Department of Electronic and Telecommunication Engineering

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EN2160 - Electronic Design Realization
Automatic Batch Code Printer

Design Methodology Report

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1.Introduction

In today's fast-paced industrial environment, the ability to efficiently and accurately label products with essential information such as manufacturing dates, expiry dates, and batch numbers is crucial. Automatic batch coding technologies have emerged as a vital component in various sectors, including pharmaceuticals, food and beverage, cosmetics, and electronics. These technologies enhance traceability, compliance, and quality control, ensuring that consumers receive reliable and safe products.

The advancements in automatic batch coding devices, particularly those utilizing inkjet printing technology, represent a significant leap forward in the industry. Inkjet printing technology stands out due to its versatility, speed, and precision, making it an ideal choice for high-volume production environments. This technology can print on a wide range of surfaces and materials, including glass, metal, plastic, and paper, which adds to its applicability across different industries.

Leading companies and universities are at the forefront of innovating and refining these technologies. Their research and development efforts focus on improving the efficiency, accuracy, and environmental sustainability of inkjet printing systems. Innovations include the development of high-resolution printers, the integration of smart technology for real-time monitoring and adjustments, and the use of environmentally friendly inks that reduce the carbon footprint of the printing process.

This report aims to provide a comprehensive overview of the current state of automatic batch coding devices using inkjet printing technology. It will cover the progress made in the field, plan the next steps for future advancements, and map the stakeholders involved in these developments. Additionally, it will observe user requirements, stimulate ideas for further innovation, and present conceptual designs and functional block diagrams. The evaluation criteria for selecting the best solutions, along with detailed considerations for ink and ink tube selection, will also be discussed. Finally, the report will delve into the schematics of selected conceptual designs, PCB design and 3D views, and enclosure design, providing a holistic view of the development and implementation of these cutting-edge technologies.

By examining these aspects, the report seeks to highlight the importance of automatic batch coding technologies and their role in enhancing industrial productivity and product safety. Through collaboration between industry leaders and academic institutions, continuous improvements can be achieved, paving the way for more advanced and sustainable batch coding solutions.

2.Review Progress: Project- Automatic Batch Code printer.

Automatic Batch Code Printing Technologies So far.

Introduction: Automatic batch coding technologies play a crucial role in various industries by enabling efficient and accurate labeling of products with essential information such as manufacturing dates, expiry dates, and batch numbers. This report aims to provide an overview of the advancements and innovations in automatic batch coding devices utilizing inkjet printing technology, with a focus on solutions offered by leading companies and universities.

1. Hitachi Inkjet Printing Solutions: Hitachi offers a range of ink formulations and dynamic models for batch coding applications. Their ink formulations allow codes to adhere to various forms of primary packaging, including paper, PP, PET, HDPE, glass, and metal. Hitachi's dynamic models, such as the UX2, UX Basic Model, UX Dynamic Model, and Twin Nozzle Cartridge Model, provide versatility and reliability in batch coding operations. Additionally, the Hitachi Batch Code Ink Jet Printer PXR-D460W offers mobility and compact design, making it suitable for diverse production environments.

2. Domino Printing Sciences: Domino Printing Sciences provides a comprehensive range of batch coding solutions, including manual, semi-automatic, and automatic systems. Their manual batch coding solutions are suitable for small-scale production runs, while semi-automatic solutions offer electronic-driven operation for larger batches. Domino's automatic batch coding machines integrate seamlessly into production lines, applying codes without operator intervention. The company offers both contact and non-contact batch coding machines, utilizing technologies such as thermal transfer overprinting (TTO), continuous inkjet printing (CIJ), and thermal inkjet printing (TIJ).

3. Linx Printing Technologies: Linx specializes in batch coding technologies designed for high-speed printing onto various types of packaging. Their lot number printers ensure clear and durable batch codes for traceability and compliance with regulatory requirements. Linx's automatic coding machines offer ease of setup and operation, with user-friendly interfaces and smartphone-style touchscreen controls. Their continuous inkjet printer, the Linx 8900, is suitable for harsh production environments with its ingress protection (IP) rating.

4. Research and Innovations: Universities and research institutions have also contributed to advancements in automatic batch coding technologies. Research projects focus on improving printing accuracy, speed, and versatility while exploring novel ink formulations and printing methods.

Below is a short, summarized report regarding a research paper published in Linkedin.com

This research paper explores various aspects of batch coding technology, focusing on the importance, types, operation, and application of batch coding machines, particularly in the context of inkjet printing. The paper emphasizes the significance of high-quality batch coding in ensuring product traceability, compliance with regulations, and brand reputation in industries such as FMCG, pharmaceuticals, and automotive.

Key Findings:

1. **Importance of Batch Coding:** Batch codes play a crucial role in product traceability, allowing manufacturers to track products throughout the supply chain and facilitate efficient recalls if necessary. They contain vital information about manufacturing dates, expiry dates, and other relevant details.
2. **Types of Batch Coding Machines:** The paper identifies three main types of batch coding machines: manual handheld, semi-automatic, and automatic. Each type caters to different production needs, with automatic systems being the preferred choice for large-scale manufacturing.
3. **Technology Overview:** Various technologies are available for batch coding, including thermal transfer overprinting (TTO), thermal inkjet (TIJ), continuous inkjet (CIJ), laser marking, and large character marking (LCM). Each technology offers distinct advantages in terms of printing quality, speed, and suitability for different substrates.
4. **Operation of Inkjet Batch Coding Machines:** Inkjet batch coding machines are user-friendly and offer flexibility in customization. Operators can easily set up the machines to print alphanumeric characters, barcodes, and other information according to specific requirements.
5. **Application Examples:** The paper provides insights into the application of batch coding machines in different packaging formats, such as plastic bags, bottles, jars, and cartons. It highlights the importance of selecting the appropriate coding technology based on packaging features and production line requirements.

3.Plan Next Steps

After outlining the objectives and methodology for the development of an automatic batch coding system utilizing inkjet printing technology, the next crucial step is to plan the subsequent actions to ensure the successful execution of the project. This report presents a comprehensive plan for the next steps based on the outlined project proposal.

1. Review Project Scope and Objectives

- Conduct a thorough review of the project scope and objectives to ensure alignment with stakeholders' expectations and industry requirements.
- Verify that all necessary components and functionalities are adequately addressed in the project plan.

2. Establish Timeline and Milestones

- Develop a detailed timeline with specific milestones for each phase of the project, including design, fabrication, programming, testing, documentation, and support.
- Assign responsibilities to team members and establish deadlines for each milestone to maintain accountability and track progress effectively.

3. Procurement and Material Acquisition:

- Identify and procure all necessary materials, components, and equipment required for the fabrication of the custom print head, microcontroller programming, enclosure construction, and ink selection.
- Ensure that materials meet quality standards and specifications outlined in the project requirements.

4. Design and Fabrication of Print Head

- Initiate the design and fabrication process for the custom print head, considering factors such as nozzle size, heating element placement, and ink delivery mechanisms.
- Conduct prototype testing to validate design specifications and functionality before proceeding to full-scale fabrication.

5. Microcontroller Programming

- Begin the development of control algorithms and software to interface with the print head and manage printing operations.
- Program the ATmega328P microcontroller to receive batch information from the user interface and command the print head accordingly.

6. Enclosure Design and Construction:

- Commence the design phase for the enclosure, ensuring compatibility with the system components and providing accessibility for maintenance.
- Fabricate the enclosure using appropriate materials and assembly techniques to ensure protection and ease of use.

7. Integration and Testing:

- Assemble the system components within the enclosure and perform rigorous testing to validate functionality, reliability, and print quality.
- Iterate on design and software as necessary based on testing results to optimize performance and address any identified issues.

8. Documentation and Support:

- Create comprehensive documentation, including assembly instructions, operating procedures, and troubleshooting guidelines, concurrently with system development.
- Provide ongoing support and assistance to users for successful implementation and operation of the automatic batch coding system.

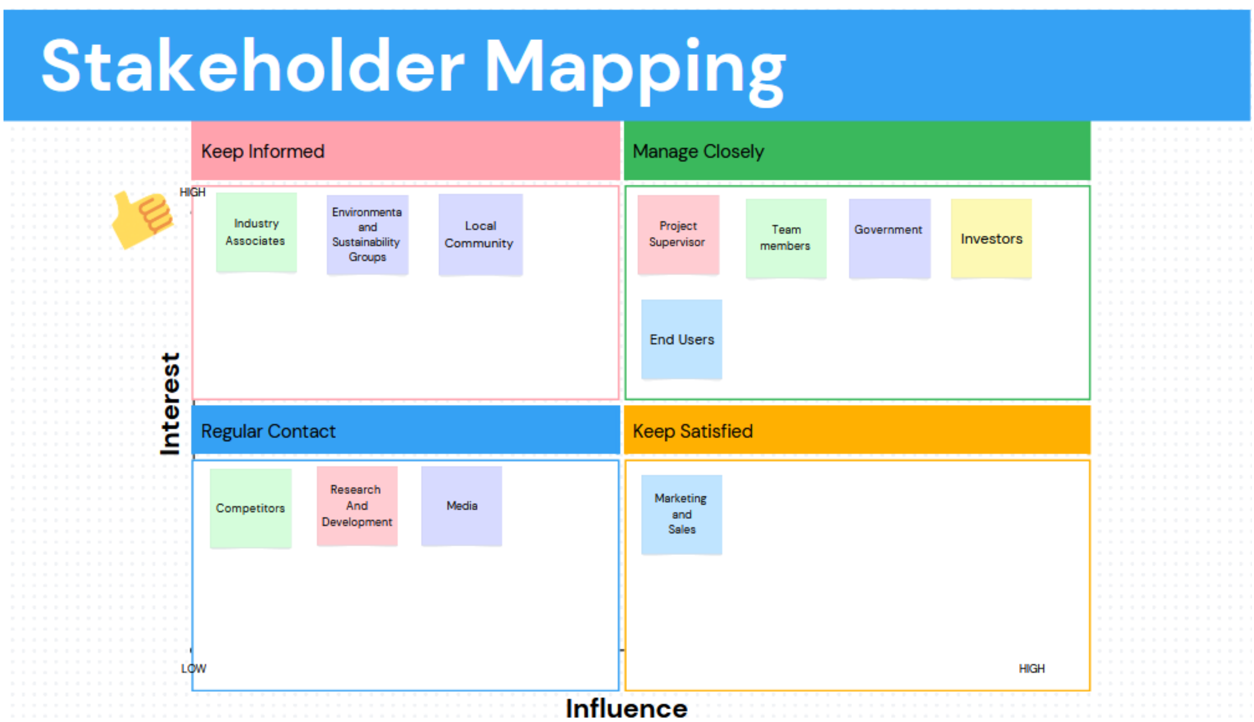
9. Stakeholder Communication and Feedback:

- Maintain regular communication with stakeholders to provide updates on project progress, address any concerns or feedback, and ensure alignment with expectations.
- Solicit feedback from stakeholders throughout the project lifecycle to incorporate any necessary adjustments or refinements

4.Stake Holder Mapping

The list of stakeholders that are related to our project is given below.

1. Project Team Members:
2. Project Supervisor
3. End-Users/ Customers
4. Regulatory Bodies (Government)
5. Industry Associations (Packaging and manufacturing industry)
6. Financial Stakeholders
7. Marketing and Sales
8. Environmental and Sustainability Groups:
9. Community
10. Competitors (Competing companies in the same industry)
11. Research and Development
12. Media (News outlets covering advancements in manufacturing or technology)



5.Observe Users

1. **User Interface Preferences:**

- Users expressed a preference for a simple and intuitive user interface that allows for easy input of batch information.
- Clear and legible display screens were highlighted as important for readability in busy production environments.

