COURSE NUMBER: DP2110

COURSE TITLE: Digital Systems II (Interfacing)

COURSE DESCRIPTION:

This course provides the learner with knowledge of the hardware and software associated with digital systems and interfacing requirements for communication from a PC to external environments. Advanced FPGA technologies will be used to interface hardware devices. Interfacing using pneumatics will be used to expand the knowledge of interfacing from electronics to mechatronics.

PREREQUISITES: DP1110 – Digital Systems I - Logic
CT2300 – Applied Programming or
CP1270 – Programming Fundamentals

CO-REQUISITES: None

CREDIT VALUE: Five (5)

COURSE HOURS PER WEEK: Four (4)

LAB HOURS PER WEEK: Three (3)

SUGGESTED TEXT:

Kleitz, W. (2012). *Digital electronics: A practical approach with VHDL.* Prentice Hall. ISBN 13: 978-0-13-254303-3

LEARNING RESOURCES:

Instructor notes and internet resources

MAJOR TOPICS:

1.0 Logic Families
2.0 Advanced FPGA Design
3.0 Microprocessor Bus Structure
4.0 Memory Interfacing
5.0 Digital Input/Output
6.0 Sensor Interfacing
7.0 Analog to Digital
8.0 Digital to Analog

9.0 Data Communication Systems
10.0 Mechatronics

LEARNING OBJECTIVES:

The expected learning outcomes are that the learner will be able to:

1.0 Logic Families

- 1.1 Demonstrate an understanding of TTL characteristics
  - 1.1.1 Illustrate the internal diagram of a logic gate
  - 1.1.2 State the acceptable range of voltages produced by logic '0' or logic ‘1'
  - 1.1.3 Discuss logic levels as it relates to speed
  - 1.1.4 Describe and calculate fanout capability of logic gates
  - 1.1.5 Propagation Delays
    - 1.1.5.1 Describe propagation delays
    - 1.1.5.2 Explain how propagation delays affect digital circuit operations
    - 1.1.5.3 In a lab environment demonstrate using proto-board and computer simulated circuits

- 1.2 Demonstrate an understanding of Metal Oxide Semiconductor (MOS) characteristics
  - 1.2.1 Identify the CMOS digital gates from diagrams
  - 1.2.2 State the typical power requirements of CMOS gates
  - 1.2.3 State the acceptable range of voltages produced by logic '0' or logic '1'
  - 1.2.4 Compare the speed of CMOS with other logic devices
  - 1.2.5 State the maximum fan-out of a typical CMOS gate
  - 1.2.6 Identify the 74Cxx series of CMOS in diagrams

2.0 Advanced FPGA Design

- 2.1 Define system requirements
- 2.2 Describe FPGA architectures
- 2.3 Define I/O types
- 2.4 Explain reconfigurable I/O
- 2.5 Examine real-time FPGA configurations
- 2.6 Develop an FPGA programming model
- 2.7 Describe the characteristics of embedded FPGA devices
- 2.8 Construct FPGA circuits
  - 2.8.1 Design state machines
  - 2.8.2 Design decoding circuits
  - 2.8.3 Design data control circuits
  - 2.8.4 Design motor control circuits

3.0 Microprocessor Bus Structure

- 3.1 Demonstrate an understanding of Data Bus characteristics
  - 3.1.1 Describe the characteristics of the data bus
  - 3.1.2 Identify the information flowing on the data bus in diagrams

- 3.2 Demonstrate an understanding of Address Bus characteristics
  - 3.2.1 Describe the characteristics of the address bus
  - 3.2.2 Identify the information flowing on the address bus in diagrams
  - 3.2.3 Describe the relationship between bus size and memory size

- 3.3 Demonstrate an understanding of Control Bus Signals
  - 3.3.1 Identify the functions of the control lines in diagrams
  - 3.3.2 Describe the event sequence on the control bus as instructions are executed

4.0 Memory Interfacing

- 4.1 Explain semiconductor memory capacity
- 4.2 Illustrate semiconductor memory organization
- 4.3 Explain how access time in semiconductor memory can affect Central Processing Unit (CPU) operation
- 4.4 Demonstrate an understanding of the characteristics of memory types
  - 4.4.1 Describe the characteristics of memory types
  - 4.4.2 Describe the organization of the memory array
  - 4.4.3 Identify the relationship between memory size and address line

- 4.5 Use Chips in Programming
  - 4.5.1 Describe and illustrate how memory chips are programmed
  - 4.5.2 Design a memory circuit to expand the word length of the data being stored

- 4.6 Design an Interface to Memory
  - 4.6.1 Identify the control lines which indicate access to memory
  - 4.6.2 Describe the purpose of tri-state busses on the memory devices
  - 4.6.3 Design decoding circuitry to select a memory chip using comparator chips
  - 4.6.4 Design decoding circuitry to select a memory chip using decoder chips

