Department of Electronic and Telecommunication Engineering
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Design of the Prototype

Multi-turn Absolute Magnetic Encoder

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This report is submitted as a partial fulfilment of module EN2160

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Contents

1 User Requirements

- Absolute Positioning
  The encoder should be able to provide the absolute angular position of the shaft over multiple turns, accurately indicating its position.
- Multi-Turn Capability
  The encoder should be capable of tracking multiple revolutions of the shaft, allowing users to determine the absolute position across several complete rotations.
- Accuracy
  Accuracy of the encoder is essential where precise positioning is critical. Specific tolerance should be defined based on the requirements.
- Resolution
  The encoder should offer resolution sufficient enough for the requirement of the user to detect even minor changes in position.
- Reliability
  The device should provide the same accuracy of angle data over a long period of time and each and every time the output should be the same for a specific position.
- Operating Range
  The encoder must operate effectively within a specified range of temperature and other environmental conditions. The operating range should be defined based on the expected conditions in the application environment.
- Communication Interface
  The encoder should support commonly used communication protocols to transmit the encoder output data.
- Size
  The encoder should fit within the physical constraints of the application. Also it should be relatively small for it to be accommodated by the motor.
- Fast Response Time
  Users may require the encoder to provide position information quickly, especially in applications where rapid changes in position occur.
- Cost-effectiveness
  One of the main concerns of the user is the cost per item. It should be as minimum as possible while also maintaining the functionality upto a certain standard.
- Power Requirements
  The encoder should operate within a specified power supply range and should have low power consumption to ensure energy efficiency.
- Lifespan and Maintenance
  Users typically require a long lifespan with minimal maintenance. It should be able to withstand the expected usage without requiring frequent repairs or replacements.