2. **Print Head Interaction:**

- Operators emphasized the importance of a reliable and durable print head that requires minimal maintenance.
- Ease of access to the print head for cleaning and replacement of ink cartridges was identified as a key consideration.

3. **Enclosure Design:**

- Observations revealed a need for an enclosure that provides adequate protection for the internal components while allowing for easy access during maintenance and troubleshooting.

4. **Documentation and Support:**

- Stakeholders highlighted the importance of comprehensive documentation and support materials to assist with assembly, operation, and troubleshooting of the automatic batch coding system.
- User training programs and ongoing technical support were identified as essential for successful implementation and operation of the system.

6.User Requirements

Introduction: Inkjet printing technology has emerged as a versatile tool with diverse applications, ranging from graphical patterning to precise material deposition in various industries. As we embark on the journey of developing an inkjet printer tailored for batch coding purposes, it is imperative to understand the specific user requirements associated with this technology. This report aims to outline these requirements comprehensively, facilitating the creation of conceptual designs that effectively address user needs.

Batch code printing is widely utilized across various industries for product identification, tracking, and compliance purposes. Some industrial uses of batch code printing include:

- Pharmaceutical: Ensure traceability and regulatory compliance throughout the supply chain.
- Food and Beverage: Track inventory, monitor product freshness, and facilitate recalls.
- Cosmetics and Personal Care: Track formulations, expiration dates, and ensure regulatory compliance.
- Automotive: Label parts for identification, quality control, and traceability in manufacturing.
- Electronics: Label components for inventory management, quality control, and defect identification.
- Chemical: Label products for tracking, regulatory compliance, and safety standards.

6.1User requirements from Inkjet batch code printing.

1. **Accuracy and should be precise.**

Users demand high precision and accuracy in batch coding to ensure legibility and compliance with stringent regulatory standards. The ability to consistently produce clear and error-free batch codes is critical for product identification, traceability, and quality control purposes. Whether the substrate is flat or irregular, the inkjet printer must be capable of depositing ink with precision, ensuring that each batch code is accurately applied regardless of surface variations. This level of accuracy is essential to prevent misidentification, minimize errors in product tracking, and uphold regulatory compliance requirements across industries. Therefore, the inkjet printer's capability to maintain precision and accuracy, even under challenging printing conditions, is paramount to meet the exacting demands of users in various manufacturing environments.

2. **Speed and efficiency in batch coding.**

Efficient batch coding necessitates fast printing speeds to minimize production downtime and meet the demands of high-volume manufacturing environments. Users expect the inkjet printer to offer rapid printing capabilities without sacrificing quality, ensuring that batch codes are

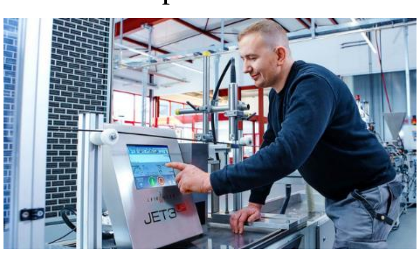
applied swiftly and accurately to keep pace with production schedules. The ability to achieve high-speed printing while maintaining precision and legibility is crucial for streamlining manufacturing processes and maximizing productivity. Furthermore, fast printing speeds enable manufacturers to meet tight deadlines, respond quickly to market demands, and optimize operational efficiency. Therefore, the inkjet printer must deliver rapid printing performance to meet user expectations for timely batch code application and ensure seamless integration into production workflows.

3. **Cost effectiveness over other printing technologies**

Cost considerations play a crucial role in industrial operations, requiring a delicate balance between performance and affordability. Users are keen to invest in an inkjet printer solution that offers cost-effective batch coding solutions, allowing them to minimize operational expenses while maximizing productivity. This entails not only the initial investment in the printer hardware but also ongoing costs such as ink consumption, maintenance, and operational efficiency. Users expect the inkjet printer to provide a favorable return on investment by delivering reliable performance at a competitive price point. Therefore, affordability is a key factor that influences user preferences when selecting an inkjet printer for batch coding applications. Additionally, cost-effective solutions enable businesses to remain competitive in the market while maintaining profitability and sustainability in their operations.

4. **Reliability and Maintenance**

Continuous operation is vital for industrial applications, highlighting the need for a reliable inkjet printing solution with minimal downtime. Users demand an inkjet printer that can sustain continuous operation over extended periods without encountering frequent malfunctions or



breakdowns. This requires robust hardware components, advanced technology, and efficient ink delivery systems that can withstand the rigors of industrial production environments.In addition to reliability, users also emphasize the importance of ease of maintenance for the inkjet printer. They expect the printer to have accessible components and straightforward troubleshooting procedures, enabling maintenance personnel to quickly diagnose and resolve any issues that may arise. This minimizes downtime associated with maintenance tasks and ensures that production schedules remain on track.Furthermore, users value proactive support and timely assistance from the printer manufacturer or service provider. Access to technical support, spare parts availability, and comprehensive maintenance contracts are essential considerations for users when selecting an inkjet printing solution.

Understanding user requirements is paramount in the development of an inkjet printer tailored for batch coding applications. By addressing the precision, speed, versatility, cost-effectiveness, integration, reliability, and maintenance aspects outlined above, we can create conceptual designs that meet the diverse needs of users across various industries. These designs will pave the way for the development of a robust inkjet printing solution that sets new standards in batch coding efficiency and effectiveness.

7.Stimulating Ideas:

Following the thorough analysis of user requirements for automatic batch coding, the next crucial step in the project lifecycle is to stimulate innovative ideas that will inform the conceptual designs of the system. This phase serves as a creative brainstorming session aimed at exploring potential solutions, technologies, and approaches to address the identified user needs and industry challenges. By fostering a collaborative and forward-thinking environment, the team can generate novel ideas that push the boundaries of conventional batch coding practices and pave the way for groundbreaking innovations in the field.

1. Advanced Printing Technologies:

   In our pursuit of enhancing batch coding efficiency, we're exploring cutting-edge printing technologies like inkjet, laser, and thermal printing. These methods offer high-speed and high-resolution capabilities, promising clear, legible, and compliant batch codes. We're also integrating machine vision systems and AI algorithms for real-time quality control, ensuring error detection and rectification during printing. Through this innovative approach, we aim to set new standards of excellence in batch coding across industries.

2. Intelligent Ink Formulations:

   Developing custom ink formulations designed for specific substrates and environmental conditions, prioritizing optimal adhesion, durability, and readability of batch codes. Additionally, our research focuses on eco-friendly and sustainable ink options, aiming to minimize environmental impact without compromising printing performance or quality. Through these efforts, we're committed to delivering efficient and environmentally responsible batch coding solutions.

3. Smart Packaging Technologies:

   Delving into smart packaging solutions like RFID tags and QR codes to enhance batch coding efforts, adding layers of product identification and authentication. Additionally, exploring IoT sensor integration to enable real-time monitoring and management of batch-coded products during transit and storage. These advancements promise enhanced traceability and security throughout the supply chain, bolstering product integrity and consumer confidence.

4. Customization and Personalization:

Diving into batch coding customization and personalization to cater to diverse branding and labeling needs across industries and product categories. Additionally, we're exploring variable data printing technologies to facilitate on-demand batch coding of serialized or individually labeled products. These initiatives aim to provide flexible and tailored solutions, empowering businesses to meet specific regulatory and consumer demands with ease and efficiency.

5. Regulatory Compliance and Security:

   Focused on implementing robust security features and anti-counterfeiting measures to safeguard batch codes against unauthorized tampering or replication, ensuring adherence to regulatory standards. Additionally, we're exploring the potential of blockchain technology and distributed ledger systems to enable immutable tracking and authentication of batch-coded products across their lifecycle. These efforts aim to enhance transparency, traceability, and trust in the supply chain while mitigating the risks associated with counterfeit products.

6. Collaborative Partnerships and Industry Collaboration:

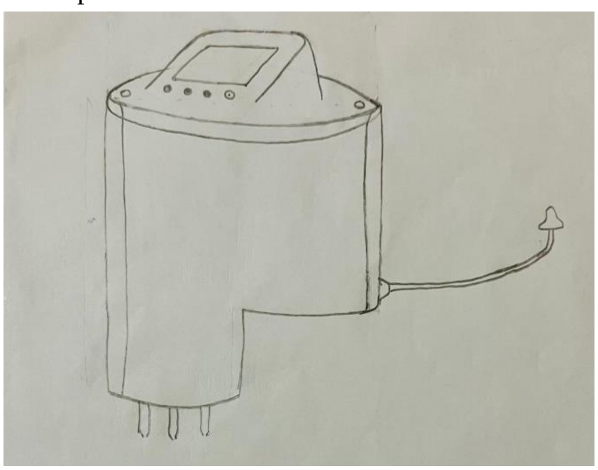
   Fostering collaborative partnerships with key industry stakeholders, including manufacturers, suppliers, regulatory agencies, and technology providers, to leverage collective expertise and resources in advancing batch coding practices. Additionally, we're exploring opportunities for cross-disciplinary collaboration and knowledge sharing to accelerate innovation and drive continuous improvement in automatic batch coding technologies. These collaborative efforts aim to enhance industry standards, promote best practices, and deliver cutting-edge solutions that meet the evolving needs of our customers and the broader market.

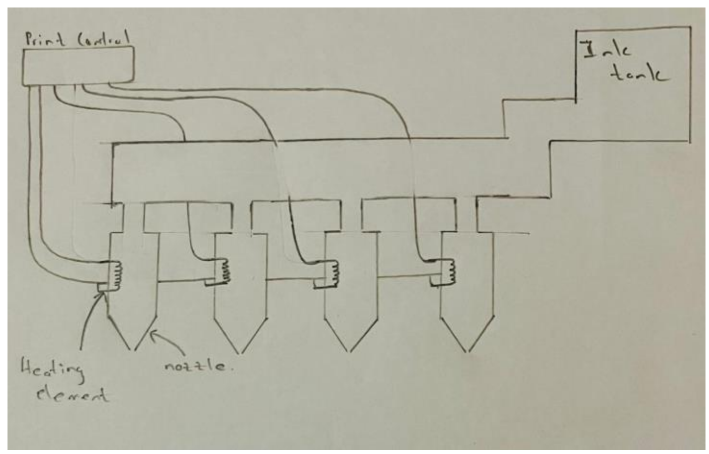
8.Conceptual Designs.

Introduction
An automatic batch coding device is designed to streamline the process of marking or labeling batches of products in manufacturing or warehouse environments. It typically functions by automatically applying codes, such as batch numbers, expiration dates, or other relevant information, onto the packaging or products themselves. This is achieved through precise control mechanisms that ensure accurate placement and legibility of the codes. Additionally, these devices may integrate with software systems to manage batch data and synchronize with production lines, enabling efficient tracking and traceability throughout the supply chain.

8.1 Conceptual Design 1

Concept for enclosure





In the first conceptual design, we leverage heating elements integrated within each individual nozzle to create a localized pressure differential relative to atmospheric pressure upon receiving a signal from the print control system. Each nozzle is equipped with its own dedicated heating element, comprising a coil-like structure embedded within the nozzle assembly during fabrication.

