterson, "Computer Architecture: A Quantitative approach", Elsevier India Publishers, 5th Edition, 2017.
5. David A. Patterson, John L. Hennessy, "Computer Organization and Design MIPS Edition: The Hardware/Software Interface", Morgan Kaufmann,2014.

21EE25 PYTHON FOR EMBEDDED SYSTEMS

3 0 0 3

BASICS AND OBJECT ORIENTED FEATURES: Variables - Keywords - Data Types – Lists- Tuples - Sets - Dictionaries – Operators – Control Statements – Loops – Functions - Lambda – Modules - Standard Functions - Classes and Objects – Instance Methods – Special Methods - Class Variables – Inheritance – Polymorphism (11)

I/O HANDLING AND ERROR HANDLING: File Handling- Access Modes – Read, Write, Create and Delete File –Exception Handling: Run Time Errors - Exception Model - Exception Hierarchy - Handling Multiple Exceptions - Handling I/O Exceptions - Regular Expressions (11)

APPLICATIONS USING PYTHON: Network programming-Database Access- Creating simple Graphical User Interfaces - Sending e-mail using SMTP Library-Multithreading-CGI Programming - Extensions- Web application development: opening an URL-creating a simple web page- Overview of webapp2 and Flask – Programming Raspberry Pi and Arduino using Python (12)

MICRO PYTHON: Introduction-Supporting Boards- GPIO- Digital and Analog Inputs and Outputs-PWM-Interrupts- Installation and Programming- Web Servers-Sensors and Modules-MQTT- IoT case study (11)

Total L: 45

REFERENCES:

1. Wesley J Chun, “Core Python Applications Programming”, Prentice Hall, 2012.
2. Mark Summerfield. “Programming in Python 3: A Complete introduction to the Python Language”, Addison-Wesley Professional, 2009.
3. Sumit Gupta “Building Web Applications with Python and Neo4j”,Packt publishers,2015
4. Ron DuPlain, “ Instant Flask Web Development “,Packt publishers ,Second edition ,2013.
5. Nicholas H. Tollervey, “Programming with MicroPython: Embedded Programming with Microcontrollers and Python“, O’Reilly Publications, 2018.

21EE26 ARTIFICIAL INTELLIGENCE

3 0 0 3

INTRODUCTION: Overview, foundations, scope, problems and approaches of AI, Intelligent Agents and environments, Structure of Agents, Problem Solving Agents, Search Algorithms, Uninformed Search Strategies, Informed (Heuristic) Search Strategies, Heuristic Functions, Search in complex Environments (12)

KNOWLEDGE REPRESENTATION AND REASONING: Ontologies, foundations of knowledge representation and reasoning, Logical Agents, Proportional Logic, First Order Logic, Inference in first order logic, Rule based systems, Knowledge representation, Automated planning. (11)

UNCERTAIN KNOWLEDGE AND REASONING: Quantifying Uncertainty, Basic probability notation, Naïve bayes models, Probabilistic reasoning, Exact and Approximate Inference in Bayesian Network, Causal Networks, Time and Uncertainty, Hidden Markov models, Kalman filter, Probabilistic programming. (11)

DECISION MAKING: Basis of Utility Theory, Utility Functions, Decision Networks, Sequential Decision Problems, Properties of Multi agent Environments, Game theory, Making Collective Decisions, Bargaining, Sample applications: Industrial automation and Business Intelligence. (11)

Total: L: 45

REFERENCES:

1. Deepak Khemani, “A First Course in Artificial Intelligence”, McGraw Hill Education (India) Private Limited, New Delhi, 2014
2. Stuart Russsel and Peter Norvig, “Artificial Intelligence – A Modern Approach”, Pearson Education, New Delhi, 2020
3. Padhy N P, “Artificial Intelligence and Intelligent Systems”, Oxford University Press, New Delhi, 2005
4. Nils J Nilsson, “Artificial Intelligence – A New Synthesis:, Morgan Kaufmann, New Delhi, 2007
5. George F Luger, “Artificial Intelligence – Structures and Strategies for Complex Problem Solving”, Pearson Education, New Delhi, 2009

21EE27 MULTI-CORE EMBEDDED SYSTEMS

3 0 0 3

MULTI-CORE ARCHITECTURES: Introduction to parallel computers: Instruction Level Parallelism (ILP) vs. Thread Level Parallelism (TLP); performance issues: brief introduction to cache- hierarchy and communication latency. Shared memory multiprocessors: general architecture and the problem of cache- coherence; synchronization primitives: atomic primitives; locks: tickets, array; barriers: central and tree; performance implications in shared memory programs. (12)

PROGRAM OPTIMIZATION IN MULTI-CORE PROCESSORS: overview of parallelism, shared memory programming; introduction to OpenMP; data flow analysis, pointer analysis, alias analysis, data dependence analysis, solving data dependence equations (integer linear programming problem); loop optimizations; memory hierarchy issues in code optimization (11)