2 Conceptual Designs and Functional Block Diagrams

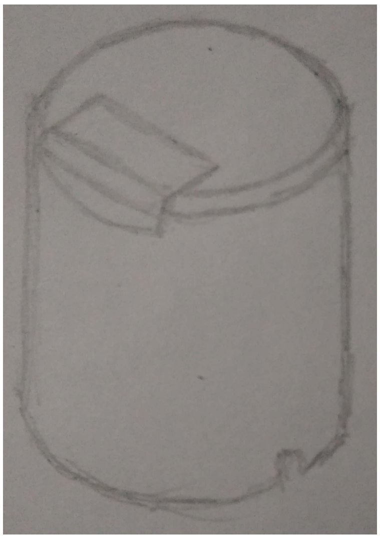


Figure 1: *Conceptual Design 1*

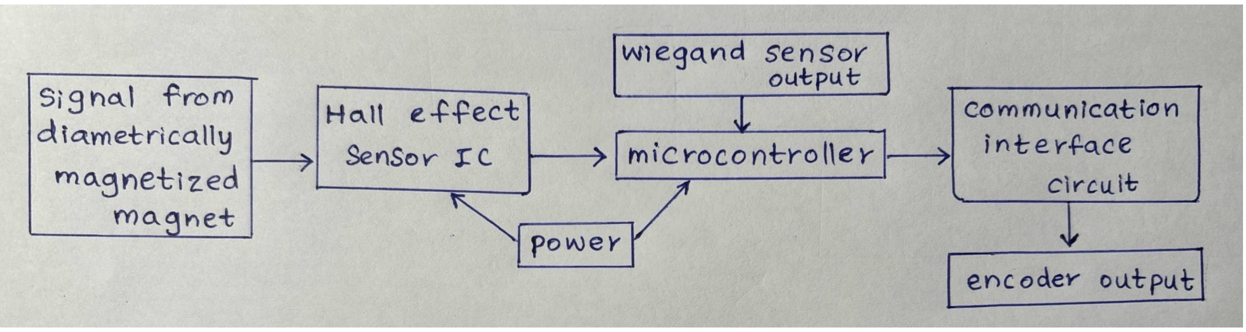


Figure 2: *Functional Block Diagram for Conceptual Design 1*

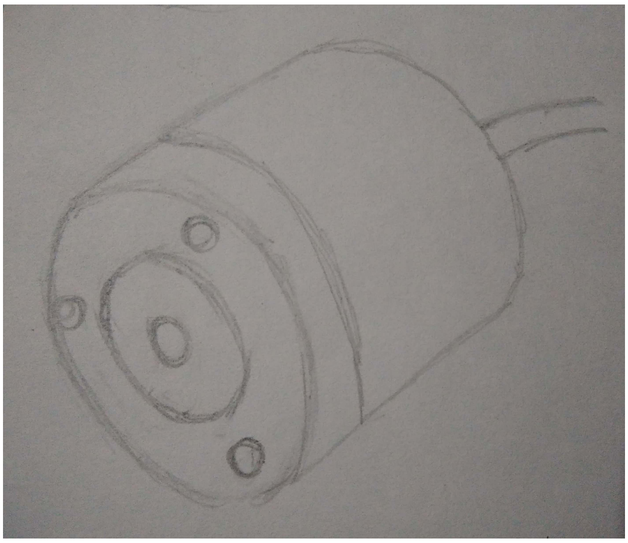


Figure 3: *Conceptual Design 2*

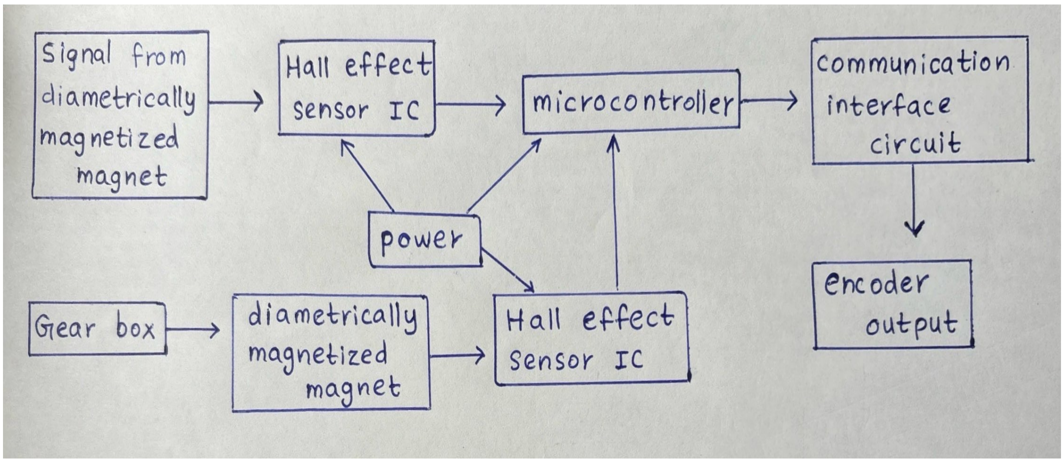


Figure 4: *Functional Block Diagram for Conceptual Design 2*

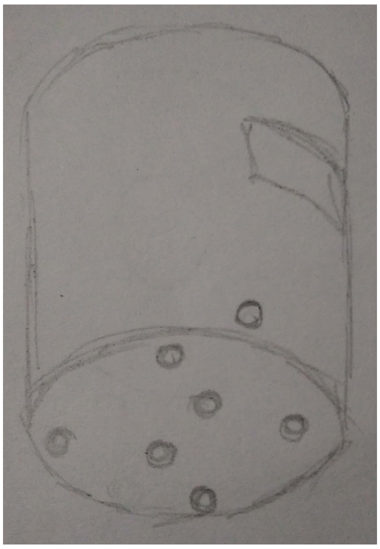


Figure 5: *Conceptual Design 3*

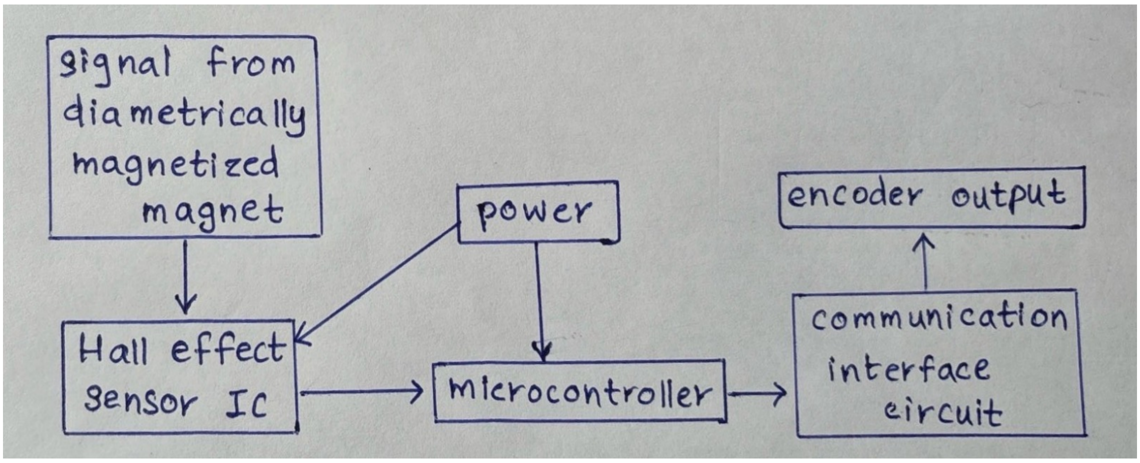


Figure 6: *Functional Block Diagram for Conceptual Design 3*

3 Complete Comparison

	Conceptual design 1	Conceptual design 2	Conceptual design 3
Newly added features	Multi turn capability using wiegand sensor which doesn't require power to operate	Multi turn capability using Gear box and two hall effect sensor ICs	Multi turn counting using the microcontroller and one hall effect sensor
Removed features	Removed the necessity to give internal power for the circuitry to function during power outages	removed the need for wiegand sensor	removed extra sensors and circuitry to address the multi turn capability
Enclosure design criteria comparison: 1. Functionality 2. Size and weight 3. Ergonomic 4. Heat dissipation 5. Mounting and alignment 6. Simplicity	 9 9 8 8 8 7	 9 5 7 6 6 6	 9 8 8 8 8 8
Functional block design criteria comparison: 1. Functionality 2. Requirements 3. Power consumption 4. Future proofing 5. Cost 6. Manufacturing feasibility	 8 7 9 6 6 5	 9 9 8 6 4 4	 8 7 8 8 9 8
Total	90	79	97