To ensure a continuous ink supply to the nozzles, a centralized ink tank is employed, serving as the primary reservoir for ink distribution. This centralized ink tank facilitates seamless and uninterrupted ink flow to each nozzle, optimizing printing performance and efficiency.

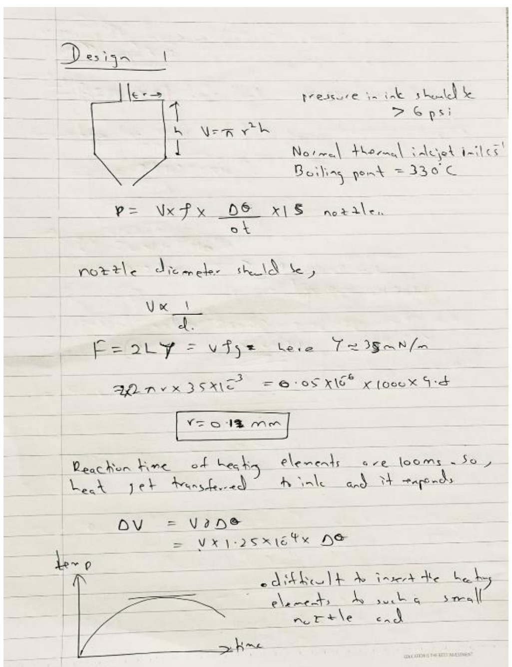
By utilizing heating elements and a centralized ink distribution system, this conceptual design offers precise control over ink ejection and distribution, resulting in enhanced print quality and consistency. Moreover, the individual heating elements enable independent operation of each nozzle, allowing for greater flexibility and customization in batch code printing applications.

While the first conceptual design offers certain advantages, there are notable inefficiencies that warrant consideration.

Firstly, the design's reliance on individual heating elements for each nozzle results in elevated power consumption. The continuous supply of power to numerous heating elements contributes to higher energy usage, posing challenges in terms of operational costs and environmental sustainability.

Secondly, the design's heating elements face difficulties in rapid cooling after ejecting ink droplets. Due to the lingering heat within the heating elements, ink flow may persist beyond the intended duration, potentially leading to inaccuracies or inconsistencies in batch code printing. This prolonged heat retention impedes efficient ink ejection and overall printing performance, detracting from the design's effectiveness and reliability.

Those two reasons are also proved by following calculations.


Design 1

$V = \pi r^2 h$

pressure in ink should be > 6 psi

Normal thermal inkjet inks'
Boiling point $= 330^\circ C$

$P = V \times \rho \times \frac{\Delta\theta}{\Delta t} \times 15$ nozzles

nozzle diameter should be,

$V \propto \frac{1}{d}$

$F = 2L\gamma = V\rho g$ here $\gamma \approx 35$ mN/m

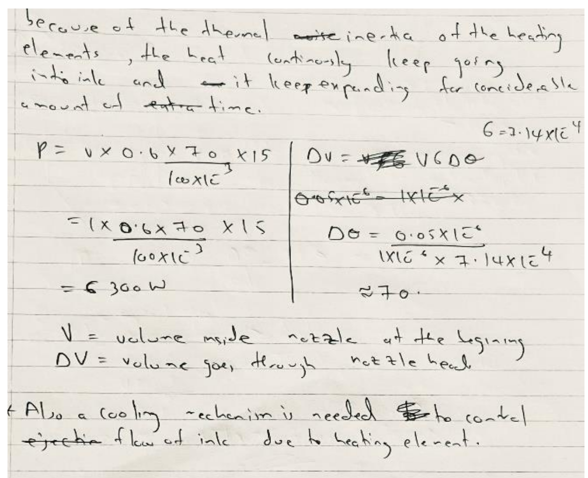
$2 \times 2\pi r \times 35 \times 10^{-3} = 0.05 \times 10^{-6} \times 1000 \times 9.8$

$\boxed{r = 0.13 \text{ mm}}$

Reaction time of heating elements are 100ms. So, heat get transferred to ink and it expands

$\Delta V = V \gamma \Delta\theta$
$= V \times 1.25 \times 10^{-4} \times \Delta\theta$

- difficult to insert the heating elements to such a small nozzle end


because of the thermal ~~noise~~ inertia of the heating elements, the heat continuously keep going into ink and it keep expanding for considerable amount of ~~extra~~ time.

$\gamma = 7.14 \times 10^{-4}$

$P = V \times 0.6 \times \frac{70}{100 \times 10^{-3}} \times 15$

$= 1 \times \frac{0.6 \times 70}{100 \times 10^{-3}} \times 15$

$= 6300$ W

$\Delta V = V \gamma \Delta\theta$

~~$0.05 \times 10^{-6} = 1 \times 10^{-6} \times$~~

$\Delta\theta = \frac{0.05 \times 10^{-6}}{1 \times 10^{-6} \times 7.14 \times 10^{-4}}$

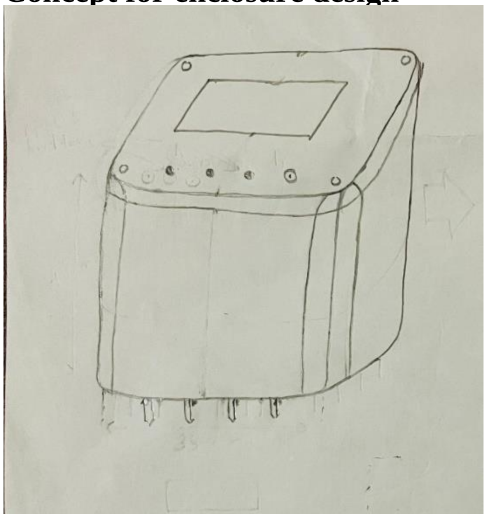
≈ 70.

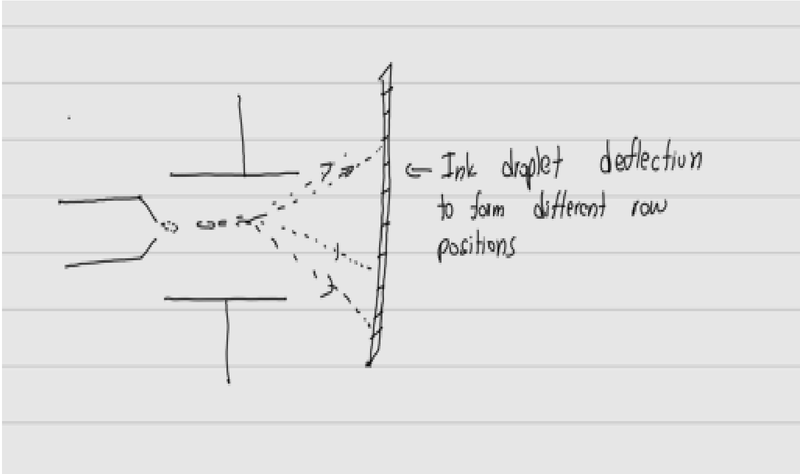
V = volume inside nozzle at the begining
ΔV = volume goes through nozzle head

Also a cooling mechanism is needed to control ~~ejection~~ flow of ink due to heating element.

8.2 Conceptual Design 2

Concept for enclosure design





In the second conceptual design, a distinct approach is adopted to address the inefficiencies encountered in the first design iteration. Rather than employing individual heating elements, this design integrates individual valves for nozzles and a pressure inkjet system for the nozzle array with a electric field generator to deflect the ink jet path.

Upon receiving a signal from the control circuit the designated nozzle valve opens as the pressure of the ink pressure chamber is high the ink rushes outside of the nozzle. The pressure of the pressure chamber will be controlled for optimum ink ejection as ink bubbles. Then when the ink droplet does through the electric field it gets charged and get deflected. By deflecting these ink droplets we can print different rows using one nozzle array without using multiple nozzle arrays.

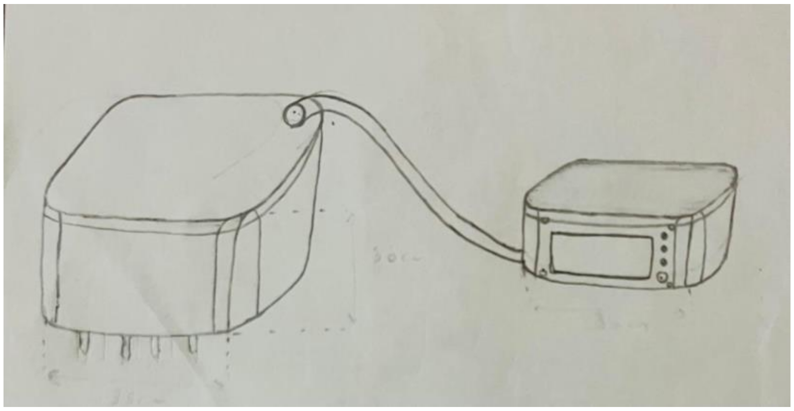
This enhanced control capability facilitates precise regulation of ink flow, enabling accurate batch code printing while mitigating potential issues associated with ink over-dispersion. Additionally, by eliminating the need for individual heating elements, this design reduces power consumption and, thereby offering a more sustainable and cost-effective solution for batch code printing applications.

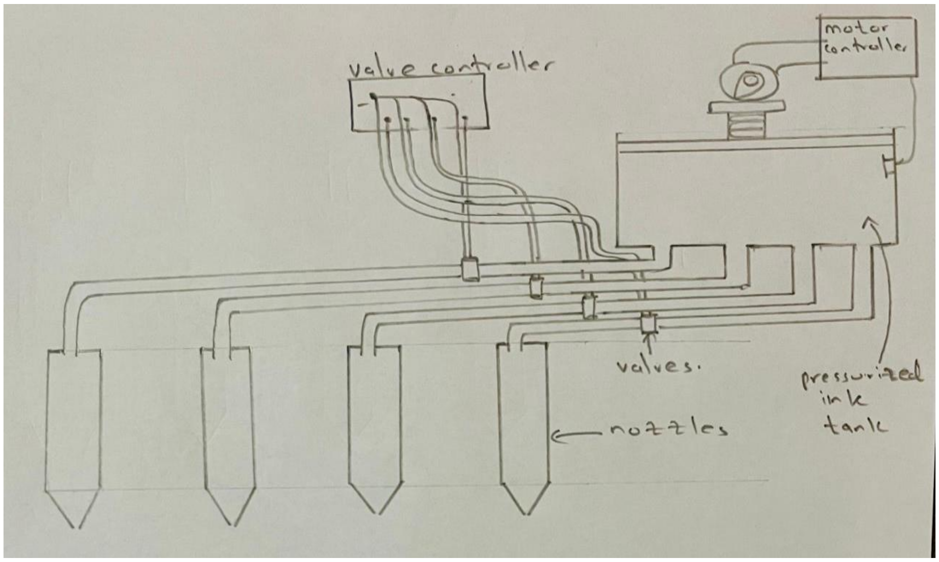
Furthermore, the second conceptual design boasts reduced power consumption compared to its predecessor, the first design iteration. By eschewing individual heating elements for pressure and electric field control systems this design significantly lowers the overall power requirements. This not only contributes to operational cost savings but also aligns with sustainability goals by minimizing energy consumption. This will be proved by the below calculations.

However, a notable drawback of this approach is the its high design complexity the controls need to calculate the electric field strength and adjust it accordingly. These calculations need to have high precision as the gap bet ween the dotted rows are small. And we need ti implement different controls for pressure management also.

