17ES008 EMBEDDED SYSTEM DESIGN WITH FPGA

Hours Per Week :

L	T	P	C
3	1	-	4

Total Hours :

L	T	P	WA/RA	SSH/HSH	CS	SA	S	BS
45	15	-	15	30	-	5	5	-

Course Objectives:

The basic objective of this course is to understand how a FPGA and the Hardware Description Language (HDL) can be used in the design of embedded digital systems. Simulation and synthesis of HDL code of digital logic using HDL, for a given FPGA device and processor-based FPGA devices.

Course Outcomes:

The student will be able to:

- Understand the fundamentals of embedded systems from both hardware and software perspective,
- Understand how to design digital circuits with VHDL.
- Understand how to design complex state machines in VHDL and also verify the designs using Modelsim simulator.
- Prototype digital design on an FPGA.
- Understand logic simulation and synthesis for FPGA.
- Understand basic aspects of embedded processors (ARM) and Bus Interfaces.

SKILLS:

- Basic digital circuits in HDL using data flow, behavioral and structural modeling styles
- Embedded cores in modern FPGAs.
- Input/output interfacing principles, bus architectures and standard interfaces.

UNIT – I

Introduction : Introduction to Embedded System Overview, Hypothetical Robot Control System, Digital Design Platforms - Microprocessor-based Design, Single-chip Computer/Microcontroller-based Design, Application Specific Standard Products (ASSPs), Design Using FPGA; Hardware Description Language: Verilog Software and Hardware Description Languages, Let's Use Verilog as Our HDL, Design Examples Using Verilog - Gate Level Model, Combinational Circuits Using Data Flow Modelling, Behavioural Logic, Finite State Machine (FSM), Arithmetic Using HDL, Pipelining, Module Instantiation and Port Mapping, Use of Pre-designed HDL Codes, Simulating Digital Logic Using Verilog - EDA Tool Flow for Simulation, Creating a Test Bench for HDL-based Digital Logic, Post Place and Route Simulation, Simulation of Algorithm Using Pre-designed Codes.

UNIT – II

FPGA Devices : FPGA and CPLD, Architecture of a FPGA - FPGA Interconnect Technology, Logic Cell, FPGA Memory, Clock Distribution and Scaling, I/O Standards, Multipliers, Floor Plan and Routing, Timing Model for a FPGA, FPGA Power Usage.

FPGA-based Embedded Processor : Hardware–Software Task Partitioning, FPGA Fabric Immersed Processors, Soft Processors, Hard Processors, Tool Flow for Hardware–Software Co-design, Interfacing Memory to the Processor, Interfacing Processor with Peripherals, Types of On-chip Interfaces, Wishbone Interface, Avalon Switch Matrix, OPB Bus Interface, Design Re-use Using On-chip Bus Interface, Creating a Customized Microcontroller, Robot Axis Position Control.

UNIT – III

FPGA-BASED SIGNAL INTERFACING AND CONDITIONING : Serial Data Communication, Physical Layer for Serial Communication, RS-232-based Point-to-Point Communication, RS-485-based Multi-point Communication, Serial Peripheral Interface (SPI), Signal Conditioning with FPGAs.

UNIT – IV

Motor Control Using FPGA : Introduction to Motor Drives, Digital Block Diagram for Robot Axis Control, Position Loop, Speed Loop, Power Module, Case Studies for Motor Control - Stepper Motor Controller, Permanent Magnet DC Motor, Brushless DC Motor, Permanent Magnet Rotor (PMR) Synchronous Motor, Permanent Magnet Synchronous Motor (PMSM).

UNIT – V

Prototyping Using FPGA : Prototyping Using FPGAs, Test Environment for the Robot Controller, FPGA Design Test Methodology, UART for Software Testing, FPGA Hardware Testing Methodology.

TEXT BOOKS:

1. Rahul Dubay " Introduction to Embedded System Design Using Field Programmable Gate Arrays", , © 2009 Springer-Verlag London Limited

2. Frank Vahid & Tony Givargis, "Embedded System Design, A Unified Hardware/Software Introduction", ISBN 978-0-471-38678-0 2014

REFERENCE BOOKS:

1. VHDL and FPLDs, by Zoran Salcic, Kluwer,1998

2. Computers as Components, Principles of Embedded Computing System Design, by Wayne Wolf, Morgan Kauffman, 2001

3. A VHDL Primer, by Jayaram Bhasker. Prentice Hall, 1998

4. HDL Chip Design, by Douglas J. Smith, 1999

5. VHDL Analysis and Modeling of Digital Systems, by Z. Navabi, McGraw-Hill, 1993.

ACTIVITIES:

o Implementation of digital applications such as LED, LCD interface using Micro Blaze and Pico blaze processor.

o Design of a hypothetical industrial robot controllers for different industrial automation applications using FPGA and HDL