Department of Electronics and Telecommunication Engineering
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EN2160 - Electronic Design Realization

Product Sorting Conveyor Belt
Design Methodology

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Abstract

This report highlights the progress and future plans for the development of a Product Sorting Conveyor Belt employing Computer Vision technology. Significant milestones achieved include thorough research, conceptualization, and finalization of design. The chosen design utilizes real-time image capture for product dimension extraction via computer vision. Technical feasibility, system workflow, and stakeholder mapping have been carefully considered. Moving forward, the focus lies on prototype development, software design, testing, integration, and documentation. User requirements have been identified, leading to the selection of a suitable conceptual design. The report concludes with the evaluation of designs and the presentation of the final SolidWork design, schematics, and PCB layout.

Introduction

In today's dynamic industrial landscape, efficient product sorting systems are imperative for streamlining operations and maximizing productivity. The project at hand, the Product Sorting Conveyor Belt employing Computer Vision, addresses this need by leveraging cutting-edge technology to enhance sorting processes. Since its inception, the project has made significant strides, progressing from thorough research to the finalization of a design concept. By identifying key stakeholders and their respective roles, the project ensures alignment with end-user expectations and industry requirements. The subsequent sections of this report delve into the project's progression, outlining achieved milestones and proposing future steps for prototype development, software implementation, testing, and integration. Additionally, the report provides insights into user requirements, conceptual designs, evaluation criteria, and the final SolidWork design, schematics, and PCB layout. Through meticulous planning and execution, the project aims to deliver a robust and efficient product sorting solution tailored to industry needs.

1. Review Progress

Since the inception of the project, significant progress has been made in research, conceptualizing and finalizing the design for the Product Sorting Conveyor Belt utilizing Computer Vision. Key achievements include:

Research: By identifying similar products in the industry, it was quite evident how important this project is. In various industries which handles products, there are many levels of sorting based on different criteria as well. This video provides a greater insight to that.

- Product Focus: Sortation Conveyor by Hytrol
  (Link - https://www.youtube.com/watch?v=lsVCGXX6Tc8&t=45s)

Product Sorting based on dimensions is in fact one of the important methods of sorting. It can not only be used in several levels to sort products out but also to remove faulty products as well. With that background as the next step conceptual designs were built.

Conceptual Design: Several conceptual designs were explored, and one has been finalized. This design leverages real-time image capture of products on the conveyor belt, utilizing computer vision to extract dimensions.

Technical Feasibility: The feasibility of the chosen design has been evaluated, considering factors such as image capture capabilities, wireless data transfer, machine learning algorithm implementation, and mechanical arm operability.

System Workflow: A clear workflow has been established, wherein real-time images are transmitted to a server computer via Wi-Fi, processed using machine learning algorithms to determine dimensions, and subsequently, instructions are sent back to a microcontroller to operate a mechanical arm for sorting.

2. Planning Next Steps

Moving forward, the following steps are proposed to advance the project:

Prototype Development: Initiate the development of a prototype system based on the finalized design. This involves integrating components such as cameras, microcontrollers, Wi-Fi modules, and a mechanical arm.

Software Development: Develop software modules for image processing, machine learning algorithm implementation, and communication protocols between the server computer and microcontroller. (Already tested algorithm to get dimensions using the webcam)

Schematic and PCB Design: Building the main schematics required using Altium and designing a functioning PCB.

Testing and Optimization: Conduct rigorous testing to ensure the accuracy and efficiency of the system. Optimize algorithms and parameters for better performance.

Enclosure: Enclosure design will include building the control box, an arm for the overhead camera and a mechanical arm to sort the products.

Integration and Validation: Integrating the PCB and the enclosure components together and running the final tests and ensuring it’s in proper standard for the demonstrations.

Documentation: Continuously document the progress, challenges faced, and solutions implemented throughout the development phase for future reference and knowledge sharing.

3. Stakeholder Map

Identifying and understanding stakeholders is crucial for the success of the project. The key stakeholders involved in the Product Sorting Conveyor Belt project include:

End Users: Operators and personnel responsible for managing and monitoring the conveyor belt system in industrial settings.

Customers: Companies or organizations investing in or utilizing the product sorting conveyor belt system for their manufacturing or logistics operations.

4. Observe Users

Observing end users in real-world scenarios will provide valuable insights into their needs, challenges, and preferences. Key areas for observation include:

User Interaction: How operators interact with the conveyor belt system, including loading/unloading products, monitoring operations, and resolving issues.

Efficiency and Ergonomics: Assess the efficiency of the system in sorting products accurately and timely. Evaluate ergonomic factors such as ease of use, accessibility, and safety.

Feedback and Suggestions: Gather feedback from users regarding the functionality, usability, and performance of the system. Incorporate user suggestions for continuous improvement.

5. User Requirements

In various industries that involve product management conveyor belts are a key component. There are many methods used to sort out these products while travelling on the conveyor belt. There are complex mechanisms to sort out products based on their size, color, material etc. After some thorough research it was clear that sorting based on the size (dimensions) is one of the important methods in the industry. The main requirements for the above project are as follows:

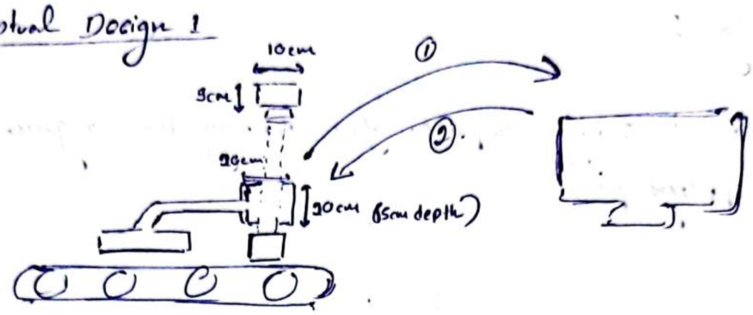
- An overhead cam over the conveyor belt to get real time images of the products.
- A procedure to figure out their dimensions.
- A mechanical arm that should be activated and push the product if the dimensions are within a given range.