8.3 Conceptual Design 3

Concept for enclosure design





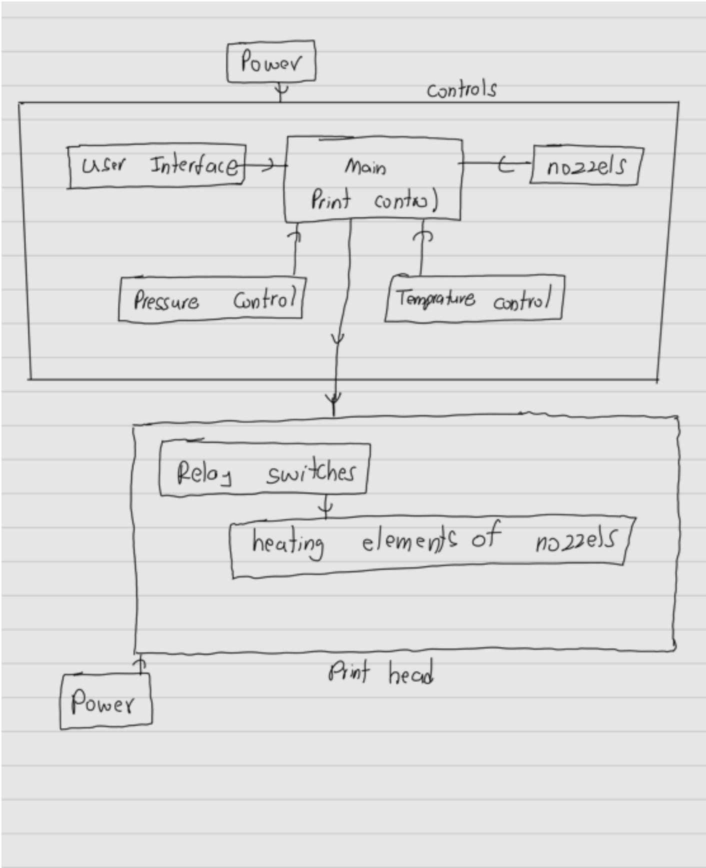
The third conceptual design incorporates a centralized pressure ink tank and individually controlled electronic solenoid ink valves, representing a sophisticated approach to batch code printing. Each ink valve is meticulously activated by a signal from the control circuit through a relay switch, enabling precise regulation of ink flow. Upon activation, the corresponding ink valve promptly opens, facilitating the seamless transfer of ink from the centralized pressure chamber to the nozzle chamber. This equilibrium of pressure within the nozzle chamber ensures controlled ink ejection, resulting in the precise deposition of ink droplets through the nozzle.

One of the notable advantages of this design is its versatility in arranging the nozzles in a clustered configuration, promoting clarity and legibility in the printed letters. By dispensing ink droplets in close proximity, the clustered arrangement enhances the visibility and distinction of the printed content. Additionally, the centralized approach eliminates the need for separate ink ejection mechanisms for each nozzle, streamlining the ink delivery process and bolstering overall efficiency and reliability in batch code printing applications.

One disadvantage of this method is the potential complexity and maintenance requirements associated with the centralized pressure ink tank and individually controlled electronic solenoid ink valves. Moreover, the centralized approach may necessitate regular calibration and adjustment to ensure uniform ink flow and consistent printing performance across all nozzles, adding to maintenance overhead and operational complexity.

9.Functional Block Diagram

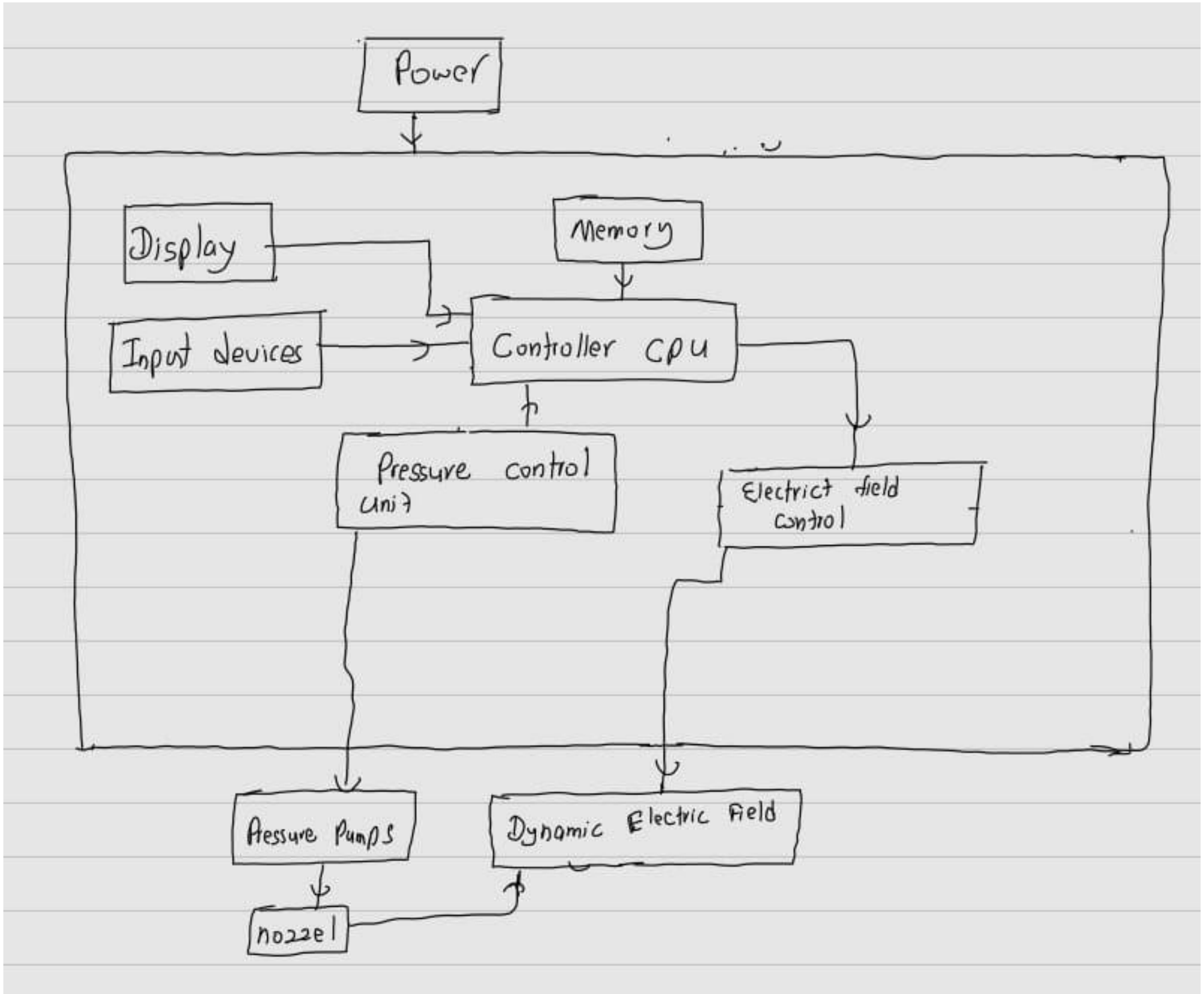
9.1 Design 1



The functional block diagram begins with the power circuit, serving as the foundational element to provide the necessary electrical energy for the entire system. Following this, the control circuit takes precedence, featuring a programmable matrix responsible for orchestrating the printing process. This matrix is meticulously programmed to execute the desired letter sequences along with associated numerical data, ensuring precise and accurate batch code generation.

Adjacent to the control circuit lies the temperature and print controller, a pivotal component equipped with relay switches tailored to regulate each individual nozzle. This controller acts as the intermediary between the control circuit and the printing mechanism, facilitating seamless communication and coordination. Additionally, integrated temperature sensors further enhance functionality by monitoring and maintaining optimal operating conditions, ensuring consistent performance and reliability throughout the printing process

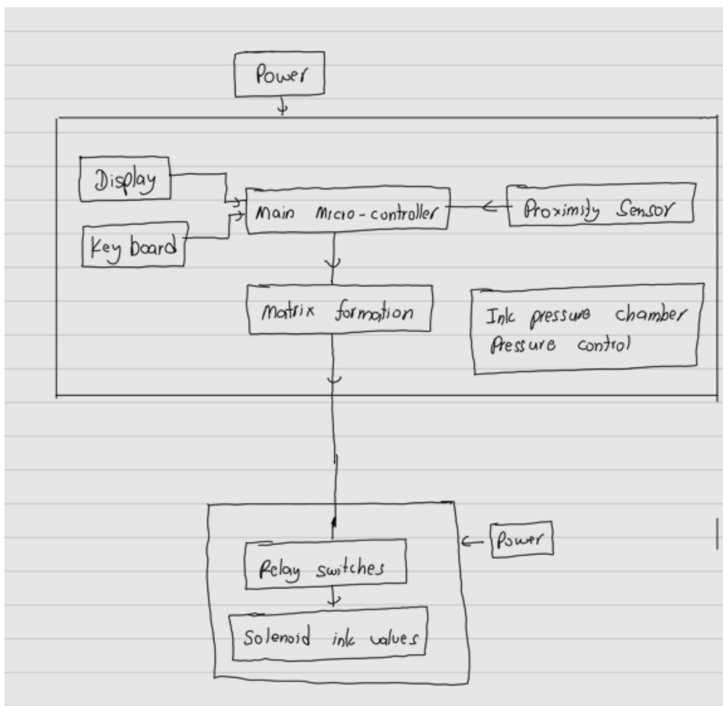
9.2 Design 2



Input Device is where the code to be printed is entered. This could be a computer a keyboard, or a storage device such as a USB drive. Then the Controller CPU formats the data and sends it to the printer. Memory stores the code to be printed. Display shows the user the status of the printer, such as the current job or any errors. Then it makes the 2d dot matrix and send it to the Engine CPU which controls the printing mechanism. Proximity Sensor detects the presence of media (like labels or tags) and ensures the printer is ready to print. Pressure Control This unit regulates the amount of ink used during printing. Engine CPU monitor both of these processors and give necessary signals to Relay Switches which controls nozzle valves which control the flow of ink to the print nozzles.

Nozzles and Metal Plates: These are the components that create the printed image on the media. An essential feature of the motor controller circuit is its integration with pressure sensors, which are intricately linked to the nozzles. These sensors serve to monitor the pressure levels within the nozzles, providing crucial feedback to the motor controller circuit to ensure optimal performance and ink ejection consistency. Notably, the motors are strategically mounted atop the nozzles, directly interfacing with pressure chambers to facilitate efficient ink delivery.

9.3 Design 3



The third functional block diagram initiates with the power circuit, serving as the foundational element responsible for supplying electrical power throughout the system. Subsequently, the control circuit assumes control, housing a meticulously programmed matrix tailored to execute the desired letter sequences and numerical data required for batch code generation.

Following the control circuit, the signal is seamlessly transmitted to a specialized circuit equipped with relay switches. We can see a centralized pressure tank in this block diagram, which serves as the focal point for ink distribution. Each nozzle is intricately connected to this tank via rubber tubes, establishing a network for efficient ink delivery.

Within this arrangement, electronically controlled solenoid ink valves are strategically positioned along the tubing, precisely regulating ink flow to each nozzle. These valves operate in tandem with the relay switches, ensuring synchronized control and seamless ink distribution across the printing array.

Integral to the functionality of this system is the incorporation of pressure sensors, meticulously attached to the centralized pressure tank. These sensors play a pivotal role in monitoring pressure levels within the tank, providing vital feedback to optimize ink distribution and maintain operational consistency.