OPERATING SYSTEM ISSUES FOR MULTIPROCESSING: scheduling techniques: usual OS scheduling techniques, threads, distributed- scheduler, multiprocessor scheduling , gang scheduling; communication between processes, message boxes, shared memory; sharing issues and synchronization, sharing memory and other structures. (11)

POWER MANAGEMENT IN EMBEDDED MULTI-CORES : Power Management Techniques: Clock Gating, Power Gating, Dynamic Voltage Scaling, Dynamic Frequency Scaling, Smart Caching, Scheduling – Role of RTOS in Power Management – Autonomous Power Saving Techniques in Multi-Core Processors – Power Saving Algorithms: Local PMU and Global PMU (11)

Total: L: 45

REFERENCES:

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21EE28 ROBOTICS PROCESS AUTOMATION

3 0 0 3

PROGRAMMING BASICS: Programming Concepts Basics - Understanding the application - Basic Web Concepts - Protocols - Email Clients -. Data Structures - Data Tables - Algorithms - Software Processes - Software Design - Scripting - .Net Framework - .Net Fundamentals - XML - Control structures and functions - XML - HTML - CSS - Variables & Arguments. (10)

RPA CONCEPTS: Basics - RPA vs Automation - Processes & Flowcharts - Programming Constructs in RPA - Types of Bots - Workloads and Proces to be automated - Advanced Concepts - Standardization of processes - Developemt methodologies - Difference from SDLC - Robotic control flow architecture - Business case - RPA Team - Process Design Document/Solution Design Document - Industries best suited for RPA - Risks & Challenges - RPA and emerging ecosystem. (11)

RPA TOOL INTRODUCTION & BASICS: Introduction to RPA Tool - The User Interface - Variables – Types - Managing Variables - Naming Best Practices - The Variables Panel - Managing Arguments - Naming Best Practices - The Arguments Panel - Using Arguments - Importing New Namespaces- Control Flow - Advanced Control Flow - Sequences - Flowcharts - Control Flow Activities - Data Manipulation - Scalar variables, collections and Tables - Text Manipulation - Gathering and Assembling Data (12)

ADVANCED AUTOMATION CONCEPTS AND TECHNIQUES: Recording and Advanced UI Interaction - Recording Introduction - Basic and Desktop Recording - Input/Output Methods - Screen Scraping - Data Scraping - Scraping advanced techniques - Selectors - Defining and Assessing Selectors - Customization - Debugging - Dynamic Selectors - Partial Selectors - RPA Challenge - Image, Text & Advanced Citrix Automation - Best Practices - - Excel Data Tables & PDF - Extracting a single piece of data - Anchors - Using anchors in PDF- Email Automation. (12)

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2. Tom Taulli, The Robotic Process Automation Handbook: A Guide to implementing RPA Systems, Springer, USA, 2020.
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21EE29 ADVANCED EMBEDDED CONTROLLERS

3 0 0 3

ARCHITECTURE OF MIXED SIGNAL PROCESSOR: Introduction to 16-bit Mixed Signal Controller- Important aspects of Mixed Signal Controller's Hardware – CPU – Functional Block Diagram - Memory Mapping – Clock System - Addressing Modes - Register Mode – Indexed Mode – Introduction to functions – Interrupts - Low Power Modes - Development Environment - Programming and Debugging (10)

PERIPERALS OF MIXED SIGNAL PROCESSOR : Parallel ports - Digital Inputs/ Outputs – Timers - Watchdog Timer- Capture/Compare module –Generation of Periodic Signal – Generation of PWM Signal - Operation of the ADC Peripheral (ADC10) - Internal Temperature Sensor – Serial Communication Protocols (12)

ARCHITECTURE OF ARM CORTEX M_x: ARM Cortex-M_x Processor Core overview - Programmers Model - Memory Model - Exception and Fault Handling - Power Management - Instruction Set Summary - CMSIS Functions - Hardware-Software Synchronization - Interrupt Synchronization - Multithreading - Register Map - System Timer - Nested Vectored Interrupt Controller - Floating Point Unit (FPU)-Optional Memory Protection Unit. (11)

PERIPHERALS OF ARM CORTEX – Mx CONTROLLER: Cortex-Mx Peripherals - Parallel I/O Ports - Timer Interfacing - Pulse Width Modulation - Frequency Measurement - Binary Actuators - Integral Control of a DC Motor – DAC - ADC -Serial Communication Protocols (12)

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21EE30 BLOCKCHAIN TECHNOLOGY

3 0 0 3

DISTRIBUTED SYSTEMS AND CRYPTOGRAPHY: Distributed Database, Two General Problem, Byzantine General problem and Fault Tolerance, Hadoop Distributed File System, Distributed Hash Table, ASIC resistance, Turing Complete. Cryptography: Hash function, Digital Signature - ECDSA, Merkle Tree, Memory Hard Algorithm, Zero Knowledge Proof. (10)

BASIC BLOCKCHAIN: Concepts germane to Bitcoin and contemporary proof-of-work based consensus mechanisms, operations of Bitcoin blockchain, crypto-currency as application of blockchain technology (11)

