COURSE SYLLABUS

Name of the Division: *Smart Technology & Education Division (STED)*

Name of the Course: *Online PG Diploma in Embedded System Design*

Course Code: *ED 500-Online*

Duration: *24 Weeks [120 days/ 840 hours]*

Course Coordinator: *Shoukath Cherukat, +91 9447423306*

Course Structure: The ED 500-On course contains eight modules including project work. The participants are required to do a project work in any one of the modular areas, for a period of 8 weeks to be eligible for issue of Online PG Diploma in Embedded System Design.

The modules are as follows:

Module Code	Module Title	Duration		
		Weeks	Days	Hours
VE 501	Analog and Digital System Design	3	15	105
VE 502	Embedded C and ARM Cortex Microcontrollers	4	20	140
VE 503	Linux OS & Internals	2	10	70
ED 504	Embedded RTOS	2	10	70
ED 505	Cyber Physical Systems &IoT	2	10	70
VE 506	OS Porting on FPGA with ARM Core	1	5	35
VE 507	Industrial Product Design	2	10	70
VE 508	Project Work	8	40	280
	Total Duration	**24**	**120**	**840**

VE 501: Analog and Digital System Design

Module Duration: 105 Hours

Objective

The objective of the course is to provide a thorough understanding about the elements and techniques for analog and digital system design.

Course Description

Analog Concepts

- Introduction to Analog Circuits
- BJT Small Signal Model
- MOS Circuit Model, Biasing of Circuits
- Amplifiers, MOS Amplifiers
- Frequency Response of Amplifier
- Differential Amplifier
- Feedback Theory
- OPAMP Circuits
- ADC/DAC

Digital Concepts

- Combinational Circuit Design
- Sequential Circuit Design
- Design of controller and Data path units
- State Machines
- Design Examples & Case Studies

Learning Outcomes

On successful completion of the module, the candidate shall be able to:

- Design and analyse Analog and Digital Electronic systems

Reading List

1. Design of Analog CMOS ICs - Razavi. The best book available on CMOS analog.
2. Microelectronic circuits : Adel Sedra and Kenneth C. Smith
3. Franco S, Design with Operational Amplifiers and Analog Integrated Circutis
4. CMOS Analog circuit design - Allan and Holberg
5. Analog Integrated Circuit Design - Ken Martin and David Johns
6. Digital Design by Morris Mano & Michael D Ciletti
7. Digital Design: Principles and Practices by John F. Wakerly
8. Digital Design by Frank Vahid

VE 502: Embedded C and ARM Cortex Microcontrollers

Module Duration: 140 Hours

Objective

This module is framed to set the required background in embedded system concepts and 'C' language for the rest of the modules. It aims at familiarizing the students in embedded concepts and programming in 'C'. This module covers the advanced topics in 'C' such as Memory management, Pointers, Data structures which are of high relevance in embedded software is considered in depth. This module also covers application development with ARM Cortex Microcontrollers.

Course Description

Embedded Concepts

Introduction to embedded systems, Application areas, Categories of embedded systems, Overview of embedded system architecture, Specialties and trends of embedded systems, Architecture of embedded systems, Development and debugging Tools.

'C' and Embedded C

Introduction to 'C' programming, Storage Classes, Data Types, Controlling program flow, Arrays, Functions, Memory Management, Pointers, Arrays and Pointers, Pointer to Functions and advanced topics on Pointers, Structures and Unions, Data Structures, Linked List, Stacks, Queues, Conditional Compilation, Preprocessor directives, File operations, Variable arguments in Functions, Command line arguments, bitwise operations.

Introduction to ARM Cortex Architecture

Introduction to ARM Architecture, Overview of ARM, Overview of Cortex Architecture

Cortex M3 Microcontrollers & Peripherals

Cortex M3 based controller architecture, Memory mapping, Cortex M3 Peripherals – GPIOs, Timers, UARTs, Cortex M3 interrupt handling – NVIC. Application development with Cortex M3 controllers with standard peripheral libraries.

Learning Outcomes

After successful completion of the module, the students shall be able to:

- Develop Embedded application using Embedded C Programming
- Use ARM Cortex Microcontrollers with Embedded C Programming for Application Development

Text Books:

1. Embedded/Real Time Systems Concepts, Design and Programming Black Book, Prasad, KVK.
2. Let us C by Yashwant Kanetkar.
3. The Definitive Guide to the ARM Cortex M3, Joseph Yiu, Newnes.