Based on above requirements 3 conceptual designs were made.

6. Conceptual Designs

Conceptual Design 1 (Server Computer):

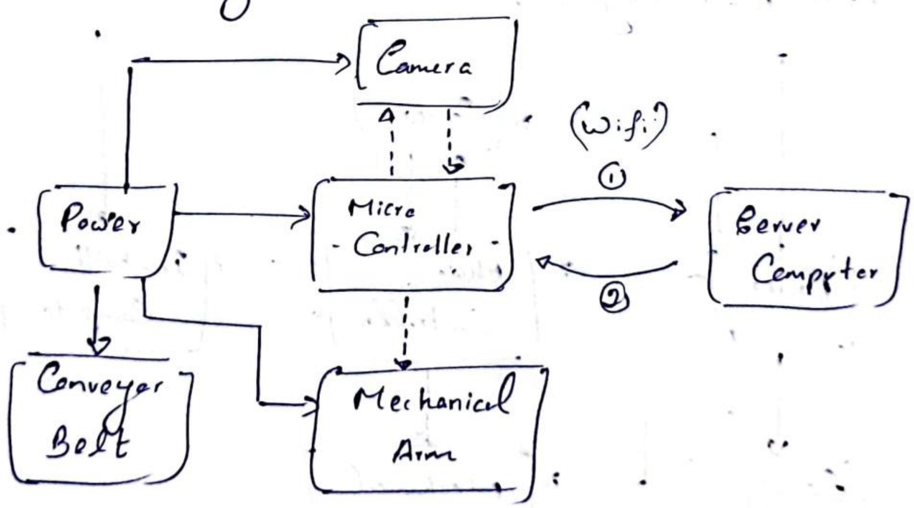
Conceptual Design 1



①. Sending captured images to the server computer to run machine learning algorithm. and get the dimensions. (over Wifi).

②. Sending the dimensions back to the micro-controller. (over wifi)

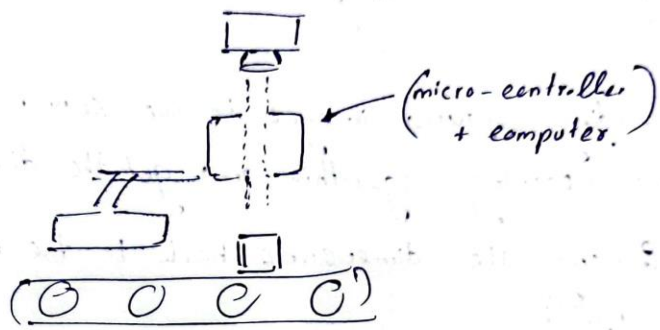
Functional Block Diagram :-



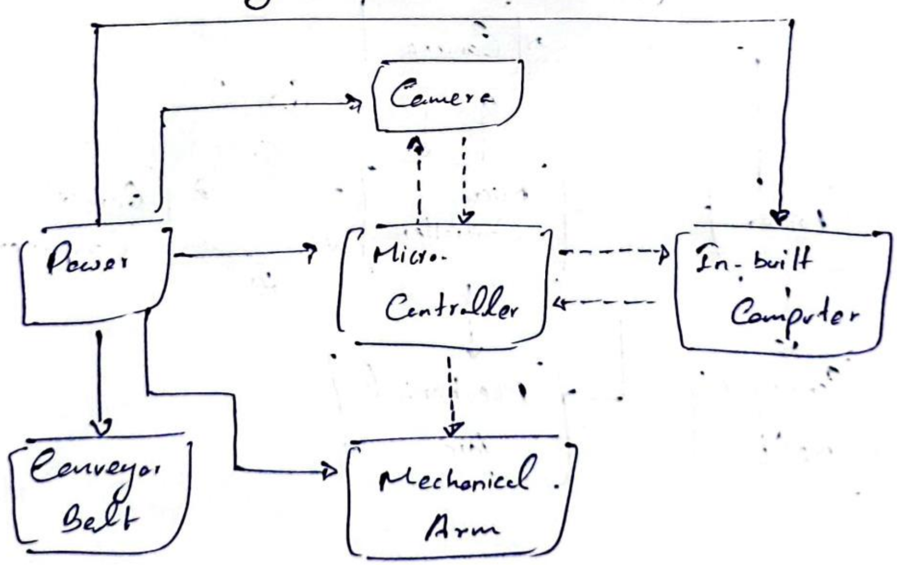
Conceptual Design 2 (In-built Computer):

Conceptual Design 2

* Using a inbuilt server computer for running the algorithm.
(such as raspberry pi)

