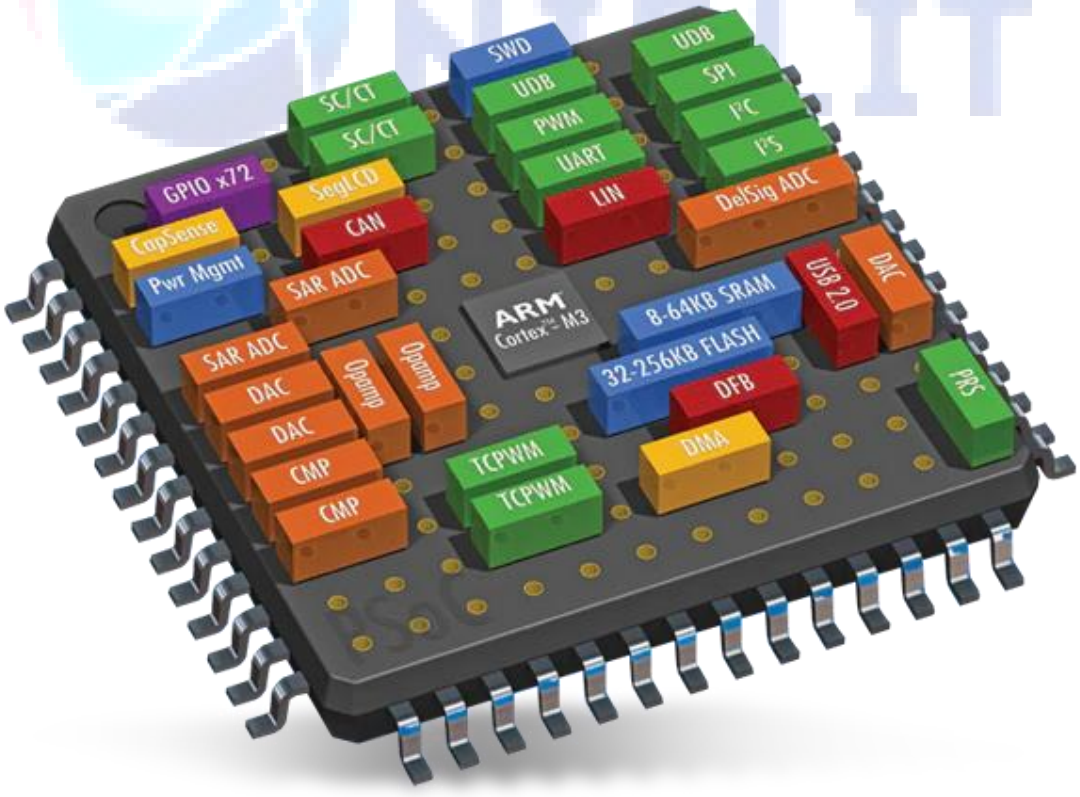
नेशनल इंस्टीट्यूट ऑफ इलेक्ट्रॉनिक्स एंड इंफॉर्मेशन टेक्नोलॉजी, चेन्नई
National Institute of Electronics and Information Technology, Chennai
Autonomous Scientific Society of Ministry of Electronics & Information Technology (MeitY), Govt. of India
ISTE Complex, 25, Gandhi Mandapam Road, Chennai - 600025

Course Prospectus

PG Program in Embedded and SoC Design

Mode: Online



Index

Course Prospectus

Course Name: PG Program in Embedded and SoC Design (Online Mode)

Course Code: ES 600

Duration: 840 Hours, 6 Months

Last Date of Registration: 01-09-2022

Date of publishing Provisional Selection List: 02-09-2022

Payment of first instalment fee: 02-09-2022 to 04-09-2022

Course Start Date: 05-09-2022

Fee Details:

Registration Fee- Rs. 1,000 /- (Adjusted with Total Fee)

Total Fee - Rs. 35,000 /-

Preamble:

The emergence of India as a global economy has opened up a huge demand for electronic products. National Policy on Electronics and Make in India initiative of the Government of India has resulted in the setting up of many industries in the Electronics sector and has led to a huge demand for trained manpower in the Embedded and VLSI. With the development of semiconductor process technology, more and more transistors are integrated into a single chip. As consequence, Integrated Circuits (ICs) can now host more functionality on one chip, leading us to the System-on-Chip (SoC) era.

