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>
<thead>
<tr>
<th>Course Code</th>
<th>Type</th>
<th>Course</th>
<th>L T P</th>
<th>Cr</th>
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<tbody>
<tr>
<td>16MA610</td>
<td>FC</td>
<td>Probability and Random Processes</td>
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<td>16ES602</td>
<td>FC</td>
<td>FPGA-Based System Design</td>
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<td>16ES603</td>
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<tr>
<td>16ES611</td>
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<td>HU</td>
<td>Cultural Education*</td>
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Credits **18**

*Non-credit course

## Second Semester

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Credits **18**

*Non-credit course

## Third Semester

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Credits **15**

## Fourth Semester

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Credits **14**

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

#### Foundation Core

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<td>Signal and Image Processing</td>
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#### Subject Core

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#### Electives

**Groups of Streams**

**I. Embedded Applications**

<table>
<thead>
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<td>Advanced Mobile and Wireless Networks</td>
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<td>16ES703</td>
<td>Embedded Systems in Biomedical Applications</td>
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<td>Embedded Systems in Robotics</td>
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<td>16ES706</td>
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**II. Architecture and Programming**

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<td>Fault Tolerant Systems</td>
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III. Controls and Systems

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Project Work

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16MA610      PROBABILITY AND RANDOM PROCESSES  3-0-0-3


TEXT BOOKS / REFERENCES:
16ES602  FPGA-BASED SYSTEM DESIGN  3-0-1-4

TEXT BOOKS / REFERENCES

16ES603  EMBEDDED SYSTEM PROGRAMMING  3-0-1-4

TEXT BOOKS / REFERENCES:
**16ES604**  
**SIGNAL AND IMAGE PROCESSING**  
3-0-1-4


**TEXT BOOKS / REFERENCES:**


**16ES611**  
**DISTRIBUTED EMBEDDED SYSTEMS**  
3-0-0-3

Distributed embedded systems, Characteristics of Real-time systems, Functional, Temporal and Dependability requirements, Distributed computing-System architecture, CNI, Communication system, Composability, Scalability, Extensibility, Complexity, Distributed and Centralized architecture, Time and Order, Clock, Clock drift, Time measurements, Dense and Sparse time, External and Internal clock synchronization, Time gateways, Modelling distributed real-time systems-Assumption coverage, Structure of a node, Fault tolerant unit, Real time communication, Requirements of real time communication system, Flow control-Explicit and Implicit, Thrashing, Protocol mechanisms protocol performance, OSI reference model, CAN Bus architecture, USB Architecture, Embedded Ethernet, Embedded TCP/IP, Embedded Internet.

**TEXT BOOKS / REFERENCES:**

16HU601 CULTURAL EDUCATION P/F
Students will undergo self-awareness / personality development and yoga training classes. They will also experience learning form ancient Indian culture.

16ES612 EMBEDDED PROCESSOR ARCHITECTURE AND DESIGN 3-0-1-4
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- Floating Point data processing, Interrupts & Exception Handling- ARM Programming , DSP Extensions, Mixed C and Assembly programming, AMBA bus system Peripherals, SoC design using ARM core, Debug support, Memory system design- Cache Memory, Memory Management unit - Virtual Memory, ARM advanced CPU cores, Applications development using Keil IDE.

TEXT BOOKS / REFERENCES:


16ES613 SENSOR NETWORKS 3-0-1-4
TEXT BOOKS / REFERENCES:

16ES614 REAL TIME SYSTEMS 3-0-1-4
Introduction to real-time systems, clock synchronization – RTOS basics-architecture, RTOS VsgPOS, RTOS Kernel, Kernel services, task attributes and components- task management, taskstates and transition, time services, interrupt handling, interrupt latency, memory management,input-output handling, task communication and synchronization, task assignment andsscheduling- scheduling algorithms, RM, DM and EDF, schedulability, response time analysis,preemption-context switching, blocking, deadlock, priority inversion problem- PIP, PCP,response time analysis with blocking, fault tolerant techniques, case studiesin real-time operating systems. RT Linux.