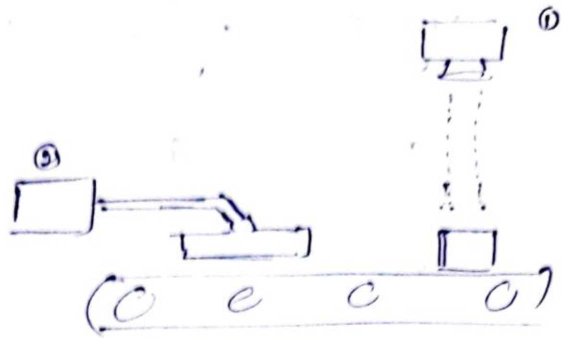


Functional Block Diagram :-



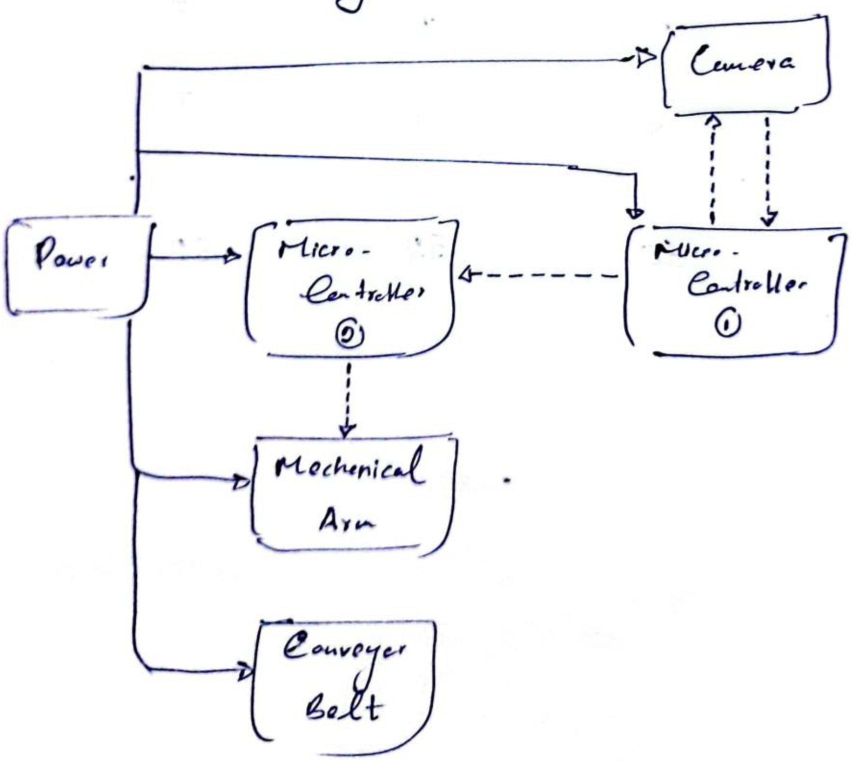
Conceptual Design 3 (Dual Micro-Processor):

Conceptual Design 3



* Two micro controllers :
  1. For capturing image & running the algorithm.
  2. Mechanical arm.

Functional Block Diagram :-



7. Evaluation of the Designs

Evaluation Criteria	Conceptual Design 1	Conceptual Design 2	Conceptual Design 3
Functionality	9	8	7
Simplicity	8	7	7
Durability	9	8	8
Maintenance	9	7	8
User Experience	9	8	8
Cost (Less)	8	7	7
Power (Less)	8	7	7
Total	**60**	**52**	**52**

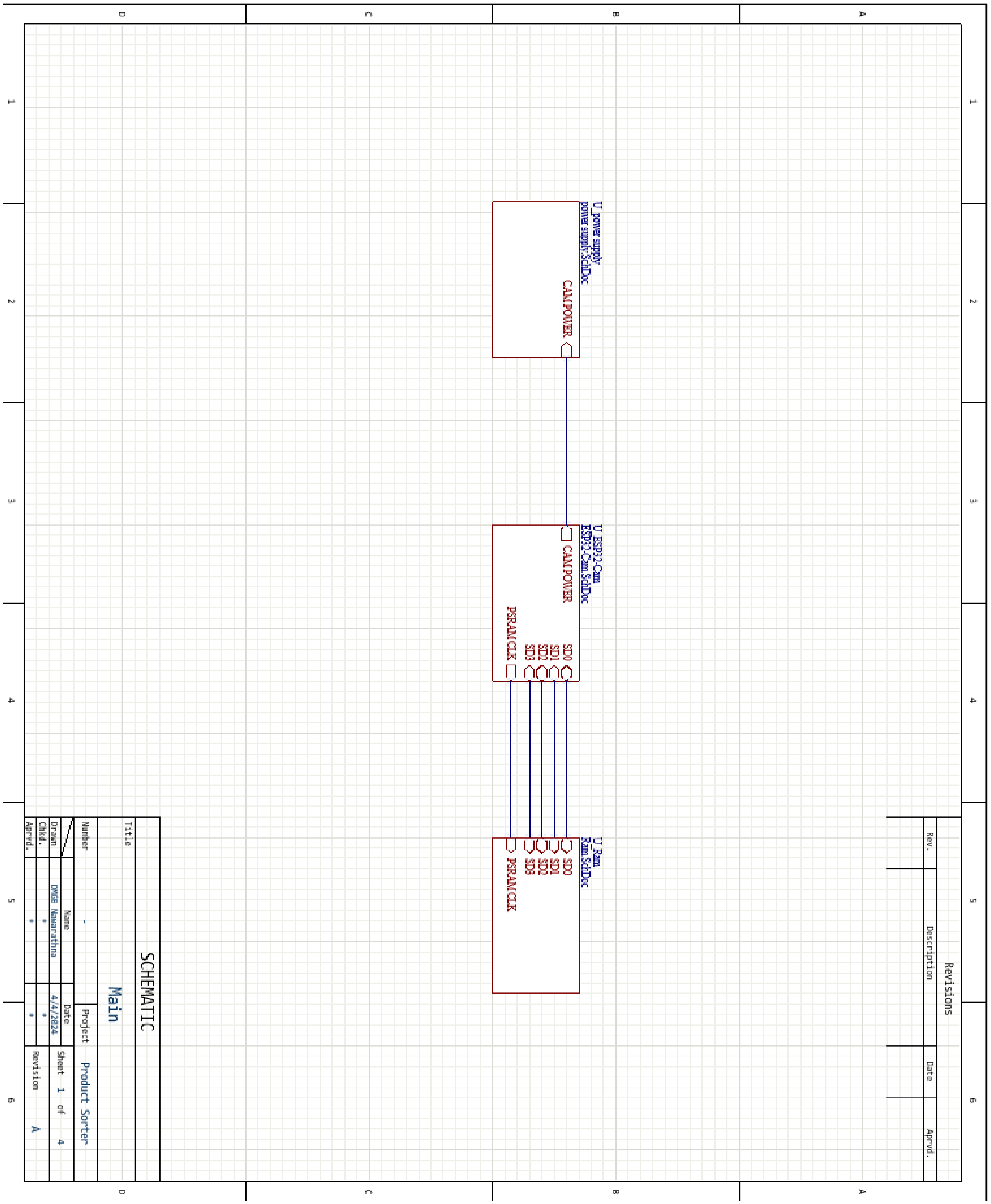
The first design got the best score out of the evaluation. Few main reasons for that are explained below:

- Simplicity: Out of all the 3 designs it has the minimal components and the component density is low as well which is ideal for the design process.
- Cost: Since it doesn't require any in-built computers and has lesser components, it is far more cost effective as well.
- Power: Since the machine learning algorithm is running on a separate server computer the power will be saved. The additional power consumed will be for the Wi-Fi but compared to in-built computers or dual micro-processors it is far more efficient.