Today SoC is prevalent in all kinds of electronics systems. From embedded systems to cloud computers, SoCs are being used in various configurations for versatile types of tasks. The growing class of complex applications such as machine learning and image processing makes it difficult for engineers to close the increasingly severe productivity gap that arises from the integration of hardware and software. The complexity challenge can only be tackled by well-trained engineers with good understanding of the requirements and challenges at all levels of the design process. Hence, there need an advanced training program that promote the integration of hardware and software as a single discipline. This course focuses on the architecture and programming of embedded processors and its implementation on the target FPGA platform.

Objective of the Course:

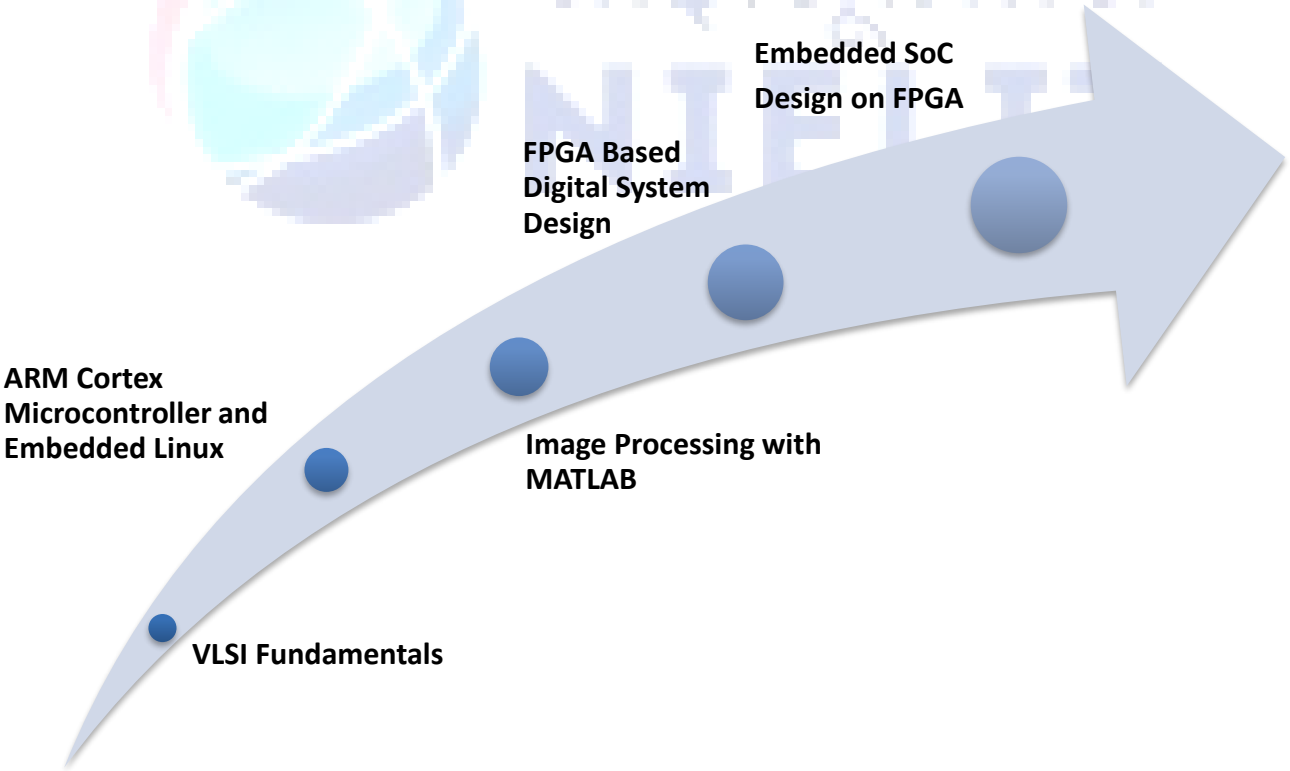
To develop the skill set required for the Design and Development the Embedded System Applications using suitable Hardware and Software tools and its implementation on the target FPGA platform. The qualifiers will acquire hands-on experience in embedded system design, state-of-the-art design methodologies and platforms. The program is an immediate relevance to industry and makes the participants exactly suitable for Embedded and VLSI Industry

Outcome of the Course:

After successful completion of this Course, students will be able to:

- Develop Embedded Application using ARM Cortex Microcontroller with Embedded- C Programming.
- Implement the Image Processing algorithms using MATLAB
- Design and Develop IPs for VLSI using Verilog HDL and prototype them on FPGAs
- Create their own IP and SoC design for FPGA implementation
- Develop their own software application with Zynq APSoC

Full Flow of Course



Course Structure

This course contains totally Nine modules. After completing the first Eight modules, the students have to do a six weeks project using any of the topics studied to earn the PG Program in Embedded and SoC Design certificate.