4 Evaluation Criteria

Enclosure Design Criteria:

1. Functionality: How well does the design support internal functionality?

2. Size and weight: How compact and lightweight is the enclosure for easy integration?

3. Ergonomics: How well does the enclosure design allow for easy handling installation and maintenance?

4. Heat dissipation: How much heat is generated and how well it has been managed?

5. Mounting and alignment: How easy is it to mount and align the encoder with the shaft, and how well does the enclosure maintain its alignment?

6. Simplicity

Functional Block Diagram Criteria:

1. Functionality: How well the circuit design meets functional requirements such as resolution, accuracy, and speed?

2. Requirements: How well does the components (magnet, hall effect sensors, etc) meet the requirements for accuracy and resolution?

3. Power consumption: How efficiently does the design manage power consumption?

4. Future proofing: To what extent does the design allow for easy replacement or upgrade of individual components?

5. Cost: Overall cost effectiveness for the provided functionality

6. Manufacturing feasibility: Feasibility of manufacturing the design

5 Selected Design

From the above three designs, we have selected the final design. There are several reasons for this.

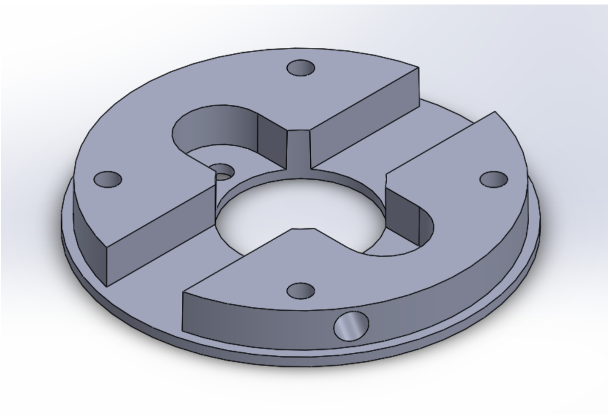
Design 1 included a wiegand sensor which isn't available to purchase at small quantities. Even though we tried to find out an alternative part for that, we got no success.

Design 2 utilizes a gear box which isn't practical because of the size. Also it will make the encoder complex and ultimately limit the number of multi turns which the encoder can count. Durability and the weight of the encoder is also affected because of this.

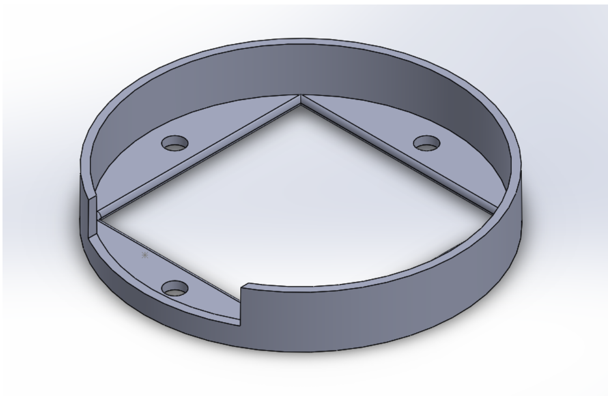
The third design is the option we can go for in this situation. A battery backup is used in this design to power the encoder every time and it's charged when the main supply is available.

6 Final Solidworks Design

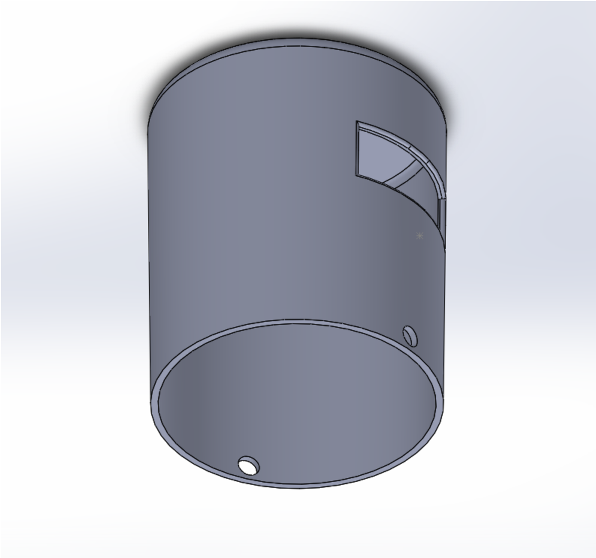
Solidworks design contains four main parts.