BLOCKCHAIN 2.0 : Blockchains with smart contracts and Turing complete blockchain scripting – issues of correctness and verifiability, Ethereum platform and its smart contract mechanism - **BLOCKCHAIN 3.0 –** Plug-and-play mechanisms for consensus and smart contract evaluation engines, Hyperledger fabric platform (13)

BEYOND CRYPTOCURRENCY – Applications of blockchain in cyber security, integrity of information, E-Governance and other contract enforcement mechanisms - Limitations of blockchain as a technology - myths vs. reality of blockchain technology (11)

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2. S. Shukla, M. Dhawan, S. Sharma, S. Venkatesan, 'Blockchain Technology: Cryptocurrency and Applications', Oxford University Press, 2019.
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21EE31 / 21EA41 / 21EM41 AUTOMOTIVE EMBEDDED SYSTEMS

3 0 0 3

INTRODUCTION: Current trends in modern automobiles – – Drive by wire Systems -Vehicle functional domains and their requirements - Components of an Automobile Electronic system and their functions: Sensors, Actuators, Control Units and Software structure of Control units. (9)

POWER TRAIN, BODY AND CHASSIS DOMAIN: Power Train Domain: Gasoline engine management -Body Electronics: Vehicle power supply controllers – Lighting technology– Adaptive lighting system – Automatic wiper system – Door control modules - Vehicle to vehicle communication - Chassis Domain: Antilock Braking System (ABS) – Electronic Stability Program (ESP) (12)

AUTOMOTIVE INFOTRONICS AND SAFETY & SECURITY SYSTEMS : Automotive Vision System - Advanced Driver Assistant Systems (ADAS) – Multimedia systems- Intelligent Automotive Systems: Navigation Systems – Adaptive Cruise Control (ACC) - Active and Passive safety- Airbag System – Seat belt tightening system - Electronic Brake Force Distribution (EBD) - Lane Departure Warning System - Anti-theft technologies – Electronic Immobilizers – Remote Keyless entry. (12)

AUTOMOTIVE NETWORKING AND DIAGNOSTICS : Cross-system functions - Bus systems: Requirements, classification and applications — Introduction – Diagnostics Theory – On-Board Diagnostics – Off-board diagnostics – Diagnostics Link Connector – Vehicle Condition Monitoring - Diagnostic Interfaces – examples of networked vehicles. (12)

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21EE32 AUTOMOTIVE SOFTWARE ARCHITECTURE

3 0 0 3

AUTOMOTIVE SOFTWARE ARCHITECTURES: Introduction - History of Software in the Automotive Industry- Software Architectures: Views and Documentation - Common View on Architecture in General - Architectural Views - Architectural Styles - Describing the Architectures - Current Trends in Automotive Software Architectures. (11)

AUTOMOTIVE SOFTWARE DEVELOPMENT: V-Model of Automotive Software Development – Requirements – Variant Management - Testing Strategies - Construction Database and Its Role in Automotive Software Engineering - Design of Automotive Software: Simulink Modelling - Simulink Compared to SySML/UML - MISRA. (11)

AUTOSAR: AUTOSAR Reference Architecture - AUTOSAR Development Methodology – AUTOSAR Meta-Model - AUTOSAR ECU Middleware - AUTOSAR Evolution – ARTOP – MICROSAR - Functional Safety of Automotive Software: Management and Support for Functional Safety - Concept and System Development - Planning of Software Development - Software Safety Requirements - Software Architectural Design - Software Unit Design. (11)

SOFTWARE STANDARD: Functional Safety Standards – ISO-26262 - IEC 62304 and ISO 14971- DESIGN VALIDATION: Markov Models - The Fault Tree - Software Failure Rates - Coding Guidelines - Code Coverage Metrics - Static Analysis - Implementation and Testing - Software Integration and Testing - Verification of Software Safety Requirements - Integration, Testing, Validation, Assessment. (12)

Total L:45

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21EE33 GRAPHICAL PROGRAMMING FOR REAL-TIME APPLICATIONS

3 0 0 3

GRAPHICAL PROGRAMMING CONCEPTS: Fundamental Concepts of Virtual Instrumentation and Graphical Programming-Data Flow Programming-Data Types–Modular Programming - Debugging Techniques– Customization of VI Properties-VI Documentation
Programming Structures: Formula Nodes-Expression Nodes –Loops –Shift Registers – Feedback Nodes - Local and Global Variables – Case and Sequence Structures –Key Navigation-Dialog Boxes - Arrays and Clusters-Graphs and Charts-Mechanical Action of Boolean Switches - String and File I/O (14)

DATA ACQUISITION AND INTERFACING STANDARDS: Temperature Monitoring System using PC based Data Acquisition System- Motion Control- Image Acquisition and Processing-Communication: RS232 - RS485- GPIB – System Interface Buses: USB-PXI (9)

ADVANCED PROGRAMMING OPTIONS: Event Driven Programming - Diagram Disable Structures- Sound VI's- Reentrant VIs- VI server -Web publishing tool- Multithreading in LabVIEW-State Machines –Nest Case Selector- Property Nodes-Invoke Nodes- LabVIEW Interface for Arduino – Introduction to Object Oriented Programming in LabVIEW (9)

