Laboratory Project – EN2090 Laboratory Practice II

Introduction

Main goal of this project is to improve analog electronics knowledge along with engineering discipline and best practices related to electronics engineering field. Your ability to apply learned knowledge and **self-learn** new knowledge will be tested. You have freedom to propose a project with sufficient use of analog electronics or you can select a project from following list of offered projects.

Offered project list

	Project	**Main supervisor**	**Contact details**
1	Analog Line Follower	Lahiru Wijerathna	lahiruw@uom.lk
2	Lux Meter	Dinithi Hemakumara	dinithir@uom.lk
3	Linear Power Supply	Pramitha Muthukudaraachchi	pramitham@uom.lk
4	Function Generator	Pasan Dissanayake	pasand@uom.lk
5	Simplex Line Coding Transceiver	Mevan Wijewardena	mevanw@uom.lk
6	High Frequency Amplifier	Vinu Maddumage	vinum@uom.lk
7	Hot-plate Controller	Gershom Seneviratne	gershoms@uom.lk
8	Lead Acid Battery Charger	Hiran Perera	hiranp@uom.lk
9	Hot Water Dispenser	Bhanuka Silva	bhanukas@uom.lk
10	PIR Sensor	Thamidu Pathirana	thamidup@uom.lk

You will be provided with an online form to submit your project preferences.

- Form will be made available to you at 06.00PM on Friday 17th.
- Form will be closed at 11.59PM on Sunday 19th.
- Only one response from each group is required.
- You will be needed to pick a group leader and provide his/her contact details, along with the names and index numbers of the group members.
- Give your first preference from the project drop down list.
- Give your second preference from the project drop down list. Make sure it is not the same as the first choice.
- Give your third preference from the project drop down list. Make sure it is not the same as the first and second choices.
- If you fill any of the three slots as a “proposed design”, You are required to attach a one-page (A4) project proposal including an introduction to the project and necessary technical specifications. You will be awarded some bonus marks if your proposal is accepted.
- If your **first** preference is a project from the offered list, then you are required to submit a document with **no more than 300** words on your team’s approach, skills and potentials in successfully completing the project.

The Design Cycle

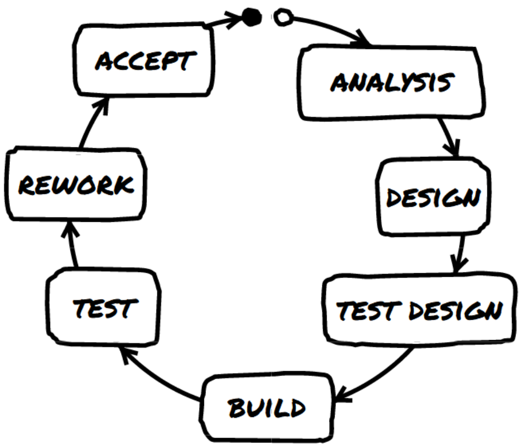

Fig. 01(Credit: Engineering Design Center, University of Cambridge)

Fig. 01 depicts an engineering product design cycle. Design cycle starts with analysis. All the projects given to you, or projects proposed by you, in its simplest form is a problem. And you are tasked with applying relevant engineering knowledge to address that problem. First you must analyze the problem and identify its objectives and constraints. After that you must apply theoretical knowledge and propose a solution, this is called design phase. Next phase is testing the design. The design is still virtual (on a Computer Aided Design platform). At this phase the design is validated via various simulations. Up until now no physical product was built. In Build (or prototyping) stage the design is physically implemented. In the next stage it is tested, and performance is evaluated. If required objectives are not achieved, design is slightly changed (reworked). If required objectives are reached, design cycle can be stopped, or else cycle must be continued till a solution is reached.

In this project you are tasked with following the design cycle and produce a solution to the given project. It is recommended to invest more time in the design phase and minimize the number of design cycles to achieve the objectives. At your stage going through multiple design cycles is financially infeasible. A typical electronic product has two major components, a PCB (electronics) and an enclosure. You must develop both parts in this project. Evaluation will be weighted more for the electronics design; thus, you should give more attention to electronics design. A typical design flow for this project is depicted below (Fig. 02). As the figure depicts you are expected to follow one design cycle, hence more time should be invested in design phase to minimize design errors.