Reference Books:

1. Embedded Systems Architecture Programming and Design: Raj Kamal, Tata McGraw Hill.
2. Embedded C, Pont, Michael J
3. Embedded Systems an Integrated Approach: Lyla B Das, Pearson
4. C Programming language, Kernighan, Brian W, Ritchie, Dennis M

5. Art of C Programming, JONES, ROBIN,STEWART, IAN
6. ARM System Developer's Guide - Designing and Optimizing System Software by: Andrew N Sloss, Dominic Symes, Chris Wright; 2004, Elseiver.
7. Cortex M3 Reference manual.
8. STM32Ldiscovery datasheets, reference manuals & Application notes.

VE 503: Linux OS & Internals

Module Duration: 70 Hours

Objective

The objective of the course is to provide understanding of the Operating System concepts and internals with focus on Linux OS.

Course Description

- **Introduction**
  Basic Operating System Concepts, Linux as OS for System , Comparison of OSes, Tools and Development, Discussion on Embedded OS Applications and Products.
- **System architecture of a Basic OS**
  Internals of Linux OS, System Calls, Linux Compiler options, Process, Multithreading and Synchronization, Serial port and Network programming, Kernel module programming and Device drivers
- **Inter Process Communication**
  Pipe and FIFOs, Shared memory, Sockets
- **Practical Sessions**
  Programming with Linux Processes, Threads and IPC mechanisms

Learning Outcomes

After successful completion of the module, the students shall be able to:

- Understand Internals of Linux OS
- Develop applications with Linux OS

Reading List

1. GNU/LINUX Application Programming, Jones, M Tims
2. Embedded Linux: Hardware, Software, and Interfacing, Hollabaugh, Craig,
3. Building Embedded Linux Systems: Yaghmour, Karim
4. Embedded Software Primer: Simon, David E.
5. Linux Kernel Internals: Beck, Michael At Al
6. UNIX Network Programming : Steven, Richard
7. Linux: The Complete Reference: Petersen, Richard
8. Linux Device Drivers: Rubini, Alessandro, Corbet, Jonathan
9. Linux Kernel Programming: Algorithms and Structures of version 2.4: Beck, Michael At Al

10. Linux Kernel Development: Love, Robert
11. Operating System Concepts, Peter B. Galvin, Abraham Silberschatz, Gerg Gagne, Wiley Publishers

ED 504: Embedded RTOS

Module Duration: 70 Hours

Objective

The objectives of the course is to provide the students with an understanding of the aspects of the Real-time systems and Real-time Operating Systems and to provide an understanding of the techniques essential to the design and implementation of real-time embedded systems. This course covers the freeRTOS which is widely used RTOS embedded system development with for microcontrollers.

- **Introduction**
  Embedded Software – Real-time Vs Non Real-time
  Introduction to Real-time systems and Embedded Real-time Systems
  Comparison of Embedded RTOSs
  Design Goals for Real-time software
  Discussion on Embedded Real-time applications
  Considerations for real-time programming

- **System architecture of freeRTOS**
  Introduction to Free RTOS
  Task Management in Free RTOS
  Synchronization in FreeRTOS
  Inter Task Communication Mechanisms

- **Practical Sessions**
  Application Development with freeRTOS
  Working with Visual studio/Eclipse IDE

Learning Outcomes

After successful completion of the module, the students shall be able to:

- Develop an Embedded Real Time software that is required to run embedded systems
- Develop real-time applications using free RTOS
- Develop real-time applications using free RTOS
- Port free RTOS applications on ARM
- Build real-time embedded systems using freeRTOS

Reading List

1. Embedded Systems Architecture Programming and Design: Raj Kamal, Tata McGraw Hill

2. Embedded/Real Time Systems Concepts, Design and Programming Black Book, Prasad, KVK
3. Software Design for Real-Time Systems: Cooling, J E Proceedings of 17the IEEE Real-Time Systems Symposium December 4-6, 1996 Washington, DC: IEEE Computer Society
4. Real-time Systems – Jane Liu, PH 2000
5. freeRTOS Users Guide
6. Real-Time Systems Design and Analysis : An Engineer's Handbook: Laplante, Phillip A
7. Structured Development for Real - Time Systems V3 : Implementation Modeling Techniques: Ward, Paul T & Mellor, Stephen J
8. Monitoring and Debugging of Distributed Real-Time Systems: TSAI, Jeffrey J P & Yang, J H
9. Embedded Software Primer: Simon, David E.

ED 505: Cyber Physical Systems & IoT

Module Duration: 70 Hours

Objective

The objective of the course is to provide the students with understanding of Cyber Physical Systems and Internet of Things (IoT). All IoT devices are Cyber Physical Systems, but CPSs are not necessarily connected to the Internet and thus, not necessarily IoT devices. This module focuses on Overview of Cyber Physical Systems and details more on IoT.

