Design of Prototype

EN2160 - Electronic Design Realization

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Fabric Rolling Machine
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Contents

1 User Requirements

The fabric rolling machine should meet the following user requirements:

1. **Accuracy of Fabric Length Measurement:** The machine must accurately measure the length of fabric to be rolled. It should have a minimal margin of error to ensure precise cutting and minimize fabric wastage.

2. **Handling Various Fabric Types:** The machine should be able to handle a wide range of fabric types, including but not limited to cotton, polyester, silk, wool, and blends. It should accommodate different fabric widths and thicknesses, ranging from lightweight to heavyweight fabrics.

3. **Ease of Operation:** The machine must be user-friendly and easy to operate, even for individuals with minimal technical expertise. Intuitive controls, clear labeling, and ergonomic design elements should facilitate smooth operation and minimize the risk of errors.

4. **Safety Features:** Safety is paramount in the operation of the fabric rolling machine. It should be equipped with safety features such as emergency stop buttons, interlocks, and guards to prevent accidents and protect operators from hazards such as entanglement, crushing, or electrical shock.

5. **Durability and Reliability:** The machine should be robustly constructed from high-quality materials to withstand the rigors of industrial use. It should be designed for long-term reliability, with components and mechanisms engineered for durability and resistance to wear and tear.

6. **Ease of Maintenance:** Maintenance of the fabric rolling machine should be straightforward and cost-effective. Components requiring regular servicing or replacement should be easily accessible, and maintenance procedures should be clearly documented in the user manual.

7. **Integration with Existing Systems:** The fabric rolling machine should seamlessly integrate with other machinery and production systems commonly found in textile manufacturing facilities. Compatibility with industry-standard communication protocols and interfaces would facilitate interoperability and data exchange.

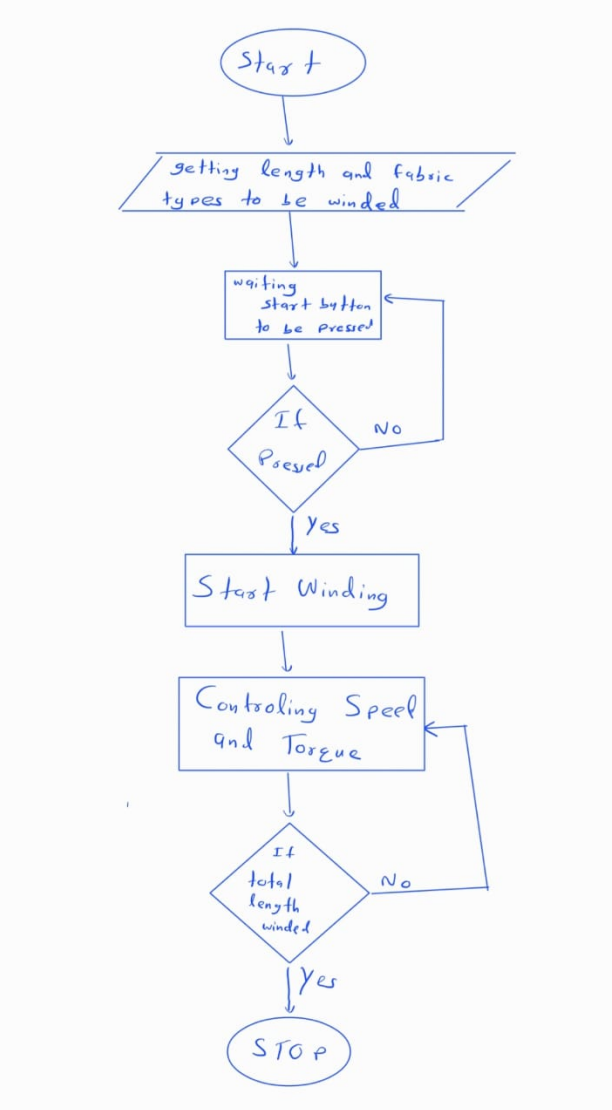
8. **Energy Efficiency:** To minimize operational costs and environmental impact, the machine should be designed for energy efficiency. Energy-saving features such as variable speed drives, power management systems, and automatic shutdown modes would contribute to reduced electricity consumption.

9. **Cost-Effectiveness:** While meeting the above requirements, the fabric rolling machine should offer good value for money in terms of initial investment, operational efficiency, and total cost of ownership. The total cost of ownership should include factors such as purchase price, maintenance costs, energy consumption, and expected lifespan.

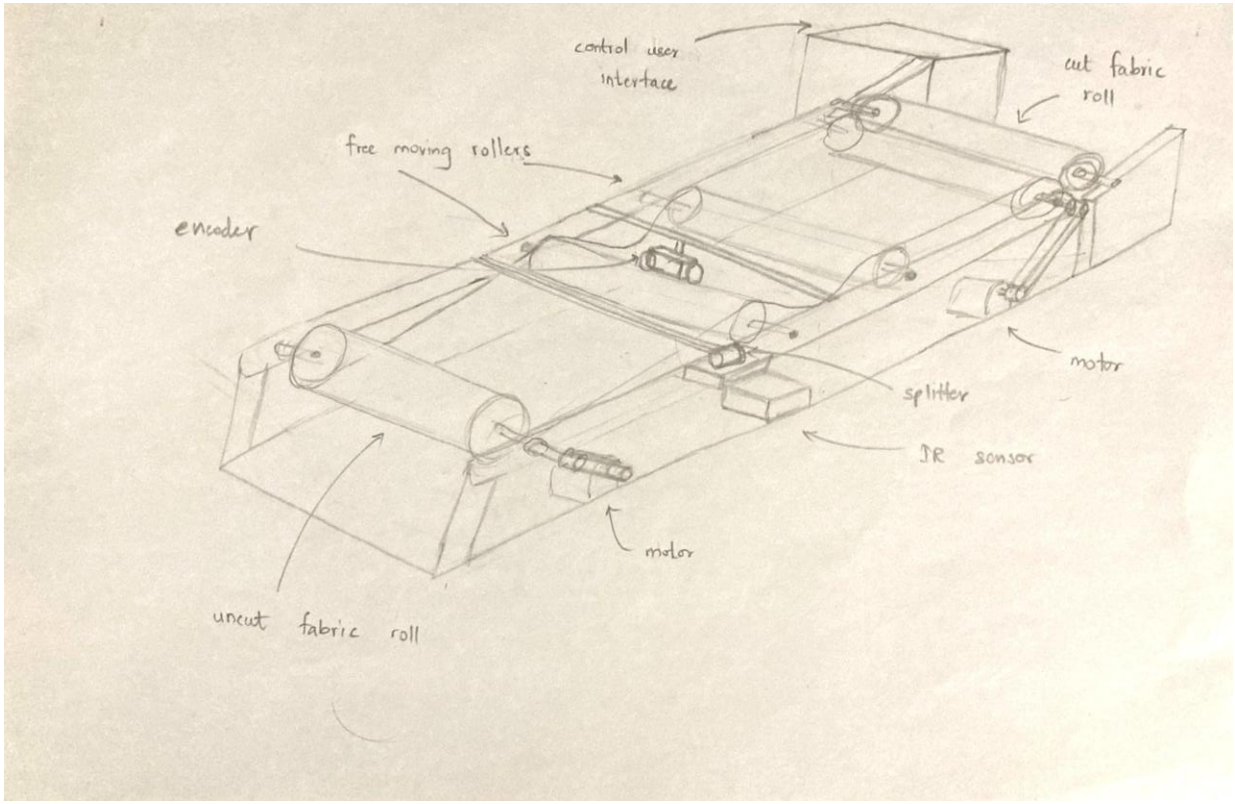
Adhering to these user requirements will ensure that the fabric rolling machine fulfills the needs of textile manufacturers and contributes to their operational efficiency, product quality, and overall competitiveness in the market.