Module Code	Module Name	Duration(in Hours)
ES 601	VLSI Fundamentals	70
ES 602	Embedded C and ARM Cortex Microcontroller	140
ES 603	Embedded Linux	70
ES 604	Image Processing with MATLAB	70
ES 605	Verilog HDL: Language and Coding for Synthesis	70
ES 606	FPGA-Based Digital System Design Module	70
ES 607	Embedded SoC Design on FPGA	70
ES 608	IoT Basics	70
ES 609	Project Work	210
	Total Duration	**840**

Course Fees

Course fee is Rs. 35,000/- Including GST. (Can be paid as a single instalment of Rs. 35,000/- or in 2 instalments as given below)

Registration Fee	Rs. 1000/- for SC-ST (Adjustable with total fee)	Rs. 1000/- for others (Adjustable with total fee)	
Instalment No.	SC-ST Candidates (Fee including GST in Rs.)	General Candidates (Fee including GST in Rs.)	Last Date
1	17,000.00	17,000.00	04-09-2022
2	17,000.00	17,000.00	21-11-2022
Total	35,000.00	35,000.00	

**GST is Applicable as per Govt. Norms GST (currently it is 18%).*

Registration Fee.

(**Non-Refundable if candidate is selected for admission but did not join and if a candidate has applied but not eligible.)**

SC/ST: Rs. 1,000/- (Adjustable with Total fee for candidates).

Others: Rs. 1,000/- (Adjustable with Total fee for candidates)

However, the above registration fee shall be refunded on few special cases as given below

- ✓ Candidates are eligible but not selected for admission.
- ✓ Course postponed and new date is not convenient for the student.
- ✓ Course cancelled.

Eligibility

- ✓ B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control /Biomedical /Computer Science/Information Technology /M.Sc. (Electronics)/AMIE in Electronics/ Electronics & Communication.

Number of Seats: 30 – Total

Category	No. of Seats
SC (15%)	4
ST (7.5%)	2
GENERAL	24
Total	**30**

Note: Seats are allocated based on the merit of the Qualification.

How to Apply?

Candidates can apply online in our website http://reg.nielitchennai.edu.in. Payment towards non-refundable registration fee can be paid through any of the following modes:

- ✓ Online transaction: Account Name: NIELIT CHENNAI, Account No: 31185720641, Bank name: State Bank of India (SBI), Branch: Kottur (Chennai), IFSC Code: SBIN0001669.
- ✓ Pay through UPI Mobile Apps

Note: *The Institute will not be responsible for any mistakes done by either the bank concerned or by the depositor while remitting the amount into our account*

Last date of Registration: 01-09-2022

Registration Procedure

All interested candidates are required to fill the Registration form online with registration fees before **01-09-2022** with all the necessary information.

Selection Criteria of candidates

The selection to the course shall be based on the following criteria:

Selection of candidates will be based on their marks in the qualifying examination subject to eligibility and availability of seats.

- ✓ The first list of Provisionally Selected Candidates will be published on NIELIT Chennai website (www.nielit.gov.in/chennai) **02-09-2022** by **5:00 PM**. In case of vacancy, an additional selection list will be prepared and the selection will be intimated by email only.
- ✓ Provisionally selected candidate has to upload their document on registration portal for online verification.

  - Original Copies of Proof of Age, Qualifying Degree (Consolidated Mark sheet & Degree Certificate/Course Completion Certificate), 10th and 12th mark sheet.
  - One passport size photograph.
  - Self-attested copy of Govt. issued photo ID card

- ✓ After document verification, selected candidates have to pay first instalment of **Rs. 17,000/-** or as applicable on or before **04-09-2022** by payment mode mentioned above. Selected candidates are requested to upload the proof of remittance of fee on registration portal and also send the proof of remittance of fee as email to ishant[at]nielit[dot]gov[dot]in / trng[dot]chennai[at]nielit[dot]gov[dot]in.

Admission:

All provisionally selected candidates whose documents are verified and paid the fees (full or first instalment) and verified by accounts section of NIELIT Chennai will get a welcome message in his/her login ID provided during registration. The Credential and URL for online portal will be shared through WhatsApp or email.