REAL-TIME APPLICATIONS: Real-Time Concepts including Determinism and Jitter – Configuration of Real-Time I/O Hardware in MAX - Host & Target VI – Prioritization of Tasks – Timed Programming Structures in LabVIEW Real-Time – Sharing Data between Deterministic & Non-Deterministic Processes – Real-Time Application Deployment using myRIO – Run-time Interaction with Deployed Applications – Running Web Services in myRIO (13)

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21EE34 INDUSTRIAL NETWORKING AND STANDARDS

3 0 0 3

SERIAL INTERFACE STANDARDS: Modern Instrumentation and Control Systems – Open Systems Interconnection Model – EIA-232 Interface Standard – Major Elements of EIA-232 – Half-Duplex and Full-Duplex operation of EIA-232 Interface – Overview of EIA-422 and EIA-423 Interface Standards- EIA-485 Interface Standard – Comparison of Serial Interface Standards–Noise problems in serial communication and troubleshooting. (11)

HART AND MODBUS PROTOCOL: HART PROTOCOL over 4-20 mA Signal Base – Wireless HART Protocol - **MODBUS:** Modbus Protocol Structure: Data types, Transmission modes, Messaging Structure–Modbus Function Codes- Fault Handling Mechanisms of Modbus Protocol – Applications of Modbus Protocol (11)

FIELD AREA NETWORKING PROTOCOLS: Actuator Sensor Interface - Structure of AS-i slave ICs, AS-i messages, AS-i modulation technique, Troubleshooting-**Device Net:** Physical Layer Topology – Device Taps – Datalink Layer: Frame Format – Medium Access – Fragmentation- Process Field Bus (PROFIBUS) –Profisafe – ProfiDrive - **Foundation Fieldbus**: Physical Layer and Wiring Rules – Datalink Layer– Application Layer – Error Detection and Diagnostics – SERCOS III – ControlNET(11)

INDUSTRIAL ETHERNET: Overview – Ethernet Hardware Basics – Ethernet Protocol and Addressing – Introduction to10 Mbps, 100 Mbps and Gigabit Ethernet – Real-time Ethernet for Automation Applications – Time-triggered Ethernet – Security in Industrial Communications – EtherCAT (12)

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21EE35 / 21EA27 INTERNETWORKING AND ITS APPLICATIONS

3 0 0 3

INTERNETWORKING : Overview of Internetworking, Underlying networking technologies, Concept and Architectural model, Protocol layering – LAN Fundamentals – Wired LANS– Wireless LANS : 1EEE 802.11, Bluetooth - Connecting Devices : Hub, Switches, Routers, Access point, Wireless Router (10)

NETWORK AND TRANSPORT LAYERPROTOCOLS : Network layer protocols : IPv4 Datagram Format, IPv4 Addresses, Forwarding IP packets, Subletting -ICMPv4 – DHCP -Next Generation IP, Transport layer protocols - Transmission Control Protocol (TCP)- Connection Establishment and closing- Data transfer- Sliding window protocol – User Datagram Protocols (UDP) (10)

APPLICATION LAYER PROTOCOLS AND NETWORK SECURITY : Simple Mail Transfer Protocol (SMTP) - Online Payments - Secure Electronic Transactions (SET) – Multipurpose Internet Mail Extension (MIME) – World Wide Web and HTTP – FTP - Remote login : Telnet, Electronic Mail -Areas of Network Management – SNMP – SMI – MIB - ASN.1, Introduction to network security – Confidentiality – Message Integrity - Message Authentication - Digital Signature– HTTPS- Entry Authentication - Key management – Internet Security – Firewall (12)

MULTIMEDIA APPLICATIONS & MOBILE NETWORKS : Multimedia Networking Applications, Streaming stored video, Voice over IP, Protocols for real-time conversational applications, network support for multimedia - Cellular Networks - Evolution of Mobile Networks-1G, 2G,3G,4G,5G and 6G.Working principles of GSM, GPRS, UMTS and LTE (13)

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21EE36 / 21EA33 WIRELESS SENSOR NETWORKS

3 0 0 3

CHARACTERISTICS OF WSN: Characteristic requirements for WSN, Challenges for WSNs, WSN vs Adhoc Networks, Sensor node architecture, Commercially available sensor nodes, Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations. (11)

MEDIUM ACCESS AND ROUTING: Fundamentals of MAC protocols, Low duty cycle protocols and wakeup concepts, Contention based protocols, Schedule-based protocols: SMAC - BMAC - TRAMA, IEEE 802.15.4 MAC protocol. Routing and Data Gathering Protocols, Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding and gossiping, Energy aware and Hierarchical Routing, Real Time routing Protocols. (12)

NETWORK MANAGEMENT AND LOCALIZATION: Network Management Requirements – Network Management Design Issues –Naming and addressing: Fundamentals-Address and Name Management in WSN- Assignment of MAC addresses-Localization and positioning: Properties - Possible approaches- Proximity-Trilateration and Triangulation. - Coverage and connectivity, Single-hop and multihop localization, Self-configuring localization systems, Sensor management. (11)