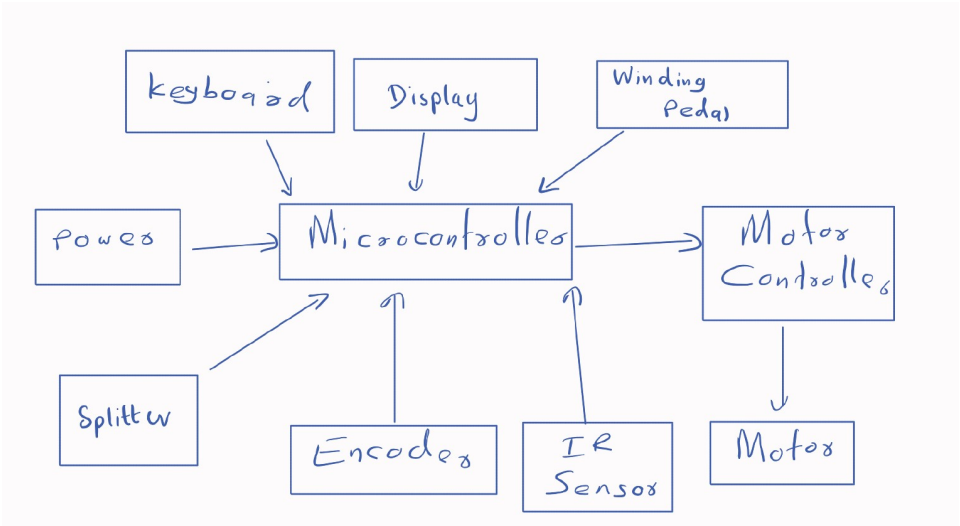
2 Conceptual Design of The Rolling Machine

Our project focuses on developing a controller for an existing fabric rolling machine. While the fabric rolling machine itself already exists, we're tasked with creating a prototype design to facilitate testing and implementation of our controller. As for the controller, we have multiple design ideas which will be explored and discussed in later sections of our project. The following flowchart shows the logical behaviour of our machine.



2.1 Design 1





We have developed the following conceptual design for the fabric rolling machine, incorporating innovative features to meet user requirements:

2.1.1 Sagging Mechanism:

To ensure accurate measurement of fabric length, we have incorporated a sag between the two rollers. This sagging mechanism allows the fabric to relax and reach zero tension before being measured. By eliminating tension, we minimize the risk of fabric distortion and ensure precise length measurement.

2.1.2 Encoder Placement:

The encoder, responsible for measuring the length of fabric, is strategically placed within the low tension area created by the sagging mechanism. This placement ensures that the encoder accurately captures the fabric's length without being affected by tension variations. It enables precise length measurement, enhancing the overall accuracy of the fabric rolling process.

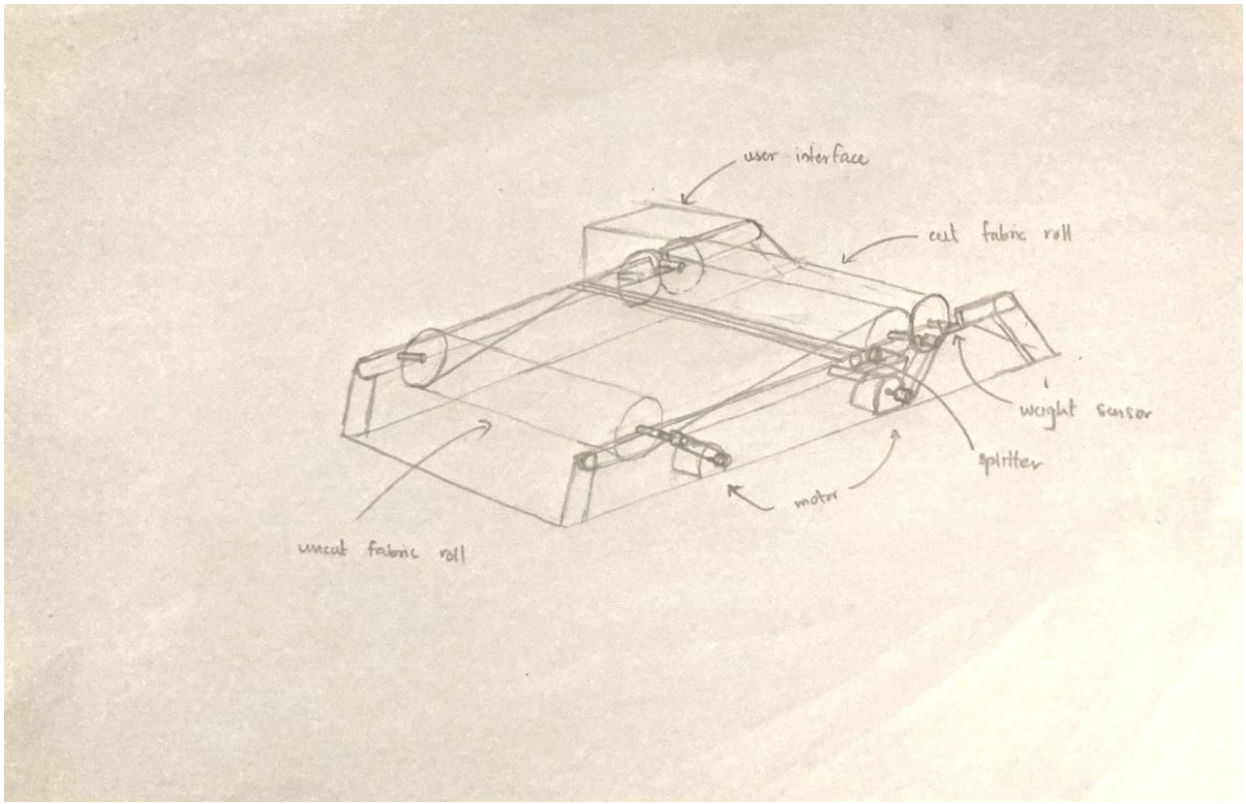
2.1.3 Time-of-Flight (TOF) Sensor:

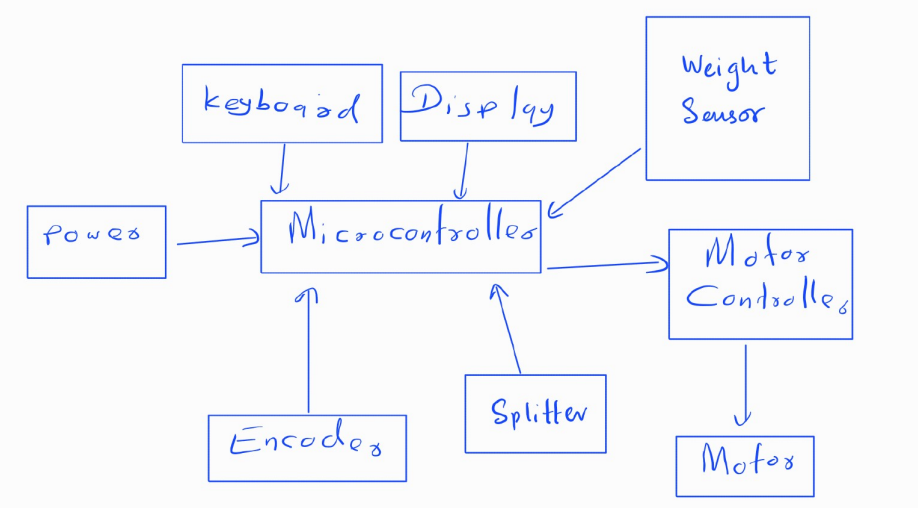
To monitor the height of the sag and maintain it at a constant level, we propose the use of a Time-of-Flight (TOF) sensor. The TOF sensor accurately measures the distance between the fabric surface and the sensor, providing real-time feedback on the sag's height. By continuously monitoring the sag's height, we can adjust the speed of the motors driving the rollers to maintain a consistent sag height, ensuring optimal fabric relaxation and length measurement accuracy.

2.1.4 Motor Speed Adjustment:

Based on the feedback from the TOF sensor, we will implement motor speed adjustment mechanisms to regulate the rollers' rotation speed. By dynamically adjusting the speed of the motors, we can ensure that the sag remains at the desired height, even when processing different fabric types or encountering variations in fabric properties. This adaptive control mechanism enhances the machine's capability to maintain consistent tension levels and achieve accurate fabric length measurement.

2.2 Design 2





We present the following conceptual design for the fabric rolling machine, incorporating innovative features to meet user requirements:

2.2.1 Weight Sensor Integration:

In this design iteration, we propose incorporating a weight sensor into the fabric rolling machine. The weight sensor will measure the weight of the fabric roll as it is being rolled onto the cylinder. This real-time weight measurement provides crucial data for accurately calculating the length of fabric rolled.

2.2.2 Planar Density Input:

Upon activating the fabric rolling machine, the user will be prompted to enter the planar density of the fabric being rolled. Alternatively, users can select a preset fabric from a predefined list. The planar density information is essential for accurately converting fabric weight to length.

2.2.3 Fabric Length Calculation:

Using the weight measurement from the sensor and the entered or selected planar density, the fabric rolling machine will calculate the length of fabric rolled in real-time. The calculation is performed continuously as the fabric is rolled onto the spool.

2.2.4 Automatic Stop and Cut:

Once the calculated length of fabric reaches the desired value entered by the user, the fabric rolling machine will automatically stop the motor and trigger the cutting mechanism. The fabric will be cut using the splitter, ensuring precise and accurate cutting at the specified length.

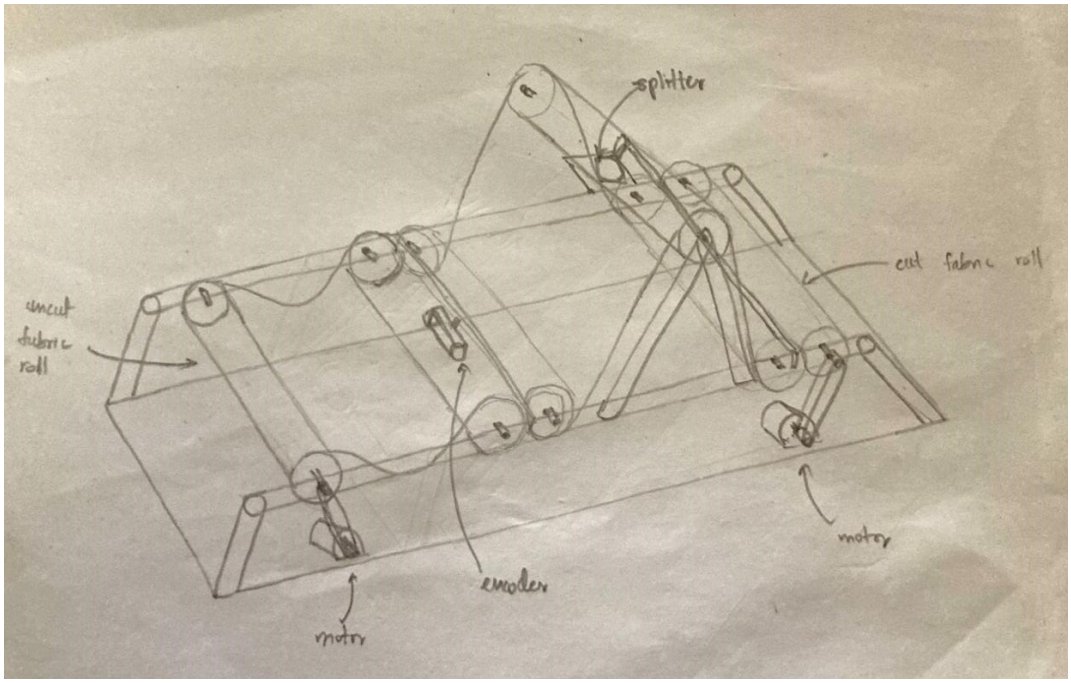
2.2.5 User Interface and Controls:

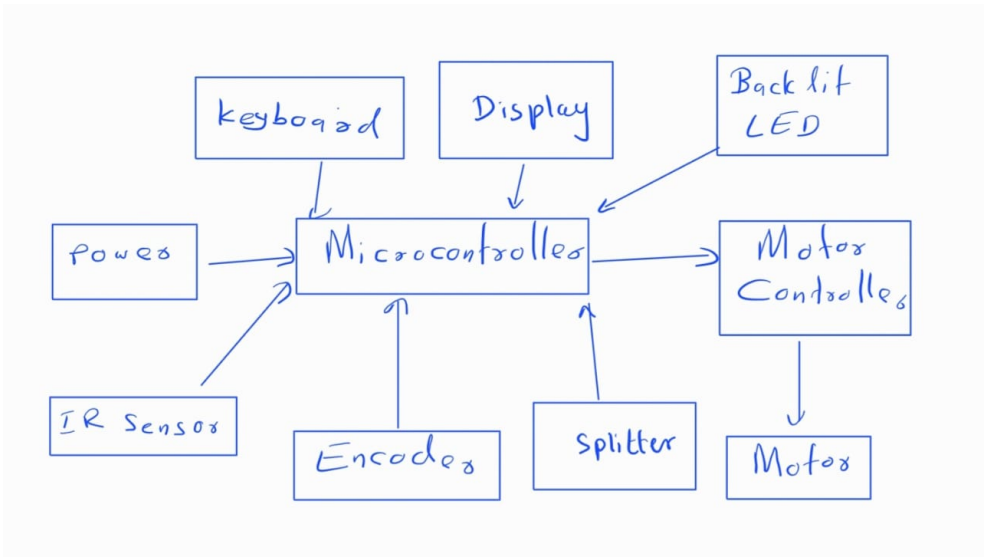
The fabric rolling machine will feature a user-friendly interface with intuitive controls for entering the planar density, selecting preset fabrics, and setting the desired fabric length. Clear prompts and feedback messages will guide users through the operation of the machine, enhancing ease of use and minimizing errors.