Discontinuing the course

- ✓ No fees (including the security deposit) under any circumstances, shall be refunded in the event of a student who have completed the process of admission or discontinuing the course in between. No certificate shall be issued for the classes attended. Only Grade Sheet will be issued.
- ✓ If candidates are not uploading consecutive 3 assignments within assigned time their candidature will be cancelled without any notice and all fees paid will be forfeited.

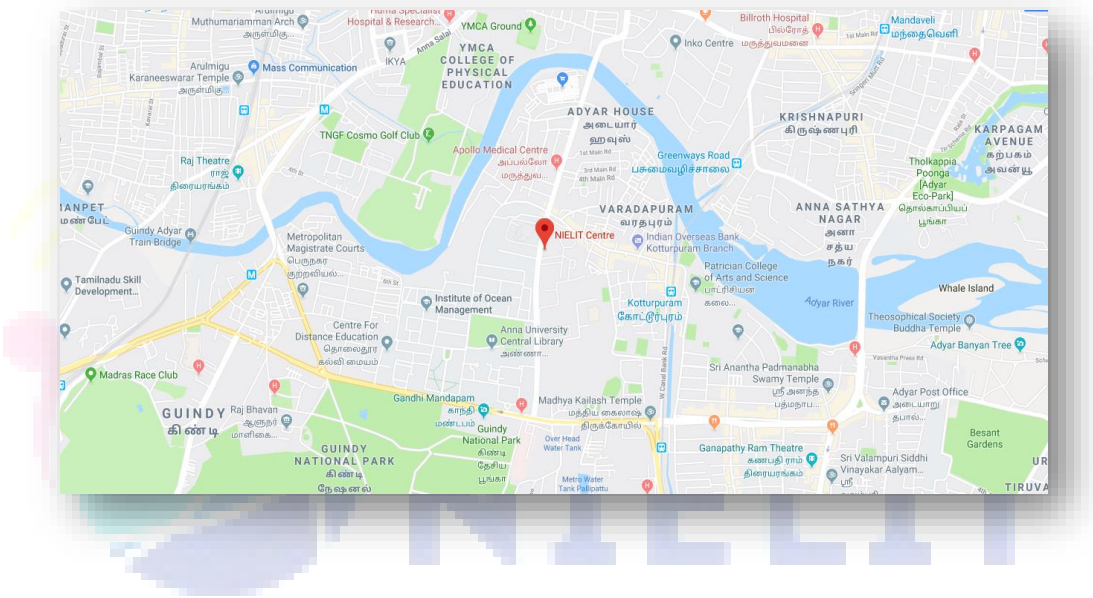
- ✓ If candidates are not appearing for any internal examinations/practical their candidature will be cancelled without any notice and all fees paid will be forfeited

Course Timings:

This program is a practical oriented one and hence there shall be more lab than theory classes. The cloud based online theory classes will be on forenoon and lab session will be conducted mostly on afternoon time.

Location:

NIELIT Chennai is located at Gandhi Mandapam Road, Kotturpuram, Chennai (Landmark: Opp.To Anna Centenary Library).



Address:

National institute of Electronics and Information Technology

ISTE Complex, No. 25, Gandhi Mandapam Road, Chennai – 600025

E-mail: ishant[at]nielit[dot]gov[dot]in/ Phone: 044-24421445

Contact Person: Mr. Ishant Kumar Bajpai Mobile: 99580 16673 (Call @ 9 AM to 6 PM)

Course enquiries

Students can enquire about the various courses either on telephone or by personal contact between 9.15 A.M. to 5.15 P.M. (Lunch time 1.00 pm to 1.30 pm) Monday to Friday.

Placement:

Students who have completed the course successfully and qualified, will be given placement guidance and career counselling to crack the interviews.

Important Dates

Last Date of Registration: 01-09-2022

Date of publishing Provisional Selection List: 02-09-2022

Payment of first instalment fee: 02-09-2022 to 04-09-2022

Course Start Date: 05-09-2022

Payment of second instalment fee: 21-11-2022

Examination & Certification

- ✓ Final Certificates will be issued after successful completion of all the modules including mini project. For getting certificate a candidate has to pass each module individually with minimum required marks of 50%.