OPERATING SYSTEMS AND APPLICATIONS: Operating Systems for Wireless Sensor Networks, Design Issues, Examples of Operating Systems: Tiny - Mate - Magnet - MANTIS. WSN Applications: Home Control, Medical, Reconfigurable Sensor Networks, Civil and Environmental Engineering, Nanoscopic Sensor. Case Study: IEEE 802.15.4 LR - WPANs Standard - Target detection and tracking - Contour/edge detection - Field sampling. (11)

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21EE37 WIRELESS AND MOBILE COMMUNICATION

3 0 0 3

PRINCIPLES OF WIRELESS COMMUNICATION : Digital modulation techniques – Linear modulation techniques – Spread spectrum modulation – Performance of modulation – Multiple access techniques – TDMA – FDMA – CDMA – SDMA – Overview of cellular networks – Cellular concept – Hand-off strategies – Path loss – Fading and Doppler effect. (10)

WIRELESS PROTOCOLS : Issues and challenges of wireless networks – Location management – Resource management – Routing – Power management – Security – Wireless media access techniques – ALOHA – CSMA – Wireless LAN – MAN – IEEE 802.11- Wireless routing protocols – Mobile IP – IPv4 – IPv6 – Wireless TCP -Protocols for 3G; 4G cellular networks – IMT – 2000 – UMTS – CDMA2000 – Mobility management and handover technologies – All-IP based cellular network (11)

TYPES OF WIRELESS NETWORKS: Mobile networks – Ad-hoc networks – Ad-hoc routing – Sensor networks – Peer-Peer networks – Mobile routing protocols – DSR – AODV – Reactive routing – Location aided routing – Mobility models – Entity based – Group mobility – Random way – Point mobility model. Issues and challenges of mobile networks – Security issues – Authentication in mobile applications – Privacy issues – Power management – Energy awareness computing. Mobile IP and Ad-hoc networks – VoIP applications. (12)

CELLULAR TECHNOLOGIES : GSM, GPS, GPRS, CDMA and 3G: Bluetooth – Radio Frequency Identification – Wireless Broadband – Mobile IP – IPv6 – Java Card – GSM: Architecture, Entities, Call Routing, PLMN Interfaces, addresses and Identifiers, Network aspects, Authentication and Security – GPRS: Network Architecture, Network Operations, Data Services, Applications, Limitations – Spread Spectrum technology – Is-95 – 4G and 5G Applications. (12)

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21EE38 CRYPTOGRAPHY AND NETWORK SECURITY

3 0 0 3

SECURITY BASICS: The OSI Security Architectures-Conventional Encryption – Classical Techniques and Modern Techniques-Modes of operation - DES, AES, Key Distribution. (11)

PUBLICKEY CRYPTOGRAPHY AND HASH FUNCTIONS: Number Theory Concepts – Prime numbers- Modular Arithmetic – Fermat & Euler Theorem – Euclid Algorithm – RSA Algorithm – Diffie Hellman Key Exchange Elliptic Curve Cryptography – Hashing techniques- SHA-HMAC – Digital Signatures- DSS, Digital Signature Algorithm. (12)

NETWORK SECURITYAND STANDARDS: Intruders and Intrusion – Viruses and Worms – OS Security – Firewalls – Design Principles – Packet Filtering – Application gateways – Trusted systems - Security Standards**:**IEEE, RSA and ISO standards- Blueprint for Security – Design of Security Architecture. (11)

NETWORK ISSUES: Authentication Applications – Kerberos –Electronic Mail Security –PGP –IP Security –Architecture- Web Security- SSL – TLS – SET. (11)

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21EE39 ADVANCED DIGITAL SIGNAL PROCESSING

3 0 0 3

MULTIRATE DSP: Sampling–Spectral representation: DFT and FFT–Review of Digital filters-Decimation and Interpolation by an integer and rational factors– Multistaging– Decimation and Interpolation with poly phase filters – Realizations – Applications multirate signal processing. (11)

FILTER BANKS: Analysis and Synthesis of Filter Banks– Quadrature Mirror Filter (QMF) banks– Filter bank with perfect reconstruction– 2-Channel and M-channel– Parauunitary filter banks– Biorthogonal and Linear phase filter banks– Tree and parallel structured filter banks–Transmultiplexer filter banks– Multi resolution analysis – Subband coding and its applications (12)

WAVELET TRANSFORM: Short-Time Fourier Transform – limitations - time-frequency scaling- Heisenberg’s uncertainty – Continuous Wavelet Transform – Discrete Wavelet Transform – Haar, Daubechy’s wavelets – Multi Resolution Analysis of audio signal. (11)

ADAPTIVE FILTERS: FIR adaptive filters – adaptive filters based on steepest descent method – LMS algorithm – Variants of LMS algorithm – adaptive channel equalization – adaptive echo cancellation – RLS adaptive algorithm (11)