2.2.6 Integration and Compatibility:

This design will be seamlessly integrated with the existing components of the fabric rolling machine, including the motor, cutting mechanism, and control system. Compatibility with standard communication protocols and interfaces will ensure interoperability with other machinery and production systems in textile manufacturing environments.

2.3 Design 3





We present the following conceptual design for the fabric rolling machine, which combines features from previous designs and introduces a new element for fabric inspection:

2.3.1 Sagging Mechanism:

Similar to Design 1, this design incorporates a sag between the two rollers to ensure accurate measurement of fabric length. The sagging mechanism allows the fabric to relax and reach zero tension before being measured, minimizing the risk of distortion and ensuring precise length measurement.

2.3.2 Frame Design for Fabric Inspection:

In this iteration, the frame of the fabric rolling machine is specifically designed to facilitate fabric inspection. The frame features adjustable lighting and magnification options to enhance visibility and allow operators to inspect the fabric for defects, inconsistencies, or irregularities during the rolling process. This feature enhances quality control and ensures that only defect-free fabric is rolled onto the spool.

2.3.3 Integration of Sag and Inspection Features:

The sagging mechanism and fabric inspection features are seamlessly integrated into the overall design of the fabric rolling machine. The adjustable frame allows operators to position the fabric for inspection while ensuring that the sag remains consistent for accurate length measurement. This integration maximizes the efficiency and effectiveness of fabric inspection without compromising on the accuracy of length measurement.

2.3.4 User Interface and Controls:

The fabric rolling machine features a user-friendly interface with intuitive controls for adjusting lighting, magnification, and other inspection parameters. Operators can easily navigate the interface to customize inspection settings according to their specific requirements. Clear prompts and feedback messages guide users through the inspection process, enhancing usability and minimizing errors.

By incorporating these innovative features into our conceptual design, we aim to develop a fabric rolling machine that offers precise length measurement, efficient operation, and enhanced fabric inspection capabilities, ultimately improving productivity and quality in textile manufacturing processes.

3 Evaluation of the designs

Table 1: Comparison of Features in Design 1, Design 2, and Design 3

Feature	**Design 1**	**Design 2**	**Design 3**
Sagging Mechanism	Incorporates a sag between the two rollers to ensure accurate measurement of fabric length.		Retains the sagging mechanism from Design 1 and introduces a frame design for easy fabric inspection.
Weight Sensor Integration		Introduces a weight sensor to measure the weight of the fabric roll for accurate length calculation.	
Encoder Placement	Encoder placed within the low tension area created by the sagging mechanism for accurate length measurement.	Encoder not needed to measure length of fabric.	Encoder placed in low Tension area.
Time-of-Flight (TOF) Sensor	Utilizes a TOF sensor to monitor the height of the sag and maintain it at a constant level.		
Motor Speed Adjustment	Adjusts motor speed based on TOF sensor feedback to maintain consistent sag height and ensure accurate length measurement.		
Automatic Stop and Cut	Automatically stops the motor and triggers the cutting mechanism when the desired fabric length is reached.	Retains the automatic stop and cut feature from Design 1.	
User Interface and Controls		Features a user-friendly interface with intuitive controls for entering fabric planar density, selecting preset fabrics, and setting desired length.	Features a user-friendly interface with controls for adjusting lighting, magnification, and other inspection parameters.

Continued on next page

Table 1 – Continued from previous page

Feature	**Design 1**	**Design 2**	**Design 3**
Frame Design for Fabric Inspection			Incorporates a frame design specifically for fabric inspection, with adjustable lighting and magnification options.
Integration of Sag and Inspection Features			Seamlessly integrates the sagging mechanism with the fabric inspection features to maximize efficiency and effectiveness.
Compatibility and Adaptability			Ensures compatibility and adaptability with existing fabric rolling machine components and systems.

Table 2: Enclosure Design Criteria Comparison

Criteria	**Design 1**	**Design 2**	**Design 3**
Functionality	8	7	8
Aesthetics	9	7	9
Heat dissipation	9	8	9
Assembly and serviceability	8	7	8
Ergonomics	8	9	9
Simplicity	9	7	7
Durability	9	8	9
Total	60	53	59

4 Final Design

Design 1 is selected as the final design for several compelling reasons:

1. **Accuracy and Precision**: The incorporation of a sagging mechanism between the two rollers ensures that the fabric remains in a low tension area, allowing for precise measurement of fabric length. This feature is crucial for industries requiring accurate cutting and measurement of fabric, such as garment manufacturing and wholesale distribution.

2. **Innovative Sensor Integration**: Design 1 utilizes a Time-of-Flight (TOF) sensor to monitor the height of the sag and maintain it at a constant level. This integration of advanced sensor technology ensures consistent performance and reliable measurements, enhancing the overall functionality of the fabric rolling machine.

3. **Automatic Stop and Cut Feature**: The inclusion of an automatic stop and cut feature in Design 1 further enhances its usability and efficiency. Once the desired fabric length is reached, the machine automatically stops the motor and triggers the cutting mechanism, streamlining the fabric rolling process and reducing the need for manual intervention.

4. **User-Centric Approach**: Design 1 prioritizes user experience by focusing on functionality and ease of operation. The intuitive design allows for straightforward operation, minimizing the learning curve for operators and reducing the likelihood of errors during fabric rolling.

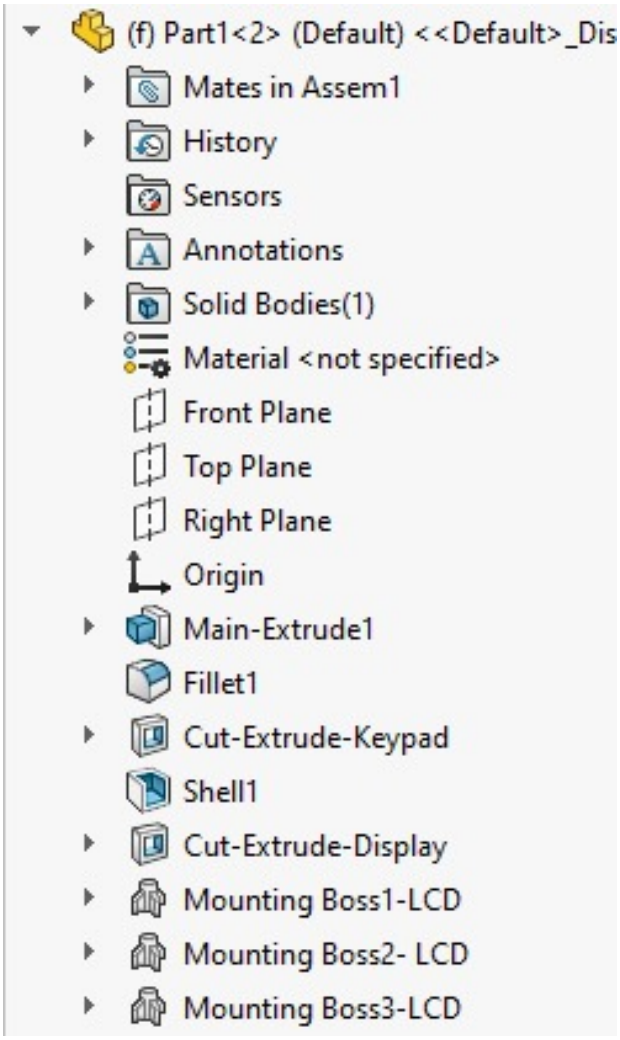
5. **Durability and Reliability**: With a sturdy construction and reliable components, Design 1 is built to withstand the rigors of industrial use. Its robust design ensures long-term durability, reducing maintenance costs and downtime associated with frequent repairs.

