Approval: 14th Senate Meeting

Course Number : EE529
Course Name : Embedded Systems
Credits : 3-0-2-4.
Pre-requisite : IC161 - Applied Electronics, CS201 – Computer Organization or any course on microprocessors or Equivalent
Intended for : BTech Computer Science Engineering (CSE) and Electrical Engineering (EE), MS, M. Tech. & PhD.
Distribution : Elective for Third and Final year B. Tech (CSE/EE), MS, M. Tech. in VLSI/Signal Processing and Communication/Power Electronics and Drives & PhD
Semester : Even or Odd.

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1. Preamble:

The Embedded Systems course aim at building up an in depth understanding among the advanced B.Tech / M.Tech / M.S./ Ph.D students of embedded systems architecture, design space exploration and design optimization of embedded systems through a perfect synergy of class lectures and hands on assignments. The goal is to illustrate the concepts discussed in the classroom teaching and to give students an opportunity to build, feel and test real systems. Since the embedded systems of today are centered around a wide variety of embedded cores such as micro-controllers and FPGA, topics in lecture should focus around the system design issues with the different types of embedded cores. Finally, topics of recent interest such as hardware software co-design, Internet of Things give the student an idea of the state of the art technological practices in Embedded Systems.

2. Course Modules with Quantitative Lecture Hours:

1. **Introduction to embedded systems:** Understanding an embedded system, design metrics, design challenges, technologies for embedded systems. **(2 Lectures)**

2. **Custom Single Purpose Processor for Embedded Systems**: Design of data-paths and controllers, finite state machines, custom single purpose processor design at RT level, optimizing custom single purpose processors. **(3 Lectures)**

3. **Hardware Description Language:** Introduction to hardware description language, overview of structural, behavioral and dataflow modeling of digital systems using hardware description language, notion of finite state machines, delay modeling, memory modeling, synthesizable & non-synthesizable HDL codes for digital system design. **(3 Lectures)**

4. **Introduction to FPGA:** Introduction to complex digital systems design, notion of programmable logic devices, overview of FPGA architecture, realization of data-path and controller, timing analysis of data-path and controller, synthesis, placement, routing, performance optimization. **(3 Lectures)**

5. **FPGA based systems design:** Implementation of simple systems using FPGA exercising the timing closure paths. **(2 Lectures)**

6. **Physical design automation of embedded systems (from the perspective of custom single purpose processors for embedded systems):** Partitioning, floor-planning, placement, routing; clock design considerations, timing margins, clock skew, clock distribution networks. **(3 Lectures)**

7. **Dynamically reconfigurable Embedded Systems:** Static versus dynamic reconfiguration of embedded systems, full versus partial reconfiguration, voltage scaling and power management issues in dynamic reconfiguration. **(3 Lectures)**

8. **Introduction to Microcontrollers:** Introduction to microcontrollers, overview of architecture of a typical microcontroller such as AVR microcontroller, addressing, assembly language programming. **(4 Lectures)**

9. **Memory interfacing:** Memory technologies – SRAM, DRAM and ROM, different types of DRAM architectures – 2D RAM, FPMDRAM, EDODRAM, SDRAM, RDRAM, DDRRAM, DDR2RAM, etc, different types of ROM- PROM, EPROM, EEPROM, memory interfacing circuits, single cycle versus multiple cycle interfacing, timing diagrams, etc. **(3 Lectures)**

10. **Interfacing with I/O devices:** Port and bus based I/O, Memory mapped and I/O mapped I/O, register and tristate buffer based I/O interfacing, arbitration methods – priority, daisy chain and network oriented arbitration methods, serial protocols – SPI and I2C. **(4 Lectures)**

11. **Timers and Counters:** Timer/counter programming, notion of watch dog timers and real time clocks. **(2 Lectures)**

12. **Interrupt processing:** Introduction to interrupts, external versus internal interrupts, software versus hardware interrupts, synchronous versus asynchronous interrupts, single interrupt versus multiple interrupt systems, prioritization of interrupts, inversion of interrupt priorities, inheritance of interrupt priorities and associated protocols.**(4 Lectures)**

13. **Real world interfacing of microcontrollers:** Interfacing with simple devices such as LCD, keyboard, motor control, sensors, LED 7 segment display, DTMF decoder, etc. **(2 Lectures)**

14. **Hardware Software Codesign:** Notion of hardware software partitioning, graph based and pareto optimal approaches to hardware software partitioning, resource and timing constrained hardware software partitioning. **(3 Lectures)**

15. **Internet of Things (IoT):** Overview of Internet of Things, IoT architecture, Communication protocols, Notion of internet of everything. **(1 Lecture)**

Laboratory Experiments: Laboratory exercises based on timers and counters, interrupts, serial peripheral interface, inter-integrated circuit, hardware description language based hardware modeling of embedded cores, hybrid embedded processors, FPGA implementation of embedded processor architectures.

3. Text Books:

1. F. Vahid and T. Givargis, "Embedded Systems: A Unified Hardware Software Introduction", John Wiley and Sons, 2011.

4. References:

1. G. Nicholescu and P.J. Mosterman, "Model based design of Embedded Systems", CRC Press, 2009.
2. DhananjayGadre, "Programming and Customizing the AVR microcontroller", Tata McGraw Hill, 2014.
3. Wayne Wolf, "FPGA based Systems Design", Pearson Education, 2003.
4. Volnei A. Pedroni, "Circuit Design with VHDL", The MIT Press, 2004.
5. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation and Optimization", J. Wiley and Sons, 2007.
6. SeetharamanRamachandran, "Digital VLSI Systems Design", Springer Verlag, 2012.
7. Peter J. Ashenden, "The designer's guide top VHDL", Morgan Kaufmann, 2008.
8. Charles H. Roth Jr., "Digital Systems Design using VHDL", Cengage Learning, 2014.

5. Similarity Content Declaration with Existing Courses:

S.N.	Course Code	Similarity Content	Approx. % of Content
1.	EE208P	Hardware Description Languages, Introduction to FPGA, Introduction to Microcontrollers (Total 10L)	25%

6. Justification for new course proposal if cumulative similarity content is > 30%: N/A