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10.Evaluation Criteria

Enclosure Design Criteria:

1. Functionality: How well the design supports the main functionalities?
2. Aesthetics: How much eye catching and overall appeal of the user?
3. Heat dissipation: How much heat is generated and how well it has been managed?
4. Assembly and serviceability: How easily does the assembly and disassembly is done?
5. Ergonomics: How well does the design fit in the user's hand and allow easy interaction?
6. Durability: How well does the design withstand impacts and environmental conditions?
7. Simplicity

Functional block diagram criteria:

1. Functionality: How well the circuit design meets functional requirements?
2. Manufacturing feasibility: Evaluate the feasibility of manufacturing the design
3. Cost: Evaluate the overall cost effectiveness for the provided functionality
4. Print quality: Evaluate print quality, resolution ?
5. Future proofing: To what extent does the design allow for easy replacement or upgrade of individual components?
6. Power Efficiency : How effectively does the device manage power consumption?

11.Selection Matrix

	Criteria	Design 1	Design 2	Design 3
Enclosure design criteria	Functionality	6	5	7
	Aesthetics	6	6	6
	Heat Dissipation	2	6	6
	Assembly And Serviceability	6	5	4
	Ergonomics	6	6	4
	Durability and Reliability	4	7	6
	Simplicity	6	3	7
Functional block diagram criteria	Functionality	5	7	4
	Feasibility	3	7	6
	Cost	**3**	**6**	**4**
	Print quality	**5**	**7**	**4**
	Future Proofing	**4**	**5**	**7**
	Power Efficiency	**2**	**6**	**6**
	Total	**45**	**58**	**55**

Selected Design

According to the above results Design 2, which was implemented considering user input, has got 58 marks out of 100 (10 marks per each criteria and there are 13 criterias). Therefore the selected design is design 2.

12.Ink Selection for printing

The realm of product coding encompasses a wide array of solutions tailored to diverse applications. Factors such as substrate selection, processing setups, line configurations, environmental conditions within the facility, and other variables all exert influence on the efficacy of an ink formula in generating clear, high-quality codes. This multifaceted landscape demands careful consideration to ensure that the chosen solution aligns with the specific requirements of the application, avoiding the risk of producing illegible or distorted codes.

Basically two types of inks that are being currently used in the industry for inkjet printing.
They are,

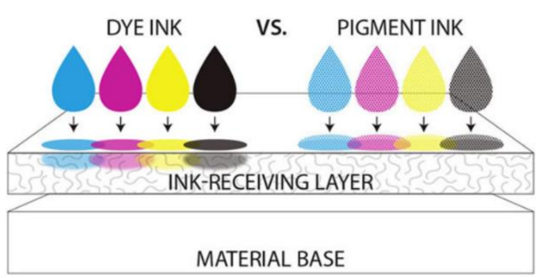
1. Dye based ink
2. Pigment based ink

1.Dye based ink
Dye-based ink comprises colorants dissolved in a liquid medium, typically water or glycol. This formulation facilitates smooth flow from the printer head to the page and promotes rapid drying upon contact. Commonly employed in standard inkjet printers due to its cost-effectiveness, dye-based ink offers crisp text rendering and produces vivid, vibrant colors in printed images. However, it is important to note that dye-based inks lack waterproof properties and may experience fading over time, with color retention typically lasting between 5 to 25 years.

2.Pigment based ink
Pigmented ink is formulated specifically to produce durable, high-quality color prints suited for professional applications. Unlike standard dye-based ink sets, pigment ink sets offer a broader spectrum of tones, tailored to complement various types of paper. This specialized ink provides professional photographers with enhanced flexibility to enhance color depth, sharpness, and tone through experimentation with different ink and paper combinations. While manufacturers often optimize their ink and paper products for specific pairings, high-end photo printers typically feature both matte black and glossy black options to achieve optimal results across different media types.
Why Dye based ink preferred over pigment based ink in batch code printing?

Dye-based ink is often preferred over pigment-based ink for batch code printing due to several factors. Firstly, dye ink cartridges are typically more cost-effective compared to pigment ink cartridges, as the latter can be priced two to three times higher due to raw material costs.

Additionally, pigment inks require periodic circulation to prevent clumping, particularly in thermal inkjet (TIJ) printers. While pigment continuous inkjet (CIJ) printers automate this process, TIJ printers necessitate manual shaking of the cartridge after periods of inactivity to maintain ink consistency.



Moreover, pigment inks may not offer the same brightness as dye inks, as the larger pigment particles scatter light differently. However, black pigment ink tends to produce darker and more opaque results compared to dye ink, which can be advantageous for certain applications.Overall, dye inks provide softer and more vibrant colors, particularly on light-colored substrates, due to their smaller colorant particles. Additionally, dye inks generally offer quicker drying times, which is beneficial for efficient production line printing.

Furthermore, pigment ink is often deemed more suitable for industrial or heavy-duty outdoor printing applications, while dye ink is predominantly utilized for text-based documents or indoor printing.

Both dye and pigment inks maintain high-quality output, yet dye-based inks tend to produce more

vivid and colorful prints compared to pigment-based inks. Dye-based inks offer a wider color gamut, enhancing the overall quality and performance of printed materials. Particularly, dye-based inks excel in text-based creations and produce sharper prints, with black text appearing notably crisper and darker compared to pigmented ink.

So, by considering above facts Dye based ink is more preferable over pigment based ink for the final objective of the ongoing project.

Compositions of several types of dye-based inks.

Chemical concentration (%)						Properties			
Ink number	Solvent	Surfynol 465	pH buffer	PVP K30	Water	Viscosity (mPa·s)	Surface tension (mN/m)	pH	Conductivity (μs/cm)
A0	0	1	0.5	2.5	86.0	3.32	34.0	6.98	16.22
A1	20	1	0.5	0	68.5	3.03	34.4	6.90	10.10
A2	20	1	0.5	0	68.5	3.31	34.3	7.00	9.56
A3	20	1	0.5	0	68.5	3.72	36.6	7.18	8.39
A4	20	1	0.5	0	68.5	4.46	34.1	7.10	7.73
A5	20	1	0.5	0	68.5	3.84	29.6	7.14	7.56
A6	20	1	0.5	0	68.5	2.94	30.6	7.12	10.05
A7	20	1	0.5	0	68.5	3.23	35.5	7.20	8.74

A1: diethylene glycol; A2: triethylene glycol; A3: 1,3-butanediol; A4: hexylene glycol; A5: isopropyl alcohol; A6: glycerol; A7: 1,2-propanediol; PVP: polyvinylpyrrolidone K30.

13.Ink Tube Selection

When selecting a tube for inkjet printers, its importance cannot be overstated, as it serves as a crucial component in ink transportation, directly impacting ink quality and printing precision. A high-quality tube is essential to meet the diverse requirements of various applications and ink types.

Key attributes of an ideal tube include **exceptional solvent resistance**, **effective gas barrier properties, minimal moisture permeability, flexibility, smooth outer surface for enhanced sliding properties and flame retardancy.**

Maintaining high solvent resistance ensures that the tube can withstand exposure to various ink formulations without degradation, preserving ink quality and preventing clogging or inkjet ejection failures. Effective gas barrier properties prevent oxygen ingress, which can alter ink composition and lead to ink instability or bubble formation, adversely affecting print quality.

Likewise, minimizing moisture permeability is crucial to prevent moisture intrusion into the ink, which can also compromise print quality and lead to malfunctioning printing heads.

Furthermore, flexibility is vital to accommodate the dynamic movements and requirements of inkjet printing systems, ensuring smooth ink flow and consistent performance.

A smooth outer surface enhances the tube's sliding properties, facilitating seamless ink flow and minimizing friction-related issues during printing operations.

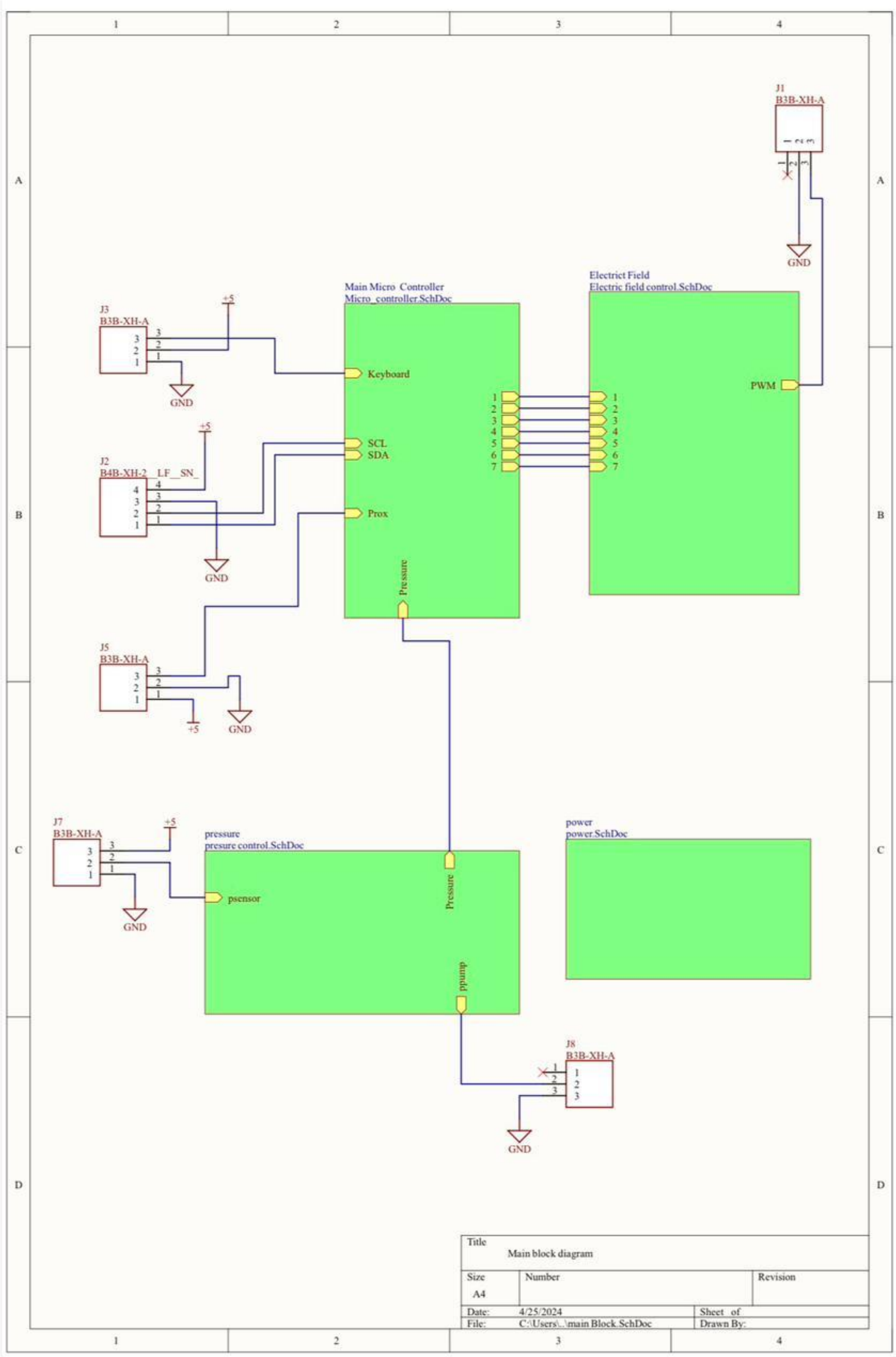
Lastly, ensuring flame retardancy mitigates potential safety hazards, safeguarding both the printer and the printing environment.