Examination Scheme

Examination scheme for each module is as follows:

Module Name	Total Marks	Written	Practical / Assignment
VLSI Fundamentals	**100**	25	75
Embedded C and ARM Cortex Microcontroller	**100**	25	75
Embedded Linux	**100**	20	80
Image Processing with MATLAB	**100**	25	75
Verilog HDL: Language and Coding for Synthesis	**100**	20	80
FPGA-Based Digital System Design Module	**100**	25	75
Embedded SoC Design on FPGA	**100**	25	75
IoT Basics	**100**	25	80
Project Work	**100**	NA	100
Total	**900**	**190**	**710**

Grading Scheme

- ✓ Following Grading Scheme (on the basis of total marks) will be followed:

Grade	S	A	B	C	D	Fail

Marks Range (in %)	85 to 100	75 to 84	65 to 74	55 to 64	50 to 54	Below 50

- ✓ Final Grading as per above grading scheme will be given on the basis of total marks obtained in all modules. For last module (ES 609) grade will be given on the basis of project demonstration.

Lab Infrastructure Details:

Hardware Facilities:

- ✓ Development Boards - STM32, ARM Cortex-M4
- ✓ Sensors–PIR, Ultrasonic, Soil Moisture, Accelerometer & Gyro meter
- ✓ FPGA- Xilinx Kintex-KC705 Evaluation Kit, Xilinx Virtex - VC 707 Evaluation Kit, ZedBoard-Zyng-7000 Development Board
- ✓ DSP Evaluation Board – TI-EVK2H with Arm Cortex-A15 processor

Software Facilities:

- ✓ OpenSTM, CubeMX
- ✓ Xilinx Vivado
- ✓ Xilinx Vitis
- ✓ Matlab

Director, NIELIT Chennai

Dr. Pratap Kumar S

Director

Dr. Pratap Kumar S, is B.Tech (Electrical Engineering), M.Tech (Digital Electronics), MBA (Marketing) and PhD (Strategic Management). He has More than 29 years' experience in planning and execution of industrial consultancy projects, and capacity building projects funded by both industry and central & state ministries. Executed 7 major industrial consultancy projects and associated with the development of more than 50 product technologies, empowered more than 10,000 candidates through various capacity building programs and facilitated more than 40,000 job seekers through various job fairs and outreach programs. He has expertise in Strategy, Product Development, Automotive Electronics, Embedded Systems, and Power Electronics.

Faculty Profile:

Shoukath Cherukat

Scientist 'E'

Shoukath Cherukat, Scientist 'E', NIELIT Chennai has more than 21 years of Experience in Teaching and Consultancy Projects. He has successfully completed Consultancy Activities such as Collimator Test JIG for OEN, Technology Development of Wireless Token Display System for Keltron, Integrated Microcontroller Development Systems for 8051 & 80C196 Microcontrollers (IMDS-51, IMDS-196 & IMDS-196D) supplied to various industries. He is having wide hands-on experience in Embedded Controllers (8, 16 & 32-bit), Digital Signal Processors, FPGAs, IoT, Embedded OS and Real Time Operating Systems (RTOS).

Ishant Kumar Bajpai

Scientist 'C'

Ishant Kumar Bajpai, Scientist 'C', NIELIT Chennai Has more than 8 years' experience in Coordination and Implementation of funded projects in the area of IoT and VLSI with the application in Biomedical & Automotive. He has successfully executed 1 funded capacity building project in Karnataka & Kerala State and involved in the implementation of 4 skill development /capacity building projects funded by MeitY in the states of Tamil Nadu, Andhra Pradesh and Telangana. Before joining the NIELIT, he was working as a Scientific Officer in the IT Research Academy Division of Digital India Corporation (erst. Media Lab Asia), where he was involved in the Project Planning, Design and Implementation of projects in the domain of Mobile Computing, Networking & Applications.

S. Raghavendra

Resource Person-RPA

Raghavendran. S, Resource Person RPA having 3 years of experience in Robotics and automation and handing training session and Labs on UiPath studio with the background of electronics and instrumentation.

Balakumar V

Resource Person-PA

Balakumar , Resource Person-PA having 2 years of experience in handing training sessions and Labs on Electronic systems, Image Processing with the background of Deep Learning and its implementation on FPGA .

Annexure

Detailed Syllabus of the Course

ES 601: VLSI Fundamentals

Objective:

The objective of the module is to provide a detailed review of VLSI fundamentals for a thorough understanding of the concepts and techniques for analog and digital system design.