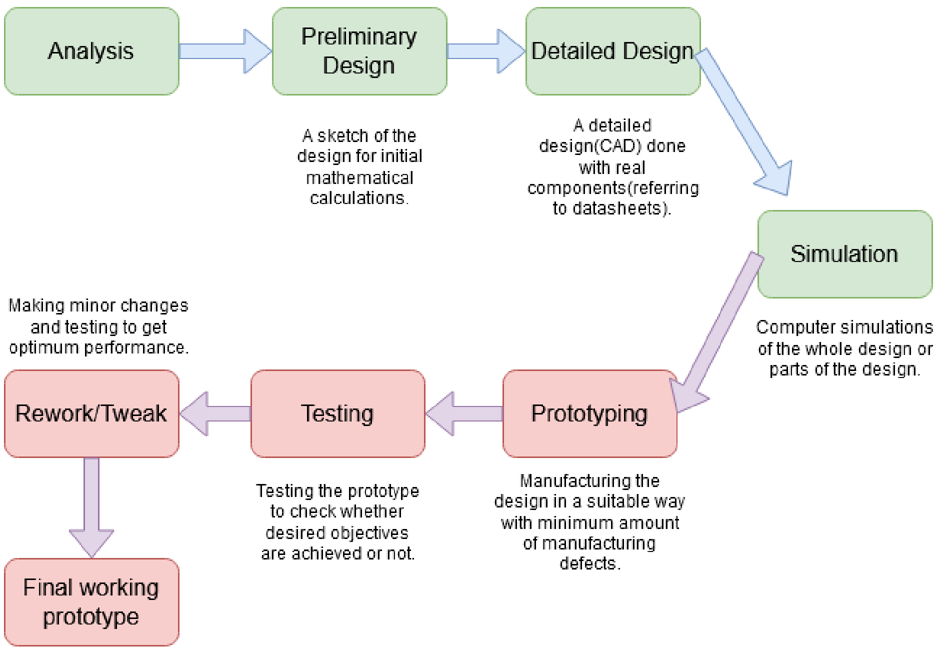

Fig. 02 Design flow

General guidelines

- Any change of project specifications is negotiable only before the mid review.
- All the circuits **must** be simulated using software (**Ex- LT Spice, Multisim, PLECS** etc.) before the implementation.
- All the circuits **must** be designed using professional software used in electronic product design and manufacturing. (**Ex – Orcad, Altium Designer**)
- Complete set of design and manufacturing documents such as **Schematics, Layout, 3D Model, Gerber files, Assembly files, Bill of Materials (BOM)** etc. **must** be generated and properly documented.
- It is **encouraged** to procure materials/components from a reputable electronic component distributor such as **Mouser, Digi-Key, Arrow Electronics, LCSC** etc. (Latter two suppliers offer affordable shipping options.)
- It is **encouraged** to outsource PCB manufacturing to external suppliers (**Ex- PCBWay, JLCPCB** etc.), and **discouraged** from making PCBs inhouse.
- **Main functionality** of the project **must** be achieved with basic electronics components such as **Resistors, Capacitors, Inductors, Diodes, Transistors, Operational Amplifiers and other analog Integrated Circuits**. Using any other pre-built **programmable** ICs are **prohibited**.
- Microcontrollers can be **only** used for **User Interface** operation.
- Enclosure design must be done using a professional software. (**Ex-SOLIDWORKS** etc.)
- Enclosure and 3D Model of the circuit **must** be **assembled** and **inspected** before manufacturing.
- 3D printing, Laser Cutting and Sheet Metal bending can be used to manufacture the enclosure.
- At completion of the project, a detailed datasheet of the product **must** be submitted.

01. Analog Line Following Robot

Description

Line following robot is the stepping stone for any robotics enthusiast who starts studying about robotics. Purpose of this project is to develop a line following robot without using microcontrollers.

Outcomes

Develop an analog line following robot capable of following a white line (3cm width) on a black background and stop at a white line, perpendicular to the path. The robot should have a minimum of four sensors to detect the line. The dimensions of the robot should be such that it completely fits in a box of 25cm * 25cm * 25cm (l * w * h).

The project will be evaluated on the following criteria:

1. Design: Safety, Neatness and suitability of electronic circuits.
2. Speed of the robot
3. Performance of the robot: Smooth Navigation, capability to stop at the end.

Notes

1. You don't have to build the robot from the scratch, you can buy a robot kit with the chassis, motors and wheels. (Available in UNITECH, LankaTronics).
2. You should use control algorithms like PID implemented with analog electronics for smooth navigation.
3. Refer to the "General Instructions" document for additional guidelines.

02. Designing a Lux Meter

Description

A lux meter is used to measure illuminance/light intensity. The 'lux' is a measure of the brightness or intensity of light as it appears to the human eye. The lux meter is used to ensure optimum lighting conditions for workplaces, streets and parking lots, museums and other public areas.

Outcomes

You need to design a Lux meter with measuring range of 0 Lux to 20000 Lux that can measure white and colored LED light under normal environment conditions.

The project will be evaluated on the following criteria

- Accuracy : in comparison to a standard industrial lux meter
- Resolution : ability to detect small changes
- Range of measurable illuminance
- Range of angular displacement to the light source
- Additional features

You must provide a specifications sheet for the product following the formats of already available commercial Lux Meters.