In essence, selecting a high-quality tube for inkjet printers is paramount to achieving optimal printing results, ensuring ink stability, and maintaining the integrity of the printing process.

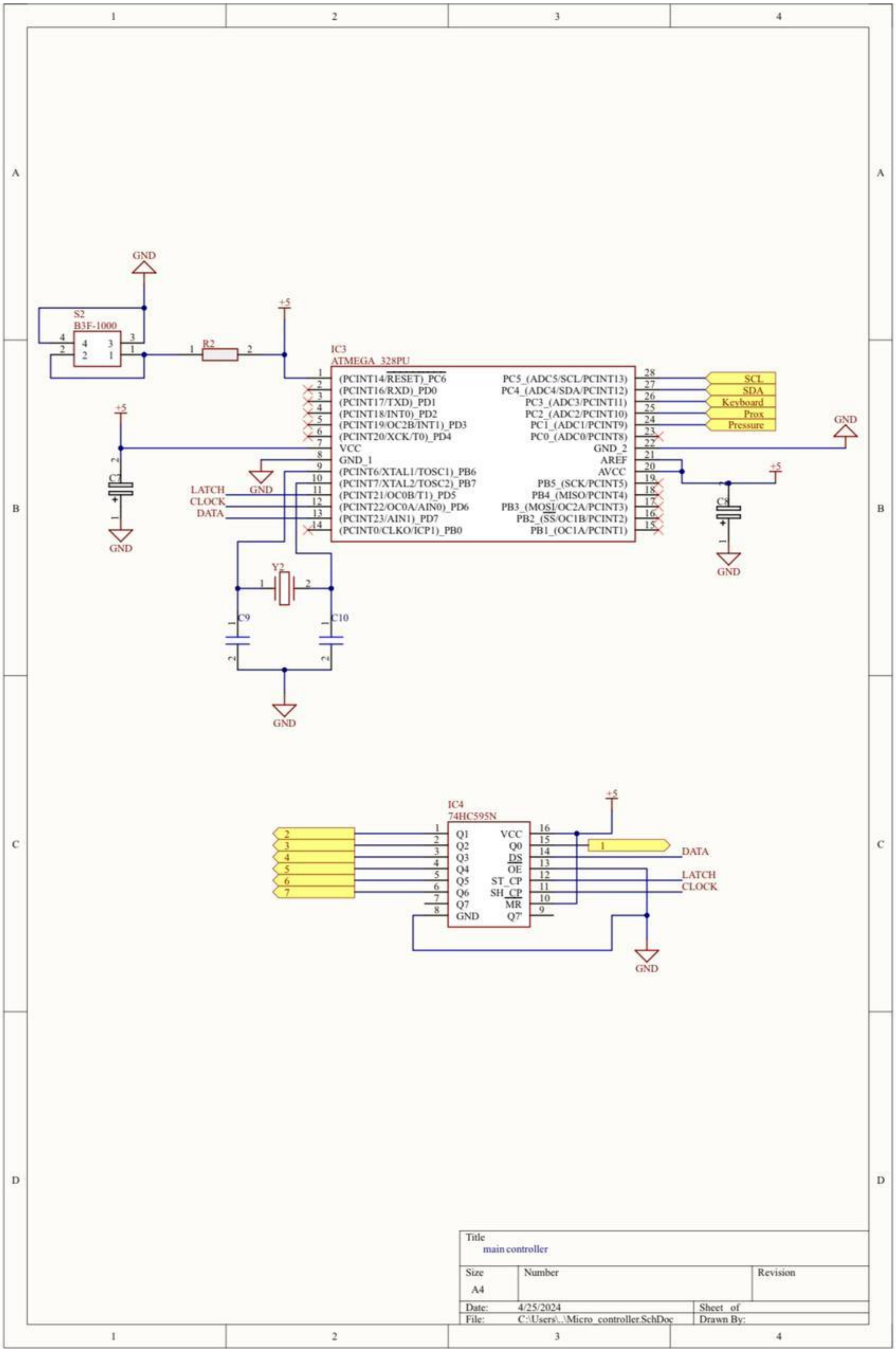
So, in our project we hope to use a solvent resistance ink tube with above qualities for the propagation of ink.

14.Schematics for the selected conceptual design.