Outcomes:

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

- Design and analyze analog as well as digital systems

Duration: 70 Hours

Course Description

Analog Concepts

- Introduction to VLSI
- MOS Circuit Model, Biasing of Circuits
- Amplifiers, MOS Amplifiers
- Frequency Response of Amplifier
- Differential Amplifier
- Feedback Theory
- OPAMP Circuits

Digital Concept

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

ES 602: Embedded C and ARM Cortex Microcontrollers Module

Objective:

The objective of the module is to set the required background in embedded system concepts, Embedded 'C' language such as Memory Management, Pointers, Data structures, and architecture of the ARM Cortex processor for highly deterministic real-time applications.

Outcomes

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

- Develop embedded application using Embedded C Programming
- Choose right ARM Cortex controller with Embedded C Programming for various Applications

Duration: 140 Hours

Course Description

'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
- Pre-processor directives
- File operations
- Bitwise operations
- Typecasting

Embedded Concepts

- Introduction to embedded systemApplication Areas
- Categories of embedded systems
- Overview of embedded system architecture
- Specialties of embedded systems
- Recent trends in embedded systems
- Architecture of embedded systems
- Hardware architecture
- Software architecture
- Application Software
- Communication Software

- Development and debugging Tools

Introduction to ARM Cortex

- Architecture Introduction to 32-bit Processors
- The ARM Architecture
- Overview of ARM
- Overview of Cortex Architecture
- Cortex M4 Register Set and Modes
- Cortex M4 Processor Core
- Data Path and Instruction Decoding
- ARM Cortex M4 Development Environment
- Assembler and Compiler
- Linkers and Debuggers
- ARM-Thumb & Thumb2 instructions
- Mixing ARM & Thumb Instructions
- Memory hierarchy
- Memory Mapping
- Cache

Cortex M4 Microcontrollers & Peripherals

- Cortex M4 based controller architecture
- Memory mapping, Cortex M4 Peripherals – RCC
- GPIO
- Timer, System timer
- UARTs, LCD,ADC & PWM
- Cortex M4 interrupt handling – NVIC
- AMBA Bus
- Application development with Cortex M4 controllers using standard peripheral libraries

ES 603: Embedded Linux Module

Objective

The objective of the module is to skill the participants in configuration, deployment and debugging of the Linux OS on to a Target Board to build a complete Embedded Product.

Outcomes

After successful completion of this module, Students will be able to:

- Configure Linux environment for ARM based Target Boards.
- Configure Tool-Chain for ARM Platforms.
- Demonstrate Linux Booting Process and to configure Linux Kernels on ARM based Embedded Boards.

- Develop ARM based Embedded Applications with Linux OS.

Duration: 70 Hours

Course Description

Introduction

- Basic Operating System Concepts
- History& Benefits of Linux
- Fundamentals of Embedded Linux OS
- Comparison of Embedded OS
- Embedded OS Tools and IDE
- Embedded Linux Applications and Products.

Architecture of Embedded Linux

- What is Kernel?
- Task of kernels
- Types of kernels
- Kernel Architecture Overview
  - User Space
  - Kernel Space
- Kernel Functional Overview
  - File System
  - Process Management
  - Address Spaces and Privilege Levels
  - Memory Management
  - System Calls
  - Inter Process Communication (IPC) – Pipes, FIFo & Shared Memory
  - Device Drivers
  - Network

Commands in Linux

- Log In Linux system and Log in Remote Linux Systems- Getting Help
- Accessing & Working with the Command Line and Shell
- System Access, Entering Commands
- Boot Methods-Creating User Accounts &Managing Users
- Creating Groups & Managing Groups
- Directory Management
- File Permissions and Ownership
- vi Text Editor

Configuring the Linux Environment

- Linux environment

- Types of Hosts
- Types of Host/Target Development Setups
- Types of Host/Target Debug Setups
- Embedded Environment Tools
- GNU Tool-chain Cross Compilers

Tool-chain: Configuration and Cross-Compilation

- What is a tool-chain?
- Native vs. cross-compilation
- Toolchain Components
- Toolchain choices
- Using build root to build the toolchain
- Configuration options
- Adding path variables to startup scripts (.bashrc)
- The CROSS_COMPILE variable
- Validating the cross-compiler

Linux Bootloader & U-Boot

- Boot-loader Phases
- U-boot – Embedded boot loader
- What does u-boot do?
- Navigating the u-boot sources
- Configuring and Cross-compiling u-boot
- Installing u-boot on the target
- Understanding u-boot commands
- Changing environment variables to setup kernel booting
- Transferring files to the target using tftp

