EE - 3173
Hardware/Software Integration

Curricular Designation:  EE: elective  CpE: required

Catalog Description:
EE 3173 – Hardware/Software Integration: Covers the integration of hardware and software into a complete working system. Includes design and construction of I/O devices for microprocessor or microcontroller-based systems, communication and bus protocols, programming in assembler language and in "C", system integration and testing. Also covers the use of FPGAs and HDL design tools.

Credits: 4.0 Lec-Rec-Lab: (0-3-3) Semesters Offered: Fall Spring Pre-requisites: EE 2174 and EE 3131 and CS 3421 and (CS 1141 or CS 2141) and (MA 3710 or EE 3180).

Textbooks(s) and/or Other Required Materials:
2. John Carsoulis, Designing Embedded Hardware, 2nd Ed., O'Reilly, 2005 (required).
3. Relevant manuals for the hardware and software tools used in the course.
4. Specifications or other documents relevant to industry standards presented in the course.

Prerequisites by Topic:
1. Familiarity with programming using C, Verilog, and one assembly language.
2. Introduction to uniprocessor organization, including RISC, memory systems, and basic pipelining.
3. Familiarity with combinatorial and sequential logic designs, including laboratory practice with logic chip breadboarding, multimeters, oscilloscopes and signal generators.
4. Introduction to digital logic implementation technologies such as NMOS, CMOS, and TTL, and with electronic devices such as diodes, transistors, and op-amps.
5. Familiarity with basic statistical concepts, including: correlation & regression.

Course Objectives:
1. Familiarity and practice with System-On-a-Programmable Chip (SOPC) concepts and implementation in contemporary FPGA technology; including embedded processor cores, and selected industry standards for busses and I/O interfaces.
2. Familiarity and practice using a contemporary design tools suite for hardware and software design and integration in an SOPC environment.
3. Familiarity and practice interfacing an SOPC system with off-chip components.
4. Familiarity and practice programming a processor in both high level and assembly languages to monitor and control a real-world process, system, or device.
5. Familiarity and Practice designing experiments and analyzing the resultant data.
Topics Covered:
1. Microcontroller architectures, typical I/O devices & applications in embedded systems,
2. Principles & practice of I/O and communication including
   (a) Programmed I/O, DMA and I/O Processors (I/O channels),
   (b) Interrupt and Exception handling,
3. How to use the suite of design tools for a chosen SOPC system, including:
   (a) Coordinated hardware and software generation integration and debugging,
   (b) Empirical performance evaluation for both high level and assembly languages,
   (c) Analysis of experimental data, including correlation & regression.
4. Interfacing SOPC systems to external hardware, including I/O ports, D/A, and higher power devices in order monitor and control a real-world process, system, or device.
5. Generic internal bus and I/O signaling protocols, and selected industry standards, including:
   (a) At least one parallel system expansion bus (e.g. PCI),
   (b) Industry Standard serial I/O port protocols (e.g. SPI, I2C, UART, JTAG),
   (c) Industry Standard external comm. protocols (e.g. CAN, USB, PCIe, Bluetooth).

Relationship of the Course Content to Program Outcomes:

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<tr>
<th>Outcome</th>
<th>Topics and Level of Coverage</th>
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<tbody>
<tr>
<td>a an ability to apply knowledge of mathematics, science and engineering</td>
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<td>b an ability to design and conduct experiments, as well as to analyze and interpret data</td>
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<td>c the ability to design a system, component, or process to meet desired needs within realistic constraints such as...</td>
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<td>d an ability to function on multi-disciplinary teams</td>
<td>Important</td>
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<td>e an ability to identify, formulate and solve engineering problems</td>
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<td>f an understanding of professional and ethical responsibility</td>
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<td>g an ability to communicate effectively</td>
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<td>h the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context</td>
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<td>i recognition of the need for, and an ability to engage in life-long learning</td>
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<td>j a knowledge of contemporary issues</td>
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<td>k the ability to use the techniques, skills, and modern engineering tools necessary for the practice of computer engineering</td>
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Contribution of Course to Meeting Degree Requirements:
4 Credit Hours – Engineering Topics

Class/Laboratory Schedule (note: 1 hour = 50 minutes):
Lecture: 40 hours = 3 hours/week for 13.33 weeks
Lab: 36 hours = 3 hours/week for 12 weeks

Prepared by: Roger M. Kieckhafer, Associate Professor, December 8, 2016.