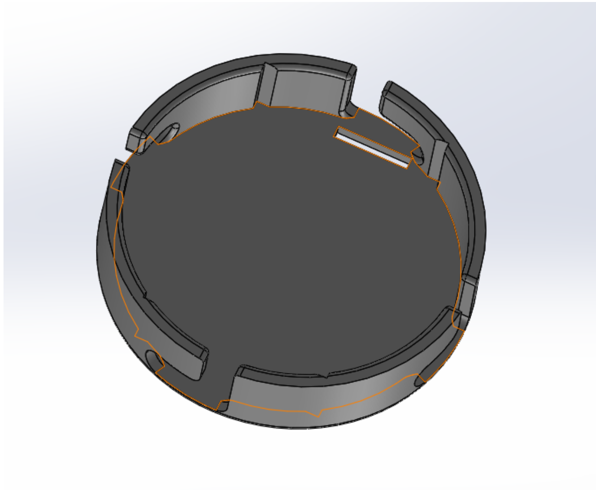
(a) Base



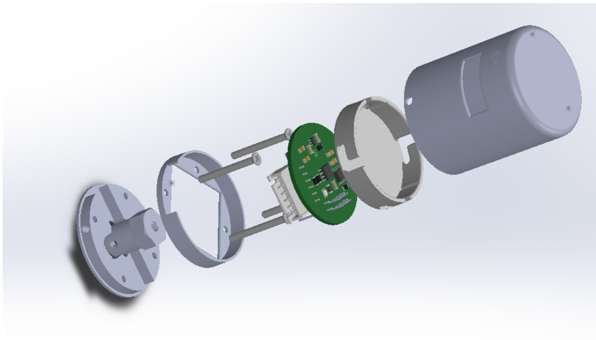
(b) Middle



(a) Housing



(b) Battery Holder

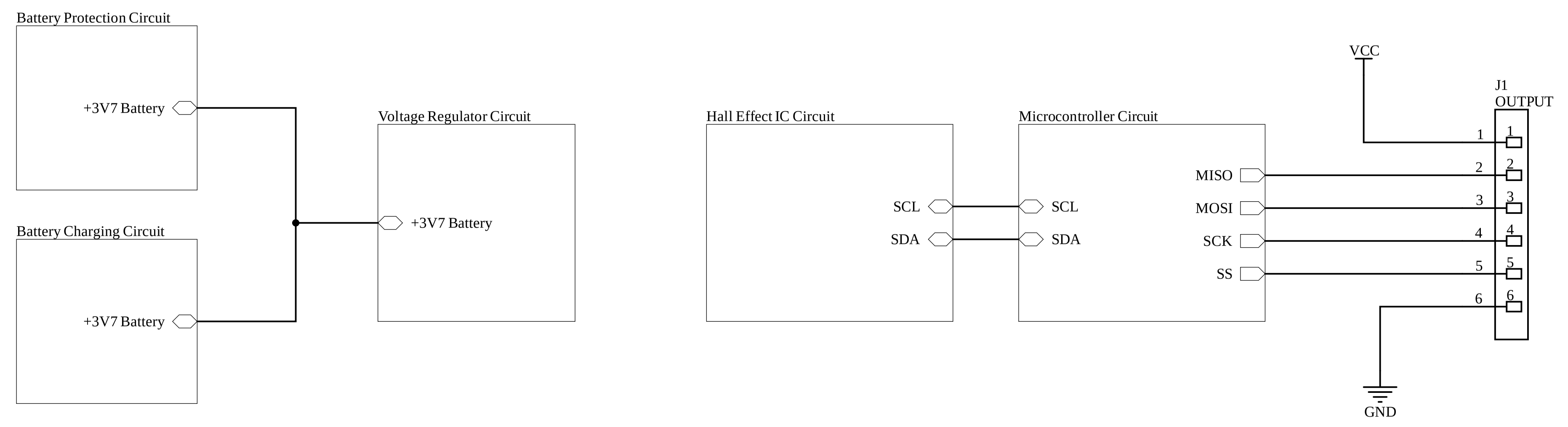


(c) Assembly

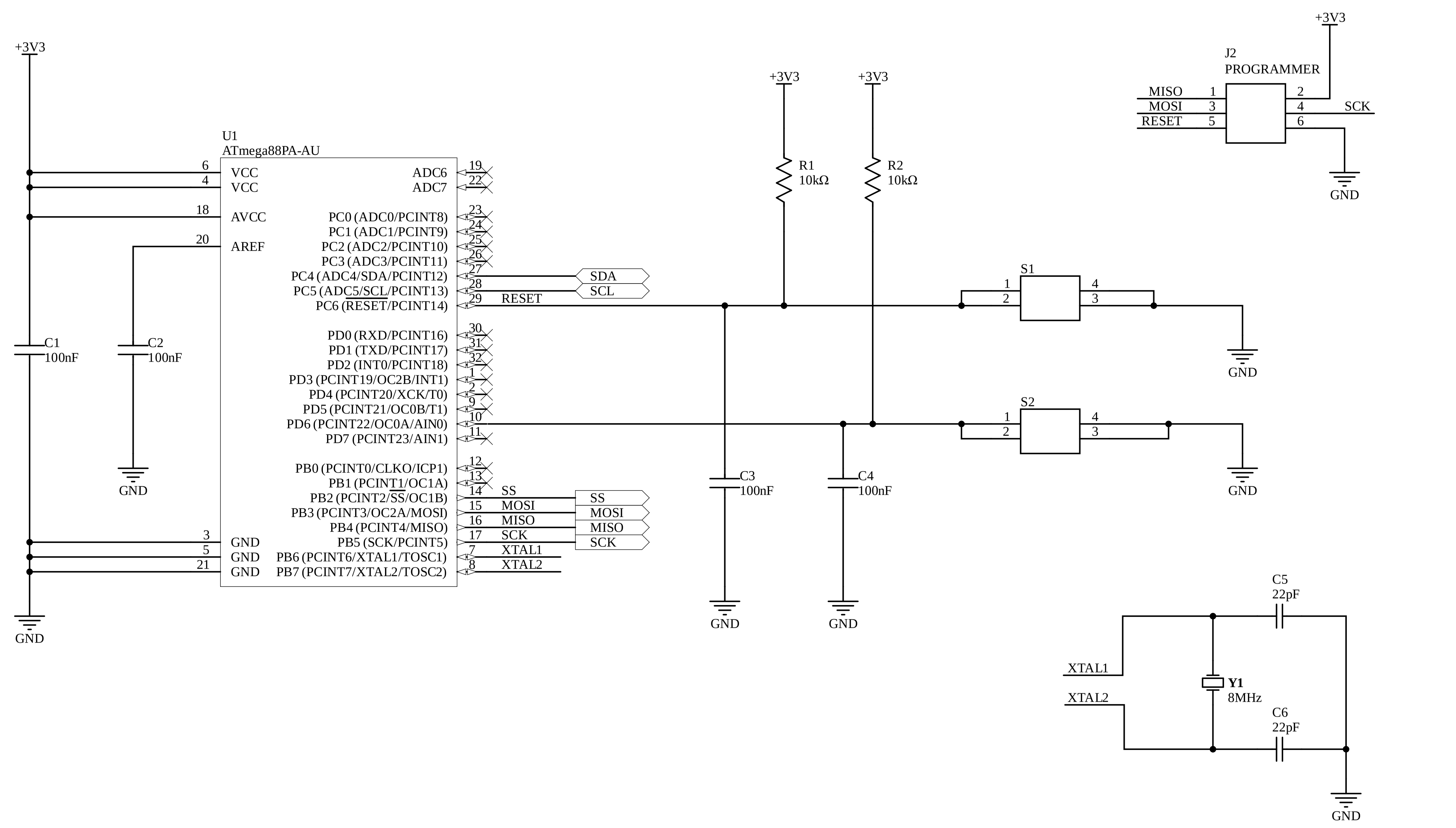
7 Final Schematic Design