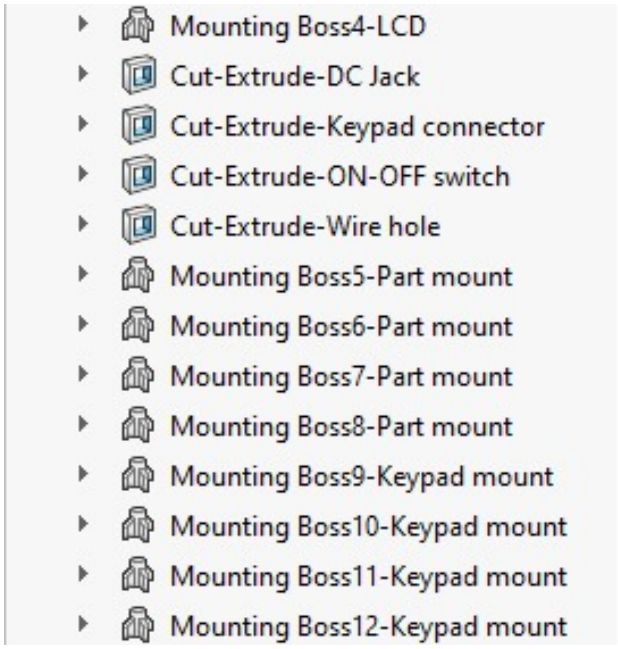
6. **Cost-Effectiveness**: Despite its advanced features and innovative technology, Design 1 remains cost-effective compared to alternative solutions. Its efficient design and reliable performance offer excellent value for money, making it an attractive option for businesses seeking high-quality fabric rolling machines within budget constraints.

Overall, Design 1 stands out as the optimal choice for fabric rolling applications due to its combination of accuracy, efficiency, user-friendliness, durability, and cost-effectiveness. Its innovative features and user-centric design make it well-suited for various industries requiring precise fabric measurement and cutting, ultimately contributing to improved productivity and operational efficiency.

