Almost all Electronics, Electrical and Mechanical systems are now controlled by a controller, which is embedded as a part of the complete system. Such a system is called an Embedded System. Examples are tele-communication systems, chemical-processing plants, transportation systems such as aircrafts and automobiles, bio-medical instruments and home appliances like microwave ovens and washing machines. The characteristics of embedded systems are that they are designed to do some specific tasks often in real time satisfying certain performance requirements. It is achieved through the controllers and software called firmware stored in read only memory of the controller.

The vast majority of control systems built today are embedded, that is, they rely on built-in, special-purpose microcontrollers (digital computers) to close their feedback loops. Some systems may contain large number of controllers. In such settings, controllers often use shared networks to communicate with each other and with large numbers of sensors and actuators scattered throughout the system. The design of embedded controllers and the intricate, automated communication networks that support them raises many new problems-theoretical and practical-about network protocols, compatibility of operating systems, and ways to maximize the effectiveness of the embedded hardware. This course will address many such questions and aspects of embedded and networked control.
# CURRICULUM

## First Semester

<table>
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<tr>
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** Credits 12**

** Total Credits: 65 **
## List of Courses

### Foundation Core

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### Subject Core

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### Electives

#### Groups of Streams

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**II. Architecture and Programming**

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<td>18ES718</td>
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### Project Work

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TEXT BOOKS / REFERENCES:


TEXT BOOKS / REFERENCES:


Segmentation & Morphological operations: segmentation and threshold function, Different algorithms in thresholding, Line detection, Edge detection, Hough transform, Region based segmentation, Morphological-dilation and erosion, opening and closing. (Qualitatively). Selection of sensors and Processors for real time implementation. Shape Identification, Texture Identification, Colour Identification Applications in Real Time Scenario using Raspberry Pi Processor.

TEXTBOOKS/REFERENCES

18ES603 EMBEDDED PROCESSOR ARCHITECTURES AND DESIGN 3-0-2-4

An introduction to Embedded Processors – RISC verses CISC - CPU Performance Metrics – Benchmark - Integer and Floating Point data representation - RISC processor design
ARM Architecture – Programming Model, Pipelined data path design - Pipeline Hazards, Addressing Modes, ARM Instruction set - Thumb Instruction Set - ARM Programming - Vector Floating Point Unit, Interrupts & Exception Handling - DSP Extensions, Mixed C and Assembly programming, Memory system design - Cache Memory, Memory Management unit - Virtual Memory. Introduction to ARM based Microcontrollers – Peripherals – Interfacing – Application development – Case studies. ARM advanced CPU cores, Comparison with other architectures like PowerPC, DSP, PIC, MSP, FPGA, etc.
**TEXT BOOKS / REFERENCES:**


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**18ES621 DISTRIBUTED COMPUTING 3-0-0-3**


Modeling distributed real-time systems, Real time communication, Requirements of real time communication system, Flow control-Explicit and Implicit, Thrashing, Inter-process communication: Message passing communication, Remote procedure call, Transaction communication, Group communication; Broadcast atomic protocols, Deadlocks in distributed systems, Load scheduling and balancing techniques, Consistency Models, Fault Tolerance.


**TEXT BOOKS / REFERENCES:**


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**18ES622 INTERNET OF THINGS 3-0-2-4**

Introduction to IoT - Definitions, frameworks and key technologies. Challenges to solve in IoT - Embedded systems architecture: Key hardware and software elements. Low power and very low power embedded systems, peripherals and sensors in embedded systems, peripheral interfacing - SPI, I2C & CAN.

System design of an IoT - Sensor network architecture, scenarios, optimization goals, design principles & Protocol Stack, Hardware and software protocol stacks modifications for IoT - MAC, Routing and application layers, performance considerations. Modern trends in IOT – Wearable, industrial standards. Applications of IoT - Smart Homes/Buildings, Smart Cities, Smart Industry, and Smart Medical care, Smart Automation etc.

TEXT BOOKS / REFERENCES:

18ES623 REAL TIME OPERATING SYSTEMS 3-0-2-4


TEXT BOOKS / REFERENCES:


TEXT BOOK / REFERENCES

18ES625 EMBEDDED SYSTEM APPLICATION LAB 1-0-2-2

Each student in consultation with the faculty in-charge will select a topic related to embedded systems and applications and develop an embedded product/system following the embedded system design principles.