There are 6 schematics sheets in our circuit. They are,

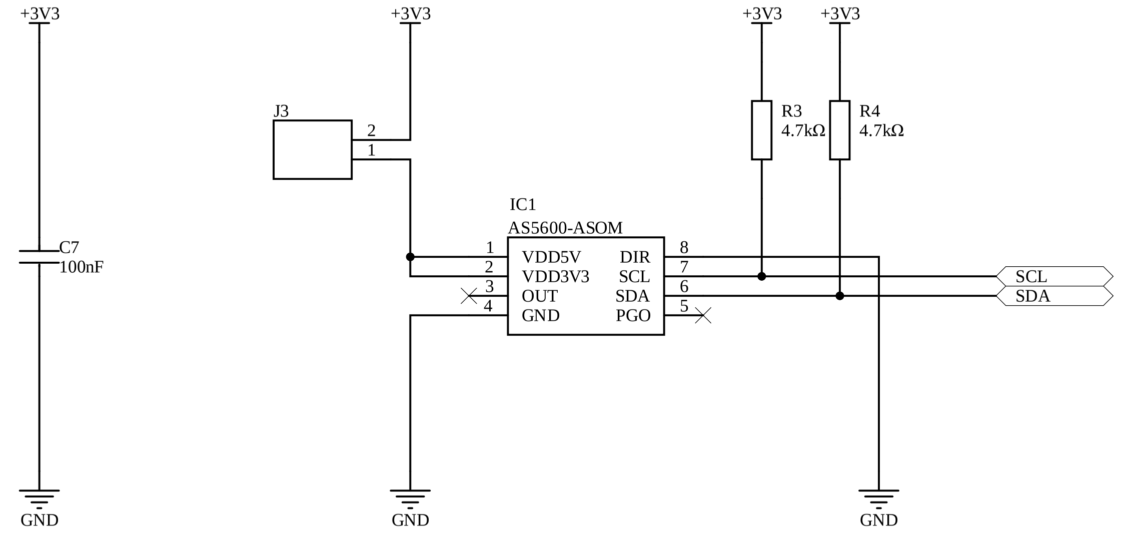
- Encoder Circuit (top sheet)
- Microcontroller Circuit
- Hall Effect IC Circuit
- Voltage Regulator Circuit
- Battery Protection Circuit
- Battery Charging Circuit