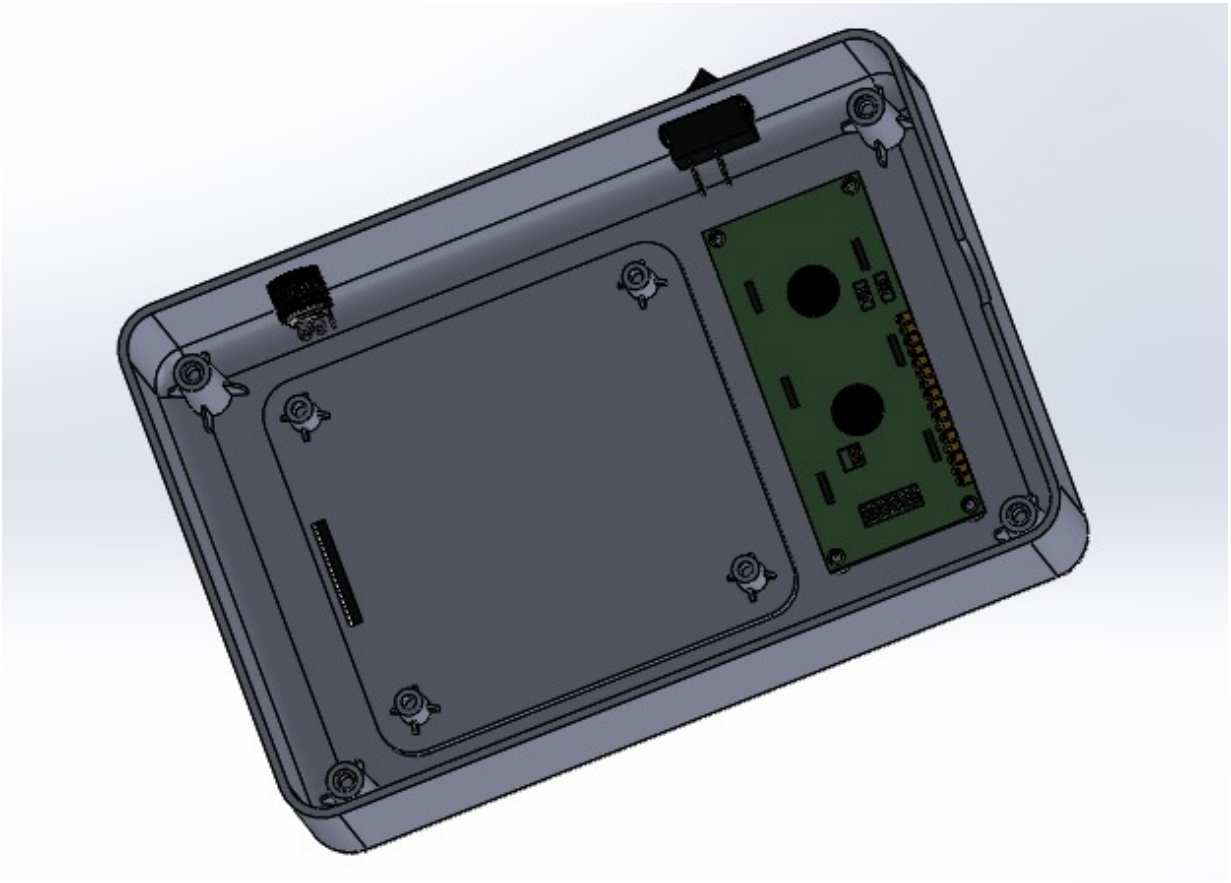
5 Final Solidworks design

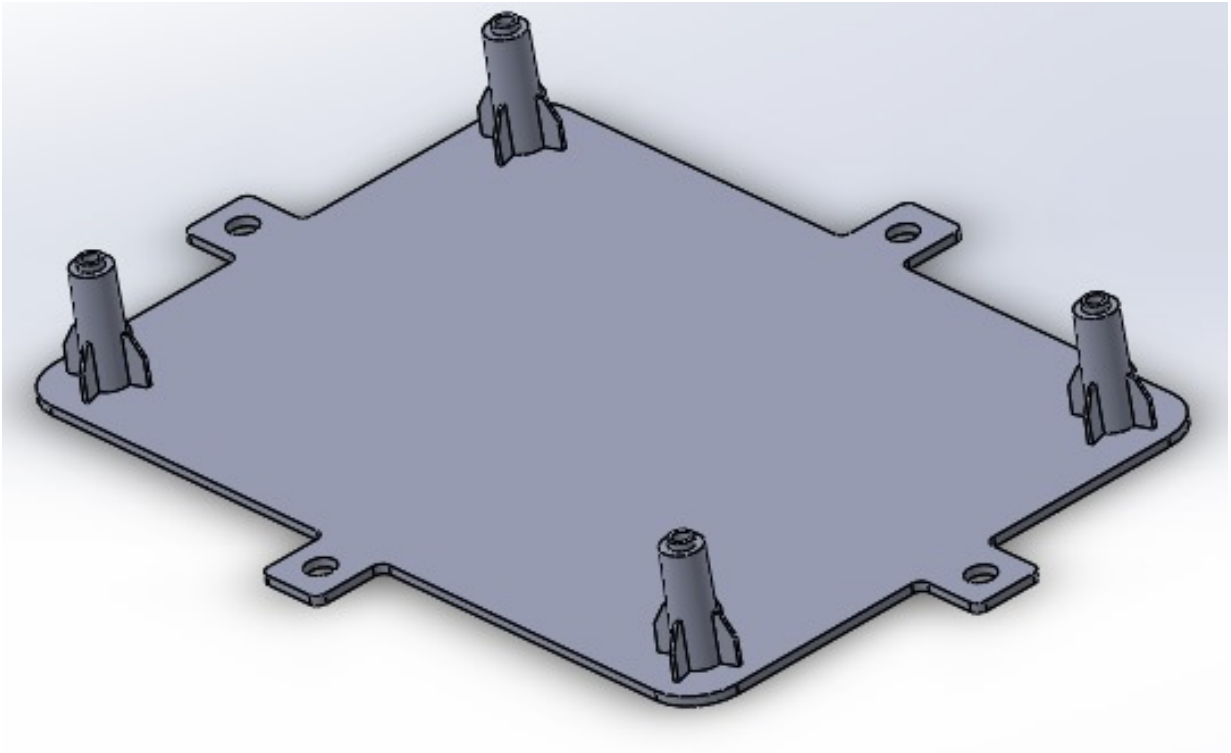
5.1 Feature tree of the design



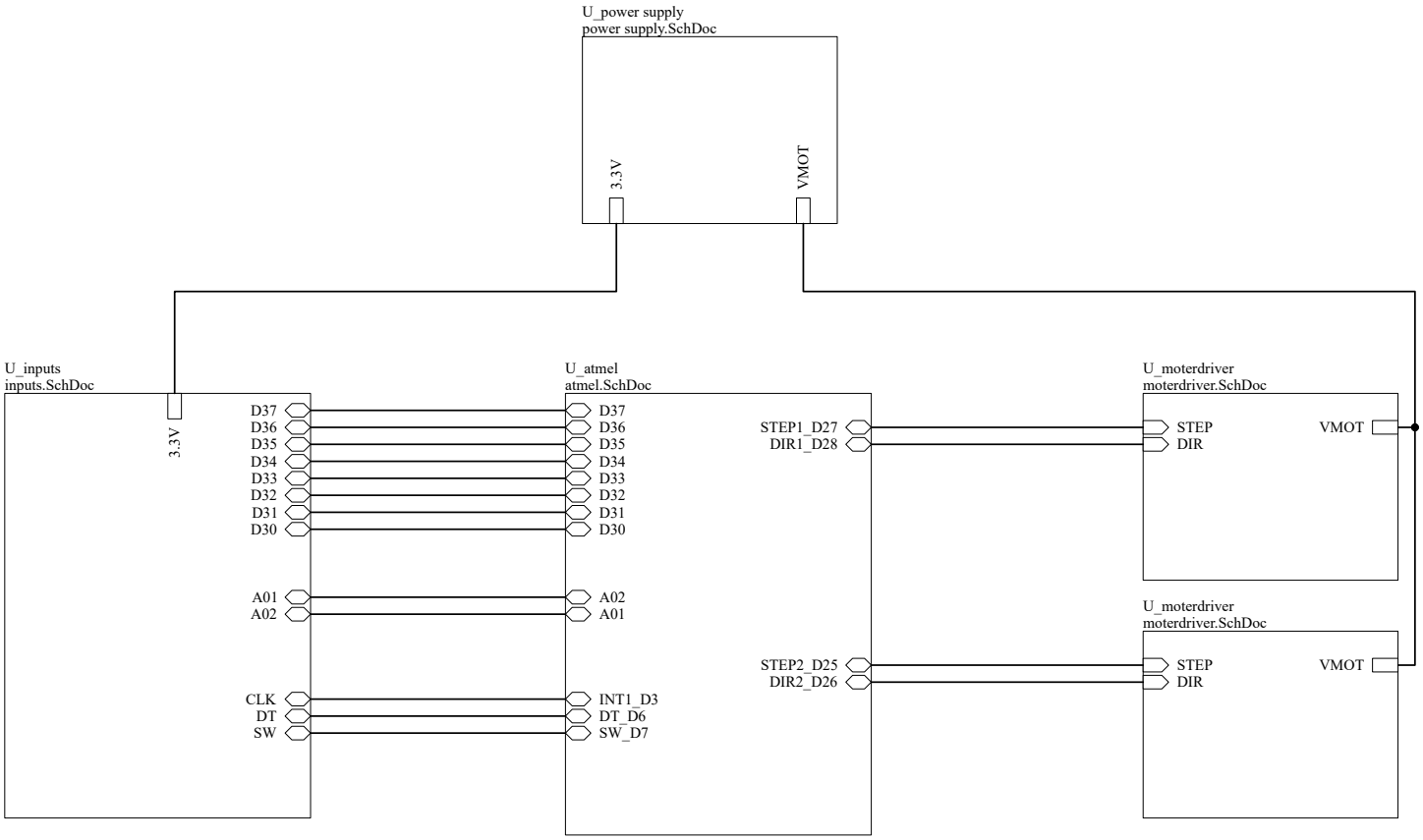


5.2 Images of the design





6 PCB Design and Schematics



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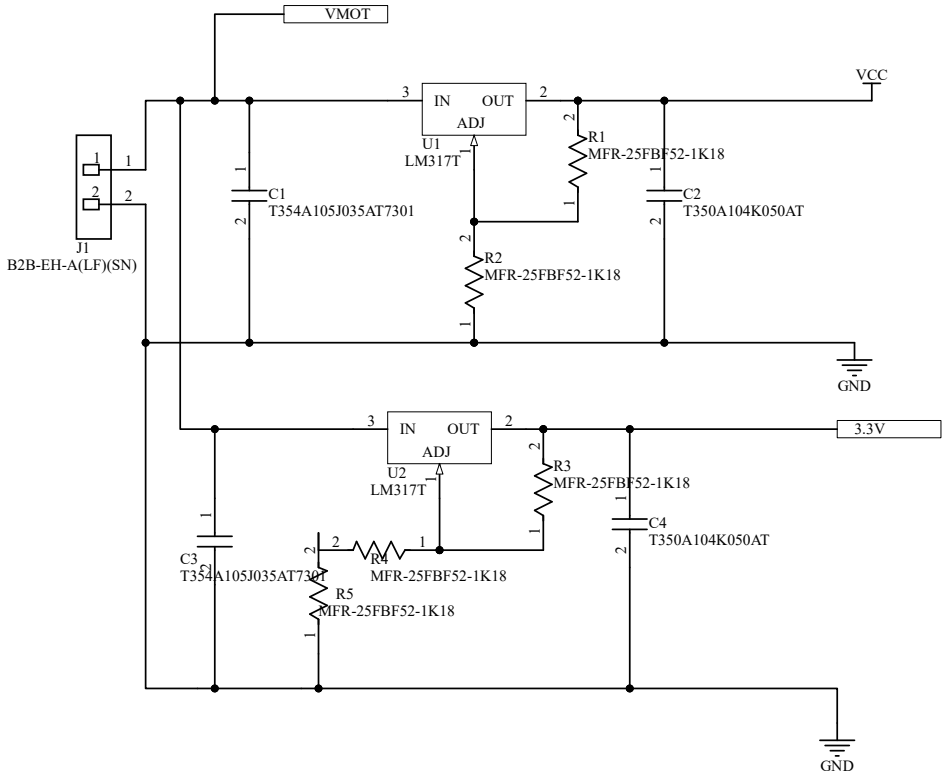

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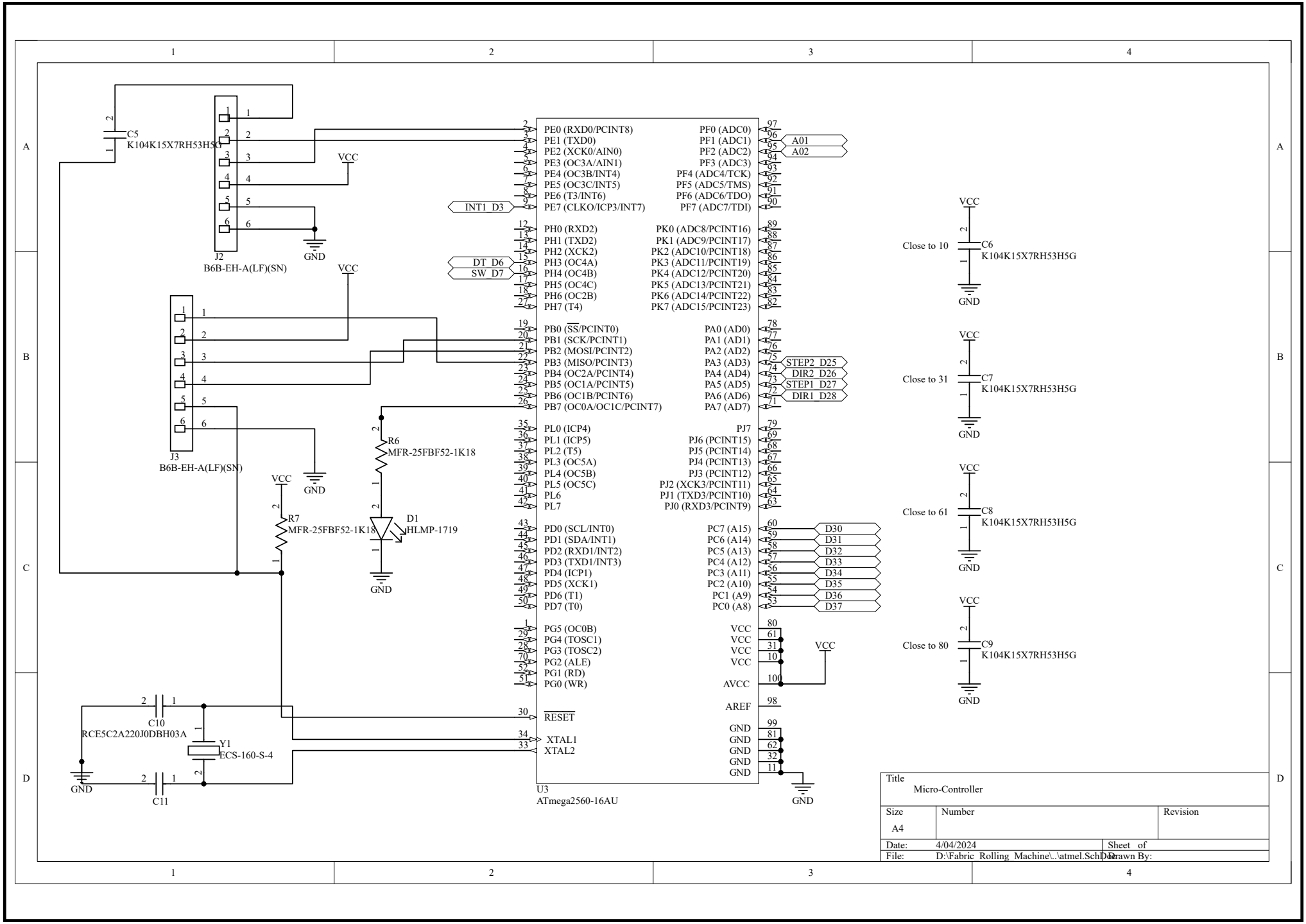
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R7
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Y1
ECS-160-S-4
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SW_D7
A01
A02
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DIR2_D26
STEP1_D27
DIR1_D28
D30
D31
D32
D33
D34
D35
D36
D37
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PE3 (OC3A/AIN1)
PE4 (OC3B/INT4)
PE5 (OC3C/INT5)
PE6 (T3/INT6)
PE7 (CLKO/ICP3/INT7)
PH0 (RXD2)