Course Description

Cyber-Physical Systems

- CPS Overview
- Basics of Robotics and control systems

Internet of Things

- IoT Overview
- Sensors & Actuators
- IoT Architecture
- IoT Node
- Connectivity Solutions
- IoT Gateway and IoT EDGE computing
- IoT Cloud
- IoT Protocols

Learning Outcomes

After successful completion of this module, students should be able to:

- Understand and apply the concepts of CPS and IoT to develop applications
- Implement IoT applications using proper hardware and software platforms
- Develop IoT Applications with open source platforms

Reading List

1. 6LoWPAN: The Wireless Embedded Internet, Zach Shelby, Carsten Bormann, Wiley
2. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Dr. OvidiuVermesan, Dr. Peter Friess, River Publishers
3. Interconnecting Smart Objects with IP: The Next Internet, Jean-Philippe Vasseur, Adam Dunkels, Morgan Kuffmann
4. The Internet of Things: From RFID to the Next-Generation Pervasive Networked Lu Yan, Yan Zhang, Laurence T. Yang, HuanshengNing
5. Internet of Things (A Hands-on-Approach), Vijay Madisetti , ArshdeepBahga
6. Designing the Internet of Things , Adrian McEwen (Author), Hakim Cassimally
7. Asoke K Talukder and Roopa R Yavagal, "Mobile Computing," Tata McGraw Hill, 2010.
8. Computer Networks; By:Tanenbaum, Andrew S; Pearson Education Pte. Ltd., Delhi, 4th Edition
9. Data and Computer Communications; By:Stallings, William; Pearson Education Pte. Ltd., Delhi, 6th Edition
10. F. Adelstein and S.K.S. Gupta, "Fundamentals of Mobile and Pervasive Computing," McGraw Hill, 2009.

VE 506: OS Porting on FPGA with ARM Core

Module Duration: 35 Hours

Objective

The objective of the course is to provide understanding of the techniques essential to port Operating System on FPGA with ARM Core.

Course Description

- ARM IP core Porting on FPGA
- Linux Porting
  - Linux booting procedures
  - Linux Kernel compilation
  - Boot loader for Embedded Systems
  - Debuggers

- Techniques of Linux OS Porting on FPGA with ARM Core

- **Practical Sessions**
  Porting Linux OS on FPGA with ARM Core

Learning Outcomes
After successful completion of the module, the students shall be able to:
- ARM IP core Porting on FPGA
- Port the Linux OS on FPGA with ARM Core

Reading List
1. GNU/LINUX Application Programming, Jones, M Tims
2. Embedded Linux: Hardware, Software, and Interfacing, Hollabaugh, Craig,
3. Building Embedded Linux Systems: Yaghmour, Karim
4. Embedded/Real-Time Systems: Concepts, Design and Programming: The Ultimate Reference, Dr. K.V.K.K. Prasad, Published by Wiley DreamTech, 2003
5. ARM System Developer's Guide - Designing and Optimizing System Software by: Andrew N Sloss, Dominic Symes, Chris Wright; 2004, Elseiver.
6. FPGA-Based System Design by Wayne Wolf
7. Advanced FPGA Design Architecture, Implementation and optimization by Kilts
8. Xilinx® User guides & documentation available at https://www.xilinx.com/support/documentation-navigation/overview.html

VE 507: Industrial Product Design

Module Duration: 70 Hours

Objective

The objective of this module is to help fresh graduates and practicing engineers to enhance their knowledge and skills of industrial product design covering the various aspects of product development process and design of an Industrial Electronics Product.

Course Description

Product Development Process
- Electronic Hardware Design Flow
- Hardware and software integration issues and testing
- Hardware and software co-verification
- Component cost and costing in product design

Embedded Hardware design
- Understanding component datasheet
- Selection of passive components
- Interfacing of sensors with microcontrollers

- Power supply requirements for Electronic circuits.

Printed Circuit Board Design

- Evolution and Classification of Printed Circuit Boards
- PCB fabrication methodologies design considerations
- Design rules for analog, digital and power applications,
- EMI/EMC, crosstalk, reflection
- Basics if IPC standards
- Thermal management of electronic devices and systems.

Semiconductor Packages

- SMD packages, Single chip packages or modules (SCM)
- Commonly used packages and advanced packages
- Materials in packages, Current trends in Packaging

Industrial Design

- Enclosure designing aspects
- IP ratings overview
- Product standards.

Learning Outcomes

After successful completion of the module, the students shall be able

- Understand the design and development process of an Industrial Electronics Product
- Apply product development process for realization of the product

Reading List

1. Product Design & Development - Karl T Ulrich & Steven D. Eppinger; Mc Graw Hill
2. Relevant Data sheets and application notes

VE 508: Project Work

Module Duration: 280 Hours

Description

The students can select hardware, software or system level projects. The project can be implemented using Microcontrollers, Open Source Hardware Platforms and Embedded/Real Time Operating Systems which students have studied and used during the course.