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21EE40 COMPUTER VISION

3 0 0 3

IMAGE PROCESSING FOUNDATIONS: Review of image processing techniques – classical filtering operations – thresholding techniques – edge detection techniques – corner and interest point detection – mathematical morphology – texture. (11)

SHAPES AND REGIONS: Binary shape analysis – connectedness – object labeling and counting – size filtering – distance functions – skeletons and thinning – deformable shape analysis – boundary tracking procedures – active contours – shape models and shape recognition – centroidal profiles – handling occlusion – boundary descriptors – chain codes – Fourier descriptors – region descriptors-moments. (11)

HOUGH TRANSFORM: Line detection – Hough Transform (HT) for line detection – foot-of-normal method – RANSAC for straight line detection – HT based circular object detection –– ellipse detection – Case study: Human Iris location – hole detection – generalized Hough Transform (GHT) – spatial matched filtering – GHT for ellipse detection. (11)

3D VISION AND MOTION: Methods for 3D vision – projection schemes – shape from shading – photometric stereo – shape from texture – shape from focus – active range finding – surface representations - 3D object recognition – 3D reconstruction – introduction to motion – parametric motion – optical flow. (12)

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2. S. Jayaraman, S. Esakkirajan, T. Veerakumar, “Digital Image Processing”, Tata McGraw Hill, 2011.
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21EE41 GRAPH THEORY AND APPLICATIONS

3 0 0 3

BASICS : Simple Graph – Finite and infinite Graphs – Incidence and Degree –Isolated and Pendent Vertices – Sub-Graphs – Isomorphism – Paths and Connections – Connected Graphs, Disconnected Graphs and Components – The Shortest Path Problem – Trees – Spanning Tree Algorithms – Cut Edges and Bonds – Cut Vertices – Cayley’s Formula – The Connector Problem (11)

CUT-SETS, PLANAR AND DUAL GRAPHS AND CONNECTIVITY: Cut-sets – Properties – Connectivity – Blocks – Construction of Reliable Communication Networks – Euler Trees and Hamiltonian Cycles – Planar and Dual graphs – Kuratowski's Graphs – Directed Graphs – Euler Digraphs – The Chinese Postman Problem – The Traveling Salesman Problem (11)

MATCHING, COLOURING AND COVERING: Matching – Covering in Bipartite Graphs – Perfect Matching – The Personal Assignment Problem – The Optimal Assignment Problem – Edge Colouring – Edge Chromatic Number – Vizing's Theorem – The Time Tabling Problem – Independent Sets and Cliques – Applications – Vertex Colouring – Chromatic Polynomials – Five Colour Theorem – Application (12)

MATRIX REPRESENTATION OF GRAPHS AND GRAPH ENUMERATION: Operations on Graphs – Incidence Matrix – Circuit Matrix – Fundamental Circuit Matrix – Cut-set Matrix – Path Matrix – Adjacency Matrix – Types of Enumeration – Counting Labeled and Unlabeled Trees – Polya's Counting Theorem – Graphs Enumeration with Polya's Theorem - **GRAPH THEORY APPLICATIONS**: Network Flows – Transport Networks – Max-Flow Min-Cut Theorem – Activity Networks – Graphs in Game Theory (11)

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21EE42 / 21EA32 / 21ED34 / 21EM32 OPTIMIZATION TECHNIQUES

3 0 0 3

LINEAR PROGRAMMING: Statement of Optimization problems, Graphical method, Simplex method, Revised simplex method, Two phase simplex method, Duality in linear programming, Sensitivity analysis. (12)

NON-LINEAR PROGRAMMING (UNCONSTRAINED OPTIMIZATION): Direct search methods: Univariate method, Pattern search method, Simplex method, Descent methods: Steepest Descent method, Conjugate gradient method, Quasi Newton method. (11)

NON-LINEAR PROGRAMMING (CONSTRAINED OPTIMIZATION): Direct methods: The Complex method, Zoutendijk's Method of Feasible Directions, Rosen's Gradient Projection Method , Indirect methods: Transformation Techniques, Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Exterior Penalty Function Method. (11)

DYNAMIC PROGRAMMING: Multistage decision process, Suboptimization and Principle of Optimality, Computational procedure, Final value problem to initial value problem, Linear Programming as a Case of Dynamic Programming, Continuous dynamic programming. (11)

Total L:45

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21EE43 / 21ED26 / 21EM26 DIGITAL CONTROLLERS FOR POWER ELECTRONICS

3 0 0 3

TMS C2XX DSP : Introduction to the C2xx DSP core and code generation. The components of the C2xx DSP core, Peripherals and Peripheral Interface, System configuration registers, Memory , Types of Physical Memory , memory Addressing Modes , Code Composer Studio for C2xx DSP. (12)

I/O AND INTERRUPTS: Pin Multiplexing (MUX) and General Purpose I/O Overview, Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software. (11)

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 (11)

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. (11)

Total L: 45

REFERENCES:

1. Hamid.A.Toliyat and Steven G.Campbell “DSP Based Electro Mechanical Motion Control“ CRC Press New York, 2004.
2. TMS320C28x CPU and Instruction Set Reference Guide -SPRU430
3. TMS320x28xx, 28xxx Peripheral Reference Guide -SPRU566
4. TMS320x2833x System Control and Interrupts Reference Guide -SPRUFB0
5. TMS320x2833x Analog-to-Digital Converter (ADC) Reference Guide -SPRU812
6. MS320x28xx, 28xxx Enhanced Pulse Width Modulator (ePWM) & High-Resolution Pulse Width Modulator (HRPWM) Module Reference Guide -SPRU791 & -SPRU924

21EE44 / 21ED36 / 21EM36 SMART GRID TECHNOLOGIES

3 0 0 3

SMART GRID ARCHITECTURE AND COMPONENTS: Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Concept of Robust & Self-Healing Grid, Smart Grid Architecture - Models - Standards, and Road map for Smart Grid in India. WIDE AREA MONITORING SYSTEM: Fundamentals of Synchrophasor Technology. Structure and functions of Phasor Measuring Unit (PMU) and Phasor Data Concentrator (PDC). Operational experience and Blackout analysis using PMU - Case study on Blackout on Indian Grid. (11)

MICROGRIDS AND DISTRIBUTED ENERGY RESOURCES: Distributed Generation – Concept and topologies, Renewable Energy in Distributed Generation - Grid integration of DGs - IEEE 1547 Standard – Issues in Grid Interface of DGs – Inverter and rotating machine based DGs. Power Quality issues of Grid connected Renewable Energy Sources - Web based Power Quality monitoring and Audit. MICRO GRIDS: Introduction to Micro grids – types – Structure and configuration of Microgrids – AC and DC Micro grids – Power Electronic Interfaces – Energy Management and Protection Control Strategies of a Micro grid - Case Studies. (12)

SMART METERING AND DISTRIBUTION MANAGEMENT SYSTEM (DMS): Volt / VAR control – Digital Substations - IEC61850 based Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Effect of Plug in Hybrid Electric Vehicles, V2G AND G2V topologies. Energy Storage for Smart Grids: Electric and Non-Electric Storage Systems. Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards, Demand response programs and Demand pricing. (11)

COMMUNICATION NETWORKS AND CYBER SECURITY FOR SMART GRID: Communication Architecture for Smart Grids, Home Area Network (HAN): Zigbee Smart Energy Profile, IEEE 802.11, Neighbourhood Area Network (NAN) : RF Mesh, Wireless Star, Radio over Power-Lines (BPL/PLC), Wide Area Network (WAN) : OFC, Cellular Networks, Wi-Max and Wireless Sensor Networks. Smart Grid Cyber Security Requirements - Attacks against Cyber-Physical Systems - Mapping of Cyber Attacks to Control Actions and System Impact. Smart Grid Cyber Security Potential Threats, Vulnerabilities and Risks in Advanced Metering Infrastructure. (11)

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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. Ali Keyhani, “Design of Smart Power Grid Renewable Energy Systems”, Wiley, 2016
4. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press , 2009
5. IEEE Transactions on Smart Grid.

21EE45 / 21EA38 SOFT COMPUTING

3 0 0 3

FEED FORWARD NETWORKS AND SUPERVISED LEARNING: Fundamentals – Biological neural network – Artificial neuron – Activation function – Learning rules - Perceptron Networks – Adaline – Madaline – Back propagation networks - Hopfield network – Discrete Hopfield networks – Associative memories – Recurrent auto association memory – Bi-directional associative memory. (12)

UNSUPERVISED LEARNING NETWORKS: Hamming networks – Self-organising feature maps – Adaptive resonance theory network – Instar model – Outstar model – Counter propagation network – Boltzman machine. (11)

FUZZY SETS AND RELATIONS: Properties and Operations on Classical and Fuzzy Sets - Crisp and Fuzzy Relations - Cardinality, Properties and Operations, Composition, Tolerance and Equivalence Relations - Fuzzy Ordering - Simple Problems. ,Features of membership function - Standard forms and Boundaries - fuzzification - membership value assignments - Fuzzy to Crisp Conversions - Lambda Cuts for fuzzy sets and relations – Defuzzification methods. (11)

GENETIC ALGORITHMS AND SOFT COMPUTING APPLICATIONS: Introduction –Genetic operators – Selection, cross-over and mutation – Fitness function – A simple genetic algorithm – Applications, .Application of Neural Networks: Pattern Recognition - Image compression – Control systems, Applications of Fuzzy Logic: Fuzzy Clustering - Fuzzy Image Analysis - Fuzzy Logic controller. (11)

Total L: 45

REFERENCES:

1. Sivanandam S N, and Deepa S. N., "Principles of Soft Computing", Wiley India (P) Ltd.,New Delhi,2nd Edition, June 2011.
2. Sivanandam S N, Sumathi S., and Deepa S. N., "Introduction to Neural Networks using Matlab 6.0", Tata McGrawHill Publications, New Delhi, 20th reprint 2014.
3. LaureneFausett, "Fundamentals of Neural Networks", Pearson Education India, New Delhi, 2004.
4. Timothy Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill, Singapore, 3rd Edition, 2010.
5. David E Goldberg, "Genetic Algorithms in Search, Optimisation and Machine Learning", Pearson Education, New Delhi, 2004.