PH1 (TXD2)
PH2 (XCK2)
PH3 (OC4A)
PH4 (OC4B)
PH5 (OC4C)
PH6 (OC2B)
PH7 (T4)
PB0 (SS/PCINT0)
PB1 (SCK/PCINT1)
PB2 (MOSI/PCINT2)
PB3 (MISO/PCINT3)
PB4 (OC2A/PCINT4)
PB5 (OC1A/PCINT5)
PB6 (OC1B/PCINT6)
PB7 (OC0A/OC1C/PCINT7)
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PL1 (ICP5)
PL2 (T5)
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PL4 (OC5B)
PL5 (OC5C)
PL6
PL7
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PD1 (SDA/INT1)
PD2 (RXD1/INT2)
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PG3 (TOSC2)
PG2 (ALE)
PG1 (RD)
PG0 (WR)
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XTAL2
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PF2 (ADC2)
PF3 (ADC3)
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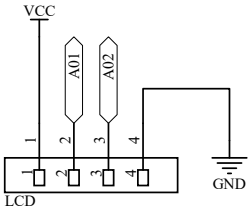

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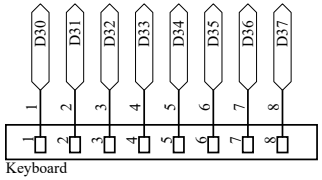