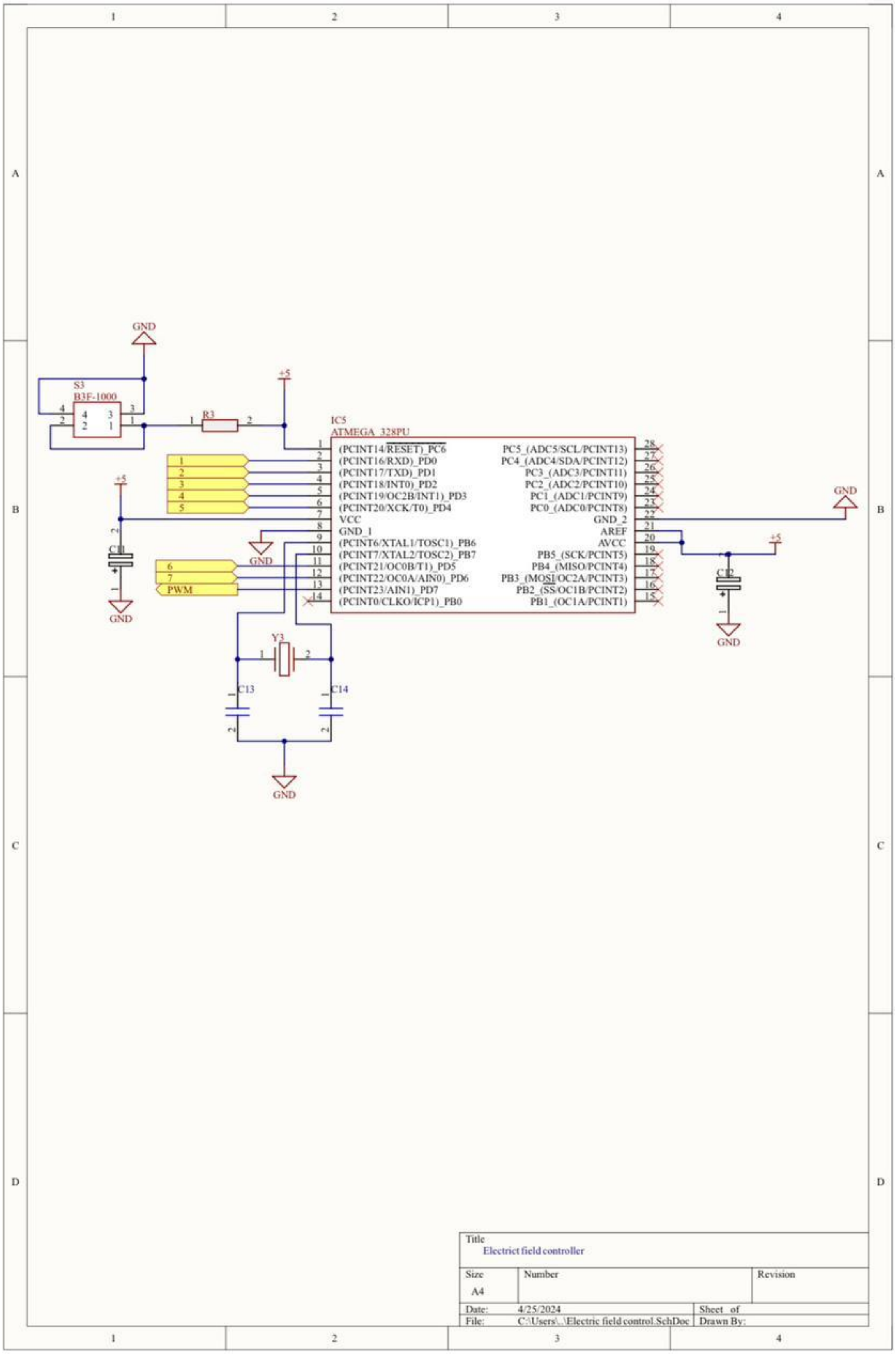
14.1 Main Block Diagram



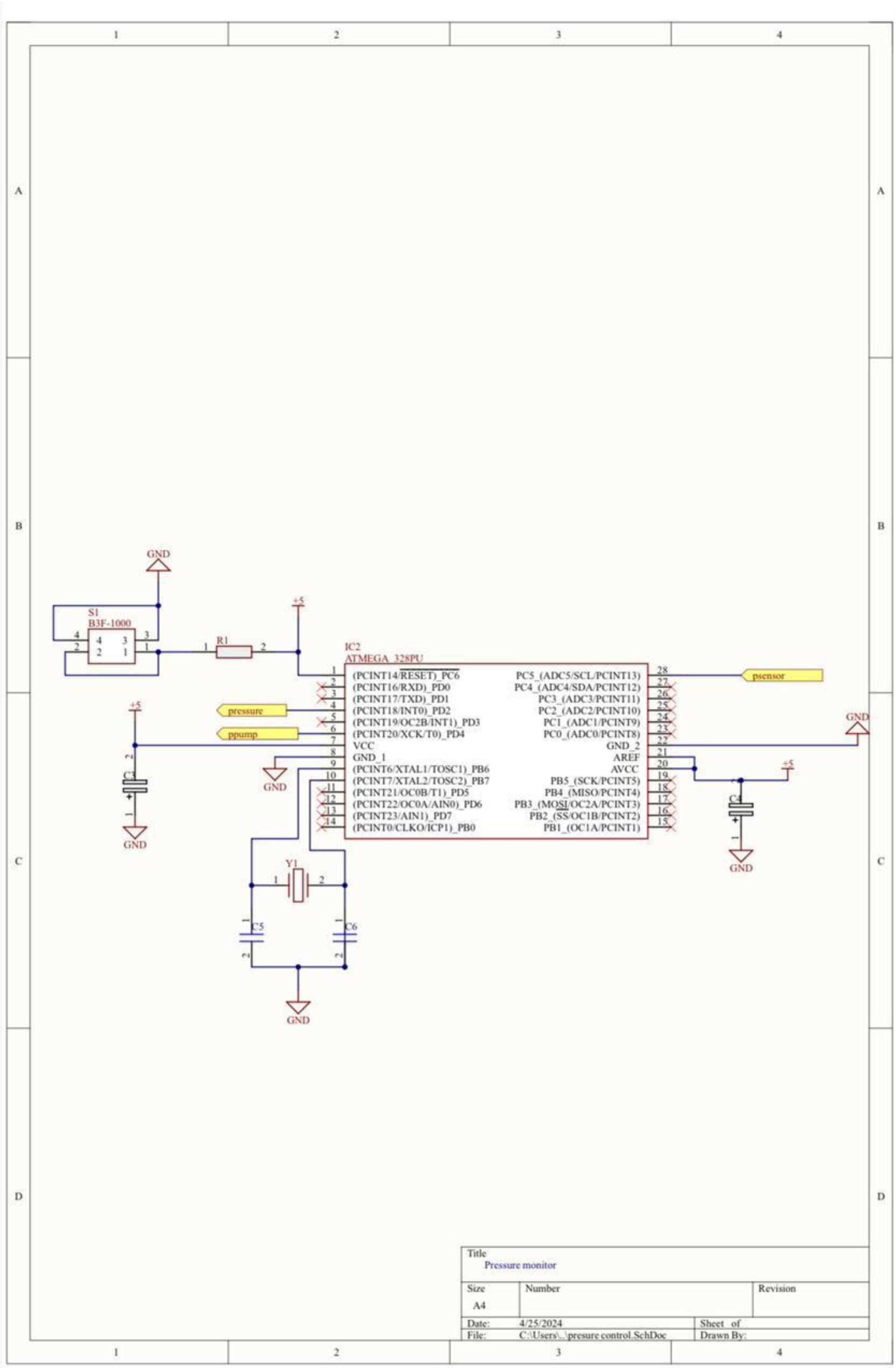
14.2 Main Controller



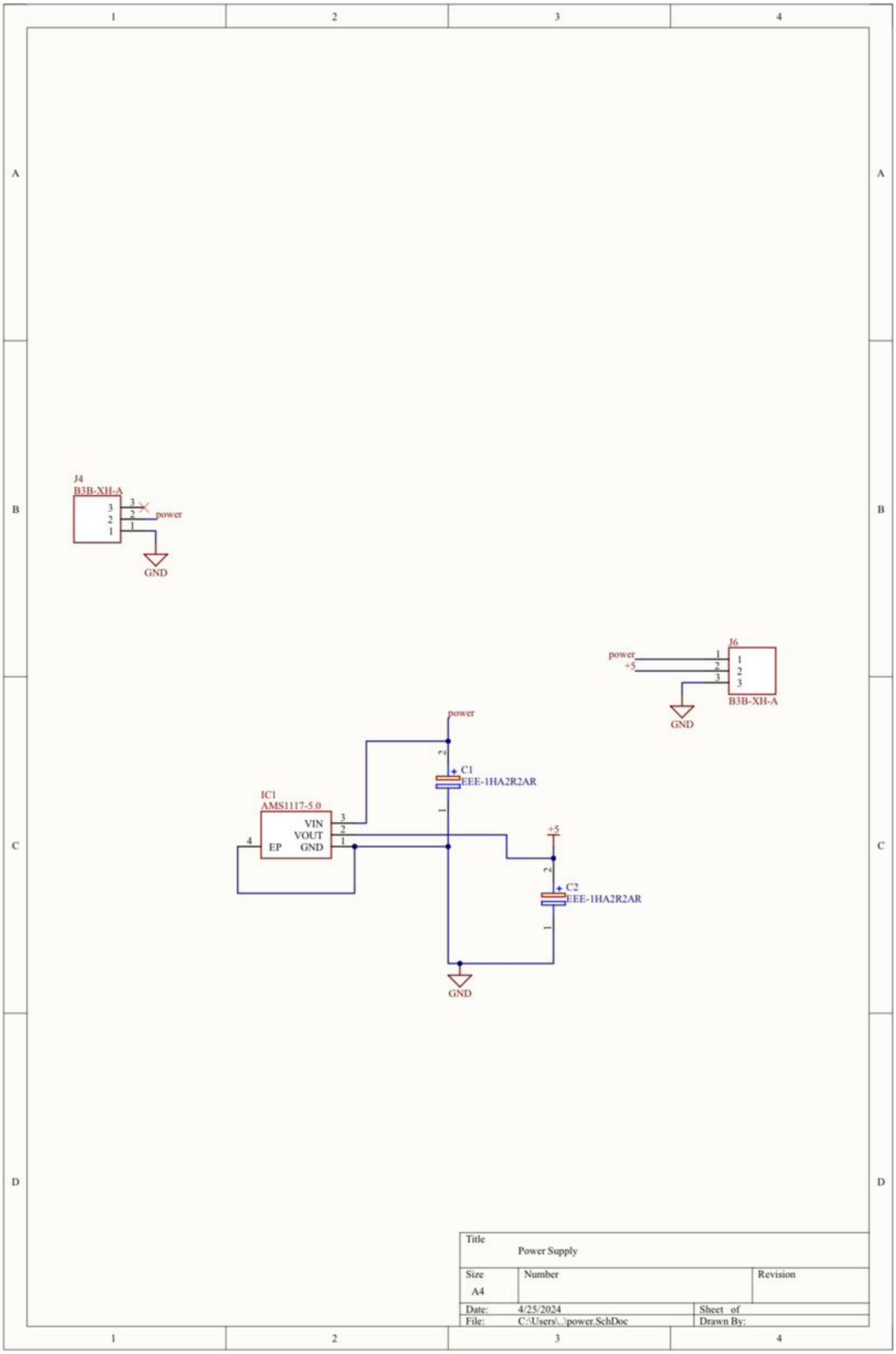
14.3 Electric Field Controller



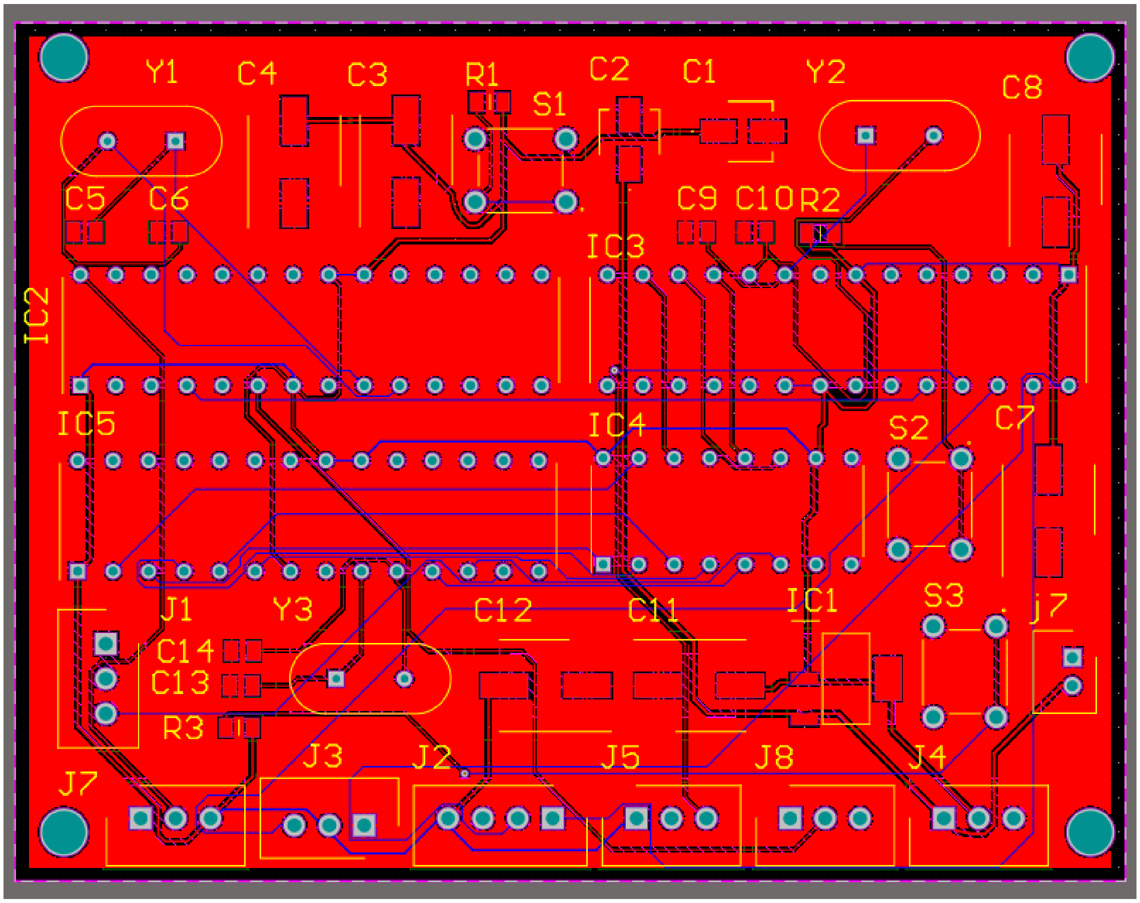
14.4 Pressure Controller

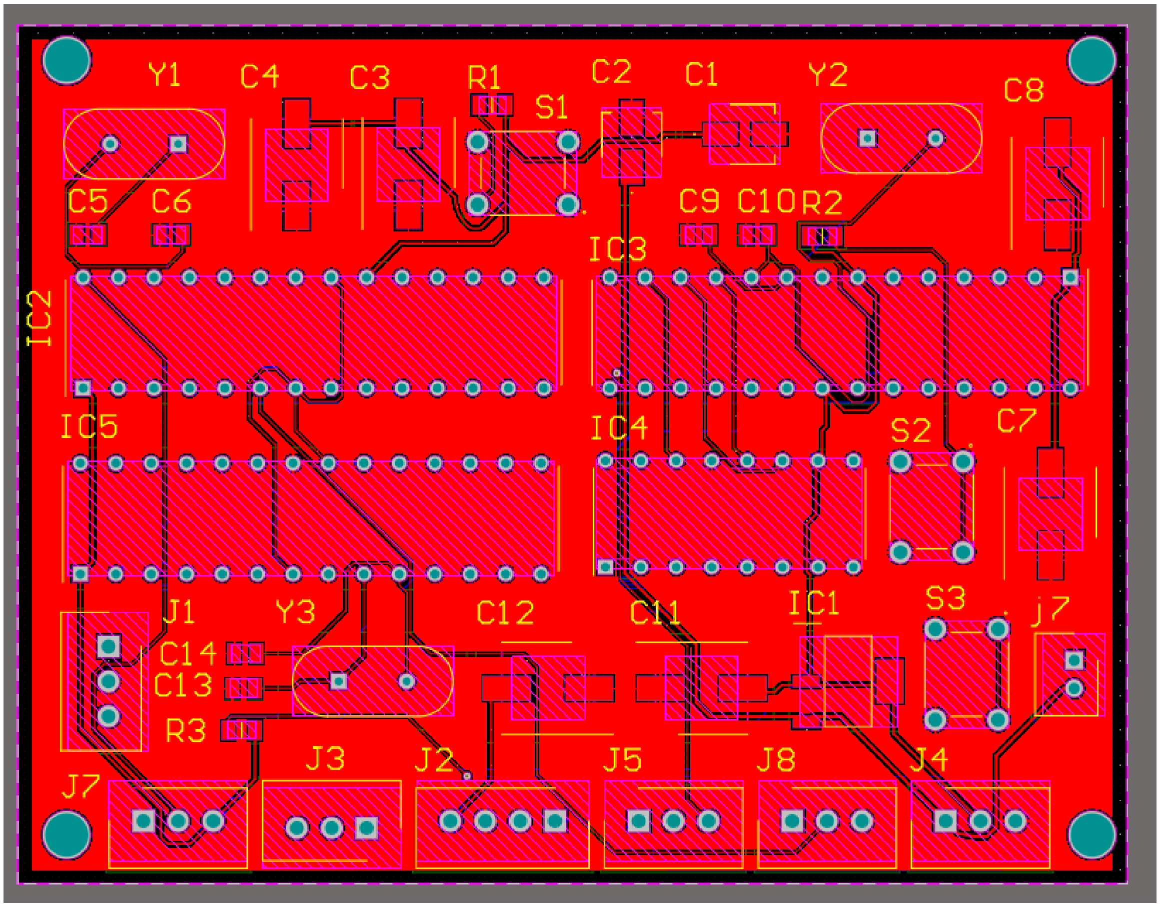


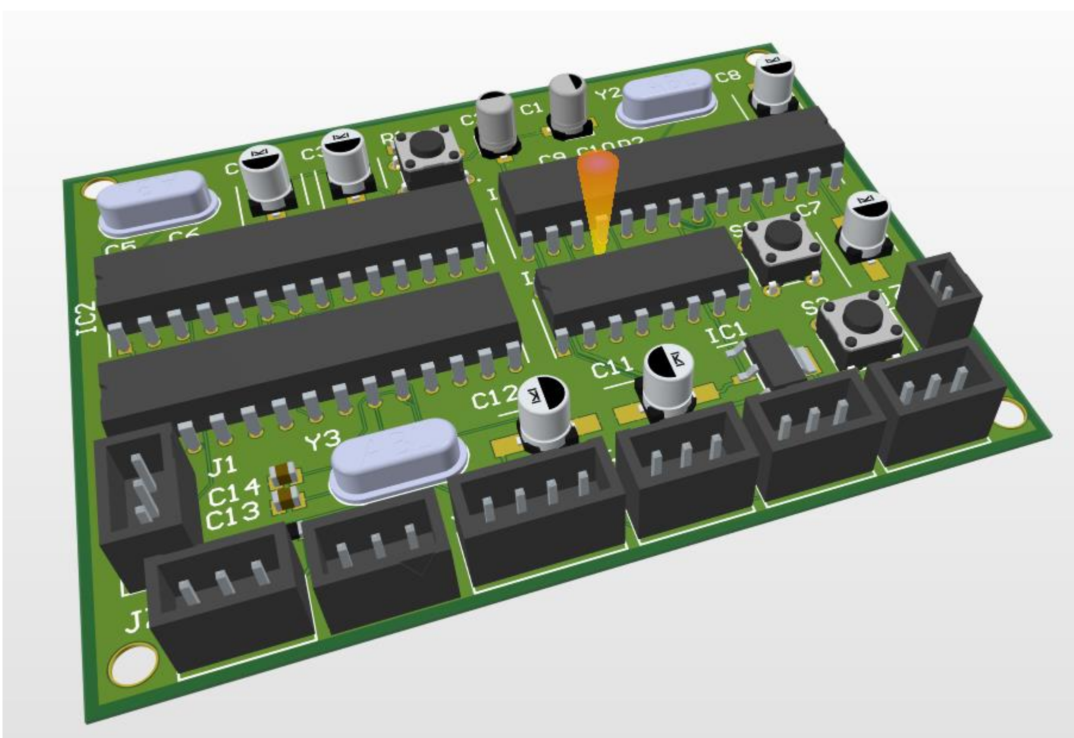
14.5 Power Supply



15.PCB Design and 3D view

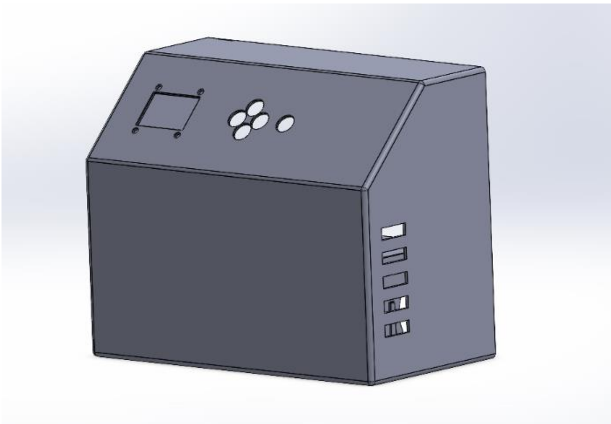


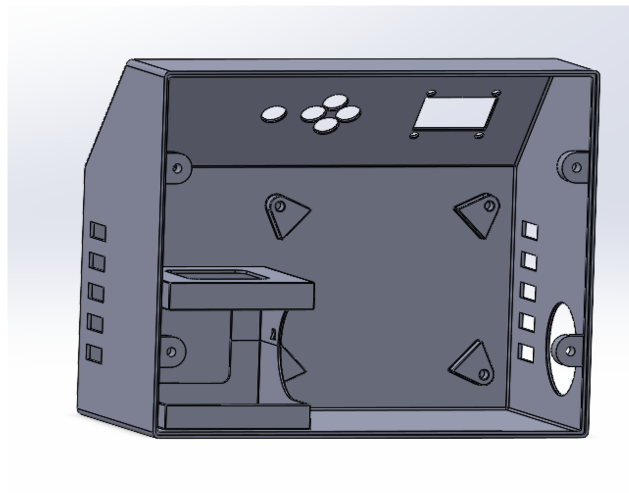