Notes

- You can use microcontrollers for the display, but all sensing and amplification must be done using analog components.
- It is recommended to use an external PCB manufacturer for producing the circuits.
- All the groups together have to create a common platform which able to change inside light intensity for testing and demonstrations. The platform should be able to isolate the testing environment from the ambient light. (For evaluation)

03. Linear Power Supply

Description

Power supplies are used to drive a load under constant voltage/current conditions. When designing power supplies several factors should be taken into consideration including efficiency, load and line regulation, short circuit protection etc. You are expected to design a voltage regulator from scratch to drive a high-power load (100 W) from 230 V input voltage.

Notes

- 10 V Linear power supply with a maximum current rating of 10 A.
- Should include circuit protection mechanisms.
- Power supply efficiency should be considered when developing the circuit.
- A step-down transformer will be provided (230 V rms – 15 V rms). Your design should include every step (rectification, regulation) after transformer output.

Evaluation

- Students must develop a PCB.
- When necessary all relevant components should be evaluated and selected using their respective datasheets. i.e. The selection of a component requires a proper justification.
- A datasheet similar to **LM7805** should be prepared for your power supply with all possible characteristics.
- Operation of the power supply at maximum rating should be demonstrated by connecting a heating element (domestic water heater coil) to the output of the supply.

04. Building an analog function generator

Description

Function generators are commonly used to generate analog waveforms (like sine waves, square waves, sawtooth waves etc.) in a variety of applications, such as sweep generation, AM/FM generation and Phase Locked Loops (PLLs). Some of the popular analog ICs used in the past were MAX038, XR2206 and NTE864. Now they have been mostly replaced with chips using Direct Digital Synthesis (AD9850 DDS signal generator module).

Function generators can usually change their waveform frequency precisely among a wide range of values (0.1 Hz to 1 MHz). Furthermore, they can even change their amplitudes and average DC values. In some sensitive applications, capability of a function generator to create a clean, noise-free waveform becomes extremely important.

Your project here is to build an analog circuit using transistors and op-amps which can generate sine waves, square waves (with variable duty cycle), sawtooth waves and triangular waves.

Outcomes

1. Design an analog function generator which generates sine, square, sawtooth and triangular waves.
2. The output amplitude should be variable from 0V to 10V, and the output frequency should be variable from 20 Hz to 20000 Hz.
3. It should be able to drive at least a 50 Ohm load without significant waveform distortion or amplitude reduction.
4. Function generator should output a clean, noise-free waveform. (Marks will be deducted for noticeable distortions)
5. Square pulse waveform should have a variable pulse width (1% to 99%).
6. Along with the demonstration, the group must provide a datasheet for the circuit, following the formats of already available function generator ICs. During the demonstration they have to prove that their circuits closely follow the characteristics given in their datasheet.
7.

Additional Rules

1. Any change of the above specifications is negotiable only before the mid review.
2. All the circuits should be simulated using software before the implementation.
3. It is allowed to use an external PCB manufacturer for producing the circuits, and no marks will be reduced or added.
4. Using any other pre-built ICs (other than transistors and op-amps) are prohibited.
5. Regardless of the method of PCB manufacture, the full set of output files required to mass produce the PCBs, to assemble the circuit and to package it is required.
6. Follow provided “General guidelines”.

05. Simplex Line Coding Transceiver

Description

Line coding is the use of waveform shaping to allow a wire transmitted bit stream to be accurately detected at the receiver. Though it is technically possible to transmit the original bit stream itself, factors such as noise and attenuation during transmission can cause detection errors. Line coding minimizes such errors at the expense of additional circuitry. This project aims to construct a basic line coding scheme using analog electronics for wired data transmission.

Notes

- Fully analog, simplex wired communication link capable of communicating at a bit rate of at least 10 kbps. The bit error rate must be less than 1 in 1000.
- The wire medium has to be a twisted pair of at least 0.5m in length
- Power supply can be up to 12V.

Evaluation

- Students must develop a PCB.
- When necessary all relevant components should be evaluated and selected using their respective datasheets. i.e. The selection of a component requires a proper justification.

06. High Frequency Amplifier

Description

An amplifier is an electronic device that can increase the power of a signal (a time varying voltage or current). Depending on its frequency of operation we have several types of amplifiers. As name suggests high frequency amplifiers are designed to operate at high frequencies. These have a vast variety of applications like telecommunication, high-speed electronic measurements, laser research and photonic research.

When designing a high frequency amplifier, factors like bandwidth, low noise, high gain and noise immunity are extremely important.

Your project is to build a high frequency amplifier using transistors which can drive a head-phone.

