Complex Engineering Problem

Design and Implement a complete Embedded System with firmware written in C language

Course Code and Title: EE-273: Microprocessor Systems
Semester: Fall 2022 (5th Semester - Session-2020)
Instructor: Mr. Umer Shahid & Ms. Shehzeen Malik
Total Marks: 30 (in Lab)
Deadline: Last week of Semester

CLOs and PLOs for Complex Engineering Problem

Please state CLOs and PLOs addressed in the complex engineering problem along with domain and level. These are the CLOs from the theory/lab course which are already defined.

CLOs		Description	Domains & Levels	PLOs, Levels
CLO1	Lab	Design and implement a project to master programming skills.	Psychomotor, 5	PLO11 High

Problem Statement

The purpose of this Complex Engineering problem is to analyze, specify, design, implement, document, and demonstrate a complete embedded system. A list of projects has been given to the students in Week-10 of the semester. Students will choose any one project as their CEP. The abstract requirement for each CEP is given below whereas the basic requirement is to interface at least three different peripherals as Input or Output of the design and write its firmware as bare-metal C program.

Complex Engineering Problem Attributes

WP1: Depth of knowledge WP2: Range of conflicting requirements WP3: Depth of analysis WP4: Familiarity of issues WP5: Extent of applicable codes WP6: Extent of stakeholders WP7: Interdependence	• **WP1: Depth of Knowledge** Requires knowledge of Digital Systems and Embedded Systems (WK4), design of closed loop system using digital sensors and output devices (WK5), use of Modern Tools (Keil uVision) to program and test the code on Microcontroller (WK6) and engagement in research literature (WK8) • **WP3: Depth of analysis** Numerous approaches can be adopted. Choice of the selected algorithm requires in-detail analysis • **WP5: Extent of applicable codes** Require going beyond the use of standardized convention of control systems.	
	Rubrics	
	Methodically investigates different design approaches and techniques to design an Embedded System. (CLO1)	**WP1, WP3**

	Selects an optimal methodology to design the firmware of the system (CLO1)	**WP3, WP5**
	Identifies limitations and implications of the proposed solution (CLO1)	**WP1**

EA1: Range of resources EA2: Level of interaction EA3: Innovation EA4: Consequences for society and environment EA5: Familiarity	• ***EA1: Range of resources*** The design involves internet resources, information related to software usage and technology. • ***EA3: Innovation*** Addressing sustainability and optimization of the design based on engineering principles and knowledge.	
	Rubrics	
	Methodically investigates different design approaches and techniques to design a closed loop system. (CLO1)	**EA1, EA3**
	Selects an optimal methodology to design the firmware of the system (CLO1)	**EA1, EA3**
	Identifies limitations and implications of the proposed solution (CLO1)	**EA1, EA3**

Grading Policy

The project consists of 2 phases which are discussed below.

No	Phase	Due Date
I	Progress Report	11th December, 2022
II	Final competition	Last week of Semester

Phase I

The deliverables include a brief report including:

a. a cover page (chosen project name and listed names and roll numbers of all of the members in the team with their respective sections)
b. Working of the project
c. Complete block diagram of the project based on your own understanding
d. List of equipment used, details of the equipment
e. Budget of the project
f. Circuit Diagram of hardware connectivity with TIVA (including exact name of components and their power ratings)
g. Tasks performed by each group member. (Be fair in this evaluation as you have made groups yourselves so we trust you completely in this aspect)

Phase II

There will be a departmental level exhibition during the last week of the semester. All groups will compete against each-other. Grading will be done based on the working of the project.

Partial deliverables for Phase 2 are:

1. Hardware assembled (PCBs should be used not breadboards)
2. Code
3. Working project

The project will consist of two phases (deliverables) including the final demonstration. Phase I of the project is worth 20% credit and phase II is worth 80% credit of the marks assigned to the final project.