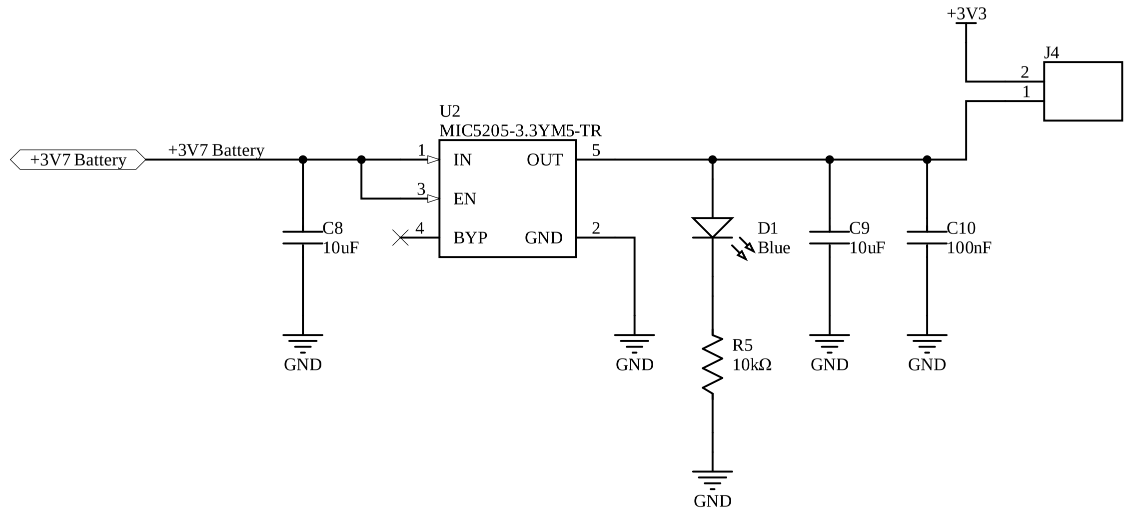
Title	Encoder Circuit		
Size: A4	Number: 1		Revision: 1
Date:	4/02/2024	Sheet 1 of 6	
File:	F:\Altium Projects\..\Encode Schematic.SchDoc	Drawn By:	



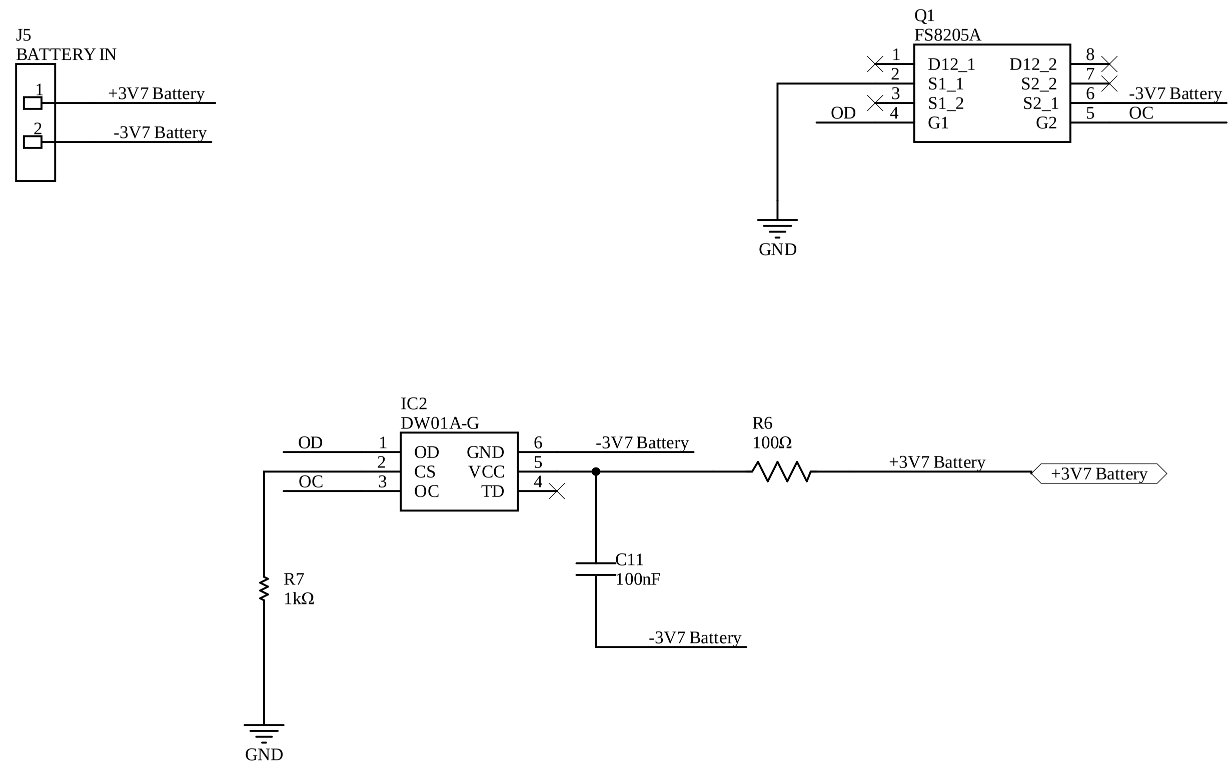
Title	Microcontroller		
Size A4	Number 1		Revision 1
Date:	4/02/2024	Sheet 2 of 6	
File:	F:\Altium Projects\..\Microcontroller.SchDoc	Drawn By:	