21EE46 / 21EM29 MACHINE LEARNING AND ITS APPLICATIONS

3 0 0 3

PROBABILITY DISTRIBUTIONS: Basic Definitions, Types of learning, Probability Theory, Probability Reasoning, Model Selection, Curse of Dimensionality, Decision Theory, Information Theory, Binary Variables, Multinomial Variables, Gaussian Distribution, Exponential Family, Nonparametric Methods, Belief Networks. (12)

LINEAR MODELS FOR REGRESSION AND CLASSIFICATION: Linear Basis Function Models, Bias-Variance Decomposition, Bayesian Linear Regression, Bayesian Model Comparison, Evidence Approximation, Limitations of Fixed Basis Functions, Discriminant Functions, Probabilistic Generative and Discriminative Models, Laplace Approximation, Bayesian Logistic Regression (11)

NEURAL NETWORKS: Introduction, Reforcement Learning, Feed-forward Network functions, Error Backpropogation, Hessian Matrix, Mixture Density Networks, Bayesian Neural Networks, Convolution Neural Network, Dual Representations, Constructing Kernels, Gaussian Processes, Maximum Margin Classifiers, Relevance Vector Machines (11)

APPLICATIONS OF MACHINE LEARNING ALGORITHMS: Content Based Image Retrieval, Machine Learning Approach for face Recognition, Computer Aided Diagnosis, Computer Vision, Speech Recognition,Text Mining, Thinking Machines, Smart Machines, Business Applications of Deep Learning, Software Reliability Prediction, Medical Imaging (11)

Total L : 45

REFERENCES:

1. Christopher M Bishop., "Pattern Recognition and Machine Learning", Springer New Delhi, 2013.
2. David Barber., "Bayesian Reasoning and Machine Learning", Cambridge University Press, New Delhi, 2014.
3. SiddhivinayakKulkarni., "Machine Learning Algorithms for Problem Solving in computational Applications: Intelligent Techniques" IGI Global, 2012
4. Pradeep Kumar and ArvindTiwari., "Ubiquitous Machine Learning and Its Applications", IGI Global, 2017.
5. EthemAlpaydin, "Introduction to Machine Learning", Prentice Hall of India, New Delhi, 2014.

21EE47 E-MOBILITY

3 0 0 3

ENVIRONMENTAL IMPACT AND HISTORY OF MODERN TRANSPORTATION: Working Principles of Internal Combustion Engine based Vehicles - Air Pollution - Global Warming – Societal Impact – Road Safety - Petroleum Resources – Induced Costs – Importance of Different Transportation Development – Re-emergence of Electric Vehicles (EV) – History of EV and Hybrid EV (6)

POWERTRAIN IN EV/HEV: Architecture of EV – Performance Analysis – Architectures of HEV: Series and Parallel – Electric Propulsion Systems: DC Motor Drives, Induction Motor Drives, Permanent Magnetic BLDC Motor Drives, Switched Reluctance Motor Drives – Series Hybrid Electric Drive Train Design - Series Hybrid Electric Drive Train Design (13)

ENERGY STORAGE: Electrochemical Batteries– Ultra Capacitor Technologies – Ultra high-speed Flywheels – Hybridization of Energy Storages – Battery Management System - Regenerative Braking**:** Energy Consumption in Braking – Braking Power and Energy on Front and Rear Wheels – Brake System of EVs and HEVs: Series and Parallel – Antilock Braking System (13)

FUEL CELL VEHICLES: Operating Principles of Fuel Cells – Electrode Potential and Current-Voltage Curve – Fuel and Oxidant Consumption – Fuel Cell System Characteristics – Fuel Cell Technologies – Fuel Supply Process – Fuel Cell Hybrid Electric Drive Train Design

RECENT TRENDS AND CASE STUDIES: Integration of Renewable Energy Sources with EVs – Vehicle to Smart Grid Integration – Smart Charging - Autonomous Cars- Connected Cars – Fleet Management - Electric Vehicles: Status and Roadmap for India. (13)

Total L : 45

REFERENCES:

1. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
2. Tariq Muneer, Mohan Lal Kolhe, Aisling Doyle, "Electric Vehicles: Prospects and Challenges", Elsevier, 2017.
3. Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.

4. Larminie, James, and John Lowry, “Electric Vehicle Technology Explained” John Wiley and Sons, 2012.

OPEN ELECTIVES

21EE91 BUSINESS ANALYTICS

21EA91 vide Applied Electronics

21EE92 ELECTRONIC WASTE MANAGEMENT

21EA92 vide Applied Electronics

21EE93 INDUSTRIAL SAFETY AND STANDARDS

21EA93 vide Applied Electronics

21EE94 INNOVATION AND PRODUCT DEVELOPMENT

21EA94 vide Applied Electronics