Complex Engineering Problem Rubrics

	Good (8-10)	Average (4-7)	Bad (0-3)
Report (20% Marks)	Latex Used References properly added in IEEE Format All required sections.	Latex not used References properly added in IEEE Format Formatting is not properly done but all sections have been covered	If any section is missing.
Hardware Viva (20% Marks)	100% answer rate.	60-90% answer rate	0-50% answer rate
Software Viva (20% Marks)	100% Understanding.	60-90% Understanding	0-50% Understanding
Hardware Setup and Wiring (20% Marks)	Take care of voltage and current ratings, perfect hardware connection, clean wiring	Won't care of voltage and current rating Perfectly hardware connection Poor wiring	Wrong Hardware Circuit.
Hardware Working (20% Marks)	Perfectly/Minor issues in working with all constraints fulfilled	Working with not able to fulfill few constraints	Not Working/Working with not able to fulfill many constraints

Note: If you are unable to explain the working of your project, then no matter how perfectly your project is working, you will be awarded ZERO marks. Because it simply means you have not done it yourself and you don't deserve the credit.

What Is Expected

Good class projects can vary dramatically in complexity, scope, and topic. The only requirement is that they be related to something we have studied in this class and that they contain some element of research — e.g., that you do more than simply engineer a piece of software that someone else has described or architected.

List of Projects

1. Smart Home
2. Smart Energy Meter
3. RC Meter
4. Separate control of two bulbs with same power source using IR remote
5. Contactless Tachometer
6. Automatic Soil irrigation system
7. Frequency measurement of different signals
8. Object detection and distance measurement using Ultrasonic sensor
9. Voice controlled Car
10. Automatic Door and Timed Bidirectional meter
11. Balancing object on a platform

Details of Projects

1. **Smart Home**

Home automation is the automation process of home appliances and other home functions so that they can be controlled with your phone remotely. The main objective of this project is to interface a bluetooth (or Wifi) module with TIVA C board at the receiver end, while on the transmitted end, A GUI application on the cell phone sends ON/OFF commands to the receiver where loads (lights and Fans) are connected. By touching the specified location on the GUI, the loads can be turned ON/OFF remotely through the interface.

2. **Smart Energy Meter**

“Smart Energy Meter” compute the power and energy consumed from different loads. The idea is to compute the consumed energy from the set of loads, calculate the accumulated cost of the consumed energy as per terrif rate provided by LESCO, update the customer with the current cost, and display the electricity bill to the customer. Also it is recommended to keep a log (track) of the history of the energy consumed by the customer.

3. **RC Meter**

Simple Digital Multimeters (DMMs) cannot measure the capacitance and in order to find the capacitance, you either need to go for an advanced, expensive DMM or find a dedicated Capacitance module. In this project, the idea is to build a simple Resistance and Capacitance Meter with Auto-Ranging feature. It can measure capacitance from 10 pF to 10, 000 μF. The

measurement should take place in automatic mode, it is enough to connect the capacitor to the measuring contacts. The device has two ranges: "nF" and "μF". When measuring a capacitor, the "nF" range is first switched on, if the capacitance is too large, then the transition to the "μF" range occurs. Each capacitance meter has an RC circuit with known resistor values and an unknown capacitor value. The microcontroller will measure the voltage at the capacitor and record the time it takes to reach a certain percentage of its voltage when fully charged (the time constant). Since the resistance value is already known, you can use the formula in a program that will calculate the unknown capacitance. The capacitor under test is charged using one of the resistors.
For RLC meter, current across the inductor is measured and record the time it takes to reach a certain percentage of its current when fully charged (the time constant). Since the resistance value is already known, you can use the formula in a program that will calculate the unknown inductance.

4. **Separate control of two bulbs with same power source using IR remote**

When two bulbs are connected to the same power source, turning on the power would turn both of them ON. You are required to design an IR remote and circuitry at the bulbs that would provide the user with the choice to switch ON and OFF only one of them at a time and also control their brightness independent of each other. For the IR remote, the IR sensor sends a unique sequence for each button press which detected by the receiver, placed at the bulb's end, will result in the required functionality performed for the bulbs.