18RM600 RESEARCH METHODOLOGY 2-0-0-2

Unit I:

Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review, Referencing, Information Sources, Information Retrieval, Role of libraries in Information Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes
Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Field Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics, and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents

Unit V:

TEXT BOOKS/ REFERENCES:


18ES701 EMBEDDED SYSTEMS FOR AUTOMOTIVE APPLICATIONS 3-0-0-3

TEXT BOOKS / REFERENCES:

18ES702 ADVANCED MOBILE AND WIRELESS NETWORKS 3-0-0-3


TEXT BOOKS / REFERENCES:

18ES703 EMBEDDED SYSTEMS IN BIOMEDICAL APPLICATIONS 3-0-0-3

TEXT BOOKS / REFERENCES:

18ES704 EMBEDDED SYSTEMS IN ROBOTICS 3-0-0-3


TEXT BOOKS / REFERENCES:

18ES705 EMBEDDED SYSTEMS IN SMART GRID 2-0-2-3

Smart Grid features- Distributed generation, storage, DD, DR, AMI, WAMS, WACS). Sensors - CT, PT; Embedded Devices - IED, PMU, PDC, CT, PT, relays, DR Switch; Algorithms; Communication- Standards, Technology and protocols. IoT applications in power system – Case study 1 generation control, load management, dynamic pricing etc; IoT for domestic prosumers. Case Study 2 - Smart microgrid simulator (SMGS), DR, DD, Energystorage, Communication.

TEXT BOOKS / REFERENCES:

18ES706  DESIGN FOR INTERNET OF THINGS AND CLOUD COMPUTING  2-0-2-3

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things -RFIDs, NFC, Web of Things - Embedded Systems Design: Partitioning to hardware and software; principles of co-design; performance of these systems - estimation of speed, throughput, power and energy consumption; hardware design elements - design, validation, and testing tools; software platforms – OS and applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Creating virtual prototypes - hardware software emulation. IOT Reference Architectures, Introduction to Node Red, Visual Prototyping with Arduino and connectivity to IOT platforms, Applications: Healthcare and home automation examples. Cloud Computing: Infrastructure as a Service (IaaS), Cloud Database, Cloud Storage. Platform as a Service (PaaS) for Web Rapid Application Development (RAD), Distributed Storage, Distributed Computing frameworks. Connectivity to remote server database, data access-storage-processing. Development of cloud server and web applications.

TEXTBOOKS / REFERENCES:
System analysis-user and market requirement, project specifications, structured analysis. System Modelling, Preliminary design – Hardware and Software Partitioning, Component Selection - Selecting the right sensors, processors, interfacing circuits, actuators, software modules and development environments, Testing and Debugging, User interface design and prototyping. Approaches to implementation-top down, bottom up, threads.

Major trends in embedded system - Processor - Single core, Multi-core, Multi-processor, Pervasive or ubiquitous or context-aware computing, Artificial Intelligence, Virtual and Augmented Reality, Embedded software, IoT, Computer/Machine vision, Cyber-physical systems.

Applications and Use cases - Wearable Electronics, Smart Healthcare, Automotive Embedded Systems, Smart agriculture, Consumer electronics like PDA, mobile phones, Smart homes/environments, Smart Community, Smart cities and Smart grids, Virtual assistants, Robotics, Smart Security/Surveillance systems, Autonomous systems.

TEXTBOOKS/REFERENCES


18ES708  MULTI-CORE ARCHITECTURES  3-0-0-3


TEXTBOOKS / REFERENCES:

18ES709 FAULT TOLERANT SYSTEMS 3-0-0-3

Hardware fault tolerance, software fault tolerance, information redundancy, check pointing, fault tolerant networks, reconfiguration-based fault tolerance, and simulation techniques. Students will gain familiarity with the core and contemporary literature in the area for dependable computing. Dependability concepts: Dependable system, techniques for achieving dependability, dependability measure, fault, error, failure, and classification of faults and failures. Fault Tolerance Strategies: Fault detection, masking, containment, location, reconfiguration, and recovery. Fault Tolerant Design Techniques: Hardware redundancy, software redundancy, time redundancy and information redundancy. Dependable communication: Dependable channels, survivable networks, fault-tolerant routing. Fault recovery, Stable storage and RAID architectures, and Data replication and resiliency. Case studies of fault tolerant multiprocessor and distributed systems.