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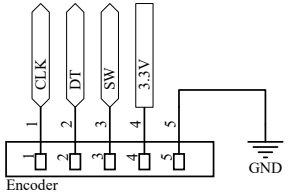

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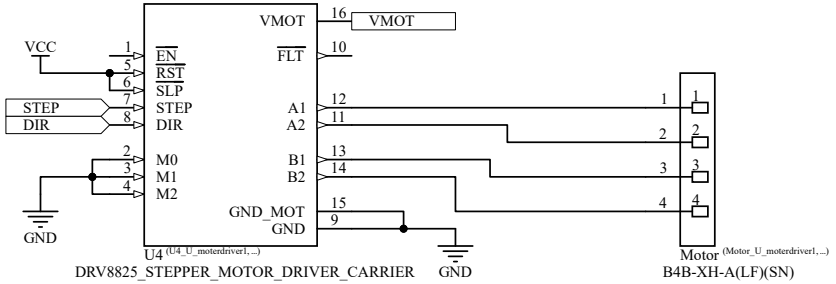

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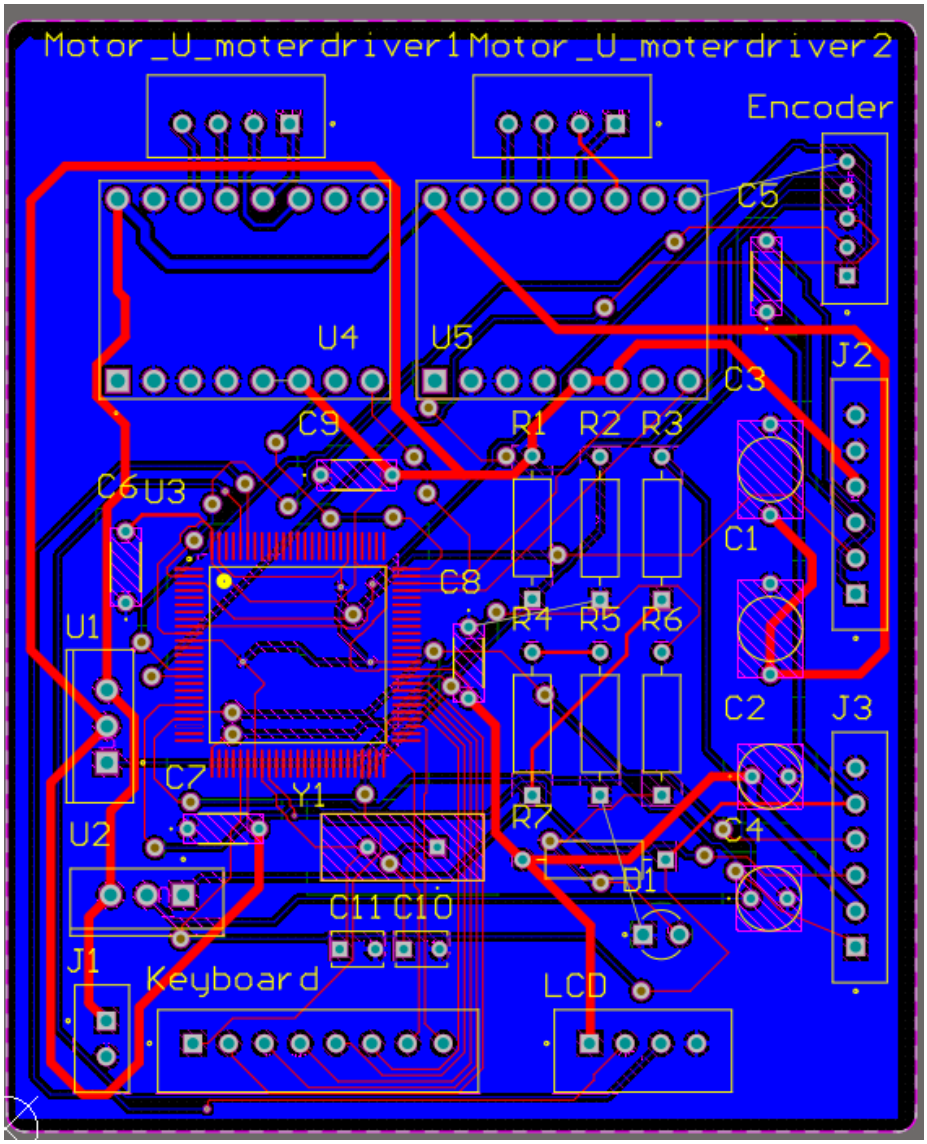
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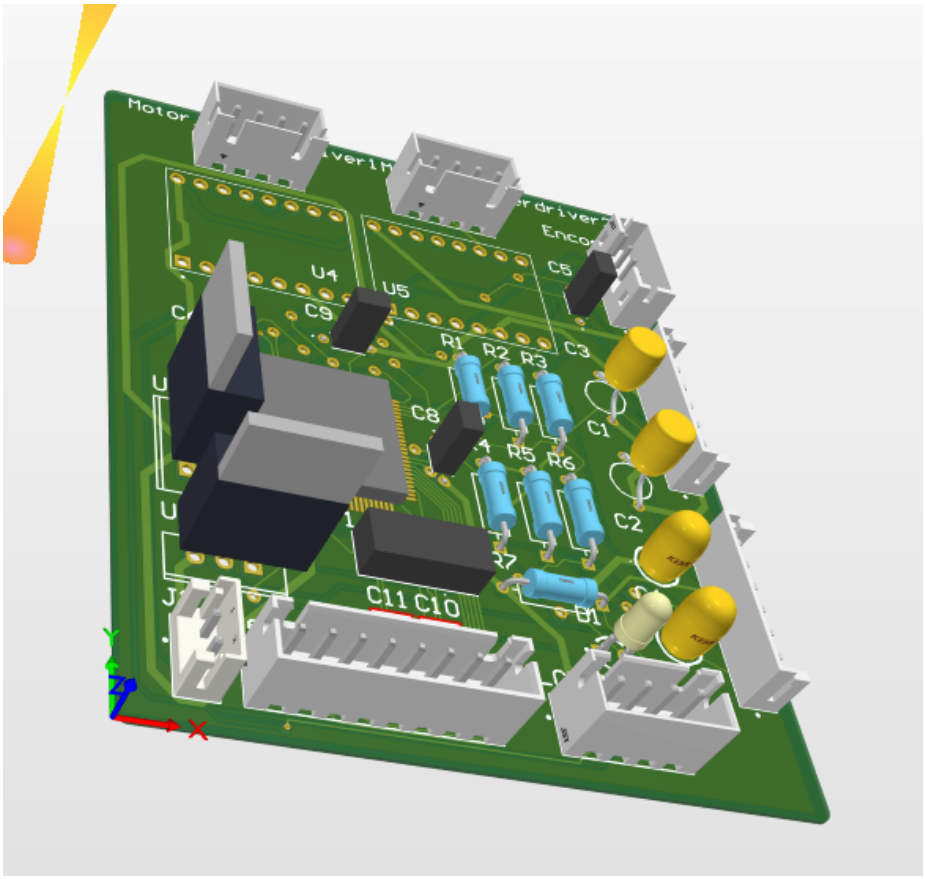
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