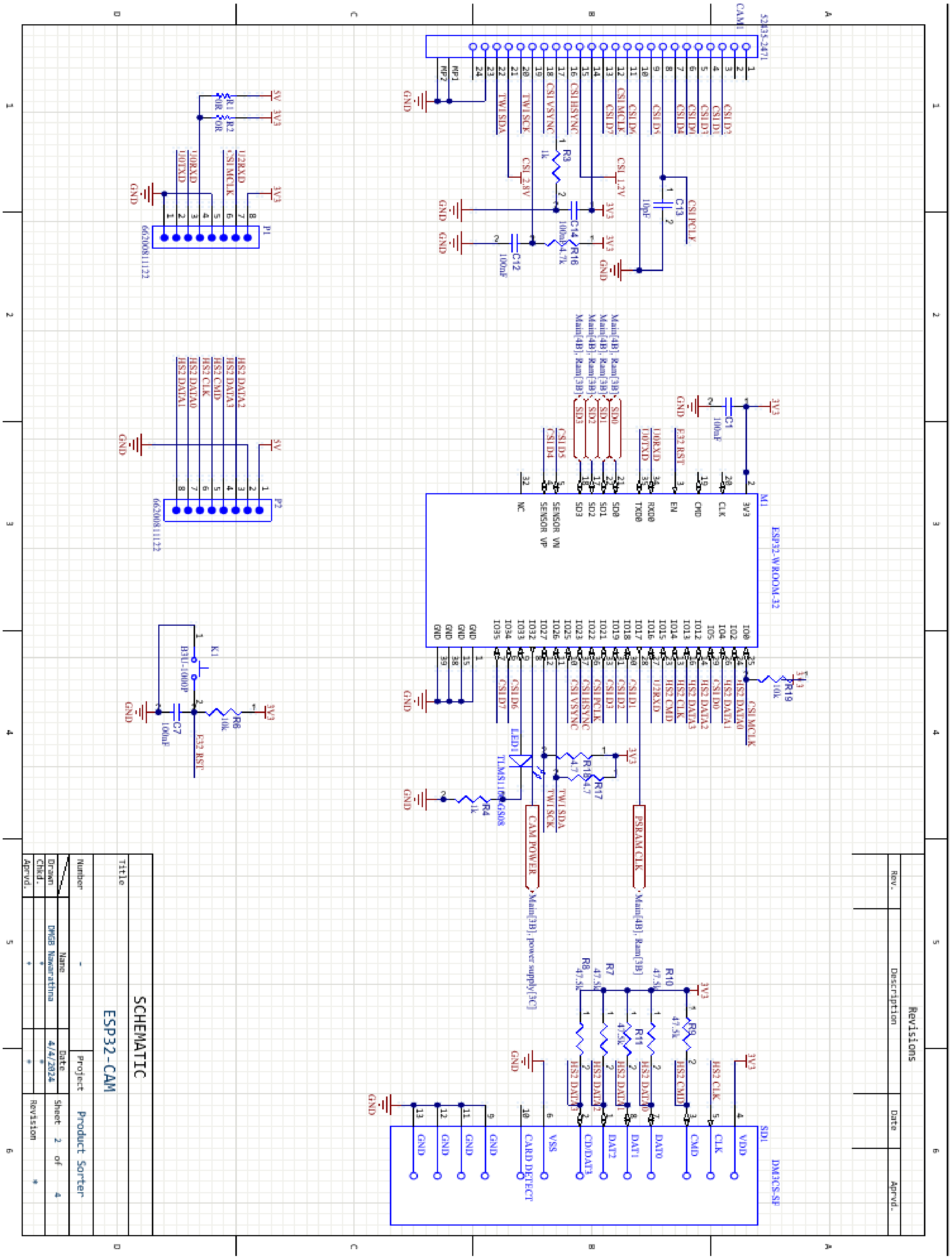
Therefore, based on the above results **Conceptual Design 1** was selected as the design to go forward. As the next steps the SolidWork design, the schematics and the PCB design are made.