Embedded Linux Kernel:

- Kernel Features
- Kernel Subsystems
  - Memory Manager
  - Scheduler
  - Embedded Storage
  - I/O Subsystem
  - Network Subsystem
- Navigating the kernel sources
- Kernel Configuration
- Kernel Compilation
- Booting the kernel using u-boot
- Module compilation and Installation to RootFS
- Procedure for adding a new driver to the kernel
- Applying patches

Building Root File System:

- Introduction to File system

- Linux directory structure
  - Organization and Important directories
  - /dev file system
- What next after kernel booting
  - init and startup scripts
- Downloading & Compiling RootFS
- RootFS in Flash/SD Card Storage

Porting OS in ARM Board:

- Kernel Compilation
- Booting the kernel using u-boot
- Porting Linux in ARM Board

Embedded Linux Application Programming

- Application Developments using Input Devices
- Application Developments using Output Devices
- Application Developments using Peripherals

ES 604: Image Processing with MATLAB

Objective

The objective of the module is to provide a thorough understanding of and hands-on with geometric Transformation of Imaging using MATLAB

Outcomes

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

- Understand the geometric Transformation of Image
- Iimplement the Image Processing application using MATLAB

Duration: 70 Hours

Course Description

- Introduction to Image Processing
- Notion of pixel, resolution, quantization, photon noise, Geometric transformations,
- source-to-target and target-to-source mapping, planar and rotational homography,
- Image registration and change detection,
- Motion Blur and Image Formation
- Image Transform
- Image Enhancement, Restoration, and Edge Detection Design Verification using Test benches
- Typical image processing application implementation using MATLAB

ES 605: Verilog HDL: Language and Coding for Synthesis

Objective

The objective of the module is to provide a thorough understanding of and hands-on with digital design & Verification using Verilog HDL

Outcomes

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

- Design IPs for VLSI using Verilog HDL
- Develop Test benches using Verilog HDL

Duration: 70 Hours

Course Description

- Introduction to Verilog HDL & Hierarchical Modeling Concepts
- Lexical Conventions & Data Types
- System Tasks & Compiler Directives
- Modules, Ports, and Module Instantiation Methods
- Gate Level Modeling
- Dataflow Modeling
- Behavioral Modeling
- RTL Design and Logic Synthesis and Synthesis issues
- Design Verification using Test benches
- Mini-project and Case Studies

ES 606: FPGA Based Digital System Design Module

Objective

The objective of the module is to provide a thorough understanding about and hands-on practice with FPGA based digital system design and emulation

Outcomes

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

- Prototype digital Systems using FPGA
- Emulate, debug & Characterize reusable IPs

Duration: 70 Hours

Course Description

- Introduction to Programmable Logic and FPGAs

- Architecture of popular Xilinx FPGAs
- FPGA Design Flow Xilinx Vivado®
- Advanced FPGA Design tips
- Logic Synthesis for FPGA
- Implementation Details and optimization techniques
- Static Timing Analysis
- Introduction to AXI4/Avalon Interfaces
- Design problems using Xilinx® Platforms
- Case Studies on FPGA-Based implementations

ES 607: Embedded SoC Design on FPGA

Objective

The objective of this module is to enable the participant to optimize throughput and adapt processors to meet the specific needs of different Image processing/ML architectures by the effective implementation on FPGAs.

Outcomes

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

- Create their own IP and SoC design for FPGA implementation
- Perform in-system Hardware-debugging of the post-implemented design
- Develop their own software application with Zynq APSoC

Duration: 70 Hours

Course Description

VLSI implementation architectures for Image Processing/ML

- Multi-core, many-core, and hardware accelerators
- Hardware acceleration of Image Processing Algorithms
- Design steps- Software Design Flow, Platform Project Creation, Application Project Creation, and Debugging using Xilinx Vitis
- Case Studies: Realization of Image Processing algorithms on FPGA

Metrics for Analysis and Comparison of Architectures

- Hardware performance matrices-Processing time and a maximum frequency of operation, memory footprint, etc.
- Performance comparison with DSPs and Multi-core SoCs.

ES 608: IoT Basics

Objective

The objective of this module is to familiarize the students with IoT Technology and application development in IoT. .

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

Duration: 70 Hours

Course Description

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

ES 609: Project Work Module

Duration: 210 Hours

Description

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

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