Y1
C4
C3
R1
S1
C2
C1
Y2
C8
C5
C6
C9
C10
R2
IC3
IC2
IC5
IC4
S2
C7
J1
Y3
C12
C11
IC1
S3
j7
C14
C13
R3
J3
J2
J5
J8
J4
J7

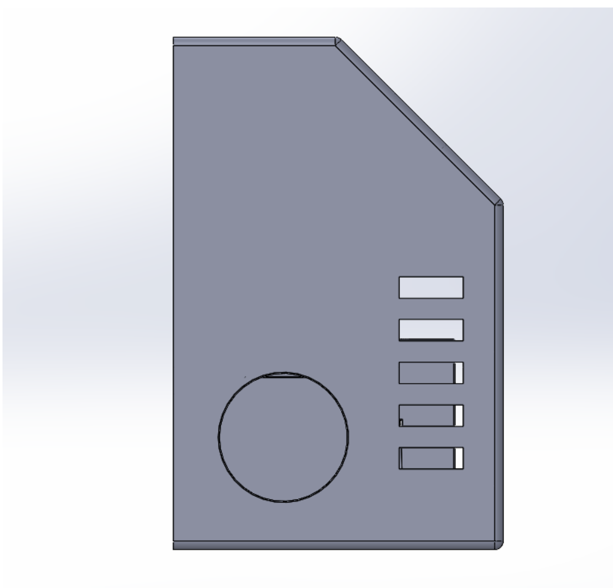


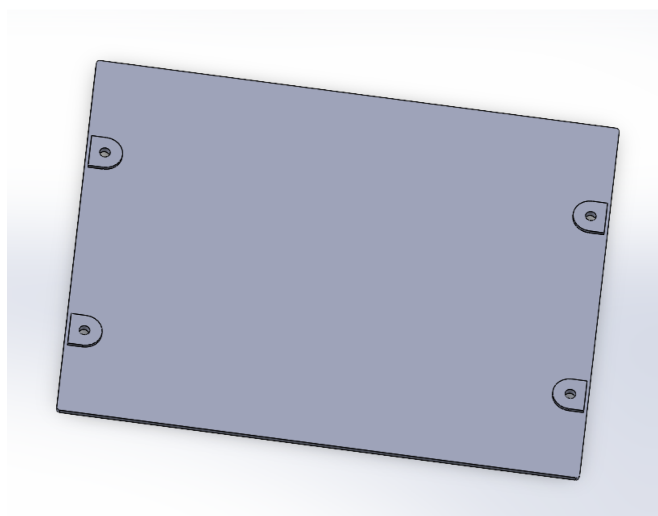
16.Enclosure Designs

1. **Print Controller Enclosure Designs.**

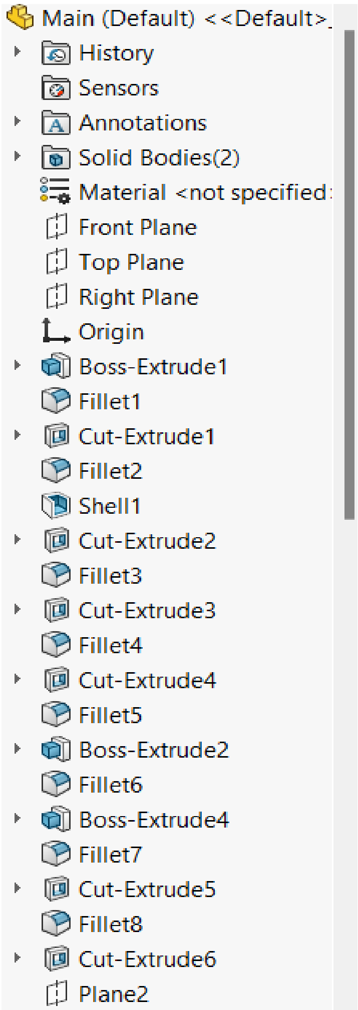


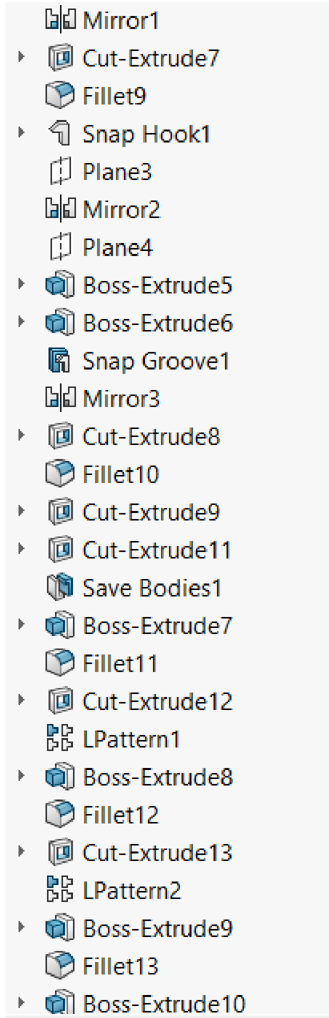


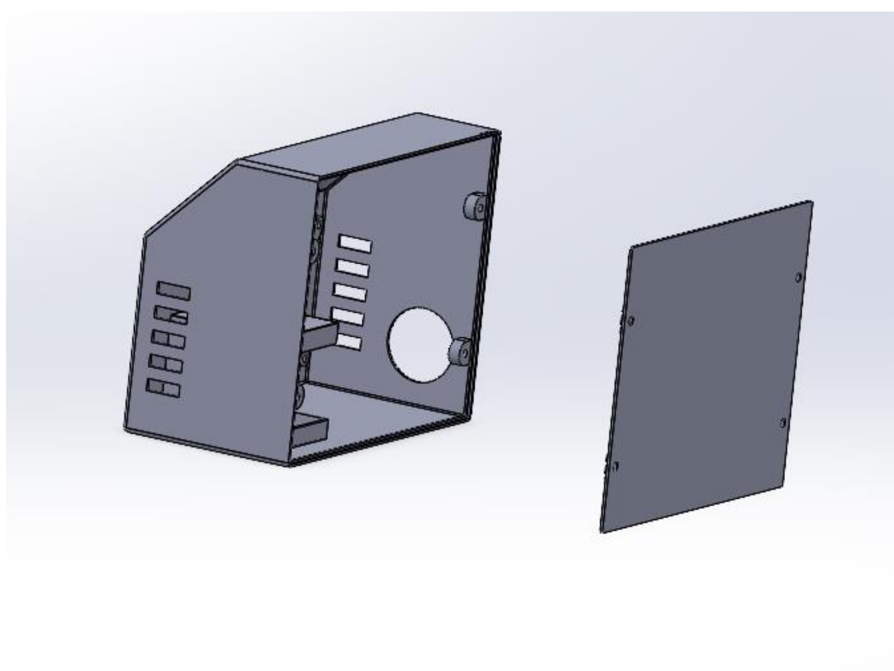




Design Tree and Assembly







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