8. Final Schematics

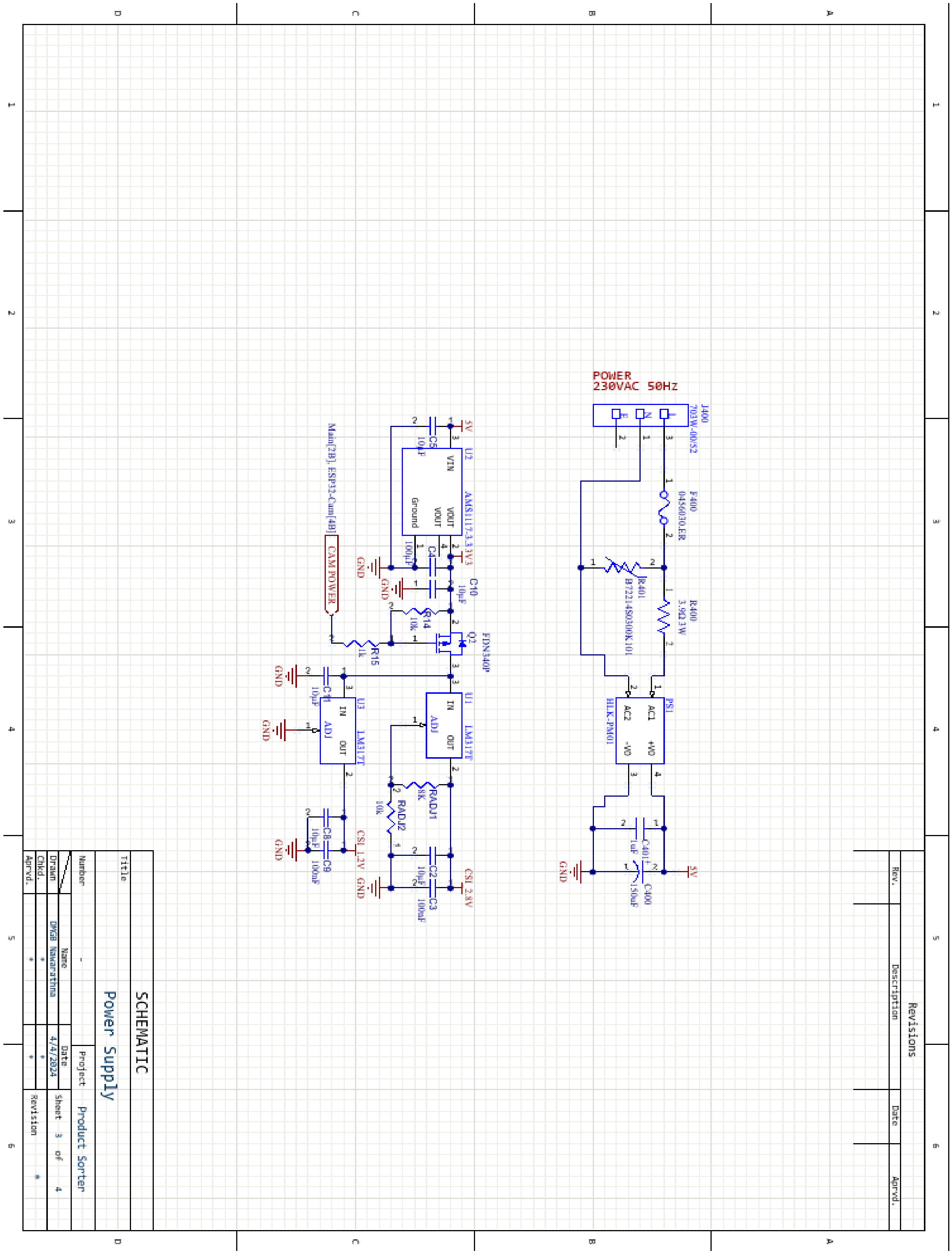
Main:



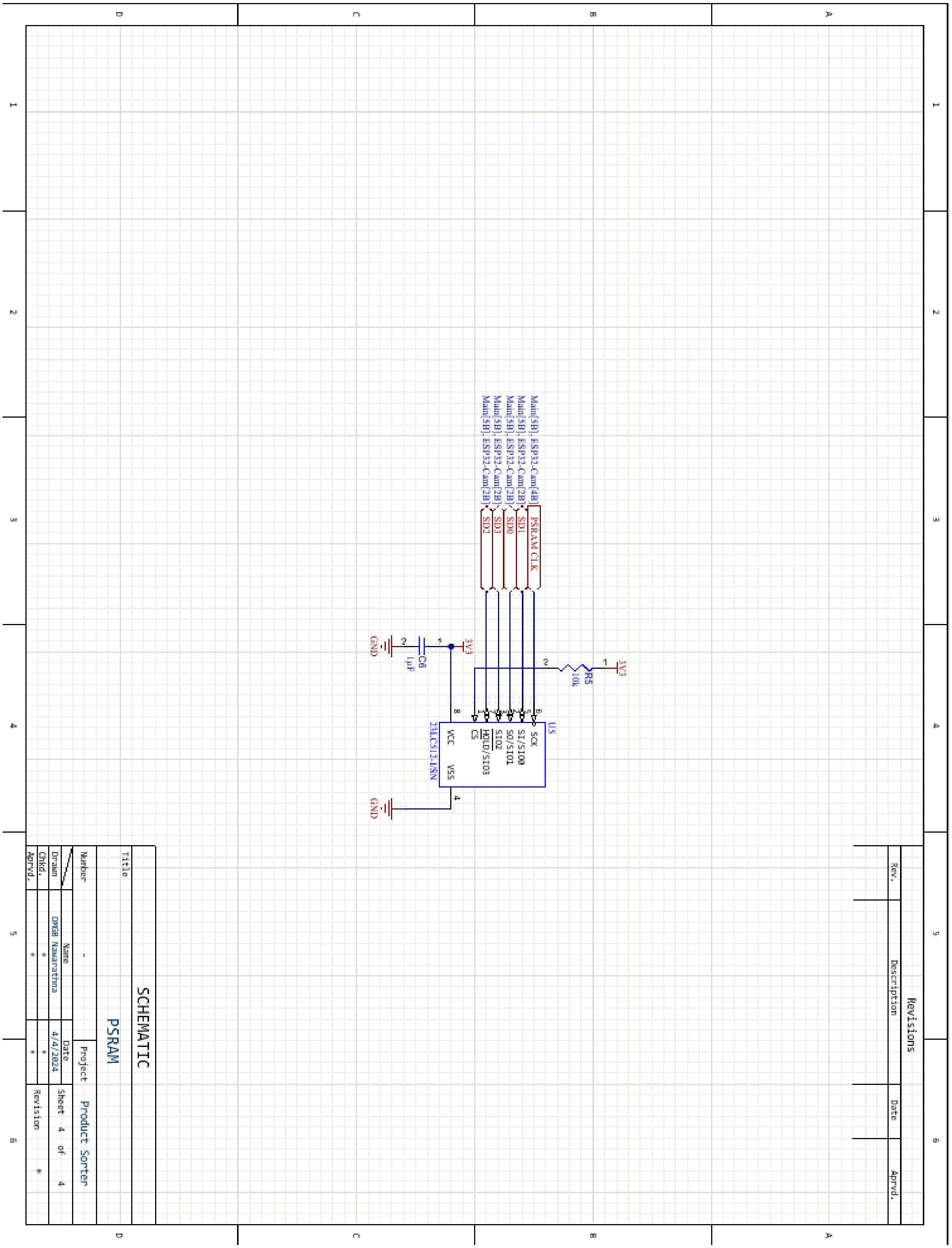
ESP32-Cam Module:



Power Supply:

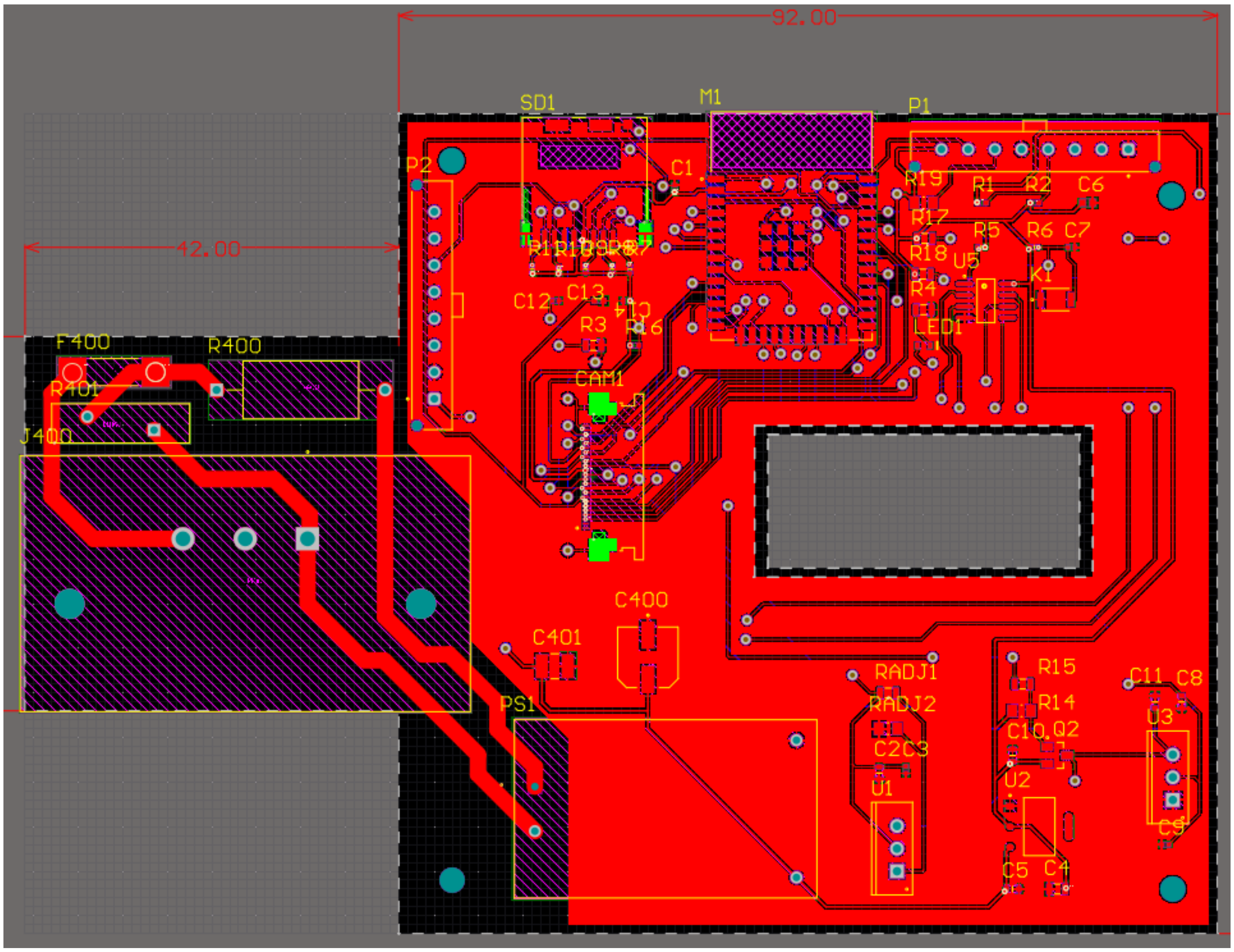


PSRAM:

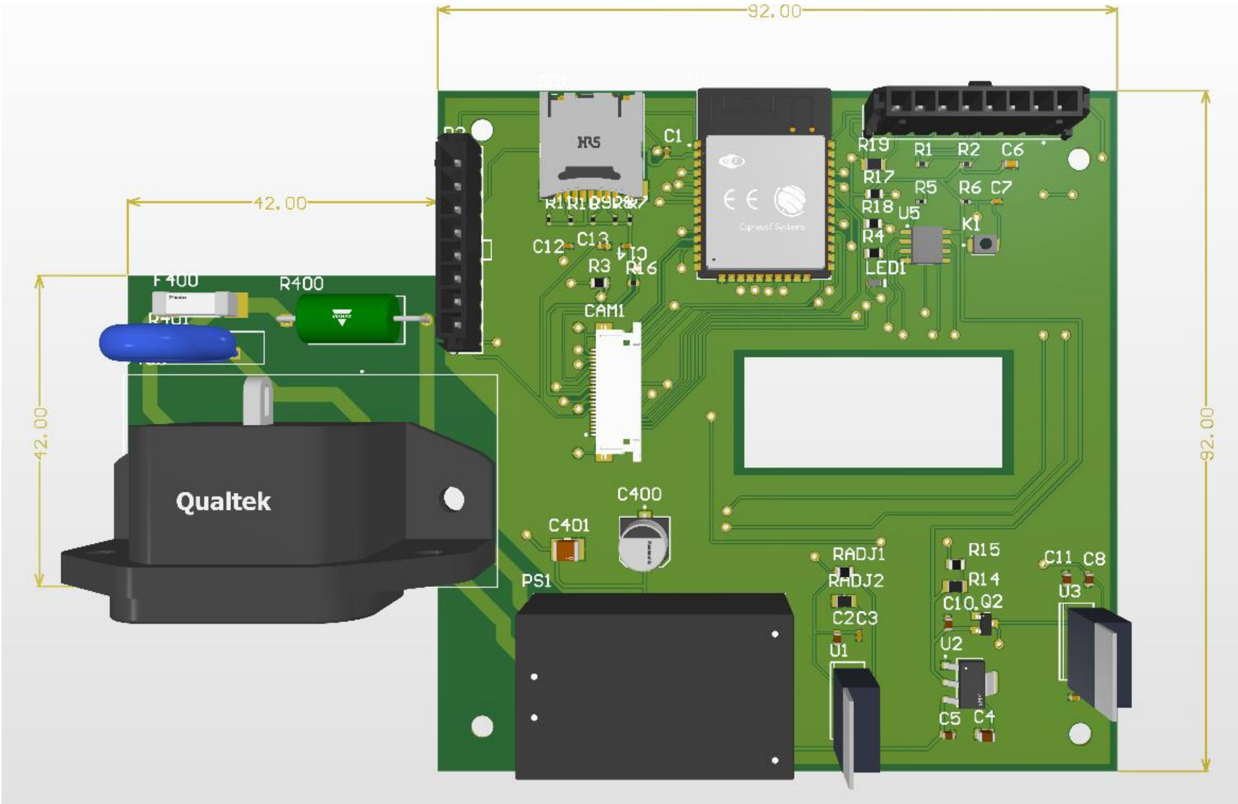

SCHEMATIC
PSRAM
Project Product Sorter
Drawn DMSB Nawarathna 4/4/2024
Sheet 4 of 4
Revisions
U5
23LC512-I/SN
SCK
SI/SIO0
SO/SIO1
SIO2
HOLD/SIO3
CS
VCC
VSS
C6
1μF
R5
10k
3V3
GND
PSRAM CLK
SD1
SD0
SD3
SD2

9. PCB Design

2D Design:

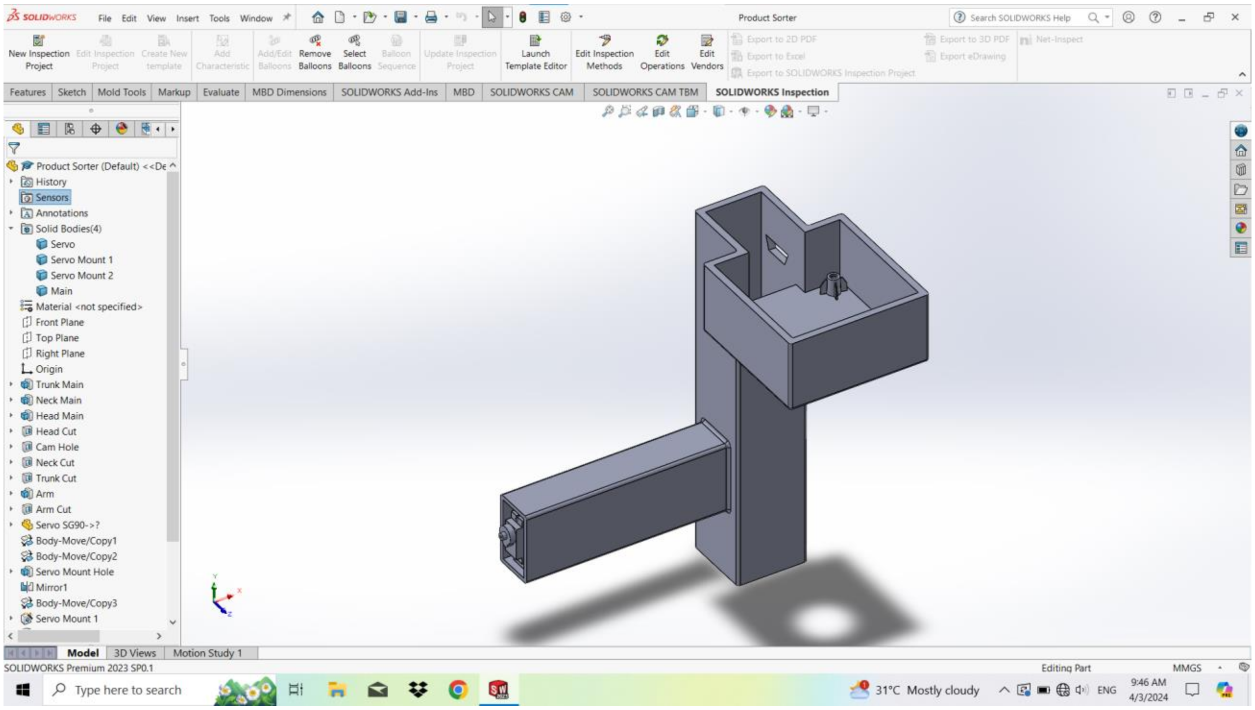


3D Design:

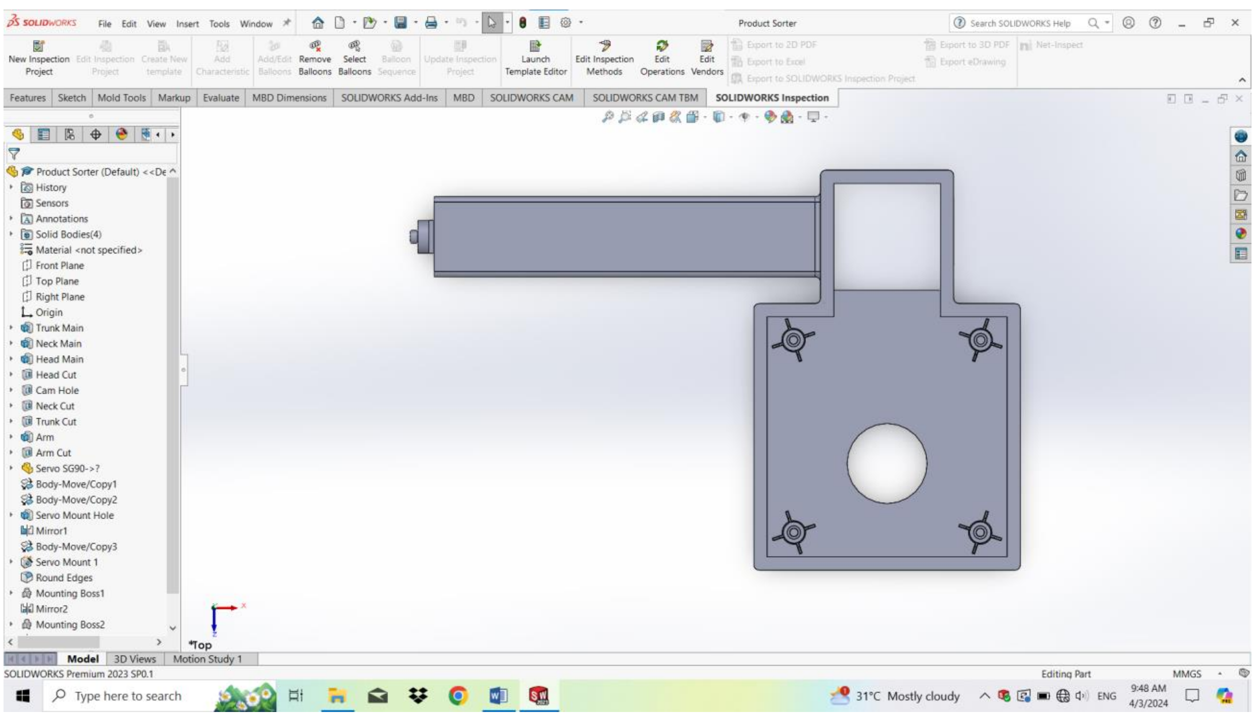

92.00
42.00
42.00
92.00
Qualtek
F400
R400
C1
R19
R1
R2
C6
R17
R5
R6
C7
R18
U5
R4
K1
LED1
C12
C13
R3
R16
CAM1
C400
C401
PS1
RADJ1
RADJ2
C2C3
U1
R15
R14
C10
Q2
U2
C5
C4
C11
C8
U3

10. Final SolidWork Design

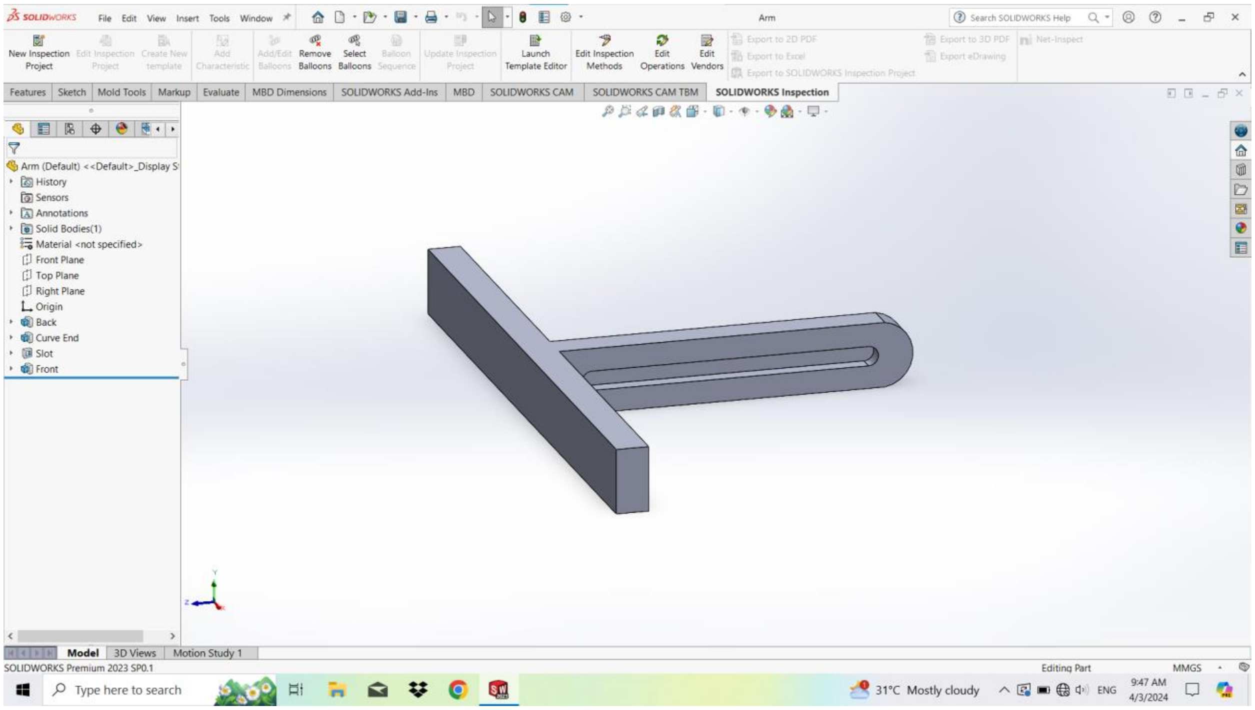
Final Look of the Main Body:



Top View (PCB Mounting):



Mechanical Arm:



The Mechanical arm will be connected to the stepper motor in the main body.

11. Conclusion

In summary, the journey towards developing the Product Sorting Conveyor Belt employing Computer Vision technology has been characterized by meticulous planning and innovative design. Guided by stakeholder needs and a commitment to excellence, significant progress has been made from conceptualization to final design.

As we advance to prototype development and integration, we remain focused on validating performance and refining the system based on user feedback. Ultimately, this project represents a leap forward in industrial sorting technology, driven by innovation and customer satisfaction. With confidence in the approach, I anticipate delivering a solution that will redefine product sorting in industrial environments.