TEXT BOOKS / REFERENCES:

18ES710 GPU ARCHITECTURE AND PROGRAMMING 2-0-2-3

Introduction to Parallel Programming - Introduction to OpenCL - OpenCL Device Architectures - Basic OpenCL – examples - Understanding OpenCL - Concurrency and Execution Model - Dissecting a CPU/GPU - OpenCL Implementation - OpenCL case study: Convolution, Video Processing, Histogram and Mixed Particle Simulation - OpenCL Extensions - OpenCL Profiling and Debugging – WebCL.

TEXT BOOKS / REFERENCES:

**18ES711 SOFT COMPUTING 3-0-0-3**


**TEXT BOOKS / REFERENCES:**

**18ES712 HARDWARE SOFTWARE CO-DESIGN 3-0-0-3**


**TEXT BOOKS / REFERENCES:**
Introduction to object oriented software design, Comparison of programming methodologies, Object Basics, Java Environment, Classes and Object, Data Members, Access Specifiers, Arrays within a Class, Array of Objects, Constructors, Default Constructors, Destructors, Static Members, Constant Members, Object Oriented Design with UML, Class s, object diagrams and sequence diagrams. Overview of Streams, Bytes vs. Characters, File Object, Binary Input and Output, Reading and Writing Objects, Method Overriding, Polymorphism, Super, Interfaces and Abstract Classes, Packages, Use case diagrams and activity diagrams. Introduction to Threads, Creating Threads, Thread States, Runnable Threads, Coordinating Threads, Interrupting Threads, Runnable Interface Applets: Applet Architecture- Parameters to Applet - Embedding Applets in Web page, Component diagrams and Deployment diagrams.

TEXT BOOK / REFERENCES:

Introduction to Machine learning, different forms of learning: supervised and unsupervised learning, classification and regression, parametric and nonparametric models, curse of dimensionality, linear and logistic regression, Basics of probability theory and probability distributions, information theory, Bayesian learning, Neural Networks, Gaussian Mixture models and the EM algorithm, Factor analysis, Principal components analysis, Independent Component Analysis, Kernels and kernel functions, Support vector machines for regression and classification, Decision trees, CART, Ensemble Methods: Boosting - Adaboost, Gradient Boosting; Bagging - Simple methods, Random Forest, Markov and hidden Markov models, Introduction to deep learning, Examples and case studies in machine learning.

TEXT BOOKS / REFERENCES:

TEXTBOOKS/REFERENCES

18ES716 CRYPTOGRAPHY AND NETWORK SECURITY 3-0-0-3


TEXT BOOKS / REFERENCES:

18ES717 SPEECH AND LANGUAGE PROCESSING 3-0-0-3


TEXT BOOKS / REFERENCES:

18ES718 ADVANCED DIGITAL SIGNAL PROCESSING AND PROCESSORS 3-0-0-3


TEXT BOOKS / REFERENCES:

18ES719 MODERN CONTROL SYSTEMS 3-0-0-3

Hurwitz criterion and Liapunov’s direct method, construction of Liapunov functions for nonlinear system.

TEXT BOOKS/ REFERENCES:

18ES720 VIDEO PROCESSING 3-0-0-3


TEXT BOOKS / REFERENCES:

18ES798 DISSERTATION 8

Each student should select and work on a topic related to his/her field of specialization during summer of second semester under the supervision of a faculty member. By the end of the third semester he/she must prepare a report in the approved format and present it.

18ES799 DISSERTATION 12

During fourth semester each student should work further on the topic of the minor project or a new topic under the supervision of a faculty member. By the end of fourth semester the student has to prepare a report in the approved format and present it. Finally, there has to be a research paper published in a scopus indexed conference or journal with proper affiliation and approval from the department.