- 4.7 Demonstrate an understanding of the fundamental aspects of RAM chips
  - 4.7.1 Describe the characteristics of RAM chips
  - 4.7.2 Identify the function of each pin on a RAM chip
  - 4.7.3 Explain the memory organization of RAM chips
  - 4.7.4 Describe the capacity of RAM chips
  - 4.7.5 Identify the need to refresh RAM
  - 4.7.6 Compare characteristics of various forms of RAM

5.0 Digital Input/Output

- 5.1 Describe programming considerations

5.1.1 Describe the use of a separate input/output (I/O) address space
5.1.2 Describe the use of separate I/O instructions
5.1.3 Describe the I/O map on a microcomputer system

5.2 Interfacing considerations
5.2.1 Identify the control lines which indicate access to I/O devices in diagrams
5.2.2 Design decode circuitry to select an I/O device at a given location
5.2.3 Create decoding circuitry to select an I/O device at a given location

5.3 Design Parallel I/O Interfaces
5.3.1 Design an interface for digital input using SSI latches
5.3.2 Design an interface for digital output using SSI flip-flops

5.4 Design Programmable Peripheral Interfaces (PPI)
5.4.1 Configure the PPI for proper operation
5.4.2 Access appropriate ports for I/O operations
5.4.3 Select appropriate operating modes for the PPI chip
5.4.4 Design an interface for a PPI

6.0 Sensor Interfacing

6.1 Discuss the various sensor characteristics
6.2 List and describe different sensor types
6.2.1 Voltage scaling
6.2.2 Impedance matching

6.3 Describe the theory of mechanical relays
6.4 Describe the theory of solid state relays
6.5 Interface a relay to a computer

7.0 Analog to Digital

7.1 Identify the limits of resolution for digital representation of analog data
7.2 Calculate the resolution given the dynamic range and the number of data bits
7.3 Describe the limits of accuracy when converting a digital signal to an analog signal
7.4 Explain the time required for a converted digital value to settle to an analog signal
7.5 Describe how analog signals are represented digitally
7.6 Describe the errors which are associated with analog to digital conversion
7.7 Describe the limits of resolution for digital representation of analog data
7.8 Calculate the resolution given the dynamic range and the number of data bits
7.9 Measure the accuracy of a digital signal converted to a digital value
7.10 Identify the time required to convert a digital signal to an analog signal
7.11 Describe the operation of a counter Analog to Digital Conversion (ADC)
7.12 Describe the operation and advantages of the Successive Approximation ADC
7.13 Describe the operation of the Integrator ADC

7.14 Describe the operation of the flash converter
7.15 Use industry software design to interface an ADC IC chip to a computer, in the lab environment

8.0 Digital to Analog

8.1 Describe the operation of the binary weighted Digital to Analog Converter (DAC)
8.2 Describe the operation of the R/2R Ladder
8.3 Use industry software design to interface a DAC IC chip to a computer in the lab environment

9.0 Data Communication Systems

9.1 Describe the asynchronous data format (start/data/stop bits)
9.2 Calculate the time required to transfer data at a given BAUD rate
9.3 Describe how errors are detected using a parity bit
9.4 Draw the signal transmitted for a given data protocol
9.5 Describe the USB data format
9.6 Analyze the time required to transfer data using USB
9.7 Describe the communication protocol for USB
9.8 Interface a USB device to a computer
9.9 Demonstrate the use of Network Devices in data delivery
9.10 Demonstrate the use of wireless technologies to interface peripheral devices

10.0 Mechatronics

10.1 Define mechatronics
10.2 Explain the mechatronic design approach
10.3 Describe sensors and actuators in mechatronic systems
10.4 Illustrate the relationship between electrical components and magnetics
10.5 Describe the various sensors in mechatronics
- 10.5.1 Linear and rotational sensors
- 10.5.2 Acceleration sensors
- 10.5.3 Force measurement
- 10.5.4 Flow measurement
- 10.5.5 Temperature measurements
- 10.5.6 Distance measuring and proximity sensors
- 10.5.7 Light detection, image, and vision systems

10.6 Demonstrate an understanding of electro-pneumatics in mechatronics
- 10.6.1 Identify the electro-pneumatic control chain
- 10.6.2 Design circuits using solenoid actuated valves in a lab
- 10.6.3 Illustrate how to convert electrical signals to pneumatic signals
- 10.6.4 Design electro-pneumatic memory circuits in a lab
- 10.6.5 Design electrical latch circuits in a lab
- 10.6.6 Design and construct relay and timer based logic in a lab

10.6.7 Describe safety issues in electro-pneumatics

10.7 Demonstrate a system design using a mechatronic system

EVALUATION:

Laboratories	15%
Assignments	5%
Quizzes	30%
Final Exam	50%

DATE DEVELOPED: March 2012 **DATE REVIEWED:**

REVISION NUMBER: **DATE REVISED:**

Note to instructor: Check PIRS to ensure this outline is the most current version.