Separate Control of two motors with same power using IR remote: Instead of bulbs, two DC motors would be used. Their switching, speed and direction will be controlled by the IR remote.

5. **Contactless Tachometer**

In this project, the idea is to design a Digital Tachometer using an IR Sensor with a microcontroller for measuring the number of rotations of the rotating Motor in RPM. You will be interfacing the IR sensor module with microcontroller and the 16*2 LCD modules for display. The IR sensor module consists of an IR Transmitter & Receiver in a single pair that can work as a Digital Tachometer for speed measurement of any rotating object.

6. **Automatic Soil Irrigation System**

This project is about building up a Automatic plants water irrigation whenever the soil moisture sensor senses soil is dry then pump start automatically and watering the plant. In this project the microcontroller will be used with an analogue soil moisture sensor to determine moisture level of the soil. The relay module (or solenoid pump) should be used to control the pump connected across it. As moisture sensor value goes below some reference, the microcontroller should turn ON the pump and after some time when moisture sensor sense value reaches the reference, the pump should get automatically OFF.

7. **Frequency Measurement**

The main idea to calculate the frequency of any signal (triangular, square, sinusoidal) through a signal generator ranges from 10Hz to 1MHz and display its value on 16x2 LCD. An extension to this project can be added by measuring the duty cycle of the pulse via time capture method.

8. **Object Detection using Ultrasonic sensor**

The ultrasonic sensor is a type of proximity sensor. These proximity sensors all use the basic detection principle. The sensor emits a signal which will bounce back once it detects an obstacle. The sensor will read the bounced signal and compare it to the original signal emitted. If there is a difference between those signals, the sensor will then consider that it has encountered an obstacle. In this project, the main idea is to use HC-SR04 ultrasonic sensor module to detect objects from 2 cm to 400 cm, or roughly, 1 inch to 13 feet along with the number of objects. That is the ultrasonic sensor will be mounted on servo/stepper motor, it makes one 360 degree rotation and displays the number of objects and their respective distances.The data should either be displayed on a UART based hyperterminal or on an LCD.
Object detection and distance measurement using Ultrasonic sensor for a car: Ultrasonic sensor will be mounted on a car and data of the changing distance as the car moves will be displayed on a UART based hyperterminal or on an LCD. When the object is too close, the car will stop.
An extension to these projects can be that the speed of objects be calculated and displayed if they are moving away from the sensor.

9. **Voice Controlled Car**

The principle of this toy concept is based on voice recognition technology. The toy car operates by having a voice receiver box on it where it receives your voice commands. Demonstrators should interact with the car by shouting out commands/saying these to the phone like "faster", "slower", "right", "left", and "stop".

Voice Controlled Car (Group10 SecA): Commands should include all four directions, speed control and start stop functionality.

10. **Automatic Door and Bidirectional person counter**

In this project, you will make a Bidirectional Visitor Counter and an automatic door opener by sensing the person. This project is based on a pair of Infrared Sensor that detects an interrupt when it detects an obstacle. The pair of IR sensors can detect the visitor from both directions, i.e. the number of entering visitors and the number of leaving visitors. You are required to display the number of persons in the room and their time of entry and exit on LCD display or UART terminal along with opening the door for a person for entering and exiting. An extension can be added by introducing the light control in the room. While counting the total number of people currently present inside the room, when no people are inside the room, i.e. the total number of people is zero then the room light is turned off. When even a single person is found inside the room, the light turns on. The light control system is automatic based on the visitors' presence.

11. Balancing object on a platform

Nowadays the Self-stabilizing platform finds its use in various applications from as simple as camera stabilization to surgery platforms. The idea of this project is to make your own two axis Self-stabilizing platform using two servo motors and MPU6050 MEMS Sensor. MPU6050 is a MEMS Sensor with an accelerometer and gyro sensor in a single chip. It is very accurate and has an internal 16-bit ADC for each channel. The sensors interface easily to any microcontroller using I2C protocol.