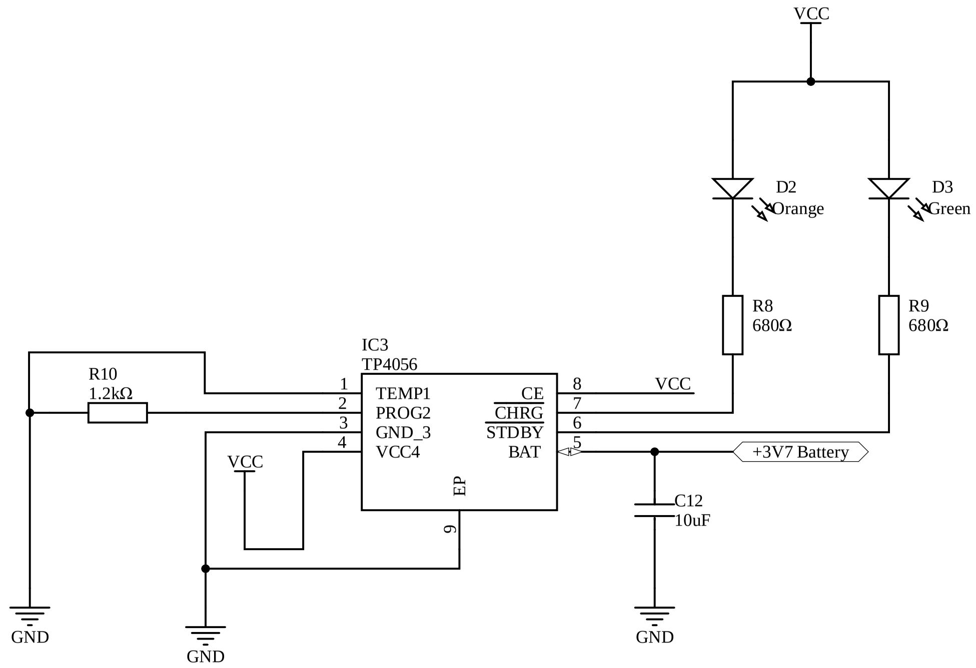
Title: Hall Effect IC			
Size: A4	Number: 1		Revision: 1
Date: 4/02/2024		Sheet 3 of 6	
File: F:\Altium Projects\..\Hall Effect IC.SchDoc		Drawn By:	



Title	Voltage Regulator		
Size A4	Number 1		Revision 1
Date:	4/02/2024	Sheet 4 of 6	
File:	F:\Altium Projects\..\Voltage Regulator.SchDoc	Drawn By:	



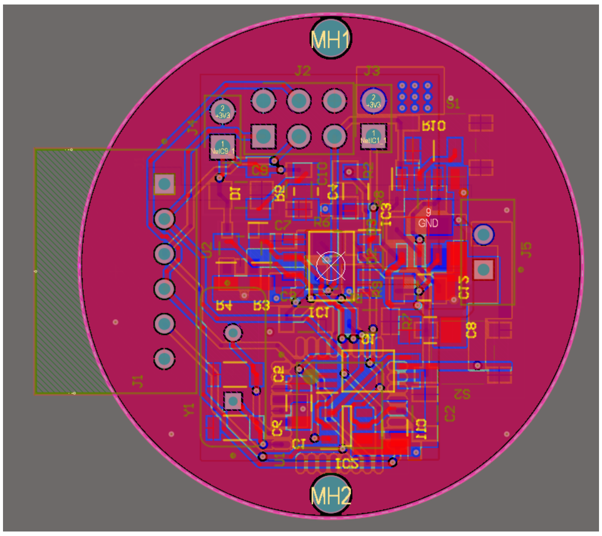
Title: Battery Protection Circuit		
Size: A4	Number: 1	Revision: 1
Date: 4/02/2024		Sheet 5 of 6
File: F:\Altium Projects\..\Battery Protection.SchDoc		Drawn By:



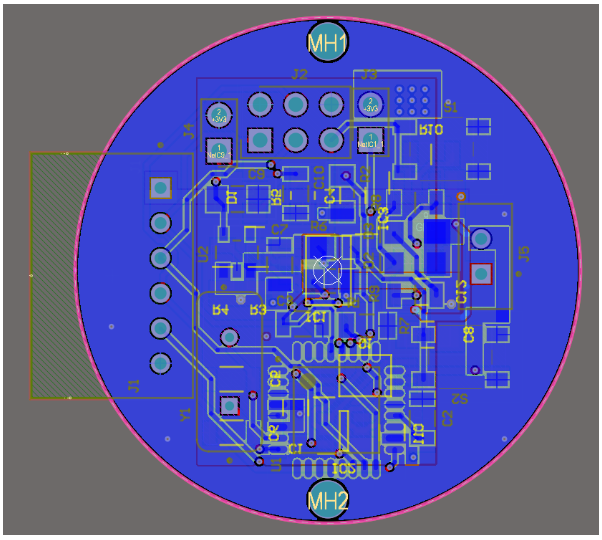
Title: Battery Charger		
Size: A4	Number: 1	Revision: 1
Date: 4/02/2024		Sheet 6 of 6
File: F:\Altium Projects\..\Battery Charger.SchDoc		Drawn By:

8 Final PCB Design

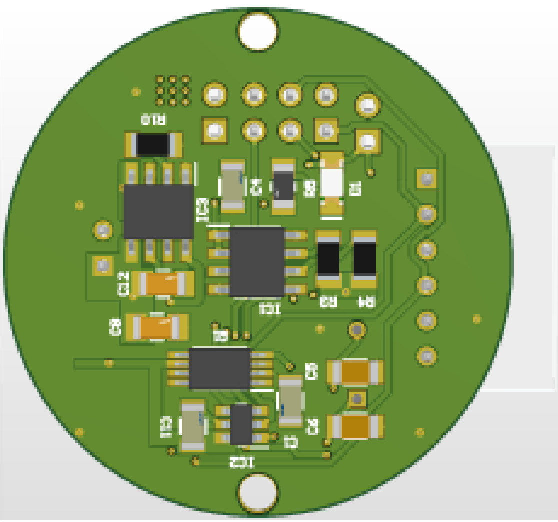
Our final PCB Design is of round shape and is only 36mm in diameter. We have used smd components to minimize the size of it.



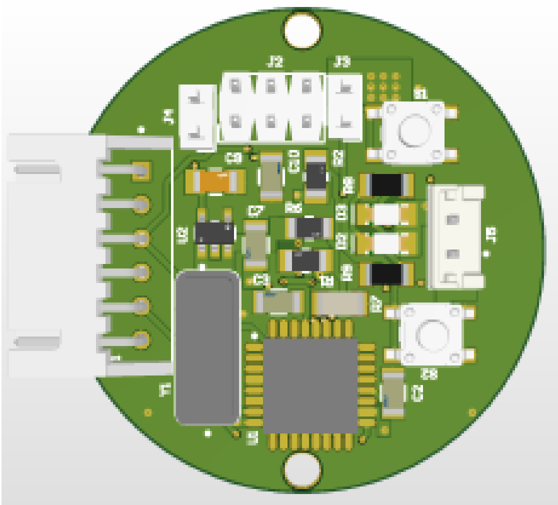
(d) PCB Layout



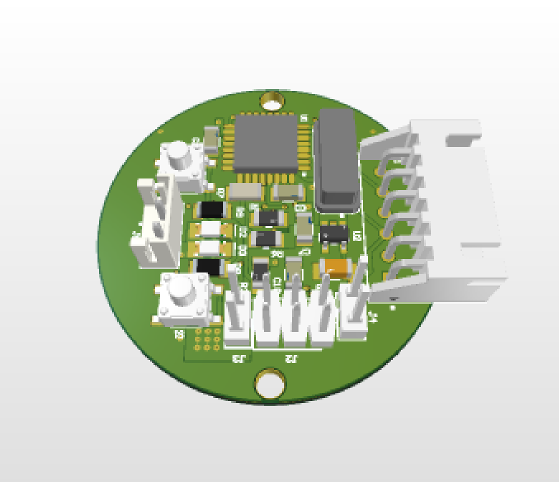
(e) PCB Layout



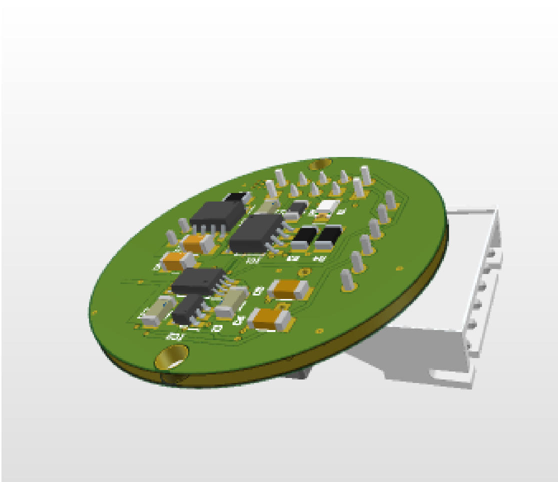
(f) Top view



(g) Bottom view



(h) Side view



(i) Side view