TEXT BOOKS / REFERENCES:

16ES615 MODEL BASED DESIGN FOR EMBEDDED SYSTEM 3-0-0-3

TEXT BOOKS / REFERENCES:

16ES616 EMBEDDED SYSTEM APPLICATION LAB 0-0-1-1
Each student in consultation with the faculty in-charge will select a topic related to embedded systems and applications and implement it in the lab.

16EN600 TECHNICAL WRITING P/F
Technical terms- Definitions- extended definitions- grammar checks- error detectionpunctuation-spelling and number rules - tone and style- pre-writing techniques - Online and offline library resources- citing references – plagiarism - Graphical representation -documentation styles- instruction manuals- information brochures- research papers, proposals– reports (dissertation, project reports etc.) - Oral presentations.

TEXTBOOKS/REFERENCES:

16ES701 EMBEDDED SYSTEMS FOR AUTOMOTIVE APPLICATIONS 3-0-0-3

TEXT BOOKS / REFERENCES:

16ES702 ADVANCED MOBILE AND WIRELESS NETWORKS 3-0-0-3

TEXT BOOKS / REFERENCES:

16ES703 EMBEDDED SYSTEMS IN BIOMEDICAL APPLICATIONS 3-0-0-3
systems in surgical devices - endoscopy/laparoscopy, medical robots, anesthesia machine, surgical table, haptics augmented reality in minimally invasive surgery, lithotripsy, drug delivery systems, therapeutic application of laser. Embedded system applications in Medical Imaging systems, Therapeutic and prosthetic devices, Tele Medical system, Micro Fluidics and Lab-on-a-chip devices, Clinical Laboratory equipments.

TEXT BOOKS / REFERENCES:

16ES704 EMBEDDED SYSTEMS IN ROBOTICS 3-0-0-3

TEXT BOOKS / REFERENCES:
**16ES705  EMBEDDED SYSTEMS IN SMART GRID  3-0-0-3**


**TEXT BOOKS / REFERENCES:**

**16ES706  DESIGN FOR INTERNET OF THINGS  3-0-0-3**

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things -RFIDs, NFC, Web of Things - Network of interconnected and collaborating objects, Embedded systems architecture: Key hardware and software elements, typical embedded processors like ATOM. Low power and very low power embedded systems, peripherals and sensors in embedded systems, peripheral interfacing -SPI and I2C, Hardware and software protocol stacks -MAC, Routing and application layers, performance considerations. 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. Applications: Healthcare and home automation examples.

**TEXTBOOKS / REFERENCES**
16ES707 MULTI-CORE ARCHITECTURES 3-0-0-3

TEXT BOOKS / REFERENCES:

16ES708 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:

16ES709 GPU ARCHITECTURE AND PROGRAMMING 2-0-1-3
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:

16ES710 SOFT COMPUTING 3-0-0-3

TEXT BOOKS / REFERENCES:

16ES711 HARDWARE SOFTWARE CO-DESIGN 3-0-0-3
Introduction to system level design, Models of computation for Embedded Systems, Architectural selection, Partitioning, scheduling and communication, Simulation, synthesis
and verification, Implementation case studies, Performance Analysis and Optimization, Retargetable code generation, FPGAs.

**TEXT BOOKS / REFERENCES:**


**16ES712 OBJECT ORIENTED PROGRAMMING 3-0-0-3**

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:**


**16ES713 MACHINE LEARNING 3-0-0-3**

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

TEXT BOOKS / REFERENCES:

16ES714 CRYPTOGRAPHY AND NETWORK SECURITY 3-0-0-3

TEXT BOOKS / REFERENCES:

16ES715 SPEECH AND LANGUAGE PROCESSING 3-0-0-3
TEXT BOOKS / REFERENCES:

16ES716 ADVANCED DIGITAL SIGNAL PROCESSING AND PROCESSORS  3-0-0-3

TEXT BOOKS / REFERENCES:

16ES717 MODERN CONTROL SYSTEMS  3-0-0-3

**TEXT BOOKS/REFERENCES:**

**16ES718 OBJECT ORIENTED ANALYSIS AND DESIGN 3-0-0-3**
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.

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**TEXT BOOKS/REFERENCES:**
**16ES719 VIDEO PROCESSING 3-0-0-3**


**TEXT BOOKS / REFERENCES:**


**16ES798 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.

**16ES799 DISSERTATION 14**

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.