Outcomes

1. Design a high frequency amplifier which can drive a load impedance of 8Ω (head-phone).
2. The design must be compatible with working 12V.
3. The design must be able to amplify a sine wave of 0.1V (peak-peak voltage).
4. The design must be work in the frequency range of 20 kHz – 100kHz (Bandwidth requirement)
5. The design must consist of minimum 3 transistors (usage of op-amps is prohibited).
6. Apart from the demonstration, a datasheet must be provided for the design.

07. Hot-plate Controller using PID

Description

PID controller, which consist of proportional, integral and differential parts is widely used in controlling systems. PID systems in general work as a control feedback loop mechanism. In these systems, error; the difference between required output and the current output is calculated continuously and adjusted using proportional, integral and differential parts until the desired, stable output level is reached. In this project the temperature of a hot-plate is controlled using PID.

Outcomes

You need to design an Analog PID Controller to control the temperature of a hotplate with following specifications.

- Temperature range: up to 200^{o} C
- The complete design should be in analog domain
- It should be able to maintain any given temperature value (in the given range)
- All the groups together need to create a common platform to measure the temperature and plot the temperature variation with time (For evaluation)

Notes

- Schematic design of the circuit needs to be prepared.
- The calculations need to be clearly given.
  You are allowed to use one PCB for the product and PCB should be designed using Altium Designer.
- Marks will be allocated based on the transient time of the controller.

08. Lead acid battery charger

Description

Each battery has their own charging profile. In order to maintain a healthy battery, this charging profile should be followed correctly. Normally, this charging profile is comprised of constant current charging followed by a constant voltage stage. In this project you must design a power source which can operate in both conditions.

Outcomes

- Design a constant current source to charge a 12v Lead acid battery, with a maximum charging current of 1A
- Input voltage for the system should be 230v AC.
- System **must** be based on **Pulse Width Modulation (PWM)** technique.
- Design a suitable enclosure to enclose all the circuits in a safe and ergonomic manner.

Additional Notes

- Follow provided “General guidelines” in the introduction.
- Lead acid battery charging - https://batteryuniversity.com/learn/article/charging_the_lead_acid_battery

09. Hot Water Dispenser

Description

Hot water dispensers are widely used due to instant near-boiling water availability with quick pouring access to the user. There are two main categories called “boil-on-demand" and “hot-water-tank" dispensers. The former type is preferable for lower quantities of water where the heating up occurs during the demand, therefore, reducing the power consumption.

PID controller, which consist of proportional, integral and differential parts is widely used in controlling systems. PID systems in general work as a control feedback loop mechanism. In these systems, error; the difference between required output and the current output is calculated continuously and adjusted using proportional, integral and differential parts until the desired, stable output level is reached.

Specifications

You need to design an Analog PID Controller to maintain the temperature of the dispensed water inclusive of the following specifications.

- Temperature range within 40^0C - 60^0C.
- The complete design should be in analog domain.
- It should be able to maintain any given temperature value (in the given range) irrespective of the flow rate of the output.
- Manually controllable output flowrate is advisable.
- 01 litre water storage option should be utilized as the input to the dispenser while the heating chamber capacity should be significantly less than that.
- Safety precautions must be taken into consideration where necessary.
- Power input to the system can either be AC or DC.
- All the groups together are allowed to create a common platform to measure the temperature and the flow rate of the dispensed water. (For evaluation)

Notes

- Refer to the “General Instructions” document for additional guidelines.
- Detailed mathematical calculations are expected at each stage of your design.
- A reliable isolation of water from electronics is highly anticipated.

10. Designing a PIR Sensor

Description

A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. They are most often used in PIR-based motion detectors and automatic lighting controllers. A PIR sensor can detect changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor.

Outcomes

- You need to design a PIR sensor that can adjust,
  I. Sensitivity so that differently sized IR emitting objects moving at different distances from the sensor can be detected. (IR emitting objects moving in a field of view of at least 120° cone angle and at least within 5 meters from the sensor should be detected).
  II. Delay time (How long the output of the PIR sensor module will remain HIGH after detection of motion of an IR emitting object)
  III. Trigger mode.
  Retrigger mode – Output remains HIGH when sensor is retriggered repeatedly. Output is low when idle
  Normal mode – Output goes HIGH and then LOW when triggered. Continuous motion will result in repeated HIGH/LOW pulses. Output is low when idle.
  IV. The sensitivity to daylight so that the device operates only at night/low light conditions.

- You may use potentiometers to set configurations I, II and IV.
- You may use a jumper or a switch to change trigger mode.
- For part IV, you may use an LDR to detect light intensity.

You must provide a specifications sheet for the sensor you are developing, following the formats of already available PIR Sensor datasheets.

Notes

- All the sensing and amplification must be done using analog components.
- The sensor should be powered from the 230V mains supply.
- You may use a buzzer or a lamp to indicate the output state.
- You are allowed (recommended) to manufacture circuit boards using external PCB manufacturers (no marks will be reduced or added.)